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REFERENCE

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Mingzhong Tian *Editors*

Dictionary of Geotourism

Science Press
Beijing

Springer

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Anze Chen • Young Ng • Erkuang Zhang
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Editors

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With 635 Figures and 12 Tables

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Foreword 1

Nature inspires. Since time immemorial, nature has been a powerful source of inspiration to all human societies, irrespective of culture, religions, or civilization. Even the most mundane of us would be awestruck by the stunningly picturesque rocks of Huangshan in our country, the grandeur of the Alps in Europe, and the mystic volcanoes of Gunung Sewu in Indonesia. Nature's flora and fauna are fascinating and beautiful, but without the unique, primordial landforms that host them, we self-absorbed *Homo sapiens* would perhaps be less impressed and humbled. Perhaps this is why geoscience and geotourism matter to academia in both natural and social sciences as well as they do to governments, businesses, and people who make a living in the fast-growing global tourism industry.

I am highly impressed with the tireless dedication that Professor Anze Chen and his team have given to promoting geotourism through academic researches, teaching, as well as publishing. It is indeed an honor for me in presenting this new book *Dictionary of Geotourism*, which is an invaluable gift to students, followers, and simply all those interested to explore the wonders of nature and get to know what geotourism could bring to us and our community.

I for one can say that I am among the advocates and practitioners of geotourism in my home city of Hong Kong in my previous and current positions in Government. Blessed with a highly unique volcanic landscape of hexagonal columns lined up in tens of thousands along the cliff walls of a stunning Pacific Ocean facing coasting line, Hong Kong has joined the UNESCO Global Geoparks Network since 2009 and is still holding this global status at the moment.

Hong Kong is a strong testimony that our geopark, especially one that is situated within a stone's throw from our bustling metropolitan city, has proven to be a rediscovered treasure that never fails to excite millions of visitors both local and abroad.

My appreciation and admiration go to Professor Chen's decades of dedication and efforts in promoting tourism and earth science in China. I see this publication not just a masterpiece of Professor Chen's contribution to the professional field he proudly represents, but also a useful tool that helps to better equip practitioners of geotourism in their pursuit of interest and excellence. I congratulate his great work.

Edward Yau Tang-wah, GBS, JP

Secretary for Commerce and
Economic Development
The Government of the Hong Kong
Special Administrative Region
16 July, 2019

Foreword 2

How wonderful it is to have a book dedicated to explaining the many aspects of Geotourism. While the term is relatively young, the concept of travelling to see landscapes for recreation and enjoyment has been around for a long time. The Chinese have characterized this as "Tourism Earth-Science," and the China Tourism Earth-Science Research Association, founded in 1987, published *A Grand Tourism Earth Science Dictionary* in Chinese. This is a legacy of the pioneering work of the preeminent Chinese geologist, researcher, and educator, Professor Anze Chen, who brought together the fields of geography and geology with a view to finding the intersection of the two with tourism research.

Much later, those interested in tourism and geology in the West sought to define and characterize "geo-tourism." In Europe, the first published definition of geotourism as geology-based tourism was made by Thomas Hose. He defined it as the provision of interpretive and service facilities to enable tourists to acquire knowledge and understanding of the geology and geomorphology of a site including its contribution to the development of the Earth sciences. Further refinements were made by Hose. Inherent in these definitions was that geotourism is a vehicle to foster geoconservation, understand geological heritage (geoheritage), and appreciate geological diversity (geodiversity). Taken together, the notion is that geotourism as a form of tourism is underpinned by the concept of sustainability. In the early 2000s, the geoparks movement adopted this approach and reflected geotourism as being essentially "*Geological* Tourism."

In the USA, the National Geographic characterized geotourism as "*Geographical* Tourism." The Australian pioneers Professors Ross Dowling and David Newsome initially defined geotourism as being "geological tourism" but in recent years they have widened their definition by adding some of the National Geographic's "geographical" elements into their definition. Today geotourism is being universally accepted as a combination of all of the approaches above and is being viewed as both a form of tourism as well as an approach to it, but one that firmly ties itself first to the geologic nature of an area's "sense of place." Such tourism development generates benefits for conservation (especially geoconservation), appreciation (through geoheritage interpretation), and the economy.

While the definition has been debated and refined, there has been no stopping the interest and growth in geotourism around the world. The rapid

growth of the geoparks movement, and subsequent adoption of it by UNESCO, is reflected in the establishment of 147 UNESCO Global Geoparks in 41 countries in 2019. In addition, there are hundreds of more "national" level geoparks and as many "aspiring" geoparks in a movement which is taking the world by storm. Whereas geoparks are viewed as the "vehicle" for sustainable regional development, geotourism is the "engine" powering this phenomenal growth. Therefore, this book represents the engine "manual" with which to understand the subject.

This dictionary is an essential repository of knowledge which defines and characterizes the many facets of geotourism. It will be a major source of knowledge for all those working in geology and tourism around the world. The dictionary defines and characterizes the large number of important terms which are used within geotourism. These include geodiversity, geoconservation, geotrails, geosites, geoparks, mining parks, world heritage, etc. The book is central to the understanding of the subject and will be sure to be used as a marquee reference by the growing number of geotourism academics, researchers, practitioners, and professionals around the world. I recommend it wholeheartedly.

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Honorary Professor of Tourism
Edith Cowan University
Austria

Co-Editor, *Handbook of Geotourism*
Founder, Global Geotourism Conferences
Geotourism Advisor, UNESCO Global Geoparks

Preface

Geotourism can be defined as tourism which focuses on an area's geology and landscape as the basis for providing visitor engagement, learning, and enjoyment. This form of tourism has been addressed academically as "Tourism Earth Science" in China. In Chinese, Dixue (地学) is a combination of "land" or "Earth" (Di) and "study" (Xue), which refers to earth study or earth science study. It is one of the six major basic sciences including mathematics, physics, chemistry, biology, and astronomy. Tourism Earth Science has turned out to be a newly emerging branch of science, falling under the category of earth science. The new discipline was first established by the first author of this dictionary in the 1980s in China by applying the theories and methods of earth science to serve the tourism industry. Tourism Earth Science has contributed greatly to advance the development of China's tourism industry in a healthy and sustainable way. It has given impetus to the establishment of national geoparks in China. It also acts as a theoretical basis and guidance for tourism and geopark development. Here is an introduction to the concept of Tourism Earth Science, its background, and the need for compiling this Dictionary of Geotourism.

Definition of Tourism Earth Science

In China, geotourism has been named by geoscientists as Tourism Earth Science. The Association for Tourism Earth Science was established in 1985 in China. It defined Tourism Earth Science in Article 2 of its constitution as "a newly emerging interdisciplinary science, aims at investigating, studying, planning, developing and protecting tourism resources by applying its theories and methodology." In 1991, the definition was further refined in the book *An Introduction to Tourism Earth Science* (written by Anze Chen and Yunting Lu et al.) as "a newly emerging branch of earth science, a discipline that deals with relationships of travel and sightseeing, leisure therapy and therapeutic recreation to the composition and structure of the Earth's surface materials and their energy migration and change, comprising both geological and geographical tourism environments." Tourism Earth Science is actually a general term standing for two different disciplines namely geoscience and tourism. The *Grand Tourism Earth Science Dictionary* published in 2013 expanded this definition to "a newly emerging, interdisciplinary science created by integrating earth science with the tourist industry, consisting two sub-disciplines

which are tourism geology and tourism geography." Theories and methodology of earth science, together with other disciplines such as art, aesthetics, landscape, and environmental and tourism sciences, are adopted to address tourism issues associated with the Earth. These challenges derived mainly from tourism market, resources, planning, development, and management.

Research Areas

Tourism Market

Knowledge of human geography, economic geography, and regional geography are used to identify regional distribution and influencing factors characterizing tourist behaviors and activities. These factors may include the current geographical environment, climate, traffic, population, and economy.

Tourism Resources

Many tourism resources are studied by using the theories and methods of physical geography. Geology and geomorphology, in particular, applied together with aesthetics, landscape science, and town and rural planning in the preparation of tourism plans are extremely useful in identifying and proper utilization of natural tourism resources. With a better understanding of their distribution, values, and potentials, as well as their association with ecology, culture, and history, an inventory can be built up for more detailed and effective tourism planning and design.

Tourism Facilities

Theories and methods of earth and environmental sciences can be applied in site selection of tourism facilities. They can also be used to determine the type and scale of the facilities as well as assessing the values of the sites. Such studies include ground and foundation stability; levels of radioactivity, magnetism, trace elements, and negative ions; and water quality for spa and bath facilities in health resorts. Besides, geological hazards such as landslide, flooding, and earthquake need to be assessed to ensure safety of the tourism facilities. They also help to formulate environmental protection laws and regulations for the protection of valuable tourism resources.

Geopark Establishment and Management

The concepts of geological heritage, geoconservation, and geotourism can be applied in the course of geopark development and establishment. They involve identifying geological heritage sites, preparing and planning of heritage and protection sites, designing tourism routes, and setting up indoor and outdoor interpretation system, including contents of museum, panels, books, pamphlets, audio-video display, and other multimedia and social media channels. Tourism earth science also plays an important role in empowering geopark and national parks rangers and guides for telling geoscience, ecological, and cultural stories to tourists. It is very helpful in assisting the establishment of research and visitor centers, safety monitoring system, and building up database for tourism resources.

Development Background

Due to the significant political and socioeconomic changes in China since 1978, tourism has flourished in line with the improvement of the livelihood of people. Tourism industry requires inputs from other disciplines to address its diversified problems. Geology and geography are able to help in exploring, preparing, planning, and managing such tourism development projects. Earth science is an old and mature branch of science. With the increasing social and economic demands, the discipline is fuelled by tourism with new momentum. Its theories and methodology provide a solid foundation to meet these needs and have far-reaching impacts on tourism worldwide.

History and Current Situation

The involvement of geoscience in tourism starts not earlier than 1930 when the IUGS included geotourism as one of the discussion themes in its meeting agenda. In 1965, Nice Brouno, an Italian geographer, published *Research in Geographic Tourism.* In 1974, Chigaku Zasshi, a Japanese geographer, published the *Sight-seeing Geography*, while, in 1976, H. Robinson published *Tourism Geography*. In the meantime, American and Russian geographers also published papers of *Leisure Geography, Travel and Leisure System Geography*. In 1981, during the 24th International Geographers Association Congress, tourism geography was declared a branch of geography. Geologists' involvement in tourism began earlier than geographers' but the reports appeared only sporadically in research papers. Formal publication of tourism geology started only after 1990. Chinese scholars had first integrated tourism geography and tourism geology to form the new discipline of Tourism Earth Science. This was initiated by Anze Chen and Yunting Lu in 1991 in their publication *The Principles of Tourism Earth Science*. Therefore, the development of Tourism Earth Science can be summarized in five different stages:

Early Stage (1978–1985)

In 1978, China commenced its economic reform. The improved economic conditions led to rapid development and sudden growth of tourism industry. Tourist destinations with famous mountains and rivers attracted many thousands of tourists. At the same time, various academic societies in China also revived and the Commission on Geological Science Popularisation was set up by the Geological Society of China. The 1st National Symposium on Tourism Earth Science was organized in Beijing in 1985. Anze Chen, the chairman of the Commission, and Weixin Li, the Secretary-General, started using the name "Tourism Earth Science" to describe this new discipline. The name was extensively accepted by the symposium delegates with backgrounds in geology, geography, landscape gardening, architecture, environmental protection, tourism, cultural heritage management and protection, archaeology, and museums. In order to enhance the linkage of professionals from different areas, the Chinese Tourism Earth Science Research Association (Preparatory) was established. This preparatory association was affiliated to

the Geological Museum of China. This was an important milestone for the development of Tourism Earth Science.

Developing Stage (1986–1991)

The most important task after the founding of the preparatory association was to set up the discipline of Tourism Earth Science. It is essential to establish a brand-new discipline with independent research objectives, a complete set of methodology, and theoretical basis. Contributions from its members during this period had enabled putting theories into practice and applying various methodologies in conducting research as well as in addressing the various issues faced by the tourism industry. Much data and information were collected to form a sound foundation for different research projects. Inspired by the works done during this developing period, Anze Chen started preparing the book *An Introduction to Tourism Earth Science*, and the book was published by the Beijing Press in 1991. Since then the book has been used as a textbook for many universities around the country.

Growing Stage (1992–2000)

This was a growing period of Tourism Earth Science, which marked its entry in the international academic arena. In 1996, during the 30th International Geological Congress held in Beijing, Anze Chen and Maoxun Chen presented a paper on "Tourism Earth Science—A New Frontier of Earth Science" to over 6,000 earth scientists from 120 countries. At the same time, the Association organized and held the Symposium on the Strategy of Development of Tourism Resources in the Western Region of China. The impacts were far-reaching in arousing interests and involvement of many young earth scientists in Tourism Earth Science. During this period, this new discipline had been taken seriously by local universities and the first batch of master's and doctorate degrees in Tourism Earth were conferred by the Chengdu College of Geology.

Recent Development (2001 to Date)

With the development of national geoparks, new frontiers have opened to all geoscientists, which marks a new era for earth science. During this period, the concepts and methodology have been applied to assist the establishment of geoparks. In 2010, the Geological Society of China renamed China Tourism Earth Science Research Association to China Association of Tourism Earth Science and Geopark Research to highlight the important role of research in geoparks. The translation and publication of the *Principles of Geotourism and Dictionary of Geotourism* from the original Chinese versions of *Principles of Tourism Earth Science* and *Grand Dictionary of Tourism Earth Science*, will effectively help international promotion of the discipline. Tourism Earth Science is still a young discipline and requires more research on its theory, content, and methodology. The development of geoparks and geotourism in China comes at the right time for the discipline to grow stronger and be extensively accepted by the world.

Compilation of the *Grand Dictionary of Tourism Earth Science*

The initial idea of having a dictionary began in 1991 during the preparation of the Principles of Tourism Earth Science. Similar to other academic disciplines, there is always a need for reference and quick checking for information. A *Terminology of Tourism Earth Science* was proposed in 1994 and a preliminary manuscript was published in 1995. Fuelled by the rapid growth of geotourism and geoparks in China, the publication of a more formal dictionary of Tourism Earth Science became essential. This was made possible in 2013 with the help of many colleagues, particularly from the editors, Sanbao Wu and Haiyan Zhu of Science Publication, Beijing. To make the discipline readily available to overseas readers, an English version is also needed. The publication of this English version is made possible with the support and help of Lisa Fan, Senior Editor, Earth Science and Geography, Springer Beijing, and her colleagues. We need to emphasize that this dictionary is based on the original Chinese version but is characterized by presenting the entries in a more attractive and easily understandable format for the usage of non-geoscientists. The inclusion of many pictures and diagrams makes the explanation and illustration of the concepts and knowledge of Tourism Earth Science more interesting. The dictionary is definitely a tool for colleagues in geological heritage survey, assessment, and research. It is also a useful reference for managers, planners, and operators of national parks, geoparks and world heritage sites, science interpretation, tourism planning, museum, and visitor center design. It is a tool for teachers and students of schools and institutes of geoscience and tourism as well as for tourist guides and interpreters. The dictionary can also be used by more demanding visitors in acquiring knowledge of the natural and cultural environment that they will visit. Due to time limitation in preparation and publication, the dictionary can certainly be improved in future editions with the comments and suggestions from readers.

Last but not least, I would like to extend my gratitude to the tremendous efforts given by my colleagues Min Wang, Hongyan Sun, and other contributors in the preparation of this dictionary. Special thanks have to be given to the Huangshi Municipal Government, Hubei Province, for its generosity in sponsoring this publication.

Chinese Academy of Geological Sciences Anze Chen
Beijing
31 July, 2019

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Abraded Gravel Landscape
Abrasion Terrace Landscape
Absolute Age
Abstract Stone
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About the Editors



Professor Anze Chen is a research scholar at the Chinese Academy of Geological Sciences. He specializes in petrology since the 1960s with early publications such as "Micro-structure of Igneous Rocks" and "Structure of Kimberlite." In 1985, he set up the Tourism Earth Science Research Association of China and began promoting tourism earth science as a new academic discipline. His major publications in the past decade include "The Principles of Tourism Earth Science," "Research on the Karst Landscape of China," "Granite of Huangshan in China," "China's Geomorphological Landscape," "The Dictionary of Tourism Earth Science," and the latest English version of *The Principles of Geotourism*. Professor Chen is the initiator of the concepts of geotourism and geopark in China. He submitted a detailed proposal in 1985 to the State Council on the establishment of geoparks in China and has made significant contribution to China's national geopark development in the past two decades. He is currently a member of the National Geopark Assessment Board of the Ministry of Land and Resources. His major works in recent years involve the establishment of tourism earth science as an independent academic discipline in both Chinese and overseas universities.



Dr. Young Ng is a geoscientist at Danxiashan UNESCO Global Geopark and advisor of several other UNESCO global geoparks in China. He is a pioneer in geotourism, geological heritage conservation and geoparks in the Asia Pacific region and has been awarded various medals for his contributions in geological heritage conservation including the Hong Kong Government's Medal of Honor in 2012. He is the original proposer and advocator of the Hong Kong UNESCO Global Geopark and the founder of its Recommended Geopark Guides (R2G) System. Dr Ng is experienced in training, planning, nomination, assessment, and revalidation of national and global geoparks and world heritage sites since 2006. He co-authored *The Principles of Geotourism* in 2015, the first English version of the Chinese geotourism book extensively used as a textbook in universities in China. His research interests are in geotourism, geological heritage conservation, geoparks, and sustainable development. He is currently a member of the advisory committee of the National Geotourism Strategy Reference Group of Australian Geoscience Council, assisting the formulation of geotourism strategy and policies for Australia. He is also a member of the Geotourism Standing Committee of the Geological Society of Australia and a founding member of the Geotourism Forum of Ecotourism Australia.



Professor Erkuang Zhang is the deputy secretary and deputy chair of the Tourism Earth Science and Geopark Research Sub-Committee of the Geological Society of China. He has played a significant role in the establishment and development of the sub-committee since 1985. He is also a contributor to chapter three entitled "Basic Formation Conditions of Natural Tourism Resources" of the book *The Principles of Geotourism*. Professor Zhang had led the research and survey team in the compilation of the 1:2,000,000 map of "Distribution of tourism earth science resources in China." His other important publications include "Discussion on the Distribution Pattern, Development and Utilisation of Tourism Earth Science Resources in China," "Characteristics and Development of the Tourism Earth Science Resources of Hebei Province, China," "Tourism Resource of Danxia Landform in Yanshan Region," "Tourism Resource of Ancient Underground Warfare Tunnels Along the Song Liao Border," and "Historical Wonder of Underground Great Wall."



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A

AA Lava Landscape This is a type of blocky lava landform. Blocky lava is different from ropy lava because its surface is blocky in shape. In the local Hawaiian language, it is called 'Ah'; hence, aa has been used in the literature to represent this blocky lava. The surfaces of aa lava flows often contain porous or dense fragments, and small fragments of the same composition fill the gaps between the large fragments. This lava sometimes transforms into 'secondary lava' due to its heat. The central portion of the lava is often a monolithic lump. The bottom of the lava can either be composed of fragments accumulated from the broken shell of the lower part of the lava flow or debris accumulated from the peeled off or disintegrated surface of the lava flow as a result of movement in a rolling wave pattern. The lava blocks in Wudalianchi are a typical example (Fig. 1).

Abraded Gravel Landscape ▶ Striated Pebble Landscape

Abrasion Terrace Landscape This is a landscape consisting of terrace-like landforms that form on exposed wave-cut platforms as a result of decreasing sea level or land uplift. Ancient sea cliffs and sea notches can often be found on the landward parts of abrasion terraces, all formed by seawater erosion in various stages. The terrace surface is often covered with gravel. The formation of abrasion terraces depends on climatic changes (i.e., sea level changes) and neotectonic movements. The former are called hydrodynamic change abrasion terraces, and the latter are known as earth movement abrasion terraces. Since the Quaternary, due to alternating ice ages and interglacial climate conditions, uplifting and subsidence have been common. As a result, many abrasion terraces of different stages and heights have formed. For example, 10-m-high terraces are widespread on Zhoushan Island, and 30-m-high terraces can be clearly identified (Fig. 2).

Absolute Age *Synonym:* ▶ *Isotopic age*.
The absolute age is the actual age of a rock calculated based on the quantity of decayed products of radioactive isotopes in the rock since its formation. Isotopic age dating methods include the uranium-lead dating, potassium-argon and rubidium-strontium dating methods. Significant progress in isotopic age dating has been made in recent years, and the methods have become more sophisticated and popular, particularly in studies of Precambrian metamorphic rocks. However, because of the limits of the sampling techniques, isotopic ages are still approximate. The obtained age is sometimes also called the numerical age.

Abstract Stone Abstractness is related to people's consideration of abandoning the external characteristics of an object and extracting a certain internal essence of an object during the process of cognitive thinking. Abstract art is a kind of artistic phenomenon with abstract characteristics, as opposed to figurative art. An abstract stone is a natural ornamental stone with abstract art characteristics and aesthetic appeal. Through the abstraction of human thought, it forms a type of ornamental stone that is indescribable and can only be sensed. A relatively stable abstract stone is far more concise and clearer than an image stone, enabling people to experience infinite space and strength. This sentiment varies from person to person based on the age, knowledge, accomplishment and quality of the viewer. It is also a reflection of the levels of aesthetic appreciation of the viewer and collector. Each stone has a certain philosophical meaning associated with its shape, colour, quality, pattern, rhyme and sound, and the implications are profound and can play an educational role. A good abstract stone can be described as a 'Yuli stone' (educational stone) as the stone itself is attached

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Fig. 1 Aa lava landscape in Longmen Shizhai, Wudalianchi



Fig. 2 Diagram of an abrasion terrace landscape

with a special meaning or rationale that enlightens viewers upon their perception of the stone. This may result in life-long significance to the viewer. The so-called Moore stones (called this because some are similar to Henry Moore's sculptures) are well recognised abstract stones. From the perspective of abstract art, stones with the qualities of 'slimness, wrinkliness, leaking and penetrability' can be considered abstract stones. Because few people can understand the actual meaning of abstractness and because sound natural abstract stones are rare, abstract stones with visual beauty are considered to be precious (Fig. 3).

Accretionary Lapilli Accretionary lapilli are pyroclastics. During volcanic eruptions, some of the small volcanic ash and water vaper condense to form spherical or pisolitic accretionary bodies called accretionary lapilli, pisolites or volcanic ash balls. These bodies are common in volcaniclastic rocks. Accretionary lapilli are also found in the base surge tuff in the Beihai Weizhoudao National Geopark, which formed during a phreatomagmatic eruption.

Accretionary lapilli are spherical, bean-shaped features that form by the accretion of minute volcanic ash in the presence of steam or water vapour during volcanic eruptions. They are also called pea stones or volcanic ash spheres. They are common in the pyroclastic rocks in the volcanic regions of eastern China (Fig. 4).



Fig. 3 Abstract stone: bird (Lingbi stone)

Accumulation Landform Tourism Landscape This is a landscape that is formed by the deposition and accumulation of eroded materials by various geological processes, such as wind-blown sand dunes, moraine banks, alluvial terraces, river islands, alluvial fans and deltas. Accumulation landform landscapes have great tourism value. Examples are the coastal sand dune landscape in the Changli Gold Coast tourist area, Hebei Province, the desert landscapes in NW China and the Gobi landscape.

Acid Rain With the combustion of fossil fuels, the sulphur dioxide and nitrogen hydrides that are discharged into the atmosphere will transform into sulphuric and nitric acids. When these acids combine with rain and snow, the precipitation becomes acidic (less than 5.6 pH). Acid rain can cause the acidification of soil, corrosion of buildings, and endanger animals, plants and human health.

Acidic Rocks Acidic rocks also form a large group of igneous rocks. They mainly form by the intrusion of acidic magma into the country rock or by eruption onto the ground surface. The rocks contain more than 66% SiO_2 and higher contents of light-coloured minerals than dark minerals. The light-coloured minerals



Fig. 4 Accretionary lapilli (Credit: ResearchGate)

include quartz, plagioclase, and alkali feldspar, and quartz makes up 1/4 to 1/3 of the minerals. The dark minerals mainly include biotite and hornblende. Granite is the most common intrusive acidic rock, while rhyolite is the most common extrusive acidic rock. They are important rocks that form landscape features.

Acoustic Environment Protection Acoustic environment pollution refers to noise that causes discomfort and health damage to people in the environment, including traffic and industrial noise. Protection measures include classification of sound levels, delineation of functional areas and implementation of environmental noise control and management. Geoparks require strict controls on traffic and other human-generated noises.

Actinolite Actinolite is composed of $Ca_2 (Mg,Fe)_5 [Si_4 O_{11}](OH)_2$ and belongs to the same polymorph series as tremolite. It has a monoclinic crystal structure, and the crystals are long columns. The aggregates are radial, granular or blocky. The fibrous type is known as actinolite asbestos. It has various colours of green, while the lustre is vitreous, the Mohs hardness is 5.5–6, and the density is 3.0–3.3/cm^3. It is often found in contact-metamorphosed rocks.

Action Plan For Popular Science Education One obligation of a geopark is to promote science to the general public. Action plans are formulated by the geopark authority to help the public learn more about the Earth's history and the natural environment through various kinds of science popularisation activities. These activities are carried out on a regular basis and target the young people living within or near the geopark, and they focus on the natural environment, local culture and history. They are also aimed at university students and the general public. Activity plans are usually prepared on annual, short-term and long-term (3 years) basis. These plans include the project names, activities, completion times, responsible organisations and members, and the goals and expected results. They are either fully funded and supported by the geopark authority, jointly funded by the relevant organisations or sponsored by private enterprises.

Active Volcano Active volcanoes are volcanoes that are currently erupting or expected to erupt very soon. The definition of active volcanoes varies in different countries. The most popular classification is to categorise those volcanoes that have erupted since the Holocene (11,700 years ago) as active volcanoes. Some countries, such as Japan, classify volcanoes that have erupted in the past 2,000 years as active volcanoes. There are approximately 1,343 active volcanoes on Earth, including Laohei Mountain and Huoshao Mountain in Wudalianchi, Tengchong Volcano in Yunnan Province, Tianchi of Changbai Mountain and Ma'anling in Haikou (Fig. 5).

Adamello Brenta Geopark, Italy This geopark is located in the northwestern part of the Italian province of Trento and has an area of approximately 1 km^2. It became a global geopark in 2008. The area of the geopark consists of the Adamello-Pelesangola igneous mountain range in part of the province of Trento and the entire Brenta Delomiti mountain range. Both mountain ranges represent the main elements of the Adamello Brenta Geopark due to its unique geological and natural features. The characteristics and diversity of the area have had direct impacts on the lives of local residents, who continue to interact with the geological environment.

Adventure Tourism Adventure tourism includes travel and leisure activities in unusual, exotic, remote or uninhabited destinations. It is usually connected with high-intensity outdoor activities. The most common adventure tourism activities include: (1) air activities, such as hot air balloons, hang-gliding, gliding, bungee jumping, parachuting, skydiving, and air tours by small aircraft and helicopters; (2) water activities, including river rafting, cave exploration, charter sailing, diving, motorboats, sailing, rafting, kayaking, canoeing, surfing, water skiing, and fishing; and (3) land activities, including cross-country skiing, downhill skiing, helicopter skiing, ski tours, ox-drawn carts and sleds, hunting expeditions, cable cars, mountain bikes, horse-drawn carts, hunting, mountain exploration, rappelling and rock climbing.



Fig. 5 Active volcano landscape

Aeolian Landform Aeolian landforms form by wind erosion, transport and accumulation and can be classified as wind erosion landforms, caves, grooves, depressions, mushrooms, sand dunes and longitudinal sand ridges. Aeolian landforms are mainly located in arid and semi-arid areas but can also form in windy coastal areas (Fig. 6).

Aeolian Sandy Soil This type of soil can be found in arid and semi-arid deserts and areas of wind erosion desertification as well as rivers, lakes, and coastal beach areas. The soil formation is weak, and there are no obvious layers in the profile. These soils can be categorised as mobile aeolian sandy soils, semi-fixed aeolian sandy soils and fixed aeolian sandy soils based on the soil formation process.

Aerial Remote Sensing Remote sensing is based on the principle that different objects respond differently to the electromagnetic spectrum, and so sensors can be used to detect the nature and characteristics of ground objects from the air and to identify various types of ground features on the ground. Aircraft, airships, drones and balloons are often used as platforms for sensors. The technical system for conducting ground observations from high altitudes is called aerial remote sensing. Aerial remote sensing can generally obtain high-resolution surface information and is an important technique for tourism planning and tourism resource development and management.

Aesthetics Aesthetics is the study of people's mind and emotions in relation to the sense and evaluation of beauty. Based on the essence and principles of beauty, aesthetics studies human judgement of beauty, the relationship between the sense of beauty and the respective object, the experience of the sense of beauty, and the process of beauty creation and development. Traditionally, aesthetics has been categorised under philosophy with art as the main focus, which is known as 'The Artistic Philosophy of Beauty'. Aesthetics is one of the supporting theories of tourism earth science. Since the pursuit of scenic beauty is an important objective of tourism, the evaluation, appreciation, planning and utilisation of natural landscape resources related to earth sciences require detailed knowledge of aesthetics.

Agalmatolite *Synonym:* ▶ *Shoushan stone*

Shoushan stone is an aqueous aluminium silicate that is mainly composed of

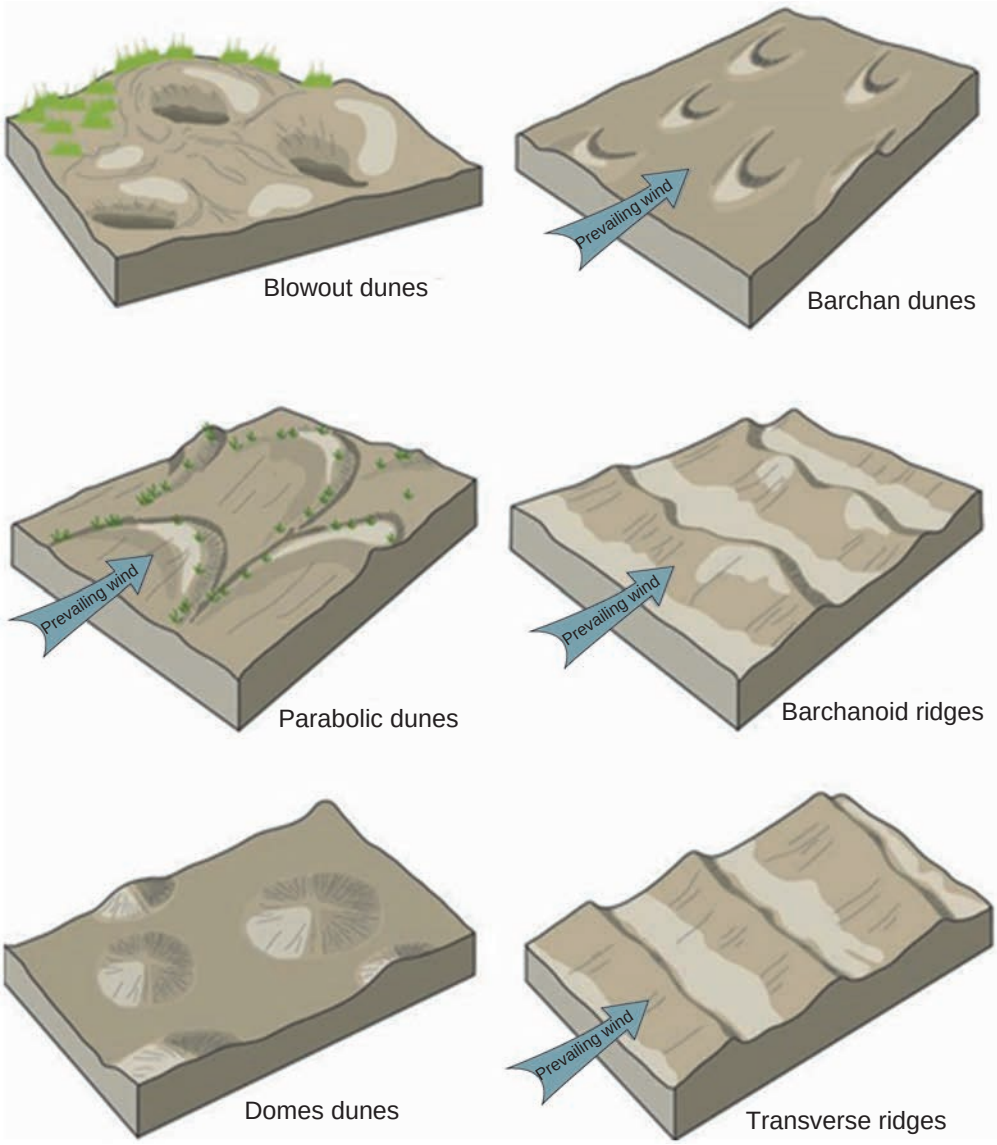


Fig. 6 Aeolian landform (Credit: US National Park Service)

pyrophyllite and dickite. It gets its name from Shoushan Village in the northern suburbs of Fuzhou, Fujian Province, where it is mainly mined. It has a very compact blocky structure with unique stripes (radish pattern). The pure stones are whitish, while those with impurities are red, purple, orange, brownish yellow or whitish yellow. Shoushan stone has a weak waxy lustre, which creates a creamy impression. It is opaque to slightly transparent, and some specimens look transparent. It is a soft rock with a density of 2.5–2.7 g/cm^3. Shoushan stone is generally harder than Qinghtian stone and is suitable for carving. There are three main types, including Tian Keng (arable field pit) stone, Shui Keng (water pit) stone and Shan Keng (mountain pit) stone, and 65 varieties. Tian Keng stone comes from arable fields and is pure without veins, and the yellow stones are called 'Tian Huang (arable field yellow)' and are the best type of Shoushan stone. Shui Keng stone comes from rock pits



Fig. 7 Shoushan stone craft

along streams and ranks second among all stones. Shan Keng stone is mined in the surrounding hilly areas and ranks third. The pits for mining include the Shoushan pit, Jiaoshan pit, Jiuchashan pit, Yuewei Creek pit, Douling pit and Kengtou cave (Crystal Cave). Shoushan stone formed approximately 150 million years ago during the Late Jurassic. It can be a volcanic hydrothermal metasomatism (filling) pyrophyllite or a volcanic metamorphic rock. The stone products are popular in China and around the world (Fig. 7).

Agate Agate is a cryptocrystalline silica colloidal aggregate. Its chemical composition is SiO_2. It can be monochromatic but more commonly has layers, stripes or bands of various colours. It is mainly found in cavities in extrusive volcanic rocks and is a low-temperature hydrothermal colloid mineral. It can also be found in sediments in residual slope layers or alluvial layers. The Chinese word for agate, 'manao', first appeared in Emperor Wei Wendi's (220–225 A.D.) writing 'Manao (agate) Lei Script': 'Agate is jade from the west with a staggered pattern like a horse brain and hence has the name manao'. Based on its colour and pattern, agate can be called hezi (black body with white or green dots in the middle) agate, jiezi (red and white band) agate, chanzi (twining) agate, blue agate, green agate, gao (plain white silk) agate, paste spot agate, moss agate, red agate and rhino agate (Fig. 8).



Fig. 8 Cut agate

Age And Stage Age is a geologic time interval (geochronologic unit) corresponding to a 'stage'. An age is a subdivision of an epoch, which generally has a time interval of three to ten million years. A stage is a basic lithostratigraphic unit below a series in the formal chronostratigraphic terminology hierarchy. A series can be subdivided into several stages. Different biogeographical regions can have different stage names, and a series can consist of different stages in different biogeographical regions. The stage symbols are not consistent in different countries.

Agenda 21 Agenda 21 was a document adopted at the World Conference on Environment and Development in Rio de Janeiro in 1992 that incorporated environmental, economic, and social concerns into a single policy framework. It was a legally non-binding effort to encourage development while protecting the environment. It was a blueprint for a landmark achievement in promoting a global sustainable development plan.

Agricultural Tourism Agricultural tourism includes tourism activities that focus on agricultural processes, rural landscapes and scenes of farmers' work and life. This type of tourism

includes rural landscapes, agricultural and associated products, native products, handicrafts, rural food and clothing, farming activities, rural villages and civilian residences, rural ancestral temples, and folk customs and culture.

Aïr and Ténéré Natural Reserves, Niger These reserves are located in the high desert of northern Niger and have a total area of 77,360 km^2. Although the protected sanctuary makes up only 1/6 of the total natural area, it is the largest protected area in Africa. It includes the volcanic rock mass of the Aïr and a small Sahelian area. Its climate and flora and fauna are isolated because Ténéré is situated in the Saharan desert. The reserves boast an outstanding variety of landscapes, plant species and wild animals.

Air Pollution Index (API) The pollutant concentration determines the air quality of the environment. High concentrations of pollutants can have severe negative impacts on the ecological environment and humans. Short and long-term air qualities are important in determining the liveability of a city. Air pollutants include soot, total suspended particulate matter, respirable suspended particulate matter (floating dust), nitrogen dioxide, sulphur dioxide, carbon monoxide, ozone and volatile organic compounds. Carbon dioxide is not considered a pollutant.

Air Temperature The air temperature is the temperature referred to by a weather station, which is measured in a meteorological monitoring shutter box at a height of 1.5 m above the ground. China measures and expresses temperatures in degrees Celsius.

Albite The composition of albite is Na $[AlSi_3O_8]$. It is a plagioclase with a triclinic crystal system. The crystals appear as bladed blocks, and crystal twinning is common. It can sometimes appear as block, granular or flaky aggregates. Thin slices are often curved. The colour is generally white or colourless, and can also be light blue, grey, green or pale red with white streaks. It has transparent to translucent diaphaneity, a vitreous or pearly lustre, a specific gravity of 2.60–2.63, a Mohs hardness of 6–6.5 and uneven fractures. It is a main component of several magmatic rocks, such as granite, rhyolite, andesite and syenite. Albite can also form in metamorphic rocks, such as schist and gneiss, and certain sedimentary rocks. It can also be found in hydrothermal veins.

Albite Jade Albite jade is considered a variety of jade by gemstone craftsman in China. It is made up of sodium silicate minerals. It mainly consists of feldspar, omphacite, epidote and chlorite. Its usual colours are white, greyish white, greyish green, green and colourless. Albite jade looks very similar to jadeite; it is often confused with real jadeite and can only be differentiated by professionals. In the trade, it is also called 'Shuimozi (water foam jade)'. High-quality gemstone-grade albite jade ore mainly occurs together with jadeite, and it is currently mainly mined in Myanmar.

Aldabra Atoll, Tanzania Aldabra Atoll is located approximately 1,000 km southwest of the Seychelles and covers 500 km of the Indian Ocean along the southeastern coast of Tanzania. It covers a core protection area of 350 km^2. The atoll is composed of four large coral islands that enclose a shallow lagoon. The group of islands is itself surrounded by a larger coral reef. Due to difficult accessibility and geographical isolation, Aldabra has been protected from human influences and thus retains some 152,000 giant tortoises.

Alejandro de Humöboldt National Park, Cuba This park is located along the border between Guantanamo and Guort provinces in eastern Cuba, and it covers a core protection area of 693 km^2. The complex geological landscape features of the park contain the best examples of ecosystem diversity and species diversity in the Caribbean and have made Cuba one of the richest tropical islands on Earth. Because many of the underlying rocks contain toxins, only plants that have developed anti-toxic mechanisms have survived. The unique evolution of life in this region has led to the development of numerous new species, making the park one of the most important local plant protection sites in the Western Hemisphere.

Alexander Von Humboldt Alexander von Humboldt (1769–1859) was a famous German naturalist, geographer and explorer. He was one of the founders of modern geology, geography, climatology, geomagnetism, and phytogeography. He travelled all over Western Europe and later to North America and South America to investigate and explore. His 30 volume 'Personal Narrative Travels to the Equinoctial Regions of the New Continent' is considered the first regional geographic masterpiece in the world. His other famous works include 'Cosmos (5 volumes)' and 'Central Asia (3 volumes)'.

Algae Fossil In general, algae fossils include all types of algae preserved as fossils throughout geological history. The main species are Cyanophyta, Chrysophyta, Xanthophyta, Rhodophyta, Chlorophyta, Charophyta, Pyrrophyta, diatoms, and Phaeophyta. Most algae is aquatic and lives in a planktonic or benthic manner. Algae fossils can preserve the entire algae group or only part of it. Algae fossils that have gone through the calcification process are also called 'calcareous algae fossils'. Abundant Cyanophyta and Rhodophyta fossils have been found in the late Precambrian strata in China. The fossils have diverse forms; some formed parts of stromatolites, whereas others grew on the side or outer margin of rock. Some clustered to form radial structures with black and white stripes, and some are cloud-shaped, jagged or tussock-like. The Mesozoic and Cenozoic strata are rich in diatoms, Charophyta and Pyrrophyta fossils (Fig. 9).

Alkali Granite Alkali granite is a type of granite that contains alkali feldspar and alkaline iron-magnesium minerals. It is mainly composed of quartz, alkali feldspar and alkaline dark minerals. The dark alkaline minerals include alkaline hornblende (such as riebeckite) and alkaline pyroxene (such as acmite augite and aegirine). These dark alkaline minerals give the granites different names, such as acmite augite granite, Suzhou granite, Fuzhou Kuiqi granite and Zhejiang Taohuadao granite.

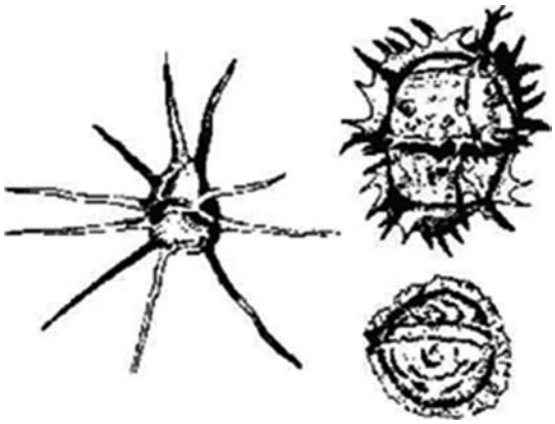


Fig. 9 Algae fossils

Alkaline Rocks Alkaline rocks are rocks that contain alkaline minerals (such as nepheline, aegirine and riebeckite). Alkaline rocks include ultrabasic, basic, intermediate and acidic rocks. The bulk rocks usually have low O_2 contents but high alkaline (K_2O+Na_2O) contents. The rocks contain alkali feldspar, sodium pyroxene (such as aegirine and acmite augite), or sodium pyroxene (such as riebeckite and arfvedsonite). When the alkali content is high, the rock will not contain quartz but will contain feldspar minerals (such as nepheline, hauynite, and noselite). Typical examples are nepheline-syenite and phonolite. A rare type of nosean phonolite has been found at Niangniang (Empress) Mountain in Nanjing.

Allite; Bauxitic Rock; Aluminous Rock Bauxite is a chemical sedimentary rock that is rich in alumina and aluminosilicate minerals. In general, when bauxite contains over 40% Al_2O_3, and the Al_2O_3/SiO_2 ratio is greater than 2.5, it is known as bauxite ore. Bauxite rock is similar to clay rock but is denser and harder. It has low plasticity and often has an oolitic or pisolitic texture and a blocky, botryoidal or grumose structure. It is sometimes in the form of a breccia aggregate with a clotted structure. It forms due to strong chemical weathering of aluminium silicate minerals, during which the alumina and kaolinite dissolve, are then transported to lower areas and deposited. It can also form by aquatolysis.

Alluvial Fan Landscape This is a fan-shaped landscape formed by alluvial deposits. When rivers in a mountainous area enter a flat region, their transportation capacity decreases drastically due to the abrupt reduction in the gradient. The debris carried by the water accumulates to form an alluvial fan that radiates out from where the river exits the mountains. Sometimes, the migration of a riverbed can cause the formation of an alluvial fan with a wide extent and gentle gradient. The superimposition and deformation of an alluvial fan is a direct evidence of neotectonic activity. The new and old alluvial fans in the hills near Beijing are superimposed and deformed.

Alluvial Plain An alluvial plain formed by fluvial sedimentation. Rivers carry large amounts of sand and silt from their upstream regions, and the flow velocity decreases in the lower course due to the gentle gradient. As a result, sediments accumulate along the river banks to gradually form an alluvial plain. In general, alluvial plains refer to the extensive plains that form by proluvial deposition and the expansion of deltas. They include piedmont plains, alluvial plains and coastal plains. An example is the North China Plain. In a narrower sense, alluvial plains only refer to those typical alluvial plains that form by long-term deposition along river banks triggered by shifting of the river courses during flood periods.

Alpine Glacier Alpine glaciers mainly refer to glaciers in the alpine zone at middle and low latitudes. These glaciers are linear and flow along low-lying valleys between mountains. Based on their mode of development, they can be categorised into cirque glaciers, hanging valley glaciers, valley glaciers and flat-topped glaciers (Fig. 10).

Alpine Glacier Tourism Landscape This is a landscape with glaciers formed as a result of neotectonic uplift in temperate and tropical regions. Examples are the snow-capped Kilimanjaro Mountain in Tanzania, which is located on the Equator and has become a famous destination for tourists, and the Waterton-Glacier International Peace Park in the North American Rockies, which covers more than one million acres and contains numerous high peaks and more than 50 glaciers and 200 lakes among the mountains and valleys. In China, the Kanas Glacier in Xinjiang and the Gongga Mountain Glacier in Sichuan have been established as glacier-type national geological parks.

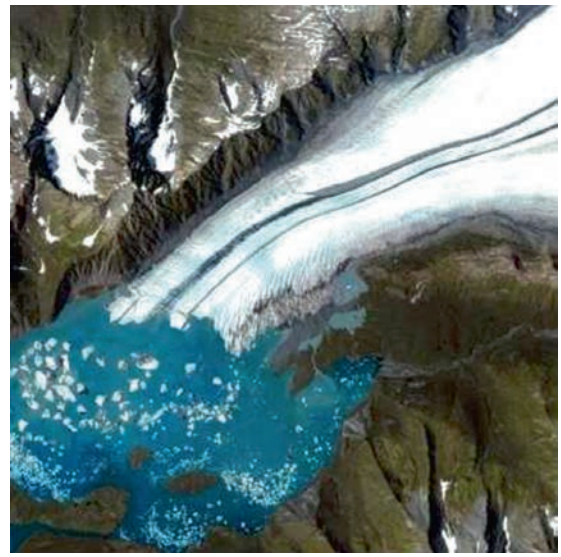


Fig. 10 Alpine glacier landscape

Alpine Meadow Soil *Synonym:* ▶ *Grass soil*

Alpine meadow soil is also known as grass soil. It is an alpine soil that forms under meadow vegetation in moist and semi-humid alpine environments, usually above the forest line, where the surface layer contains a thick layer of grass roots and weak redox characteristics. These soils are mainly distributed in the eastern and southeastern parts of the Qinghai-Tibet Plateau as well as in small areas to the northwest and northeast of the plateau.

Alpine Movement In Europe, scientists mainly take the Alpine movement as the crustal movement that occurred in the Mesozoic and Cenozoic Eras. However, there are different interpretations of its duration. Chinese scientists call the Permian crustal movement in China the Indosinian movement, the Jurassic-Cretaceous crustal movement the Yanshanian movement, and the Cenozoic crustal movement the Himalayan movement.

Altitude Altitude is the height above sea level and is also known as the absolute height, absolute elevation or average vertical height above sea level. China adopts the Yellow Sea average sea level and its base plane as the country's unified land elevation starting plane.

Alxa Global Geopark, China This geopark is located in the western Inner Mongolia Autonomous Region and covers an area of 630 km^2. It became a global geopark in 2009. It has three scenic districts: Bataan Jilin, Tenggeri and Juyan, with a total of ten scenic sites. Its unique geographical location, geological structure, ecological environment, and climatic conditions have formed a landscape dominated by deserts and Gobi and have preserved various typical geological features formed by wind and geological actions. In addition to the ancient fossils that have been discovered, the park systematically and completely illustrates the effects of wind processes and geological events. The Badain Jaran Desert is the second largest desert in China. It contains the highest sand hills and largest singing sand area in the world. There are more than 140 lakes in the desert, which supported an ancient culture that developed Mongolian customs. The Tengger Desert is the fourth largest desert in China, and it is the desert with the most abundant freshwater lakes in China. The lake scenery in the Tengger Desert is charming. The Ulan Buh Desert is located in the northeastern part of Alxa Zuoqi. Its active sand dunes are mainly distributed in the southern and central sections and are composed of crescent dune chains, grid crescent dunes and crescent sand hills. The Ejin Gobi landform is mainly located in the central part of Ejin Qi. The gravel layer of the Gobi is up to 700–800 m thick. The black Gobi around Mazong Mountain is typical and is an ideal place to study the formation, development and evolution of Gobi. Juyanhai Lake is the second largest inland river in China. It protects the oases in Ejin. The Tonghu Lake area is now a unique grassland but is surrounded by sand dunes and has been regarded as an Eden in the desert by domestic and foreign visitors. Haisenchulu is located in the northwestern part of Alxa Youqi. The wind-eroded Jurassic granite landforms are large and beautiful. The steep canyons have many tafoni, mushroom-shaped stones and other features common in the Eribugai and Aolunbylage areas.

Amber In ancient China, amber was called the 'Tiger Soul'. Amber forms through the fossilisation of Palaeogene or Neogene pine or cypress resin that lost its volatile properties and solidified after long periods of time. It is often associated with coal seams. Amber is a hydrocarbon containing succinic acid and copal. Its chemical composition is $C_{10}H_{16}O$, and it is composed of 79% carbon, 10.5% hydrogen, 10.5% oxygen and sometimes a small amount of hydrogen sulphide. It is frequently shaped like a pie, kidney, nodules, elongated water droplets or other irregular shapes. There are numerous colours, such as yellow, orange yellow, brown, brownish yellow, and brownish red. Light green, yellow or light purple amber is rare. Amber has a greasy lustre and is transparent or translucent. It often contains insects, seeds or other inclusions (Fig. 11).

Amber Fossil Amber formed from the resins of coniferous plants that underwent the fossilisation process during the Cretaceous to Neogene periods. As the amber formed, insects, seeds and foliage were sometimes covered by the resin to become fossils inside the amber; hence, they are called amber fossils.

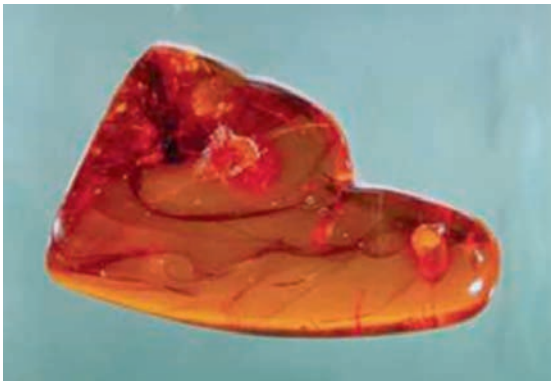


Fig. 11 Amber



Fig. 12 Insects inside amber

Some are small animals (e.g., beetles, flies and mosquitoes), and some are plants (e.g., fruit, seeds and leaves). Most of China's amber fossils come from the Palaeogene coalfields in Fushun, Liaoning Province, where high-quality insect amber has been mined. Similar fossils have been excavated in Nanyang in Xixia, Henan Province, Baoshan, Lijiang Ailao Mountain in Yunnan Province and Zhang Pu in Fujian Province (Fig. 12).

American Plate The western margin of the American Plate is composed of the San Andreas Fault, Middle America Trench and Peru-Chile Trench. Its eastern border is composed of the Mid-Atlantic Ridges. The plate has been divided into the North American Plate and South American Plate.

Amethyst Purple amethysts with transparent and flawless properties are valuable as gems. Amethysts are popular and inexpensive gemstones. The purple colour is caused by manganese and titanium. Amethysts are mainly found in cavities of volcanic rock and pegmatite. Brazil is most famous for mining amethyst (Fig. 13).



Fig. 13 Amethyst crystal

Ammonite Ammonite obtained its Chinese name Chrysanthemum Stone because it looks like a blooming chrysanthemum. There are many species, and they vary greatly in size from a few centimetres to more than 10 cm. The largest is larger than a cooking pan. Ammonites were marine invertebrates that lived 400 million to 65 million years ago. Due to their rapid evolution, they had remarkable characteristics and were widely distributed. Ammonites are the most effective index fossils for the determination and comparison of rock strata, and they have facilitated the demarcation of many Jurassic and Cretaceous marine facies. The longitudinal section of an ammonite looks like a beautiful spiral with a colour like amber (Fig. 14).

Amphibians During the process of ontogenetic development, some animals must undergo metamorphism. The young generally breathe with gills to be able to live in an aquatic environment, but the adults breathe with lungs to adapt to terrestrial conditions (Fig. 15). Few amphibian fossils have been found in China, but all have substantial scientific research and ornamental value. Amphibians first appeared in the late Devonian and flourished in the Carboniferous-Permian. Fossils of *Rana basaltica* have been

found in the diatomite shale in Linqu, Shandong Province. This fossil frog has been well preserved, and the skin prints and bones are clearly identifiable. Many tadpole fossils have also been found. Abundant well-preserved fossils of amphibians have been discovered in the Jehol (Rehe) biota, and this discovery fills the gap in China's Mesozoic Lissamphibia fossils and thus has facilitated the study of the early evolution and migration of amphibians in China. Signature species are Callobatrachus, Mesophryne, Cynops and Liaoxitriton.



Fig. 14 Ammonite (Credit: Hemswell Antique Centres)

Amphibole Amphibole is the general name for the hornblende family of minerals. These minerals can be divided into two sub-families: orthorhombic amphibole and monoclinic amphibole. These subfamilies can be further subdivided into anthophyllite, tremolite, actinolite, hornblende, riebeckite and glaucophane. Amphibole has a long columnar shape, and the aggregates are granular, fibrous or radiating. It has deep colours that vary from green, brown and tan to black. It has a vitreous lustre, a specific gravity of 3.0–3.5, and a Mohs hardness of 5–6. Amphibole is a common rock-forming mineral that is mainly found in metamorphic rocks. Hornblende is also an important mineral in intermediate and intermediate-acidic igneous rocks. Tremolite and actinolite with a dense blocky aphanitic texture are called soft jade (nephrite).

Amygdaloidal Structure The pores of volcanic rocks are called an amygdaloidal structure when they are filled with minerals that precipitated in a later stage. The fillings are usually calcite, zeolite, chalcedony, quartz and chlorite, which are common in basalt. In some geoparks with basalt, these structures tend to attract the interest of tourists (Fig. 16).



Fig. 15 Fossil of a frog (*Rana basaltica*)

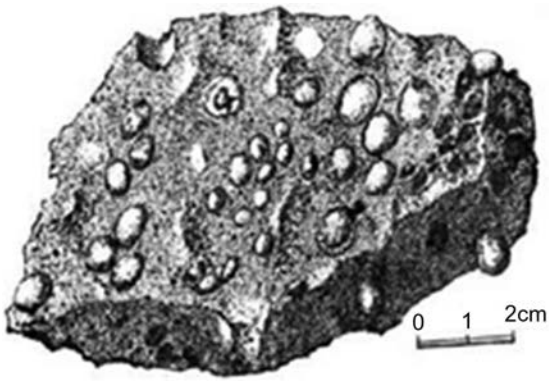


Fig. 16 Amygdaloidal structure

An Introduction to Tourism Earth Science This book was edited by Anze Chen and Yunting Lu and was published by Peking University Press in 1991. The book consists of 10 chapters, which focus on the system of tourism earth science and tourism, targets and objectives of tourism earth science research, classification of nature-based tourism resources and conditions of geological formations, the background of cultural tourism resources, the principles of the aesthetic judgement of the landscape, survey and evaluation methods of tourism resources, and preparation methods of tourism planning and systems, tourism resources and environmental protection. This book was the first monograph to discuss tourism earth science, a new discipline that expounds the relationship between tourism and earth science. It lays a solid theoretical foundation for the development of tourism earth science. In the 1990s, it was used as teaching material and a reference book for tourism studies in colleges and universities. It played an important role in nurturing the first group of tourism professionals (bachelors, masters, and doctors) in China.

Anatexis Under conditions of increasing temperature (or increasing temperature and pressure), the existing rock melts and fuses to form new magma; this process is called anatexis. In general, the anatexis process does not involve the addition of new materials. The process is characterized by sequential melting from low-melting point minerals (such as feldspar and quartz) to high-melting point minerals.

Ancient Bridge Landscapes of China China is home to many bridges and has been described as 'the country of bridges' since ancient times. The superb bridge-building techniques and architecture have led China's ancient bridges to become important landscape resources, such as the Zhaozhou Bridge in Hebei Province, Luoyang Bridge in Quanzhou, Lugou Bridge in Beijing and Xiangzi Bridge in Chaozhou. China covers a large area, which has led to the evolution of unique bridge characteristics and styles to suit the local conditions of different regions. The bridges in the north are mainly broad and composed of stone arches and stone beams, and the bridges in southwestern and northwestern China are mainly built of rattans, bamboo ropes and wood posts and are mainly in the form of rope suspension bridges or cantilever wood bridges. In the Fujian and Guangdong coastal areas in southern China, hard granite is abundant; therefore, stone bridges are common in these regions. In the areas of the minority tribes in Yunnan Province, distinctive bamboo bridges with unique characteristics are widespread because bamboo is a common plant resource here (Fig. 17).

Ancient Earthquake Relics These are relics that remain from earthquakes over geological history. The main features include the following: (1) seismic ruptures, which are extensive ground cracks formed by earthquakes, usually distributed like a ribbon; (2) earthquake lakes, which are lakes formed by damming of rivers by earthquake-induced landslides, slope failures and mudslides; they usually exist in mountainous regions and have a potential risk of dam breaking; (3) earthquake bulges, which are small uplifted ridges on the ground surface due to the fault displacement during an earthquake; they always form between ground cracks and are arrayed in groups; (4) earthquake landslides, which are masses of rocks and soils on slopes that slide due to gravity after being triggered by earthquakes; they are a major secondary hazard caused by earthquakes; and (5) earthquake ruins, which



Fig. 17 Zhaozhou Bridge, Hebei Province

are the remnants of structures damaged by earthquakes.

Ancient Glaciers Ancient glaciers are glaciers that formed prior to modern glaciers. There have been several glacial periods over geological history, such as the Sinian glacial period and the Carboniferous-Quaternary glacial period. Glaciers were widely developed during these periods, and only some remaining features can be found today. In general, all glaciers prior to the currently active glaciers are called ancient glaciers (Fig. 18).

Ancient Organisms ► Palaeobionts

Ancient Roads of China China's ancient roads mainly refer to the roads built before the late Qing Dynasty, when modern road building techniques were not known in China. At the site of the Shang Dynasty ruins, traces of road pavement with pottery pieces and gravel have been discovered. During the Warring States period, the roads became important. The erection of boardwalks on steep terrain was a major characteristic of road construction at that time. After unifying China, Emperor Qinshihuang began building an extensive road network that radiated from the capital Xianyang to the rest of the country. The Han Dynasty inherited this road system and improved the management of the transport system and the associated postal stations. The Sui Dynasty built one thousand miles of imperial roads. The Tang Dynasty put much effort into managing the courier stations along the roads. Suburban roads had smooth traffic, and the urban roads inside the cities also had a prominent design. The road network in the capital city of Chang'an was in a chessboard pattern. The Zhuque Main Street along the central axis of this chessboard pattern was 150 m wide and was paved with bricks, and there were gutters and trees on both sides. The road design was neat and orderly, which became a model for urban road construction in the coming eras and influenced areas as far away as Japan. Since then, the quality of road construction increased based on the past experience in the Song, Yuan and Ming Dynasties. In particular, the Yuan Dynasty built 7 main trunk roads radiating from Dadu (today's Beijing) to the entire country, forming an extensive road network. Based on this network, the Qing Dynasty built a route network of 150,000 km, which is known as the 'Postman Route'.



Fig. 18 Pleistocene glacial landscape in Dangxiong, Tibetan Plateau

Ancient Volcano An ancient volcano is a volcano that erupted long ago. Its nature and type can be determined through geological investigations. This type of volcano had been denuded, leaving an exposed neck, and the original crater is usually absent. Typical examples are Mesozoic volcanoes that have been deeply eroded, exposing the structure of the volcanic base.

Andalusite Andalusite, together with kyanite and sillimanite, are polymorphs of aluminium silicate. It has an orthorhombic crystal structure, and the crystal form is columnar with a nearly square cross-section. Black carbon inclusions are sometimes located at the four corners or at the centres of the crystals, arranged like a regular cross, which is called chiastolite. The aggregates are radial, like a chrysanthemum flower, so it is also locally called the 'chrysanthemum flower stone'. It is pink, light red, light brown, light white, light grey or light green in colour. It has transparent to opaque diaphaneity, a vitreous lustre, a specific gravity of 3.13–3.16, a Mohs hardness of 6.5–7.5 and uneven to conchoidal fractures. Andalusite is mainly a product of contact metamorphism and is commonly found in the contact zone between intrusive rocks and argillaceous rocks. It can sometimes be found in crystalline schist. It often forms together with kyanite, cordierite, sillimanite and corundum. Transparent andalusite with good colours can be used as gemstones (Fig. 19).

Andesite Andesite is an intermediate extrusive rock characterized by dark grey, light purplish red or brown colours, a porphyritic structure, phenocrysts made of pyroxene, hornblende or biotite, intermediate plagioclase with a concentric structure, and a hyalopilitic or glassy texture. Andesite is widely distributed along the continental margin of the East Pacific Rim, which is also called the andesite line. Andesite is also widely distributed in eastern China.

Angular Unconformity An angular unconformity is simply called an unconformity. This term refers to an obvious sedimentary discontinuity between two rock strata in the same



Fig. 19 Andalusite (Credit: Gem Select)

location. Angular unconformities form due to prolonged denudation. After the underlying rock layer forms, intense crustal movement causes the upper and lower strata to have different attitudes.

Antarctic Ice Sheet Landscape Ninety-eight percent of the Antarctic continent is covered by ice. A long-term survey by scientists estimated that the total volume of the Antarctic ice sheet is 28 million km^3 with an average thickness of 2,000 m and a maximum thickness of 4,800 m. The thickest ice cover is located 510 km east of the Australian Casey Station. Covered by permanent ice, the Antarctic continent, especially its southeastern portion, has become a dome-shaped plateau with an average elevation of 2,350 m. It is the world's highest continent with an average elevation more than 2.5 times that of the Asian continent, which contains the Tibetan Plateau. However, if the ice sheet is removed, the average height of Antarctica is only 410 m, significantly lower than the average height of all of the continents on Earth. The Antarctic ice and snow cover compose the world's largest freshwater reserve whereas 90% of the world's ice is stored here, which accounts for 72% of the freshwater reserve on the Earth's surface (Fig. 20).

Antarctic Plate The Antarctic Plate has Antarctica at its centre and includes the surrounding oceanic basins. Because the Antarctic Plate is separated from the adjacent plates by mid-ocean ridges, which serve as discrete boundaries, and also sits on Earth's rotational axis, it is more stable than the other plates. Hence, it is always used as a reference point for calculations of plate velocities.

Anthropogenic Pollution Anthropogenic pollution is environmental pollution and harm caused by human activities. It can be in the form of industrial, agricultural, transportation and urban pollution. Examples include the industrial production of waste gas, wastewater, waste residue, and waste heat; the use of chemical fertilizers and pesticides in agricultural production; noise, dust, and automobile exhaust generated by transportation; and sewage, garbage, plastic waste, waste paper and metals. It can be classified as air, water, noise and soil pollution.

Anticline An anticline is also called an antiform and is a convex-up fold, where the limbs are the sides of the fold that dip away from the hinge. The oldest beds are in the centre, and the youngest beds are on the outside. Secondary anticlinal folds can develop and be superimposed on large anticlines and this type of feature is called an anticlinorium. In cross-section, secondary folds are fan-shaped. Anticlines and synclines are the basic components of folds. There are many types of anticlines: (1) linear anticlines (linear folds), which tend to form in active compressional orogenic belts; (2) dome anticlines, which form in stable platform areas; and (3) box anticlines and comb anticlines, which are typical features of anticlinal folds in transitional regions. Studies of anticlines can help to determine the mechanism and environment of folding. In a practical sense, anticlines are the main type of structure containing oil and gas, and they are the main targets for oil and gas exploration.

Anticlinorium See ▶ Anticline

Antiform See ▶ Anticline

Anxian Bioherm-Karst National Geopark, Sichuan This geopark is located in northwestern An County, Sichuan Province. It is in the north-central segment of the Longmen mountain range in the Sichuan Basin and borders the



Fig. 20 Landscape of the Antarctic ice sheet

Minjiang alluvial plain, hills and mountains. It became a national geopark in 2002. The northwestern part is in the Longmen Mountains, and the highest peak has an elevation of 2,922 m. The park features deepwater siliceous sponge reefs, including hexactinellids in large-scale reefs that formed in the Late Triassic (approximately 230 million years ago). In Anxian County, 6 new sponge families, 31 new families and 55 new species have been identified. The sponge reefs have sizes of 40–60 m. More than 100 reefs can be observed at the surface in Anxian County and the vicinity. The spacing between the reefs ranges from 100 m to 2 km. Rocky hills, which are prominent landforms, are distributed in front of the and Longmen Mountains and cover an area of 266 km^2.

Anxian-Type Calcigravel Stone Forest Landscape, Sichuan This is a representative type of carbonate stone forest landscape. It is composed of Jurassic calcareous conglomerate, and the Anxian Shilin in Sichuan Province is a typical example. It is a unique type of stone forest in which the clasts of the conglomerate are mainly limestone and dolomite. The clasts are 2–15 cm in diameter, and the largest can reach 20–50 cm with calcareous coagulation. The conglomerate is part of the alluvial fan facies of the ancient Longmen Mountains. The columns are generally 2–4 m tall and can be up to 8 m. The stone forest is accompanied by dissolved depressions and dolines with a semi-exposed formation, which is often covered by Middle-Late Pleistocene sediments. The column bodies are rugged and robust, and they are one of the relic geological landscapes in Anxian Bioherm National Geopark (Fig. 21).

Anze Chen Anze Chen (1933–) is a native of Linying County, Henan Province, and is a researcher and visiting professor. He graduated from the Wuhan Geological School in 1954 and from Beijing Geological Institute in 1961. He was the director of the President Office of the Chinese Academy of Geological Sciences, deputy director of The Geological Museum of China, full-time deputy secretary-general of the Geological Society of China, and the founding president of the China Tourism Earth Science Research Institute. He is currently the vice president of the Chinese Academy of Tourism Earth Science and Geopark Research, the Geological Society of China, the assessor of national geoparks of the Ministry of Land and Resources, the consultant of landscape architecture of the Ministry

of Construction (currently the Ministry of Housing and Urban-Rural Development), and a visiting professor of the Tourism Institute of Beijing. He has engaged in petrological research and is the author of 'Structure of Igneous Rock Brochure' and 'Kimberlite Brochure'. In 1978, he began studying the application of earth science to tourism. He established the Chinese Tourism Earth Science Research Institute and founded the discipline of tourism earth science. He is the author of 'Introduction to Tourism Earth Science' and 'Research of Stone Forest Karst Landscapes in China'. He is the chief editor of 19 volumes of 'Tourism Earth Science Proceedings' and 'The Geotourism Guide to the 30th International Geological Congress (including 6 volumes in English)' and has published more than 20 papers on tourism earth science. In 1999, he proposed the establishment of national geoparks in China and assisted the Ministry of Land and Resources to promote the construction and management of geoparks. He edited the national geoparks series and chaired the geological landscape research of eight geoparks, including Huangshan. He participates in the assessment and consultation of all geoparks in China and several national scenic areas, world heritage sites, national forest parks and the standards of the China National Tourism Administration (currently the Ministry of Culture and Tourism of the People's Republic of China). He is one of the founders and academic leaders of tourism earth science. He has contributed significantly to the establishment and development of geotourism and geoparks in China

Apatite Apatite is a phosphate-bearing mineral with the chemical formula $Ca_5[PO_4]_3$. It has a hexagonal crystal system, and the crystals are hexagonal columns. The aggregates are granular, dense block or nodule-like. Apatite has several colours, such as grey, brownish yellow and light green. It has a vitreous lustre, and the fractures are uneven and greasy. Its specific gravity is 3.2, and its Mohs hardness is 5. It can form from endogenous, exogenous and metamorphic processes. It is an important raw material for the manufacturing of agricultural phosphate fertilizer and for phosphorus extraction. Hydroxyapatite crystals can be used as laser-emitting materials.

Aplite Aplite is a light-coloured rock in dykes that does not contain dark minerals. It is mainly composed of fine granular quartz and alkali feldspar. It often occurs in fissures in intrusive country rocks.

Applied Physical Geography Applied physical geography focuses on applying the theories and methodologies of physical geography to address practical problems in areas such as production, construction, economic



Fig. 21 Anxian-type calcigravel stone forest landscape, Sichuan Province

development and environmental protection. For example, physical geography can be applied to the classification of natural scenic areas for better planning for tourism, conservation and the sustainable usage of natural resources.

Appreciation and Development of Tourism Resources This book was edited by Chuankang Chen and Zhenli Liu and was published by Tongji University Press in 1990. It has a total of 16 chapters and 250,000 words, and it provides an overview of tourism resources. It categorises, introduces and analyses tourism resources, including landforms, water landscapes, flora and fauna, climate and meteorological landscapes, cities, palaces and ritual architecture, garden landscapes, the Great Wall, religious architecture and art, mausoleums, folk customs, literature and art, and tourism aesthetics, and it is divided into categories for appreciation and introduction. It also elaborates on the aesthetic analysis of tourism resources, criteria for tourism aesthetic judgement, and strategies and plans for regional tourism development.

Apuan Alps Geopark, Italy This geopark is located in the transitional zone between the Central European and Mediterranean Biogeographical Areas. It has an area of 494 km^2 and became a global geopark in 2011. The geopark includes the Apuan Alps Regional Park and the surrounding area in the Apuan Alps. It extends from the northwestern corner of Tuscany in central Italy to the northern end of the peninsula. The geopark is home to many endemic species and contains interesting rocks, minerals, fossils, and tectonic structures. This area is also known for its beautiful marble, deep gorges and huge caverns. It has attracted millions of visitors since the sixteenth century.

Aquamarine Aquamarine is an azure or sea blue beryl. It is called 'blue crystal' in the gem industry in China. Aquamarine, emerald and some green gems are all beryl crystals with limpid transparency. The bright blue hue is its main characteristic, which comes from trace Fe^{2+}. Some aquamarine stones in the market are actually beryl that has been subjected to heat to alter the colour. Certification by professionals is crucial in purchasing. Famous aquamarine production areas include Brazil and Russia, and China's Xinjiang and Yunnan Provinces also mine this mineral (Fig. 22).

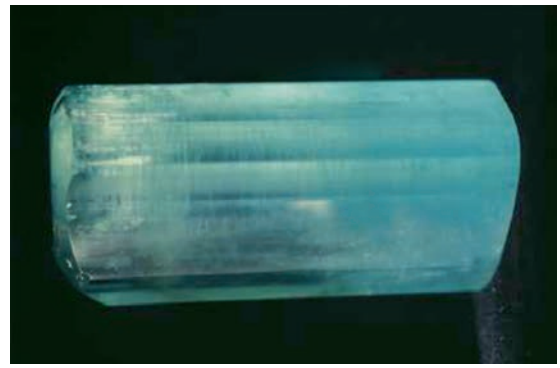


Fig. 22 Aquamarine crystal

Arabian Oryx Sanctuary (1994), Oman (Delisted) This sanctuary was located on the boundary between Al Wusta and Dhofar, Oman, and was bounded by Saudi Arabia. It had a planned core protected area of 27,500 km^2. The World Heritage Committee deleted the property from the World Heritage List because of Oman's decision to reduce the size of the protected area by 90%, in contravention of the *Operational Guidelines for the Implementation of the World Heritage Convention*. This was seen by the Committee as destroying the outstanding universal value of the site, which was originally inscribed in 1994. In 1996, the population of the Arabian Oryx in the sanctuary was at 450, but it has since dwindled to 65 with only approximately four breeding pairs, making its future viability uncertain. This decline is due to poaching and habitat degradation. The sanctuary became the first site to be deleted from UNESCO's World Heritage List.

Aragonite Aragonite is considered a variety of jade by gemstone craftsman in China. It is composed of aragonite, calcite and siderite, and aragonite and calcite are the main minerals. Aragonite is a polymorph of calcite. Its crystals are prismatic or elongated prismatic but usually in the form of botryoidal,

encrusting, stalactitic, fibrous, radiating, coralloid and oolitic aggregates. Aragonite can be white, colourless, grey, light yellow, green, blue, violet, light red or brown. It can be transparent or translucent with a glassy lustre. It has a Mohs hardness of 3.5–4, a specific gravity of 2.94–2.95 and conchoidal fracture. It is mainly found in recently deposited sediment or clay on the seafloor, the sediments of thermal springs and in the fissures and pores of volcanic rocks.

Araripe Geopark, Brazil The geopark is located in the southern part of the state of Ceara, Brazil. It has an area of 5,000 km^2, and it joined the Global Geoparks Network in 2006. From the most beautiful point of Santa Cruz at an elevation of 750 m, a panoramic view of parts of the Alari Basin is visible. The geopark provides visitors with leisure facilities such as restaurants, playgrounds with ancient animal themes, and a small church near the observation building. The area is covered by vegetation, with dirt roads and paths that lead visitors to geosites and scenic sites. The URCA Museum of Palaeontology in Santana do Cariri is a facility for palaeontology research, and it has become a popular site for learning about local fossils.

Archaefructus Liaoningensis This is an Early Cretaceous angiosperm fossil that was discovered in 1996. The fossil plant looks like a V-shaped slender fern-like branch with a spiral pattern of 40 pod-like fruit, and each fruit contains 2–4 seeds the size of rice grains. This fossil was excavated in Huangbanji Grove, 3 km northwest of Sihetun in Shangyuan Town, Beipiao, northern Chaoyang, Liaoning Province. The name '*Archaefructus liaoningensis*' literally means 'Liaoning Ancient Fruit'. In the spring of 1997, eight additional pieces of similar fossils were collected from the same strata, and in 2002, a new plant species called '*Archaefructus sinensis*' was unearthed from the tuffaceous sandstone in the Lower Cretaceous Yixian Formation in Dawangzhangzi Village, Ling Yuan, Zhaoyang. This plant is considered a type of aquatic angiosperm (Fig. 23).



Fig. 23 Archaefructus liaoningensis

Archaeozoic Eon The Archaeozoic Eon currently represents the early stage of the Earth and has a clear geological history. Its time span is from approximately four billion to 2.5 billion years ago. The Archaeozoic Eonothem refers to the rocks that formed during this period, most of which are complex metamorphic rocks. The term Archaeozoic was used earlier than the term Archaean, but for convenience, the latter has been adopted in current stratigraphic charts.

Arch-Type Sandstone Landscape This is a representative sandstone landscape. Arches National Park in Utah, USA, is the most typical example, and abundant and concentrated arches form this unique landscape. The park contains more than 700 arches at various stages of development. These natural arches, caves and stone windows have strange and varying shapes and different sizes. Among them is the world's longest and highest natural arch, which is 32 m tall and has a span up to 89 m long. Some small caves and rock windows are so small that they do not allow a single person to pass through. Some look like a pot handle, and others are similar to an arch bridge or flying arch. The colours range from



Fig. 24 Arched door-type sandstone landscape – Arches National Park, USA

purple, red, brown, and light yellow to milky white, and the hues continually change with time, climatic changes and variations in light. The rock that forms these arches is the orange-red sandstone of the Jurassic Entrada Formation, which overlies the salt strata of the Paradox Formation. The salt strata collapse easily because they are soluble, and eventually produce a series of faults and joints in the overlying sandstone. Weathering along fractures and joints causes exfoliation of the sandstone, which is the main cause of the formation of the natural arches (Fig. 24).

Area de Conservación Guanacaste, Costa Rica This site is located in the border area of northwestern Costa Rica near the Pacific Ocean. In 2004, St. Elena Private Reserve was added, which increased the total area to 150 km^2. As an important natural habitat for protecting biodiversity, the site contains the best-preserved arid forest environment from Central Africa to northern Mexico, providing a key natural habitat for endangered and rare animal and plant species. Its terrestrial and marine environments and its coastal environment characterise the interface between the land and the sea, and they illustrate important natural ecological processes.

Areal Type Areal types are geographical units composed of regions or units with similar development conditions, production structures, development characteristics and patterns in a given natural geographical and historical environment. These geographic units are relatively stable. Different tourist areas in the same geographical area often have similar types and structures of tourism resources and are mutually substitutable. Large tourist areas or tourist routes may also include several geographic types.

Arete, Knife-Edge Crest Landscape This is a landform resembling a blade-shaped ridge formed by glacial erosion. During the development of two adjacent cirques or glacial valleys, their back walls continually recede, causing the cirques to become closer to each other. As a result, the watershed between the cirques narrows until a knife-edge crest or fish fin-like ridge forms, which is called an arête. The associated landscape is called a knife-edge crest landscape.

Arkose Arkose is a detrital sandstone that contains at least 25% feldspar. It includes felsic arkose and lithic arkose. Arkose usually forms in areas of strong tectonic movements and dry and cold climates, where the parent rock is granite or granitic gneiss. Arkose forms due to physical weathering, severe erosion and rapid deposition of quartz-containing parent rocks. Arkose is generally associated with

continental sediments, whereas it is rare in marine sediments. It is generally pale red to grey and has a coarse-grained texture. It often contains a highly mixed matrix, and the cement is mainly siliceous, ferrous or carbonate-based. Arkose that contains a highly mixed matrix is called feldspathic greywacke. When the sand grains consist of abundant quartz clastics (greater than 75% quartz), it is called feldspathic quartz sandstone or sub-arkose. Arkose is well developed in the Sinian system of Tangshan, and the feldspar content can exceed 50%. Based on the formation conditions, arkose can be divided into three types: structural feldspar arkose, basal arkose and climatic arkose.

Arouca Geopark, Portugal This geopark is located in northern Portugal and covers an area of 330 km^2. The geopark acquired its global status in 2009. It has three large geological groups, including bedrock (metamorphic and sedimentary rocks in a mixed schist-sandstone complex), Palaeozoic sequences (Ordovician and Silurian quartzites and schists) and a magma body. The park has important Carboniferous outcrops composed of clastic rocks, rivers and slopes associated with the current hydrological system, modern Quaternary sedimentary units and Ordovician fossil slate with a high thorium content. There are a total of 41 geological sites. Among them, two are of particular international importance: the Canelas Slate Site and On-site Museum and the Castanheira Nodular Granite.

Arsenic Water This is hot mineral water that contains arsenic. Based on the content, arsenic water can be classified into medical arsenic water and drinking arsenic water, which can be used for bathing and drinking.

Artificial Lake Tourism Landscape This type of landscape includes artificial water bodies in natural depressions in scenic areas, including reservoirs. Examples are the Thousand Island Lake on the Fuchun River, Zhejiang Province, Yansaihu Lake in Qinhuangdao and Jinhaihu Lake in Pinggu, Beijing.

Ash Flow Tuff Ash flow tuff refers to an ignimbrite with a pyroclastic particle size less than 1.2 mm. This type of rock is widely distributed in acidic volcanic rock areas, such as Yellowstone National Park, the Valley of Ten Thousand Smokes and Mt. St. Helens in the United States and the Mesozoic volcanic areas in eastern China.

Aster Tourism This refers to tourism that includes star watching. Americans landed on the Moon in the 1960s and 1970s. Currently, there are several international collaborations on simulations and preparations for landing on Venus. China has expedited its lunar project with the Chang'e 1 and 2 spacecraft towards this goal. In the near future, the Moon and Venus and other planets will become tourist destinations.

Asthenosphere The asthenosphere is a secondary spherical layer in the upper-middle part of the upper mantle at depths of approximately 60–400 km. Inside the asthenosphere, the longitudinal and transverse wave speeds are significantly lower, so it is also called the low-speed layer. The asthenosphere is mainly composed of solid materials, but the rock strength is low, and the plasticity is high; therefore, it is easy to deform, and some scientists believe that the rock in the asthenosphere is molten. The asthenosphere is generally believed to be the source of magma for ultramafic rocks, and the lithosphere plates move above it.

Astronomical Observation Tourism The growing interest in the observation of astronomical phenomena such as solar radiation, magnetic storms, sunspot activities and cosmic rays has made astronomy a tourism resource. The historical Beijing Observatory and Dengfeng Observatory as well as the modern Zijinshan Observatory in Nanjing, Beijing Observatory and Beijing Planetarium are well-known science popularisation sites that attract tens of thousands of tourists every year.

Atlantic Forest South-East Reserves, Brazil This site is located on the border between Paraná State, southeastern Brazil, and São Paulo. It has a core protection area of 4,700 km^2 surrounded by a 12,236-km^2-long buffer zone. It is the largest reserve group with the highest quality forests on Brazil's Atlantic coast. The 25 reserves in its heartland have rich

biodiversity and are also the last remaining Atlantic coastal forest. The dense forests in the mountains, the gentle wetlands in the foothills, the islands and sandbars in the coastal areas, the karst landforms, the rivers and their estuaries, and numerous waterfalls make up the diverse natural beauty.

Atmospheric Circulation Atmospheric circulation is large-scale airflow movement in the atmosphere, including global circulation and regional circulation, horizontal and vertical airflows, and low-level and high-level airflows. The basic feature of atmospheric circulation is the horizontal movement of the atmosphere centred on the polar regions. In both the northern and southern hemispheres, there are three latitudinal wind zones in the lower and middle layers of the atmosphere, and the north-south movement of the high- and low-altitude atmospheres forms three vertical circulation cycles. Atmospheric circulation is an important factor for achieving heat balance, vapor transport, and energy exchange in the atmosphere.

Atmospheric Pollution When emissions gases and solid particles in the atmosphere reach a certain concentration over time, they can endanger the well-being of humans. Any substance that can deteriorate air quality is an air pollutant. Air pollutants can come from human sources, such as industrial emissions, gas leaks, coal and wood burning, vehicle exhaust, construction, and nuclear tests, as well as from natural sources, such as bush fires, volcanic eruptions and sandstorms.

Atoll Landscape *Synonym:* ▶ *Ring reef landscape*

This is a type of coral reef landscape consisting of circular coral reefs in the ocean. An atoll contains an enclosed or semi-enclosed lagoon in the middle but no central islands; this is the main difference between an atoll and a barrier reef. An atoll consists of a coral reef several metres above sea level, and it is circular, elliptical or horseshoe-shaped. It has a diameter of 1–130 km and a depth of several metres to hundreds of metres. The seaward side is steeper, with a gradient up to 45°, and the upper part can reach 90°. In general, an atoll consists of a layer of limestone approximately 1,000 m thick that sits on an underwater basalt volcano. Atolls are mainly located in the tropical and subtropical seas of the Pacific and Indian Oceans, where corals grow easily. Typical examples are the atolls of the Marshall Islands and the Maldives Islands (Fig. 25).

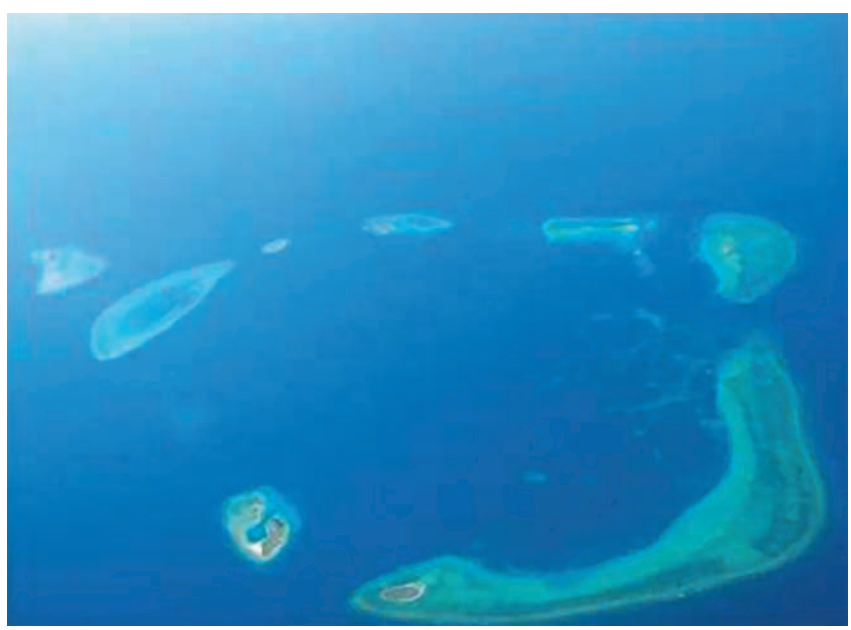


Fig. 25 Atoll landscape

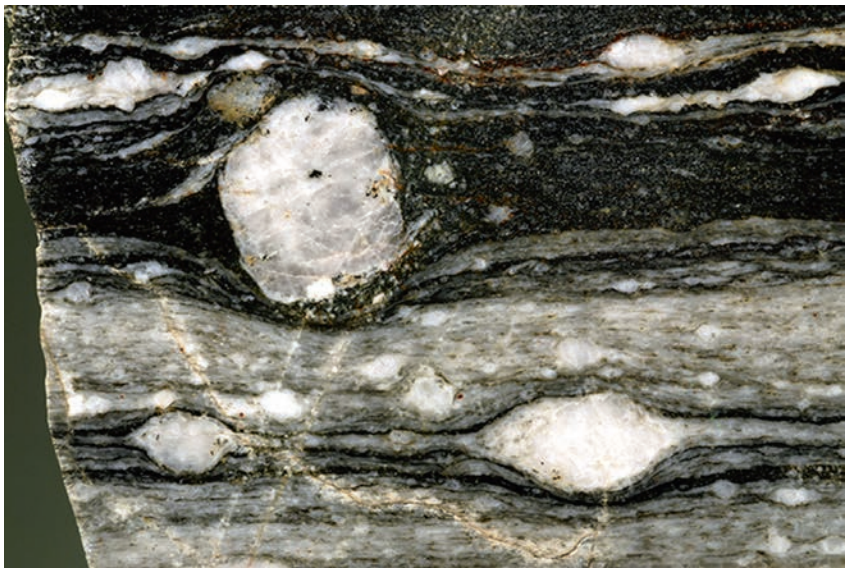


Fig. 26 Augen structure (Credit: Alex Strekeisen)

Attitude of Strata This term refers to the spatial orientations of geologic surfaces or lineations. The components that indicate the orientation of a structure are called the 'attitude element'. Planar structures have three main elements: strike, dip direction and dip angle. The elements of a linear structure are the bearing (plunge) and inclination (representing the absolute spatial orientation of the linear structure) as well as the pitch and pitch angle (the pitch direction and the angle between the orientation of the planar surfaces). Both primary structures (such as strata surfaces) and secondary structures (such as fractures) must be described by attitudes to record their orientation.

Audio and Video Popular Science Publication Many science popularisation materials are in electronic audio-visual formats. Using animations and other interactive means, geological processes and landscapes can be vividly explained in interesting ways, which makes learning by students and the general public much easier than before.

Augen Structure An augen structure is a unique structure in metamorphic rocks and migmatite. Augen are lenticular eye-shaped or bean-shaped structures composed of flaky or columnar minerals around feldspar crystals (or aggregates of feldspar and quartz). Augen can form by metamorphic differentiation, metasomatism or deformation. A typical gneiss in augen structure is located in the rock strata near the exit of the cable car station at Taishan Mountain (Fig. 26).

Augite Augite is mainly composed of $(Ca,Mg,Al)_2[(Si,Al)_2O_6]$ and is in the pyroxene family. The crystals are equant, and crystal twinning is common. They often appear in blocky, granular or aggregate form. They can be brown, light green or black with greyish green streaks. The crystal diaphaneity ranges from translucent to opaque. Augite has a specific gravity of 3.23–3.52, a Mohs hardness of 5.5–6, and uneven to conchoidal fractures. It mainly forms in various types of mafic and ultramafic rocks as well as in deep metamorphic rocks.

Australian Fossil Mammal Sites (Riversleigh / Naracoorte), Australia These sites include two important fossil sites in Australia, one in Riversleigh of northwest Queensland in the north and the other in Naracoorte of southeastern South Australia in the south. They are listed in the top ten fossil sites in the world and are extremely rich in species and well-preserved.

Automatic Information Service Desk Automatic information service desks are used to offer visitors convenient services without

wasting time in queues at conventional information desks, particularly during peak seasons and holidays. They are part of the geopark information management system. They can be in the form of digital information machines available at the visitor centre or as apps on mobile phones. All information related to the geopark, including dining facilities, accommodations, transportation and shopping, is easily available through these apps.

Aventurine In Chinese, aventurine is also known as 'Dongling Stone' or 'India Jade'. Its main component is silica (SiO_2), and its mineral composition is mainly quartz with approximately 10–18% chrome mica and other trace minerals, such as dumortierite, sillimanite, rutile, haematite and zircon. Because the chrome mica is in very small (0.2–2 mm in diameter) flakes with a uniform texture, aventurine is bright and oily green or bluish green, has a prominent greasy or glassy lustre and is translucent or semi-transparent. Its refractive index is approximately 1.544–1.560, its Mohs hardness is 7, and its density is 2.65–2.8 g/cm^3. It is relatively brittle, and the texture is dense, delicate, tough and smooth. When polished, small spots (e.g., rutile, haematite and chrome mica) flash from the background green colour, giving it a spectacular appearance. These spots are also known as 'eyes', and high-quality aventurine has many eyes that flash in a uniform pattern from the green base. The main countries that mine aventurine include India, where the emerald green aventurine was given the name 'India's Jadeite', and Spain, Russia, Brazil, Chile and the United States. In China, aventurine is found in Xinjiang Province, and it is called Xinjiang Dongling Stone (Fig. 27).



Fig. 27 Aventurine craft

B

Badain Jaran Desert landscape This landscape is located in Ejin Banner and Alxa Right Banner, Inner Mongolia, as well as in a small area to the east in Alxa Left Banner. The landscape areas lie in the middle of the barren desert in Alxa, west of Yabulai Mountain, north of Beishan (Bei Mountain) and east of the Rou River. It is the third largest desert in China and covers a total area of approximately 44,300 km^2. Mobile dunes cover approximately 83% of the desert. In the central desert, there are large sand hills that are generally 200–300 m high, and the highest can reach 500 m. There are 144 inland lakes in the lowlands between the sand hills. The Badain Jaran Desert has been called the 'most beautiful desert in China'. It is the core area of the Alxa Desert Global Geopark (Fig. 1).

Baijiang Soil Baijiang soil contains a grey and white leached layer and forms on the light and sticky parent material in temperate, moist and semi-humid forests and meadow vegetation. It usually forms between dark brown soil and black soil. It is mainly located on both sides of mountainous terrains such as Xiaoxing'anling and Changbai Mountain. This soil is viscous, acidic and infertile.

Baise Leye Dashiwei Sinkholes National Geopark, Guangxi This geopark is located in Leye County, Baise City, Guangxi Province, and it covers an area of 175 km^2 and became a national geopark in 2004. It is recognised by karst experts as the world's first group of tiankengs. It is famous for its magnificent karst landscape. The main geological relics in the park are pits and caves, canyons, dark rivers, peaks and converging planes, arches and giant panda skull fossils. There are also rare animal and plant resources. Twenty-six of the tiankengs are more than 100 m deep, and two have volumes of more than 5000 m^3. There are more than 30 karst caves, and the Red Rose Cave hall is the second largest in China and the fifth largest in the world. There are more than 200 lotus thrones or basins in Luomei Cave. The largest has a diameter of 9.2 m and is known as the lotus basin king. There is also a 280 m long natural arch bridge with a height of 145 m that resembles a rainbow across the Willow River Grand Canyon. These features have great scientific research and tourism value.

Baiyang Lake landscape Baiyang Lake is also known as the West Lake, and it was formerly called Jueli (Carp Digging) Lake. It is the largest lake in the Haihe Plain and is located in Baoding City, Hebei Province. It receives water from Tanghe River along the upstream parts of the Daqinghe River and Zhulong River of the Haihe River system. Downstreams, the lake water is discharged through the Daqinghe River. This lake has rich aquatic resources, including more than 50 species of freshwater fish, an extensive area of reefs and thousands of acres of lotus, which make this lake famous for its name the 'Pearl of Northern China'. The Yanling (Wild Geese) water guerrilla's brigade was based here during the anti-Japanese war (Fig. 2).

Baiyin Huoyanshan National Mining Park, Gansu This park is located in Baiyin City, Gansu Province, covers a total area of 6.9 km^2 and became a national mining park in 2005. The mining remains are represented by typical lumpy sulphide deposits. The main mining remains are Zheyao Mountain and Huoyan Mountain, which are abandoned open-pit mines that are dominated by precious metals such as copper, sulphur, gold and silver. When the Zheyao Mountain open-pit mine was closed, it was transformed into an underground deep copper mine, which is currently active, and the Xiaotieshan Mine, where modern surface mining is ongoing. The park is a modern bio-metallurgy demonstration project that uses bioheap leaching technology to recycle the discarded copper metals and valuable elements and extract them from the ores. The park

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Fig. 1 Badain Jaran Desert landscape



Fig. 2. Lake Baiyangdian landscape

contains the remains of ancient mining activity and modern mining production equipment.

Baiyinchang pyrite-type copper-lead-zinc deposit, Gansu The Baiyinchang copper-polymetallic mine is located in Baiyin City, Gansu Province. It includes the Zheyaoshan copper mining area, Huoyanshan copper mining area, Tongchanggou copper mining area, Xiaotieshan polymetallic mining area and Sigequan polymetallic mining area, which cover a total area of 25 km^2 to form the Baiyinchang field. The ore bed is in the Middle Cambrian sodium-rich spilitic keratophyre layer, which was formed by a marine volcanic eruption. Baiyinchang is an old mine. According to historical records, silver and gold mining were already occurring during the early Hongwu period of the Ming Dynasty. During this time, the Jinfangou in the Houyashan was already producing a full bucket of gold every day. Lanzhou was once called Jincheng (literally 'Gold Town') because it was said to be a gathering and distribution centre of gold manufactured by Baiyinchang. The Baiyin Nonferrous Metal Company was founded in September 1954. The discovery of metallic ores in Baiyinchang facilitated the founding of Tongcheng (Copper Town)-Baiyinshi (White Silver City). In October 1986, the People's Government of Gansu Province and the Ministry of Geology and Mineral Resources of the PRC built a



Fig. 3 Baiyinchang No.2 Mine

monument in the Jinyu Park (Gold Fish Park) in Baiyin City dedicated to the pioneers of Tongcheng. This park is now a national mining park (Fig. 3).

Bakony-Balaton Global Geopark, Hungary This geopark is located in western Hungary in the Carpathian Basin of Balaton. It covers an area of 3,200 km^2, and it became a global geopark in 2012. The area is surrounded by young folded mountains. The geopark covers the adjacent areas of the Bakony Scenic Reserve, the Somlo Scenic Reserve and the town of Fonyod. Lake Balaton is the largest lake in central Europe and is also known as the 'Hungary Sea'. The geopark features a variety of geological and geomorphological relics, such as steep cliffs, hot springs, volcanoes, and basalt columns, and it is rich in fossils. The most important mission of the geopark is to protect and interpret the rich land and geomorphological heritage. The geopark encourages local residents and communities to actively participate in geotourism and educational activities, thereby raising public awareness.

Balin Stone This stone gets its name because it is mainly produced in Bairin Right Banner in Chifeng City, Inner Mongolia. It has a very fine texture with crystal-clear colours of vermilion, orange, yellow, green, blue, purple, white, grey and black. It mainly contains minerals such as kaolinite and pyrophyllite with a small amount of alunite. It is composed of Al_2O and SiO_2 with trace elements of iron, manganese, titanium and other oxides, and some samples have a higher content of mercury sulphide cinnabar. It is a soft stone with a density of 2.4–2.7 g/cm^3. Based on the colour, texture, pattern and structure, this stone can be divided into chicken blood stone, Fu yellow stone, frozen stone, colour stone and pattern stone. There are numerous varieties, and similar stones can be found in Shoushan, Qingtian and Changhua. The Balin stone comes from the intermediate acidic volcanic rocks of the Late Jurassic Manitu Formation that have been subjected to hydrothermal alteration.

Banc d'Arguin National Park, Mauritania This park is located in the coastal area of the southwestern part of the Dakhlet Nouadhibou Region, Mauritania, and covers an area of 12,000 km^2. Bordering the Atlantic coast, the park ranges from 5 m below sea level to 15 m above sea level. It contains sand dunes, coastal swamps, small islands and shallow coastal waters. The contrast between the harsh desert environment and the biodiversity of the marine zone has resulted in a landscape and seascape of outstanding natural significance. A wide variety of migrating birds fly to this region to spend the winter.

Banded Structure A banded structure refers to an alternating striped arrangement of light-coloured (mainly quartz, feldspar, and calcite) and dark-coloured (mainly biotite, hornblende and magnetite) minerals. It is a typical structure of metamorphic rocks and migmatite, and it mainly forms by metamorphism and differentiation (Fig. 4).

Bantang Hot Spring landscape in Chaohu Lake This is a spring landscape consisting of a combination of a cool spring and a hot spring. It is located in the foothills of Tangshan Mountain 6 km northeast of Chaohu City, Anhui Province. The landscape is formed from the merging of a cold spring with a hot spring which are one kilometre apart. At the point of convergence, half of the spring is cold, while the other half is hot. Amazed, people began calling it Bantang (Half Spring). It has both hot and cold clear spring water. The water temperature at the spring is generally 55 °C, and the spring water contains more than 30 types of trace elements. Each millilitre of water contains 80–120 pCi/L of radon gas, which is very rare in China. Bantang Hot Spring is suitable for bathing and drinking. The water quality is superb and comparable to the eight most famous drinking springs in the world. The spring water has a curative effect on more than 50 kinds of diseases, particularly those related to the skeletal system, nervous system and skin (Fig. 5).

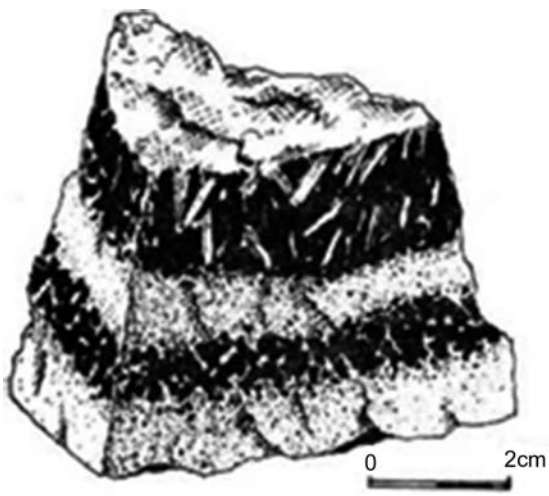


Fig. 4 Banded structure

Baoshan National Mining Park, Hunan This park is located in Guiyang County, Ganzhou City, in southeastern Hunan Province. The total area is 7.80 km^2. It became a mining park in 2010 after being approved by the Ministry of Land and Resources. The ore body is a skarn-type copper-molybdenum tungsten polymetallic ore deposit. The park comprises six rare and important (primary and secondary) mining geological sites and 20 secondary sites. Underground mining began in 1997. The



Fig. 5 Bantang Hot Spring landscape in Chaohu Lake, Anhui Province

mines used both vertical and inclined shafts. The geological profiles of the 6th and 165th exploration lines in the western and central parts of the mining area signify the distribution of different types of deposits in the mining area.

Baotu Spring Landscape This is a spring landscape consisting of the Baotu Spring, which ranks first among Jinan's 'Seventy-Two Springs' and was given the title of 'China's Top Spring'. It is located in Jinan Baotou Park in front of Luoyuan Hall. According to the oracle inscriptions unearthed in Ayang, Henan Province, in 2002, the name Baotu Spring can be traced back to the Shang Dynasty 3543 years ago. There are three spring sections with constant flowing water. The stongest emerging flow can reach several feet high. In the vicinity of Baotu Spring, there are more than 30 famous springs, such as Jinxian (Gold Thread) Spring, Shuyu (Jade Cleansing) Spring, Xibo (Bowl Washing) Spring, Liuxu (Willow Catkins) Spring, Huanghua (Emperor Flower) Spring, Dukang Spring and Bailong (White Dragon) Spring, which altogether constitute the Baotu Spring group and are an ideal source of natural drinking water (Fig. 6).

Barchan Dune Landscape or Crescent Dune Landscape This is a type of sand dune resembling a crescent moon and is the most basic type of mobile dune. Sand tends to accumulate into a crescent moon shape on a planar surface due to the wind. It is a mature form of dune development. The dunes move because of the wind and can reach heights of more than ten metres and widths from tens to hundreds of metres. The two slopes of the dune are asymmetrical. The windward slope is convex and gentle with a gradient of 5–20°, but the leeward slope is concave and steep with a dip of 28–34°. The two slopes connect to form an arc-shaped ridge. The dune ends extend along the prevailing wind direction. The extent is controlled by the strength of the dominant wind. The stronger the dominant wind, the smaller is the angle of intersection. Barchan dunes are often found along the desert margins and in large deserts. Chains of large barchan dunes can be found along the middle of the Southern Xinjiang Desert Highway in Xinjiang Province (Fig. 7).

Barite The composition of barite is $BaSO_4$, and it is a sulphate mineral. It crystallises in an orthorhombic crystal system and always forms very large crystals. It can also form small sand-containing rosette nodules that are called 'Desert Rose'. Its aggregates can be granular, platy, fibrous, coxcomb, earthy or



Fig. 6 Baotu Spring landscape, Shandong Province



Fig. 7 Barchan dune landscape



Fig. 8 Barite

prismatic. It can be colourless, white, grey, light yellow, brown, light red, light blue or light green. It has a vitreous, resinous or pearly lustre, a specific gravity of 4.5, a Mohs hardness of 3–3.5, and uneven fractures. It mainly forms in hydrothermal or sedimentary ore deposits. Barite is widely used in the petroleum, chemical products, rubber-making, paper-making, ceramics, enamel, glass, leather-making and sugar refining industries. It is also used for the extraction of the metal barium (Fig. 8).

Barium Water This is hot mineral water that contains barium. According to the National Medical Hot Mineral Water Quality Standard, water with a barium content over 5 mg/L can be called medical barium water. In Europe, the standard for natural drinking barium water is also 5 mg/L or above. In China, a standard for natural drinking barium water has not been set.

Bar Landscape ▶ Barrier Landscape

Baron Ferdinand Von Richthofen Baron Ferdinand von Richthofen (1833–1905) was a German physical geographer and geologist. He served as a professor at several universities, including Bonn, Leipzig and Berlin, as well as the president of the University of Berlin and president of the German Geographical Society. His works include 'China – The Results of My Travels and the Studies Based Thereon, 5 Volumes and Atlas', 'The Tasks and Methods of Modern Geography', 'Leading Methods for Investigation and Research' and 'The Impetus and Directions of Geography in the 19th Century'. From 1868 to 1872, he travelled extensively in China to study geology, minerals, and loess, and he made significant contributions to the development of modern Chinese geology by bringing and exchanging new concepts and ideas.

Barrier Lake Landscape *Synonym:* ▶ *Dammed lake landscape*

This is a type of lake landscape consisting of lakes formed by blocking of a valley or a river channel by lava flows, glacial moraines or landslides and rock slides triggered by earthquakes. The Kanas glacial barrier lake in Xinjiang Province is a typical example. Barrier lakes can become severe flood hazards when the dams are broken (Fig. 9).

Barrier Landscape *Synonym:* ▶ *Bar landscape*

This is a general term for the landscape comprising elongated depositional landforms at the outer margin of a coastal beach formed by waves and marine currents. A bar is composed



Fig. 9 Glacial barrier lake in Kanasi, Xinjiang



Fig. 10 Barrier landscape

of sand or gravel mixed with shell fragments and other materials. Its top is generally above the sea surface. Bars can be several kilometres long, hundreds of metres wide and several metres above sea level. They can be categorised into offshore bars, bay bars, tombolos and sand spits based on the location of deposition. According to the coastal topography, sources of depositional materials and the wave action and direction, bars can be divided into arc-shaped bars, circular bars and hook-shaped bars. Bars reflect a bay environment with abundant sand subject to waves from a fixed direction. In China, there are often different types of bars at the outer margin of coastal beaches (Fig. 10).

Barrier Reef Landscape This is a type of coral reef landscape. A barrier reef is also known as the embankment reef or offshore reef, and it is an embankment-like coral reef around an island or a continent. It is separated from the coast by a deep and wide lagoon or an atoll



Fig. 11 Barrier reef landscape

lake. These reefs are mainly distributed around volcanic islands and in reef seas off the mainland. A typical example is the Great Barrier Reef (2,000 km long, 80 km wide) along the northeastern coast of Australia. This reef is mainly composed of an inner reef attached to the coast and an outer reef outside the atoll lake. The outer reef is approximately 500 m wide, but some can be up to several kilometres wide. The width of the atoll lake can be just wide enough for navigation or up to several kilometres wide. The water is 20–100 m deep (Fig. 11).

Basalt Basalt is a common basic extrusive rock with a greyish black colour that occurs in the form of fine-grained blocks. It often has a porous structure filled with calcite, zeolite and other minerals. The common minerals are olivine, pyroxene, and mafic plagioclase. The grains are usually cryptocrystalline and have a glassy matrix. Based on the chemical composition and mineral content, basalts can be divided into tholeiitic basalts and alkali basalts. Basalts have been formed in different geologic periods, such as the Permian basalt of Emeishan Mountain in Sichuan Province. However, the basalts with greater geologic landscape and tourism value are mainly Neogene basalts, such as the basalts in Zhangzhou in Fujian Province, Liuhe in Nanjing and Penghu in Taiwan. These basalts were all formed during Miocene volcanic eruptions. The basalts of the Wudalianchi and Haikou volcanoes were formed during Quaternary and Holocene volcanic eruptions. The columnar joints and lava landscapes of basalt have important ornamental value.

Basic Rocks Basic rocks are another large group of igneous rocks. They are usually formed from the intrusion of mantle magma into the Earth's crust or from the eruption of magma onto the ground surface. The rocks contain 45–53% SiO_2, and the main minerals are pyroxene and mafic plagioclase, but the rocks contain little or no quartz. They are dark and have high densities. A common intrusive basic rock is gabbro, and a common extrusive basic rock is basalt. Basalt is an important basic rock that forms landscape features.

Basin Building *Synonym:* ▶ *Basining*

Basin building is the dynamic process that causes the formation of basins. Basins have various sizes and types. In general, basins refer to large and medium areas of subsidence on the continents, but some scientists use this term for areas of subsidence in the ocean.

Different basins have different formation mechanisms. Based on the cause of formation, basins can be divided into structural basins (basins formed by crustal movement) and erosion basins. Structural basins can be subdivided into depression basins and fault basins. According to the kinematics, basins can be classified into compressional basins (such as depressions), extensional basins (such as rift basins and faulted basins) and strike-slip basins (such as pull-apart basins). The geosyncline theory states that basins are stable platform areas. Geomechanics scientists postulate that basins (structural subsidence zones) and orogenic belts (structural uplift zones) are associated with negative tectonics and positive tectonics, respectively, and include them in the same structural system, where the basins and orogenic belts have similar evolution processes and the same dynamic development mechanisms. Plate tectonics scientists consider basins on the edges of plates to be part of the trench, arc and basin system, which can be illustrated by the plate dynamics. Basin formation is limited by the deep geologic structure and deep geologic activity. All basin mechanism models must be able to describe the causes of the deep geologic activity in detail. The standing hypothesis of basin formation only focuses on the basin but does not address the orogenic process. Currently, there is no unified theory that includes basin formation, orogenesis and plateau formation.

Basins *Synonym:* ▶ *Depression basins;* ▶ *Erosion basins*

Most basins are formed by tectonic activities. The Tarim Basin, Junggar Basin, Qaidam Basin and the Sichuan Basin are the four major basins in China.

Basining ▶ Basin Building

Basque Coast Geopark, Spain This geopark is located on the west coast of the province of Buzko in Basque Country, northern Spain. It has an area of 89 km^2 and became a global geopark in 2010. This geopark contains impressive deformed geological structures, such as folds and faults of different types and sizes. The two geologic fields of coastal flysch (turbidites) and the limestone hills in the early Cretaceous karst landscape are prominent. The geological and geomorphological variations along the 23-km-long coastline are abrupt. The coast consists of a steep cliff landscape and one of Europe's most extensive sea erosion platforms. The coast records a complete history of more than 600,000 years of uninterrupted geological development, and the stratigraphy records the corresponding marine environment. In addition, there are important fossil sites and other outstanding natural and cultural assets, such as the rich architecture and cultural heritage of the seaside and rural environment.

Batholith A batholith is a large mass of intrusive rock. The exposed outcrop area can exceed 100 km^2, and it is usually oblong in map view. Batholiths are often located in uplifted areas of orogenic fold belts, and their orientation is consistent with or similar to the fold axis. Granite is the most common type of rock in batholiths.

Batur Global Geopark, Indonesia This geopark is centred on an active volcano in Bali, northeastern Indonesia, between two huge calderas that were formed 22,000 years ago, which is part of the active Pacific volcanic chain. It became a member of the Global Geopark Network in 2012. The area is rich in macro- and micro-volcanic landforms formed over the past few millennia. The Batur volcano is a typical stratovolcano composed of volcanic debris and lava flows. Over geologic history, two large volcanic eruptions produced a unique crater wall and formed today's deep crater lake. The Batur volcano has erupted at least 22 times since 1800. There are many natural and cultural attractions on Bali, and the active Batur volcano is special because of its unique geological features and magnificent scenery. The geopark also illustrates the distinctive local customs related to Hinduism of the Balinese people.

Bauges Geopark, France This geopark is located in the northwestern Alps in France and covers an area of 856 km^2. It became a global geopark in 2011. The area is like a rock

fortress and a protected natural green island within a cluster of cities. The sturdy limestone and sedimentary rocks form a steep escarpment with an oblique structure, giving it a unique geomorphological character. A major fault demonstrates that a strong orogeny occurred in this area. The karst landscape is extensive with small gorges that were formed in the Cretaceous limestone, which in turn developed into wetlands, lakes, fountains and caves. The famous 'Sayah'ah' cliff is located at the southern tip of the area. It is a sedimentary limestone fold with a stunning shape that resembles a traditional headdress worn by women in this area.

Bauxite Bauxite is a mixture of several minerals, including gibbsite, diaspore, boehmite, haematite, kaolinite and opal. Its variable composition gives it variable characteristics. Bauxite often appears as platy, nodular, oolitic or pisolitic aggregates. The colour variation is also significant, which can range from white, light yellow, and red to reddish brown. The streaks are usually white. It has a dark or earthy lustre, opaque diaphaneity, a specific gravity of 2.3–2.7, a Mohs hardness of 1–3, and uneven fractures. It is mainly formed in igneous and metamorphic rocks with high aluminium contents. Under hot and humid conditions, rain will leach the silicate from the rock, leaving bauxite minerals behind as the residual material.

Bayan Obo Niobium-Rare Earth-Iron Deposit, Inner Mongolia This is an unparalleled mineral deposit of rare earth elements and one of the largest iron ore deposits in the world. Located in the Baiyun Ebo District, Baotou City, Inner Mongolia Autonomous Region, the Bayan Obo niobium-rare earth-iron deposit is divided into five districts, namely, the main mine, east mine, west mine, East Jieleigele and Dulahala. Geological surveys have found 73 elements and 160 minerals in the deposit, of which 30 were first discovered there, and 26 are of economic value. In July 1927, the Chinese geologist Ding Daoheng discovered the Baiyun Obo iron ore. In 1935, He Zuolin discovered rare earth element ores, including the 'Baiyun ore' and 'Obo ore', and other new rare earth element ores, such as the 'Baotou Ore', 'Huanghe Ore', 'barium/iron/titanium ore', 'Daqingshan ore', and 'Zhonghua cerium ore', were discovered later. The deposit accounts for at least 90% of the domestic reserves and 77% of the world's reserves of rare earth elements (Fig. 12).

Bayannaoer Geopark, Inner Mongolia This geopark is located in Bayannur, Inner Mongolia Autonomous Region, and has an area of 327 km^2. It became a national geopark in 2011. The park mainly features a dinosaur fossil site in Urad Rear Banner, typical stratigraphy and granite wind-erosion landforms. Since 2006, a Linheraptor under Dromaeosaurus, new types of Troodon, Oviraptor and Linhenykus under Mononykus have been discovered in the dinosaur fossil preserve. The distinctive wind-erosion landforms and landscapes are mainly represented by



Fig. 12 Bayan Obo niobium-rare earth element-iron mine

granite stone forests, which are quite typical. The geopark also boasts abundant natural and human cultural landscapes. The natural landscapes mainly include the Ulan Buh Desert and desert lakes. Mobile dunes are common in the southern part of the Ulan Buh Desert, longitudinal dunes are common in the middle, and fixed and semi-fixed dunes are common in the north. The desert lakes mainly include Nalin Lake, Dongqing Lake, Desert Sanhu and Ulansuhai Nur. The surrounding areas have beautiful environments and scenery.

Beach Landscape A beach landscape is a part of the coastline, and it consists of gentle flat ground where deposition occurs due to wave and marine sea currents along the coast. These landscapes are located in the intertidal zone and are a product of wave action and the associated longshore drift. When waves approach a shallow shore, the peaks become steep, and the troughs become gentler due to friction along the sea floor. The water moves back and forth, and the movement towards the shore is faster than the movement away from the shore. As a result, the seafloor material is transported towards the shore and deposited. The beach dips gently towards the sea and is mainly composed of silt and shingles. Beaches can be divided into muddy beaches, sandy beaches and gravel beaches based on the grain size. The large-scale development of beaches can result in the formation of a marine depositional plain (Fig. 13).

Beach; Tidal Flat; Shoal Originally these terms refer to the marine flat and they are the transitional zones between the ocean and the land. They are areas of deposition between the highest and lowest tide levels, where sediments such as gravels, silts or mud are deposited. Tidal flats are sometimes submerged by tides, and they can be exposed to the air. China's tidal flats are mainly located on the coastal areas north of Liaoning and south of Guangdong, Guangxi, and Hainan, and they cover a total area of approximately 2.704 million hectares. China's land use classification system defines beaches as sea beaches, river beaches and lake beaches.



海积沙滩景观



海积砾滩景观



海积泥滩景观

Fig. 13 Sandy, gravel and muddy beaches

Bean Curd Rock Structure This is a geological structure located along the beach near Keelung, Taiwan. It consists of Miocene sandstone of the Daliao Formation, which was cut into the shape of bean curds by two sets of vertical joints. Compounded by marine erosion, this



Fig. 14 Two sets of vertical joints forming the bean curd structure

structure has formed a distinctive landform and may develop further into mushroom-shaped rock features (Fig. 14).

Bedding *Synonym:* ▶ *Stratification*

Bedding is used to illustrate the phenomenon of layer formation due to differences in the composition, colour, particle size, shape and structure of materials. Bedding is common in most sedimentary rocks and some volcanic rocks, and it is an important marker for the formation of sedimentary rocks and some volcaniclastic rocks. Beds can be from several centimetres to several metres thick, and their lateral extent can range from several centimetres to thousands of metres. Based on the morphology of small beds and the interfaces between the bedding systems, bedding can be divided into three basic types: horizontal bedding, wavy bedding and cross-bedding. Based on the morphology of small beds and the bedding system and the cause of formation, bedding can be categorized as planar bedding, wedge-shaped bedding and trough bedding.

Bedding is rock layers or strata that form through abrupt or gradual variations in rock composition, structure and colour. Bedding is an important indicator of sedimentary rocks and certain volcaniclastic rocks. Bedding in sedimentary rocks is usually an important marker of changes in sedimentation and the depositional environment. These changes cause differences across bedding planes, which result in clear bedding surfaces. Hence, bedding is always regarded as an important feature of sedimentary rocks.

Bedding Plane A bedding plane is the interface between different sedimentary layers, and it represents a sedimentary discontinuity or an erosion surface. A bedding plane has no impact on the bed thickness; it mainly reflects the existence of a difference in the material and structure between the overlying and underlying strata. Bedding planes can be horizontal or inclined and can be linear, curved or wavy.

Behavioural Geography Behavioural geography is a discipline that studies human behavioural processes, including space and location selection and the development processes in a geographical environment. It studies the process of human understanding of different geographical environments and behaviours and is a field of human geography. Behavioural geography research provides important guidance for understanding the choices of destinations by tourists and their spatial behaviour.

Beheaded River Landscape When river capture occurs in a watershed, the upper course of the captured river changes its course, while the lower course, which has lost its headwaters, will have a greatly reduced volume; therefore, it is called a beheaded or misfit river.

Beihai Weizhou Island Volcano National Geopark, Guangxi Located in Beihai City, Guangxi Zhuang Autonomous Region, Weizhou Island is one of the largest islands in the Beibu Gulf and one of the youngest volcanic islands in China. It is 21 nautical miles from Beihai City and has a total area of approximately 27.70 km^2 (including Xieyang Island). It became a national geopark in 2004. The geopark has typical volcanic structures (including craters) and a rich volcanic landscape that records a large variety of volcanic activities. Weizhou Island is also the largest volcanic island in China, and it is nearly circular. Numerous volcanic eruptions occurred from 130,000 to 10,000 years ago, forming the Nanwan, Hengluo Mountain, Crocodile Mountain, Xiyang Village and Xiyang Island Powan Craters. Marine and coastal erosion have shaped the current attractive volcanic landscape.

Beijing Pinggu Huangsongyu National Mining Park, Beijing This park is located in Tawa Village (also known as Taojingu, which means gold-mining valley), Huangsongyu Township, Pinggu District, Beijing. It was approved by the Ministry of Land and Resources on 23 August, 2005, as one of the first group of national mining parks. The park has abundant mineral resources, such as gold, silver, copper, potassium and rare metals. It is composed of three parts, including a mining heritage museum, mine exploitation and metallurgy experience and a display hall of mining equipment. The park employs pictures, inscriptions, models, physical objects, videos, information systems and other multimedia tools that provide tourists an extensive introduction to the discovery and development of the gold mine in the Pinggu District as well as the exploitation, refining and processing technologies and methods used in gold mines. The underground mine tunnel in the park is also open to tourists to allow them to experience the process of gold exploitation.

Beijing-Hangzhou Grand Canal This is simply called the Grand Canal and is the oldest and longest man-made river channel in the world. This canal starts in Hangzhou in the south and extends to Beijing in the north. It passes through 5 major river systems, including the Qiantang River, Changjiang (Yangtze River), Huai River, Huanghe (Yellow River) and Hai River, with a total length of 1,795 km. Its construction began in 485 B.C., when King Fuchai of the Wu State excavated the Bang Ditch, diverting the Qiantang River from the ancient Han City (now northwest of Yangzhou City) north via Mokou (now north of Huaicheng, Huai'an City) into the Huai River. The Hong Ditch was excavated in 361 B.C. during the Wei Dynasty, and it linked the Huai River to the Yellow River. Large-scale excavation and renovation work on the canal occurred during the Sui Dynasty, and the Tongji Ditch was constructed in 605 A.D., which linked up with the Han Ditch in Qingjian in Jiangsu Province (now Huaiyin) from Luoyang via Kaifeng. In 608 A.D., the Yongji Ditch was excavated, which ran from Luoyang through Wushe and Linqing to Zhuo County (now Zuozhou in Hebei Province) and connected with the Hai River system. Enhancements continued through the Tang, Song, Yuan, Ming and Qing Dynasties, especially those extensive excavation and improvement works during the Yuan Dynasty. From 1283 to 1293 A.D., the Jizhou Canal from Jining to Dongping Lake, the Huitong Canal from Dongping Lake to Linqing, and the Tonghui Canal from Beijing to Tongzhou were excavated. This work straightened the canal, shortening the navigation distance from 2700 km to 1795 km, which is the current waterway length of the Beijing-Hangzhou Grand Canal. Today, in addition to shipping purposes (part of the waterway), the Grand Canal also serves as the pipeline of the eastern line of the South-to-North Water Diversion Project (Fig. 15).

Beitou Hot Spring landscape This is a famous spring landscape in Taiwan, which is located on the Jinshan Fault in the Datun Volcano Group in the Beitou District, Taipei. It has been Taiwan's most famous hot spring district for more than a century. The water of the Beitou Hot Spring mainly comes from the Diregu (Thermal Valley, Hell Valley) and Longfeng Valley below Xingyi Road. The hot spring that flows from Diregu Valley is clear and green like jade, which led to the name Green Sulphur. The spring water from Longfeng Valley is known as the Star Spring, and it contains white sulphur. Both kinds of spring water are effective at treating chronic arthritis, muscle aches and chronic dermatitis (Fig. 16).

Belize Barrier Reef Reserve System, Belize This site is located in Belize and has an area of 963 km^2. The site is divided into seven different parts. Its outstanding natural system includes the largest barrier reef in the Northern Hemisphere. In addition, there are offshore atolls, hundreds of sandbanks, stretches of mangroves, coastal lagoons and estuarine ecological zones. Seven groups of heritage sites, which illustrate the natural ecological development of coral reefs, are important habitats for such endangered species as sea turtles, sea cows and American alligators. Moreover, the Belize Barrier Reef Reserve System is a



Fig. 15 A section of the Beijing-Hangzhou Grand Canal

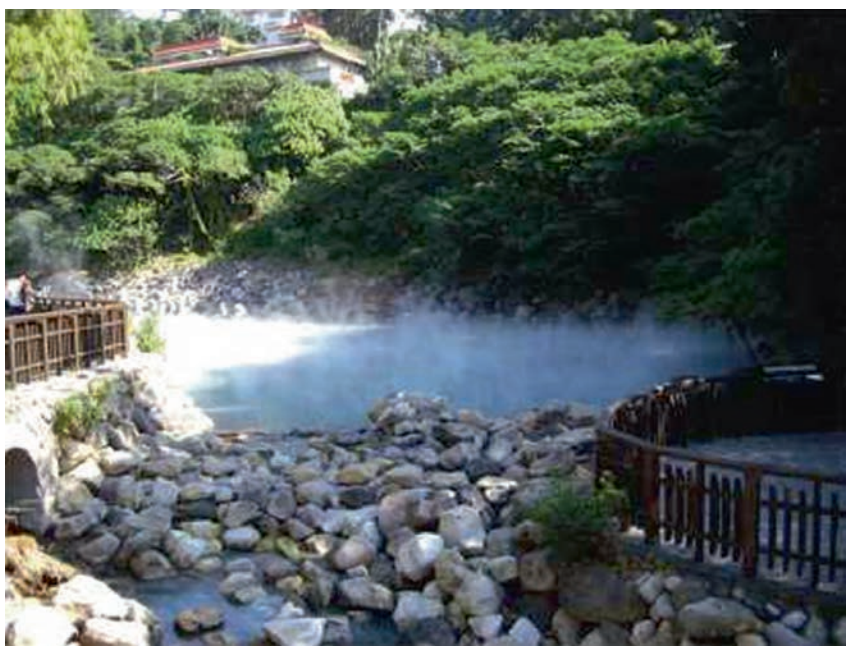


Fig. 16 Beitou Hot Spring landscape, Taiwan

classic demonstration area of such halobios as fringing reefs, barrier reefs and atolls as well for as the evolution of marine geology and geomorphology.

Belovezhskaya Pushha/Białowieża Forest, Poland This cross-border world heritage site is composed of Białowieża Forest Park in Podlaskie Voivodeship in northeastern Poland and the contiguous natural reserves of Białowieża Forest in Grodno, southwestern Belarus. It is located in the mountainous watershed area of the Baltic Sea and the Black Sea. It became a cross-border natural heritage site in 1992 due to Belarus's extension of a former heritage site (Białowieża National Park of Poland). The forest reserves have a vast area

of evergreen broadleaf forest and are inhabited by a variety of endemic wild animals. The heritage site, which is located along the border between the two counties, was also a historical hunting and summer resort for the Polish and Russian royal families.

Benthos Benthos are living creatures that live at the bottom of the water. They include most invertebrates and algae and a few higher plants, freshwater molluscs, annelids and seaweeds. Benthos can be divided into epibenthos and endobenthos, and they can also be categorised into sessile benthos and vigil benthos.

Benxi National Geopark, Liaoning This geopark is located in Benxi City, Liaoning Province, in the low mountains and hills along the western extension of the Changbai Mountains. It became a national geopark in 2005. The main geological landscapes include karst caves, solution depressions, sinkholes, stratigraphic sections, historic sites of early humans, tectonic relics, volcanic relics, and geohazard relics. The unique landscapes include the Benxi Water Tunnel and karst sinkhole with an underground river that is approximately 3,000 m long, the Maoyan Cave (a cave from which steam rises), and early human fossils and cultural relics at the historic site of Miaohou Mountain.

Bihu Wu Bihu Wu (1962–) graduated from East China Normal University and is currently a professor and doctoral tutor at the School of Environment at Peking University. He is an expert in tourism geography and tourism planning. He is the chief editor of the 'Young Geographer' of the Geographical Society of China, the deputy director of the Professional Committee of Tourism Geography, and the director of the Regional Tourism Development Professional Committee of the Regional Science Association of China. He has engaged in research on regional tourism planning and recreation space planning for many years. He has published more than 100 papers on tourism development and planning and has also published and translated 12 books, including the 'Principles of Regional Tourism Planning'.

Bingling Danxia Geopark, Gansu This geopark is located in Yongjing County, Gansu Province, and has an area of 26 km^2. Its main geological features are concentrated in an area of 6 km^2. It was designated as a national geopark by the Ministry of Land and Resources in December 2011. The Danxia landforms that formed in the Cretaceous Hekou Group feature diverse shapes that are representative of the Danxia landforms in arid and semi-arid areas. The geomorphologic landscapes in the geopark mainly include the Danxia landforms, which are dominated by gorges, peak clusters and pinnacles. Other geological features include bowl-shaped landforms, which are thought to be a result of meteorite impacts, and features such as contacts between different strata, geohazards, differential weathering and statoliths. Different types of Danxia landforms and their stages of development have been preserved. With complete sequences and clear profiles, the Cretaceous Hekou Group in the main part of the geopark is a natural specimen for studying Danxia landforms in arid areas. The natural profiles are ideal for studying petrology, stratigraphy and sedimentology as well as a natural record for studying Mesozoic geology. In addition, the prosperity and extinction of dinosaurs in the Cretaceous Hekou Group and the bowl-shaped landforms in the northern part of the geopark provide opportunities for further scientific research. The Danxia landforms and the beautiful rocks are natural classrooms for geoscience popularisation and geotourism.

Binominal Nomenclature Binominal nomenclature is an international system of naming species of living things by giving each a name composed of two parts, both of which use Latin grammatical forms. The first part is a noun of a genus, and the latter part is an adjective. An example is *Nankinella orbicularia*, where Nankinella is the genus and is capitalised, and orbus is the adjective, which is not capitalized. The names are always italicized. Sometimes, the surname of the person that discovered the species is attached after the binominal name; the first letter is capitalised and printed in Roman words. In addition, the year the species is named can be added after the name, separated by a comma. For example,

Nankinella orbicularia Lee, 1934 means that this species was named in 1934 by Siguang Li (Lee). For nomenclature in Chinese, the adjective is usually put before the genus but sometimes after. For example, *Nankinella orbicularia* is translated directly from Chinese as 'Nanjing Shovel round species'. Scientific names of species must be typeset in Latin or Latinized words and represent the biological characteristics of the organism, a place or a person.

Biochemical Sedimentary Rock Biochemical sedimentary rocks are also known as biochemical rocks and are rocks that form from the aggregation of abundant substances dissolved from weathered parent rocks (in solution or colloid form) through various biochemical functions or biological activities. These rocks often contain the bodies of organisms or biological clastic structures. The most common biochemical rocks are diatomite, reef limestone, phosphorite and coquina.

Bioclastic Limestone Bioclastic limestone is also called clastic shelly limestone. It is a limestone that is formed by the cementation of broken shells with calcium carbonate. It often forms in areas with strong waves or currents or on the flanks of reefs, and the organisms in the rock can be characterised by their varying geographic origins.

Biodiversity Biodiversity is the variability and diversity of biological elements at different levels, such as genes, species, ecosystems and landscapes. Different levels of living groups have large variations in genetics, metabolism, physiology, morphology, and behaviour as well as differences in the compositional structure and ecological functions of the population. Species diversity is the key to biodiversity. Biodiversity research and conservation are prerequisites for the sustainable development of the biosphere. Biodiversity includes genetic diversity, species diversity and ecosystem diversity.

Biogeography Biogeography is the study of the geographical distribution of organisms in time and space. It is an interdisciplinary field between biology and physical geography that focuses on the distribution patterns and compositions of biota and community types on the Earth's surface. It can be divided into biogeographic geography and bio-ecological geography. It can also be divided into plant geography, animal geography, and insect geography based on the biological groups.

Bioherm Landscape *Synonym:* ► *Organic reef landscape*

This is a general term for a landscape consisting of wave-resistant biogenic reef structures that have built up by in situ reef-building organisms. These islands are mainly located in deep tropical and sub-tropical seas. The reefs contain abundant fossils of reef-building creatures. In addition to corals, which are common reef-building organisms, there are many other organisms, such as algae, moss worms, calcareous sponges, stromatoporoids and archaeocyathids. The bioherms range in length from tens of metres to tens of kilometres and even hundreds of kilometres. The reefs can be circular, such as atolls, horseshoe-shaped, tower-shaped, and narrow and long like an embankment.

Biological Coast; Coral Coast and Mangrove Coast This type of coast is composed of the remains of shellfish, coral reefs or mangroves. Shell banks, biological reef beaches, coral reefs and mangrove coasts have significant recreational and scientific value.

Biological Factors of Landscape Formation The complex ecosystem on the Earth's surface consists of animals, plants, microbes and other organisms that constitute a large and complex ecosystem. This ecosystem has formed different biota landscapes and influenced landscape formation through weathering.

Biological Weathering in Landscape Formation Biological weathering refers to the disintegration of rocks caused by various activities of living organisms, including reproduction, multiplication, growth, death and decomposition. Biological weathering can be induced by mechanical means, for instance, when the roots of growing plants exert pressure on fractures in rocks, they would widen and deepen the cracks, and eventually disintegrate the rocks. Biological weathering can also

be chemical, for instance, metabolic secretions and organic acids, hydrogen, ammonia, and nitrogen produced by the decomposition of living organisms would degrade and break down the rock. Human activities such as construction projects also contribute to biological weathering. Many exotic landforms in nature are closely related to the activities of living organisms and biological weathering.

Biosphere The biosphere is the surface layer of the biological components of Earth and its living environment. It is the largest ecosystem on the planet and comprises the lower stratosphere, the entire troposphere, the lithosphere and the hydrosphere. It represents a unique space for the interactions between different regions as well as the development and survival of human beings.

Biosphere Reserves Protected terrestrial, coastal, and marine ecosystems have gradually transitioned from traditional completely protected areas to open, multi-functional actively protected areas with the aim of protecting ecosystem safety and biodiversity as well as promoting the sustainable development of resources. This concept will enable people to live in harmony with nature and ease the conflicts between protection and development and between nature reserves and the local residents' activities and life. These new nature reserves are called biosphere reserves.

Biostratigraphic Unit A biostratigraphic unit is a unit assigned to a rock layer that contains a unique type of fossil or fossil assemblage. This unit is generally called a biological zone and can be further divided into range zones, interval zones, lineage zones, assemblage zones and enrichment zones. The fossils generally reflect the pattern of evolution over geologic time, and this evolution is not duplicated in the stratigraphic record. In this respect, the biostratigraphic unit represents a relative geologic age. In the same stratigraphic interval, several range zones, interval zones, lineage zones, assemblage zones and enrichments zones can be independently categorised based on the characteristics of the selected fossils. Biostratigraphic units are different from chronostratigraphic units and from lithostratigraphic units. Their boundaries are sometimes similar but sometimes cross each other.

Biota Biota is all of the living creatures in a specific area, include all fauna and flora.

Biotite The composition of biotite is $K(Mg,Fe)_3[AlSi_3O_{10}](OH,F)_2$. It crystallises in the monoclinic crystal system, and the crystals are blocky or conical columnar in shape. It often has a pseudohexagonal platy form. Its colour varies from black or dark brown to reddish brown and is rarely green or white, always with white streaks. Its diaphaneity ranges from transparent to opaque, and it has a pearly or vitreous lustre. The specific gravity is 2.7–3.4, the Mohs hardness is 2.5–3, and the fractures are uneven. Biotite is usually found in igneous and metamorphic rocks.

Bird Fossil Bird fossil is a collective term for fossils of all Aves. Bird fossils were discovered only a few decades ago in China. The recent discovery of Sinosauropteryx fossils in western Liaoning Province shows that Sinosauropteryx is the ancestor of small theropods and strongly supports the hypothesis that birds evolved from small theropods. These findings further facilitate the division of the evolution of primitive Protoavis into four phases: Sinosauropteryx phase, Archaeopteryx phase, Confuciusornis phase, and Euornthes phase. Fossils representative of all four phases have been found in western Liaoning Province, and these findings have attracted the world's attention. To date, more than 250 pieces of bird fossils have been unearthed in Chaoyang National Geopark in Liaoning Province. Associated with these fossils, three subclasses, 11 genera and 14 species have been identified by experts (Fig. 17).

Birthstone There are 12 birthstones:

(January birthstone: garnet) Garnet symbolises chastity, sincerity, friendliness and truthfulness. It is also the gemstone for the 17th wedding anniversary.

(February birthstone: amethyst) Amethyst symbolises honesty and peace of mind, and it is the gemstone for the 17th wedding anniversary.



Fig. 17 Bird fossil

(March birthstone: aquamarine) Aquamarine symbolises composure, bravery, happiness and longevity.

(April birthstone: diamond) Diamond symbolises chastity and purity, and it is also the gemstone for the 75th wedding anniversary.

(May birthstone: emerald) Emerald symbolises a happy couple and is also the gemstone for the 55th wedding anniversary. As a gift, it is a token of luck and happiness.

(June birthstones: pearl, alexandrite and moonstone) Alexandrite is a chromium-containing chrysoberyl. It is green under sunlight but appears red under an incandescent light. Poets have described it as 'the emerald of the day and ruby of the dark'. Moonstone can emit a light blue halo like moonlight, which is the origin of its name. People believe that wearing a moonstone can bring luck. It is also the gemstone for the 13th wedding anniversary. It symbolises good health, longevity and wealth.

(July birthstone: ruby) Ruby represents high quality and fiery love.

(August birthstone: olivine) Olivine is known as the stone of happiness. It symbolises a happy and harmonious marriage for a couple.

(September birthstone: sapphire) Sapphire has a unique clear blue colour, and it symbolises kindness and love.

(October birthstone: tourmaline and opal) Tourmaline has a shorter history of gem making, but because of its rich bright colour and high transparency, it has been described as an amorous gemstone. Opal has various attractive colours resembling a colourful dream that leaves room for speculation. It symbolises hope and happiness. In Europe, it also represents luck, hope and purity.

(November birthstone: topaz) In China's gem industry, topaz is also known as 'Yellow Jade'. In the past, it was called the wine yellow gemstone. Outside China, it is called the oriental yellow gemstone or Brazilia yellow gemstone. It is also the gemstone for the 16th wedding anniversary. It symbolises friendship, hope, purity and happiness.

(December birthstone: zircon, turquoise and lapis lazuli) Zircon is also called 'Hyacinth Stone'. In ancient India, it was called 'Lunar Eclipse Stone'. Zircon, turquoise and lapis lazuli symbolise victory, good luck and success.

There are 12 horoscope sign birthstones:

Aquarius birthstone (21 January–19 February): sapphire or light blue diamond ring.

Pisces birthstone (20 February–20 March): coral or pink diamond ring.

Aries birthstone (21 March–20 April): amethyst or purple tourmaline ring.

Taurus birthstone (21 April–20 May): emerald ring; a square emerald is best.

Gemini birthstone (21 May–20 June): amber ring.

Cancer birthstone (21 June–22 July): jadeite ring.

Leo birthstone (23 July–22 August): ruby, red amber, blood amber or red garnet ring.

Virgo birthstone (23 August–22 September): chalcedony ring.

Libra birthstone (23 September–22-October): diamond ring; the classical style is better.

Scorpio birthstone (23 October–22-November): topaz ring.

Sagittarius birthstone (23 November–22-December): turquoise or pearl ring.

Capricorn birthstone (23 December–20 Jan): agate or amber ring.

Bitter Spring This is a type of spring with a bitter taste caused by bitter sulphate minerals. Shen Kuo, a scholar in Song Dynasty, in his book

'A Note of Dream Brook', stated 'There is a bitter spring in Qianshan County in Xinzhou, where the spring flow forms a stream. Upon boiling, the water turns into danfan (chalcanthite), and upon further stewing, the danfan turns into copper, and the iron kettle also turns into copper upon prolonged stewing. It is amazing that water can turn into copper; the change of material is unpredictable'. In fact, the bitter spring described by Shen Kuo contained copper sulphate, and after evaporation, the copper precipitated into copper metal, which attached to the surface of the iron kettle.

Black Jade Black jade is a nephrite that contains graphite. Its colour ranges from inky black to light black depending on the amount and pattern of the graphite. Its colour is often cloudy or striped, and it can be labelled as dark cloud-like, light ink-like, marten beard-like or belle beard-like. On a single piece of jade, the intensity and distribution of the black can vary, and so it can be further divided into 'all black', 'clustered black' and 'dotted black'. Clustered black refers to clustering of graphite in white or green nephrite, and it can be crafted to become a complementary colour or feature on the stone. However, dotted black stones are difficult to craft due to the scattered pattern. The all black type with a moistened appearance can be used as high-grade gemstone.

Black Soil *Synonym:* ▶ *Phaeozem*

Neutral black soil forms by the substantial accumulation of humus and water in temperate semi-humid steppe meadow vegetation. Its parent material is loess-like clay sediments, which are viscous but uniform in texture. It normally has no lime reaction. The humus layer is tongue-shaped and contains white silica powder, brown-black iron-manganese nodules and rust-coloured markings. It can be found in the central Heilongjiang and Jilin Provinces in northeast China.

Black Steel Stone This stone is also called 'marcasite stone' or' Africa black gold'. It is a steel-white iron sulphide mineral used for jewellery. It can be composed of haematite, goethite, or both. It contains 6–7% silica and has a Mohs hardness of 6.5, a specific gravity of 4.67–4.87 and a refractive index of 2.26–2.39. It has a unique non-fading lustre and is often used in various types of jewellery. It has remarkable decoration effects. Marcasite jewellery originated in the Victorian era (mid-eighteenth century) and was crafted by royal craftsmen. Only the royal family was allowed to wear this jewellery. In the late eighteenth century, this type of jewellery began to be produced outside the royal family and spread across Europe and then throughout the world in the nineteenth century.

Blind Valley This is a landform in karst areas where the river valley has no obvious exit. In this landform, the surface water disappears into a cave at a steep wall near the end of a valley and becomes a subterranean waterflow or underground river. This blind valley landform is often located near the contact between soluble and non-soluble rocks, where streams on non-soluble rock tend to flow into the ground when they reach soluble rock strata (Fig. 18).

Block Blocks are usually areas of old rocks in a geo-synclinal fold belt. Their sizes vary from approximately tens to hundreds of square kilometres for the small ones and up to thousands of square kilometres for the large ones. They are generally considered to be uplifted areas in a geosyncline. Because some are covered with sedimentary strata of different thicknesses, they are sometimes called 'intermediate massifs'.

Block Mountain Block mountains, or fault-block mountains, form along faults where rock blocks are forced upwards. They have flat and straight foothill margins and steep slopes like cliffs (i.e., fault scarps). There is no transition zone between the steep slope and the adjacent flat ground, and the slope is always abrupt. When such fault scarp is cut across by a transverse valley, triangular slope facets form, which are called triangular fault facets. Block mountains can form in various types of geological structures. Some have a fault on one side, while others are influenced by faults on both sides. Some exist alone, and some are in groups. They can be parallel, echelon (side by side), crossing each other or have



Fig. 18 Blind valley landscape –Yanwang Groove, Wulong, Chongqing

a concentric pattern. Common block mountains are the horsts and tilted fault-block mountains that are widespread in northern and northeastern China, such as Taishan, Huashan and Hengshan mountains.

Block Packing Landscape ▶ End Moraine Bar Landscape

Block Sea Landscape *Synonym:* ▶ *Rock block field landscape*

This is a landscape in permafrost regions. In these regions, the temperature is permanently below zero (−5 to −15 °C), and physical weathering is severe. Under such low-temperature conditions and due to the effect of plucking, abundant rock pieces and gravels are left behind on the ground, and this landform is called a block sea or a rock block field. Block seas are generally located in the ground with a slope less than 10°, where no horizontal movement takes place. The formation of a block sea is generally associated with rock block masses, such as granite, basalt, sandstone and quartzite (Fig. 19).

Block Stream *Synonym:* ▶ *Stone river landscape*

This is a landscape in a permafrost region in where owing to the effect of plucking, abundant rock pieces and gravels remain behind on the ground. Due to gravity, these rocks and gravels gather in depressions or valleys and creep downwards like a flow induced by frost heaving, contraction and thawing of the subsoil in the spring. This feature is called a stone river (Fig. 20).

Bloodstone *Synonym:* ▶ *Oriental jasper*

This is a craft stone that contains cinnabar and comprises cinnabar-containing rhyolitic crystal tuff composed of kaolinite, dickite, nacrite, and small amounts of alunite and cinnabar. It gets its name because dickite contains bright red cinnabar, which looks like chicken blood. The red portion is called 'blood', and the remainder is called 'ground', 'small ground' or 'base'. When the mercury sulphide content is greater than 0.5%, microcrystalline cinnabar may precipitate and make up more than 20% of the stone. This stone has a dense blocky structure with a soil-like lustre, but the high-quality stone can have a greasy lustre and be slightly transparent or translucent. It has a density of 2.7–3.0 g/cm^3. Bloodstone can be divided into frozen ground, soft ground, rigid ground, hard ground and suet ground types, and the suet ground stone that is completely red and has a high cinnabar content is the most valuable. It can be more



Fig. 19 Block sea landscape at Zheduo Mountain, western Sichuan



Fig. 20 Block stream landscape at Zheduo Mountain, western Sichuan (grey stripe in the middle and lower parts of the photo)

valuable than Tian Huang stone. Bloodstone is mainly found in the 144-million-years-old neutral or acidic volcanic rocks. Famous production areas include Changhua Town in Linan County, Zhejiang Province, and Daban Town in Bairin Right Banner, Inner Mongolia. The Balin bloodstone has a bright red colour, while the Changhua bloodstone is darker. The former has a finer and softer texture with more patterns, while the latter has a more constant blood colour (Fig. 21).

Blueschist Blueschist is another name for glaucophane schist, which specifically refers to metamorphic rocks with minerals of glaucophane characteristics formed during high-pressure regional metamorphism. It has complex metamorphic mineral combinations and is characterised by the presence of



Fig. 21 Bloodstone

glaucophane, magnesio-riebeckite, crossite, jadeite, jadeite pyroxene, and pumpellyite, and it often contains quartz, plagioclase, muscovite, actinolite, chlorite, epidote, zoisite and garnet. Blueschist often forms in association with eclogite and greenschist to form a unique rock combination. Detailed research has shown that blueschist forms under the conditions of high-pressure metamorphism and is often produced in high-pressure geological zones. Plate tectonics theory holds that blueschist forms in the subduction zones of oceanic plates towards continental plates, and blueschists are widely distributed in the Pacific Rim. There are also several blueschist outcrops in the Dabie-Sulu metamorphic belt in China.

Body Fossil A body fossil refers to the actual animal or plant body that has been fossilised. Body fossils are most abundant and include animal bones, teeth, crustaceans, shells, plant stems, leaves, flower, and fruit. Due to long-term burial, the original material hardens through the chemical exchange process with calcium, silicon and sulphide in the groundwater. Some animal and plant debris are imprinted on soft sediment surfaces, and during the diagenesis process, they leave traces in the rock in the form of prints, moulds or films.

Bog Soil Bog soil is formed by the accumulation of a thick layer of organic matter under long-term or seasonal water accumulation and wet conditions. The soil is characterised by peat and slime layers and is neutral or slightly acidic. The organic matter content of the peat and slime layers is less than 200 g/kg. Soils less than 50 cm thick are classified as swamp soil, which is an intrazonal soil commonly found in low-lying areas.

Bohemian Paradise Geopark, Czech Republic This geopark is located 100 km northeast of Prague and covers an area of 700 km^2. It became a global geopark in 2005. It includes a karst system of Cretaceous limestone. The Izera River formed a scenic valley and flows through the towns of Seminye and Turnov. The gorge is surrounded by dense forests and geological features with remarkable rocks on both sides. Because of these outstanding landscapes, it was set up as a nature reserve. The Loucsky waters used to have nine ponds. Only three ponds currently remain in Cihlak, Krizak and Nohavice, which form the northernmost pond system. Podtrosecka Udoli (valley under Trosky) and the Classic Geologic Square Uile are fascinating scenic sites. As early as the sixteenth century, people had established a pond system that drained floodplains and swamps in the valley to develop the economy of the region. Today, it has become an extraordinary tourist attraction. The unique canyon valley is surrounded by sandstone cliffs, which also lie along the shores of the ponds.

Boiling Mud Pot Landscape This is a landscape consisting of ponds filled with boiling water and thin mud. The mud is mainly composed of hydrothermally altered clay mixed with alunite, iron oxide and iron sulphide. The mud is black, but some boiling mud pots are milky white, whitish, grey, yellow, brown, red, purple or orange-red, resembling a pot of mixed paints. Gas emissions from the boiling mud pot are common, which cause the mud to splash from the pond surface. Boiling mud pots are also called mud-frog pots. When the temperature is below the boiling point, it is called a hot-mud pot. If the mud is viscous, the splashed mud tends to accumulate around the air holes to form small and low cones like mud volcanoes with gas emissions on the top. Boiling mud pots are common in volcanic areas and are always associated with geysers or hot springs.

Boiling Spring Landscape This is a landscape composed of hot springs with water

temperatures that reach the local boiling point at the spring outlet. The saturation temperature of boiling springs is a function of the elevation of the spring mouth. The boiling point is lower at higher elevations, but the rate of decrease is not constant. At elevations below 5000 m, the boiling point decreases by 1 °C for every 303 m increase in elevation. The saturation temperature of boiling springs at the seafloor increases rapidly with depth. The dissolved gas in the water can cause the boiling point to decrease slightly, but dissolved minerals cause the boiling point to rise. Boiling springs are examples of two-phase high-temperature hydrothermal activity on the Earth's surface. They usually only occur in geothermal regions at the edges of tectonic plates (Fig. 22).

Boron Water Boron water is a type of medical mineral water. According to the National Medical Hot Mineral Water Quality Standard, water with oxoboric acid concentrations over 50 mg/L and 1.2 mg/L can be used for medical and drinking purposes, respectively. Water labelled as boron water must contain boron over 50 mg/L. In Europe, the standard for natural drinking boron water is 5 mg/L or above. Boron water is common in hot springs around the world. In the Shuimogou hot spring in Urumqi, Xinjiang Province, the boron content is as high as 140.44 mg/L, and the spring has been transformed into a spa and sanatorium for medical and healthcare purposes.

Bosten Lake Landscape This is the largest inland freshwater lake in China. It is located in Bohu County on the southeastern side of the Yanqi Basin. It was formerly called Xihai (West Sea) and Tangweiyu Sea. In the middle Qing Dynasty, its name was changed to Bosten Lake, which means 'oasis' in Ur. It is also called Bagrash Lake. The lake has an elevation of 1,048 m, an east-west length of 55 km and a north-south width of 25 km. It has a triangular shape, a surface area of 988 km^2 and a water storage volume of 9.9 billion m^3. There are dozens of small lakes along the southeastern corner of the lake. Bosten Lake and the nearby snowy mountains, lakes, oases and deserts form a picturesque landscape like a painting, which has been called the 'Xanandu' on Earth (Fig. 23).

Botanical Garden Tourism Landscape Botanic gardens have tourism value and can be divided into two major categories, namely, large-scale comprehensive botanical gardens and special thematic botanical gardens. Many botanical gardens are meant for research but also for

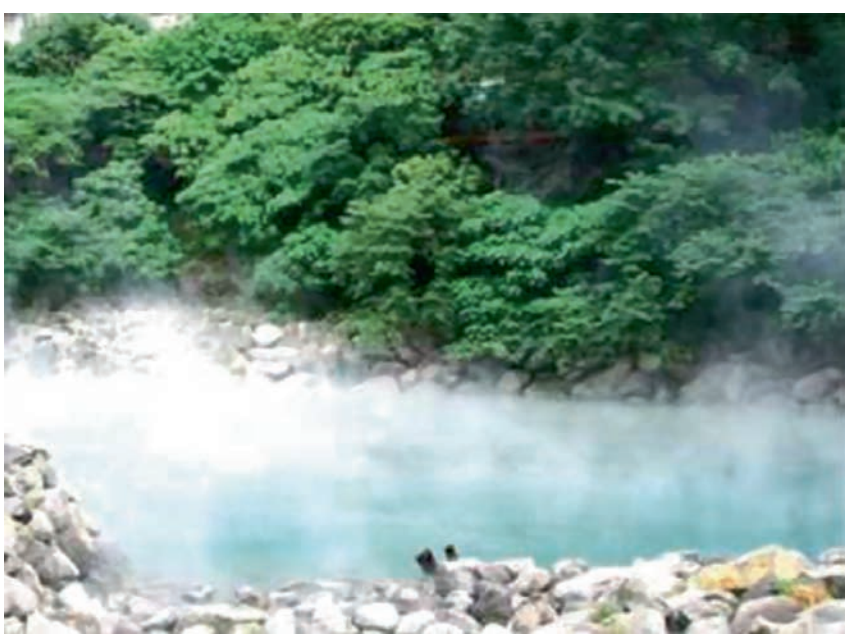


Fig. 22 Boiling spring landscape in Mugecuo Lake



Fig. 23 Bosten Lake landscape

visits by tourists. For example, the Beijing Botanical Garden, Lushan Botanical Garden, Yunnan Xishuangbanna Tropical Botanical Garden and the botanical gardens for subtropical plants in Hangzhou and Nanjing receive millions of visitors every year and have become important tourism resources.

Brachiopod Fossil Brachiopods are benthic invertebrates that live as single entity or in groups. They have concrete cavities, no segments and are bilaterally symmetrical. They also have two shells of unequal sizes, which are composed mainly of calcium or chitinophosphatic materials. There are approximately 100 genera and 300 species of existing brachiopods, but they flourished in the past. Approximately 3,500 genera and more than 30,000 species have already been illustrated. Brachiopod fossils are important for determining geological age. Brachiopods thrived from the Silurian to the Permian and are mainly preserved in limestone, marl and calcareous shale. Some specimens have higher ornamental value because many individual fossils tend to cluster together in the same rock. Brachiopod fossils have mainly been found in Hunan, Guangxi, Hubei, Yunnan and Guizhou Provinces (Fig. 24).

Brackish Lake A brackish lake, also called a weakly mineralised lake, has a salinity of 1–35 g/L. Some consider brackish lakes to have salinities of 0.3–24.7 g/L or 1–24.7 g/L. Most brackish lakes are sulphate or chloride lakes and are inflowing and undrained lakes. An example is Qinghai Lake.

Brazilian Atlantic Islands, Brazil Fernando de Noronha and Atol das Rocas Reserves are located in the Atlantic northeast of Rio Grande do Sul in eastern Brazil. Their core protected area covers 422.7 km^2. These islands and atolls formed from the exposure of the South Atlantic Seamounts above sea level. They are outstanding representatives of the islands in the South Atlantic region and are primary bases for the breeding and feeding of tuna, sharks, sea turtles and marine mammals. The island area is also home to the greatest concentration of tropical seabirds in the western Atlantic Ocean. The Bay of Goffenjo is a haven for dolphins, and the Roccas Atoll has spectacular lagoons, tidal pools, fish pools and seascapes at low tide. The region is a natural aquarium in the tropical waters of the South Atlantic Ocean.

Breccia Breccia is a coarse sedimentary clastic rock cemented with angular gravel particles larger than 2 mm that have not been polished.



Fig. 24 Brachiopod fossils

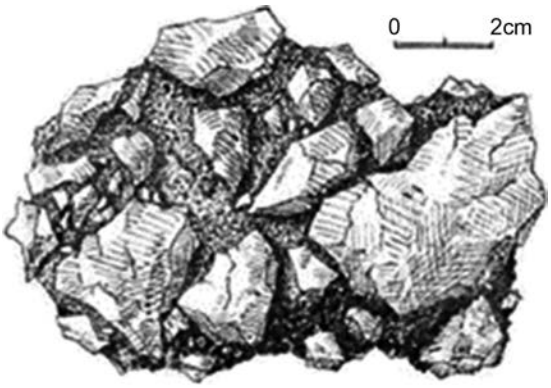


Fig. 25 Breccia

The clastic materials that make up breccia generally have not been transported at all, or have only been moved for a short distance. The gravel is characterised by different sizes and shapes, low roundness and angular shapes. Based on the causes of formation, breccias can be divided into karst breccia, volcanic breccia, glacial breccia, fault breccia, diagenetic breccia and epigenetic breccia. Breccia is also useful for analysing palaeogeographical environments, tectonic movements and mineral ore distributions (Fig. 25).

Brine This is a liquid with a salt content greater than 5%. Brine on the ground surface is called surface brine or lake brine, and brine below the ground surface is called underground brine. It is called petroleum brine when it is associated with crude oil. Based on the underground enrichment conditions, brine can be classified into pore brine, intercrystal brine and fissure brine. Based on the hydraulics, brine can be divided into submerged brine and pressurised brine. Brine often contains ions of K^+, Na^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^-, CO_3^-, HCO_3^-, B, Li, Br, I, Sr, Rb and Cs.

Broad Valley Landscape This is a landscape comprising river valleys with wide cross-sectional profiles. Generally, there are floodplains on the valley floor and multi-level terraces along the slopes. Broad valleys usually develop in areas of stable crust or with less resistant rock strata (Fig. 26).

Brodelboden Landscape *Synonym:* ► *Involution landscape*

This is a landscape that forms by bending of sediment layers due to compaction, freezing and thawing. In permafrost, when the active layer freezes downwards, the unfrozen middle layer that contains water is blocked by the permanently frozen layers and will creep under pressure. As a result, a curling structure develops which is called a brodelboden (Fig. 27).

Bromine Water This is hot mineral water that contains bromine. Bromine water is a type of industrial raw water and also medical hot mineral water and natural drinking water with medical and therapeutic effects on the human body. Based on the content of bromine in the water and its usage, bromine water can be divided into three categories: industrial bromine water, medical bromine water and drinking bromine water. Bromine is an essential trace element for the human body. When used for bathing and drinking, it has the function of calming and regulating the central nerve system. It is suitable for treating neurosis, autonomic disorders, neuropathy and insomnia with good curative effect.

Brown Desert Soil Brown desert soil is found in the extreme temperate arid desert areas and develops on sandy gravel-bearing sediments left by the parent materials on slopes. The surface has obvious gravel layers, pore-like crusts, iron-stained layers, gypsum accumulation layers and salt-bearing layers. It is widely distributed in the Tianshan Mountains, west of Jiayuguan and in the Gobi Plain north of the Kunlun Mountains.

Brown Earth *Synonym:* ► *Brown soil*

Brown earth is also called brown forest soil. It is a mildly acidic brown soil with a rich salt



Fig. 26 Broad valley landscape



Fig. 27 Soil involution in Xinghai, Qinghai Province

base in warm-temperate deciduous broadleaf forests. It forms by adhesion, leaching and strong bioaccumulation. The texture is sticky with rust markings. Strong leaching is obvious, and there is no lime reaction in the entire section. These soils are concentrated in the lowland and hilly areas of the Liaodong Peninsula and Shandong Peninsula and extend southwards to the hills of northern Jiangsu. These soils develop through the processes of clayification and calcification under semi-humid conditions in warm temperate regions. They are well-drained, semi-leached, neutral to slightly alkaline, brown and contain some carbonate. The soil zones are located between 34–40°N and 103–122°E and at elevations below 500 m with phreatic groundwater below 3 m.

Brown Soil ▶ Brown Earth

Bryce-Type Sandstone Forest Landscape This is a representative type of sandstone landscape found in the Bryce Mountains in southern Utah, U.S.A., in inland lacustrine facies sedimentary red, pink and purple sandstone strata of the Palaeogene-Palaeocene Claron Formation. From the watershed towards the valley, numerous stone pillars and walls have been developed in a series of circular and horseshoe-shaped depressions and they become the major elements of this type of



Fig. 28 Bryce-type siltstone column forest landscape – Bryce Canyon National Park, U.S.A.

landscape. These rock pillars are cylindrical, conical, mushroom-shaped, or castle-like. The stone walls have different heights and sometimes have holes and caves, the colours and shapes of which change with the light. These pillars, which are 5–30 m high, are in compact layers and look like a forest when viewed from a distance. This area is hot and dry with concentrated precipitation. Therefore, torrential rain can wash away the weathered residue in the concave depressions, making the stone forest look cleaner, brighter and more mysterious (Fig. 28).

Buddha's Halo *Synonym:* ► *Light of Buddha*

Buddha's halo is a unique natural physical phenomenon. It is the shadow of the viewer projected by sunlight from behind onto a cloud layer in the front. The halo is a concentric rainbow formed by the tiny ice crystals and water droplets in the cloud. The shadow's movement inside the rainbow looks like a gesture of the figure, forming a peculiar scenery. The formation of Buddha's halo hinges on a combination of physical factors, such as the sunlight, topography, clouds and mists. Buddha's halo is very common in the Golden Summit of Emei Mountain in China; therefore, this type of phenomenon is also called 'Emei's Precious Light'. This halo also frequently occurs at Bixia Temple at the top of Taishan Mountain and hence is also locally called 'Bixia's Precious Light'.

Burqin Kanas Lake National Geopark, Xinjiang This geopark became a national geopark in 2004. It is located in the northern Xinjiang Uygur Autonomous Region, which is under the jurisdiction of Burqin County in the Altay Region, near the border between China and Kazakhstan, Russia, and Mongolia. The Kanas River basin is the only basin upstream of the Irtysh River in the Arctic Ocean. The park includes four scenic districts: Kanas Lake, Hewan, Black Lake, and East Sileke. It is mainly composed of Quaternary glacial remains, geological structures, and flowing water landscape features. Kanas is the Mongolian word for 'lake in the canyon'. The Lanshan Ice Lake and Moon Bay, which are represented by Kanas Lake, are typical landscapes that were formed by glaciers, flowing water, and tectonics during the Quaternary approximately 2.6 million years ago. Kanas Lake is a glacial and faulted lake. Glaciers, glacial boulders, ice erosion lakes, glacier-shaped valleys, hills, glacial terraces, rocky rivers, icicles, nicks, ridges, horns and other

ice erosion and moraine depositional landscapes are present in this geopark.

Burren and Cliffs of Moher Geopark, Ireland This geopark is located between the cities of Limerick and Galway on the western coast of Ireland. It became a global geopark in 2011. The landscape of the cliffs is formed by a limestone hill and ridge that connect the ocean and the waterways to form a vast network of underground caves. The key attraction is the Cliff of Moher. The park contains traces of human inhabitation from 6,000 years ago.

Business Tourism Business tourism is the tourism undertaken for business purposes. It is one of the fastest growing types of tourism in recent years. Since 1990s, with the economic recovery of industrialised countries, the global economic integration and the loosening of border restrictions, economic activities and transnational technological cooperation between countries have become increasingly integrated with international business tourism. According to statistics, global business tourists account for approximately one-third of the total tourism activities.

Bwindi Impenetrable National Park, Uganda This park is located in the southwestern corner of Uganda near the borders with Rwanda and Democratic Republic of the Congo. The core protection area covers 321 km^2. It is situated at the intersection of plains and mountain forests and is famous for its rich biodiversity with more than 160 species of trees and 100 species of ferns. It also has many types of birds, butterflies and animals, including endangered animals, such as mountain gorillas.

C

Cabo de Gata Natural Park, Spain This geopark is located on the coast of Costa Blanca and covers an area of 500 km^2. It became a global geopark in 2006. The park is located in a semi-arid region with poor soil but abundant plant species. It ranks among the most diverse and unique ecological areas in Europe. There are thousands of native plant species, hundreds of which are small and have short lifespans (days to months). The animal species include eye-catching marine birds, steppe birds and salt marsh birds. Participating in ecological diving in the Cavo de Gata Geopark is an unforgettable experience because the water along the coast is the cleanest and clearest in the Mediterranean. In addition, the geopark has a vast marine grassland of *Posidonia oceanica*, where sea urchins, starfish, sponges, molluscs and many species of fish have ideal feeding and breeding grounds.

Calcareous Conglomerate Karst Landscape This is a unique type of karst landform that develops in calcareous conglomerates, such as the Longmen Mountain landform in Anxian, Sichuan Province, where dissolution is rare and has caused the formation of peak clusters. Another example is Luofu Mountain, which also has a formation of stone forests, conglomerate caves and subterranean rivers in the lower strata. The Longmen conglomerate cave is located in Lushan County in Ya'an City, Sichuan Province. It is more than 20 km long, and 13.2 km have been surveyed. Its vertical depth is 356 m, and it is the longest and deepest maze-type cave to be discovered in China. Part of it has been opened to tourists (Fig. 1).

Calcareous Soil ▶ Sierozem

Calcareous Sinter *Synonym:* ▶ *Travertine;* ▶ *Calcareous tufa;* ▶ *Calcareous tuff landscape*

This is a type of sinter landscape containing chemical deposits of calcium carbonate formed when geothermal water containing calcium bicarbonate reaches the ground surface and releases abundant carbon dioxide. Calcareous sinter is mainly composed of calcite and aragonite. It is hard, dense, fine-grained, blocky, hollow or spherical. It can be in the form of thick blocks or thin layers and has fibrous or concentric circular structures. Calcareous sinter has variable forms, such as cones, mounds, fans and stalactites. The 'travertine stone forest' in the Longma'er Hot Spring area in the northern Tibetan Plateau is world famous and unique. The sinter pillars can be 7 m high. In general, calcareous sinter is an indicator of low-temperature geothermal conditions. Calcite is most common in calcareous sinter, and aragonite sinter only forms when crystallisation is rapid. The increase in strontium ions in a spring can facilitate the formation of the aragonite sinter, whereas alkali metal chloride is unfavourable for its formation. High-temperature hot springs generally have aragonite precipitation, but when abundant carbon dioxide is released, only calcite can form (Fig. 2).

Calcareous Tufa ▶ Calcareous Sinter

Calcareous Tuff Landscape ▶ Calcareous Sinter.

Calcareous Tufa Landscape, Sinter Landscape In areas with rivers, springs and caves, carbonates, especially calcium carbonate, can precipitate and deposit to form this type of sinter landform with porous sediments. Based on the formation environment, sinters can be divided into two kinds: (1) Chemically formed carbonate rocks that precipitate from the surface water or groundwater with high calcium carbonate content. Mosses, lichens and other organisms also play a role in their formation. This type of sinter commonly forms on slopes with flowing water or at the spring outlets. It is irregular in shape and loose with many pores. An example is the abundant calcareous sinters along Qikongxiao Stream in the Maolan

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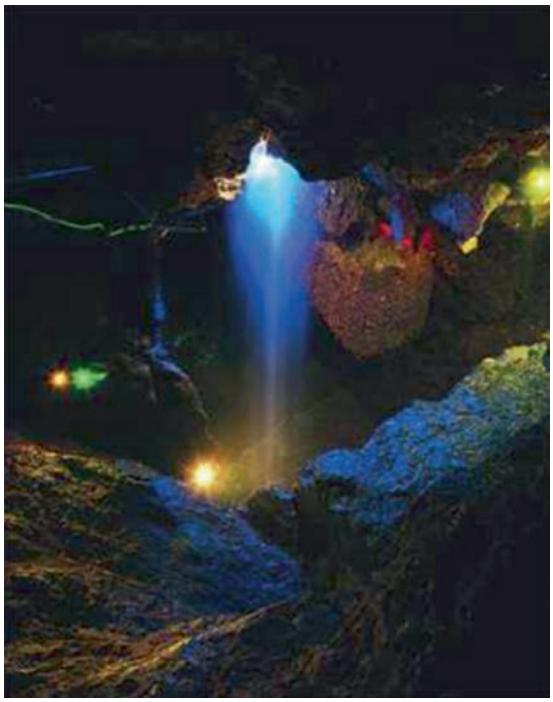


Fig. 1 Calcareous conglomerate karst cave landscape – Longmen, Lushan County, Ya'an, Sichuan Province



Fig. 2 Travertine landscape – Yunnan Baishuitai

Nature Reserve area in Guizhou Province. (2) In karst areas with unique formation conditions (such as active fault zones), karst springs often contain high concentrations of carbon dioxide and calcium-magnesium ions.



Fig. 3 Calcareous tufa white platform multi-coloured pool landscape – Zhongdian, Yunnan Province

When groundwater flows from the relatively enclosed environment, a large amount of carbon dioxide is released due to degassing, causing over-saturation of carbonate and resulting in sedimentation of calcareous tufa at a large scale. China's extensive sinter accumulation landforms are mainly located on the Qinghai-Tibet Plateau and on the Yunnan-Guizhou Plateau (Fig. 3).

Calcic Nodule This is a carbonate clump in loess. Carbonate ($CaCO_3$, $MgCO_3$) solution moves through the loess pores or along vertical joints and aggregates into nodules of irregular rods, spheres or clumps. A calcic nodule layer forms when these nodules accumulate in a layer. Calcic nodules are common in loess. Because the nodules are shaped like a piece of ginger, they are also called 'ginger stone'. Calcic nodules are important ornamental stones because of their unusual shapes. A piece of calcic nodule that resembles the shape of a lady was discovered in the Xiashu Loess in Nanjing. This nodule was later called 'Lady Mochou' and became well known when exhibited. It is considered a priceless treasure (Fig. 4).

Calcite The composition of calcite is $CaCO_3$, and it is a type of carbonate mineral. It often contains magnesium, iron, manganese and zinc. It belongs to the trigonal crystal system, and the crystals are rhombohedral or scalenohedral. The combinate form has spiked or tooth shapes. The aggregates can be in crystalline



Fig. 4 Calcic nodule in loess

clusters, granular, stalactitic, oolitic, dense lumps or travertine forms. It can be colourless or white but often is coloured due to impurities. Colourless calcite is called 'ice island stone' in Chinese. It has a vitreous to pearly lustre, a specific gravity of 2.71, a Mohs hardness of three and sub-conchoidal fractures. Calcite forms in many types of rocks but commonly in limestone and marble.

Caldera Landscape A caldera landscape is a type of volcanic landscape consisting of large circular or near-circular volcanic depressions. Calderas form due to the collapse or subsidence of volcano top. They are large circular or near-circular depressions with uneven bottoms surrounded by steep slopes. The general characteristics of a caldera are: (1) round or nearly round in map view but sometimes with an irregular triangular shape; (2) circular or radial cracks that look like grabens or terraced faults; (3) multiple regional faults or shear bands that cut through and intersect with circular faults, leading to fragmentation of the rock formations in the crater, and intense fractures that are obviously different from the structure on the caldera periphery; (4) various types of volcanic rocks with different facies, and ignimbrite and tuff are best developed; and (5) deposition of sediments inside the caldera upon the formation of a depression after the collapse and subsidence of the caldera and the accumulation of pyroclastic materials. Hence, caldera formation can generally be divided into two stages, namely, the eruption stage and the subsidence stage (Fig. 5).

Caledonian Movement The Caledonian movement was an orogeny that occurred in the early Palaeozoic in Europe. In China, the tectonic movement during this period is called the Caledonian cycle, and it is the main event occurred between the Silurian and Devonian Periods. It is represented by the Guangxi movement and the Qilian movement, which occurred 410 million years ago. The ages of the upper and lower layers are different, and they are separated by angular unconformities. However, they did not form in a single event. The orogenic belt of the Qilian Mountains in China formed during the Caledonian movement.

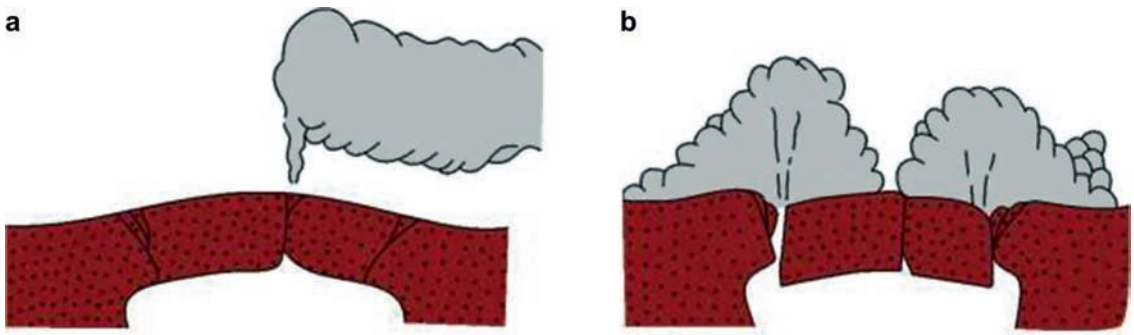


Fig. 5 (**a**) Upper part loses support, forming faults. (**b**) Massive explosion and collapse of the upper part

Cambrian Period The Cambrian Period is the first period of the Palaeozoic Era, and it lasted from 542 million to 488 million years ago. The Cambrian System includes the rocks that formed during the Cambrian Period. The term Cambrian System was first used by R.A. Sedgwick in 1838 and at that time generally represented the entire Lower Palaeozoic Erathem below the ancient red sandstone of the Devonian System. The Cambrian Period was characterised by the remarkable growth of living organisms and the preservation of abundant fossils. Starting in the Cambrian Period, the demarcation of series and stages could be established based on concrete biostratigraphic evidence and biological evolution, and this information had significance for global correlations. Trilobites are the most important fauna fossils of the Cambrian Period; and hence, the Cambrian is also known as the 'trilobite period'. Many phyla of organisms of the Chengjiang Biota from the Early Cambrian Period in Yunnan Province have been discovered; and this is representative of the so-called 'Cambrian biological explosion'. On the International Stratigraphic Chart, the Cambrian Epoch is subdivided into four series and 10 stages, and the Guzhangian Stage, Jiangshanian Stage, and Paibian Stage of the Furongian Series are all present in western Hunan Province. The Cambrian System is widely distributed throughout China.

Cambrian Stratotype Section (GSSP 'Golden Spike' in Paibi, Huayuan, Hunan This geological boundary is located in Paibi Village in Huayuan County, Hunan Province. In August 2003, the International Union of Geological Sciences approved the bottom boundary of the 'Paibian Stage' and the 'Furongian Series' bottom boundary as a global stratotype standard section and point (i.e., the 'Golden Spike', or GSSP). The 'Paibian Stage' became the first primary global standard unit of the Cambrian, and the 'Furongian Series' became the first standard system unit. In 2005, the Cambrian branch of the International Commission on Stratigraphy approved the global division of Cambrian System into four series and ten stages. The GSSP number four 'Furongian Series' and stage number eight 'Paibian Stage' are based on the Paibi geological section in Huayuan County, western Hunan Province. The rock layers of this section extend across the Middle and Upper Cambrian Huaqiao Formation and are composed of micrite and rudstone with a total thickness of 388.5 m (not measured to the top), and it can be divided into 39 beds. This section is rich in trilobites (including *Trilobite globosum* and *Trilobite multilocularis*). This section of the Huaqiao Formation is divided into eight fossil zones from the bottom to the top based on the fossil distribution and the first occurrence of important components. The first appearance of *Glyptagnostus reticulatus* 369.06 m from the bottom of the Huaqiao Formation has been defined as the bottom boundary of the 'Paibian Stage' and the 'Furongian Series'.

Canadian Rocky Mountain Parks, Canada This site, which contains the location of the

Burgess Shale fossils, is located in Yoho National Park in the Rocky Mountains. After two extensions in 1984 and 1990, the site was renamed 'Canadian Rocky Mountain Parks' and now covers the contiguous national parks of Banff and Jasper (Alberta Province), Kootenay and Yoho (British Columbia), Mount Robson, Mount Assiniboine and three provincial parks in Hamber (British Columbia). It has a core protection area of 23,069 km^2. It includes the watersheds of three oceans, namely, the Atlantic Ocean, the Pacific Ocean and the Arctic Ocean. It is studded with mountain peaks, glaciers, lakes, waterfalls, canyons and limestone caves, which form a striking mountain landscape.

Canaima National Park, Venezuela This park is located in the border area of Bolívar in southeastern Venezuela near Guyana and Brazil, and it has a core protection area of 30,000 km^2. Approximately 65% of the park is composed of tabular platform mountains. Therefore, it has become a unique bio-geophysical entity with important geological scientific value. Cliffs and waterfalls, including the world's highest waterfall, Angel Falls (1,000 m), constitute the park's natural beauty.

Canine Tooth-Shaped Ridge-Type Granite Landscape – Laoshan Type This granite landscape looks like rows of canine tooth-like peaks on the narrow and elongated ridges. They are characterised by small jagged peaks along the ridge, which are sharp-edged, rugged and exist in groups. They are a typical landscape that are formed by congelifraction with associated disintegration and erosion. Some researchers believe that during the Quaternary, glacial activity occurred in the mountains in Laoshan and formed this landscape, which includes aretes and horns. The issue of Quaternary glacial activity in eastern China is still controversial. However, Laoshan experienced extensive congelifraction processes. The climatic variation between northern and southern China as well as the elevation difference of granite outcrops are the determining factors for the formation of different granite landscapes. The Laoshan Scenic Area is a typical canine tooth-shaped ridge-type granite landscape (Fig. 6).

Canyon and River Tourism Landscape Canyon landscapes are impotant in tourism. They are characterised by narrow and deep valleys with steep slopes and greater depths. They generally form in areas of tectonic uplift with slopes composed of hard rocks. These features are the result of neotectonic movements of the Earth's crust and strong river



Fig. 6 Canine tooth-shaped granite ridge at Laoshan in Shandong Province

erosion. Based on their length, canyons can be classified into large canyons (longer than 100 km and 500–1,000 m deep), medium canyons (100–30 km long and 100–500 m deep), and small canyons (less than 30 km long and less than 100 m deep). Based on the type of rocks, canyons can be divided into soluble rock canyons, such as those found in the limestone regions; clastic rock canyons, such as canyons that are formed in sandstone and conglomerate; igneous rock canyons, including those that are formed in granite and basalt; and metamorphic rock canyons. Based on the width, canyons can be classified as broad valleys (thousands of kilometres wide with river floodplains and multiple terraces), cliff gorges (vertical valley slopes and widths of 5–10 m), narrow gorges (slope steeper than 45 degrees and valley bottoms more than 5 m wide that are accessible), and narrow valleys (also called a line of sky; with steep valley walls and valley width less than 5 m). Famous examples include the Three Gorges in Changjiang (Yangtze River), the Yarlungzangbo Grand Canyon, the Liujiaxia in Huanghe (Yellow River) and the Grand Canyon in Colorado, U.S.A.

Canyon Landscape *Synonym:* ► *Gorge landscape;* ► *Valley landscape*

A canyon landscape is a type of river valley landscape. It differs from the narrow gorge and cliffy gorge landscapes in that the valley slopes always have erosional terraces and valley shoulders. Stable gravel shores or rock shores are always present on the valley floor, and traces of the wide valley can be found at the top of the valley. Canyons often develop in regions of substantial neotectonic movement, such as the Three Gorges (Fig. 7).

Cape Floral Region Protected Areas, South Africa This site is located along the border between South Africa's Southern Cape Province and Eastern Cape Province. The total protected area covers 5,530 km^2. The region includes a series of heritage sites consisting of eight protected areas and has some of the most abundant plant species in the world. Although it covers less than 0.5% of the total area of Africa, it is home to 20% of the continent's species. The heritage site also exhibits the most outstanding examples of the ecological and biological processes associated with the fine vegetation of the Fynbos shrubland, which is a major feature of the local plant world. The site's plant species diversity, population density, and native biological characteristics are among the best in the world. The reproduction strategies of the local plant community, the unique adaptation to fire, the insect-mediated seed transmission route, the local species types, and the adaptive radiation expansion model all have high scientific research value.

Carboniferous Period The Carboniferous Period is the fifth period of the Palaeozoic Era. It lasted for 60 million years, from 359 to 299 million years ago. Because the strata are rich in coal (anthracite), the geologists William Conybeare and William Phillips coined this term for the coal-bearing rocks in northern England in 1822. During the Carboniferous Period, the land area started to increase continuously, and extensive forests first occurred on Earth. This period was the first of the three major coal-forming periods. The coal reserves of this period account for more than 50% of the world's reserves. The Carboniferous System includes the rocks that formed during the Carboniferous Period. In Western Europe and North America, the lower part of the Carboniferous System is composed of marine limestone, whereas the upper portion contains coal-bearing strata that are composed of alternating marine and terrestrial facies. These dual characteristics are very clear, but in Russia, Carboniferous marine facies strata are well developed, and so a tripartite division is generally adopted. The Carboniferous System is widely distributed in China, and the sedimentary types are complete; this is particularly true in South China and northwest China, where the Carboniferous System is well developed, and fossils are abundant. These areas have long been key areas of study. The GSSP for the Visean Stage's bottom boundary is located in Pengchong in Liuzhou, Guangxi Province.

Carboniferous-Permian Type Section in Guizhou This section is one of the most important stratigraphic sections in southern China and

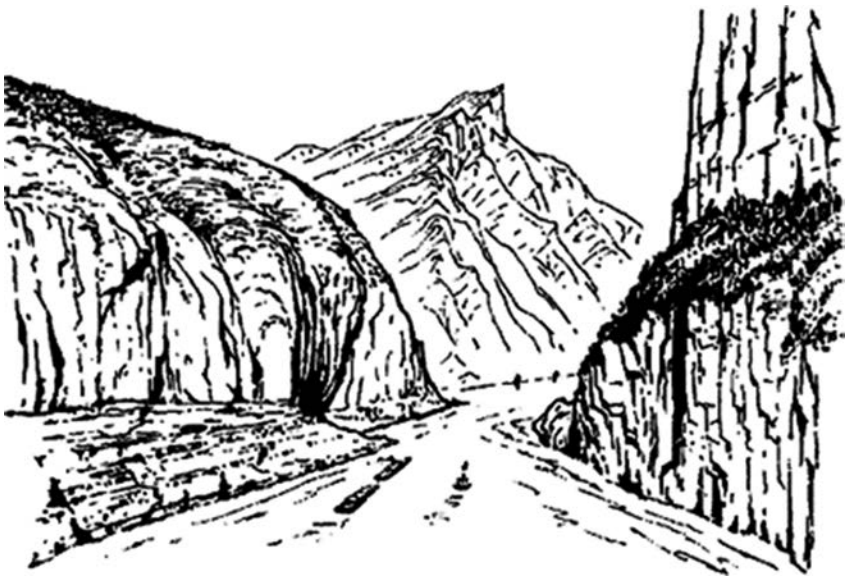


Fig. 7 Sketch of Qutang Gorge

contains intact Carboniferous and Permian outcrops with abundant corals, brachiopods and dragonfly fossils. It is located in the Guiyang, Dushan, Huishui, Panxian and Ziyun areas and includes all seven stages of the Carboniferous and five stages of the Middle and Lower Permian. From the bottom to the top, the sequence includes the Yanguan Stage, Datang Stage and Dewu Stage of the Lower Carboniferous Series, the Luosu Stage, Huashiban Stage, Dala Stage and Xiaoyao Stage of the Upper Carboniferous Series, the Zisong Stage and Longlin Stage of the Lower Permian Series, and the Qixia, Xiangbo and Maokou Stages of the Middle Permian Series (Fig. 8).

Carl Ritter Carl Ritter (1779–1859) was a German geographer. He graduated from the University of Halley. He and Humboldt are considered the founders of modern geography. He introduced the term geography, emphasising the comprehensiveness and unity of man and earth. His masterpiece was 'Earth Science in Relation to Nature and the History of Man (19 volumes)'. His other works included 'European Geography', 'General Theory of Geology', and 'Comparative Geography'.

Carlsbad Caverns National Park, U.S.A. This park is located in southern New Mexico near Texas, and it has a core protection area of 189 km^2. The karst scenic area contains more than 80 identified caves. The karst caves, which are known for their scale, have diverse structures, different types and a high level of beauty. The 'Tequila Cave' stands out among all caves.

Carrying Capacity of Tourist Spots This is also known as scenic tourism capacity. It is the capacity of tourism activities within a certain range of tourism resources over a certain period of time. The carrying capacity must meet the minimum tourist requirements for physical space and their psychological needs and provide protection for tourism resources. The carrying capacity of a scenic location reflects the land use intensity, economic benefits and tourist density at a tourism destination. It includes the spatial carrying capacities of resources, environmental ecology, the Earth, economic development and society. The regional and tourism carrying capacities of a tourist destination are the comprehensive capabilities of these different capacities.

Cartography Cartography is the study of maps, mapping techniques, methods and their applications. It involves studies of the spatial distributions of natural and social phenomena to identify their relationships, connections and changes. Maps are products of the combination of technology and art. With the aid of

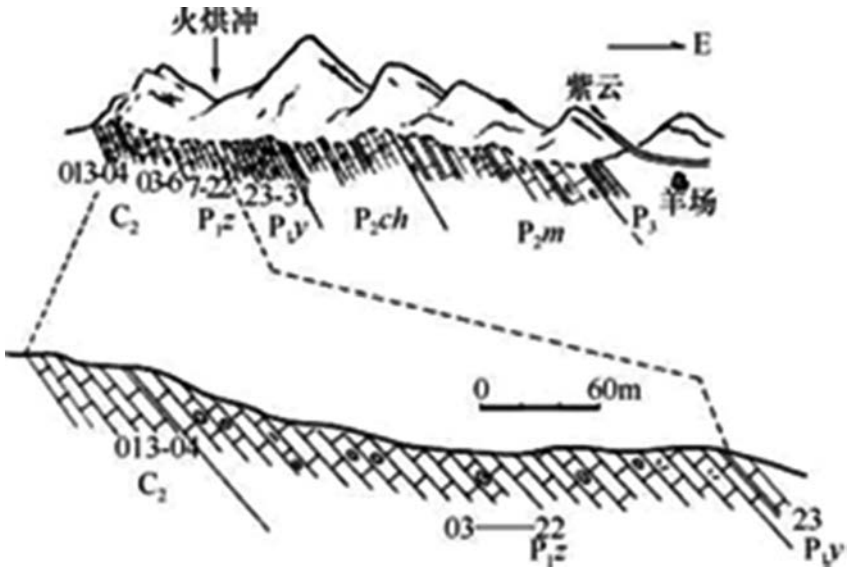


Fig. 8 Section of Carboniferous-Permian section at Ziyunyangchang, Guizhou

cartographic knowledge, maps of various tourism-related elements can be produced to help tourists understand information about tourism destinations.

Cassiterite Cassiterite has the composition SnO_2, and it contains 78.8% tin. It often contains niobium and tantalum. It belongs to the tetragonal crystal system, and the crystals are equant, prismatic, double cone-shaped, blocky, granular, botryoidal or reniform aggregates. It is waxy yellow, light brown or deep black and has translucent to opaque diaphaneity, an adamantine lustre, greasy fracture surfaces, a specific gravity of 7.0, a Mohs hardness of 6–7 and sub-conchoidal to uneven fractures. It usually coexists with quartz, chalcopyrite and tourmaline in high-temperature hydrothermal veins. The original cassiterite can be transported to placer deposits upon weathering. Cassiterite is the main raw material for smelting tin. Cassiterite crystals can be used as ornamental stones.

Castle-Like Granite Peak, Fort-Like Granite Peak This type of granite peak is large, is surrounded by steep terrain and looks majestic. It is nearly circular in cross-section, like a castle or fortress-shaped hill. Vertical joints are not well developed in granite castle-like peaks; and the joints are mostly widely spaced oblique joints or conjugate joints. In general, the rocks do not easily collapse or fall. The peak's summit is comparatively flat with remnants resulting from earlier erosion (Fig. 9).



Fig. 9 Pagoda Peak in Beihai, Huangshan

Catagraph Landscape, Deformed Pebble Landscape This is a landscape composed of deformed pebbles formed by compression due to the heavy load of a glacier. Li Siguang labelled these deformed pebbles with different names symbolising their forms, such as oil lamp stone, saddle stone, iron stone, and sling chair stone. Later, additional varieties were



Fig. 10 Glacier iron rock

proposed, such as pit stone, fractured stone, slipper stone and monkey face stone (Fig. 10).

Catastrophism This school of geology is related to the catastrophe theory, which was founded by the French biologist and palaeontologist Georges Curier (1769–1832). Based on his palaeontological studies, he determined that some biological species had experienced periods of sudden extinction over geologic history. This finding indicated the occurrence of multiple sudden catastrophes, each of which destroyed numerous biomes and caused the complete transformation of surface terrains. After the devastating changes, new and completely different biomes developed, and a new world formed. The theory of catastrophism prevailed for a short period of time before it was challenged by the theory of phyletic evolution. In the 1970s, several geologists made new discoveries based on satellite photographs, astronomical observations, geological surveys and palaeontological research that proved that catastrophic events caused by meteorite impacts had occurred over geological time. This renewed the interest of geologists in catastrophism.

Cathaysian Block This block is located on the southeast coast of China from East Zhejiang to Fujian. Sporadic dark metamorphic rocks are present below the widely distributed volcanic rocks. The block was named the 'Cathysian Block' in 1924 by A.W. Grabau. An isotope age of 1.4–1.8 billion years was obtained from these metamorphic rocks, and other studies have revealed that the Lower Palaeozoic clastic rocks in southwestern Fujian came from the eastern side of this block. Based on this fact, it was postulated that another Precambrian continental block in addition to the Yangtze Block might have extended from Zhejiang and Fujian Provinces to the Yunkai area. To its east, the area might have been submerged under the ocean. There are still many interpretations on the boundaries, nature, and evolution of the Cathysian Block and its relationship with the surrounding continental blocks.

Cave Animal Cave animals are animals that inhabit caves. They mainly include invertebrates, such as turbellaria, gastropods, diplopods, arachnids, pseudoscorpionida, opiliones and crustaceans; insects, such as collembola, coleoptera and orthoptera; and vertebrates, such as bats, fish, salamanders and frogs. In the unique cave environment, cave animals are characterised by a lack of pigmentation, eye degeneration, lengthened tentacles and slow metabolism. According to the life-history characteristics of cave animals, most scientists categorise them into three types: (1) Trogloxenes, which are cave animals that do not complete their life cycle in caves but use them for shelter in winters for refuge. Examples are moths, mosquitoes and raccoons, which live in cave areas with less light. (2) Troglophiles, which are cave-dwelling animals that may complete their life cycle in a cave but can also survive in above-ground habitats. Examples are earthworms and certain crustaceans that maintain a constant body colour. (3) Troglobites, which are cave-dwelling animals that live and have adapted to their dark surroundings in dark caves and complete their life cycle within the cave. Their bodies are transparent, and their eyes are degraded. Typical cave animals have unique morphologies, physiological behaviours and life histories to adapt to the cave environment (Fig. 11).

Cave Cake Landscape, Lampstand Stone Landscape This is a landscape of cave sediments that looks like an old-fashioned candlestick. After the formation of a stalactite, stalagmite or stone column, water fills the



Fig. 11 Sinocyclocheilus grahami – a blind fish in a subterranean river, Dashiwei sinkhole, Guangxi Province

cave bottom again, and the rising water eventually submerges these features. Deposits start to extend around them on the water surface, forming candlestick-like or lotus leaf-like depositional features, which are also called 'High Hopes' abroad (Fig. 12).

Cave Coral Landscape This is a landscape of calcium carbonate or gypsum deposits that form on the surfaces of stalactites or stalagmites. Coral-like features are common in caves, and they are a type of isohomogeneous sediment. They have several causes of formation. They can form in the splashing or capillary water or underwater, but it is difficult to make a strict distinction based on their morphology (Fig. 13).

Cave Deposits Of The Zhoukoudian Formation in Beijing Palaeo-anthropological fossil relics have been found at Beijing Zhoukoudian Site 1. The layer is more than 40 m thick and contains fossils of *Homo erectus*, stone artefacts and fossils of fauna and flora as well as information about long-term continuous climate fluctuations that can be used for comparisons with past global climate changes. From top to bottom, this section can be divided into thirteen basic beds and a basal gravel bed, which can be further sub-divided into beds 14 (the bottom gravel bed), 15, 16 and 17. The upper beds (1–3) are 230,000 years old. The lithology and the fossils reflect the climate conditions and provide dating information. This section can be divided into seven sedimentary cycles that reflect the influence of climate fluctuations.



Fig. 12 Lampstand stone landscape – Meishan Mountain in Xinhua, Hunan Province



Fig. 13 Cave coral landscape – Wannian Shennong, Jiangxi Province

An important characteristic of the Peking Man Cave deposits is the alternating beds of breccias and non-breccias. The former reflect cold weather and severe physical weathering, and the latter reflect warmer climatic conditions.

Cave Flag Landscape Cave flags get their name because they are shaped like a flag composed of sediments in a karst cave. When a rock protrudes from the top or wall of a cave, water



Fig. 14 Cave flag landscape – Shihua Cave, Beijing



Fig. 15 Gypsum flower landscape, Wulong, Chongqing



Fig. 16 Calcite flower landscape

flows along the sloping rock surface and releases calcium carbonate. If this deposit is wide enough, it will form a cave flag. A cave flag's width may reach 1 m, and the thickness is between 2.5 mm and 10 mm. Cave flags can be transparent or translucent and generate excellent percussion sounds. Stripes of different colours can form when the seeping water contains various impurities (Fig. 14).

Cave Flower Landscape *Synonym:* ► *Popcorn landscape*
A cave flower is a karst cave depositional feature resembling a flower. Cave flowers are a type of non-gravitational water deposit. They form in dry caves with low humidity, and they generally have needle-like or dendritic crystals of calcite, aragonite or gypsum. They are generally white and appear like a flower cluster scattered on the cave walls or surfaces of other deposits. They have many forms and causes of formation. Cave flowers are common in China. The Xuehua (Snowflake) Cave in Gong County, Henan Province, and the Shihua (Stone Flower) Cave in Beijing are typical examples (Figs. 15, 16).

Cave Landscape Protection With the development of cave tourism, the main problems facing cave landscapes are a series of complicated and interrelated elements affecting the life span of the cave. These elements include the cave's hydrology, temperature, humidity, air quality, chemical weathering, discolouration and physical damage. Cave landscapes are closed systems and are extremely delicate and fragile. Thorough scientific studies and planning are necessary before opening a cave for tourists. Effective measures must be taken to prevent over-development and unnecessary construction of entrances and exits. Strict controls on the number of tourists, preservation of the geological and hydrological environments, protection of surface vegetation, and prevention of soil erosion, excessive runoff and loss of water are also required. Regular and detailed monitoring of the cave hydrology, micro-climate, air quality, fauna and flora and sedimentation is essential.

Cave Medicine The unique conditions of caves can be used for medical purposes. Several studies have shown that caves are ideal for use as 'natural rehabilitation infirmaries'. Cave therapy is most suitable for and has



Fig. 17 Cave therapy station in Sezana, the Republic of Slovenia

significant effects on many kinds of geriatric and chronic illness, especially chronic respiratory diseases such as bronchial asthma, chronic bronchitis and emphysema. Such treatment is also effective on child's asthma. Cave therapy has been practised in many European countries, which have so far established more than 30 cave medical treatment sites (Fig. 17).

Cave Organisms Cave organisms are organisms that grow and thrive in a cave environment without light or in weak light, accompanied by constant temperature and dampness. According to the four-level classification of organisms, cave organisms can be classified into prokaryotic organisms, fungi, low plants and animals. Prokaryotic organisms include cyanobacteria and bacteria. Cyanobacteria are mostly located at the cave mouth or areas with weak light. Bacteria can be divided into autotrophic and heterotrophic types. In the deeper parts of the cave, the organisms are mainly chemoautotrophic bacteria and heterotrophic bacteria, whereas the organisms in the areas where light can reach are mainly photoautotrophic bacteria. Fungi and heterotrophic bacteria mainly feed on decomposed animal remains and waste. Lower plants in caves, such as ferns, mosses, lichens and algae, are mainly located at the cave mouth and areas of weak light. In caves open to tourists, some plants grow in the deep areas and grow in response to artificial light. In the mid-twentieth century, a relatively independent branch of science, speleolobiology, was established on the basis of geology, speleology and biology.

Cave Pearl Landscape Cave pearls are also known as cave bombs, cave balls and cave pisolites. This landform feature is composed of cave deposits with a bead-shaped appearance. Their shapes can be spherical, egg-shaped, oval, subrounded, club-shaped or other irregular shapes, and the colour can be white, greyish white, grey, earthy yellow, meaty red and brown. They can vary significantly in size; the smallest can be 1 mm in diameter, most are 1–3 mm in diameter, and the largest can be dozens of centimetres in diameter (a cave ball). A cave pearl is generally composed of a core and a shell. The core mainly consists of muddy materials, calcite microcrystals and sometimes clastic quartz, limestone or travertine fragments, or even animal skeletons or wood fragments. The shell is composed of fine granular or short columnar calcite with a concentric layered structure. They usually form in water bodies subjected to constant disturbance; under these conditions, not all calcium carbonate balls are deposited and connected to the pool bottom. The chamber of the Pearl Cave in Yizhou, Guangxi Province, is completely covered with tens of millions of cave pearls. A type of cookie-like cave pearl called the cave cake is located in the Egu Cave in Xingping, Yangshuo County. Tens of thousands of these cave cakes tile the cave floor (Fig. 18).

Cave Raft Landscape A travertine film or membrane on the water surface inside a karst cave is called a cave raft or a calcium film, and the scenery composed of these films is called a cave raft landscape. These calcium films are composed of micro-calcite grains released from the over-saturated cave bottom solution. They look like a thin membrane, are less than



Fig. 18 Cave pearl

1 mm thick and float on the pool water like thin floating ice. When their thickness increases to the point exceeding the buoyancy, they sink to the bottom in flakes.

Cave Shield Landscape This is a shield-like depositional feature in a karst cave, and it gets its name from its appearance. It usually has a hollow circular shape and attaches to the cave roof or wall with a diameter between 10 cm and 4–5 m and a thickness of 2 to 10 cm. When water from cracks under hydrostatic pressure flows along the rock layers of the cave shield, the shield grows outwards continuously, forming an incremental circular pattern. When the water supply is adequate, a shield weight can form along the edge of the shield. A large shield weight is called a cave tent, and it may look like a round mosquito net. Cave shields can form individually or be connected in an array. There are four connected cave shields in the Chuanshan Cave, Guilin (Fig. 19).

Cave Tourism This book was written by Chen Shicai and was published by Fujian People's Publishing House in 2003. The book covers both theories and practicalities of cave tourism and caters to both academics and the general public. It is a useful cave tourism reference book.

Cave Tourism Landscapes These are caves other than the soluble cave types. Examples include underground caves formed by erosion of sandstone and fragmented rocks by water. Caves can also form by differential weathering

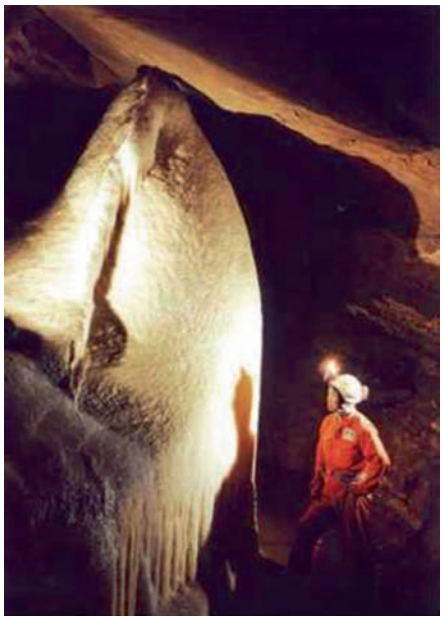


Fig. 19 Landscape of a 4 m-high white cave shield in Xueyu Cave, Chongqing

in various rock types, and stacked caves can form by rock collapses. Old mines and tunnels constructed by humans are other types of caves. For example, the underground war passage from the Song and Liao Dynasties at the border between Xiong County and Yongqing, Heibei Province, and the underground passages used during the anti-Japanese war at Ranzhang, Qingyuan, Heibei Province, are man-made caves and tunnels with high tourism value.

Cave Tourism Resource System Certain geological processes in some rock layers can form complex, spectacular cave tourism resource systems. Examples are karst caves formed by the dissolution of rocks composed of calcium carbonate as well as lava tunnels formed in lava flows, caves formed by the stacking of fallen rocks, sea caves formed by wave erosion, and caves formed by groundwater erosion. These features constitute a cave tourism resource system below the ground, inside mountains and deep in the Earth's crust.

Caves of Aggtelek Karst and Slovak Karst, Hungary and Slovakia This site is located along the border between northeastern

Hungary and southeastern Slovakia. After two extensions in 2000 and 2008, its core protection area has reached 565 km^2. It is a typical temperate karst natural system with diverse landforms, and it contains 712 confirmed and unusually concentrated cave systems.

Ceiling Pot Landscape This is a kind of pot-like landscape composed of circular and hemispherical concave depressions and pits of various sizes on the cave wall and cave roof. The ceiling pot diameters range from less than 2 cm to several tens of metres. These pots often appear in dense groups, and the pot depth and width are usually approximately equal, but the width is sometimes greater. The cross-section is generally symmetrical. The cause of ceiling pot formation is complex. They can form due to corrosion and the combination of corrosion, water erosion, water abrasion, drip erosion, and even the biokarst action (Fig. 20).

Celestial Landscape Tourism Resource System This is a tourism resource that focuses on appreciating and understanding astronomical phenomena. It deals with astronomical records, myths and legends as well as meteorites, meteorite showers, cosmic rays, high-energy particles and aliens.

Celestite Celestite is a gem-quality lapis lazuli mineral. It is composed of (Sr, Ba)SO_4 and often contains Pb, Ca, and Fe. Gem-grade lapis lazuli is seldom mono-crystalline but is often in the form of stalactites or nodular aggregates. Celestite can be blue, blue-green, green, yellowish green or orange, and the blue stones are most valuable. The main mining areas include the United States, Canada, Namibia, Mexico, Britain, France and Italy (Fig. 21).

Cement Cement is the material that bonds rock grains, soil particles and structural surfaces. In general, the cement content of clastic rocks does not exceed 50%. Cement has two general definitions: (1) the chemical sediment in clastic rock, excluding the clastic grains and the matrix; and (2) chemically precipitated sediment that fills the pores between the clastic grains, excluding clay and other fine materials. The latter interpretation is more common. Typical cements include siliceous, calcareous, ferrous, phosphorous, pelitic and soluble salts.

Cenozoic Era The Cenozoic Era is the geologic period from 65.5 million years ago until the present. It includes the Palaeogene, Neogene and Quaternary Periods. The Cenozoic biological features were akin to those of the present day; hence, they were called Cenozoic. The Cenozoic Erathem includes the rocks formed during the Cenozoic Era.

Central Amazon Conservation Complex, Brazil The Amazon Conservation Centre in the Amazon region of northern Brazil was formed by expanding the Crows National

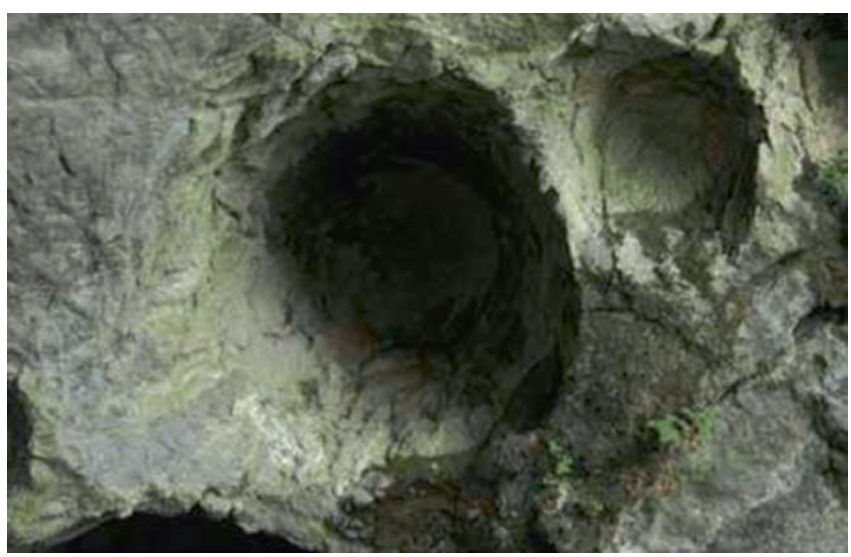


Fig. 20 Ceiling pot landscape – Hubei

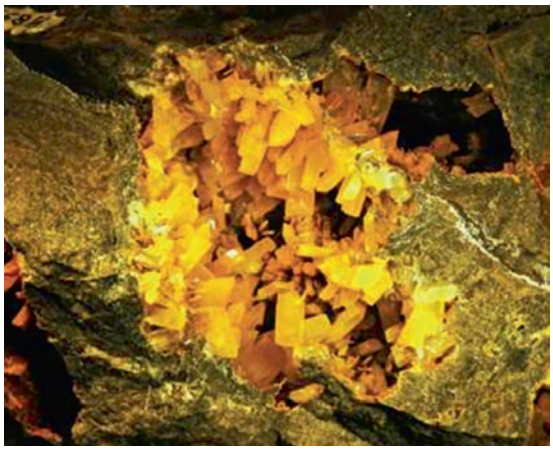


Fig. 21 Celestite

Park. Its core protection area is 53,230 km^2, and it is the largest protected area in the Amazon. The community is also the most biodiverse region in the world. It includes outstanding examples of floodplain ecosystems, Igapo forests, lakes and natural riverbeds, and its constantly evolving aquatic environment provides a paradise for the world's largest population of electric fish. The heritage site also protects important endangered species such as bigeye fish, Amazonian manatees, black skinned caimans, and pufferfish.

Central Catalonia Global Geopark, Spain This geopark was established based on the Geological and Mineral Park in Central Catalonia. It became a global geopark in 2012. Its main attractions include stratigraphy, sedimentology, tectonics, karst systems, palaeontology and palaeoanthropology. The biota in the sedimentary rocks illustrate the rich and varied life throughout geological history. The most famous and abundant fossils are the marine organic organisms that lived in a warm shallow sea 55 million years ago. The Catalonian Potash Basin, Europe's largest potash mineralisation region, is also the world's best example of evaporate deposits, which are derived from seawater evaporation. Important heritage from the mining activities in the area remains. The exploitation of rock salt first occurred here during the Neolithic period and continued until the Roman Empire. Workshops using traditional techniques such as kilns and porcelain firing are also important tourist attractions.

Central Eruption A central eruption occurs when magma flows along vertical or steep conduits to the surface to form lava or volcanic domes. Clastic cones can also form due to volcanic explosions. Most volcanoes are associated with this type of eruption.

Central Highlands, Sri Lanka This heritage site is located in south-central Sri Lanka. It comprises the Peak Wilderness Reserve, Holton Plains National Park and the Nakola Conservation Forest. The area of these mountain forests reaches an elevation of 2,500 m. It has extremely high biodiversity, including several endangered species, such as western purple-faced langurs, grey lazy monkeys, and Sri Lankan leopards. It is considered an important protection zone for biodiversity.

Central Mountain Songshan Songshan is one of China's Wuyue (Five Peaks) and is also known as Zhongyue (Middle Peak). It is located north of Dengfeng City in Henan Province and is part of the northern Qinling Mountains. Songshan mainly consists of Taishi Hill and Shaoshi Hill. It is a fault-block mountain composed of Archaean, Proterozoic, Palaeozoic, Mesozoic and Cenozoic rocks, and the five geological periods are the origin of its name 'Five Generations Inside One Hall'. There are 72 peaks; the main peak, Junji Peak (Song Peak), has an elevation of 1,491 m and towers over the Yuzhong (Central Henan) Plain with a relative height difference of more than 1,000 m. It looks extremely spectacular. Songshan has a long cultural history. It was called Songgao Mountain and Chong Mountain during the Xia and Shang Dynasties, respectively. During the Western Zhou Dynasty, it was called Yue Mountain, and during the Eastern Zhou Dynasty, it was called Zhongyue (Central Peak). During the Tang Dynasty, it was named Shenyue (Holy Peak), and it obtained the name Songshan Mountain in the Five Dynasties. It was used as a land for worship by many monarchs. Therefore, there are many cultural relics, such as the Zhongyue Temple,

which was built in the Qin Dynasty and is one of the earliest Taoist architectural features in China; and Shaolin Temple, which is a holy Buddhism site that was built in the Northern Wei Dynasty (495 A.D.) and was where the Indian monk Dharma began his practice and first established Chan (Zen) Buddhism in 527 A.D. Other relics include the Pagoda Forest, Songyang Academy, Northern Wei Songyue Pagoda, Huishan Temple, Chuzu (First Master) Covent, Hansan Tower, Guanxing (Star Watching) Tower and the Yangchen ruins. In recent years, many Shaolin martial art studios have been established for teaching Kungfu. These studios have become very famous abroad.

Central Orogenic Belt in China This belt is an extensive east-west-trending tectonic zone in central China. Its name was first proposed by Jiang Chunfa in 1993. The belt includes five orogenic belts: West Kunlun, East Kunlun, West Qinling Mountain, East Qinling Mountain and Dabie Mountain. Jiang Chunfa et al. (2000) suggested that the Central Orogenic Belt can be divided into northern, central and southern subduction belts, which belong to the Palaeo-Asian tectonic domain and the Tethyan tectonic domain, respectively.

Central Sikhote-Alin, Russia This site is located in the Primorsky region on the Pacific coast of Russia's Far Eastern Federal District. The core protection area covers 15,539 km^2. The heritage site contains some of the richest and most unusual temperate forests in the world. In this confluence of northern and southern subtropical forests, southern species, such as Asian tigers and Himalayan wild bears, coexist in harmony with northern species, such as brown bears and clams. The vast area of the heritage site extends from the peaks of the Seahort-Alin Mountains at approximately 2,000 m above sea level to the Sea of Japan, providing an important habitat for the survival of many endangered animals, such as the Siberian tiger.

Central Suriname Nature Reserve, Suriname This reserve is a virgin tropical forest located in the centre of the southern part of the state of Suriname, and it has a core protected area of 16,000 km^2. The heritage area is along the upper reaches of the Corpaneur River and is the source of many other rivers, such as Lucie, Oost, Zuid, Saramaccz and Gran Rio. It includes a wide range of landform types and ecosystems that are valuable for nature conservation. The mountain forests and lowland forests have a unique diversity of plant life. To date, only 5,000 species of vascular plants have been identified. The animals include jaguars, giant buzzards, giant river otters, dragonflies, eight species of primates, and 400 species of birds, including American short-winged eagles, flying crown birds and macaws.

Cephalopod Fossil Cephalopods are a higher class of the fossils of the phylum Mollusca. Modern squids, octopuses and nautilus fall within this class. Cephalopoda get their name because they have circular tentacles in their head used for hunting, crawling and swimming. All Cephalopoda lived in marine environments. They began to emerge in the Late Cambrian and have lived until the present day, and they are widely distributed. These fossils are important index fossils. Nautiloids and ammonites are cephalopod fossils of high ornamental value. China is rich in Cephalopoda - Armenoceras fossils. Typical examples are the Ordosoceras, Armenoceras, and grey Armenoceras in the Ordovician strata in the north and the Sinoceras, Discoceras and Michelinoceras in the Ordovician strata in the south.

Cerrado Protected Areas, Brazil Chapada dos Veadeiros and Emas National Parks are located in the centre of Brazil's Ebara, 300 km north of Brasilia, Brazil. They are administratively affiliated with Goias and have a core protected area of 655 km^2. The two heritage sites in the Cerrado region are characteristic animal and plant habitats and one of the world's longest-growing and richest tropical ecosystems. The Cerrado Conservation Area has been regarded as a refuge for numerous species.

Chablais Global Geopark, France This geopark is located in Haute-Savoie in eastern France, bordering Italy and the Swiss Sleeping Region. It became a global geopark in 2012. It contains diverse terrain types, from alpine peaks to glaciers to Baililong Lake, which is the largest freshwater lake in western Europe. The unique geological heritage of the Alps has assisted in the economic and cultural development of the area through tourism. Thanks to its beautiful and diverse environment, Chablis has become a habitat for many fauna and flora.

Chalcedony The main composition of chalcedony is SiO_2, and it is a cryptocrystalline variety of quartz. It often appears as stalactitic or botryoidal blocks with varied colours, such as white, blue, red, green, brown or black. Its varieties include opaque jasper, agate with a concentric pattern, banded agate and dendritic green chalcedony, onyx with parallel stripes and red or brown carnelian. Chalcedony has a Mohs hardness of 6.5–7, a specific gravity of 2.58–2.64, a refractive index of 1.53–1.54, a glassy or waxy lustre and conchoidal fracture. It forms under low-temperature hydrothermal conditions or at the surface. It can be found in hydro-thermal veins in extrusive rocks, in hot spring deposits or in weathered crusts and oxidation zones. Chalcedony is a common material for arts and crafts (Fig. 22).

Changchengian Period The Changchengian Period is the first geologic period of the Mesoproterozoic Era in China. This geologic period extended from 1.8 billion to 1.4 billion years ago, a duration of 400 million years. However, recent dating data indicate that the lower limit of the Changchengian Period was not older than 1.65 billion years. The Changchengian System includes the rocks that formed during the Chengchengian Period. The standard section of the system is located in Jixian County, Tianjin. The Changchengian System quartz sandstone is the material basis of the Zhangshiyan landform.

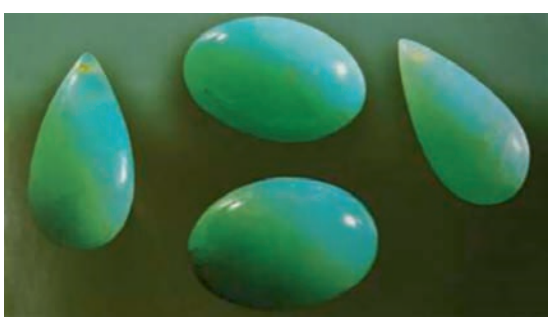


Fig. 22 Chalcedony stones

Changjiang (Yangtze River) Stone Changjiang (Yangtze River) stones mainly refer to the pebbles found along the main course and tributaries of the Changjiang. These pebbles are widely distributed over thousands of kilometres. Pebbles of igneous, sedimentary and metamorphic rocks can be found on the river banks, and the high-quality stones with striking colours, fine textures and unique shapes are mostly siliceous and volcanic rocks. The Three Gorges stone is typical and is mainly found in the section of Changjiang from Yichang to Zhijiang, where there are gravel layers on the primary and secondary terraces on the Holocene to Pleistocene floodplains. The original rocks are in the gravel layer of the early Mesozoic Cretaceous deposits, which contain large amounts of opal, agate and chalcedony gravel that have become marvellous Three Gorges stones due to internal and external geological forces. The Three Gorges stones have unique patterns, colours and cracks. There are numerous varieties, and the valuable types include grape stones, plum flower stones, Changjiang red stones, green mud stones, Yuhua (rain flower) stones, coral fossils, pattern stones and the Changjiang colourful egg stones (Fig. 23).

Changshan National Geopark, Zhejiang This geopark is located in Changshan County, Zhejiang Province. The main geologic features are the global boundaries of the Middle Ordovician Darrellian stage (approximately 460 million to 455 million years ago) and the combination of biofossils. In February 2002, the Ministry of Land and Resources approved it as one of the second group of national geoparks. The section of the Huangnitang Formation in the park is the global boundary



Fig. 23 Changjiang (Yangtze River) stone with fold structures

stratotype section and point (GSSP) of the Middle Ordovician Darrellian terrace, and a permanent mark was established on this section (namely, the 'golden spike' that is commonly known by the geoscience community). Fossils such as graptolites and conodonts are abundant in the section.

Changyang Man Site The Changyang Man site is a site of ancient human fossils that is located in a deposit in the Long Cave (Dragon Cave) in the lower Zhongjiawan, Changyang County, Hubei Province. It was discovered in 1956 by the Chanyang County Cultural Team, who found a piece of an ancient human jaw bone and one upper molar. The upper jaw fragment is from the left jaw, and the gullet is attached with a first premolar and a second premolar. These human fossils have many characteristics of modern man, and they should belong to an early Homo sapiens. Uranium dating provided an age of 195,000 years. The mammal species include common species in southern China, including the Chinese Physignathus, tiger, panda, badger and Ursus thibetanus kokeni, which date from the late stage of the Middle Pleistocene to the Late Pleistocene.

Chaohu Lake Landscape Chaohu Lake is the fifth largest freshwater lake in China. It is located in central Anhui Province and has an area of 769.5 km^2. The Hangbu River, Fengle River, Shangpai River, Nanfei River and Zhegao River flow into the lake, and the lake pours into the Changjiang (Yangtze River) via the Yuxi River. Chaohu Lake is used for water storage and irrigation supply. It is also famous for producing the Silver Fish. It is vast and wavy and looks like a mirror. Laoshan Island and Tianmen Mountain are inside the lake, and the lake is surrounded by several hot springs and four national forest parks, such as the Taihu Hill, Jilong Hill, Yefu Hill and Tianjing Hill National Forest Parks. These parks are known as the 'Four Jades' in the northern Changjiang (Yangtze River). There are also scenic locations, such as the 'underground long river' Shuangjing (Double Wells) Hole, the 'cliff grotto' Wangqiao Cave, 'dragon-like strange rock' Xianren (Fairy) Cave, the world-famous Huayang Cave and the 'Jianghuai wonders' Poshan Cave. These five caves have been called the 'Five Underground Art Chambers' (Fig. 24).

Chaoyang Fossil National Geopark, Liaoning This geopark is located in Chaoyang City, Liaoning Province. It became a national geopark in 2004. The main geological attractions are fossils, fossil-bearing strata, and geologic structures. It has five main scenic areas: Heshou, Sihetun, Lingyuan and Dazhangzi (both of which are major production areas of the famous 'Rehe River Biota' fossils), Fenghuangshan Park, and Zhangshudong. Numerous Mesozoic and Palaeozoic fossils have been found in Chaoyang City, including the discoveries of the earliest birds and flowering plants. These fossils are unique and rare, and so they are world-class fossil treasures.

Chatoyancy Chatoyancy is an optical reflectance effect on a curved gemstone surface that can be likened to the sheen of a spool of silk, and it looks like a cat's eye. Chatoyancy arises from the fibrous structure or fibrous inclusions within a stone that are in parallel alignment. When the incoming light is reflected or scattered, a luminous streak of reflected light perpendicular to the direction of the fibres can be seen, like a cat's eye. The band of light is sharp and moves across the stone in correspondence to the light intensity. This effect is called chatoyancy or the 'cat's eye effect'. Many



Fig. 24 Chaohu Lake landscape

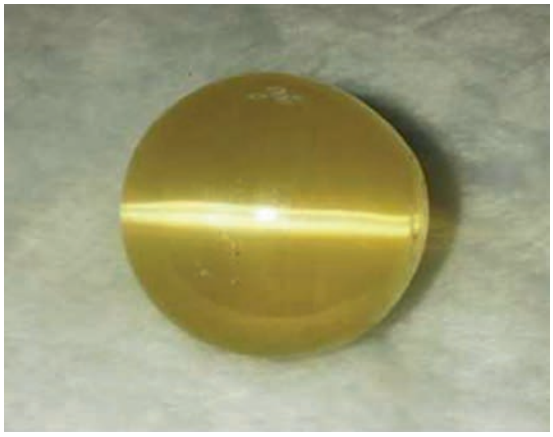


Fig. 25 Cat's eye effect

gems, such as cat's eye aquamarine, cat's eye tourmaline and cat's eye apatite, have this effect, and chrysoberyl has the most remarkable cat's eye effect (Fig. 25).

Chelmos-Vouraikos Geopark, Greece This geopark is located on the Peloponnese Peninsula in northern Greece and has an area of 0.99 km^2. It became a member of the Global Geopark Network in 2009. The area is in the Shermer Mountains, which is the source of four rivers. The Hermes Mountains have experienced millions of years of flowing water, and the geology has taken on various forms, including the magnificent Vura Icos Gorge, the beautiful caves in the Lake District, the cool springs of the Aroanios River and the Styx. There are many geological structures (e.g., conglomerates and limestones), rare plants and butterflies in the Kuraei Canyon in Voraei. Visitors can also visit the village of Zachlorou to taste the local food and visit the museum of the Mega Spilaio monastery.

Chelonians, Turtles and Tortoises Chelonians have round and flat bodies, where the soft muscles and organs are enclosed between the carapace and plastron. The head, neck, tail and four legs can be pulled into the shell. Their carapace and plastron are commonly preserved as fossils. Chelonian fossils such as the snake-necked turtle (*Chelodina siebenrocki*), ancient Chinese turtle, Nanxiong turtle (*Nanhsiungchelys wuchingensis*), tortoise and pitted shell turtle (Anosteria) have been found in southern and eastern China (Fig. 26).

Chemical Fossil Chemical fossils are the remnants of various organic compounds of palaeobionts preserved in geological strata and fossils. Although these organic compounds are not similar to the body fossils or remains fossils that have definite forms, they



Fig. 26 Chelonians or turtle fossils

can confirm the existence of the palaeobionts; therefore, they were given the name chemical fossils. The residual organic materials that have been detected in strata and fossils include amino acids, fatty acid pigments, porphyrin, phenol, hydrocarbons and polysaccharides. In Precambrian strata, it is extremely difficult to preserve fossils of the remains of biological bodies, but chemical fossils may be preserved. For example, many types of amino acids have been detected in the 3.2-billion-year-old rocks from the Palaeoarchean Era to the Neoarchean Era in South Africa and North America. Chemical fossil assessment is a new field of palaeontology in the domain of molecular analysis, which is important for the exploration of the origin and evolution of life. The racemic characteristics of amino acids can be applied to the determination of the geologic age and the palaeoenvironment.

Chemical Sedimentary Rock Chemical sedimentary rocks are also called chemical rocks. These rocks are formed by the lithification of substances that dissolved from weathered parent rocks (in solution or colloid form) and then chemically precipitated. Typical types include aluminous rocks, manganous rocks, ferruginous rocks, phosphorous rocks, some siliceous rocks and carbonaceous rocks, and also rock salts. Chemical rocks usually have simple compositions and a crystalline structure, cryptocrystalline structure, pisolitic structure or oolitic structure. Most chemical sedimentary rocks form in marine or lake basins, and some form due to groundwater. The rocks are often important sedimentary mineral deposits, such as ores of rock salt, gypsum, potash, mirabilite, iron, bauxite, limestone and dolomite.

Chemical Weathering Landforms can be formed by chemical weathering, which includes reactions between the soil, rock and water or other solutions. The common types of chemical weathering include solution, hydration, hydrolysis, oxidation and carbonation, which not only break down the rocks but also alter the mineral and chemical compositions, forming new substances. Chemical weathering is most significant in hot and humid conditions. The chemical weathering of hard granite into white kaolin in southern China is a typical example.

Chengde Geopark, Hebei This geopark is situated in the area surrounding Chengde (a prefecture-level city in Hebei Province) and the administrative divisions covering Shuangqiao, Shuangluan and Chengde Counties. The park has an area of 48 km^2, and the major geological features are concentrated in an area of 24 km^2. It became a national geopark in 2011. Sandstone landforms are the key component of the geopark. It also includes landscapes with geological sections, geological structures, palaeontology, water bodies and environmental geological relics. The sandstone landforms are mainly located in the areas of the Jurassic-Cretaceous strata across the Chengde Graben Basins, which cover parts of Shuangqiao, Shuangluan and Chengde Counties. With unique landforms and landscapes, the park has extremely high scientific,

aesthetic and tourist value and contains valuable natural heritage.

Chengji Wu Chengji Wu (1944–) graduated from Beijing Geological Institute in 1967 and is a tourism earth science expert. Since 1976, he has been a professor and doctoral tutor at the School of Tourism and Environment at Shaanxi Normal University. He has long been engaged in the research and teaching of environmental geology and tourism earth science as well as geopark planning. He has published more than 40 papers.

Chengjiang Fauna This is a typical fossil site of the Cambrian Explosion. This site is located in the Maotianshan area, Chengjiang County, Yunnan Province. The Chengjiang fauna has preserved more than 40 phyla and more than 100 species of Cambrian fossils, including Spongia, Coelenterata, Mollusca, Anthropoda, vertebrates and the extincted Vetulicolida. Due to the unique geological conditions, both the hard bodies and traces of the soft bodies were preserved as rare and elegant fossils. They serve as samples for studying the physiology, habitat, evolution and living environment of the biota in the early stage of the Cambrian Explosion. These fossils are valuable geological relics, and the Chengjiang fauna, together with the Ediacaran fauna in Australia and the Burgess Shale Formation fauna in Canada, are praised as the three wonders of the early biological evolution of Earth's history. They are all typical fossil sites for the Cambrian Explosion (Fig. 27).

Chengjiang Faunal Paleobios National Geopark, Yunnan This geopark is located in the Maotian Mountain area in Chengjiang County, Yunnan Province. It became a national geopark in 2001. The main attraction of the geopark is the 'Chengjiang Animal Fossils'. It preserves more than 40 different types and more than 100 species of animals from the Early Cambrian (530 million years ago), including sponges, coelenterates, molluscs and arthropods. Due to the unique burial conditions, very rare and exquisite fossils of biological materials and soft deposits have been preserved. This is an excellent site for studying the Cambrian Explosion and the physiological structure, living habits, and system evolution of animals during this period. The ecological environment provides abundant physical information. These fossils, along with the Australian Ediacaran fossils (580 million years old) and Canada's Burgess Shale fossils (508 million years ago), are listed as the three major examples of early biological evolution in Earth's history and have been described as 'the most surprising discovery of the twentieth century'.

Chengjiang Fossil Site, China This site is located on Maotian Mountain in Chengjiang County, Yuxi City, Yunnan Province, and it has an area of 5.1 km^2. It contains the most complete record of marine life in the early Cambrian. The well-preserved biota include hard and soft tissue structures of many living organisms, such as the invertebrates and vertebrates. These fossils document the early development of the complex marine ecosystems. The Chengjiang Fossil Heritage Site contains at least 16 phyla, many unexplored biomes and 196 species, providing an excellent evidence of the rapid and diverse evolution of life over 530 million years ago. Most of the major fauna

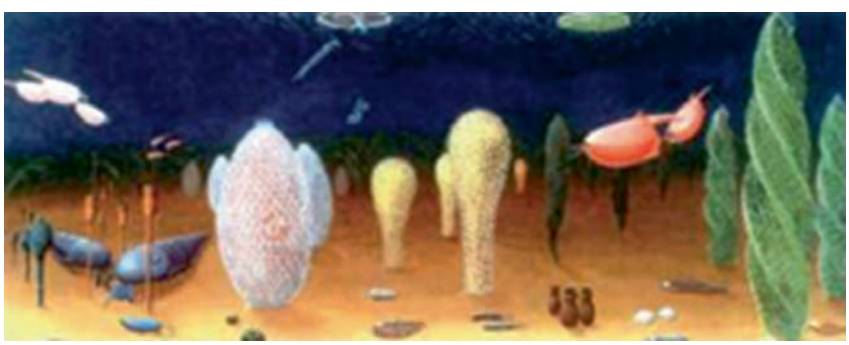


Fig. 27 Chengjiang fauna

that survive today can be found in the fossils from this period. The heritage site is a significant window for the study of palaeontology.

Chengshantou Landscape This is a marine erosional landscape of granite. It is also known as Chengshan Cape or the 'End of the Sky', and it is located in Longxudao (Dragon Beard Island) in Rongcheng City, Shandong Province. It gets its name from its location at the eastern end of the Chengshan Range. Chengshan Peak is 200 m above sea level, and it has an E-W width of 0.75 km and a N-S length of 1 km. It has an area of 2.5 km^2, is surrounded by the ocean on three sides and connects to the mainland on one side. South Korea is only 94 nautical miles away across the ocean. It is one of the places to witness the earliest sunrise, and so it is called the 'Land of the Rising Sun'. During the Spring and Autumn Period, it was called 'Morning Dance'. It is also known as 'China's Cape of Good Hope' and has become a famous tourist destination (Fig. 28).

Chenzhou Shizuyuan National Mining Park, Hunan This park is located east of Chenzhou City, Hunan Province, and has an area of 86 km^2 with a core scenic area of 47 km^2. It became a national mining park in 2010. The park has five major types of mining heritage: mining geology, mining production, mining products and remains, mining society and life and mining development literature, such as historical records. The mining park contains four rare mining heritage sites and ten important mining heritage sites.

Chernozem This soil is formed by humus accumulation and calcification under temperate semi-humid meadow and meadow vegetation. It has a thick, black humus layer with obvious infiltration. It is mainly distributed in the western part of Heilongjiang and Jilin Provinces and extends to the north of Yanshan and in a zone on Yinshan Mountain.

Chestnut Soil ▶ Kastanozem

Chifeng Balin Stone National Mining Park, Inner Mongolia This park became a national mining park in 2005. It is located on the banks of the Chagan River in Bahimi Banner, Chifeng City, Inner Mongolia Autonomous Region, and it covers an area of 96 km^2. The mining park was designed to introduce mining activities, simulate the ancient exploitation of Balin Stone, explore for interesting treasure, and construct viewing platforms, sand fields, and artificial lakes for fishing and other entertainment. The original natural geological remains illustrate the mineralisation and mining production process of Balin Stone to demonstrate its beauty.

China Danxia, China China Danxia is a generic name used by Chinese scientists to describe the unique landform created by the deposition of terrestrial materials to form red sandstones and conglomerates that were then uplifted by subsequent external forces, including tectonic



Fig. 28 Chengshan headland landscape

movements, weathering and erosion. The world heritage site comprises six sites in south-eastern China, including Chishui in Guizhou, Taining in Fujian, Kunshan in Hunan, Danxiashan in Guangdong, Longhushan in Jiangxi (including Guifeng) and Jianglangshan in Zhejiang. The landform is characterised by spectacular red cliffs and several types of eroded features, including majestic natural rock pillars, rock towers, gullies, canyons, and waterfalls. The topography of the landform creates ideal habitats for fauna and flora, including approximately 400 rare or endangered species and subtropical evergreen broad-leaved forests.

China Ecological Function Zoning According to the requirements of the State Council's 'Outline of National Eco-environmental Protection', the Ministry of Environmental Protection and the Chinese Academy of Sciences jointly prepared this zoning policy and officially announced it on 18 July 2008. The policy paper includes the ideology, principles and objectives, zoning method and basis, national zoning plan, types and overview of ecological function areas, national important ecological function areas, protection and implementation.

China National Geopark Series Anze Chen and Jianjun Jiang were the chief editors of the China National Geopark Series, which was published by the Chinese Map Society from 2004 to 2007. Each volume describes the geopark(s) of each county. The first series introduces geoparks such as Lushan, Huangshan, Wudalianchi, Zhangjiajie, Songshan, Xingwen, Dajin Lake of Taining and Hexigten. The formation and development of the geology and geomorphology of each geopark are described in detail with pictures. The series also describes the scenery along the tour routes, allowing visitors to increase their understanding of the earth science, history and culture of various attractions. It also provides an overview of the scenic sites around the geopark as well as information about services such as food, accommodations, transportation, shopping, and entertainment. It has practical value for self-guided tours.

China Stone Forest Karst Research Results Report Meeting The China Stone Forest Karst Research Results Report Meeting was held in Changsha, Hunan Province, on 21–25 November 2008. It was organised by the Chinese Academy of Tourism Earth Science and Geopark Research, Geological Society of China. Eleven global comparison sub-topic task groups from Yunnan, Guizhou, Sichuan, Hunan, Hubei, Guangxi, Fujian, Hainan, Hebei and Henan participated, and Anze Chen presided. The task groups reported on their research results and organised different sub-topic landform and landscape photo exhibitions. An expert group composed of the academicians Yaoru Lu, Shouyue Zhang, Zhijiu Cui and Mingzhong Tian was formed to review the results. 'China Stone Forest Karst Landscape Research Results' was published by Science Press in 2011.

China Tourism Resources Distribution Map (1:4000,000) The Chinese Academy of Tourism Earth Science and Geopark Research, Geological Society of China, was commissioned by the Land and Resources Department of the State Planning Commission to develop a tourism resources distribution map of China. The map was completed in December 1986, and it was the first national tourism resources map of China.

China's First International Symposium on Granite Geology and Geomorphology – Mount Sanqingshan The China's First International Symposium on Granite Geology and Geomorphology – Mount Sanqingshan was held in Shangrao City, Jiangxi Province, on 24–28 July 2006. It was organised by the Chinese Academy of Tourism Earth Science and Geopark Research, Geological Society of China. More than 100 geologists, geomorphologists and scenic area managers in the field of granite studies from the United States, Britain, Germany, Poland, Australia and Japan attended the symposium. More than 30 papers were submitted. The symposium was presided over by Anze Chen. The main discussions

were on the basic theories of granite geology and geomorphology and the construction and management of granite scenic areas. It was the first international symposium on granite organised in China. The meeting facilitated the establishment of the Chinese Academy of Tourism Earth Science and Geopark Research, Geological Society of China - Granite Landscape Research Centre. The proceedings of the symposium were published in the 2007 'Geological Review' supplemental edition.

China's First Karst Tourism Earth Science Symposium The China First Karst Tourism Earth Science Symposium was held in Xingwen County, Sichuan Province, in October 2003. It was organised by the China Tourism Earth Science Research Institute and was attended by 110 delegates, who submitted 65 papers. It was presided over by Anze Chen. The main themes were research on the basic theory and development of karst tourism resources and the feasibility of Xingwen's application to become a global geopark. The proceedings of the 'Research on Basic Theory and Development of Karst Tourism Resources' was published by Seismological Press in 2004.

China's Four Famous Jades See ▶ Jade

Chinese Geopark, Brief History Chinese geopark development began in the 1980s with the initiative to protect natural geological reserves and form a complete geopark system with different levels of protection. China's geoparks have undergone more than 30 years of development. At the end of the 1970s, to protect geological heritage and meet the increasing demand of the tourism industry, Chinese scientists began studying the application of earth science to the tourism industry. In April 1985, under the auspices of Professor Anze Chen, the *Chinese Tourism Earth Science Research Association,* a standing committee of the Geological Society of China, was established and formally proposed to the State Council to establish 'Earth Science Parks' throughout the country. This was the first time that the term 'earth science park' was used in China and probably in the world. In November 1985, the *Chinese Tourism Earth Science Research Association* proposed the establishment of the Wulingyuan National Geopark (Zhangjiajie) at the 'First Conference on Geological and Natural Heritage Protected Areas' organised by the Ministry of Geology and Mineral Resources of China. This was the first time that the term 'geopark' was officially adopted. Two years later, the Ministry of Geology and Mineral Resources promulgated the establishment of geological nature reserve planning (Trial), which began to include 'geoparks' as protected areas. In 1995, the Ministry of Geology and Mineral Resources promulgated the regulations for the protection and management of geological relics and formally classified geoparks as a form of protection of geological relics. In the late 1990s, UNESCO proposed the establishment of a 'geopark network' and used the English term 'geopark'. Based on this development, during the National Geological and Geomorphological Landscape Conference of the Ministry of Land Resources in December 1999, Chen Anze proposed the establishment of a 'geological park system' in China, and the proposal was accepted. In 2000, the Ministry of Land and Resources agreed to set up national geoparks in China. The first group of national geoparks was set up in China, which included eleven national geoparks, such as Shilin National Geopark. This was probably the first national geopark in the world. In 2004, the executive board of the Global Geoparks Network approved eight national geoparks in China. This became the world's first group of global geoparks. By October 2017, China had set up 204 national geoparks and more than 100 provincial geoparks, of which 35 had acquired global geopark status.

Chinese Geoparks Network (CGN) The Chinese National Geopark Network serves as a management organisation of geoparks under the Ministry of Land and Resources and as a coordinator and service hub for all of the national geoparks in China. It was established in January 2012 by the Department of Geological Environment of the Ministry of Land and Resources and was commissioned to supervise

and offer advice to geoparks on geological heritage protection, national and global geopark development, planning and management. It also provides technical support and advice on activities to all geoparks in China. The network is affiliated with the Chinese Academy of Geological Sciences.

Chinese Painting Stone This stone is also known as a fake fossil or grass flower stone. It is a hard aluminium silicate rock. It gets its name because the stone surface resembles a Chinese painting with a pleasing grass and flower pattern of various colours. This stone forms from the precipitation of impurities such as calcium, iron and manganese along cracks in siliceous rock. The colourful and clear painting pattern is revealed only after polishing. The brown or deep brown colours are caused by iron ions, the black or brownish black colours are caused by manganese ions, and the light greyish green colours come from chlorite. Chinese painting stone mainly comes from Guangxi, Shandong and Guizhou Provinces. The stone from Tiemao (Iron Hat) Mountain and Huangmao Town in Wuxuan, Guangxi Province, is most famous. Since its discovery in the 1990s, it has become popular as a gift and is valued by most collectors for its unique style and numerous colours (Fig. 29).



Fig. 29 Chinese painting stone (oxidised iron in cracks)

Chipped Stone Tool ▶ Neolith

Chishui Danxia Geopark, Guizhou This geopark is located in Chishui City in Guizhou Province. The geopark is administered by Zunyi City. It has a total area of 134 km^2, and its main geological features cover an area of only 8 km^2. It was designated as a national geopark by the Ministry of Land and Resources in December 2011. The geopark is dominated by Danxia landforms, including rare plateau and valley Danxia landscapes along the southern rim of a large subtropical basin with red strata. The thick Cretaceous continental sediments, unique geological history of landform development and favourable subtropical humid climate conditions contributed to the formation of the magnificent landscapes, such as deep gorges, undercutting valleys, cliffs, hanging walls and cascading waterfalls. The Danxia landforms have both positive and negative forms. The former includes cliffs, stone peaks and rock columns, whereas the latter includes horizontal rock troughs, giant caves, honeycomb caves, colluvial superimposed caves, arches and potholes. These geological features illustrate the evolution of the Earth since the late Cenozoic and have significant scientific value.

Chitwan National Park, Nepal This park is located in central Nepal near India and has a core protection area of 932 km^2. At the foot of the Himalayas, Chitwan is one of the few remaining undisturbed vestiges of the 'Terai' region, which formerly extended over the foothills of India and Nepal. It contains particularly rich flora and fauna. One of the last populations of single-horned Asiatic rhinoceroses lives in the park. It is also one of the last refuges of the Bengal tiger.

Chizhou Mount Jiuhuashan National Geopark, Auhui This geopark is located in the Guichi District of Shitai and Qingyang Counties in Chizhou City, Anhui Province, and has a total area of 97 km^2. It became a national geopark in August 2009. It is characterised by granitic landforms from the Yanshan stage. It also contains Quaternary glaciers, hydrological features, lavas and faults. Mount

Jiuhuashan is one of the four major Buddhist shrines in China.

Chloride Spring A chloride spring is a hot spring with a total solid content up to 1 g/L, where the anions are mainly chlorinated ions (Cl^-). Based on the cations, they can be divided into sodium chloride springs, calcium chloride springs and magnesium chloride springs. Sodium chloride springs are commonly used for therapy.

Chongming Yangtze River Delta National Geopark, Shanghai Chongming Yangtse River Delta National Geopark (Shanghai) is located at the eastern end of Chongming Island near the mouth of the Yangtze River. It became a national geopark in 2005. A combination of Tuanjiesha, Dongwangsha and Beibachesha, Chongming Island is the largest estuarine alluvial delta in the world, and it is endowed with unique geological features and diverse landforms, such as extensive tidal flats, wetlands and typical tidal creeks. Dongtan, the eastern beach of Chongming Island, is the largest wetland near the mouth of the Yangtze River.

Chromite The composition of chromite is (Mg,Fe) Cr_2O_4, and it is an important chromium ore mineral. It contains 76.91% Cr_2O_3, and it has an isometric crystal system. The crystals are octahedral and always appear as blocky, granular or nodular aggregates. The colour is black or brownish black with dark brown streaks. It has an opaque diaphaneity, a metallic lustre, a specific gravity of 4.5–4.8, a Mohs hardness of 5.5 and uneven fractures. It usually forms in magmatic rocks, especially ultramafic and mafic rocks. Sand placer deposits also often contain chromite.

Chron and Chronozone A chron is the geologic time corresponding to a chronozone. A chronozone is the rock that is formed within a time interval of an extended biological zone. A chronozone is a formal chronostratigraphic unit at the level below a stage. Another interpretation is that chrons and chronozones are informal or freely designated units. For example, a magnetostratigraphic unit or stratigraphic unit can be subdivided into corresponding chrons and chronozones.

Chronostratic Unit ► Chronostratigraphic Unit

Chronostratigraphic Unit *Synonym:* ► *Chronostratic unit*

A chronostratigraphic unit is a geologic unit that includes all of the rocks that are formed during a specific interval of geologic time. Chronostratigraphic units are ranked according to the length of time they record into eonothems (the longest), erathems, systems, series, stages and substages. The upper and lower boundaries of a chronostratigraphic unit are defined by the Global Boundary Stratotype Section and Point (GSSP), and the boundary between two chronostratigraphic units is theoretically a synchronous surface. The GSSP is the most important means to determine the synchronous interface.

Chrysanthemum Stone This is also known as stone chrysanthemum and was first discovered during the Qing Dynasty Qianlong years by a craftsman while collecting stones for building foundations. This stone gets its name from its radial pattern, which looks like a white chrysanthemum on a black base. It is composed of a greyish black base plate and whitish 'petal'. It sometimes has a distinctive pattern like a colourful autumn chrysanthemum flower with different forms of 'petals' composed of andalusite, lapis lazuli or calcite. These stones formed approximately 250 million years ago in limestone layers deposited in a shallow sea during the Lower Permian. They are the result of metasomatic recrystallisation of carbonate rock and have a very fine texture suitable for crafting. Because they often contain selenium and strontium, they have become popular for making tea sets. This stone was first discovered in Yonghe Town in Liuyang, Hunan Province, and similar stones were later found in Hubei, Shaanxi, Jiangxi, and Guangxi Provinces and also in Beijing. The Liuyang chrysanthemum stone ranks best in terms of quality (Fig. 30).

Chrysoberyl In China's gem industry, chrysoberyl is also known as 'Golden Green Jade' or 'Golden Green Beryllium'. The name chrysoberyl is derived from the Greek word 'chryso', meaning a gold-white spar. It is actually an oxide of beryllium in the spinel



Fig. 30 Chinese ink slab made of chrysanthemum stone

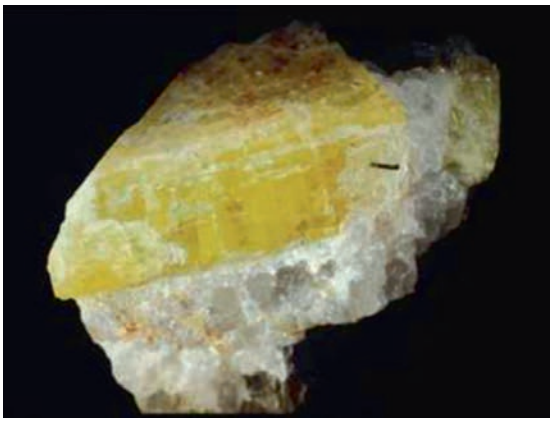


Fig. 31 Chrysoberyl

family, and its main composition is beryllium aluminate ($BeAl_2O_4$). The Mohs hardness is 8.5. It usually contains inclusions of dense silk-like or tubular rutile, and its chatoyancy (cat's eye effect) is superior to other gemstones. Therefore, the term 'cat's eye', when referring to a gemstone, only applies to cat's eye chrysoberyl. For other gems with a similar effect, the cat's eye nomenclature must be combined with the name of the mineral, such as cat's eye quartz or cat's eye aquamarine. A variety of chrysoberyl called alexandrite changes colour from daylight to artificial light. They are high-quality rare and precious gems (Fig. 31).

Chuanjun Wu Chuanjun Wu (1918–2009 AD) was a human geographer. He was a leading figure in human geography and modern economic geography and one of the pioneers of tourism geography in China. He was a committee member of the Chinese Academy of Sciences (academician). He also served as the deputy director of the Institute of Geography of the Chinese Academy of Sciences, the director of the Geographical Society of China, the deputy director of the Natural Resources Committee of the Chinese Academy of Sciences, and the vice president of the International Geographic Federation. He studied economic geography and human geography for decades. His monographs include 'Geography of Food in China' and 'Land Development, Renovation and Planning'. He was the chief editor of *Acta Geographica Sinica*, *China Agricultural Geography Series, China Agricultural Geography, China Human Geography Series,* and *1:100 China Land Use Map*.

Chuankang Chen Chuankang Chen (1931–1997) was a native of Chaozhou City, Guangdong Province, and was a geographer and tourism geographer. He graduated from the Geological and Geographical Department of Peking University. He had served as a professor at Peking University, a doctoral tutor, director of the Department of Physical Geography, director of the Physical Geography Committee of the Geographical Society of China, director of the Human Geography Specialist Committee and Tourism Geography Group, director of the Regional Tourism Development Professional Committee of the Tourism Association of China, deputy director of the Chinese Tourism Earth Science Research Institute, and vice president of the Geographical Society of China. For many years, he engaged in research on comprehensive physical geography, land science, tourism geography and comprehensive regional development. His major works include 'Tourism Geography of Beijing', 'Evaluation, Development and Strategy of China's Tourism Resources', 'Appreciation

and Development of China's Resources', and 'Tourism Landscape: New Developments in Applied Geomorphology'. He was one of the pioneers and academic leaders of tourism earth science and made important contributions to the development of China's tourism industry.

Cinnabar In Chinese, cinnabar is also known as 'red sand'. Its content is mainly HgS, and it is an important mercury mineral ore. It contains 86.2% mercury and belongs to the trigonal crystal system. The crystals appear as thick plates or are rhombohedral or columnar. Crystal twinning is common. Cinnabar also appears as blocky, shell-like or granular aggregates. The typical colours are brownish red or scarlet with scarlet streaks. It has transparent to opaque diaphaneity, an adamantine, submetallic or dark lustre, a specific gravity of 8.0–8.2, a Mohs hardness of 2.5, and conchoidal to uneven fractures. It usually forms in low-temperature hydrothermal veins or sedimentary rocks associated with volcanic activity. Cinnabar is an important ore for the extraction of mercury, and it is also an important pigment. It can also be used as a fine ornamental rock.

Circum-Pacific Volcanic Belt This is a volcanic belt along the eastern and western edges of the Pacific Ocean. Volcanoes are distributed along the plate edges. Approximately two-thirds of the world's active volcanoes are concentrated on the Pacific Rim. The western Pacific Rim starts from Indonesia and the Philippines and extends north via Japan to Kamchatka. The eastern Pacific Rim extends from North America through Central America to South America. Both rims constitute the Circum-Pacific volcanic belt, which is also called 'the Ring of Fire'.

Cirque Glacier Landscape A cirque glacier is an armchair-like glacier that develops on a slope or the uppermost part of a valley. They are moderate in size, and the largest one can reach 10 km^2 or more, but the smallest have areas less than 1 km^2. They are approximately oval but sometimes triangular. Because cirques are permanently covered with snow, the glacier's surface is always concave and tilts towards the glacier's mouth, and there is no obvious glacier tongue. Cirque glaciers are often located near the snowline and are supplied by ice from avalanches and ice disintegration behind the cirque wall. Under suitable climatic conditions, they can evolve into valley glaciers or cirque-valley glaciers.

Cirque Lake Landscape This is a type of glacial lake landscape. A cirque forms through glacial erosion on a mountain. When the glacier retreats, the cirque fills with meltwater to form a lake. Cirque lakes are common in alpine regions and are often distributed regularly at specific elevations, which represent the locations of ancient snowlines. The Luhuomahai in Sichuan Province is a typical and reliable evidence of ancient glacial action.

Cirque Landscape This landform is composed of elliptical bedrock depressions shaped by glaciers near the snowline due to the processes of nivation and glacial erosion. The initial form is a snow spot, and a cirque forms after further glacial erosion and abrasion. A typical cirque is composed of a rock basin, a back wall and a cross wall. The bottom is the rock basin. It is semi-circular and is surrounded by steep walls on three sides. A threshold is located near its exit.

Classification of Geological Heritage Geological heritage sites can be classified according to their comprehensive value based on their scientific, aesthetic, education and tourism values as well as their protection and utilisation conditions. They can be classified into global, national, provincial and local categories.

Classification of Igneous Rocks Igneous rocks can be categorised as plutonic rocks when they are formed by intrusions, hypabyssal rocks when formed near the surface, and volcanic rocks when formed from eruptions. The types of igneous rocks are complex, and their classification is based on their chemical composition, mineral content, structure and formation. The visual identification of igneous rocks can be performed as follows (Table 1):

Classification of Landscape of Geological Heritage The classification of geological heritage allows better protection and utilisation of these geotourism resources. Geological

Table 1 Visual identification of igneous rocks

	Feldspar									
	No feldspar	Mainly plagioclase				Approximately equal amounts of alkali feldspar and plagioclase		Mainly alkali feldspar		
	pH indicating mineral									
	With olivine	No quartz, sometimes with olivine	No olivine, sometimes with quartz	With quartz		No quartz	With quartz <20%	With quartz	No quartz	With feldspathoid
				<20%	>20%					
	Colour %									
Item	>75	75–35	35–20	35–20	35–20	35–20	35–20	<20	35–20	<30
Formation and structure	Rock name									
I. Intrusive rock, lava flow, rock cover, cupola porphyritic or non-porphyritic cryptocrystalline structure	Meimechite	Basalt	Andesite	Dacite	Rhyolitic dacite	Trachyandesite	Coloradoite	Rhyolite	Trachyte	Phonolite
II. Secondary volcanic rock and hypabyssal apophyse, dyke, vein, sill, laccolith, small stock	Picrite, Kimberlite	Micro-gabbro, diabase	Andesitic porphyrite, Dioritic porphyrite, microdiorite	Dacite porphyrite, Quartz diorite porphyrite, Microcrystalline quartz diorite	Dacite porphyrite, Corcovadite, Microcrystalline granodiorite	Trachyandesite, Ivernite, Microcrystalline monzonite	Quartz coarse andesitic porphyrite, Quartz ivernite, Microcrystalline quartz monzonite	Rhyolitic porphyry, Quartz porphyry, Granitic porphyry, Microcrystalline granite	Trachyte porphyry, Microcrystalline syenite	Nepheline syenitic porphyry, Microcrystalline nepheline syenite
III. Plutonic rock Batholith Stock, Lopolith Crystallolithic or porphyritic structure	Pyroxenite peridotite	Gabbro	Diorite	Quartz diorite	Granodiorite	Monzonite	Quartz monzonite	Granite	Syenite	Nepheline syenite

heritage includes all of the non-renewable geological features that have formed over the long history of Earth's evolution and the interactions between its endogenic and exogenic forces. In 1993, the UNESCO Geological and Palaeontological Working Group categorised geological heritage into thirteen types based on the geological characteristics: (1) palaeontology; (2) geomorphology; (3) palaeoenvironment; (4) petrology; (5) stratigraphy; (6) mineralogy; (7) tectonic geology; (8) economic geology; (9) historical geological sites; (10) plate tectonics; (11) ancient impact craters; (12) continental and marine geological features with global significance; and (13) submarine topography. The 'National Geopark Planning and Technical Requirements' published by China's Ministry of Land and Resources classifies geological heritage into seven major groups, 25 classes and 56 subclasses. The details are listed in the table of *geological heritage classification.*

Classification Principles For Karst Stone Forest Landscapes in China These classification principles include: (1) The principle that aligns with the stone forest definition, which states that only carbonate rock pillar clusters more than 5 m high that look like a forest when viewed from a distance can be called a stone forest. Pillars less than 5 m high are called stone buds. (2) The principle that hinges on tourism applications and focuses on viewing stone forests as a tourism resource. This principle is similar to that of the mining industry and always corresponds to a particular type of application value. For example, the 'Anshan-type' iron ore is linked to Archaean strata with striped magnetic quartzite deposits, in which the iron grade is low, but the large scale leads to great potential value for industrial development. This classification method based on industrial development and applications can be adopted for the categorisation of tourism landscapes. (3) The principle that is specifically related to the time of rock formation of the landform. Rock is the basic element of the landscape. Different types of rocks are in different layers. Rocks in the same layer (especially marine facies strata) that formed at the same time are generally similar, and the resultant landforms that are developed in the same layer are similar and comparable. (4) The geographical area principle that reflects the physical geographical characteristics of the landscape and the regional characteristics of China. Based on the known stone forest landscapes in China, each type can be given a label that is related to a particular location in China. For example, the 'Nidang-type' karst stone forest landscape represents China's southwestern regions and the Middle Triassic limestone stone forest on the South China Plate. On this basis, all stone forests in this rock layer in southwestern China are called 'Nidang-type' stone forests. The core principle is the time of landform formation. This is an attempt to apply the mining ore classification principles to the classification of landscape types.

Classification, Investigation and Evaluation of Tourism Resources These rules were announced and implemented by the General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China in 2003. The three major areas are the classification, surveys and evaluation of tourism resources. The main content consists of (1) scope; (2) referred papers; (3) terminology and definitions; (4) classification of tourism resources; (5) tourism resource surveys; (6) tourism resource evaluations; and (7) submission of documents and figures.

Clastic Rock Physical disintegration and weathering of parent rocks can result in the formation of clastic materials, which can form clastic rocks after mechanical transportation, deposition, and consolidation. Based on their material sources, clastic rocks can be divided into terrigenous clastic rocks and pyroclastic rocks. Terrigenous clastic rocks can be further divided into three types: conglomerate (breccia), sandstone and siltstone, according to the sizes of the clasts. Using the same criterion, pyroclastic rocks can be divided into agglomerate, volcanic breccia and tuff. Clastic rocks are mainly composed of clastic matter and cement. Clastic matter includes rock fragments

and mineral fragments. The former have complex compositions, and the latter mainly consist of quartz, feldspar, mica and a small amount of heavy minerals. Cement mainly includes chemical sediments, such as silicate minerals, sulphate minerals, carbonate minerals, and phosphate minerals, which fill the gaps between the clastic matter and then bind it. The pores of clastic rocks provide space for the storage of groundwater, oil and gas. Studies of clastic rocks are important due to their link to the exploration for groundwater, placer deposits, oil and gas resources, mineral ore resources, and non-metallic ore resources.

Clastic Rock Cliff Corridor Landscape This landscape is composed of cliffs and corridors in the nearly horizontal layers of sandstone interbedded with argillaceous rocks. Variations in rock hardness can cause differential weathering, and soft argillaceous rock layers can be deeply eroded, forming a concave corridor that is called a cliff corridor or horizontal rock depression. With slight modification, a cliff corridor can serve as a walkway. The ancient boardwalk in northwestern Sichuan Province was built along a cliff corridor, and these corridors are often good candidates for popular tourist spots (Fig. 32).



Fig. 32 Clastic rock cliff corridor landscape – Zhangshiyan, Hebei Province

Clastic Rock Comb-Shaped Landscape This is a type of clastic rock landscape found in arid and semi-arid regions. Due to wind erosion, inclined clastic strata can form a landform like an array of undulating fences, and the thin rock layers become aligned like a comb. Hence, this type of landform is also called a comb-shaped landscape.

Clastic Rock Forehead-Like Cave Landscape A clastic rock forehead-like cave landscape is a type of cave landform associated with sandstone caves. The upper cave is usually wider and has a circular shape, whereas the lower cave is narrower. The cave is not deep, and it looks like a human's forehead; hence, it is also called a forehead-like cave. It is a common feature in the Danxia landform.

Clastic Rock Landscape A clastic rock landscape is a type of landscape which main components are sandstone, conglomerate, siltstone and clayey siltstone. Compacted sandstone and conglomerate are hard and resistant to wind erosion. Due to these characteristics, they form outstanding features, such as cliffs, walls, pillars, mesas, natural bridges, arches and potholes. Soft siltstone with a loose structure forms a badland landscape with small knolls and depressions. Based on the geographic location, formation age, formation dynamics and landforms, clastic rock landscapes can be categorised into Zhangshiyan type, Urho type, Danxia type, Yeliu type, Yuanmou type, Luliang type and Yardang type. Clastic rock landscapes are an important tourism resource.

Clastic Rock Mesa Landscape Clastic rock mesas are also known as 'table-like mountains'. They have flat tops and are surrounded by steep cliffs. They form in areas of Mesozoic red sandstone, siltstone, shale and sandy conglomerate. The rock strata are relatively flat with extensive fractures in the structure. A mesa forms when the top (cover) has a layer of hard rock. In some Mesozoic basins



Fig. 33 Columnar sandstone pillar landscape – Zhangjiajie, Hunan Province (left). Round sandstone pillar (Danxia type) – Danxiashan, Guangdong Province (right)

in the middle and southern Sichuan Basin in China, mesa landforms with red sandstone tops are well developed.

Clastic Rock Pillar Landscape When eroded by external forces, rocks such as sandy conglomerate can form a type of landform composed of columnar pillars that are several times taller than their width. Rock pillars can be divided into pyramidal pillars, cylindrical pillars, angular pillars, mushroom-like pillars, pagoda-like pillars and pillars of various shapes. These pillars are common features in the Danxia landform and Zhangjiajie landform. They have important aesthetic and ornamental value (Fig. 33).

Clastic Rock Urn-Like Valley Landscape This type of landscape is associated with urn-like and bottle-like landforms. It is also called a bottleneck valley or hourglass valley. Urn-like valleys usually have a wide middle section but a narrow valley mouth. The cliff at the valley mouth is circular with a height of tens to hundreds of metres. In the Taihang Mountains, it is called a 'Q' valley because by backward erosion along the river tributaries, running water washes away the soft rock layer at the bottom of the cliff, and the thick quartzite layer collapses due to gravity. This type of valley wall is also called an 'echoing wall' due to its excellent acoustic effects. It is an important and popular tourism landscape. An example is the clastic rock urn-like valley in Zhangshiyan National Geopark in Hebei Province (Fig. 34).

Clastic Rock Wall Landscape This landform looks like clastic walls. These walls form when hard sandstone is subjected to fluvial erosion along parallel vertical joints during crustal uplift. The clastic rock wall that developed in the Cretaceous sandstone in Guanzhaishan National Geopark in Fujian Province is a typical example of this type (Fig. 35).

Clay Mineral Clay minerals are the main mineral components of clay rock and soil. They are hydrous aluminium and magnesium phyllosilicates. When mixed with water, clay minerals have various degrees of plasticity. Clay minerals are usually ultrafine-grained, normally less than 0.01 mm. They have a layered structure, and only a few, such as sepiolite and palygorskite, have chain-like structures. Clay mineral families include the kaolinite, illite, montmorillonite, vermiculite and sepiolite families. Clay minerals are mainly used to make ceramics and fire-resistant materials. They are also used in the petroleum, construction, textile, paper-making and paint-making sectors.



Fig. 34 Clastic rock urn-like valley landscape – Zhangshiyan, Hebei Province



Fig. 35 Clastic rock wall landscape – Guanzhishan, Fujian Province

Claystone Claystone refers to sedimentary rock that contains more than 50% particles with sizes less than 0.0039 mm and large amounts of clay minerals. A rock is called a claystone when its texture is comparatively loose and is called shale or mudstone when its texture is more consolidated. Most claystones form when fine clastic fragments weathered from a parent rock are transported in a suspended state to the sedimentation region and settle. Some claystones are the product of the in situ accumulation or colloidal consolidation of decomposed aluminium silicate minerals. They usually have pure compositions and hence have some industrial value. The main types of claystone include montmorillonitic claystone, illitic claystone, kaolinitic claystone, mudstone and shale.

Clean Energy Clean energy refers to types of energy that do not discharge pollutants, including solar energy, ocean energy, wind energy, hydrogen energy, biological energy, geothermal energy, hydropower, nuclear power stations and other renewable energy sources. With the ever-increasing demands for energy and environmental protection around the world, the promotion and use of clean energy has become an inevitable trend.

Cleavage Cleavage is a type of planar rock feature with a thin, dense and potentially fractured structure that develops as a result of splitting induced by rock deformation. Non-deformed cleavage has straight planar surfaces with very strong ‘cleavability’. Based on its orientation, cleavage can be categorised as axial-plane cleavage, bedding cleavage and fan cleavage; and based on its continuity, it can be divided into continuous cleavage and discontinuous cleavage. According to the formation mechanism, it can be divided into fracture cleavage, flow cleavage and crenulation cleavage; whereas this is the most common classification method (Fig. 36).

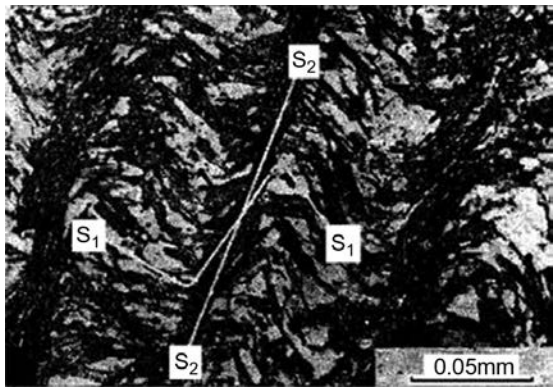


Fig. 36 Crenulation cleavage. S1 dark minerals gathered at the limb of microcrenulation cleavage. S2 light minerals gathered in the hinge zone of microcrenulation cleavage



Fig. 37 Cliff carving in Mount Huangshan

Cliff Carving A cliff carving is a type of stone carving with inscriptions on natural rock walls used to record particular incidents. Well-preserved cliff carvings are popular in many major scenic areas and historical sites in China. Eight sites in Shandong, Shaanxi, Hunan, Hubei, Sichuan, Yunnan and Fujian Provinces have been designated as major cultural relic preservation sites. The styles of calligraphy of the cliff carvings include zhuanshu (seal script), lishu (official script), kaishu (regular script), caoshu (cursive script) and xingshu (running script). The contents of the carvings are extensive, including literature, biographies, history, medicine and water conservancy. There are also abundant cliff carvings at Huangshan Mountain, Taishan Mountain and Hengshan Mountain (Fig. 37).

Cliff of Bandiagara (Land of the Dogons), Mali This site is located in the Mopti district in east-central Mali near the border with Burkina Faso. Its core protection area covers 4000 km^2. The Bandiagara Precipice is an outstanding cliff and sandstone landscape that is dotted with magnificent buildings (e.g., houses, warehouses, altars, shelters, and public gathering places ('Tokuna')). Today, many ancient social artefacts (masks, banquets, religious rites, and party ceremonies related to ancestral worship) can still be seen in the local area. Bandiagara is valuable for scientific research in geology, archaeology and ethnology. Due to its natural features, it is one of the most beautiful sites in West Africa.

Cliffy Gorge Landscape A cliffy gorge is a type of river valley landscape in the initial stage of development of a V-shaped valley. The valley slopes are steep or nearly vertical. The river valley is very narrow, the valley width is nearly identical to the width of the valley floor, and the river occupies the entire valley floor. Cliffy gorges often develop in areas with pronounced vertical joints in the bedrock and significant neotectonic uplift. For example, typical cliffy gorges are located in Jinsi Gorge National Geopark in Shangnan, Shaanxi Province.

Climate The average conditions of common and unique weather over many years are a result of climate. The three major factors that affect the climate are solar radiation, atmospheric circulation, and the nature of the underlying surface. The multi-year averages of factors such as temperature, precipitation, and humidity are

the main parameters that describe the climate conditions in a region.

Climate Comfort Index The climate comfort index refers to the physiological effects of the human body and the degree of comfort and depends on weather conditions such as sunshine, temperature, humidity, wind, air pressure, precipitation and their combination. The evaluation index includes overall comfort, body temperature, a comfort index, temperature and humidity indexes, a wind effect index and a high temperature index. The climate comfort index is a key evaluation parameter for the quality of a tourism site.

Climate Factors of Landscape Formation Climate is one of the determinants of exogenic action in landscape formation. It controls the shaping of the landscape, the formation of water bodies, and the growth and evolution of fauna and flora. Different latitudes have different climate zones, which lead to the formation of different types of scenery and natural tourism resources. Landscapes include tropical rainforests, cold and snowy areas, and arid deserts. Alpine areas accommodate a vertical zonation of plants and are ideal for mountain tourism.

Climate Tourism Resources The interaction between solar radiation, atmospheric circulation and the ground surface conditions determine the weather characteristics of a region; therefore, weather conditions suitable for tourist's activities have become a tourism resource. The temperature, humidity, sunshine, wind conditions and cloudiness of a tourist destination affect the comfort of tourists and the associated tourism environment. These parameters tend to form various climate tourism resources, such as summer resorts, winter retreats and sunshine spots. A proper evaluation of climate tourism resources is a crucial aspect of tourism planning and development.

Climate Tourism Resources System Comfortable climatic conditions can become the tourist resources. The climate of a region is determined by the interaction of solar radiation, atmospheric circulation and ground properties over a period of time. The climate determines the attraction of a tourism resource and affects the decisions of tourists in selecting their destinations and the season to make the visit. The most common objectives of climate tourism include escaping from the summer heat and winter cold, or simply doing sunbath.

Climate Type The distribution and interaction between heat and moisture can vary significantly because of the seasons or due to the impacts of large mountains and plateaus. The climates in different geographical regions with the same climate zone can be different. Therefore, climates can be divided into several types: (1) tropical climates, including tropical rainforest climate, savanna climate, tropical desert arid and semi-arid climates, and tropical monsoon climate; (2) subtropical climates, including subtropical monsoon, humid subtropical, Mediterranean, subtropical desert arid, and subtropical grassland climates; (3) temperate climates, including temperate marine, temperate continental, temperate monsoon, temperate broadleaf forest, temperate grassland semi-arid, temperate desert arid, and cold temperate coniferous forest climates; (4) cold climates, including polar tundra and polar ice climates; (5) alpine climates, including alpine plateau climate; and (6) polar climates, including the polar tundra climate.

Climatic Zone A climate zone is a region with similar climate characteristics and is based on the zonal and elevation distributions of climatic features. For example, the 2002 People's Republic of China climate atlas divided eastern China into the equatorial, middle and marginal tropics, south subtropics, middle subtropical, northern subtropical, warm temperate, middle temperate and cold temperate zones. Due to the influence of the sea and land distributions, elevation, topography and atmospheric circulation, the actual climate zone boundaries are not exactly parallel to the latitudes, especially in areas such as the Qinghai Tibet Plateau. However, the vertical variation of climatic zones is obvious. Therefore, three climatic zones, including the plateau temperate zone, plateau

cold temperate zone and plateau cold zone, are also classified. The impacts of climatic zones account for the zonal differentiations of flora, fauna, soil, hydrology and natural landscape in the geographical environment.

Climatology Climatology is the study of the causes, types, distributions, zones, and temporal and spatial variations of climate and the relationships with other factors and human activities. It is an important branch of both atmospheric science and geography.

Clint Landscape A clint is a raised bud-like rock mass in a karren. Clints are less than 5 m tall and generally do not exceed 3 m. They can form in an exposed environment or beneath the soil; therefore, they can be categorised into above-ground and below-ground types. The above-ground type is sharp, like a pointed spike, and the below-ground type is typically conical or cylindrical. They have diverse forms with different names, such as rail-like sprout, checkerboard-like sprout and cone-like sprout (Fig. 38).

Cloud and Mist Tourism Clouds and mist are attractive to many people due to their ever-changing nature, particularly in the mountainous areas. They can move like waves and arouse emotions of the tourists. The sea of clouds of Huangshan is one of the four best sceneries in the park. Clouds are also one of the three major natural attractions in Lushan. They flow like waterfalls along the topography and such scenery is breath-taking.

Coastal and Marine Tourism Coastal and marine tourism involves touring, entertainment and holidays related to the ocean. It includes the appreciation of marine life and geological landscapes, sightseeing of ocean parks and seashores as well as vacation activities on yachts and cruises. After nearly 20 years of development, China has gradually formed five major coastal and marine tourism areas around the Bohai Sea, the Yangtze River Delta, the Minjiang Delta, the Pearl River Delta and Hainan Island.

Coastal Beach Tourism Landscape This landscape type is composed of marine coastlines and shores and has high tourism value.

A coast generally is the zone of contact and interaction between the land and the sea. A beach is composed of accumulated loose and deposited materials formed by wave action. Coasts can be divided into estuarine coasts, rocky bay coasts, sand and gravel coasts, muddy coasts, mangrove coasts and coral coasts. Based on the materials, beaches can be classified into sandy beaches, gravel beaches and sand and gravel beaches. Coastal and beach scenery is the most attractive ocean tourism resource, which is commonly called the three S's ('sea', 'sand' and 'sun'). The best beaches for bathing have gentle gradients,



Fig. 38 Stony sprout landscape – Xingwen Stone Sea, Sichuan Province

fine sand, small tidal ranges, calm waves, warm weather and mild sunshine.

Coastal Landform This term refers to the coastal land, intertidal zones and underwater slopes forming the coastal zones. The various landforms in coastal areas are mainly formed by waves, tides and currents. They can be grouped into coastal erosion landforms, such as cliffs, caves, notches, arches, and wave-cut platforms, and depositional landforms, including beaches, spits and bars, underwater dams, terraces, lagoons and lakes. Tectonic activity and climate change cause the uplift and subsidence of coastal zones, which can destroy or preserve ancient coastal landforms on land or underwater. Coastal landforms can be classified into three types: bedrock coasts, muddy coasts, and biological coasts. Coastal landforms are important tourist destinations.

Coastal Landform Landscape Coastal landform landscape is a general term for landscapes formed by marine forces along the coast. Based on the formation causes and materials, coastal landforms can be divided into bedrock coasts, sandy coasts, biological coasts, muddy coasts, and embankment and sandy island coasts. During the formation process, coastal landform landscape is created by the actions of waves, tides, ocean currents and longshore drift which are hinging on the geomorphology of the coast and land (including the slope gradient and contours), geologic structures, sea level changes, river actions and biological effects. The main landforms include erosion features, such as wave-cut cliffs, wave-cut platforms and sea caves; and depositional features, such as sand beaches, sand bars and sand embankments. These landforms are important tourism resources (Figs. 39, 40).

Coastal Zone The coastal zone is the region in which oceans and lands interact, or it is the transition zone from the ocean to the land. It consists of the land above the average high tide line, the intertidal zone and the underwater slope below the average low tide line. The modern coastal zone includes the upper limit of the present seawater on the coast and the adjacent land, and the subtidal slope profile area subject to erosion and deposition caused by seawater action. Coastal ecosystems are characterised by their complex, marginal and active nature.

Cocos Island National Park, Costa Rica This park is located approximately 550 km from Costa Rica in the Pacific, and it protects a core area of 1,997 km^2. As the habitat of the only tropical forest in the tropical waters of the eastern Pacific, it also bears the brunt of the Equatorial Counter Current of the Northern Hemisphere. The multiple interactions between the islands and the surrounding marine ecosystems have made it the best natural laboratory for research on ecological processes. The underwater world of the national

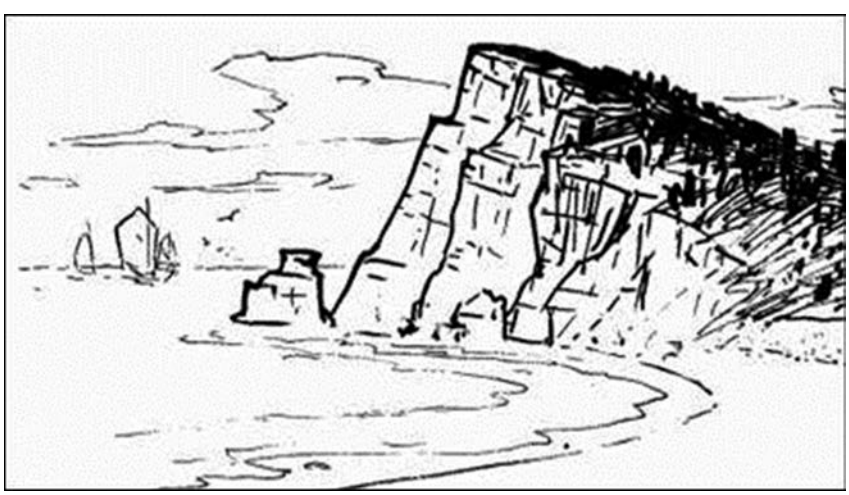


Fig. 39 Sketch of a bedrock coastal landscape



Fig. 40 Dalian coastal landscape

park has become famous and attracts large numbers of divers. It is one of the best destinations for viewing large ocean animals, such as sharks, rays, tuna and dolphins.

Coiba National Park and Its Special Zone of Marine Architecture, Panama Coiba National Park is located off the southwest coast of Panama in the waters of Chiriqui Bay. The park protects the island of Coiba and 38 smaller islands. These islands, as well as the nearby marine area, are under the jurisdiction of the provinces of Bellaguas and Chiriqui. Because the region is protected from the effects of cold air and El Niño, the ongoing evolution of new species has enabled the tropical rainforests on the island of Coiba to maintain numerous indigenous species, including mammals, birds and plants. It is also the last remaining habitat for a variety of endangered animals, such as the crested eagle.

Cold Spring Based on the nomenclature for springs, a spring with a water temperature below 20 °C is called a 'cold spring'. It is simply a carbonate spring with clear water that can be used for bathing and drinking.

Cold Wave A cold wave occurs in a wide range of strong cold air activities during the winter, late fall or early spring in association with severe weather. China's meteorological department stipulates the criteria for cold waves. North of the Yangtze River, a cold wave is defined when the minimum temperature in a 48-h period has dropped by more than 10 °C due to the intrusion of cold air. In the middle and lower reaches of the Yangtze River, a cold wave occurs when the minimum temperature reaches below 4 °C and is accompanied by winds of grades 5–7 on land and grades 6–8 at sea. In addition, a cold wave occurs if the minimum temperature is below 5 °C. Most cold waves occur during the winter and bring intense cooling and strong winds. They are often accompanied by snow and freezing rain, which have serious impacts on traffic, power transmission, and commercial, industrial and agricultural activities.

Collapsed Stacked Stone (Shed) Granite Landscape – Cuihuashan Type The stacking of large fallen granite blocks causes the formation of this granite landscape, which is characterised by irregular caves. This type of cave is also called a 'stacked stone cave' or 'stone shed'. This landscape forms from the stacking of fractured rocks that fall from pointed peaks and large stone pillars in a peak granite landscape as a result of earthquakes or other factors. In areas where collapsed stacked stones are well developed, no large pillars remain in most of the mountains. In contrast, in areas with abundant stone pillars, no

earthquakes have likely occurred. Therefore, a collapsed stacked stone granite landscape can be regarded as an indication of crustal stability in that area. Sanqingshan and Tianzhushan are granite mountains with elevations of 1,500 m above sea level. However, their landscapes are completely different. The former has numerous stone pillars on the hilltops. For example, the pillar 'Big Python Crawling Out of the Mountain' is more than 1,000 m tall. In the latter, nearly no pillars remain on the hilltops, and the foothills are covered with large collapsed stone blocks that have piled up to form a 'stone shed'. This phenomenon clearly indicates that earthquakes have occurred in the Tianzhushan region. Tianzhushan National Geopark in Anhui Province and Cuihuashan (Cuihua Mountain) National Geopark in Xi'an, Shaanxi Province, are typical examples of the collapsed stacked stone (shed) granite landscape (Fig. 41).

Column Landscape ▶ Stalactite-Stalagmite.

Columnar Joint Columnar joints are joints that divide the rock into column shapes. These joints form as a result of the rapid cooling and contraction of hot molten lava. They generally occur in the basic and acidic lava bodies. The columns are usually hexagonal or pentagonal, and most of the joint surfaces are straight and parallel to each other. The column diameter can vary from a few centimetres to several metres. Columnar joints and their associated landforms can be seen in many geoparks associated with volcanic rocks, such as the Zhangzhou Coastal Volcanic National Geopark (basalt) in Fujian Province and the Hong Kong Global Geopark (rhyolitic volcanic rock) (Fig. 42).

Columnar Joint Landscape This is a lava landscape. During the cooling of homogeneous magma, columnar joints form due to even cooling and contraction and split the rock into regular hexagonal and pentagonal columns, which are called volcanic columns. These columns are perpendicular to the cooling surface of the molten body (i.e., perpendicular to the lava surface or the rock neck contact surface). Columnar joints are very common in basalt. Typical examples are Niutou Mountain and Nandian Island in Zhangzhou Littoral Volcano National Geopark, Fujian Province, Liuheguizi Mountain in Nanjing, Penghu, and the Giant's Causeway in Ireland. Columnar joints can also develop in rhyolitic volcanic rocks, such as in the Hong Kong Global Geopark in Sai Kung, Hong Kong, Taozhu National Geopark in Linhai, Zhejiang Province, and Hua'ao Island in Xiangshan, Ningbo City (Fig. 43).

Combination of Tourism Landscapes Different types and sceneries of tourism attractions can be combined, associated and aggregated to form a cluster. A tourism cluster can be of two main types. The first is the clustering of different types of tourism attractions, such as the unusual pine trees, unique rocks, sea of clouds,



Fig. 41 Collapsed stacked stone (shed) granite landscape, at Cuihuashan, Shaanxi Province

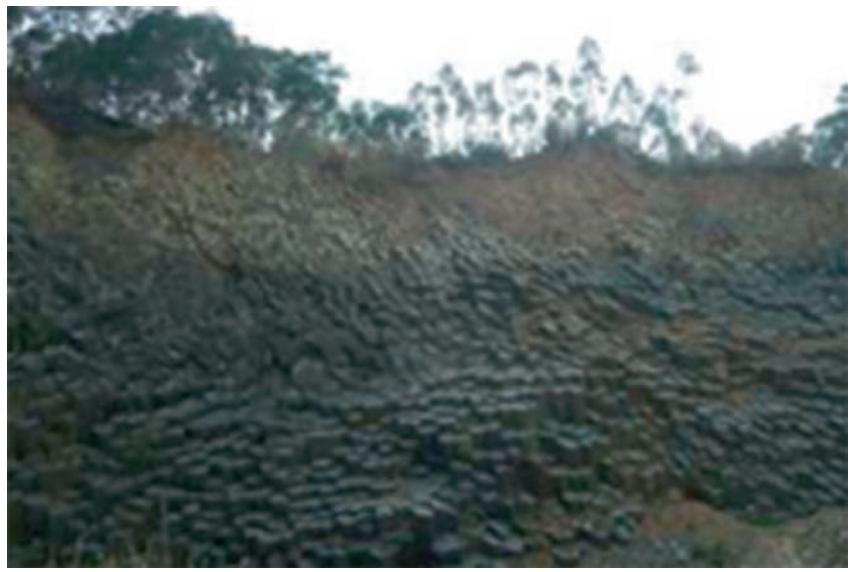


Fig. 42 Basaltic columnar joints in Zhangzhou Coastal Volcanic National Geopark



Fig. 43 Columnar joints in Liuhe National Geopark, Nanjing

and hot springs known as the 'Four Unmatched Attractions' of the Huangshan UNESCO Global Geopark. The second type of cluster is the combination of different scenic locations, which can be classified into several groups, such as converging, radiating, scattering, linear, ring-shaped, semi-ring-shaped and horseshoe-shaped clusters. A typical example of grouping tourism landscape by ancient Chinese is the illustration of the landscape of Five Great Mountains, the landform of which had been grouped with correlation to different human postures. In it, the landform of the Taishan Mountain in the East was illustrated as in a sitting posture, while the Songshan Mountain in the Central in a lying posture, the Huashan Mountain in the West was standing, the Hengshan Mountain was walking, whereas another Hengshan Mountain in the South was like flying.

Comfort Index This is a comprehensive indicator of the impacts of temperature and humidity on the human body. It reflects the degree of comfort sensed by human bodies at a certain temperature and humidity. The index is a combination of temperature and humidity and has

the formula DI = T – (0.55–0.55 f) (T – 58), where T = temperature, and f = relative humidity. In general, the index can be categorised into 11 classes: −6: extremely cold, −5: exceptionally cold, −4: very cold, −3: cold, −2: slightly cold, −1: cool, 0: comfortable, +1: warm, +2a: hot, +2b: sultry, +3: very hot. This index is one of the key evaluation indicators of the quality of a tourist site.

Committee of Tourism Earth Science, Geological Society Of China At the 5th National Academic Meeting of Tourism Earth Science in December 1990, all repesentatives discussed the affiliation of the tourism earth science organising committee. Affiliations with both the Geological Society of China and the Tourism Association of China were suggested. In August 1992, the Geological Society of China approved the formation of the Committee of Tourism Earth Science, Geological Society of China, which is externally known as the China Tourism Earth Science Research Institute.

Committee of Tourism Earth Science, National Tourism Association of China In 1993, the Committee of Tourism Earth Science became a second-tier organisation of the National Tourism Association of China. This status was cancelled with the revocation of the National Tourism Association of China in 1998.

Committee of Tourism Earth Science, Tourism Association of China In 1992, the Tourism Association of China approved the formation of the 'Committee of Tourism Earth Science, Tourism Association of China'. The affiliation ended in 1998 after the reorganisation of the Tourism Association of China.

Comoé National Park, Ivory Coast This park is located in the borderland near Burkina Faso along the middle reaches of the Comoé River in northeastern Ivory Coast. The core protection area of this park spans 11,492 km^2 and is one of the largest protected areas in West Africa. Due to the presence of the main stream and tributaries of the Comoé River, this park is characterised by great plant diversity.

Concave Bank A concave bank is the curved concave section of a river channel. It is usually subject to water erosion, whereas the water is deep, and the flow velocity is high.

Concentration Zone of Natural Tourism Resources Resources of nature-based tourism have specific formation conditions and stages of historical evolution that affect their distribution. They can be relatively concentrated or dispersed. Concentration zones are areas where the resources are more concentrated. Natural resources are generally richer along coasts, rivers, and in areas between basins and mountains. Examples are China's coastal and island nature-based tourism resources concentration zones, the Daxing'anling- Taihangshan - Wushan - Wulingshan concentration zone, Yangtze River concentration zone and Yellow River concentration zone.

Concretion; Nodule A concretion is a type of nodule in sedimentary rocks with a composition different from that of the surrounding rocks. Nodules have different sizes and shapes. They are usually spheroidal, ovoid or irregular, and they can range in size from a few centimetres to several metres. Nodules can be distributed intermittently along a layer or spread through different layers. Common nodules include calcareous nodules, ferrous nodules and siliceous nodules (Fig. 44).

Conformity Continuous sedimentation results in no prolonged gaps in time between rock strata and no loss of the evidence of biological evolution. This type of bedding surface is called a conformity and can be used to determine occurrence of major events or tectonic movements during the sedimentation process.

Conghua Hot Spring landscape Conghua Hot Spring is also known as Liuxihe (Flowing River) Hot Spring, and it is one of the few springs in the world with radon-containing soda. It is located northwest of Conghua city in Guangdong Province, 75 km from Guangzhou. It is one of the two radon-containing soda springs in the world along with a hot spring in Switzerland. The spring flows from the bottom of the Liuxihe River at a dozen locations along the banks. The spring water is crystal clear without any colour or odour. The spring temperature varies from approximately 36–71 °C.



Fig. 44 Nodule



Fig. 45 Conghua Hot Spring landscape, Guangdong Province

The water has therapeutic effects on various diseases related to arthritis, the skin, digestive organs and nervous system. This spring was developed for use during the Ming and Qing Dynasties, and it has become world-famous for its excellent water quality, high temperature and spectacular scenery (Fig. 45).

Conglomerate Conglomerate is a clastic rock containing round or sub-rounded gravels with diameters greater than 2 mm, which make up more than 30% of the rock mass. Conglomerates form due to localised environmental changes during deposition. Conglomerates with different causes of formation have clear differences in the particle shape, size distribution, composition, maturity, roundness characteristics and spatial arrangement. The clastic components in conglomerate are mainly detritus, whereas the materials that fill the gaps are sand, silt, clay and some chemical sediments. Based on the size of the gravels, conglomerates can be divided into boulders, cobbles, pebbles and fine gravel conglomerates.

Coniferous Forest ▶ Needle-Leaf Forest

Consequent River This is a river system where the direction of flow follows the general

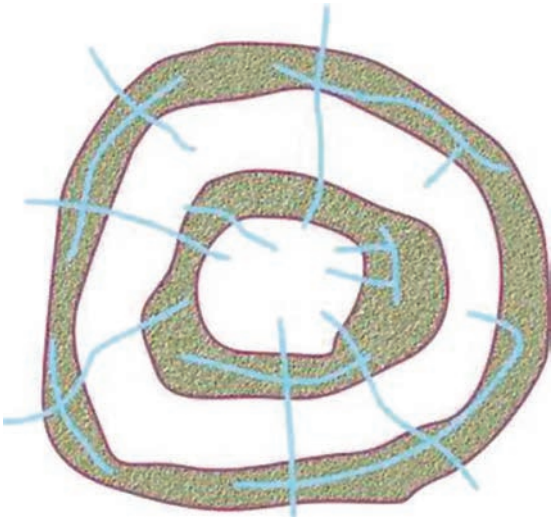


Fig. 46 Diagram of a consequent river

direction of the ground. For example, a flow in a direction directly related to the original dip, a radial flow controlled by a geological structure and a converging flow towards a basin centre are all consequent rivers. Likewise, the streams that have developed into a radial water system on the granite body in Huangshan Mountain are all consequent streams (Fig. 46).

Contact Metasomatic Metamorphism See ▶ Thermal contact metamorphism

Continental Climate Continental climates occur in mid-latitude continental hinterlands, where the effects of the ocean are minimal. Most of these areas have arid and semi-arid climates. The intensity of solar radiation is high. If the region is in a temperate zone, the winters are cold, and the summers are hot. The seasonal and daily temperature variations are large, and the spring temperatures are higher than the autumn temperatures. Precipitation is low and varies significantly seasonally. The climate is usually dry.

Continental Drift Hypothesis This hypothesis postulates that all of the present continents formed a unified Pangea (pan-continent) that began to split in the Middle Mesozoic (or Permian) Era and drifted long distances to their present locations. This hypothesis is supported by evidence from the morphology of continental margins, lithologies and rock facies, geological structure, fauna and flora, glaciers, palaeoclimate and geophysical characteristics. These data have revealed that continental drift has occurred in two main directions: towards the equator and westward. The hypothesis postulates that the mechanism of continental drift is the movement of the silica-aluminium-rich layer (sial) on top of the silica-magnesium-rich layer (sima). It is widely accepted that the lithosphere is drifting above the asthenosphere, as supported by the seafloor spreading and plate tectonics hypothesis.

Continental Facies ▶ Terrestrial Facies

Continental Glacier Continental glaciers are glaciers in arid inland regions. In these areas, the precipitation is low (less than a few hundred mm), and the snowline is relatively high. The ice temperature is low (−8 to −10 °C), and the glacier movement is characterised by internal surface deformation of ice crystals. The glacier bottom is frozen, and so glacial erosion is rapid. The glacier moves slowly in a stable manner.

Continental Nucleus A continental nucleus is the central part of a continental block. Its surface is similar to a dome with gentle slopes and is relatively stable. It often contains large basement rocks (mainly the old metamorphic Pre-Sinian System), the outcrops of which are often surrounded by platforms covered by marine continental margin deposits. In plate tectonics, the continental nucleus is also called a land shield or shield, and in the literature, it is often called a craton.

Convention Concerning the Protection of the World Cultural and Natural Heritage This is also called the 'World Heritage Convention' and was adopted by the 17th Session of the UNESCO General Conference in Paris in 1972. The convention went into force in 1975 with the establishment of the 'World Heritage List'. Its governing body is the UNESCO World Heritage Committee. Natural heritage is defined as the natural features on Earth, including non-biological and biological elements that have prominent universal aesthetic or scientific values. These may include geological and geomorphological features, endangered animal and plant habitat areas, well-defined natural sites and exceptional or well-defined natural areas

of outstanding beauty or with universal scientific and conservation values. Cultural heritage is defined as cultural relics, monuments and inscriptions of the highest universal value from a historical, artistic or scientific point of view. These include archaeological compositions or structures, inscriptions, caves, consortia, and monolithic or connected buildings of a strikingly universal value in terms of architecture, distribution or integration with the environment from a historical, artistic or scientific point of view. They can also include ruins and human engineering or integrated human-natural projects with high historical, aesthetic, ethnological or anthropological significance. The convention includes provisions for each country to determine its own protection measures for cultural and natural heritage in its own territory and submit a list of properties for review and approval by the World Heritage Committee on a regular basis.

Convention on Biological Diversity This was an international convention convened by the United Nations Environment Program in the first Intergovernmental Negotiating Committee on 1 June 1992 to protect the biodiversity of the Earth. The convention was adopted in Nairobi and signed by the signatories on 5 June 1992 at the United Nations Conference on Environment and Development in Rio de Janeiro, Brazil. China signed the convention on 11 June 1992 and ratified it on 7 November 1992. The convention stipulates that 'biological diversity' refers to the variability in living organisms from all sources, including terrestrial, marine and other aquatic ecosystems, with the ecological complexes they comprise, including the ecosystems and biodiversity within and between species.

Convention on Wetlands of International Importance Especially as Waterfowl Habitat The Convention on Wetlands of International Importance Especially as Waterfowl Habitat was signed in 1971 in Ramsar, Iran. It was revised by the Paris Protocol in 1982. The convention stipulates that wetlands are temporary or permanent, natural or man-made, brackish or non-brackish water bodies with stagnant water or little water movement, such as swamps, wetlands, peatlands and watersheds. They are usually not more than 6 m deep at low tide.

Convention Tourism Convention tourism is a form of tourism that focuses on attending conferences. It has one of the following three features: (1) the meeting is an attraction for a large group of tourists; (2) the convention is a medium for touring, and its participants come for travel and leisure as well as communicating, exchanging and solving problems; and (3) the convention is a part of the business of tourism companies that undertake the planning, receptions and other services after the meeting. Convention tourism is an important product of tourism operators.

Convex Bank The convex bank is the curved convex section of a river channel. The flow velocity is much lower, and so the sediments tend to accumulate on the convex shore (Fig. 47).

Cool Current A cool current is an ocean current with a water temperature lower than the surrounding sea. Most cool currents flow from high latitudes to mid-low latitudes and are characterised by low temperatures, low salt contents, high oxygen and nutrient contents and large amounts of plankton. When cold water flows through the warmer ocean, fog can easily form, causing navigation unsafe. In coastal areas where the cool currents flow past,

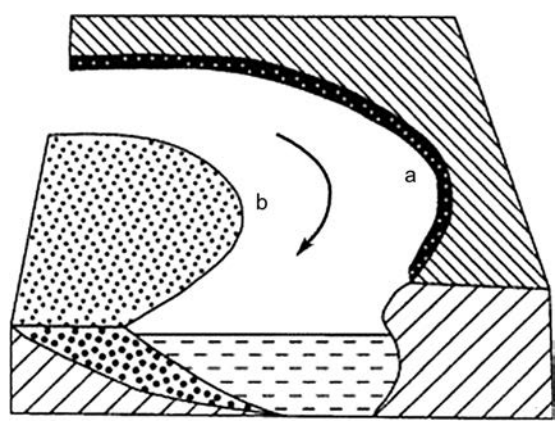


Fig. 47 Concave bank and convex bank; the arrow indicates the flow direction. (**a**) concave bank; (**b**) convex bank

water moves upward and brings nutrients to the surface. Because of their high oxygen contents, these areas are excellent breeding grounds for fish and marine life.

Copper Coast Global Geopark, Ireland The Copper Coast Geopark became a global geopark in 2004. It is located on the southeastern coast of Ireland. Extensive black shale and evidence of two volcanic eruptions can be found in the area. The ancient volcanoes were later covered by marine sediments and organic debris, which include the very rich fossil-bearing limestone. Annestown, a pretty village with a nice beach, also has one of the largest sea arches in Ireland. The rugged coastline, which includes a string of small coves, caves and harbours, as well as the forests, rivers, bogs and lakes make the area an attractive tourist destination. Other attractions, including tombs and monuments dating back as far as 5,000 years as well as medieval mines, kilns, castles and churches, can be found along the beach and in the old villages in the area.

Coral The term coral gem mainly refers to gem-grade red coral. Coral is a coelenterate that secretes lime (calcite) during the growth process to construct their bodies. To obtain food and sunlight, corals form dendritic groups. Its chemical composition is $CaCO_3$, and it is composed of microcrystalline calcite aggregates. Coral is generally white and can also be red, pink or orange red. There are also rare black and blue corals. Red coral with a translucent waxy lustre and a fine texture is considered a high-quality gem (Fig. 48).



Fig. 48 Red coral

Coral Fossil Corals are a marine invertebrate Coelenterata. The class Anthozoa includes Rugosa, Heterocorallia, Hexacorallia, Octocorallia and tabulate corals. Coral larvae are originally white and then turn red when the iron in the sea water they absorb is transmitted into the shell. After their death, corals and the sea bed materials transform into fossils through the fossilisation process (Fig. 49).

Coral Reef Ecological Landscape This is a type of ecological landscape under the water with coral reefs as the main feature. Coral reefs are built from colonies of dead stony corals, and they are composed of cohesive biological skeletons and loose clastic sediments. They provide a base for many marine species to live. Because the coral reef is a stable environment and has adequate sunlight, it facilitates the formation of a unique marine environment that is different from the surroundings. It is home to many benthos on the sediment surface and in the subsurface layers, and it is a zone of biodiversity. Coral reefs are mainly located in the tropical waters of the Indo-Pacific region (including the Red Sea, Indian Ocean, Southeast Asia and Pacific Ocean). Australia's Great Barrier Reef is the world's largest coral reef ecological landscape (Fig. 50).

Coral Reef Landscape This is a landscape consisting of reef structures in a marine environment composed of accumulated calcareous remains of reef-building corals and biological remains of lime algae. Coral reefs mainly consist of coral polyps, which are a marine coelenterate. During their growth, they absorb calcium and carbon dioxide in seawater and secrete calcium carbonate to form shells for their survival. Each polyp is only the size of a rice grain. They gather in groups to form a

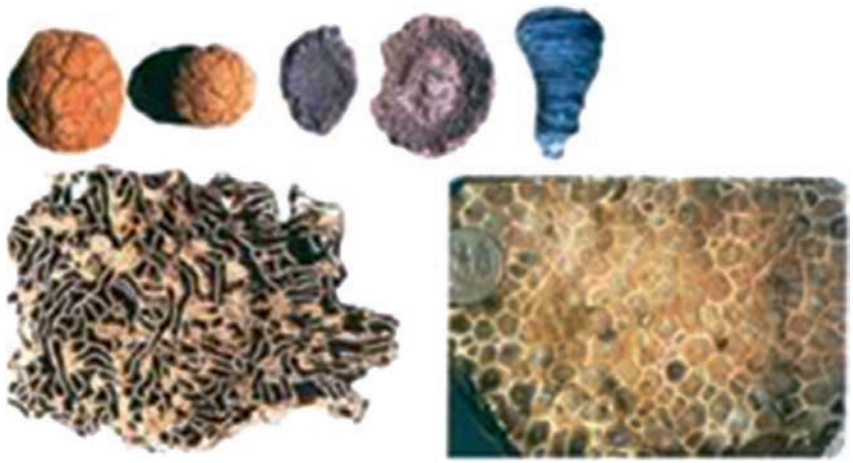


Fig. 49 Coral fossils



Fig. 50 Coral reef ecological landscape

colony and bond together with the secreted calcium carbonate over many generations. When compacted and petrified, the calcium carbonate forms islands or coral reefs. They are common in the oceans between 30° N and 30° S latitude; in particular, there are many in the central and western Pacific. Based on the morphology, coral reefs can be divided into fringing reefs (coastal reefs), barrier reefs, atolls, table reefs and the transitional types. The world's coral reefs and coral islands have an estimated total surface area of 10 million km^2. In general, the growth rate of a coral reef is approximately 2.5 cm per year (Fig. 51).

Coral Reef Tourism Landscape Coral reef landscapes have high tourism value. Coral reefs are calcareous structures that accumulate due to reef-building organisms, such as corals and



Fig. 51 Coral reef landscape

calcareous algae. They are mainly located in tropical and subtropical regions with moderate salinity shallow waters, and large reefs form on the continental shelves and shallow waters as coral reefs and islands. They can be divided into three main types: fringing reefs, barrier reefs and atolls. These islands usually have lush tropical forests, and the scenery is so magnificent that they look like pearls in the ocean. Some have become famous international tourism sites, such as the Great Barrier Reef in Australia and China's Xisha and Nansha Islands.

Cordierite Cordierite is a rock-forming mineral with the composition $Al_3(Mg,Fe)_2[Si_5AlO_{18}]$. It belongs to the orthorhombic crystal system. The crystals have a prismatic form, and crystal twinning is common. The aggregates are blocky and granular. Its colour is light blue, light yellow, grey or brown, and it often has several distinct tones. It has colourless streaks, transparent to translucent diaphaneity, a vitreous lustre, a specific gravity of 2.53–2.78, a Mohs hardness of 7–7.5 and conchoidal fractures. It is a metamorphic mineral that forms in metamorphosed rocks rich in aluminium and magnesium. It is commonly found in hornstone and sometimes in crystalline schist. Cordierite with beautiful colours can be used as carving materials.

Cosmic Space Tourism Resource System The Earth is a part of the solar system, and the solar system is one of the planet systems in the Milky Way galaxy. The Milky Way and other galaxies make up the universe. With the rapid advancement of modern science and technology since the 1950s, human activities have extended into the universe after the first landing on the Moon. Currently, humans are working towards landing on Venus. Therefore, tourist interests have been increasing. They include areas such as space, celestial bodies and different kinds of astronomical phenomena that form the important cosmic space tourism resource system.

Cover A cover, or a sedimentary cover, is the sedimentary rock above an angular unconformity on top of the crystalline basement. The sedimentary rock is not significantly deformed or metamorphosed. The sedimentary cover

forms during the stable development stage of the crustal movement. It is mainly composed of shallow marine sediments, and the deposited layers are generally not thick. The lithofacies changes are minimal. The cover has not experienced deformation or metamorphism, and magmatic activity is rare.

Crag and Tail Landscape When a glacier flows through a large mass of bedrock, the ice cannot entirely cover the mound, and the top is exposed above the ice. The mound surface facing the on-coming ice is subject to strong abrasion, and the lee accumulates glacial moraines with a long tail. The entire feature looks like a nose; hence, it is called a nose-hill-and-tail or a crag and tail landscape.

Crater Lake Landscape This is a lake landscape of craters or calderas that are filled with precipitation or groundwater to form lakes. The water can also sometimes be derived from the underground magma. Crater lake water usually contains more acidic materials and minerals, which cause the lake water to become acidic and have unique colours. Crater lakes are generally located at the tops of volcanoes, and they can form at lower elevations when the cone is eroded. Tianchi at Changbai Mountain and Huguangyan in Zhanjiang Province are famous crater lakes (Fig. 52).

Crater Landscape This is a type of volcanic landscape composed of the sunken portion of the upper part of a volcanic vent as described by M.P. Billings. Craters have become important tourist attractions. The Heilongshan crater in Wudalianchi is a mountain top crater that erupted at least 280 years ago, and the Fenglu Ridge crater in Haikou formed during an eruption more than 8,000 years ago (Fig. 53).

Craton A craton is a tectonic unit that has remained stable and has not experienced intense deformation since the Precambrian Period (540 million years ago) or the Pre-Nanhuan Period (800 million years ago). Cratons are similar to the 'ancient continental platforms' of the geosyncline-platform theory. A craton generally has a 'binary structure', which implies that it is composed of a crystalline basement formed from strong magmatic activity and metamorphism, and a sedimentary cover above an unconformity that has not experienced deformation or metamorphism. The term craton generally refers to all forms of ancient land over geologic history, particularly the ancient Canadian Shield and the Baltic Shield. In China, related terms such as 'Ghiangnania' and 'Cathaysia' have been proposed and are pending further determination. The term palaeocontinent is also translated into Chinese as having a similar meaning as craton, but this term has more stringent implications for its crustal nature.

Crescent Moon Spring landscape This is a landscape consisting of a spring in quicksand

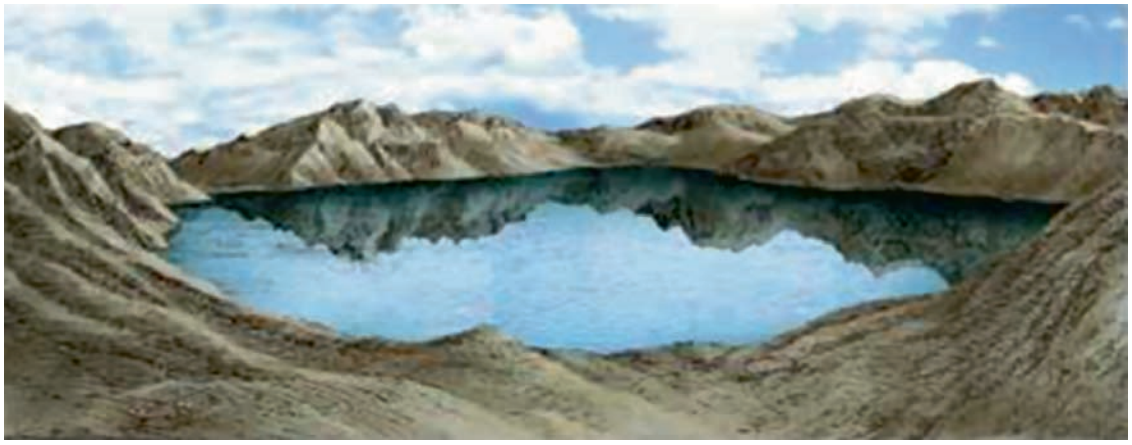


Fig. 52 Tianchi in Changbai Mountain

that is located 5 km southwest of Dunhuang in Gansu Province, west of the Hexi Corridor. It was formerly called Shajing (Sandy Well), and the locals also called it a medicine spring. It has been one of the 'Dunhuang's Eight Sceneries' since the Han Dynasty and was given the name 'Clear and Bright Crescent Moon Spring' at that time. This spring extends north-south for approximately 100 m and has an east-west width of 25 m. The eastern portion is deep, while the western portion is shallow. The maximum depth is approximately 5 m. The spring is shaped like a crescent moon, which is the origin of its name, and has also been called the 'top spring of the desert'. The spring is in quicksand and never dries up or, is sometimes covered by sand. The scenery is spectacular, and it has become a popular tourist destination (Fig. 54).



Fig. 53 Fenglu Ridge volcano landscape, Haikou

Cretaceous Period The Cretaceous Period is the last period of the Mesozoic Era. It lasted for 80 million years, from 145.5 to 65.5 million years ago. The Cretaceous System includes the rocks which were formed during the Cretaceous Period. The name comes from the chalk cliffs along the English Channel. Chalk is a white, soft, fine calcium carbonate deposit composed of calcareous pleurochrysis and planktonic foraminifera. Plants went through tremendous changes in the late Cretaceous Epoch as angiosperms gradually replaced gymnosperms and became the main phyla of terrestrial plants. Both marine and terrestrial invertebrates flourished, reptiles continued to develop, and birds emerged and developed. However, by the end of the Cretaceous Period, large reptiles (such as dinosaurs) experienced mass extinction due to catastrophic events, ending their 180-million-year rule of the planet. In China, the Cretaceous



Fig. 54 Crescent Moon Spring landscape in Dunhuang, Gansu Province

palaeogeographical pattern was similar to that of the Jurassic Period, while a large part of Tibet, the East Kala Kunlun, the southern margin of Kunlun and the western margin of Tarim in western China, Taiwan Island and the area around the Wusuli River in northeast China were submerged by the sea, other regions were land areas with mountain ranges, plateaus and basins. Currently, the international Cretaceous System is divided into two series and 12 stages. In China, the Cretaceous System includes both marine and terrestrial facies. The Upper Cretaceous Series terrestrial red glutenite is the base material for the formation of the 'Danxia landform Landscape'.

Crinoid Fossils Crinoids are marine echinoderms (phylum Echinodermata). The name comes from the Greek word krinon, which means 'a lily', and the Chinese name 'sea lilies' comes from its appearance. It is not a plant but rather an echinoderm. A complete crinoid fossil comprises three parts: a crown, a stem and roots. The crown, which is composed of the calyx and the wrist (arms), looks like the calyx and petals of a flower. The calyx is the main part of a crinoid and is composed of calcium carbonate plates. The calyx is crucial for identifying crinoids. It is often globular or cup-shaped with a few overlapping calcareous plates. Because crinoids are marine animals, they first appeared in the Ordovician, flourished in the Silurian and reached their peak in the Carboniferous.

Crocidolite Crocidolite is an asbestos mineral that can be used as a gem. It has a Mohs hardness of five and a specific gravity of 3.02–3.42 g/cm^3. It transforms into petrified wood when subject to SiO_2 metasomatism, and its hardness will increase to 7, but the specific gravity will decrease to 2.64–2.71. Crocidolite can be brownish yellow, reddish brown, grey blue or maroon, has a fine and tough texture, a fibrous structure and silky lustre. A beautiful cat's eye effect can be achieved through parallel cutting. Therefore, it is a popular raw material for making blue asbestos cat's eye gems (Fig. 55).

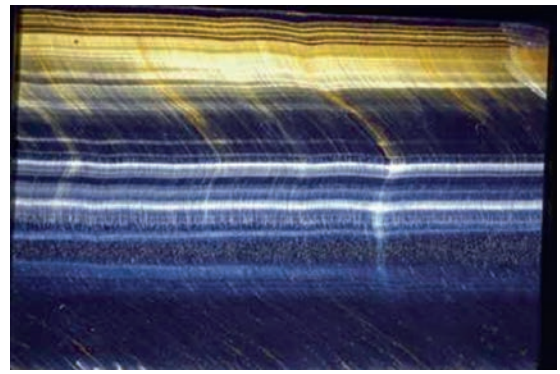


Fig. 55 Crocidolite



Fig. 56 Crocodilia

Crocodilia or Crocodiles Crocodilia, or crocodiles, is the only Archosauria that has survived to the present day. It has a primitive skull, flat body, long nose and abundant sharp cone-shaped teeth. Its skull is also marked with conspicuous pit and ridge patterns. Most of China's crocodile fossils are skulls. The main examples are the Jurassic Shantugosuchus and Sichuanosuchus and the Palaeogene Malayan crocodile (Fig. 56).

Cross Wall Landscape *Synonym:* ► *Ice bar;* ► *Riegel landscape*
This is a landscape composed of transverse ridges in a glacial valley. When a glacier flows along a U-shaped valley and meets a projection or hard bedrock on the valley floor, the glacier will slip over the obstacle. When the ice melts, a transverse rock ridge will lie across the valley floor or protrude into the valley from one side. This ridge or bar may be a few dozen metres to several hundreds of metres high. Most cross walls cause the valley floor to look like terraces, and so these cross walls are also called 'glacial terraces' (Fig. 57).

Cross-Bedding Cross-bedding is a layering that forms in sedimentary media due to fluid flow, and it is composed of a series of layers that dip at an angle to the main bedding plane. The inclined layers can cut through, cross or overlap each other. Based on the shapes, relations and properties of the inclined layers and the upper and lower interfaces, cross-bedding can be divided into wedge cross-bedding, trough cross-bedding, planar cross-bedding and other flowing-water type cross-bedding (Fig. 58).

Crust ► Earth's Crust

Crustal Movement Crustal movements cause the deformation and displacement of crustal rocks, including structural changes induced by the internal dynamics of the Earth and non-structural changes (such as effects of gravity, diagenesis, glaciers, chemical action and biological action). Based on the characteristics of the deformation, crustal movements can be divided into folding and faulting. According to the mode of movement and the resulting features, crustal movements can be categorised as mountain building (geosynclines become orogenic belts through inversion folding), epeirogenic movements (extensive uplift of land masses to form continents), and oscillatory movements (alternating uplift and subsidence). The study of crustal movement mainly focuses on the frequency, periods, nature, processes and modes, origin, and energy sources of crustal movements. The main common characteristics identified to date are as follows: (1) the dominance of horizontal movements; (2) the unique orientation of movements; (3) the periodicity of movements; (4) the global distribution of movements; (5) the universality of movements; (6) the continuity of movements; and (7) the regenerating nature of movements. There are several hypotheses for the origin of crustal movement, such as heat convection, thermal plumes, and the Earth's



Fig. 57 Cross wall landscape at Shimenjian, Lushan Mountain, Jiangxi



Fig. 58 Cross-bedding

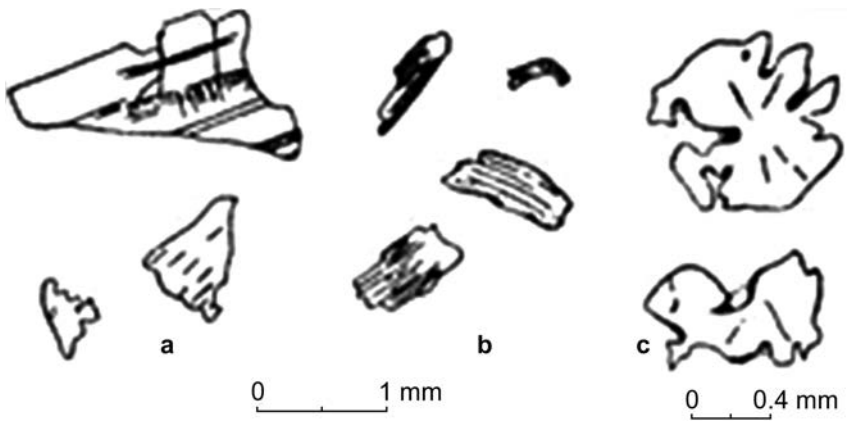


Fig. 59 Morphologies of various crystal fragments (a, b – after Tan Rongsen; c – after Sun Shanping, Wang Xiaoming, 1964). (**a**). Feldspar crystal fragment; (**b**). biotite crystal fragment with curving and darkening; (**c**). quartz crystal fragment with signs of erosion

rotation. All of these hypotheses accept that the movement of the crust, which has an average thickness of 30 km and can reach 70 km, is related to the deep geologic activity and is limited by energy conversion between various fields (such as mechanical, thermal and radiation fields).

Cryptozoic Eon ► Pre-Phanerozoic Eon

Crystal See ► *Crystalline substance*

Crystal Face A crystal face is a flat surface that bounds a crystal during the crystal growth process. A crystal face is essentially a smooth and flat plane, but in detail, there are a variety of crystal surface patterns with irregular shapes. The crystal face is essentially the outermost layer of the lattice.

Crystal Fragment A crystal fragment is a fragment that forms when crystalline minerals explode in a magma chamber or during the process of magma ascent (Fig. 59).

Crystalline Basement Crystalline basement is the basal rock beneath the undeformed and unmetamorphosed sedimentary cover. It has a complex structure and has experienced magmatic activity and strong metamorphism. It contains strong evidence of intense crustal movement.

Crystalline Substance A crystalline substance is a solid substance composed of atoms or ions that are periodically repeated in the three-dimensional space. Crystalline substances are substances that contain crystals. All crystals spontaneously grow with the inherent characteristics of a geometrical polyhedron, but many crystals are limited by the external conditions during the growth process and therefore do not necessarily have the regular shape of the geometric polyhedron. When crystallisation starts earlier in a free space or when a mineral has a stronger crystallization growth ability, more

perfect geometrical polyhedron, called euhedral crystals, would be formed. Some crystals do not have perfect geometric polyhedron shapes, and they are called subhedral crystals.

Cuesta (Monoclinal Mountain) Cuestas develop in mountainous areas with monoclinic structures. A monocline is a damaged limb of an anticline or syncline. A cuesta is characterised by mountain features oriented along the trend of the strata and has two asymmetrical slopes; one is steep and short, and the other is gentle and long. The steep face is the front slope, and the bedding is nearly vertical. The back slope is a gentle slope, and it runs parallel to and conforms to the regional dip (Fig. 60).

Cuihuashan Avalanche Relics Landscape Cuihuashan is a part of the Qinling Mountains that is composed of the Middle Proterozoic (1,000 million years ago) metamorphic rocks. A large active fault is located along the northern foothills of the Qinling Mountains. The northern side of this fault has subsided to form the Guangzhong Plain. Its southern side has been uplifted, causing the formation of the towering Qinling Mountains. Over the past 10,000 years, the uplift rate was 34–173 mm/year. Due to the severe fracturing, the brittle and hard nature of the rock of Mount Cuihua and the occurrence of torrential rain, landslides are common and have resulted in the accumulation of a collapsed mass with a volume of 300 million cubic metres at Cuihuashan and the formation of features such as rugged peaks, broken cliffs, collapse block fields and landslide dams (Tianchi) (Fig. 61).

Cuihuashan Landslides National Geopark, Shanxi This geopark is located in Chang'an County, Xi'an, Shaanxi Province, 30 km from Xi'an City. It is a branch of the Zhongnanshan in the Qinling Mountains. It became a national geopark in 2001. The main features of interest are landslide-related geological features. Cuihuashan is in the Qinling Mountains and is composed of Meso-Proterozoic migmatite that were formed due to metamorphism. It contains a large migmatite complex with faults of various types, and it is a natural laboratory for studying migmatite complexes and metamorphism. The intense fracturing, brittleness of the rocks and location in a seismic zone led to the collapse of the mountain, forming a series of impressive landslide features, including landslide cliffs, rock block fields, stacked caves, dammed lakes, rock flow, and other unique rock features. These features are well-preserved and rare in China. Therefore, Cuihuashan is known as 'China's landslide and landform museum'. It is of great scientific value for studying the formation of Qinling and the Guanzhong Plains and the roles of landslide in their evolution.

Cultural Factors of Landscape Formation Humans play a significant role in shaping the Earth's



Fig. 60 Cuesta

surface. The factors include production, living, resource development, water conservancy projects, road building, and urban and rural construction, which have profoundly changed the natural environment and landscape.

Cultural Geography Cultural geography is a branch of geography that studies the temporal and spatial changes in cultural features and their relationships to environmental factors. By focusing on the interactive relationship between the cultural and geographical environments, it studies the role of the natural geographical environment on cultural development as well as the influence of human cultural effects on the natural geographical environment. It is one of the areas of human geography.

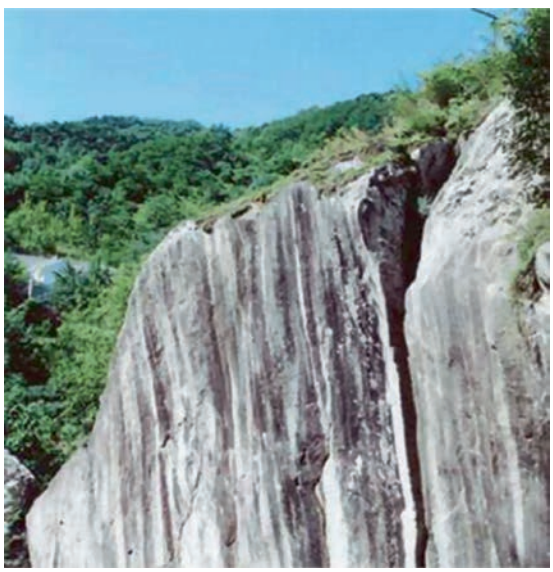


Fig. 61 Landscape of a cliff formed after the Mount Cuihuashan avalanche

Cultural Karst Cave Site Landscape Karst caves may contain ancient human and ancient vertebrate fossils, as well as stone and bone tools used by them, and also ashes or other traces of activity. These cultural karst caves have an important scientific research value. China has many caves with fossils of Neogene to late Holocene cave men in both the north and south. The Beijing ape-man (now called Peking Man or *Homo erectus pekinensis*), which was found in Zhoukoudian in Beijing, is the most well-known (Figs. 62, 63).

Cultural Landscape A cultural landscape is also known as the human landscape. It is the result of human activities in a specific area that reflects the characteristics of the cultural system and the geographical features of a region. From the perspective of earth science, a cultural landscape refers to a complex of cultural phenomena composed of buildings, villages, factories, mines, cities, transportation tools, roads, people and costumes on the background of the natural



Fig. 62 Peking Man site at Zhoukoudian, Beijing



Fig. 63 Wall calligraphy from the Ming Dynasty inside a karst cave in Guilin, Guangxi Province

landscape. The term 'cultural landscape' has been used universally since the 1920s. In 1925, C.D. Sauer pointed out in his publication 'The Morphology of Landscape' that cultural landscape is the result of human culture's effects on the natural landscape and advocated for studying cultural geography through cultural landscape. The 16th World Heritage Committee proposed that cultural landscape should be a category of world heritage, which would include three major categories: (1) the landscapes designed and created on purpose by man; (2) the organically evolved landscapes; and (3) the associative cultural ladscapes.

Cultural Landscape Category as World Cultural Heritage A cultural landscape, which falls under the category of cultural heritage, refers to the cultural properties that 'represent the combined works of nature and of man' described in Article 1 of the World Heritage Convention. This definition was accepted at the 16th session of the World Heritage Committee of the UNESCO in Santa Fe, U.S.A., in December 1992 and implemented in 1993. The World Heritage Advisory Committee classifies cultural landscapes into three types: (1) landscapes designed and created intentionally by man; (2) 'organically evolved landscapes'; and (3) 'associative cultural landscapes'. Cultural landscapes, which focus on expressing the natural flow and social evolution of the harmonious relationship between man and land, can be good examples for understanding the relationship between humans and the land.

Cultural Landscape Resources of Famous Mountains This is a landscape comprising mountains renowned for their scenery, Buddhism and Taoism. China has many famous mountains, of which the Five Mountains rank first, whereas each of them has distinctive scenery, such as Taishan's majesty, Huashan's steepness, Southern Hengshan's clouds and mist, Northern Hengshan's ruggedness and Songshan's elegance. In addition, the Huangshan Mountain has long been famous for its distinctive pines, unique rocks, sea of clouds and hot springs. China's famous mountains have long been places of worship for Buddhists and Taoists, and some were given their names to facilitate Buddhism and Taoism practices, such as the Gold Wutai Mountain, Silver Putuo Mountain, Copper Emei Mountain and Iron Jiuhua Mountain, which are associated with Buddhism, and Wudang Mountain, Qingcheng Mountain, Lungfu Mountain, Qiyun Mountain and Sanqing Mountain, which are associated with Taoism (Fig. 64).

Cultural Layer This is an archaeological term that refers to a depositional layer containing ancient human remains, traces and other associated materials. The relative ages can be detected based on the cultural remains and their stacking relationship. Each layer represents a specific period. The geological ages can be determined by C-14 dating, uranium dating, potassium-argon dating, palaeomagnetism dating and electron spin resonance dating methods. In addition to stone tools, fire remains, burnt bones, bone



Fig. 64 Panoramic view of Mount Wutaishan

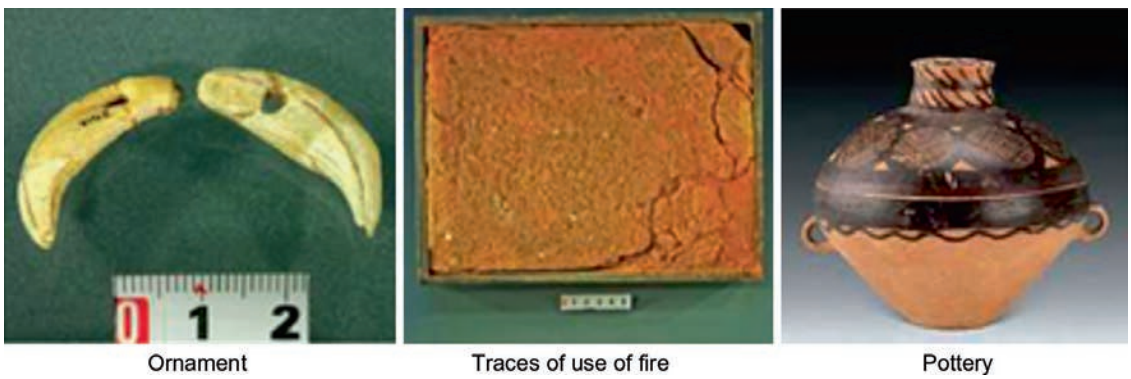


Fig. 65 (**a**) Ornament. (**b**) Traces of use of fire (**c**) Pottery

tools and food residue have also been discovered in the cultural layers. The Holocene cultural layer also contains pottery fragments, tombs and accessories. In later stages, copper, iron artefacts, bricks and tiles are also present. By studying the cultural layers, the ancient ecological environment and climatic conditions can be investigated to make comparison. These layers are also a type of tourism earth science resource (Fig. 65).

Cultural Tourism Cultural tourism is a type of tourism that focuses on understanding the local culture of an area. Cultural tourism is one of the trends of world tourism in the twentieth-first century.

Cultural Tourism Earth Science Resources This is a type of tourism earth science resource. Based on natural tourism resources, some cultural tourism earth science landscapes and sights have formed due to human activities. Examples are the Yungang Grottoes of Datong, Shanxi, the Dunhuang Grottoes in Gansu, the Maijishan Grottoes in Tianshui, the Longmen Grottoes in Luoyang, the Great Wall, as well as many other inscriptions and carvings. These tourist attractions tend to become a mixture of the cultural, geological and geomorphological aspects.

Cuprite The composition of cuprite is Cu_2O, and it contains 88.8% copper. It belongs to the isometric crystal system. The crystals are small octahedrons and are sometimes acicular or plumose. The aggregates are granular, blocky or earth-like. It is dark red and has an

adamantine or submetallic lustre, a specific gravity of 6.14, a Mohs hardness of 3.5–4 and conchoidal to uneven fractures. It forms in the oxidation zone of the copper deposits and coexists with native copper, malachite, azurite, chalcocite and iron oxides. Cuprite mineral ores with peculiar shapes can be good ornamental stones.

Curlstone Landscape Curlstones are curved dendritic travertine inside the karst caves. They are also called stone branches or spiral stalactites. A curlstone landscape is a scenery composed of these features. They are generally very delicate with diameters less than 1 mm. They can grow horizontally or curl upwards to form dendritic features. They are generally believed to be formed in connection with a process in which the calcium carbonate saturated water seeps slowly from cave cracks or the capillary pores of stalactites at such a slow rate that the effect of gravity is less than that of the surface tension, and subsequently the stone branches can grow haphazardly in every direction. Their formation is also believed to be related to the wind and microbial effects in the cave. Bama Crystal Palace, Guangxi Province, contains many stone branches. Furong Cave in Wulong, Chongqing City, has a large area of staghorn-like curlstones, the longest of which is 53 cm long. These features are rare in China and over the world (Fig. 66).

Curtain or Drapery Landscape This feature is also known as a cave mantle or a cave screen. The name comes from its appearance like a depositional curtain in a karst cave. When additional calcium carbonate- saturated water seeps out to the cave top, it flows over a large surface on the evenly sloping ceiling of the cave down the steep cave wall, and the calcium carbonate precipitates to form a curtain-like pleated flowstone (Fig. 67).

Cyrtospirifer Cyrtospirifer, also called large 'Swallow Stone', is a common traditional



Fig. 66 Curlstone landscape in Bama, Guangxi

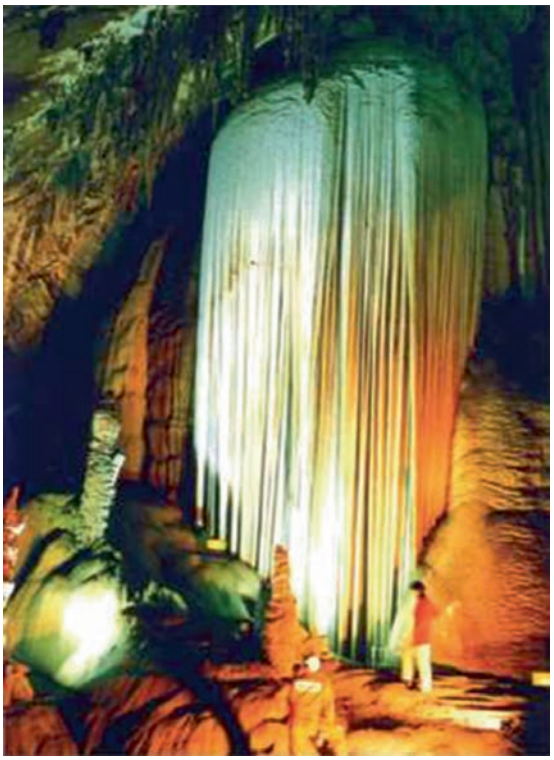


Fig. 67 Giant drapery landscape – Wolong Furong Cave, Chongqing

Chinese medicine. It is a type of fauna fossil composed of minerals such as calcite and aragonite. Cyrtospirifer fossils are mainly preserved in the Late Devonian strata and are widely distributed around the world. In China, Cyrtospirifers are mainly found in the limestone and mudstone in the Upper Devonian Xi Kuangshan (Tin Mining Hill) Formation in Hunan Province. They are also mined in the Upper Devonian marl, limestone and dolomite. Because of erosion, individual fossils are often scattered on the surface. Clusters of large and complete fossil pieces have a very ornamental value.

D

Dabashan National Geopark, Sichuan This geopark is located on the boundary between Xuanhan County in Dazhou City and Wanyuan City. It has an area of 218 km^2. In August 2009, the Ministry of Land and Resources approved it as one of the 5th group of national geoparks. It is characterised by karst landscapes and tectonic geology. The geopark contains many types of folds, such as large box folds and complex folds. The main karst features include gorges, karst caves, cliffs, pinnacles, peak clusters, dissolution basins, sprouts, dolines, vertical shafts and funnels.

Dabieshan (Huanggang) National Geopark, Hubei This geopark is located in Huanggang, Hubei, and has an area of 422 km^2. It became a national geopark in 2009. The main geological features are typical metamorphic stratigraphic sections and metamorphosed granite (TTG rock series), granite geomorphic landscapes, an ultra-high-pressure metamorphic belt, a mixed ophiolite complex, structural features and water landscapes. The geopark contains standard sections and outcrops of the Muzidian Formation, Dabieshan Group and Hong'an Group. The Archaean TTG rock type (approximately 2.8 billion years old) is the original granite in the Dabieshan area. The ultra-high-pressure metamorphic belt and the mixed ophiolite complex in Yangshuyan in Yingshan County form the boundary between the North China and South China plates.

Dachang Cassiterite-Polymetallic Sulphide (Sulphate) Deposit, Guangxi This is a world-class polymetallic tin ore field and is considered China's second tin capital. Located in Nandan County, Guangxi Province, the Dachang deposit is a mega-scale deposit of cassiterite-polymetallic sulphide (sulphate). It is one of China's large polymetallic tin ore bases and is one of the largest deposits of its kind in the world. The ore bodies are located in the Middle and Upper Devonian carbonaceous and siliceous fine clastic rocks. The long mining history of the deposit dates back to the Tang Dynasty, approximately 1,000 years ago. After nearly 40 years of exploration, the Guangxi Nonferrous Metals 215 Team made an excellent contribution by confirming the deposit as a mega-scale polymetallic tin ore field (Fig. 1).

Dadaituo Sinkhole Cluster Landscape in Pingtang, Guizhou This is a landscape of an extensive sinkhole and doline cluster located 16 km from Tangbian Town in Pingtang County. The cluster is in the Triassic carbonaceous rocks. The Dadaituo sinkhole is 547 m deep and has a north-south length of 1,830 m. Its bottom occupies an area of approximately 800,000 m^2. The sinkholes are approximately round and irregular, and they are surrounded by steep cliffs. The cave bottom has an exposed river channel approximately 2,000 m long with two inlets and one outlet. During flood periods, the sinkhole becomes a pool because the drainage capacity is inadequate. There is also a layer of soft mud and sand covered with reeds. At the sinkhole margin, where flood waters do not reach, there is a dense woodland that accommodates a group of active wild macaques. Along the Bawang River, 12 sinkholes form a sinkhole cluster with a depth of more than 300 m. They cover approximately 20 km^2 at elevations of 1,138–548 m. Approximately 10 km east of the sinkhole is the Dawodang doline, where the world's largest astronomical radio telescope has been constructed. There are also several doline clusters around the Dawodang doline. The Dadaituo sinkhole cluster and the Dawodang doline cluster combine to form the Pingtang sinkhole cluster in Guizhou Province, which covers an area over 100 km^2 (Fig. 2).

Dadu River Canyon National Geopark, Sichuan This geopark is located in Jinkouhe District, Leshan City, Sichuan Province.

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Fig. 1 Dachang cassiterite mine

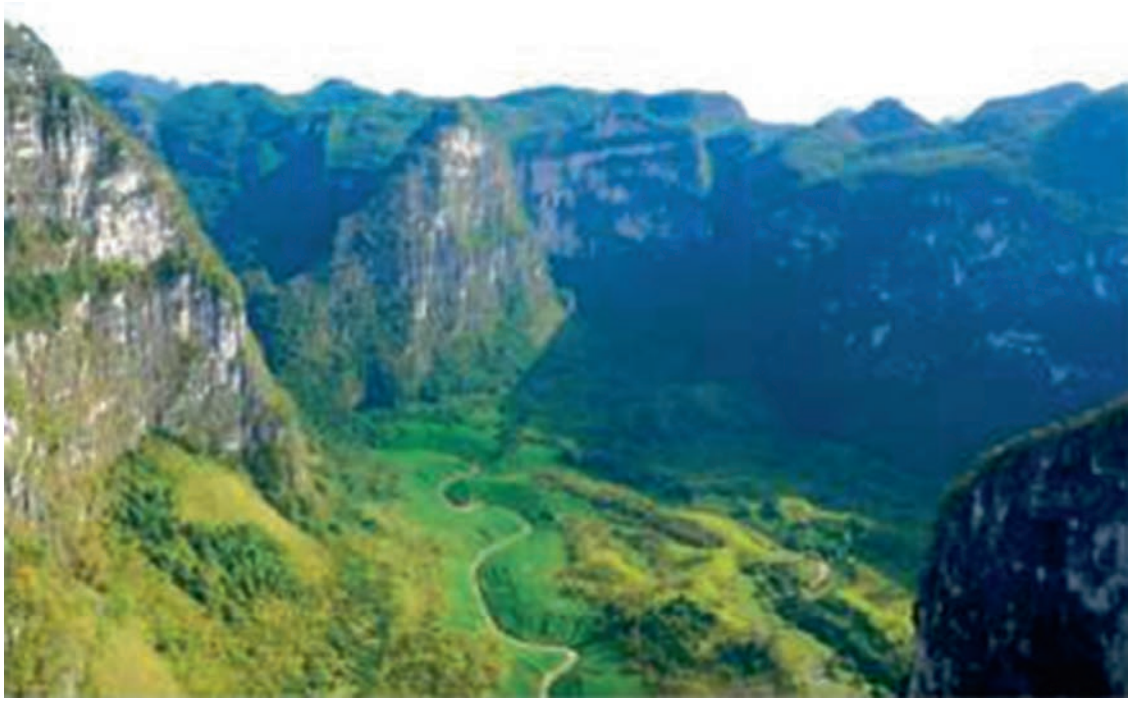


Fig. 2 Dadaituo sinkhole cluster landscape in Pingtang, Guizhou Province

It features Dadu River Grand Canyon and Davashan basalt geological features and was accredited as a national geopark in 2002. The Dadu River Grand Canyon is a typical eroded river gorge, with a length of 26 km, a valley width of 70–150 m, a local area of less than 50 m, a level difference of 1,000–1,500 m, and a maximum valley depth of 2,600 m. The valley cuts through geological sections that are several thousand metres thick and extend from the



Fig. 3 Large-scale open-pit mine of Dajiangping pyrite mine

former Sinian system to the Permian Emeishan basalts. These strata record hundreds of millions of years of geological evolution. Late Pleistocene glacial features, such as U-shaped valleys, horns, cirques and glacial lakes, are preserved on the surface of Dawa Mountain. Other geological relics include the Wuchi Ancient Glacial Landform, the Dingmugou Late Proterozoic to Permian stratigraphic section, the Yejiping crystal deposit, and multiple hydrogeological landscapes.

Dahua Qibainong National Geopark, Guangxi This geopark is located in Qibainong and Bansheng villages in the Dahua Yao Autonomous County, Guangxi Zhuang Autonomous Region. It became a national geopark in 2009. Its main geological features are karst peaks and clusters, depressions, gorges, caves and water landscapes. The park contains 2,566 deep and shallow depressions; with an average of 5.28 depressions per km^2, the area is the world's densest cluster of depressions. Banlan Gorge, which has steep slopes and high peaks, is dangerous to hike. The Disu underground stream has 15 tributaries and can be considered a super underground stream.

Dajiangping pyrite deposit, Yunfu, Guangdong This is a mega-scale pyrite deposit with large reserves and high-quality pyrite ores. Located in Yunfu County, western Guangdong Province, the Dajiangping pyrite deposit is composed of five ore bodies, which are lamellar and quasi-lamellar and are surrounded by homogeneous rocks. The ore-rich section of the deposit looks like a large lens. Geological surveys show that the pyrite reserves amount to more than 200 million tons. The ores are mainly pyrite with small amounts of other minerals, such as pyrrhotite, galena, and sphalerite. The ore bodies are shallow, and so most of the mines are opencast mines (Fig. 3).

Dajinhu National Geopark, Fujian See ► Taining Global Geopark, China

Dali Man Site The Dali Man site is a site of ancient human fossils located in Jiefang Village in Duanjia Town, Dali County, Shaanxi Province. It was discovered in 1978, and the excavated fossil bones are relatively complete. The skull and other features of the Dali Man indicate that it is between *Homo erectus* and *Homo sapiens*, and its characteristics are consistent with those of the early *Homo sapiens*. The Dali Man may be an initial stage of early Homo or a transitional type of Homo erectus. In the strata containing human skull fossils, 564 pieces of stone artefacts were found. They include stone cores, stone flakes, scrapers, a sharp-tipped spike, stone cones and carving tools. The artefacts date from the late stage of the Middle Pleistocene to the Late Pleistocene. Uranium dating indicates that the



Fig. 4 Dali Man excavation site

11th layer, which contains human fossils, is approximately 180,000–230,000 years old (Fig. 4).

Dali Mount Cangshan National Geopark, Yunnan Dali Mount Cangshan National Geopark is located in the area bordering Dali, Yangpi and Eryuan in the Bai Autonomous Prefecture, Yunnan. In August 2005, it was approved by the Ministry of Land and Resources as one of the third group of national geoparks. Cangshan mainly has remnants of Quaternary glaciers, metamorphic relics, tectonic features, hybrid granite peaks, forest landscapes, gorges, streams, waterfalls and marble landscapes. Huadian Dam has karst landforms and alpine meadows. Canyon landforms dominate the Baizhangyan Bridge and the Shimenguan Pass.

Dalian Bingyugou National Geopark, Liaoning Dalian (Liaoning) Bingyugou National Geopark is located in the northern part of Xianrendong Town, 49 km from Dalian City. It was included by the Ministry of Land and Resources in the fourth group of national geoparks in August 2005. It contains more than 70 geosites scattered throughout five scenic areas. With a geological landscape dominated by Proterozoic quartzite, this geopark contains typical pillar-like quartzites, quartzite caves, rivers (a cruise service is available) and ancient glaciers.

Dalian Coast National Geopark, Liaoning This geopark is located along the southern coast of Dalian City, Liaoning Province. It was designated as one of the fourth group of national geoparks by the Ministry of Land and Resources in August 2005. The geopark features marine erosion landscapes composed of Proterozoic and early Palaeozoic carbonate rocks. Its main geological landscapes include stratigraphic sections, typical faults, folds, ductile shear zones, sea cliffs, sea stacks, sea caves, sand bars, lagoons, sedimentary structures and trilobite fossils.

Dammed Lake Landscape ▶ Barrier Lake Landscape

Dammed Lake Tourism Landscape These are lakes that are formed through damming of a river by gravitational deposition associated with volcanic eruptions, landslides and debris flows. Typical examples are the Wudalianchi Lake and Mirror Lake, which were formed by blockage of a river with lava, and Diexi Lake in Sichuan Province, which was formed by blockage of a river with landslide debris.

Danba Muscovite National Mining Park, Sichuan This park is located in Danba County, Tibetan Autonomous Prefecture of Garzê, western Sichuan Province. It contains complete types of mining relics and became a national mining park in 2005. Based on their functions, the park can be divided into several parts: a muscovite mining culture exhibition area, mining environment display area, folk customs and service area and ecological sightseeing area. The park contains the remains of slag, mine shafts, workshops and roads in the mining area. There are more than 100 mine shafts, ore handling cableways, winches and mine car lamps that systematically illustrate the main processes of gathering

and transporting muscovite and processing it into mica paper, mica plates and mica pearl powder.

Danube Delta This site is located at the mouth of the Danube River on the Black Sea in Tulcea County, eastern Romania. The core protection area covers 3,124. 4 km^2. The Danube River flows into the Black Sea, forming the largest and best-preserved estuarine delta in Europe. In its lakes and swamps, the Danube Delta provides shelter for more than 300 species of birds and 45 species of freshwater fish.

Danxia Landform This book was written by Jin Huang and was published by Science Press in 2010. The name and term 'Danxia landform' originated in Danxiashan, which is located in Shaoguan City, Guangdong Province. The book describes the research history of the Danxia Basin, the geological basis for the formation of Mount Danxia, and the internal and external forces associated with the formation of the Mount Danxia landform and its characteristics. It divides Danxiashan into nine geomorphological areas and explains the landform characteristics of each area. The nine geomorphological areas are: the main Danxiashan area, Shaoshi area, Yunulanjiang (Jade Lady Blocking the River) - Yangyuan Stone area, Jiemei (Sister) Stone - Upper Tianlong (Heavenly Dragon) area, Ba Zhai (Village) area, Mount Guanyin (Goddess of Mercy) - Dakeng Zhai (Big Pit Village) - Mount Shinao (Lion Brain) area, Mount Fenghuo (Wind and Fire) – Changwo area, Wumaguicao (Five Horses Returning Trough) area and Yamayan (Duck Gneiss) area.

Danxiashan Global Geopark, China Danxiashan is located to the northeast of Shaoguan City in Guangdong Province. It became an UNESCO global geopark in 2004 and a world heritage site in 2010. It has a total area of 290 km^2, and half of it is covered by a 'Danxia landform' composed mainly of red multi-layered sandstones and conglomerates. The highest peak is Bazhai, in an elevation of 619 m. The Danxia landform was formed in a basin 140–65 million years ago and was subject to uplift, erosion by water and rockfalls. The red colour of the landscape is the result of a warm and wet climate, which enhanced oxidation in the sandstones and conglomerates. It is geologically significant for the studies of the evolution of the Earth's crust. The area contains rock outcrops from the Sinian, Palaeozoic, and Mesozoic to Cenozoic. The Cretaceous sedimentary strata that form the present landscape are particularly important for studying the life and distinction of dinosaurs, mammal evolution and the related regional stratigraphic correlations. Danxiashan is currently in the mature stage of landform development with deposition, uplift, weathering and erosion taking place at the same time to form diverse shapes, which are typical of this kind of landform. Danxiashan also has great natural aesthetic value because of its rivers (Jinjiang and Zhenjiang), red peaks (Yangyuanshi, Zengmaofeng), cliffs (Chahufeng, Guanyinshi), caves (Longlinyan), canyons and valleys (Bazhai). It also has high cultural and archaeological value because of the discovery of the prehistoric human 'Maba Man', who lived there 129,000 years ago. The area is also the birthplace of the four-thousand-year-old 'Nian Yu Zhuan' culture. Emperor Shun (2,233–2,184 BC) visited the area and played the local 'Shao Music'. He also named Danxiashan 'Shao Shi'. The area then became a famous scenic site. Hundreds of rock carvings from the Tang and Song Dynasties (1,500–1,000 years ago) are still well preserved. In addition, the ancient villages, temples and tombs demonstrate the interaction and harmony between humans and the nature.

Danxiashan National Geopark, Guangdong See ► Danxiashan Global Geopark, China

Danxia-type landscape This is a representative type of sandstone landscape found in the subtropical moist region in southern China, where the parent rock is Middle and Upper Cretaceous red terrestrial facies sandstone. It is a collective landform that includes features such as red cliffs, mesas, stone walls, rock peaks, stone pillars, canyons, gorges, stone corridors and caves formed by the combined effects of fluvial erosion, corrosion and gravity collapse. This



Fig. 5 Danxia-type landscape – Danxiashan, Guangdong Province

landscape is represented by Danxia Mountain in Guangdong Province. This landform was first discovered and described in geomorphological terms by the geologist Mr. Feng Jinglan in 1928. In 1939, Chen Guoda proposed the term 'Danxia mountain terrain', which was later revised to 'Danxia Landform' (Fig. 5).

Daoyuan Li Daoyuan Li (circa 470–527), also known as Shanzhang, was a native of Fanyang in Tian County. He was a geographer in Northern Wei Dynasty. While working as an official, he inspected many rivers, including the Yellow River and Huai River. He paid special attention to channels and investigated waterways and various geographical features. Based on the ancient writing 'Water Classic', which was written during the period of the Three Kingdoms, he adopted a novel style in writing the geographical monograph 'Commentary on the Water Classic' (Shuijingzhu). The book documented 1,252 rivers of various sizes with 20 times more annotations than 'Water Classic'. It consisted of 40 volumes of 300,000 characters fully recording the features, geographical conditions, establishments, developments and related historical events of mountains, forests, wetlands, cities, passes and ports along the rivers. It was the most systematic and comprehensive geographical work in China before the sixth century.

Daqing Oilfield National Mining Park, Heilongjiang This park is located in the Ranghulu and Sartu Districts, Daqing City, Heilongjiang Province. It covers an area of 249 km^2 and became a national mining park in May 2010. The main park contains 22 geosites and five heritage sites, including the Songji Oil Well Number 3 in the Honggang District, Datong District and Zhaozhou County in Daqing. The Daqing Discovery Well (Songji Oil Well Number 3), the Daqing Oil Field Historical Museum, the Sa No. 55 Oil Well (Iron Man First Oil Well), Iron Man Wang Jinxi Memorial, Daqing Petroleum Science and Technology Museum and other mining features are all well preserved and show the development of oil fields in China over time as well as the Daqing

Spirit and Iron Man Spirit of science, technology, historical records, production tools, machinery and culture.

Darien National Park, Panama Darien National Park is located in the borderland near Columbia in Darién Province, southeastern Panama. It covers a core protection area of 5,970 km^2. Forming a bridge between North and South Americas, Darien National Park contains an exceptional variety of habitats, including sandy beaches, rocky coasts, mangroves, swamps, and lowland and upland tropical forests with remarkable wildlife. The park is also inhabited by two Indian tribes.

Dark Brown Soil Dark brown soil is a neutral to acidic brown soil that develops through substantial humus accumulation, mild leaching and clayification in temperate broadleaf mixed forests. The litter layer is 4–5 cm thick and contains white mycelia.

Dashanpu Dinosaur Fauna The Dashanpu dinosaur fauna was found at the fossil site of Jurassic dinosaurs and other vertebrates that are 160 million years old. This site is located in the Da'an District in Zigong City, Sichuan Province. Within the excavated site of 2,800 m^2, more than ten thousand fossil bone pieces of over 200 individual fossil types have been found. They include dinosaurs, fish, amphibians, turtles, alligators, pterosaurs and mammal-like reptiles belonging to 18 genera and 21 species, and 20 species are new. The fossils discovered include the herbivorous long-necked Sauropoda, a full set of the short-necked Sauropoda, the fierce carnivorous dinosaurs, the 1.4 m long Ornithopoda, and also an intact set of Stegosauria fossil, which is the first of this type found in China. Fossils of the Pterosauria, which lived together with Stegosauris in the past, were first discovered in China's Jurassic strata. Fossils of the Plesiosaurus, which lived in the fluvio-lacustrine environment, was also found in this site. The Dashanpu fauna is one of the three major in situ dinosaur preservation sites in the world (Fig. 6).

Dashiqiao magnesite deposit, Haicheng, Liaoning This is China's most important magnesite deposit. Located in Haicheng City in Liaoning Province, the Dashiqiao magnesite deposit is hosted in the Lower Proterozoic dolomite marble of the Dashiqiao Formation in the Liaohe Group. The ore body is stratified, quasi-stratified and large. Most of the ores are high-grade magnesite and the ores also contain symbiotic minerals such as dolomite, talc, and serpentine. The ore bed is a sedimentary-metamorphic type. The mines include the Xiaoshengshuisi magnesite mine, Qingshanhuai magnesite mine and Gaozhuang-Pingerfang magnesite mine in Dashiqiao and the Haicheng magnesite mine and Huaziyu



Fig. 6 Dashanpu dinosaur site



Fig. 7 Dashiqiao magnesite mine

magnesite mine in Haicheng (the Huaziyu magnesite mine is China's second largest high-quality magnesite deposit) (Fig. 7).

Datong Jinhuagong National Mining Park, Shanxi This park is located 12.50 km west of Datong City and is on the opposite river bank of the famous Yungang Grottoes. It covers a total area of 19 km^2. It was approved by the Ministry of Land and Resources as the first national mine park in August 2005. It is divided into the Mawushan Scenic Area, Nanshan Scenic Area, Coal Sea Hero Scenic Area, a coal mine science and technology exhibition area, an underground exploration science exhibition area, a coal culture development area, a rest and recuperation area, a reception area, and a waterfront park.

Datong Volcanic Cluster Landscape This volcanic cluster is located in Datong County and Yanggao County, Shanxi Province, and in Yangyuan County, Hebei Province. The total area is approximately 70 km^2 and the cluster contains 32 volcanoes. The eruptions date to the Middle and Upper Pleistocene (approximately 100,000–300,000 years ago). The strata below the volcanic cones and basalt layer belong to the Nihewan Formation, and the overlying strata are Malan loess. According to the contact relationship between the upper and lower strata, the Datong volcanic cluster is the product of several eruptions that occurred before the accumulation of the Malan loess. The rock types are porphyry basalt and alkaline basalt that contain olivine inclusions and pyroxene crystals. The volcanic cones are generally well preserved. Famous examples include the Haotian Mountain, Jin (Gold) Mountain, Hei (Black) Mountain, Mati (Horseshoe) Mountain, Liangwo (Wolf's Den) Mountain and Gelao Mountain (Fig. 8).

Datong Volcano Clusters National Geopark, Shanxi This geopark is located in Datong and Yanggao Counties in Datong City, Shanxi Province. It became a national geopark in 2009. The Datong Basin, which is located at the northern end of the horst and graben system in Shanxi, is the only basin with volcanic activity in Shanxi's graben system and is an intraplate rifted fault-depression volcanic basin. The main geological features are Quaternary volcano clusters and karst landscapes. Thirty-two cinder cones, mixed volcanic cones and lava cones are well preserved and these features manage to record the nearly 300,000-year-long magmatic evolution history of the graben basins of the Datong Volcano.

Datun Volcanic Cluster Landscape This cluster is Taiwan's famous volcanic landscape and is located at the northwestern end of Taiwan Island adjacent to Taipei. The cluster is composed of more than 20 round volcanic cones. Among them, the Qixingshan Volcano has an



Fig. 8 Datong volcanic cluster landscape

elevation of 1,120 m. The Datun Volcano is 1,081 m above sea level and has four parasitic volcanoes inside it. The Miantianshan Volcano has two connected craters in a complete funnel-like shape. The lava flows of the Quanyinshan Volcano and Datun Volcano blocked the Danshui River, forming the splendid scenery of Guandu. The Datun volcanic cluster formed from the end of the Neogene to the Quaternary. This cluster is rich in geothermal resources and hot springs, and the temperature ranges from 30 °C to the boiling point. The Datun volcanic cluster is mainly made up of various types of andesite, and the Caolingshan Volcano is mainly leucite basalt. The post-volcanic features are remarkable, and H_2S, S, SO_2, CO_2 and sinter (mainly sulphur) are emitted from the fumaroles. The central part of the Datun volcanic cluster was established as the Yangming Park and covers an area of 1,156 m^2. It is one of Taiwan's famous tourist attractions and has a standardised management system and ideal interpretation system.

Dawn Moon Over The Marco Polo Bridge This is one of the Eight Peking (Beijing) Sceneries. The Lugou (Marco Polo) Bridge is a bridge across the Yongding River that is located southwest of Guang'an Gate in Beijing. This is the largest ancient stone bridge in northern China. At dawn along the Yongding River, the bright moonshine in the clear sky, the low horizon in the open wilderness, the grey colour at twilight and flashing waves on the water surface form a refreshing atmosphere, and the distant mountain landscape and the flowing river accompanied by a full or new moon would stimulate everyone to indulge in deep mediation.

Daxinganling Huma National Mining Park, Heilongjiang This park is located in central Huma County, Heilongjiang Province, and it covers an area of 1,068 km^2. It became a national mining park in 2010. It mainly includes the placer gold mining heritage in the Hanjiayuan and Xinglong gold mines. The regional geology and metallogenic models of the Huma gold deposit are world-class examples of alluvial river valley placer gold deposits. The large tailings dumps are rare and well preserved. The museum displays several types of well-preserved placer gold mining features from all historic periods and from a large area.

Debris Flow Landscape ▶ Mudflow Landscape

Deciduous Broadleaf Forest Deciduous broadleaf forests are also called 'Xialulin (summer green woodland)' in China. These are zones of vegetation that develop in warm, humid and semi-humid areas. The arbour layer is mainly composed of Brassica, Gossypium, Fraxinus, Tilia, Ulmus, Fagus and birch. The main deciduous broadleaf trees are alder and populus. In China, these forests are mainly distributed in northern and southern Northeast China. The climate in these areas has four distinct seasons. The vertical structure of the community generally has four levels: a tree layer, a shrub layer, a herb and moss layer, and a lichen layer.

Deep Fault A deep fault is a large-scale fault zone that extends to great depths and is active for long periods of time. Deep faults can be up to thousands of kilometres long and may cut through the crust or even through the lithosphere. Chinese scientists have categorised deep faults as crustal faults and lithospheric faults. Cataclastic rocks (brittle tectonites) and mylonites (ductile tectonites) develop along deep faults, indicating that they were formed during different stages and at different depths. Deep faults affect the thicknesses of the adjacent deposits, the lithofacies and rock formations; therefore, they affect the geological evolution of the region. Deep basic-ultrabasic rock intrusions and intense dynamic metamorphic zones are always located along deep faults. Because deep faults have significant effects on the surrounding region, they are often associated with geophysical anomalies.

Dehua Mount Shiniushan National Geopark, Fujian Dehua Mount Shiniushan National Geopark is located in the Mount Daiyunshan area of central Fujian. It is along the upstream section of the Dazhangxi River in northern Quanzhou. It became a national geopark in 2005. The highest peak has an elevation of 1,781 m. The mountain is named Shiniu, which means stone ox in English, because a rock on top of the peak resembles the shape of an ox. The geopark contains volcanic landforms. It contains a sound ecological environment with forests, bamboo, wetlands, cliffs, rocks resembling animals and plants, waterfalls and streams.

Delta When a river flows into the ocean or a lake, the sediment carried by the water is deposited due to the reduced flow rate, and the deposited sediments gradually accumulate to form a depositional flat that is called a delta. Deltas are also known as estuary plains. They are triangular with the top pointing upstream and the bottom edge being the outer margin. Deltas usually have large areas with thick and fertile soils. They are readily accessible and have become important areas for economic development. In general, deltas are both important attractions and source areas of tourists. China's main deltas include the Yangtze River (Changjiang) Delta, the Zhujiang Delta and the Huanghe (Yellow River) Delta.

Delta Facies A delta facies is a cone-shaped depositional system that forms in an area where a river flows into the ocean or a lake. It is a type of transitional facies, and it can cover hundreds of thousands of square kilometres. Deltas are important locations for the accumulation of terrestrial sediments, and the depositional environment is complex and varying with numerous lithologies. Delta facies mainly comprise sandy sediments and have bedding that dips towards the sea. They are transitional areas between terrestrial and marine facies where terrestrial, freshwater and marine organisms coexist. They are also favourable locations for the formation and accumulation of oil and gas. Generally, delta facies can be divided into plain facies, delta front facies and prodelta facies. They can also be categorised as the top accumulation layer, front accumulation layer and bottom accumulation layer.

Denudation Landform Tourism Landscape This is a landscape with tourism and aesthetic value formed by erosion. Examples are fluvial erosion landscapes, glacial erosion landscapes, wind erosion landscapes, gravity erosion landscapes, loess erosion landscapes, karst landscapes, marine erosion landscapes, and degradation landscapes.

Depositional Break ▶ Hiatus

Depression Basins ▶ Basins

Desembarco Del Granma National Park, Cuba This park is located in Granma Province in southeastern Cuba near the Caribbean coast and has a core protection area of 325 km^2. The sea terraces that have been constantly uplifted and the developing karst landforms in the park are examples for studying geomorphology and geological evolution.

Desert Climate This climate type is usually found in inland areas and is characterised by droughts, extremely arid conditions, summer heat, scarce rainfall, large seasonal and daily temperature variations, and frequent sandstorms, and all these parameters cause the formation of the extensive desert landscapes.

Desert Ecosystem Landscape This is a type of ecological landscape located in the extremely dry subtropical desert areas with little rainfall. Deserts have extreme continental climates with annual rainfalls of less than 250 mm. The precipitation variation is tremendous, and the evaporation exceeds the precipitation. The temperature changes are dramatic, and the daytime temperature range is large. Sand and dust storms are frequent. The soil is deficient of nutrients, and so few plants survive; whereas a few drought-tolerant small trees, subshrubs, small subshrubs and succulent cactus can survive. The plant community includes few species and has a simple community structure and low coverage. Some sites are completely exposed. Because the food resources are monotonous and deficient, few animal species live in these areas. They include insects, lizards, rodents and some birds. Many animals have adapted to the arid environment, through practising summer dormancy, adopting nocturnal activities, withstanding prolonged water deficiency, lacking sweat glands and excreting urine with high concentration.

Desert Land A desert is a natural landscape in an arid or extremely arid region with little precipitation, strong evaporation, a lack of surface runoff, severe wind-blown erosion and sand and gravel accumulation. Different types of deserts form due to differences in the geological and geographical environments, including sand deserts, gravel deserts, rock deserts, salt deserts and mud deserts.

Desert Landscape This is a collective term for sandy deserts, hamadas, gravel deserts, salt deserts and mud deserts, as well as the cold and dry barren regions.

Desert Tourism Desert tourism is a type of tourism that attracts people to desert or desert-related areas with activities that aim to meet their needs, such as seeking knowledge, novelty, adventures and environmental protection. It includes desert sightseeing tourism, desert adventure tourism, desert sports tourism, and desert ecotourism. Like urban and rural tourism, desert tourism is a new regional and comprehensive tourism product.

Desert Varnish Groundwater in the Gobi Desert rises due to capillary action and then evaporates. The dark brown oxides of several metals (e.g., iron, manganese, and chromium) in the water are deposited on the surface of the gravel like paint, which is called ‘desert varnish’ (Fig. 9).

Desertification Desertification refers to changes to the fragile ecosystems of arid, semi-arid and sub-humid areas. The ecological balance and productivity of the ecosystems of non-desert areas may be damaged or reduced by human activities, resulting in drastic environmental changes and the formation of a desert landscape. Desertification and its mitigation have high environmental education significance and can sometimes become an important ecotourism resource.

Detian Waterfall Landscape in Guangxi This is a four-level karst waterfall that crosses the China-Vietnam border on the Guichun River in Taocheng Town, Daxin County, Guangxi Province. The rock is mainly Middle Devonian dolomitic limestone, and the waterfall includes four drops with a total fall height of 49 m. There are no accurate data on the fall width because a long stretch of the cliff lies inside the Vietnamese border. The fourth terrace inside China has a surface width (the continuous length of the waterfall surface) of 140 m. The total length is 250 m if the widths of the other three levels are



Fig. 9 Desert varnish – Badain Jaran Desert (after Dong Zhibao)

aggregated. The Banyue Waterfall is located across the Vietnamese border, 180 m southeast of the Detian Waterfall. This fall is narrower (dozens of metres) and is just more than 10 m high. It is composed of grade 1 falling water and is located on the same cliff surface as the Detian Waterfall (Fig. 10).

Development of Tourism Earth Science In China In China, tourism earth science has developed along with the burgeoning tourism industry. Its development can be divided into four stages: (1) Gestation stage (1978–1985). In 1979, China proposed the major policy of reform and opening up, which ushered in the rise of the tourism industry, and academia actively used earth science knowledge to serve the tourism industry. In April 1985, the Science Popularisation Committee of the Geological Society of China held the first 'National Tourism Earth Science Symposium'. In the meeting, the 'China Tourism Earth Science Research Institute Organising Committee' was established. This set up a platform for the exchange of studies on how earth science could serve tourism, which prompted the establishment of a tourism earth science discipline. (2) Start-up stage (1986–1991). It was agreed that the National Tourism Earth Science Conference would be held once every year. The recruitment of members began, and provincial branches were established. The book 'Introduction to Tourism Earth Science' was completed and published in 1991 by Beijing University Press, and it played an important role in nurturing talent during the burgeoning stage of China's tourism industry. (3) Growth stage (1992–2000). In 1992, the Research Institute became a committee of the Geological Society of China and China Tourism Association. It is also known as the 'China Tourism Earth Science Research Association'. In 1996, at the 30th annual International Geological Conference, tourism earth science was introduced to more than 6,000 geologists from more than 120 countries. It was also introduced to Taiwan. The first group of postgraduate students who studied for master's degrees and PhDs in tourism earth science graduated and were offered jobs in national parks, forest parks and world heritage sites. The accumulation of experience with its theories and practicability allowed tourism earth science to grow and form a solid foundation for the establishment of the geopark system in China, which eventually gave birth to the national geoparks in China. (4) New stage of development (2001– present). This period has included the emergence of the China National Geopark and Global Geopark. In 2005, the Association was renamed the 'Academy of Tourism Earth



Fig. 10 Detian Waterfall landscape in Daxin County, Guangxi Province

Science and Geopark Research' under the Geological Society of China. This has opened up a new field for tourism earth science development. Future tasks include providing comprehensive and in-depth services for the tourism industry and ensuring a healthy and smooth development of the discipline.

Devils Tower landscape, Wyoming, U.S.A. The Devils Tower is located at a ranch in northwestern Wyoming, United States. It is a basalt volcanic neck that was formed approximately 50 million years ago. When the basaltic lava cooled, columnar joints developed due to contraction, forming closely arrayed large columns with pentagonal and hexagonal shapes. When the surrounding rock was eroded by weathering, the volcanic neck would be exposed, forming a large stone 'tower' composed of stone columns with a base diameter up to 300 m, a height of 265 m above the ground, and a top diameter of 85 m. This tower is visible from a distance of 160 km. The locals call it 'Devils Tower', and it has become a world-famous wonder that receives more than 600,000 visitors every year (Fig. 11).

Devonian Period The Devonian Period is the fourth period of the Palaeozoic Era, and it extended from 416 to 359 million years ago, a duration of 57 million years. It was named after Devonshire in southwest England. The Chinese words 'Nipen (Mud Basin)' came from the original Japanese translation. The Devonian Period was the time when the organisms began to occupy the continents, and terrestrial plants and freshwater fish began to flourish. Therefore, the Devonian Period is also known as the 'period of fish'. The Devonian System includes the rocks that were formed during the Devonian Period. The first international stratigraphic boundary (i.e., the GSSP for the Silurian Period and Devonian



Fig. 11 Devils Tower landscape, Wyoming, USA

Period) is located in Klonk Village, Prague, Czech Republic. Internationally, the Devonian System is generally divided into three series and seven stages. Guangxi Province and Hunan Province have long been areas of study and also contain three series and seven stages. The Upper Devonian quartz sandstone is the base material for the formation of the 'Zhangjiajie' landform.

Devonian Stratotype Section in Dale, Xiangzhou County, Guangxi This is another China's important and well-developed geologic section. It is located in the Dale area in Xiangzhou County, Guangxi Province. It includes the three stratotype sections and related rock strata of the Sipai Stage of the Lower Devonian Series and the Ying Tang and Tung Gang Ling Stages of the Middle Devonian Series. The Devonian Sipai Stage section mainly consists of biolithite, dolomite and shale. Its bottom boundary is not defined, and it contains four fossil assemblages of brachiopods and corals that are roughly equivalent to the Upper Emsian Stage on the International Stratigraphic Chart. The Ying Tang Stage of the Middle Devonian Series contains mudstone and limestone in its lower part and limestone and marble mixed with mudstone in its upper part. Its bottom boundary is not defined, and it contains two fossil brachiopod zones and is roughly equivalent to the Upper Eifelian Stage on the International Stratigraphic Chart. The Tung Gang Ling Stage contains interbedded casolite and limestone in its lower part and limestone and mudstone in its upper part. Its bottom boundary is demarcated by the first appearance of the fossil brachiopod Stringocephalus, and it contains five conodont zones, which are equivalent to the Givetian Stage on the International Stratigraphic Chart.

Dexing National Mining Park, Jiangxi This park is located in Dexing City, Jiangxi Province, and covers an area of 11 km^2. It became a national mining park in 2010. The combination of the size, mineral reserves and metallogenic models of copper and gold polymetallic ore belts in the Dexing ultra-large porphyry copper deposits are representative of gold and copper mines in the region. The mining park is representative of the intracontinental anatectic porphyry gold-copper deposits around the world. Many rare mining features can be found in the park, such as the historical records indicating copper hydro-metallurgical technologies that were

invented in the eleventh century and were applied to large-scale production. Other features include a large and ultra-large polymetallic copper-gold deposits within an area of approximately 200 km^2, and the gold-silver-copper mining sites that have been exploited for a millennium. The park also contains porphyry copper mines with world-leading exploration, mining and processing technologies as well as the largest demonstrated reserves in the world.

Diamond Diamond is also known as 'Jingang' diamond in Chinese, which means 'gold and hard rock'. It is composed of carbon, and it is the hardest mineral in nature. It has a refractive index up to 2.4, and so it can reflect almost all incident light. When polished, it is so lustrous that it radiates numerous colours, and hence it was given the name the 'king of gemstones'. The largest diamond was found in 1905 in Cullinan, South Africa. It weighed 3,106 carats and was cut into nine stones, the largest of which weighed 530.2 carats, was named the 'Star of Africa' and was set in the sceptre of the king of the United Kingdom. China's largest diamond was found in 1977 in Chang Lin Village in Linshu County, Shandong Province. It weighs 158.786 carats, was named the 'Chang Lin Diamond' and is now stored in China's central bank. Diamonds are mainly found in kimberlites and the associated secondary placer deposits. Currently, the main production areas are Congo (Kinshasa), South Africa, Russia, Australia and Brazil. Diamonds are also mined in Shandong, Hunan, Liaoning and Jiangsu Provinces in China. Four criteria are used to determine the quality of a diamond, namely, purity (the fewer impurities, the better), colour (the top grade is colourless and transparent or with a light colour, and bright red diamonds are the best), weight (in carats, where a carat is equivalent to 200 mg; diamonds larger than one carat are considered rare), and craftsmanship (the more crafted and refined, the better). These four main factors should be considered when purchasing a diamond (Figs. 12, 13).



Fig. 12 Diamond crystal



Fig. 13 Cut and polished diamonds

Dianchi Lake Landscape This is a lake that is formed by tectonic subsidence. It is located southwest of Kunming City and, along with Xishan (West Hill) on the western side of the lake, it has become a famous sightseeing destination and health resort. This lake is fed by several rivers, including the Panlong River. The lake has an elevation of 1,886 m, an area of 330 km^2, an average depth of 5 m, and a maximum depth of 8 m. The lake water flows southwest to the ocean via the Tonglang (Mantis) River, which is the upper course of the Jinsha River's tributary, the Puduo River. This lake has long been considered the 'Pearl of the Highland' and a key scenic area of Kunming that is rich in natural and cultural landscapes (Fig. 14).



Fig. 14 Dianchi Lake landscape

Dilali Flower This is a typical early angiosperm flower fossil. It was discovered in 2007. The fossil has a typical flower structure and style, including pedicels, petals, stamens and pistils. This flower fossil was found in the Yixian Formation in Huangbanji Grove in Shangyuan Town, Beipiao, Chaoyang City, Liaoning Province. Fossil experts believe that this fossil was a flower that bloomed brilliantly 125 million years ago in Chaoyang and that it was the earliest typical angiosperm flower (Fig. 15).



Fig. 15 Fossil of a Dilali flower

Diluvial Facies Diluvial facies are a type of terrestrial facies. Due to the effects of rain and snow in highland areas, weathered materials from the bedrock accumulate on slopes due to gravity. Diluvial facies mainly comprise glutenite and siltstone. The clastic material is poorly sorted and appears angular in form, often with bedding parallel to the slope.

Dingcun Man Site The Dingcun Man site is a site of ancient human fossils located on the east bank of the Fen River near Ding Village, Xiangfen County, Shanxi Province. Three human teeth were discovered in 1954, and a piece of an infant skull was found in 1976. The infant skull is thinner than the similar skull of the Peking Man infant. The teeth appear to be more primitive, but the Dingcun Man is more advanced than the Peking Man. A large number of stone artefacts and mammal fossils have been found in the sand and gravel layer on the shore of the Fen River. The sand and gravel layer is approximately 20 m thick, and soil deposits are located 5 m above it. The Dingcun Man site started from the Late Pleistocene, and uranium dating indicates ages of 180,000–230,000 years (Fig. 16).

Dinosaur Egg Fossil Dinosaurs laid eggs to reproduce. When preserved, their eggs became egg fossils, which range from 3 cm to 56 cm in diameter. Egg fossils are usually oval and rounded, but some are elongated, elliptical and olive-shaped. Fossil eggs containing embryos are

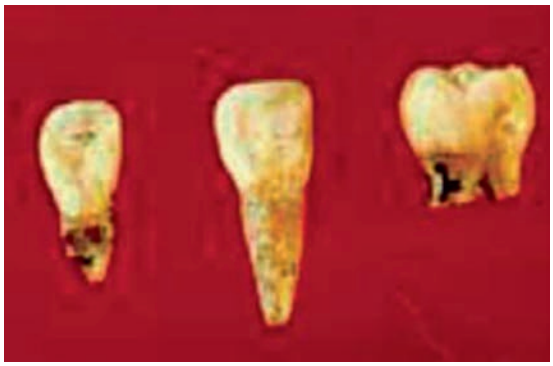


Fig. 16 Teeth of Dingcun Man

the most precious type. China's dinosaur egg fossil resources are some of the world's richest. These fossils have attracted the world's attention in terms of their quality and quantity. Important fossil sites are Nanyang in Henan Province; Nanxiong, Shixing, Huizhou and He Yuan in Guangdong Province; Xinfeng and Ganzhou in Jiangxi Province; Laiyang in Shangdong Province; Sichuan Province; Inner Mongolia; Yixing in Jiangsu Province; and Yunxia County in Hubei Province (Fig. 17).

Dinosaur Provincial Park, Canada This provincial park is located in the heart of the badlands in southern Alberta, Canada. It has a core protection area of nearly 75 km^2 and contains some of the most important fossil discoveries from the 'Age of Reptiles', with 35 species of dinosaurs dated back to 75 million years.

Dinosaur Track Fossil This refers to the dinosaur's footprints in sedimentary rocks. These footprints are clues for studying the dinosaur's type, size, limb forms and mode of motion. These fossils can be a single footprint or a series of continuous footprints (called tracks). Some track fossils are even accompanied by clear marks of their foot skin, and this type of mark is rare and precious (Fig. 18).

Dinosaurs Dinosaur is the common term referring to fossils of Saurischian and Ornithischian of the Diapsida subclass. Dinosaurs are a large family of reptiles with 900–1200 genera that lived approximately 65–225 million years ago. They have been studied for nearly 200 years since their first discovery in 1822. China has the



Fig. 17 Dinosaur egg fossils

largest number of dinosaur fossils in the world, and they are found almost everywhere in the country. Dinosaurs have important research value and are also one of the public's favourite types of fossils. Hence, they are important tourism resources. China's geoparks with dinosaurs as the theme are Zigong in Sichuan Province, Jiayin in Heilongjiang Province, Liujiaxia in Gansu Province, Lufeng in Yunnan Province, Chaoyang in Liaoning Province, Yanqing in Beijing, Xixia in Henan and Yun County in Hubei Province (Figs. 19, 20, 21).

Diopside Diopside contains $CaMg[Si_2O_6]$, and it belongs to the clinopyroxene family with a monoclinic crystal system. The crystal shape is equant, whereas the cross-section is nearly square. Crystal twinning is common, and the aggregates are blocky or columnar. It can be colourless, white, grey, green, greenish black, yellowish brown or reddish brown with white or grey streaks. It has transparent to opaque diaphaneity, a vitreous lustre, a specific gravity

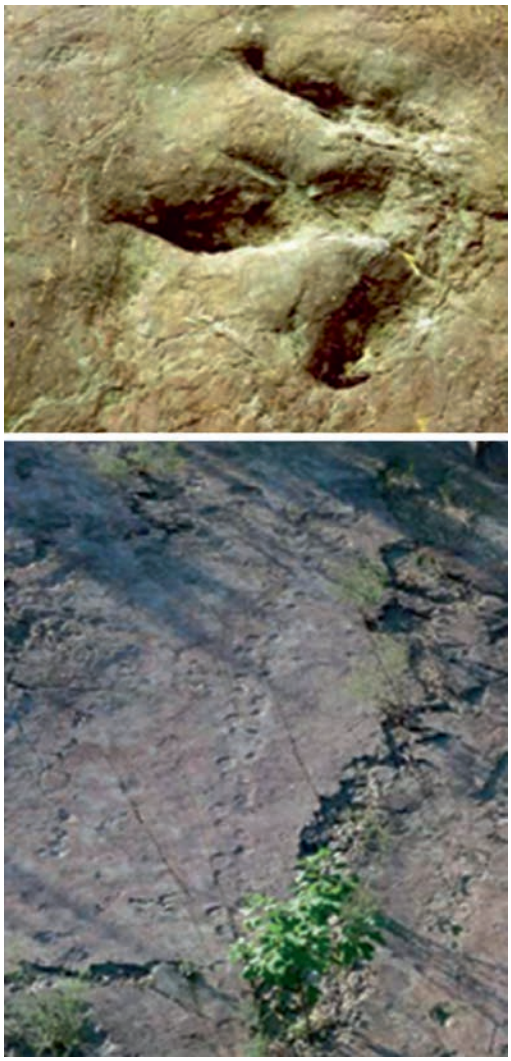


Fig. 18 Dinosaur footprints

of 3.22–3.38, a Mohs hardness of 5.5–6.5, and uneven fractures. It usually forms in the metamorphic and mafic rocks.

Dip Angle The dip angle is the maximum angle between an inclined structural plane and the horizontal plane. It is also called the 'true inclination'.

Dip Direction The dip direction represents the orientation of the projection of the line on a surface perpendicular to the strike (i.e., the steepest angle of descent) onto a horizontal plane. The dip can be expressed as an azimuth or a quadrant compass bearing.

Disconformity A disconformity is also called a parallel unconformity. It is a discontinuity surface between two sets of rocks in the same location. It can form due to extensive uplift of land, which is then subject to denudation to form a lacuna and then to extensive sedimentation again upon subsequent subsidence. A disconformity is mainly characterised by the upper and lower rock sequences that are parallel to each other; and, in other words, no crustal movement has occurred. A disconformity is also called a false conformity.

Discovery Coast Atlantic Forest Reserves, Brazil This site is located along the Atlantic coast at the junction of Bahia, northern Brazil and Espírito Santo, and it is composed of eight independent protected areas with a core protection area of 1,120 km^2. The main vegetation at the site includes Atlantic coastal forests and



Fig. 19 Tyrannosaurus rex Osborn, Late Cretaceous, 10 m long, USA



Fig. 20 *Lufengosaurus huenei* Young, Yunnan, Late Triassic



Fig. 21 *Mamenchisaurus hochuanensis* Young et Chao, Sichuan, Jurassic

shallow sandy shrubs. The tropical forest has the highest biodiversity in the world. With a high percentage of endemic species, the site illustrates a unique type of species evolution.

Dish-Like Depression Landscape On Loess This is a kind of circular depression landscape on top of the loess, 'Yuan', Liang' and 'Taiyuan' loess. The depressions form due to the localised accumulation of water, which erodes and dissolves the interior of the loess layers, causing land subsidence. In general, the depressions are 2–3 m deep with diameters of approximately 20 m. They are a typical feature of the early-stage loess gullies or loess sinkholes.

Distribution Map Of Geological Heritage And Other Natural And Artificial Resources This type of map shows the distribution of the major resources of the park. Based on the principles of 'National Geopark Planning & Technical Requirements' and the 'Geological Heritage Classification Table', the results of the field surveys of the geological, ecological and cultural attractions are categorised, classified and numbered according to the corresponding scale of the topographical base map. Pictures and descriptions are included if they are of global or national status. This map should be consistent with the geological heritage, main flora and fauna directory and cultural directory.

Distribution of Natural Tourism Resources Studying the conditions, controlling factors, spatial and temporal evolutions, classification and formation of nature-based tourism resources in a region allows the characteristics of their spatial distribution to be determined, enabling forecasting, evaluation and formulation of strategic development plans for nature-based tourism. Moreover, the research results are an important information for popularising earth science, developing nature-based tourism and serving as a basis for further scientific research in that region.

Diverter, Capturing River ▶ Pirate River

Dja Faunal Reserve, Cameroon This park is located on the border between the eastern and southern regions of Cameroon. The reserve covers a core protection area of 5,260 km^2 and is one of the largest and best-protected rainforests in Africa. Ninety percent of the

area is undisturbed. It is almost completely surrounded by the Dja River and its tributaries, which form a natural boundary. The reserve is especially noted for its biodiversity and a wide variety of primates. It contains 107 mammal species, five of which are threatened.

Djoudj National Bird Sanctuary, Senegal Djoudj National Bird Sanctuary is located in the Senegal River Delta near the border with Mauritania in the northwestern corner of Senegal. It has a core protection area of 160 km^2 and comprises a large lake surrounded by streams, ponds and backwaters. It is full of vitality due to diverse species but also experiences frequent threats. Approximately 1.5 million birds live in the sanctuary, such as the white pelican, the purple heron, the African spoonbill, the great egret and the cormorant.

Doftana National Park, Spain This heritage site is located in the Andalusian Autonomous Region in southwestern Spain. The coastal delta, which borders the Bay of Cadiz, has a core protection area of 543 km^2. The park features a wide variety of biological community habitats, notably lagoons, marshlands, fixed sand, moving sand dunes, dwarf bushes and high bushes. The park is home to five endangered bird species and is the largest heron nesting area in the Mediterranean region. It also provides a wintering base for more than 500,000 waterbirds every year.

Doline Landscape This is a round or oval, enclosed or nearly enclosed funnel-shaped depression that is formed by dissolution or collapse. The diameter can range from several metres to tens of metres, and the depths can range from several metres to a hundred metres. Dolines are also called round depressions, dissolved dolines, dissolved funnels, limestone pits, disk pits and bucket pits. Based on the formation mode, dolines can be divided into two types: dissolution dolines, which are often associated with avens, and collapse dolines, which is formed by collapse of a cave's roof slab. Based on the form, dolines can be divided into the well-shaped dolines, bucket-shaped dolines and saucer-shaped dolines. Under specific localised conditions, several other types of dolines can form (Fig. 22).

Dolomite Dolomite is a carbonate rock composed mainly of $CaMg(CO^3)_2$ and forms in the unique depositional environments or though the dolomitization process. It is usually greyish white and has a low hardness. It appears similar to limestone but does not fizz or only fizzes slightly in diluted hydrochloric



Fig. 22 Doline landscape – Guangxi Province

acid. Weathered surfaces often contain dolomite powder and have a cross knife-cut pattern. Based on the stages of formation, dolomite can be divided into contemporaneous dolomite, diagenetic dolomite and secondary dolomite. Based on the structure, it can be divided into micritic dolomite, microcrystalline dolomite, crystalline dolomite, residual allochemical dolomite and clastic dolomite. Dolomite has a high magnesium content, and it is used in the chemical industry to manufacture fused calcium-magnesium phosphate fertilizer, granular fertilizer and magnesium sulphate. In metallurgical industries, it can be used as a flux and refractory material, and some dolomites can be used for the smelting of magnesium metal and as a raw material for making ceramics, glass and building stone.

Dolomites, Italy These mountains are located on the border between the Veneto region and the Trentino Alto Adige region in northeastern Italy. The core protection area covers 1,359 km^2. The Dolomites are part of the northern Italian Alps and contain 18 peaks higher than 3,000 m. The region has outstanding diversity of mountain views, including the iconic landscape types of international geomorphological significance, such as peak clusters, peak needles, rock walls, glacial landforms and karst landscape systems. The area is characterised by dynamic geological processes such as landslides, floods and avalanches.

Dome Granite Landscape (Low Mountain) – Luoning Type This is a granite landscape that looks like a large dome that is composed of a granite mass at an elevation below 1,000 m. The surface of the dome is smooth with abundant parallel ditches on the curving surface. The landform looks like a stone waterfall; and hence, some researchers call it the 'granite waterfall landscape'. It is often found at the base of granite stocks, and the sparse joint sets, high rock density, chemical weathering and rain erosion are the main factors in the formation of this landscape. Typical examples are Shenlingzhai National Geopark in Luoning, Henan, and Fengkai National Geopark in Guangdong.

Dome Landscape A dome is a conical geological feature that forms when viscous magma squeezes out of the narrow passages to form a mound. Domes have different forms, and their interiors are usually banded (Fig. 23).

Dome Structure A dome structure is a near-isometric anticlinal fold which is nearly round in plan view. The scale varies from very large (tens of kilometres long) to very small, and there are different causes of formation. In addition to the structural domes caused by structural deformation, there are also buried depositional domes, diapiric salt domes and diapiric magmatic domes. The study of domes can reveal the formation mechanism and process, which are important for developing theories related to the geologic processes over Earth's history.

Dong Phayayen-Khao Yai Forest Complex, Thailand This site is located in the mountainous area at the junction of Saraburi, Nakhon Nayeri, Nakhon Ratchasima and Prachinburi in eastern and southern Thailand. The conservation area extends for 230 km from Ta Phraya National Park on the Cambodian border in the east to Khao Yai National Park in the west. The site is home to more than 800 animals, including 112 species of mammals (including two gibbons), 392 species of birds, and 200 species of reptiles and amphibians. It has important international significance for protecting threatened and endangered mammals, birds and reptiles, including 19 vulnerable animals, four endangered animals, and one seriously endangered animal.

Dong Van Karst Plateau Geopark, Vietnam This geopark is located in northern Ha Giang Province in Vietnam. It has an area of 2.3 km^2 and became a member of the Global Geoparks Network in 2010. The karst prairie of the Dong Van Karst Plateau Geopark consists of at least 80% limestone. The geopark contains 45 landform relics and 33 geological structures, and the sedimentary rock formations contain many fossils that are four to six million years old, of which 26 species were discovered and named for the

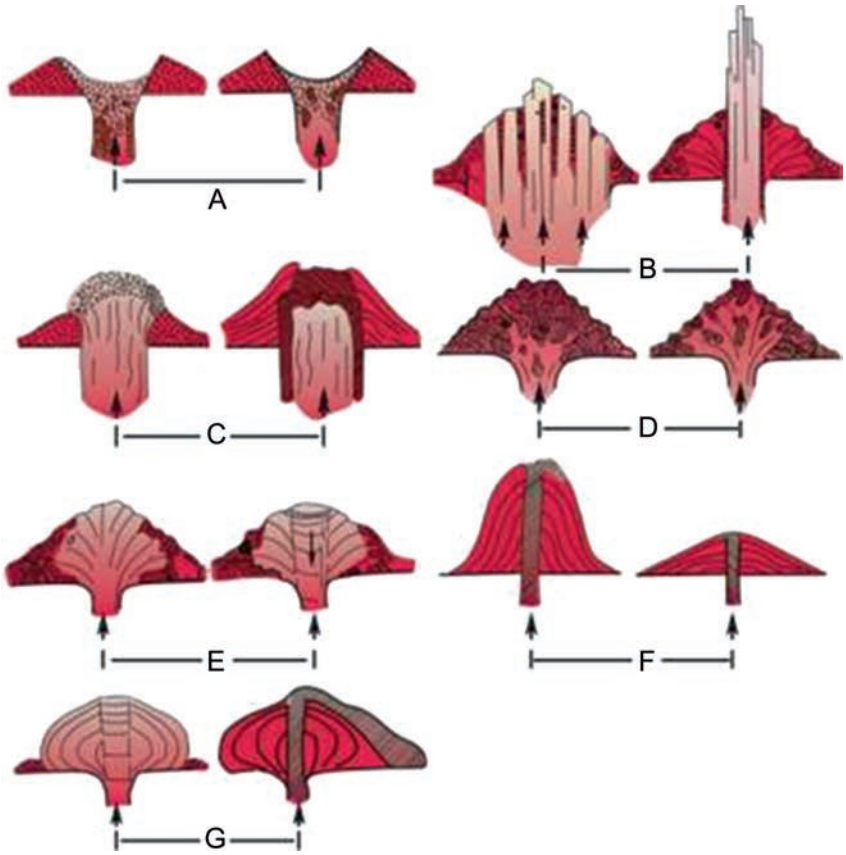


Fig. 23 Types of dome formation. *A* explosive dome, *B* volcanic pillar, *C* volcanic stele, *D* pyroclastic dome, *E* uplifting dome, *F* bell-shaped dome, *G* pressurised dome

first time. Many geologic heritage sites have been listed at the national and international level. The unique combination of Dong Van's karst geological and cultural heritage has created tremendous tourism potential and has attracted many tourists from both home and abroad.

Dongchuan National Mining Park, Yunnan This park is located in the Dongchuan District to the north of Kunming City, Yunnan Province, and covers an area of approximately 238 km^2. It was designated as one of the second group of national mining parks by the Ministry of Land and Resources of the PRC in May 2010. Based on the different functions, the park is divided into five scenic areas: a copper cultural display and visitor centre, ancient mining heritage display area, copper transportation path sightseeing area, modern mining heritage sightseeing and experience area, and the Red Land Natural Landscape Sightseeing Area. The park features mining production activity heritage, the remains of mining products and features of mining social life, including ancient and modern copper mining heritage, copper mining methods, bronzeware, coins and bornite products. Some of these mining features represent the advanced scientific and technological knowledge in China at that period.

Dongting Lake landscape Dongting Lake is China's second largest freshwater lake and is located in northern Hunan Province, south of the Jingjiang River. It covers an area of 3,968 km^2 (1998). It was previously part of the ancient Yunmeng (Cloud and Dream) Marsh. Dongting Lake is fed by the Xiang River, Zi River, Yuan River and Li River from the south and is connected to the Changjiang (Yangtze River) in the north. It receives flood water from the four rivers Songzi, Taiping, Ouchi and Diaoxian (which stopped flowing in 1958). The lake water enters the Yangtze River through Chenglingji in the east. Dongting Lake is the most important retention lake for the Yangtze River. Due to silting and reclamation,



Fig. 24 Lake Dongting landscape

Dongting Lake has been divided into East Dongting Lake, South Dongting Lake, Muping Lake and Qili Lake. The famous tourist sites include Mount Junshan, Longxian Well and Liuyi Well (Fig. 24).

Dongying Yellow River Delta National Geopark, Shandong This geopark is located in Dongying, Shandong Province. It became a national geopark in 2004. The park has three regions. The eastern region has the most complete and largest warm temperate zone wetland ecosystem in the world, including estuaries, forests, wetlands, meadows, reeds, waters and beaches as well as the Yellow River Delta and river landforms from different times. This geopark also includes the Yellow River old courses, ancient coastlines, shellfish embankments and delta plains. The southern part of the geopark is a cultural landscape area represented by the ancient Qi culture.

Dormant Volcano A dormant volcano is a type of active volcano that has not erupted for a long time but will erupt in the future. Each volcano has a different eruption cycle and frequency. A volcano will be classified as a dormant volcano when it has been calm for a long period between two eruptions. Changbai Volcano is an example of this type.

Dorr Landscape ▶ Glacial Groove Landscape

Dorset and East Devon Coast, United Kingdom This area is located along the coast of Lyme Bay in Dorset and South Devon in southwestern England. The core protection area covers 25.5 km^2. The cliffs of the heritage site expose a virtually uninterrupted sequence of Mesozoic rock formations, covering approximately 185 million years of earth history.

Drainage ▶ Water System

Drainage Area; Catchment Basin; Watershed Every river and the entire hydrologic system receive recharge water from an area of land, which is called a catchment basin, a river basin or a river system. The line connecting the

highest elevations between two adjacent river basins is the watershed boundary between the two river systems.

Driblet Cone Landscape ▶ Hornito.

Drift Scratch Landscape ▶ Glacial Striae Landscape

Drumlin Landscape This is a landscape that consists of drum-shaped mounds composed of glacial moraines. A drumlin generally refers to the oval-shaped mounds made up of supra-glacial moraines with high clay contents. The long axis is aligned with the flow direction. The size variation is remarkable; whereas the heights range from a few metres to dozens of metres, and the lengths vary from a few hundred metres to two kilometres. Drumlins often cluster in the terminal moraines at the front of continental glaciers but are rare in the alpine glacier regions.

Drunkard Forest Landscape A drunkard forest landscape refers to the scenery of soil subsidence due to a landslide, during which the trees and shrubs on the ground move with the soil layer and are deformed and staggered, looking like a group of drunk people (Fig. 25).

Dry Karst Cave Landscape This is a type of karst cave in which the cave body is separated from the groundwater surface. The Ludi (Reef Flute) Cave in Guilin is a typical example. Informal statistics indicate that China has approximately 100,000 caves of various types. Most are dry karst caves. Generally, an individual cave is less than 5 km long, but the total length of the dry cave channels in a cave system is much longer. For example, the Shuanghe Cave in Guizhou Province is 117 km long, and the dry cave channel is more than 60 km long. The Jiangzhou Cave in Fengshan, Guangxi Province, is 37.9 km long, but its dry cave channel is more than 30 km long. Karst caves attract visitors due to their aesthetic and mystical nature, and they are not influenced by the seasons. They can be open to tourists for the entire year and hence are all-weather tourism resources. Approximately 600 karst caves have been opened to tourists, and most are dry karst caves. The development potential of this resource is enormous (Fig. 26).

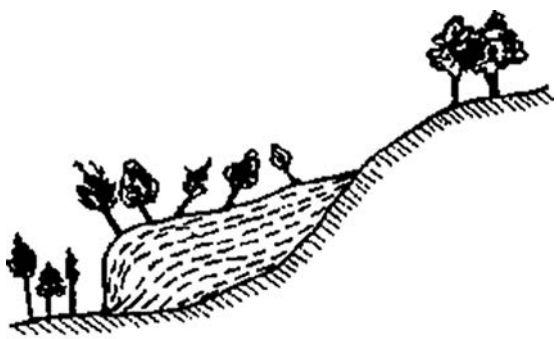


Fig. 25 Diagram of Zuihan Forest

Dry Karst Valley Landscape This is a landform that consists of dry or intermittent river valleys in karst areas. They are former surface drainage channels that became dry valleys after the development of a deeper drainage system due to lowering of the erosional surface upon crustal uplift or climate change. The bottom of a dry karst valley is flat, usually covered with loose deposits and often associated with dolines and sinkholes. Dry karst valleys are widely developed in the semi-arid karst valley region in northern China. In some dry karst valleys in Shanxi Province, sinkholes and deep leakage grooves have formed along fault zones. The drainage systems in dry karst valleys are better developed, but other than the underground runoff with high water transmissibility, subterranean rivers such as those in the south fail to develop. For example, the average flow rate of the Hekou-Zhitou section of the Fenhe River is 2.88 m^3/s, accounting for 17.8% of the surface runoff, whereas the flow rate of the Wangqiao section of the Dongzhang River in South Shanxi Province is 6.1 m^3/s.

Dry Lake A dry lake, also known as a dry salt lake, is only filled with water during the wet season. The lake water, known as brine, stays in the crystal gaps between the salt sediments and is invisible at the surface. Many kinds of salt crystals are directly exposed on the lake surface, and so it is called a salt lake. The salt deposits form an extensive salt pan that is hard and able to withstand the heavy weight of roads, buildings and airfields. In China, a



Fig. 26 Dry karst cave landscape – Fengshan, Guangxi Province

section of the Qinghai-Tibet Railway was built on the surface of the famous Chaerhan Salt Lake. The Biele Beach on the Chaerhan Salt Lake, the Chaka Salt Pool and the Keke Salt Pool in the Qaidam Basin are all dry salt lakes (Fig. 27).

Du Shi Fang Yu Ji Yao (Summary of Historical Geography Reading) This was a renowned historical geography book from the Qing Dynasty that was written by Zuyu Gu. It had 130 volumes, including four volumes of maps, and it is estimated to have been completed before 1692. Zuyu Gu (1631–1692), a native of Wuxi City, Jiangsu Province, was a historical geographer during the late Ming Dynasty and early Qing Dynasty. After the fall of the Ming Dynasty, feeling extremely indignant and grief-stricken, he lived in solitude and engaged in writing for over 30 years, from 1659 until his death. He wrote this book by making references to the twenty-one dynasty history books (histories of different Chinese dynasties written by official government historians) and more than a hundred local chronicles. The content mainly describes the territories, histories, famous mountains, major rivers, customs, and historical relics of each administrative region of the late Ming Dynasty and early Qing Dynasty (approximately 1600–1700). It is an important document for studying the historical geography, offensive/defensive conditions and military history of China.

Duanxi inkstone Duanxi inkstone, simply called Duan stone, is produced from the Duan Creek on Fuke Mountain in Gaoyao City, Guangdong Province. It obtained its name because in the past, this site was inside Duanzhou (today's Zhaoqing). The stone is mainly composed of Devonian sericite shale with small amounts of haematite (3–5%) and quartz (10–20%), and it has a density of approximately 2.78 g/cm^3. High-quality Duanxi inkstone is purple with cyan or white hues, and has a fine texture. It is also chemically stable, and weakly absorbs and percolates water but strongly holds water, and so it has the quality of 'being fine but non-slippery, tough but not rough, rapid ink making and full moistening of the writing brushes'. This inkstone has various patterns and colours and sometimes has a stone 'eye' (stone grain) that enhances its character. It has numerous features, such as cyan flowers,



Fig. 27 Chaka salt lake landscape

white banana leaves, fish brain jelly, fire brands, sky blue, ice threads, stone eyes, jade, gold and silver threads and gold dotted stars. The production of Duanxi inkstone requires attention to detail to attain the qualities of quaintness, simplicity, exquisiteness and naturalness that are appreciated by the literati. These qualities have enabled this stone to become world-famous and rank highest among all inkstones (Fig. 28).



Fig. 28 Duanxi ink stone

Dujiang Weir This was formerly known as the Du'an Weir and Jian Weir, and it was named the Dujiang Weir after the Song Dynasty. It was located to the west of Dujiang City, 59 km from Chengdu, and was an ancient dam-free water diversion project for the Minjiang River. The construction began in 256 A.D. and was supervised by Li Bing and his son. The main project included using bamboo cages to hold river pebbles to build a fish mouth-like dyke to divert the Minjiang River into an inner channel and an outer channel as well as the excavation of the Yulei Mound along the inner channel bank into the 20-m-wide Baoping (Precious Bottle) Mouth. Making use of the difference in water level, these works diverted the Minjiang River water



Fig. 29 Desert landscape – Alxa, Inner Mongolia

through the Baoping Mouth into the Chengdu Plain for irrigation. In addition, the Feisha (Flying Sand) Dyke was built between the fish mouth dyke and the Baoping Mouth for flood water control and sand discharge. These works form a self-running water diversion, flood discharge and sand discharge water conservancy system. It is a dam-free water diversion project that has been used continuously for more than 2,000 years.

Dune Landscape This is a mound-like landscape that is formed by the accumulation of aeolian sand. Based on the amount of dune movement, dunes can be divided into fixed dunes, semi-fixed dunes and mobile dune. Based on their forms, dunes can be categorised into round dunes, oval dunes and barchan dunes (Fig. 29).

Dunhuang Grottoes The Dunhuang Grottoes are also known as the Mogao Grottoes. They are one of the four major grottoes in China and a World Cultural Heritage Site. These grottoes are located in the cliffs on the eastern foothills of Mingshashan, 25 km southeast of Dunhuang, Gansu Province. These grottoes are the world's largest of this type and have abundant and well-preserved Buddhism artefacts. The grottoes extend approximately 1,600 m from north to south in five levels. Their construction began in the Early Qin Dynasty of the Sixteen Kingdoms period and continued through the Sixteen Kingdoms, Northern Dynasty, Sui Dynasty, Tang Dynasty, Five Dynasties, Xixia State and Yuan Dynasty. To date, 735 caves, 45,000 m^2 of wall paintings and 2,415 painted clay statues have been discovered. Since these grottoes were built on a cliff that is mainly composed of sandy conglomerate cemented by mud and calcium, the rock and earth texture are comparatively loose, rendering the rock unsuitable for stone sculpturing. Therefore, other than the four major Buddha statues, which were carved in stone with clay rendering, all of the statues were made of clay or mud with internal wood frames (Fig. 30).

Dunhuang Stone Dunhuang stone mainly refers to the desert wind-ground stone and riverbed patterned stones. It is named after Dunhuang, and in the past it was given to the emperor as a tribute from local officials, as described in the early records of the Song Dynasty: 'Li (polished) stone, a tribute from Suzhou'. The wind-ground stone is rough and angular as a result of erosion by the desert wind. It is mostly quartz with a Mohs hardness of more than 7. It is generally light grey with a glassy lustre and can be categorised into Datan agate, Gobi jasper, silicified wood, desert lacquer and bone



Fig. 30 Dunhuang Grotto



Fig. 31 Dunhuang stone (wind eroded siliceous rocks)

stone. High-quality Dunhuang stone has a good colour and shape resembling both simplicity and marvel (Fig. 31).

Dunhuang Yardang National Geopark, Gansu This geopark is located approximately 180 km northwest of Dunhuang City, Gansu Province. The geological remains are the Yadang landform, which was formed by wind erosion. It became a national geopark in 2002. A variety of unique wind-eroded landforms can be found in the park. At night, the wind whistles and howls, and so the area gets the name 'The Devil City'. The park attracts countless explorers to explore the mysteries of its unique desert scenery, various Yadang geomorphic features, and ancient folk tales.

Durmitor National Park, Montenegro Durmitor National Park is located in the Durmitor Mountains near Bosnia and Herzegovina along the northwestern border with the Republic of Montenegro. The site was extended in 2005. This breathtaking national park was formed by glaciers and is traversed by rivers and underground streams. Along the Tara River canyon, which is the deepest gorge in Europe, dense pine forests are interspersed with clear lakes and host a wide range of endemic flora.

Dushan Jade Dushan jade, a type of soft jade mined in Dushan in Nanyang, Henan Province, is also known as Nanyang jade. Its main components are plagioclase and zoisite with an interwoven crystalloblastic texture. Its Mohs hardness is 6–6.5, its density is 2.73–3.18 g/cm^3, and its refractive index is 1.56–1.70. It has a waxy glassy lustre and can be translucent or opaque. It is mainly zoisitised or epidotised plagioclase in gabbro. Dushan jade has long been mined and used (Fig. 32).

Dushan Jade Deposit, Nanyang, Henan This is a jade deposit in which the ore is distributed throughout an allanite mass. A single mountain composed of allanite, called 'Dushan (meaning Isolated Hill)', is located approximately 9 km northeast of Nanyang City, Henan Province, and it contains the Dushan jade deposit. The jade ore veins of the deposit spread throughout a zone of crushed gabbro. The jade has a delicate texture, and the mineral composition varies. Jade with six colours, including white, green, purple, yellow, red and black, has been mined from the deposit. The raw jade ores can be classified into more than 80 species. Dushan jade products have been found among the jade carvings in the



Fig. 32 Dushan jade craft

'Yin Ruins' in Anyang. The site of 'Yujiesi (Jade Street Temple)' from the Han Dynasty is located at Shagangdian, at the foot of southeastern Dushan. Nanyang jade carvings were sold overseas in the Song and Yuan Dynasties. The jade mining and carving industry in Dushan expanded greatly during the Ming and Qing Dynasties. The 'Nangyang County Chronicle, New Edition', which was published during the Emperor Guangxu years of the Qing Dynasty, states that jade was produced in Yushan and that most of the residents of northern Yushan worked as jade miners (Fig. 33).

Dust Storm ▶ Sandstorm

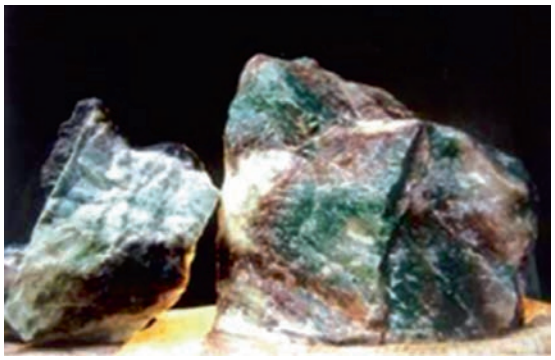


Fig. 33 Dushan jade

Dust-Floating Weather ▶ Sand-Blowing

Dyke A dyke is also known as a rock wall and is a lamellar sheet of rock formed by the intrusion of magma into a rock fracture. Dykes usually cross-cut the rock strata or are oblique to them. Dykes are generally from dozens of centimetres to dozens of metres wide and from dozens of metres to kilometres long. Dykes can form alone or in groups, whereas the dykes in a group are called dyke swarms. Dykes often form as either radial or concentric swarms. Due to differential weathering, they often stand out from the surrounding rocks. Different types of dykes or rock walls can be found in many geoparks.

Dynamic Metamorphism Dynamic metamorphism is the metamorphism induced by strong tension during the fracturing process. It causes brittle fragmentation and ductile deformation of the rock in the fault zone and is always accompanied by recrystallization. Dynamic metamorphism can create brittle tectonites (breccia, cataclasite, ultracataclasite and fault gouge) and ductile tectonites (mylonite, ultramylonite and phyllonite).

E

E'erguna National Mining Park, Inner Mongolia This park is located in Shiwei Russia Nationality Township, E'erguna City, northwestern Hulunbuir City, Inner Mongolia Autonomous Region. It was designated as a national mining park in 2010. Placer gold deposits can be found along 1,000 miles of the banks of the E'erguna River, which is praised as a 'gilded riverbank'. The gold mining in E'erguna dates back more than one hundred years. The mining features mainly include mining production heritage, historical records of mining development, mining activity heritage, mining products, and human landscapes related to mining activity. The park is a comprehensive national placer gold mining park that integrates placer gold heritage, gold culture, environmental culture, ethnic minority culture, science popularisation education, sightseeing, cultural entertainment, leisure and vacationing.

Earth Archives: National Geopark Tour This book was written by Xun Zhao, Jing Zhang, Yanru Zhang, Yecheng Zhang, Ting Zhao et al. and was published in 2005 by China Construction Industry Press. The book was published in two volumes. It briefly introduces the geoheritage and landscapes of 138 national geoparks (including the 18 global geoparks at that time) and describes the climate, transportation and tourist routes of each geopark. It can be used as a guide book for the geoparks.

Earth Science Earth science is the study of the Earth, including all disciplines associated with the Earth. It is also called geosciences. The disciplines of earth science include geology, oceanography, atmospheric physics and studies of the geomorphology, climate, hydrology, vegetation, soils, animal distribution, human activities and geography.

Earth Science of Scenic Sites This is a new interdisciplinary field combining earth science with scenic sites. It studies the earth science issues of scenic areas, such as the geographical location, unique geological and geomorphological features, rock characteristics, hydrological factors, atmospheric factors, geophysical fields (e.g., radiation field, magnetic field, electric field, temperature field, negative oxygen ion field, ground temperature), crustal stability, impacts of geological hazards on scenery and visitors, geological or geographical backgrounds of the cultural landscapes, and protection and scientific interpretation of the landscapes. The earth science of scenic sites plays an important role in determining the functional types, formulating development and environmental protection plans and evaluating the economic, social and environmental benefits of scenic sites.

Earth's Core The Earth's core is the zone beneath the 2,900-km-deep Gutenberg discontinuity. Based on seismic detection, the core can be divided into the outer core, transition layer and inner core. The core is very dense; its mass accounts for 32.5% of the global mass, but its volume is only 16.2% of the total global volume. Because transverse waves cannot pass through the outer core, it is thought to be composed of near-solid molten materials, and because transverse waves can pass through the inner core, it is thought to be solid.

Earth's Crust *Synonym:* ▶ *Crust*

The Earth's crust is the solid zone above the Mohorovicic discontinuity, and it is part of the lithosphere. The crust is composed of solid rocks and is divided into the upper crust and lower crust by the Conrad discontinuity. The upper crust is a silica-aluminium-rich layer, and the lower crust is a silica-magnesium-rich layer. The crust can be divided into the continental crust, transitional crust and oceanic crust. The continental crust contains silica-magnesium-rich and silica-aluminium-rich rocks and is 20–70 km thick. The oceanic crust often lacks the silica-aluminium-rich layer and is only 5–8 km thick in the deep

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ocean. The solid rock that makes up the crust is both elastic and plastic. Crustal movement causes the crust to deform and rupture, and most tectonic earthquakes occur in the crust. As such, the Earth's crust is the main region of study in geology and seismology. Crustal tectonic movements and seismic activity are closely related to the deeper processes in the deeper parts of the Earth.

Earth's Mantle *Synonym:* ▶ *Mantle*

The mantle is the Earth's layer from the Moho discontinuity to the Gutenberg discontinuity at a depth of 2,900 km. The crust is above the mantle, and the core is below. The mantle is divided into the upper mantle and lower mantle by the Repetti secondary discontinuity. The upper mantle is mainly composed of magnesium-iron silicate rock with olivine, and the lower mantle mainly consists of magnesium-iron silicate rock with spinel and perovskite structures. The middle part of the upper mantle at depths of 60–400 km is a low-speed seismic belt (i.e., the asthenosphere). The lower mantle is in an uneven solid state and is mainly composed of a magnesium-iron silicate of perovskite. Compared with the crust, the iron and nickel contents are significantly higher, but the content of radioactive material is low.

Earth's Sphere Tectonics The Earth is a multi-layered sphere consisting mainly of the crust, mantle and core, which can be further subdivided into the upper crust, lower crust, upper mantle, middle layer, lower mantle, outer core, transition zone and inner core. In a broader sense, the Earth's spheres also include the hydrosphere, atmosphere, biosphere and magnetosphere. The Mohorovicic discontinuity is the boundary between the mantle and the crust, and the Gutenberg discontinuity is the boundary between the core and the mantle. The crust is mainly composed of granitic and basaltic rocks. The mantle is dominated by iron and magnesium silicate rocks, whereas the core mainly consists of iron and nickel (with small quantities of light elements, such as silicon and sulphur). Seismic detection indicates that the outer core is a near-liquid molten body, but the inner core is solid. It is generally believed that the Earth was initially a sphere of homogenous matter and that its concentric spherical structure is a result of gravity differentiation. Precise detection has demonstrated than the inner core rotates 1.1° per year faster than the Earth; from 1900 to 1996, the inner core rotated 1/4 more than the Earth, which is a hundred thousand times faster than the movement of the fastest lithospheric plate. This is theoretically significant for explaining the formation of and changes in the Earth's magnetic field, the generation of mantle plumes and the Earth's evolution.

Earthquake Avalanche Landscape An earthquake avalanche landscape is a landscape of seismic features. It is composed of a collapsed body or material from slope collapses induced by earthquakes. In general, earthquakes with a Richter magnitude of 7 and above can induce massive collapses. A collapse of earth is called a mudslide, and a collapse of rock is known as a rock slide. Large-scale collapses are called landslides. The earthquakes on 12 May 2008 in Wenchuan caused massive landslides. In particular, the collapsed rock on the Douwen Road-Laohujui Road section formed a 300-m-long dam with a volume of 40,000 m^3 that caused the river level to rise by 19 m.

Earthquake Site of Submarine Villages in Hainan The bay from Dongzhai Harbour in the Qiongshan area of Haikou City to the Puqian Town area of Wenchang City is the land that subsided in a large earthquake during the Ming Dynasty's Wanli Period (1605 A.D.). Approximately 100 km^2 of land containing 72 villages gradually subsided into the sea to a depth of 3–4 m during this earthquake, forming a rare submarine village group that lies on the beach. The remains of these villages are still vaguely visible. Basalt coffins, tombstones, wells and rice pounding stones in orderly arrangements can be seen from the sea surface. The remains of the subsided ancient 'Ren Village' are located 4 km north of Puqian Bay. The village's buildings and courtyards can still be identified through the 10-m-deep water. A finely carved 'chastity



Fig. 1 Landscape of submerged villages at the earthquake site in Hainan Province

arch' with four pillars and three arches stands on the seafloor between Puqian Bay and Beichuang Harbour. Across the floor of Dongzhai Harbour floor is the 'Juewei Ditch', which is an earthquake fissure that is more than 10 m deep and more than 20 m wide. East of this ditch, a stone bridge links the two banks across the ancient river course (Fig. 1).

Earthscape An earthscape refers to the general characteristics of the terrain and all of the natural and artificial scenery in a geological area. It includes rocks, soils, vegetation, animals, bodies of water, artificial structures, and traces of human activities as well as the climatic characteristics in the area. Earthscape planning is the study of the natural and human landscapes of the earth as a whole to evaluate and analyse their environmental sensitivity on the macro level from the following three aspects: ecology, social economy, and aesthetics. The purpose of earthscape planning is to preserve the habitats of typical ecosystems as well as precious and endangered species to the greatest extent, protect biodiversity, conserve natural landscapes and precious cultural and natural heritage, and use land rationally. The scope of planning includes scenic areas, national parks, recreational resorts, theme parks, nature reserves, waterfront embankment landscapes, mining and the restoration of other landscapes. Earthscape planning is also involved in regional planning, route selection and road planning of highways and railways, and landscape planning for large-scale infrastructure projects.

East Lake Landscape in Wuhan This is China's largest urban lake. It is located in eastern Wuchang in Wuhan City, and it has an area of 33 km^2 with twisting shorelines and clear views. It was given the title of ninety-nine turns, where 34 of the turns are along the bases of peaks. There is abundant rainfall and sunshine. The moist weather and undulating landforms composed of plains, lakes and mounds support abundant plants species. More than 250 plant species have been identified, including trees, such as cedar, Metasequoia, pool cedar and camphor, and more than 390 species of woody and herbaceous and aquatic flowering plants, such as plums, lotus, Osmanthus, cherry blossoms, azalea and chrysanthemum. The plum and lotus are the most famous flowering plants. East Lake is suitable for tourism for the entire year, and it is famous for having 'spring orchids, autumn Osmanthus, summer lotus and winter plums'. In 1999, it was honoured as a 'National Civilized Scenic Tourist Zone Demonstration Unit', and in January 2001, it was named an AAAA-class scenic spot (Fig. 2).

East Rennell, Vanuatu This site is located in the southeastern Solomon Islands in western Vanuatu. It covers an area of 370 km^2 and takes up 1/3 of the land area of Rennell Island. It is the world's largest coral atoll with a length of 86 km and a width of 15 km. The site extends into the ocean approximately 3 nautical miles from the coast. Lake Tegano is a major attraction in the island area. Its predecessor was a



Fig. 2 East Lake landscape in Wuhan

lagoon in the atoll, and it is the largest high-salinity lake (155 km^2) in the Pacific Islands region. The lake is divided into numerous steep limestone islands with rich endemic species. Most of Rennell Island is covered by dense forests, in which the average height of the tree crowns is approximately 20 m.

Eastern Mountain Taishan Taishan Mountain ranks first of China's Wuyue (Five Peaks) and is located in Tai'an City, Shandong Province. In the past, Taishan was called Daishan (Dai Mountain), Daizong (Dai Origin) and Dailing (Dai Range), and it has only been called Taishan since the Spring and Autumn Period. It is a fault-block mountain composed of Archaean metamorphic rock (Taishan complex rock). Its main peak, Yuhuang Peak, has an elevation of 1,532 m and a relative height difference of more than 1,400 m from the foothill plain, and so it looks exceptionally majestic. Taishan is a historic mountain subject to frequent worshipping by past emperors. Seventy-two monarchs visited it for pilgrimages before the Zhou Dynasty, and Emperor Qinshihuang, Emperor Wudi in the Han Dynasty, Emperors Gaozong and Xuanzong in the Tang Dynasty, Emperor Zhenzong in the Song Dynasty, and Emperors Kangxi and Qianlong in the Qing Dynasty also came to worship the heavens. Confucius also visited to worship. Famous poets such as Li Bai and Du Fu of the Tang Dynasty climbed this mountain and wrote famous masterpiece poems. Famous monuments and relics at Taishan include the Dai Temple, Wangmu (King's Mother) Pool, Red Door Palace, Doumu (Mother) Palace, Yusong (Jade Pine) Pavilion, Nantian (South Heaven) Gate, Puzhao (Shining) Temple and various ancient stone carvings. Recent cultural relics include Sun Yat-sen's Tai'an monument, Feng Yuxiang's tomb and the Tomb of the Revolutionists. Taishan has a significant historical and cultural meaning and is one of the main representative sites of the Chinese culture. In 1987, it was added to the lists of 'World Natural Heritage' and 'World Cultural Heritage'.

Echinoderm Fossil Echinoderm fossils are in the higher phylum Echinodermata of invertebrates. Modern sea stars, sea urchins and sea cucumbers all belong to this phylum. Echinoderm fossils are found in rocks as old as the Cambrian. Echinoderm fossils are abundant in China. They have been found in Palaeozoic, Mesozoic and Cenozoic marine facies strata. Many are index fossils, such as Cystoidea, which gets its Chinese name 'Sea Apple' from its apple-like appearance. Cystoidea lived from the Ordovician to the Devonian. In general, structurally intact and clear fossils are rare. The Cystoidea fossils found in Baoshan in Yunnan Province have the highest quality and greatest beauty. Due to their complicated and distinctive structure and the rarity of perfect specimens, Cystoidea fossils are highly regarded for their ornamental value (Fig. 3).

Eclogite Eclogite is a moderate to deep regional metamorphic rock composed mainly of omphacite and calcium-containing pyrope and almandine. Secondary minerals include quartz, spinel, olivine, enstatite, kyanite, rutile and zoisite. Ultra-high-pressure minerals such as coesite and diamond are sometimes present and can indicate the geologic environment in which the rock formed. Eclogite has no plagioclase, a high density (generally 3.6–3.9 g/cm^3), a medium to coarse uneven granoblastic texture, a flaky structure, and a chemical composition similar to basalt. The composition of eclogite is complex and diverse. It can be in the form of



Fig. 3 Echinoderm fossil

lenses in the amphibolite facies metamorphic rock or in the glaucophane-lawsonite facies metamorphic rock. It can also exist in the form of xenoliths in layered ultramafic rocks or kimberlites. Eclogites form at high or ultra-high pressures (generally between 1–3 pascals) and high temperatures (generally between 450 and 750 °C). The cause of eclogite formation is not entirely agreed upon. Some postulate that eclogites form by the crystallization of mantle material in the upper mantle or that they are the residual part of mantle rocks that have undergone anatexis. Others believe that they form by the crystallization of basaltic magma in the upper or lower mantle or by the metamorphism of basalt in the upper and lower mantle.

Ecotone ▶ Ecological Transition Zone

Eco-City Eco-city currently does not have an commonly recognized definition. It generally means minimising the use of natural resources while at the same time ensuring a high quality of life for residents. This human habitation is called an eco-city. As an official scientific concept, eco-city was proposed during the 'Man and Biosphere Programme' initiated by UNESCO. It is an ecologically sound, compact, vigorous, and energetic settlement that coexists with nature and enables the society and ecological environment to develop in harmony in an ideal direction. An eco-city is a comprehensive concept that includes both the natural environment and humanistic values; it is an economically, socially and environmentally coordinated and unified complex system that focuses on people, is based on the natural environment, and is supported by the resource flows.

Eco-Environment ▶ Ecological Environment

Eco-Environmental Index; EI EI is an indicator that reflects the status of the ecological environment in the assessed area, and it has a numerical range of 0–100. The formula is EI = 0.25 × biological abundance index + 0.2 × vegetation coverage index + 0.2 × water network density index + 0.2 × land degradation index + 0.15 × environmental quality index.

Eco-Geographical Zone Based on the geographical correlations between the biological and non-biological elements of nature, eco-geographical zones can be divided into different grades and ecological attributes. These zones define the spatial pattern of biological elements in relation to other geographical phenomena, such as geology, physiography, vegetation, climate, hydrology, terrestrial and aquatic fauna, and soils, and they may or may not include the impacts of human activities. The distribution and composition of tourism attractions are configured according to certain ecological and geographical regions, which contain different tourist attractions, tourism methods, and tourism behaviours.

Ecological Environment *Synonym:* ▶ *Eco-Environment*

The ecological environment is the natural environment in which humans have settled. The natural environment includes climate, landforms, vegetation, soil, hydrology, natural ecosystems and artificial ecosystems. It refers to the total composition of various ecosystems composed of biological communities and abiotic natural factors. It is mainly or entirely formed by natural factors and has indirect, potential, and long-term impacts on human survival and development. Destruction of an ecological environment will lead to deterioration of the living environment of humans.

Ecological Environment Treatment Planning of National Mining Parks This topic is guided by ecological aesthetics and is driven

by the goal of improving the ecological environment of the mine. Based on the specific environmental conditions of the mine, the extent of its destruction and type of pollution, the plan proposes concrete methods and actions for ecological restoration and treatment of the mine that are consistent with the local conditions.

Ecological Landscape Tourism Resources This is a landscape resource consisting of a specific group of biological communities with ornamental and tourism value. They can be divided into two types: terrestrial ecological landscape systems and aquatic ecological landscape systems. Based on the location and the biological community, further ecological landscape types can be categorised.

Ecological Restoration The concept of ecological restoration was introduced to China in the early 1980s. It has many definitions, and the most representative definition is the one adopted by the US Natural Resource Council in 1995, which defines it as a process of restoring a system to be similar to what it was before being disturbed. The Society for Ecological Restoration International (SER) has given several definitions for ecological restoration since the 1990s. It currently defines ecological restoration as the process of assisting an ecosystem that has been degraded, damaged or destroyed in being restored (2002). This definition is concise and well-recognized.

Ecological Transition Zone *Synonym:* ▶ *Ecotone*

An ecological transition zone is a special eco-space between two or more communities or between ecosystems. It often has the eco-characteristics of the adjacent areas, and the biodiversity and landscape diversity are relatively high. These zones are also known as ecological transition zones, eco-interlaced zones or community interlaced zones.

Ecology Compensation To protect the ecological environment and maintain the harmonious development of humans and nature, ecological protection costs and development opportunity costs are considered to evaluate the environmental impacts of projects. Government finances and market instruments have been adopted to regulate fair and just transfer payments among ecological protection stakeholders. The general idea of ecological compensation is to reward those who help to protect the ecosystem and natural resources and to compensate for the damage caused by human activities. These rewards and compensation can be provided by taxes and fees imposed on those causing ecological damage and environmental pollution. The theoretical basis for ecological compensation is the ecological environmental value theory.

Economic Efficiency of Tourism The economic efficiency of tourism is the relation between the quantity of productive elements being occupied, used or consumed and the amount of output under the conditions that tourism resources are rationally exploited and the environment is being protected. When expressed in terms of value, it is a comparison between the production cost and the income of tourism products. This comparison can only be made when a tourism product has value and can meet the market demand.

Economic Geography Economic geography is an important branch of geography that studies the spatial distribution, formation and evolution of human economic activities, such as production, distribution, circulation, and consumption. It includes industrial geography, agricultural geography, traffic geography, and commercial geography.

Economic Region An economic region is also known as a comprehensive economic zone. Different levels and distinctive regional economic units are formed based on the division of labour in the region. An economic region is a regional production complex with a central city as the core, agriculture as the foundation, industry as the main component, and transportation and commodity circulation as related components. They work together to establish well-developed internal and national economic relations. Currently, with the growth of the tourism industry and its impacts on the surrounding areas, many regions have

successively established tourism economic zones, such as the Taishan Tourism Economic Development Zone and the Hainan Tourism Economic Zone.

Ecosystem The term ecosystem was coined by the British ecologist A.G. Tansley in 1935 to refer to the interaction of the biomes and their physical environments in a certain area. Modern ecology believes that an ecosystem is a functional unit of the interactions between plants, animals, microorganisms and the inorganic environment. It consists of three parts: green plants (the producers), animals (the consumers), and microbes (the decomposers). When the balance among production, consumption, and decomposition (i.e., the inputs and outputs of matter and energy) approaches equilibrium, the system develops into a relatively mature stage; otherwise, it is fragile. The study of ecosystems is important to human life and the environment. Ecosystems can be divided into many types based on the habitats, such as river ecosystems, estuarine ecosystems, lake ecosystems, marine ecosystems, urban ecosystems, and farmland ecosystems. Ecosystems can also be divided into representative biological communities, such as tropical rainforest ecosystems, grassland ecosystems, and desert ecosystems.

Ecosystem of Scenic Areas This is a type of ecosystem in a natural scenic area. These systems can be categorised into terrestrial ecosystems and aquatic ecosystems. Terrestrial ecosystems can be further subdivided into forest, grassland, agricultural and urban ecosystems based on the vegetation distribution. Aquatic ecosystems can be subdivided into marine, lacustrine and wetland ecosystems.

Ecotourism Ecotourism is an environmentally responsible type of tourism that occurs in relatively undisturbed natural areas and minimizes the negative effects of tourism. The goal of this kind of tourism is to enjoy and understand nature under strict rules of environmental protection. It benefits the local population and maintains and facilitates their welfare, work opportunities and chances to participate in society and economy.

Ecotourism (Book) This book was written by Yunting Lu and Jianjun Wang and was published in 2001 by Tourism Education Press. It covers the research objects, contents and methodologies of ecotourism; the social background, functions, conditions and potential problems of ecotourism development; the basic characteristics of ecotourism; ecotourism environmental ethics; the investigation and evaluation of ecotourism resources; functions and development planning; ecotourism market mechanisms and marketing strategies; ecotourism resources and environmental protection; the relationship between ecotourism and sustainable development; and ecotourism project management mechanisms. It is used as ecotourism teaching material in colleges and universities and has been reprinted for the third time.

Ediacaran The Ediacaran System is named after the Ediacara Hills in South Australia, which is also the origin of the Ediacaran fauna fossil that gets its name from this site. In 2003, the Late Proterozoic System Branch of the International Commission on Stratigraphy (ICS) completed its research on the standard section and submitted a report to the committee for validation. The branch proposed the nomenclature ‘Ediacaran’ for the stratigraphic unit of the uppermost period. In 2004, the International Union of Geological Sciences (IUGS) approved the inclusion of this term into the International Chronostratigraphic Chart and put it at the top of the Proterozoic Eonothem. The GSSP of this system was chosen to be marked on the Enorama Creek section in the Flinders Ranges in South Australia. The bottom boundary of this system is the bottom boundary of the cap carbonate of the Nuccaleena Formation. It also directly covers the Elatina diamictite layer, which is equivalent to the Varanger glaciation or Marinoan glaciation. The lower boundary of the Ediacaran System is assigned an age of 630 million years, whereas the upper boundary has a

Cambrian age of 542 million years. The Ediacaran Period (System) witnessed the occurrence and spread of molluscan metazoans. It is equivalent to the Sinian Period in China.

Efflorescence Landscape Efflorescence, also known as salt frost, is composed of white soluble mineral salts that form on the ground surface, shallow soil, sinter and rock surfaces in hot spring areas. The mineral compositions of efflorescence include halite (e.g., rock salt), sulphate (e.g., alunogen, alunite, mirabilite and epsomite), boric acid (borax and kernite) and carbonate (e.g., trona). Efflorescence looks like fluff, a thin shell, a ring, or can be stacked to form a cactus shape. It can also stick to a wall like hanging stalactites. It is the product of the evaporation of hot springs or the capillary effect in soil layers in springs. The efflorescence in some hydrothermal zones can become mineral resources.

E-guidance System This is an electronic guiding system that helps to guide visitors and provides information about the natural and cultural backgrounds of scenic attractions in an outdoor environment. It can also explain the exhibits and provide information in indoor geopark museums. Automatic e-guidance systems normally use mobile internet and Wi-Fi technology combined with modern digital and photographic technology to send information, pictures, maps and data directly to visitors. This information can be delivered in different languages for visitors of different nationalities.

Eifel Maars Landscape, Germany This is a volcanic landscape characterised by a low-lying crater. Eifel Maar is located to the northwest of Rheinish Slate Mountain in central Europe. There are currently 350 volcanic eruption locations. The Eifel Maar volcanic area is well known for its low and flat craters. Single volcanoes formed here when ultrabasic magma (with SiO_2 content below 45%) rose to the surface. Several volcanoes are famous for the presence of upper mantle masses. K/Ar dating shows that the youngest phase of volcanic activity started approximately 1 million years ago. Of the 270 Quaternary volcanic vents, the youngest is only 10,000 years old. The volcanic activity is likely to occur in the future (Fig. 4).



Fig. 4 Eifel maars landscape, Germany

Eighth Group of National-Level Scenic Areas On October 30, 2012, the State Council announced an additional 17 national-level scenic areas, including four in Hunan Province, three in Hebei Province, two in Fujian Province, two in Jiangxi Province and one each in Shanxi Province, Zhejiang Province, Chongqing Municipality, the Tibet Autonomous Region, the Ningxia Hui Autonomous Region and the Xinjiang Uygur Autonomous Region.

El Niño El Niño occurs in eastern equatorial waters when the water temperature of the cold water zone rises by 3–6 °C higher than normal, killing fish and other marine life. It usually occurs before and after Christmas. The word El Niño means 'Child Saint' in Spanish. The El Niño phenomenon occurs once every 3.8 years, but it is not a periodic phenomenon. Certain sea areas are sustainable for more than one year and have a major impact on the short-term oscillation of the global climate. The basic feature of the El Niño phenomenon is that the temperatures of the surface waters of the Pacific coast increase abnormally with rising seawater level, and warm currents flow southwards. This warms the eastern Pacific waters, which were originally cold, inducing strong waves, torrential rains and storms in some areas and droughts in others.

Emeishan, Sichuan This site is located in the southwestern Sichuan Basin and has an area of 154 km^2. It is a basaltic fault-block mountain. Weathering of the columnar joints as caused the rock columns to collapse, which has shaped the present landscape. The main peak is Jinding (Golden Top), which has an elevation of 3,079 m. The climate and vegetation vary vertically. The site is one of the four major Buddhist holy places in China and has had a reputation as 'the prettiest mountain in the world' since ancient times. Its famous scenic attractions include the auspicious light of Jinding, the white water and autumn wind, the emerald colour of Lingyan, the moonlight of Xiang Pond, and ten old fairy houses.

Emerald Emerald is also called Luzon Green or 'Green Gemstone' in Chinese. Emerald is a bright green translucent beryl, the composition of which is a silicate of beryllium and aluminium. It has a glassy lustre and a Mohs hardness of 7.5. It is hard but brittle and easy to crush. Its interior often has wool-like inclusions similar to those of quartz crystals. These inclusions are commonly known as bagasse or cicada wings, which are important features for the identification of natural emeralds. Top-grade emeralds should be pure, bright green and transparent without impurities. Stones larger than 2 carats are rare. Emerald has the name 'King of the Green' and is one of the world's four precious gems along with diamonds, rubies and sapphires. Gem-grade emeralds usually form in pneumatolytic hydrothermal environments and become placer deposits after weathering. The world's leading mining countries include Colombia, Brazil and Russia (Fig. 5).

En Echelon Fault En echelon faults are a series of oblique fractures with similar attitudes and mechanical properties. They are generally banded and form a transform shear zone between two rock blocks. En echelon faults can be categorised as tensional shear faults and compressional shear faults. The relative direction of shearing motion can accurately be determined based on the mechanical properties of the fault.



Fig. 5 Emerald crystal

End Moraine Bar Landscape *Synonym:* ▶ *Block packing landscape*
This is a landscape comprising embankment-like features composed of glacial terminal moraines. When the supply and melting of ice at the glacier front are in equilibrium, glacial moraines accumulate in front of the ice tongue to form a curving embankment, which is called an end moraine bar. This type of moraine is also called a terminal-type moraine or a terminal moraine. It can also be called a tail moraine or front moraine (Fig. 6).

Endorheic River ▶ Internal River

Enjoyable Stone ▶ Viewing Stone

Enping Geothermal National Geopark, Guangdong This geopark is located in Naji Town to the west of Enping City, Guangdong Province, in an area of low mountains and hills along the boundary with Yangdong County. The geopark was designated as one of the fourth group of national geoparks by the Ministry of Land and Resources in August 2005. Its main geological landscapes include the hot springs in the Yanshanian granites. These springs are high-temperature spraying sulphur springs with a constant temperature of 80 °C throughout the year, which have favourable medical effects. The park also contains granite columns, joints, giant quartz veins, tectonic fracture zones, waterfalls, historic gold mining sites and the human landscapes in Shitou Village.

Enstatite Enstatite is a type of clinopyroxene with less than 10% $Fe_2Si_2O_6$ and more than 90% $Mg_2Si_2O_6$. It has an orthorhombic crystal system and occasionally forms prismatic crystals. It is usually in the form of bladed, fibrous or platy aggregates. It can be colourless, green, brown or light yellow with colourless or grey streaks. It has transparent to



Fig. 6 Landscape with four terminal moraine bars of the Changtai ancient glacier in the northern Shaluli Mountains, western Sichuan (black arc-shaped bands in the photo)

Table 1 Animal performance for tourists

Type	Performance	Animals	Examples
Entertainment	circus	horses, monkeys, bears, dogs, pandas, elephants, lions, tigers	circuses in various countries
	permanent	elephants, seals, dolphins, crocodiles, snakes	Ocean Park in Hong Kong, Crocodile Park in Thailand
Sport	horse and dog racing	horses, dogs	various countries such as Hong Kong, Macao
	polo, elephant polo	horses, elephants	SE Asia
	bullfighting, sheep and goat fighting	bulls, sheep, goats	Spain, China
	hunting	rabbits, deer, leopards, wild boar, birds	Various countries
Appreciation	animals	tropical fish, small birds, turtles	China, Europe
	fighting	cocks, crickets, golden lion dogs	China, European and Asian countries
	bird listening & watching	parrots, starlings, orioles	China, Japan

opaque diaphaneity, a vitreous lustre, a specific gravity of 3.2–3.4, a Mohs hardness of 5–6 and uneven fractures. It usually forms in mafic and ultramafic rocks such as gabbro, coarse basalt, norite and peridotite.

Entertaining Animal Tourism This involves the breeding and domestication of different kinds of animals for performances to entertain the public. These activities are as follows (Table 1)

Environmental Aesthetics Environmental aesthetics is a sub-discipline of environmental science that studies the aesthetic requirements of the human living environment and the physiological and psychological effects of environmental aesthetics on human beings. It explores the effects of the environment on people's physical health and work efficiency. The study of environmental aesthetics involves many disciplines, such as acoustics, colourology, chemistry, physiology, psychology, ecology, landscape science, architecture, Feng Shui, and urban and rural planning.

Environmental Background Value This refers to the content and basic chemistry of various chemical elements related to environmental pollution in different uncontaminated environmental elements, such as the atmosphere, water bodies, rocks, soil, plants, crops, aquatic organisms and human tissues. The composition is also known as the environmental background value. Currently, in the context of global environmental pollution, it is difficult to find background values that are completely free of pollution. Due to the universality of environmental pollution, the environmental background value is a relative concept and can only reflect the normal chemical composition of environmental elements under relatively uncontaminated conditions.

Environmental Capacity Environmental capacity is the maximum capacity for contaminants of an environmental system or one of its elements to maintain the health of the population and the ecosystem. It includes two components, namely, the basic environmental capacity (or differential capacity) and the variable capacity (or assimilative capacity). The former can be calculated by subtracting the environmental background value from the proposed environmental labelling value, which is called the absolute capacity. The latter refers to the self-purification capability of the environmental unit.

Environmental Carrying Capacity The environmental carrying capacity is the limit of the environmental support to human society and economic activities over a certain period of

time under certain environmental conditions. It also refers to the environmental tolerance or environmental endurance. Because of the limits of available resources within an environmental system, human activities must be kept within these supporting limits or capacities.

Environmental Climatology Environmental climatology is the study of the patterns, diffusion and transformation of pollutants in the atmosphere and their influence on human health. It is an interdisciplinary field of climatology and environmental science. It examines the relationships between climate and environmental factors, their interactions and the mechanisms that influence human development. It also studies the impact of human activities on regional and global climate change.

Environmental Degradation Environmental degradation is the process of reverse environmental development that causes destruction and degradation of the Earth's ecological environment. It has occurred since the industrial revolution due to over-exploitation of natural resources, industrial pollution, urbanisation and other human activities, resulting in environmental and soil degradation, air, water and noise pollution, acid rain, ozone depletion and reduced biodiversity.

Environmental Earth Science This is a branch of environmental science that studies the composition and structure, development and changes, regulation and control, transformation and utilization of the human-earth system. Environmental earth science comprises subjects such as environmental geology, environmental geography, environmental geochemistry, environmental meteorology, environmental oceanography and environmental paedology.

Environmental Ecology Environmental ecology is the study of human disturbances to ecosystem processes, the internal mechanisms of change, the evolutionary processes, and the effects on humans. Its main research areas include the mechanisms and processes of the changes of ecosystems under human disturbances, determining the degree of damage to ecosystems, the functions and protection measures of various types of ecosystems, and the ecological solutions to environmental problems. It provides methods for the restoration, reconstruction and protection of damaged ecosystems.

Environmental Element Environmental elements include the natural elements of the environment and usually refer to water, atmosphere, biology, sunlight, lithology, landforms, and soil.

Environmental Ethics Environmental ethics is an interdisciplinary field between environmental science and social ethics. It studies the survival and development of humans, the human and natural environments, social and natural environments, individuals and societies, population, and the associated behaviours and relationships. During the process of tourism development, the basic ideas of environmental ethics help guide the sustainable development of the tourism industry and the natural environment.

Environmental Evolution Over the long history of the Earth, natural factors and human activities have changed the natural environment. These changes, which are referred to as environmental evolution, include global warming, sea level rise and natural land movements.

Environmental Geography Environmental geography is the study of the human-environmental system in a region, including its formation, development, composition, structure, interaction with environmental factors and geographic processes, regulations and controls as well as the associated transformations and utilization. The subject has the characteristics of both applied and conventional science. It is an interdisciplinary discipline between geography and environmental science. Regionality is a unique feature that distinguishes it from other branches of environmental science.

Environmental Geology Environmental geology is the study of the relationship between the geological environment and humans that involves understanding and addressing problems created by natural or human-induced environmental issues and geological disasters.

It includes practical applications of the knowledge and methodologies used by geology and environmental science. It is an important part of environmental science as well as a branch of modern geological science. Its main research areas include problems in the geological environment caused by geological phenomena and processes, natural disasters associated with geology and the application and protection of the geological environment.

Environmental Governance Environmental governance uses the guidance of modern environmental science theory and technologies to control environmental pollution and promote a virtuous cycle of ecosystems based on the migration and transformation of pollutants and the sources and negative effects of environmental pollution and destruction. When making rational use of natural resources, environmental management is planned and used to prevent the continual deterioration of environmental quality.

Environmental Interpretation Environmental interpretation is a form of environmental education conducted through tourism. It is also a kind of exchange that integrates environmental education, management and information transmission. It aims to help people understand the natural and cultural characteristics of a region and encourage them to appreciate and act to protect environment and heritage resources, regulate their own behaviour and establish good moral practices and values.

Environmental Objective The environmental management department sets the objectives of environmental quality and environmental conditions within a certain period of time. The fundamental role of environmental objectives is to develop clear directions and goals for development and to facilitate effective environmental management. The formulation of environmental goals must be compatible with the stage of socio-economic development. Environmental goals are the basis and starting point for formulating environmental strategies and environmental plans. Therefore, they can also be divided into strategic, policy and planning goals.

Environmental Protection Environmental protection is the general term for different activities or actions that humans have taken to maintain their existence and development and to solve current or potential environmental problems. It is a social action that uses the principles of science and technology as well as administrative, legal and economic means to ensure the healthy development of human society. It supports the rational use of natural resources, maintaining the ecological balance, preventing environmental pollution and destruction, and striving for the sustainable development of nature and society.

Environmental Protection Law of the People's Republic of China On 26 December 1989, the 11th meeting of the Standing Committee of the Seventh National People's Congress promulgated and executed the Order of the President of the People's Republic of China No. 22. The order comprises: Chapter I, General Provisions; Chapter II, Environmental Supervision and Administration; Chapter III, Protection and Improvement of the Environment; Chapter IV, Prevention and Control of Environmental Pollution and Other Public Hazards; Chapter V, Legal Liability; and Chapter Six, Supplementary Provisions. Chapter III stipulates that governments at all levels should pay special attention to all kinds of representative natural ecosystem areas, rare and endangered fauna and flora, important water conservation areas, geological structures of great scientific and cultural values, famous caves, fossil areas, natural landscape such as glaciers, volcanoes and hot springs, cultural and historical heritage sites, and famous and ancient trees. Measures should be taken to protect and preserve them to prevent them from being destroyed.

Environmental Quality The environmental quality is the overall level of the human environment or the pros and cons of certain environmental factors, that is, the quality of the environment. It specifically refers to a quantitative assessment of the nature, advantages and disadvantages of the environment as a whole or based on the requirements of a specific scope of the environment to reflect the

appropriate degree of environmental fundamentals for population health and socio-economic development. It includes the quality of the natural environment and the quality of the social environment.

Environmental Restoration Environmental restoration refers to the principles of restoration ecology, which involve the use of artificial measures to interrupt outside forces to restore part or all of a damaged environmental system to its original function. Examples are the restoration of polluted or damaged natural areas, such as wetlands, scenic spots, residential, commercial and industrial sites, burned forests and abandoned mines. Environmental restoration technology and its effectiveness are important in protecting and restoring ecotourism resources.

Environmental Science The main objective of environmental science is to study the natural environment, and it is one of the supporting theories of tourism earth science. It is a discipline that studies the composition of the environment, the relationship between environmental quality and human survival, the impact of human activities on the environment, and the strategies and measures taken to ensure the coordinated development of environmental quality and human survival. It includes environmental geology, environmental biology, environmental chemistry, environmental physics, environmental medicine and other branches of science. Seeking and enjoying a new environment are the main factors of people's willingness to travel. As focuses of tourism, natural and cultural landscapes are specific environments that require knowledge of environment science for evaluation of their merits and demerits, usages and improvements.

Environmental Self-purification Environmental self-purification is a process in which pollutants are gradually degraded and converted in the environment by physical, chemical and biological effects to reduce their concentration or quantities. This self-purification system includes types: physical purification, chemical purification and biological purification.

Environmental Standard To protect environmental quality and human health and maintain ecological balance, the environmental technical standards issued by the national authority are the legal basis for evaluating environmental quality and environmental protection.

Environmental System An environmental system is a complete system of environmental factors and the complex relationships that interact with or restrain each other. An environmental system has different spatial dimensions, while the global environmental system is composed of many subsystems. It is a system that can adjust or buffer minor impacts from outside the system and to maintain the stability of the system.

Environmentally Friendly Education With readily available natural resources, a geopark is an excellent venue for conducting environmentally friendly education activities. Environmental concepts, particularly geological conservation, can be introduced through activities directly organised by the geopark or jointly with schools or other organisations. Through these activities, participants learn the importance of protection and conservation, methods and skills of appreciation and caring for nature and related regulations and laws of protection.

Enyong Wang Enyong Wang (1927–) is a human geographer and a native of Fengyang City, Anhui Province. He has been a professor and doctoral tutor at Peking University. He served as the deputy director and director of the Department of Geography, deputy director of the Science Academia Branch, deputy director of the Geographical Society of China, and the deputy director of both the Expert Committee on Human Geography and Expert Committee on Geography Education. His main works include 'Introduction to Cultural Geography', 'Human Geography', 'Political Geography of China', 'Cultural Geography of China', and 'Investigation of Urban Systems in Changping County, Beijing'. He is one of the pioneers of tourism earth sciences in China.

Eon and Eonothem Eon is the longest primary time unit used in geology. Based on the emergence of fauna and flora, geologic history can be divided into: (1) the Archean Eon, which lacks fossils; (2) the Proterozoic Eon, which has numerous fossils; and (3) the Phanerozoic Eon, which has abundant fossils. An eon can be subdivided into eras. An eonothem is all of the rocks that formed during a certain eon. It is the largest unit of chronostratigraphic units; examples are the Archean Eonothem, Proterozoic Eonothem and Phanerozoic Eonothem.

Epeirogenesis; Epeirogenic Movement Epeirogenesis is the vertical crustal movements responsible for the formation of continents and large oceanic basins. The uplift of the Late Ordovician to Early Carboniferous lacuna in the North China Platform, the subsidence during the Middle Carboniferous sedimentary period, the uplift of the extensive Pre-Devonian peneplain and the Devonian subsidence of the Yangtze Platform are all typical examples of epeirogenic movements.

Epoch and Series An epoch is a time unit in a higher level than an age but lower than a period. An epoch is the rocks that formed during a series. An epoch is a subdivision of a period. A period can be divided into two or three categories of epochs: early and late epochs and early, middle and late epochs, respectively. An epoch can be further subdivided into ages. A series is a formal stratigraphic unit, which in the traditional stratigraphic scale is higher than a stage but lower than a system. A series is a subdivision of a system, and a system can be divided into two or three series, which are labelled with the same nomenclature as systems (i.e., lower, middle and upper or lower and upper). Series can also be assigned to geographical locations, such as the Furongian Series and the Lepingian Series.

Equatorial Tropical Rainforest Climate The equatorial tropical rainforest climates are found in a zone approximately 10° of latitude wide between the Tropic of Cancer in the north and the Tropic of Capricorn in the south. They are mainly distributed in the Amazon River Basin in South America, the Congo River Basin in Africa, and Indonesia and Malaysia in Asia. They are controlled by the equatorial low pressure zone; therefore, equatorial air masses prevail. The variations in annual temperature, humidity and rainfall are small. The annual temperature is high, and the rainfall is over 2,000 mm and is evenly distributed over the year. Forests are dense, and plants are widely distributed and form a natural vegetation landscape of tropical rainforests.

Era and Erathem A geologic era is a unit of geologic time that divides an eon into smaller units of time. For example, the Phanerozoic Eon is divided into the Palaeozoic, Mesozoic and Cenozoic Eras, during which the corresponding erathems of rocks formed. An erathem is all of the rocks that formed during an era. In the international chronostratigraphic units, an erathem is a subdivision of an eonothem, and it can be subdivided into systems of its own. Erathems include the Palaeozoic, Mesozoic and Cenozoic Erathems.

Erhai Lake Landscape This is China's seventh largest freshwater lake, and it was formed by tectonic subsidence. In the past, it was called Yeyuze, Kunmichuan, Xi'er River and Xi Er River. It is the 'mother lake' of the Bai people, whose ancestors called it 'Golden Moon'. Erhai Lake is located northwest of Dali City, Yunnan Province. It starts in Eryuan in the north, is 42 km long and has an east-west width of 9 km. Its surface area is 256 km^2, the average depth is 10 m, and the maximum depth is 20 m. Its only outlet is near Xiaguan Town, and it flows to the ocean via the Xi'er (West Er) River. Erhai Lake is one of the scenic locations in Dali that has incorporated the scenery of the 'wind, flower, snow and moon'. It was given the name 'Erhai' because it looks like an ear (in Chinese, 'Er' is ear, and 'Hai' is sea). The water quality is excellent, and because of its rich aquatic resources, it is a scenic location with a splendid landscape (Fig. 7).

Erkuang Zhang Erkuang Zhang (1933–) is a professor grade senior engineer. He is one of the founders of tourism earth science in China.



Fig. 7 Erhai Lake landscape

In 1954, he graduated from Wuhan Geological School. He has served as chief engineer of the Hebei Provincial Comprehensive Geological Group, deputy chairman of the China Tourism Earth Science Research Institute, and deputy chief editor of the 'Grand Tourism Earth Science Dictionary'. He participated in the establishment of the China Tourism Earth Science Research Institute. He is one of the authors of 'An Introduction to Tourism Earth Science' and has published 15 papers and books on tourism earth science.

Er-lianhaote Dinosaur National Geopark, Inner Mongolia This national geopark is located in Er-lianhaote, Inner Mongolia Autonomous Region, and has a total area of 70 km^2. It was approved by the Ministry of Land and Resources as a national geopark in August 2009. Cretaceous dinosaur fossils are the major attractions because they were first discovered and studied in this geopark. Many kinds of Late Cretaceous dinosaur fossils found here represent the biota in Asia 80 million years ago, including sauropods, archaeornithomimus, gallimimus, alectrosaurus, bactrosaurus, Xilingol gilmoreosaurus, ankylosaurus, neimongosaurus, erliansaurus, and gigantoraptor. The Er-lian Yanchi Iren Dabasu Formation geologic cross-section, which shows the Upper Cretaceous strata, is considered by palaeontologists to be the standard section of the late Cretaceous. It contains fossils of dinosaurs, ostracods, and associated vertebrates.

Erosion Basins ▶ Basins

Erosion in Landscape Formation Erosion, which is also known as denudation, is a process that removes weathered rocks from their original locations by gravity, water, wind, dissolution, glaciers, freezing and thawing, tides, currents, waves and living organisms. In a narrow sense, erosion refers to the wearing down of rocks by the force of flowing water (stream and river) as well as the abrasion of river banks and riverbeds by the sand and rocks

carried by the river. These forces deepen, widen and lengthen valleys, forming canyon landforms. Mechanical erosion is more prominent in cutting the Earth's surface, whereas chemical erosion is more significant in areas with soluble rocks. Erosion can also be classified as headward, downward, linear, sheet and lateral erosion. Erosion is a basic geological process for the formation of various landforms.

Erosional Valley Landscape This is a valley landscape created by the erosional action of a river. The Grand Canyon in Colorado, United States, is a typical erosional valley. The morphology of an erosional valley can change based on the hard and soft rock strata in the valley. When alternating hard and soft strata lie horizontally, the valley will appear to be composed of steep cliffs and platforms in alternating layers. The Grand Canyon is an example of this type. If the strata dip, the valley will appear to be composed of wide and narrow strata in alternating layers along the longitudinal profile. In general, in areas with soft rocks, the valley will be wider with a gentle river gradient and meandering course. In areas with resistant rocks, the valley will be narrower with a steep riverbed and a straight channel (Fig. 8).

Esker Landscape An esker landscape is a type of fluvioglacial depositional landform that develops in continental glacier regions. It is an elongated ridge that looks like a rail bed. It is composed of gravel and sand that are carried by water through sorting and flushing and has an uneven oblique cross-bedding.

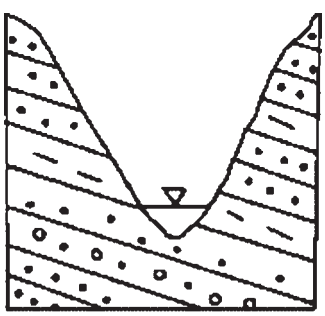


Fig. 8 Erosional valley

Estuarine Lake Landscape This is a type of landscape consisting of lakes that are developed from rivers. An estuarine lake is also called a terminal lake, Weilu (terminal tail) lake or standing lake. These lakes are located in the estuaries of inward-flowing rivers connected to a lake. They are replenished by one or several inward-flowing rivers without any outward-flowing rivers. Therefore, they are a type of inland lake. Qinhhai Lake is an estuarine lake of the Buha River and Daotanghe (Inverted) River. Academics also call lakes that are located in the estuaries of outward-flowing rivers the same name, but those lakes are actually exorheic lakes (Fig. 9).

Estuary In Chinese, estuary is also known as a triangular harbour. An estuary is a trumpet-shaped bay at a river inlet. Estuarine bays form due to land subsidence or rising sea level, where tidal action is significant. Typical examples are Hangzhou Bay at the estuary of the Qiantang River in China and the Rio de la Plata estuary in South America (Fig. 10).

Ethnogeography Every nation has its own history. It contains a group of people with common languages, values, geographical distribution, socio-economic life and cultural and psychological identities. Ethnogeography studies the formation, migration, and evolution of a nation and the relationships with its geographical environment. It is a branch of human geography.

Etna Volcano Landscape Etna Volcano is Europe's largest, tallest and most active volcano. It is also one of the world's most famous volcanoes. It is located in the northeastern corner of Sicily near the southern tip of Italy. It is cone-shaped, has an elevation of 3,520 m above sea level, is 500 m in diameter and is visible from 250 km away. There are also more than 200 small volcanic cones around it. Based on historic records, this volcano first erupted in 475 A.D., and it has erupted more than 500 times since the eighteenth century. Large eruptions occurred from August 1852 to May 1853, from 1950 to 1951, from 1977 to 1981, and also in 1987, 1989, 1990, 1992, 1998, and October 2002. The cumulative death toll is



Fig. 9 Landscape of Weilu Lake on the Wulun River



Fig. 10 Hangzhou Bay

1 million. The erupted volcanic ash has turned into fertile soil, and so the land below an elevation of 900 m has been cultivated as orchards. This area is well known for wine making. The forest belt is mainly at elevations of 1,000–1,980 m. The volcanic deposits

above 1,980 m above sea level are covered with sparse shrubs and permanent snow in some areas. Etna Volcano is now in the dormant stage. Gas emissions accompanied by thick smoke occur on the inner wall of the crater. This volcano is classified as a highly dangerous volcano. Each volcanic eruption has attracted abundant tourists around the world, and 300,000 people from local population are engaged in the tourism sector.

Eurasian Plate The Eurasian Plate is located to the west of the Pacific Oceanic Trench, north of the Himalayas and Alps, east of the Atlantic mid-ocean ridge and south of the Arctic Ocean. It includes a major part of the Eurasian continent. In the early Cenozoic, this plate merged with the Indo-Australian Plate and the African Plate along the suture zone with the Yarlung Tsangpo-Alpine Plate, forming the present integrated Eurasian Plate.

European Geopark, Development History Europe was the first continent to establish geoparks with the name of a continent. In August 1996, during the 30th International Geological Congress in Beijing, Guy Martini of France and Nickolas Zouros of Greece proposed establishing 'European Geological Parks (Eurogeoparks)' and won the support of the European Union. In June 2000, the European Geopark Network (EGN) was formed. In November 2000, the first European Geopark Conference was held in Spain with the establishment of the first four European geoparks. By the end of 2017, the European Geopark Network included 70 national geoparks in 23 countries.

European Geoparks Network (EGN) In June 2000, the European Geoparks Network (EGN) was formed by France, Greece, Germany and Spain. It has an official logo and has been registered in all countries in the European Union. Its liaison office is located in the Haute Geological Protection Area, France. The European Geopark Network has its own constitution and organises visits and exchanges, publishes journals and newsletters, and convenes regular workshops, annual meetings and exhibitions. All members are encouraged to join such activities to promote geoparks, their products and activities.

Eustatic Movement A eustatic movement denotes a worldwide change in sea level caused by a marine transgression or regression. It is also called sea level change. Sea level changes are caused by two processes: a change in the volume of seawater or a change in the volume of the marine basin. Changes in the volume of seawater are mainly caused by changes in the continental ice sheets. When the continental ice sheets grow, the amount of seawater decreases, whereas when the ice sheets retreat, the amount of seawater increases. Similarly, when the volume of the marine basin increases, sea level will fall, whereas when the basin volume decreases, sea level rises. It is still uncertain whether changes in marine basin volume are due to expansion or filling up of the basin or to morphological changes of the continents.

Eutrophication Eutrophication is an excess of nitrogen, phosphorus and other plant nutrients caused by water pollution. Due to excessive eutrophication of inorganic nutrients, algae will multiply and consume the oxygen in the water until it is depleted, and as a result, the oxygen depletion would lead to deterioration of water quality and pose threats to fish and other aquatic life.

Evaluation of Geological Heritage This is one of the evaluation methods for tourism resources. The evaluated object is controlled by several factors. Each factor can be subdivided into several levels, and each level is given a score index and a weight value. The figures are then used in a mathematical model to calculate the total score of a scene, attraction, scenic site or geopark. The total score indicates the value of the landscape tourism resource. The quantitative evaluation model has several problems in actual operation. Its basic formula is $\sum_{i=1}^{n} w_i a_{i.}$ where n is the number of indicators under each resource to be evaluated, W_i is the weight, and a_i is the standard

value set by the evaluation index. The total score is the weighted sum of the values of a_i. The value is usually expressed as a percentage; the greater the value is, the higher the level of the resource will be. Quantitative evaluation methods applied to determine the weights and indicators of the standard values may subject obvious human influences and therefore are not scientific. An accurate assessment of tourism resources can only be obtained by combining the quantitative assessment method with the qualitative assessment method.

Evaluation of Geological Heritage: Aesthetic Value This is related to evaluating the beauty and asthetic quality of geological heritage and also, the asthetics of geological heritage is hinging on the aesthetic experience of the viewers; as well as relating to the neurophysiological and psychological reaction of the humans. The value is subjective and can vary among different people. It is difficult to have consistent standards for evaluating the value (or aesthetic sensitivity). The evaluation elements of the aesthetic value of natural landscape, such as geological heritage, include the landscape morphology, texture, colour and structure. The evaluation results can be qualitatively divided into four levels: extremely beautiful, beautiful, moderately beautiful and common.

Evaluation of Geological Heritage: Conditions of Protection This is related to evaluating the conditions of protection and management of geological heritage, including the extent to which these resources are damaged, potential threats, controls, scientific research, community involvement, public understanding, management systems and standards.

Evaluation of Geological Heritage: Cultural Value Geological heritage is an important part of the natural landscape and environment. It is indispensable for assessing its importance and linkage with local history, folk culture, religion and their development and preservation. A unique geological heritage will have specific influences and effects on culture. Therefore, the cultures that have been developed in deserts, plains and mountains are all different.

Evaluation of Geological Heritage: Environmental Value Environmental value refers to the background of geological heritage as a natural environment, its significance to the survival and development of mankind, and its interaction with the ecosystem and biodiversity. The environmental value of geological heritage can be divided into usable and non-usable values. A usable value is the direct or indirect usage of environmental resources that can generate benefits to people. A non-usable value is the importance of its existence for current and future sustainable benefits to the environment and other living things. An environmental assessment is required for building tourist resorts (e.g., ski areas, summer retreats, seaside resorts, and spa holiday flats) within tourist and resort areas.

Evaluation of Geological Heritage: Science Popularisation Value This is related to the effectiveness of geological heritage to disseminate knowledge about the geosciences. Different geological heritage sites provide different types of information that can be delivered to the public in different ways. Landscapes such as volcanoes, glaciers, earthquakes, tsunamis, mudslides, river erosion, sediment transportation and deposition are natural teaching materials about crustal movement and geological processes. Fossils preserved in rocks, especially dinosaurs and ancient human skeletons, are effective means to trace and popularise early life history on Earth. All kinds of rocks that form peaks, caves and unique formations are products of the endogenic and exogenic forces of the Earth. There is a strong correlation between the science popularisation value of geological heritage and its amount of information, dissemination methods and integration with other information, and these factors are important in determining the value of geological heritage. The values can therefore be classified into four levels: extremely high, high, moderately high and common.

Evaluation of Geological Heritage: Scientific Value The scientific value of geological heritage is related to its typicality, uniqueness and rareness. Typicality refers to the formation of the geological heritage and can be used as a standard for reference. It can also refer to its size and area. It can be classified into four levels: global references, such as a Global Boundary Stratotype Section and Point (GSSP); national references (e.g., the national stratigraphic standard); regional references (e.g., the regional stratigraphic standard) and local references (local stratigraphic standard). Uniqueness refers to the unique geological evolution or unique form of the landscape. This can be subdivided into four types, namely, very unique, unique, moderately unique and unusual. Rarity refers to its geographical distribution and can be classified as the world-class (rare or the only example on Earth), country-class (only example in the country), region-class (only example in the province or region) and common (typical of an area). These elements are used to assess the scientific value of the geological heritage in a region or site. The values can be assessed in four different levels: extremely high, high, moderately high and common.

Evaluation of Geological Heritage: Tourism Development Value This term refers to the economic practicability and tourism development potential of tourism in association with geological heritage. The value is determined by factors such as the distance from sources of tourists, traffic, communications, water supply, power supply, accommodations, capital investment, ease of construction and other conditions. The values can be divided into four levels of significance: extremely high, high, moderately high and common.

Evaluation of Scenic Area: Atmospheric Quality Clean and fresh air in a scenic area is a basic requirement of every tourist. The factors affecting the air quality of a scenic area that must be evaluated include: (1) gaseous pollutants, including sulphur dioxide, nitrogen oxides, hydrocarbons, carbon oxides, fluorides and ozone; (2) solid particles, including soot and dust, greater than 10 μm and fly dust less than 10 μm; and (3) aerosols, which are particles smaller than 1 μm suspended in the air that are composed mainly of inorganic compounds and a variety of organic compounds, organic polymers and volatile organic compounds. The air quality of a scenic area must reach the Class 1 atmospheric standard, and the minimum acceptable standard is Class 2.

Evaluation of Scenic Area: Soil Quality Soil has a direct impact on tourists. Clean, non-contaminated soils are good for tourists, while dirty and contaminated soils are undesirable. The quality of soil is evaluated by assessing its: (1) organic pesticide content, such as malathion, dichlorvos, phenoxy-carboxylic acids and phenols, oils, and benzo-pyrene; (2) fertiliser content; (3) heavy metal content, including toxic metals such as arsenic, cadmium, mercury, chromium, copper, zinc, lead and nickel; (4) the presence of radioactive elements; and (5) the presence of pathogenic microorganisms. There is no uniform evaluation standard for the soil quality in China's scenic areas.

Evaluation of Scenic Area: Water Quality This term is related to the evaluation of the water quality of scenic areas (including geoparks). Water is an important landscape tourism resource that offers scenic attractions, amusement, recreational activities, personal experiences and drinking. The evaluation includes assessing the water transparency, colour, smell, taste and its bacteria level. Activities in water bodies, particularly those involving direct human contact such as swimming, rafting, health treatment and drinking, require additional testing for the presence of harmful elements, minerals, temperature, pH, suspended solids, dissolved oxygen, biological oxygen consumption, various acid radicals and ions. Some highly demanding water bodies also require checks for DDT, 666, organic phosphorus, oil and detergents. The higher the transparency of the water is, the greater the ornamental value will be. 'Transparent

water' for tourists is defined by viewing a 3-mm-diameter thread at a depth of 60 cm under the water. "Transparent water" is the ideal water quality for tourists. In the United States, the total concentration of E. coli in water of healing and scenic water bodies and lakes should not exceed 20/ml, while shower or bathing water should not exceed 10/ml. In Japan, the requirement is 10/ml. There is currently no common standard in China.

Evening Rain in the Bashan Mountains (Three Gorges of Yangtze River) Evening rain refers to the rainy period from 8 p.m. until 8 a.m. Bashan refers to the Daba Mountain Range. In general, the 'Evening Rain in the Bashan Mountains' covers the rainy nights in the mountainous areas of southwestern China (including the Sichuan Basin), and the Changjiang (Yangtze River) Three Gorges is typical of this type of scenery. The rainy nights in these areas account for more than 60% of the annual precipitation.

Event Stone Event stones are special rock bodies that remain behind after special events associated with materials that came from the sky, volcanic activity and seismic activity. Meteorites, which are also known as 'extra-terrestrial visitors', are an example. They may be fragments of asteroids, planets, large satellites or comets in the solar system. They contain information about celestial bodies and thus are valuable for collection. Another example is volcanic bombs, which are products of volcanic eruptions. When hot magma or lava is thrown into the air, volcanic bombs form due to the rapid movement and condensation. These stones reveal traces of the Earth's processes and therefore have high scientific research value. Event stones have a unique ability to attract collectors because every event stone looks different, and so each has a unique charm.

Everglades National Park, U.S.A. Everglades National Park is located in the coastal region of southern Florida. It has a core protection area of 5,929 km^2. The national park has been called 'a river of grass flowing imperceptibly from the hinterland into the sea'. The exceptional variety of its water habitats makes it a sanctuary for numerous birds and reptiles as well as for threatened species such as the manatee.

Evergreen Broadleaf Forest An evergreen broadleaf forest is a zone of forest vegetation that develops in the humid monsoon climate zones on the eastern coasts of subtropical mainland regions. It is a type of evergreen arbour vegetation. The tree species mostly include evergreen broadleaf trees such as Polygonaceae, Fagaceae, Magnoliaceae, and Camellia. The plant leaves are mostly leathery, and an undergrowth herb layer is not developed. These areas are rich in animal species. They are mainly located in low mountains, hills, plains and other regions on the southern slopes of the Qinling Mountains, Sichuan, Yunnan, Guizhou, Guangdong, Guangxi, Fujian, Zhejiang, Anhui and Jiangsu. A variety of bamboo forests are often located in the evergreen broadleaf forest areas, forming unique landscapes with high ornamental value.

Exorheic River ▶ External River

Explosion Breccia Pipe Explosion breccia pipes are also known as cryptoexplosive breccia pipes. They are cone-shaped volcanic breccia pipes formed by underground eruptions. The pipe is usually accompanied by gold, iron, copper, uranium and other mineral deposits, which are an important indicator for ore exploration. Most of the diamond deposits in South Africa are produced from such breccia pipes.

Explosion Breccias Explosion breccia is a type of breccia that forms during underground eruptions. The rock block created by the explosion can be transported away due to gas (or fluid) action to form an intrusive body of breccia. The transition from 'explosion breccia' to 'intrusion breccia' is gradual. Some kimberlites are explosion breccias.

Exterior River ▶ External River

External River *Synonym:* ▶ *Exterior river;* ▶ *Exorheic river*

A river that flows directly or indirectly into the ocean is called an exorheic river. The basin of an exorheic river is called the outflow area,



Fig. 11 Extinct volcano landscape – Jiangning Fangshan in Tangshan, Jiangsu Province

which usually comprises an extensive fluvial system with a large flow volume and perennial streams. Therefore, in an exorheic basin, alpine valleys, river terraces, sand bars and lateral bars usually form to make up an exorheic river landscape. In China, exorheic river basins cover 64% of the total area of the country. Under specific conditions, an exorheic river can transform into an endorheic river. For example, the Qinghai Lake fluvial system was previously connected to Huanghe (Yellow River), but it became endorheic due to changes in the geologic structures and the lowering of the lake surface. Eight rivers flow out of China: the Yarlungzagbo River (flows out from Tibet) via the Brahmaputra River (India), the Lancang River (flows out from Yunnan) via the Mekong River (Laos), the Nu River (flows out from Yunnan) via the Salween River (Myanmar), the Shiquan River (flows out from Tibet) via the Indus River (Kashmir), the Xiangquan River (flows out from Tibet) via the Sutlej River (India), the Majia Zangpo River (also called Kongqi River; flows out from Tibet) via the Ghaghara River (Nepal), the Pengqu River (flows out from Tibet) via the Arun River (Nepal), and the Ertix River (flows out from Xinjiang) via the Irtysh River (Russia).

Extinct Volcano An extinct volcano is a volcano that is currently inactive and has no eruptive activity for nearly 10,000 years. Some still maintain an intact volcano form, whereas others have been weathered and eroded to become incomplete relics. Examples are the mesa in Jiangning in Jiangsu Province and the Datong volcano cluster in Shanxi Province (Fig. 11).

Extrusion of Viscous Lava This is neither a violent eruption nor a calm overflow but rather a phenomenon of high-viscosity magma squeezing out of a relatively small pipe, like toothpaste being squeezed. Lava domes usually include peculiar features, such as volcanic cupolas, volcanic spines and volcanic steles. Viscous lava is extruded like ‘a burst of flame’.

F

Famous Mountains Mountains are famous because of their unique natural landscape, long history, rich cultural heritage, harmonious relationship with humans and aesthetic value. Famous mountains have great scientific research value and tourism value. China's famous mountains involve traditional religion and respect for nature, landscape aesthetics, and scientific research. They all have one or more of the following four characteristics: 'view, uniqueness, history and treasure'.

Famous Springs in China China's famous springs have different uses. These springs are markers and records of development of the Chinese civilisation. Based on the reasons for their fame, these springs can be categorised into practical, ornamental, historical and cultural, and mixed springs. The practical type refers to springs that are used as water resources for drinking, irrigation, industrial use and medical use, such as the Xingtai Hundred Springs, Aershan Mineral Spring, Xiaotangshan Hot Spring and Conghua Hot Spring. The ornamental type refers to springs considered to be landscape resources, such as Butterfly Spring, Sanchao Spring and Shuhuo Tongyuan (Water and Fire) Spring. The historical and cultural type refers to springs that are famous for legends and folklore, such as Jiuquan Spring, Zhuodao Spring and Zhaoyin Spring. The mixed type refers to springs that have become well known because of multiple factors, such as Jinci Spring, Huaqing Pool, Wudalianchi Pool, Yao (Medicine) Spring, Baotu Spring, Hui County Hundred Springs and Niangziguan Spring (Fig. 1).

Fangshan Global Geopark, China This geopark is located approximately 50 km southwest of Beijing. It covers the Fangshan District of Beijing City, Yishui County, and Baoding City, Weiyuan County in Hebei Province, and it has a total area of 953 km^2. It became a global geopark in 2006. The geopark has eight scenic districts, namely, the Zhoukoudian Peking Man Site Kepu District, Shihuadong Cave Group tourist area, Shidu Karst Canyon comprehensive tourist area, Upper Mountain-Yunju Temple religious cultural tourist area, Sanlian Mountain tourist experience area, Baihua Mountain-White Grass eco-tourism area, Yishui County Yesanpo comprehensive tourist area, and Baishishan Jumayuan Fengcong waterfall tourist area. The geopark has five major characteristics: (1) the Zhoukoudian Beijing site is an important location for studying the evolution of human development; (2) the features that formed by intracontinental orogens demonstrate the intense tectono-magmatic activity during the Mesozoic Era; (3) the surface and underground karst topography is typical of the underground karst temples and karst landforms in northern China; (4) it is the cradle of Chinese geological research and a place where geoscience professionals gather and study; and (5) it has a long history and culture of ancient construction methods.

Fangshan White Marble The source of this name in Chinese is unclear. It probably refers to a type of white marble found in Dashiwo in Fangshan, Beijing. This stone looks like the jade mined in Hotian. However, the Hotian jade is composed of pebbles found in water (also called water white jade), but the Fangshan white marble is mined in mountainous dry areas, so it is called dry white jade. It is unclear why it was given the name 'Han white jade' in Chinese. Fangshan white marble is a very pure white marble composed of $CaCO_3$, $MgCO_3$ and SiO_2 with small amounts of aluminium and iron. It is a metamorphosed limestone or dolomite. The Han white jade that was used to construct the imperial palaces in the Ming and Qing Dynasties was mainly mined in the northern foothills of the Taihang Mountains near Quyang, Hebei Province, and Dawoshi at Fangshan in Beijing. The stone

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Fig. 1 Huaqing Pool in Lishan, Xi'an

produced in these locations has a fine texture and is white, and it is an ornamental stone material used for architectural and sculptural purposes.

Fault A fault is a fracture in which the hanging wall and footwall blocks have been relatively displaced during rupture. Its characteristics are similar to those of a fracture, including the basic elements, categories and formation mechanisms. (See "► Fracture").

Fault Plane A fault plane is the surface of a fault between two rock blocks. A fault plane can have a quasi-planar or curved surface, and some have a listric surface or are part of a listric fault system. When a fault passes through different lithological strata, it can often be 'refracted' or join with a bedding fault to form a 'step fault'. A fault plane can be a continuous or intermittent surface, and it can be a surface or a zone. A fault plane (or fault zone) can be brittle or ductile. A brittle fracture is characterised by a continuous fault surface, numerous scratches, and the formation of cataclastic tectonite. Ductile fractures are characterised by discontinuous fault planes, with both sides of the fault plane having a 'pulled wire' or 'fitful' appearance, and the formation of mylonitic tectonite. As a result of the abrasion of the blocks, the fault surface always has a mirror-like surface with many fault scratches as well as a thin layer of 'dynamic encrustation'.

Fault Scarp A fault scarp is a steep cliff associated with an exposed fault plane. An example is the Longshou (Dragon's Head) Cliff at Lushan Mountain. Most fault scarps have been affected by erosion.

Fault Zone A fault zone is a banded structure consisting of a network of interconnected fractures (or fault planes) that divides two blocks. A fault zone has significant displacement, whereas a fracture zone has no obvious displacement. Tectonites are often developed along fault zones. Brittle fault zones contain cataclastic tectonites, including protocataclasite, cataclasite, ultracataclasite and unconsolidated ultracataclasite fault gouge. Ductile fault zones are composed of a series of mylonites (including protomylonite, mylonite, ultramylonite and phyllonite). Some fault zones have marked boundaries composed of a main boundary fault, whereas others are transitional and lack obvious boundaries. The sizes of fault zones can be categorised as giant, large, medium, small and minute. They can also be divided into superficial fault zones, basement fault zones, crustal fault zones and lithospheric fault zones. Fault zones can have compressional, tensional, shear, compressional-shear or tensional-shear dynamic characteristics. There are also normal

fault zones, reverse fault zones, transform fault zones, strike-slip fault zones, dip fault zones, oblique-slip fault zones and bedding fault zones. The Circum-Pacific fault zone and the Mediterranean fault zone are the largest fault zones in the world, with total lengths of thousands of kilometres. Minute fault zones can be found in hand-sized rock specimens and can only be inspected under a microscope.

Fauna Fauna includes all of the animals that have existed historically in a region, an environment, or an era. In palaeontology, it is often categorised or named according to the animal types, distribution or geologic periods. Its boundaries are not definite. Examples of spatial classification are the North China fauna and the Southeast fauna. Examples of geologic period classification are the Cambrian Period fauna and the Early Cambrian Epoch fauna. Examples of biological classification are the Actinoceras fauna and the Orthocera fauna.

Feldspar Feldspar is the collective term for the feldspar family of minerals, including orthoclase, sanidine, microcline, anorthoclase, plagioclase and celsian. Feldspar is the most important rock-forming mineral, and it occurs in the three main rock types, especially igneous rocks. It is also a main marker for rock classification. Feldspars rich in potassium or sodium are commonly used in the ceramic, glass and enamel industries. Feldspars with rare elements such as rubidium and caesium are good sources of these minerals. They are widely distributed in nature, but gem-grade minerals such as moonstone, amazonite, sunstone and labradorite are not common. The world's highest quality moonstone is mainly mined in Myanmar, Sri Lanka and Switzerland. Sunstone mainly comes from Mexico, the United States and Norway. Labradorite mainly comes from Madagascar, Finland and Russia, and amazonite is produced in the United States, Russia and India. These stones are also mined in some areas of China. Gem-grade feldspars often have unique halos and colours.

Feldspar Gem Feldspar gemstones are composed of gem-grade feldspar, which is a common mineral in the Earth's crust. Its chemical composition is K, Na, Ca and Ae silicate. Feldspar is a large mineral group with many varieties. The main sub-groups are K-feldspar, plagioclase feldspar and barium feldspar, whereas K-feldspar and plagioclase feldspar are used as gemstones. Common feldspar gems include moonstone (belomorite), adularia, sanidinite, amazonite and sunstone (sandastras) (Fig. 2).



Fig. 2 Amazonite crystal

Felsite Felsite is an extrusive acidic hypabyssal rock. It consists of microcrystals and crystallites formed by devitrification or recrystallization that appear as spherical granular structures in radial arrays. When a felsite contains feldspar porphyry, it is called felsophyre.

Feng Liu Feng Liu (1972–) is a native of Chenzhou City, Hunan Province. He obtained his doctorate degree from the Institute of Geographic Sciences and Natural Resources Research of the Chinese Academy of Sciences and was a post-doctoral scholar at Tsinghua University. He is currently a researcher of the Development Research Centre of the State



Fig. 3 Fengcong in Guilin, Guangxi Province

Council and an expert on young and middle-aged tourism geography and tourism planning. He has been responsible for the tourism development plans of more than 20 provinces, cities, and scenic regions in Ningxia, Qinghai, Hebei, Jiangxi, Tibet, Yunnan Yuxi, Shanxi Pingyao, Guangxi Beihai. His main works are 'Research on Tourism Development Strategy in Western China', and 'The Theory, Method and Application of Tourism System Planning'.

Fengcong or Conical Karst Landscape This is a landform composed of limestone peaks connected at their bases (yakou, saddles or cols), and this is its main difference from a peak forest. In addition, they are generally conical, larger, and have normal slopes. China's cone karst landform covers a total area of approximately 12,500 km^2. The main outcrops are located in western Guangxi Province, southern Guizhou Province, and eastern Yunnan Province, and a few outcrops are located in southern Hunan Province and northern Guangdong Province. There are also a few scattered locations in Fujian Province, Zhejiang Province and northern China. Based on the morphology and outcrop location, this landform can be divided into watershed peak clusters, valley peak clusters, island peak clusters, edge peak clusters, deep depression peak clusters and shallow ditch peak clusters. Based on the age of the rock formation, these landforms can be divided into the Pre-Cambrian peak clusters, Cambrian peak clusters, Ordovician peak clusters, Devonian peak clusters, Carboniferous peak clusters, Permian peak clusters and Triassic peak clusters. This peak cluster landform is magnificent with high aesthetic and ornamental value, and it is regarded as an elegant and exquisite tourism resource (Fig. 3).

Fenghuang National Geopark, Hunan This geopark is located in Fenghuang County, Xiangxi Tujia and Miao Autonomous Prefecture in Hunan Province. It lies in the southern part of the Wuling Mountains on the eastern edge of the Yunnan-Guizhou Plateau. The park acquired the national geopark status in 2005. It features Palaeozoic carbonate rock gorges, peak forests, terraces, caves, waterfalls, stream springs, structural traces and other geological features, such as Tianxing Mountain, Sanmen Cave, Paoshui Canyon, Bagong Mountain, and Qiliang Cave.

Fengkai National Geopark, Guangdong This geopark is located in Fengkai County, Zhaoqing City, in northwestern Guangdong Province along the upper reaches of the Xijiang River, adjacent to Wuzhou City in Guangxi Province, and along the Tropic of Cancer. It became a national geopark in 2005. The attractions include the giant dome-shaped Yanshanian granite landscape, the karst landscape of Palaeozoic carbonate rocks, and the Zhangjiajie sandstone columnar peak-forest landscape that formed in Devonian quartz sandstone. These features illustrate the tremendous changes that have occurred over the past 500 million years in western Guangdong and record the evolution of ancient humans in Lingnan (South China).

Fenglin Landscape, Tower Karst Landscape, Peak Forest Landscape This is a landform that features a combination of isolated tower-shaped carbonate rock peaks. Based on the position, they can be divided into plain-type peak forests and valley-type peak forests. According to statistics compiled by Zhu Dehao et al., China's karst landforms cover 125,000 km^2, of which 12,000 km^2 is in Guangxi Province, and 1,123 km^2 is in the areas around Guilin. Xingping-Fuli is a typical example (Figs. 4 and 5).

Fengyang Mount Jiushan National Geopark, Anhui This geopark is located in Fengyang County, Anhui Province, and became a national geopark in 2009. The main geological features include grid-like groove dissolution cave landscapes, cave groups, insect fossils, the Fengyang Mountain springs and the Woniu Lake volcanic wetlands. The outcrops of the grid-like groove dissolution karst landscape cover an area of approximately 1 km^2, and the grooves are 5–10 m deep. It is a new type of karst topography, and more than 10 caves have been found. The longest is more than 1,400 m long and has concave grooves on the walls that were formed by water erosion, and fossilised worm trails are present on the surfaces of the red silty shales. As many as 10 springs have been found in the Fengyang Mountain area; the Willow Spring has the highest flow rate of 25–30 l/s.

Fengye Gobang State Park, Vietnam This park is located in the mountainous region of the province of Quang Binh in central Vietnam near the border with Laos. The core protection area covers 8,575 km^2. The karst landform of the Fengye-Gobain National Park developed during the Palaeozoic (approximately 400 million years ago) and is the oldest and most important karst region in Asia. The structure



Fig. 4 Karst valley peak forest landscape – Leye, Guangxi Province

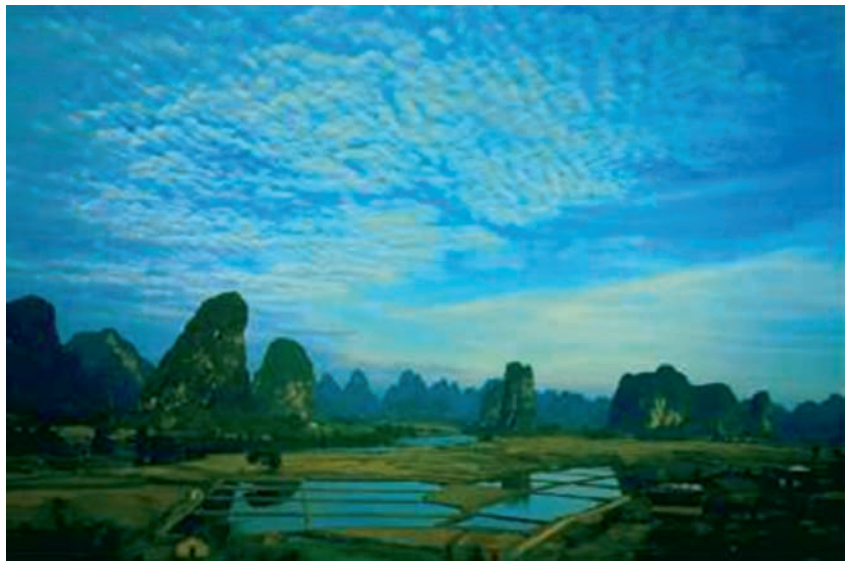


Fig. 5 Karst peak forest plain landscape – Guilin, Guangxi Province

of the karst landscape is complex, and there are many types of geomorphological features of great scientific value. The 65-km-long cave system and underground rivers are parts of the outstanding landform structure.

Fenhe-Weihe Graben *Synonym:* ▶ *Fen-Wei Graben*
The Fen-Wei Graben is located in the area between the EW-trending orogenic belts of the Yinshan Mountains and Qinling Mountains along the Fenhe River and Weihe River. It extends north of the Qinling Mountains along the Weihe River with an EW trend to Houma and Yuncheng in Shanxi Province and then turns to a NNE trend. It is composed of a graben system with a length of 1,200 km and a width of 10–50 km. The graben system began to form in the Eocene. It continued to develop in the Pliocene and began to subside in the Quaternary. The basement of the Weihe Basin is up to 6,000 m deep, which is an indication of strong subsidence. The graben system contains numerous hot springs and is also an area of recent seismic activity. These characteristics indicate that this graben is currently an active rift zone.

Fenhe-Weihe Rift *Synonym:* ▶ *Fen-Wei Rift*
This structure has been confirmed to be an active rift; hence, it is called the 'Fen-Wei Rift'.

Fenster *Synonym:* ▶ *Window*
When a nappe is cut by erosion, the underlying strata beneath the fault plane may be exposed, forming a window or fenster. A fenster is usually bounded by an exotic rock body with exposed rock outcrops composed of the lower rock layers and surrounded by faults.

Fen-Wei Graben ▶ Fenhe-Weihe Graben

Fen-Wei Rift ▶ Fenhe-Weihe Rift

Fiamme Fragment ▶ Fiamme Pumice

Fiamme Pumice *Synonym:* ▶ *Fiamme fragment,* ▶ *Magma fragment*
Magma fragments are also known as plastic fragments or fiamme. These broken fragments form when magma in a plastic viscous state explodes. The fragments have flame-like, branched, spindle-shaped or banded shapes. When the fiamme is orientated in a specific array pattern due to flowing and flattening effects, it is called a pseudo-flow structure or a quasi-flow structure. Magma fragments are indicative of welded pyroclastic debris (Fig. 6).

Field Yellow Stone ▶ Landerite

Fifth Group of National-Level Scenic Areas On January 13, 2004, the State Council announced another 26 national-level scenic areas. Among them, Tiantaishan Scenic Area in Sichuan Province was added to the World Heritage List by UNESCO as part of the 'Sichuan Giant Panda Sanctuaries'. Xiaozhai Tiankeng Scenic Area in Chongqing Municipality was

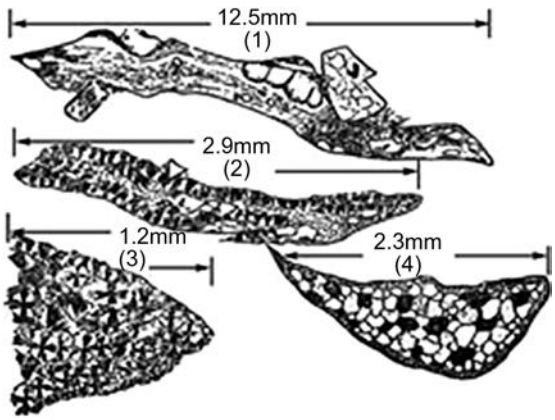


Fig. 6 Fiamme pumice and its internal structure (Yanqing and Huarou, Beijing). (1) Clastics with amygdaloidal and rhyolitic structures; (2), (3), (4) devitrified clastics with comb edges, chondrules and inlays, respectively

included in the first group of the 'Tentative List of China's Natural Heritage Sites' by the state council in January 2006.

Fine-Grained Gneiss Fine-grained gneiss is a deep regional metamorphic rock with feldspar and quartz as the main minerals (generally between 50% and 90%) and dark minerals as the supplemental minerals (generally $<30\%$). It has very fine grains, a homeo-granoblastic texture and a gneissose structure. It contains intermediate acidic plagioclase and microcline and forms by the alignment of flaky or columnar minerals such as biotite, hornblende, pyroxene, tremolite and magnetite. It is differentiated from other types of gneiss by its finer granularity, even mineral distribution and abundant light-coloured minerals. Fine-grained gneiss is a product of the migmatization of siltstone, tuff and intermediate acidic lava.

First Group of National-Level Scenic Areas On November 8, 1982, the State Council announced 44 national-level scenic areas, including the Five Great Mountains, namely, the North Great Mountain (Hengshan), the East Great Mountain (Taishan), the Central Great Mountain (Songshan), the South Great Mountain (Mount Heng) and the West Great Mountain (Huanshan). The 11 scenic areas, namely, Badaling and the Thirteen Tombs of the Ming Dynasty, Chengde Mountain Resort and its outlying temples, Wuyishan, Lushan, Taishan, Longmen Grottoes (Luoyang), Wudangshan, Emeishan, Huanglong Temple-Jiuzhaigou, Qingchengshan-Dujiangyan and the Stone Forest, were added to the World Heritage List by the United Nations Educational, Scientific and Cultural Organization (UNESCO) between 1987 and 2007. Eight scenic areas, namely, Jingpohu, Wudalianchi, Yandangshan, Lushan, Taishan, Songshan and the Stone Forest, were designated as global geoparks by UNESCO between 2004 and 2006.

Fish Fossil This is a collective term for fossils of all Ichthyolites. Fish are aquatic vertebrates of a wide range of species, including Agnatha, Placodermi, Chondrichthyes, Acanthodii and modern Placodermi. After hundreds of millions of years of evolution, fish flourished and dominated during the Devonian, and this period is called the 'Era of Fish'. Devonian fish are mainly distributed in eastern Yunnan, central Guangxi, Hunan, Hubei and Jiangxi Provinces. They are well preserved in sandstone and siltstone. However, the Early Mesozoic Chondrichthyes only have fossils of teeth, scales and fins. Fossils of Late Mesozoic Osteichthyes are common and can be found in many places, such as the Late Jurassic Lycoptera and Sinamia in northern China and the Middle Triassic Sinoengnathus kueichowensis in Guizhou. Cenozoic fish fossils are mainly found in the middle Yangtze River Basin, such as the Palaeogene Jianghanichthys hubeiensis and Ling Jiang fish, which were found in western Hubei Province and northern Jiangxi Province.

Fissure Eruption This is a type of eruption in which magma flows from linear fissures. For example, the basalt in the Deccan Plateau in India formed from the flow of lava along lateral fissures on both sides. This eruption was mainly basaltic. Laki Volcano (Lakagigar) in Iceland is a typical example with a 25-km-long fissure and lava coverage of 565 km^2. This type of eruption can also cause volcaniclastic flows. For example, the Palaeogene and

Neogene tuffs in Nevada, United States, cover 200,000 km^2 and are up to 2,500 m thick, and this tuff layer is also known as the volcaniclastic plateau (see the diagram of volcanic fissure-type eruption) (Fig. 7).

Fixed Dune Landscape Because of the development of vegetation cover on a sand dune (coverage greater than 30%), dune movement essentially stops, and the dune can maintain its form and location and become stable for a long time. An example is the fixed sand dunes in the Junggar desert (Fig. 8).

Flammule or Buddha Light Landscape Flammules, also known as buddha lights or rings, are peculiar optical phenomena in the atmosphere. They normally appear in cloud-covered high mountains at middle or low latitudes due to the diffraction of inclined sunlight by water vapour. The light usually produces gorgeous colours with a radiant glow that follows people's movements. It has become an important tourist attraction at high elevations. It can be found in Haz Mountain in Germany, Baregg Mountain in Switzerland, and Lushan, Taishan and Emeishan in China. The flammule of Emeishan is particularly spectacular. More than 320 days per year are foggy, with an average of 8.9 foggy days and 7.4 rainy days out of every 10 days. Therefore, flammule can usually be seen at the top of the mountain.

Flood Basalt Flood basalts form when low-viscosity basaltic magma flows from a volcano repeatedly for a long distance, forming a lava tableland and lava plateau, from which it gets the name flood basalt. The coverage can reach 100,000 km^2 with a very gentle slope gradient in the range of 2°–3°. The basalt on the Colombian Plateau in Oregon and Idaho, United States, is a typical flood basalt. It covers approximately 220,000 km^2 and has an estimated volume of 195,000 km^3. It formed during the Middle Miocene with an eruption period of two to three million years. The Permian Emei basalt in the border areas of Sichuan, Yunnan and Guangxi Provinces is also a type of flood basalt.

Flora Flora includes all of the plants that have existed in a particular region, an environment, or an era. In palaeontology. It is often categorised or named according to the plant types, distribution or geologic periods, and its boundaries are indefinite. Examples are the Glossopteris flora, the Cathaysia flora and the Permian flora.

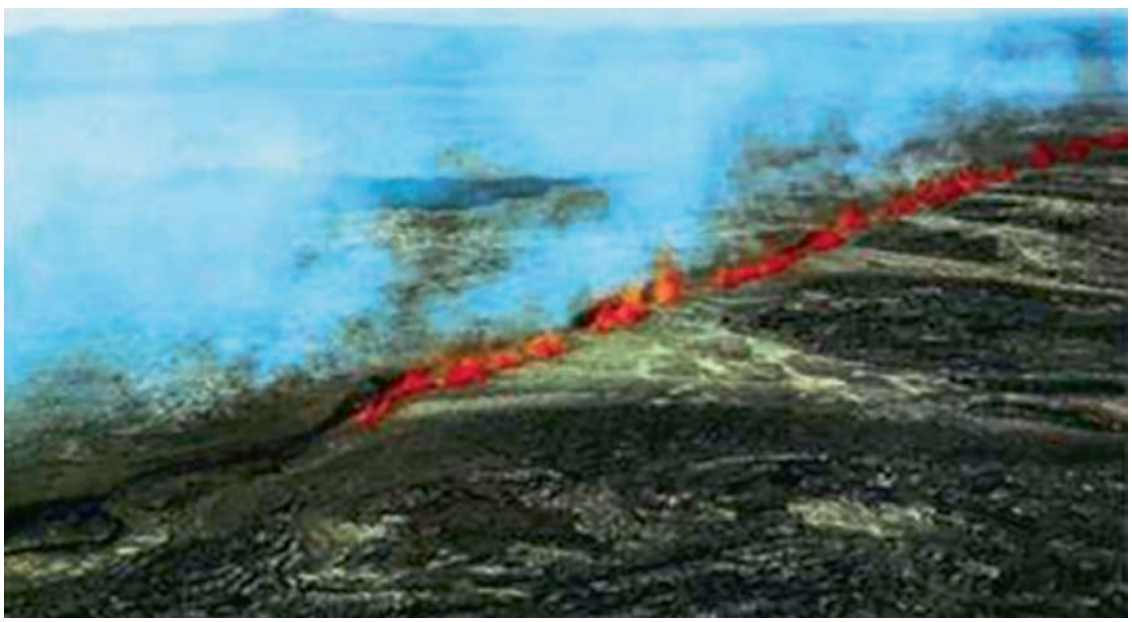


Fig. 7 Fissure eruption of a volcano



Fig. 8 Fixed dune landscape – Junggar, Xinjiang Province

Flower Show Tourism Flower shows are held for flower appreciation. They are common and have a long history in China, Japan and Southeast Asia. For example, Japan hosts the annual Cherry Blossoms Festival, and Guangzhou in China hosts the Ram City Flower Festival. Beijing hosts the Chrysanthemum Show in October every year. These events attract large numbers of tourists to these cities. In recent years, the Peony Flower Festival in Luoyang has become a major tourist attraction in central China.

Fluid Dune Landscape This is a type of sand dune landscape composed of moving dunes. Because of the sparse vegetation cover, sand dunes move easily due to wind to form new dunes. The velocity of dune movement is related to its height, the wind speed and the conditions of the underlying surface. Dunes generally move several metres to more than 10 m per year. Fluid sand dunes can be found in many desert marginal areas in China. Dune movement is a serious threat to agricultural, industrial and transport facilities. To prevent scenarios in which sand advance causes human retreat, several afforestation projects have been implemented and have managed to turn fluid dunes into fixed or semi-fixed dunes (Fig. 9).

Fluidal Structure; Rhyolitic Structure A rhyolitic structure is a trace flow structure of volcanic rocks defined by different colours, alignments of minerals, bands or strips of different compositions, or elongated pores. An example is the rhyolitic structure of the Yandang Mountain rhyolite (Fig. 10).

Fluorine Water This is a type of medical hot mineral water. According to the National Medical Hot Mineral Water Quality Standard, water with a fluorine content over 2 mg/L is classified as fluorine water. It can be used for bathing and drinking and has therapeutic and healthcare effects on the human body. Most hot springs around the world contain fluorine.

Fluorite Fluorite is also called fluorspar. Its composition is CaF_2, and it sometimes also contains rare earth elements. Fluorite that is rich in yttrium is called yttro-fluorite. Its crystals are cubic and octahedral. Crystal twinning is common, and the aggregates are blocky, granular



Fig. 9 Fluid dune landscape – Badain Jaran Desert, Inner Mongolia



Fig. 10 Rhyolitic structure, Yandangshan, Zhejiang

and dense. It has many colours, ranging from purple, green, colourless, white, yellow, pink, red, and blue to black. It has transparent to translucent diaphaneity and a vitreous lustre. Breaking of the crystal will leave a completely octahedral cleavage surface with a triangular surface at each corner of the cubic crystal body. It is fluorescent under ultraviolet light and is also thermo-luminescent. It mainly forms in hydrothermal solutions and often occurs as a single fluorite mineral vein. It is sometimes also found in lead-zinc sulphide deposits. It is the only mineral used for hydrofluoric acid production. Beautiful fluorite crystals can be used as gems.

Fluorite Gem This is gem-grade fluorite that is mainly composed of CaF_2. Fluorite usually contains impurities, where Ca is often replaced by Y and Ce. Fluorite has a rich colour, and the gem-grade stones are usually light green or dark green, blue, bluish green, purple, brown, yellow, pastel, brown, rose red, deep red and colourless. Fluorite sometimes has many colours in one stone. The colour-rich stones can



Fig. 11 Fluorite minerals

be polished to become gems. Gem-grade fluorite is mainly mined in the United States, Colombia, Canada, Russia, Australia, South Africa and Mexico. China has the highest fluorite production in the world. Fluorite is fluorescent, so glows in the dark (Fig. 11).

Fluvial Delta Tourism Landscape When rivers carry abundant sand and silt into a lake or sea, a triangular plain usually forms, which is called a delta. All of the world's major rivers that flow into an ocean or sea have created large deltas with different forms and natural landscapes, which constitute a special type of delta tourism landscape. An example is the Danube River Delta, which has wide river channels, steady and smooth flows over river flats, and flocks of birds; these features create a tourism area formed by the river network.

Fluvial Facies Fluvial facies are a type of terrestrial facies. The term refers to a set of sediments or sedimentary rocks that form by the action of rivers or other runoff. Based on the environment and sediment characteristics, fluvial facies can be further subdivided into riverbed facies, embankment facies, floodplain facies and oxbow lake facies.

Fluvial Landform Flowing water is the most active and common external force that shapes the Earth's surface in the form of rivers and streams. During the flow process, undercuts and lateral erosion occur and form valleys and plains. Erosion and deposition form river terraces, floodplains, alluvial fans and deltas.

Fluvial Landforms Landscape This is a landscape composed of landforms formed by fluvial processes. Running water is the most common and active external force that shapes the morphology of the Earth's surface, and rivers are the main form of flowing water. The vertical and lateral erosion by running water of a river can create various landforms of gullies and meanders. Erosion and deposition result in the formation of depositional landscape features, such as fluvial terraces, floodplains, alluvial fans and deltas. Fluvial landforms are important geological relics, and rivers that can be used for sightseeing, scientific research and leisure rafting are important tourism resources. The Three Gorges National Geopark, Huanghe (Yellow River) Hukou Waterfall National Geopark, Shaanxi Yanchuan Huanghe Meander National Geopark and Henan Zhengzhou Huanghe National Geopark are typical examples of geological parks with fluvial landforms as themes. Cruising the Three Gorges and rafting the Maling River and Dadu River are important sightseeing and tourism activities.

Fluvioglacial Delta Landscape ▶ Outwash Delta Landscape

Foehn A foehn is a local wind system in which mountain airflow rises on the windward slope (refer to topographic rain) and sinks on the leeward slope to become warmer and drier. The humidity of the region the wind passes decreases due to the rapid increase in temperature. In some places, the temperature during the day can increase suddenly to above 20 °C, and it is very dry. Foehns often dry and kill fruit trees and crops, reduce their productivity and cause bush and rural fires.

Fold A fold is a deformed geologic surface caused by bending or curving of strata. The most common type is folds formed by layered sedimentary rocks. A fold is composed of a fold centre, two limbs and a crest. A fold can be illustrated by the 'fold elements', such as the axial plane, axis, hinge point, crest plane, crest

line, trough surface, trough line, axial trace, saddle, crest, inflection point, plunge, tilt, fold wavelength, fold amplitude, and fold envelope surface. Folding of rocks results in a variety of scenery; in particular, many mountain systems are the result of intense folding of rocks, which forms spectacular landscapes (Fig. 12).

Fold Mountains Fold mountains are mountain systems that are formed by folding of rock strata. Typical examples are the Tianshan Mountains, Qilian Mountains, Qinling Mountains, Kunlun Mountains and the Himalayas.

Fold System A fold system is a fold belt composed of several inverted geosynclines with land masses between them, which have experienced intense structural deformation, magmatic activity and metamorphism. A fold belt always has similar tectonic characteristics and geologic histories. A typical example is the Qilian-Dabie-Kunlun-Qinling fold system.

Foliation A foliation is a structure that forms from thin and dense planar surfaces in a rock. It is a collective term for all planar structures, including micro- to macro-scale, primary to secondary structures, and foliations formed by various processes.

Folk Custom Folk customs refer to customs and traditions that have evolved from generation to generation in different places with different social and natural environments, including etiquette, food, costumes, festivals, performing arts, sports and events. Folklore is often a significant attraction to tourists.

Footwall The footwall is the rock mass below an inclined fracture plane (or fault). Based on the relative direction of movement of the hanging wall and footwall, faults can be categorised as normal faults, reverse faults (thrust faults) and transform faults (strike-slip faults).

Forest Bath The so-called forest bath refers to the inhalation of fresh air in the forest. Many respiratory diseases stem from a deficiency of oxygen and air pollution, and these phenomena may cause heart problems. The air in the forest is clean, moist and has a higher oxygen content. In addition, several volatile substances excreted by trees stimulate the cerebral cortex and relieve nerve tension. Some trees, such as pine, cypress, lemon trees and eucalyptus, also secrete substances that kill bacteria. Forests also contain higher levels of negative oxygen ions. The forest bath is best during the day because the oxygen content is higher and the dust level is much lower inside the forest.

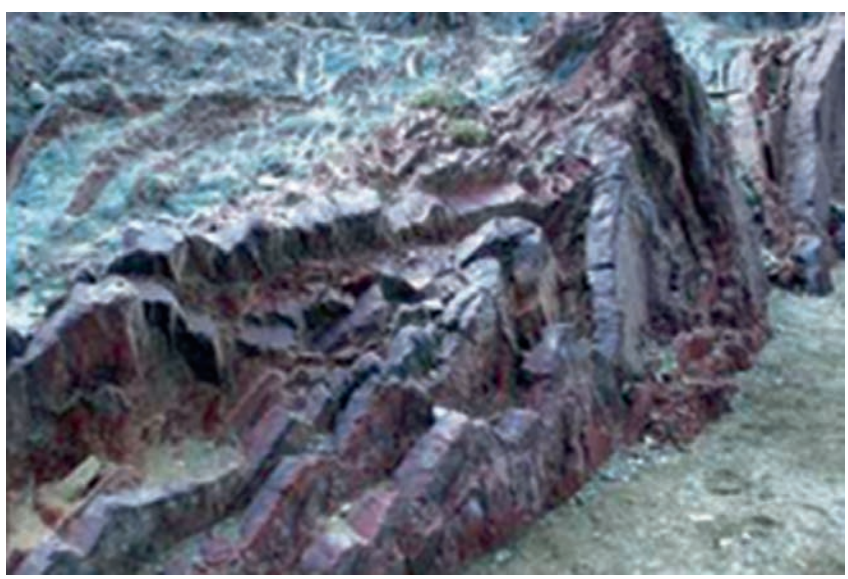


Fig. 12 Folds in Xiangshan Qun, Ningxia Province

Forest Coverage Rate The forest coverage rate is the percentage of forest area in a country or area. China stipulates that the forest coverage rate, including arbour forests, bamboo forests, shrubs, farm-related forests and forested areas surrounding villages, roads, water bodies and houses, should be a minimum canopy density of 0.2. The forest coverage rate is an important indicator that reflects the richness of forest resources and the ecological quality of a country.

Forest Ecosystem Landscape A forest ecosystem is a type of ecological landscape that mainly consists of ecological landscape systems composed of biotic communities associated with woodlands (including flora, fauna and microorganisms) and the associated abiotic environment (such as light, heat, water, air and soil). Forest ecosystems include tropical rainforests, subtropical evergreen broadleaf forests and cold temperate coniferous forests, all of which are mainly located in wet or moist regions. They are characterised by abundant plant species, complex vegetation communities and stable plant species density and plant communities. Forest ecosystems generally consist of trees with few shrubs and herbs as well as a wide range of fauna species. Because it is easier to find food and shelter in trees, there is a good variety of tree-living and tree-climbing animals, such as hornbills, tree frogs, squirrels, martens, queen monkeys, tarsiers and gibbons.

Forest Fawr Geopark, Wales, UK This geopark is located in the Brecon Beacons National Park in South Wales and covers an area of 763 km^2. It became a global geopark in 2005 and was the first geological park in the United Kingdom. The park administers the Carreg Cennen Castle, Craig-y-nos National Park, the National Showcaves Centre for Wales, Black Mountain, Peny Fan, the Brecon Mountain Railroad and the National Park Reservoir. The main geologic relics include traces of ancient oceans, movements in the mountains, sea level and climate change during the last ice age; and also waterfalls, caves, and peaks. The park preserves traces of the ice age from 2 Ma to 12,000 a. The people in this area started using stone tools very early. During the industrial revolution, people here used limestone to make fertiliser and developed iron smelting skills.

Forest Law of the People's Republic of China This law was passed and promulgated in 1998 in the second session of the Standing Committee of the Ninth National People's Congress. The contents include: Chapter I, General Provisions; Chapter II, Forest Management; Chapter III, Forest Protection; Chapter IV, Afforestation; Chapter V, Forest Harvesting; Chapter VI, Legal Responsibility; and Chapter VII, Supplementary Provisions. This law stipulates that forests will be divided into shelterbelts, timber forests, economic forests, firewood forests and special purpose forests. The law applies to typical forest ecotopes in different natural zones and areas where precious animals and plants grow and develop, natural tropical rain forest areas and areas with special conservation value. In other natural forests or areas that require special attention, nature reserves will be set up, and no logging will be permitted in these forests.

Forest Park A forest park is a natural park that is mainly composed of a planted or natural forest. It is integrated with other landscapes. Its main objectives are to popularise forest science knowledge and to provide the public with health and leisure. Forests can beautify the environment, regulate the climate, purify the air, and absorb dust and toxic gases, and 'forest baths' also have unique health effects. Therefore, many countries around the world have established forest parks. As of the end of 1998, China had established 870 forest parks with a total area of 7.48 million km^2, which accounts for more than 0.78% of the total land area of China. Of these, 292 national forest parks had a total area of 5.3 million km^2.

Forest Tourism Forest tourism is tourism in the forests. It includes driving, riding, rowing, walking, mountaineering, skiing, camping, picnicking, hunting, fishing, rafting, gathering, adventures, photography, sightseeing, and scientific exploration. Forest tourism in China

began to develop and flourish in the 1980s. Currently, it mainly takes place in China's forest parks, natural reserves, scenic areas, botanical gardens, and state-owned forest farms.

Forest Tourism Landscape These are forests and woodlands with tourism value. Forests can regulate the weather, purify the air, absorb dust, and have special medicinal functions with forest baths. They also have aesthetic value; thus, many countries around the world have used forest tourism landscapes in the construction of numerous forest parks. In China, many plantation forests and woodland plantation areas have been developed into national forest parks and provincial forest parks. In addition, several virgin forests have become destinations for eco-tourism and scientific expeditions.

Foshan Mount Xiqiaoshan National Geopark, Guangdong This national geopark is located in Foshan, Guangdong. In March 2004, it was approved by the Ministry of Land and Resources as one of the third group of national geoparks. It features volcanic landscapes, including well-preserved ancient volcanic trachytic structures, lithofacies boundaries, unique volcanic gorges and multi-level waterfalls. It also has cultural landscapes and relics, such as quarry sites from the Ming Dynasty and stone tools of pre-historic humans.

Fossil Fossils are biological remnants or relics of previous geologic times preserved in rock strata. Biological remains are usually the hard parts or prints of organisms. However, under cold and sealed environmental conditions, complete biological remains may be well preserved. In addition to the biological body, fossils also include traces of living organisms, moulds formed during the fossilisation process and the residual organic parts. Fossils can indicate the existence of ancient organisms and are the main focus of palaeontology. Based on their size, fossils are divided into large fossils, microfossils, and supermicrofossils. Based on the biological classification, fossils can also be divided into animal fossils, plant fossils, vertebrate fossils and fish fossils. Fossils are the important basis for studying biological evolution, determining stratigraphic ages, and evaluating palaeogeographic and palaeoclimatic environments.

Fossil and Non-Fossil The differences between fossils and non-fossils hinge on their association with palaeobionts. Fossils should have biological characteristics, such as form, structure, patterns and organic composition and have preserved traces of the living palaeobionts. Certain types of matter are preserved in rocks but are unrelated to living organisms, or their associated activities cannot be called fossils even though they look like some types of fossils; and these are called non-fossils. Typical examples of non-fossils are Jiang Jie Shi (Ginger stone, loess child), turtle stones and dendritic iron deposits.

Fossil Classification Fossils can be classified according to the rock type associated with the fossils or the mode of preservation. The rock type classification includes siliceous fossils, limestone fossils, dolomite fossils, marl fossils, shale fossils, and sandstone fossils. Fossils in limestone, siltstone and shale are easier to find and collect. For example, trilobites, ammonites, orthoceras, corals and sponge are usually preserved in limestone. Fossils of reptiles and plants are usually found in shale, whereas fossils of dinosaurs, dinosaur eggs and fish are preserved in sandstone. Based on the mode of preservation, fossils can be categorised into body fossils, trace fossils (including relic fossils) and chemical fossils.

Fossil Protection Rules State Council Decree No. 580 of the People's Republic of China was promulgated on January 1, 2011 and comprised six chapters and 45 rules. They define the meaning, ownership, protection and management authorities, laws, exploration, collection, import and export of fossils.

Fossil River Course *Synonym:* ▶ *Fossil stream channel*

This is a term for an abandoned river valley without running water that has been recorded in human history or identified geologically. A fossil river course forms due to river channel diversion. Oxbow lakes and abandoned river

terraces are important relics. The lower course of the (Yellow River) is a migratory river course that has left behind numerous fossil river courses. They are covered by thick gravel or sand layers that are ideal locations for searching for alluvial sand deposits and shallow groundwater. These fossil channels can also be used to recharge groundwater to return overexploited low water tables to their normal state.

Fossil Stream Channel ► Fossil River Course

Fourth Group of National-Level Scenic Areas On May 17, 2002, the State Council announced an additional 32 national-level scenic areas. Among them, Chongqing Furong River Scenic Area is one of a series of world natural heritage sites known as 'South China Karst', the Beijing Shihua Cave Scenic Area is part of the Fangshan Global Geopark, and Xingwen Shihai Dongxiang National Park has been designated as one of the second group of global geoparks.

Fracture A fracture is a crack in rock due to an external force, regardless of whether any relative displacement has occurred. Fractures include fissures, joints and faults. The fracture surface, faulted rock, hanging wall, footwall, upthrow, downthrow, displacement (including slip and throw) and slickensides are the basic elements of fractures. Based on the direction of slip, faults can be categorised as strike-slip faults, dip-slip faults, oblique-slip faults and bedding faults. Based on the relative motion of the upper and lower blocks, faults can be catetegorised as normal faults, reverse faults (thrust faults) and transform faults (strike-slip faults). According to their depth, faults can be categorised from shallow to deep as superficial faults, basement faults, crustal faults and lithospheric faults. Based on their rock mechanical properties, faults can be categorised as brittle fractures (forming cataclastic tectonites), brittle-ductile fractures and ductile fractures (forming mylonitic tectonites). Different fractures have different mechanical properties, which can be generalised into five types: compression, tension, shearing, compression-shearing and tension-shearing fractures. Based on the sliding properties during the rupture process, fractures can be divided into creeping fractures (sliding with no earthquakes) and viscous sliding (triggering earthquakes). Studying fractures not only helps to develop and formulate interpretations of the history and evolution of lithospheric deformation but can also be employed in practical applications, such as earthquake monitoring and prediction. In addition, large fractures are targets for rock and ore exploration and channels for magmatic activity.

Fracture Zone See ► Fault Zone.

Fraser Island, Queensland, Australia This island is located in southeastern Queensland and faces the Pacific Ocean. With a length of 122 km from north to south, it is the largest sand island in the world.

Freezing Rain Freezing rain is a severe weather phenomenon that often occurs in early winter and early spring. In the northern hemisphere, when strong cold air from the north meets warm and humid air from the south, the cold air flows underneath the warm air, decreasing the temperature near the ground to below zero, while the warm and humid air is lifted to form precipitation. The supercooled raindrops fall to the ground and immediately form ice. Freezing rain can break power and telephone lines, delay traffic, and lead to problems with transportation, communications and building safety.

Freshwater Lake A freshwater lake has water with a salinity less than 1 g/L, though another threshold that is used is a salinity less than 0.3 g/L. Most freshwater lakes are carbonate, drained and outflowing lakes. There are both closed and open types. Closed freshwater lakes are mostly located in alpine or inland areas with no obvious river inflow or outflow, such as cirque lakes in mountainous areas. Open freshwater lakes usually have a wide distribution. There are often islands inside the lake with numerous inflow rivers. Typical examples include Poyang Lake, Dongting Lake, Taihu Lake, Chaohu Lake, Weishan Lake and Hongze Lake, which are the six major freshwater lakes in China (Fig. 13).



Fig. 13 Lake Dongting landscape

Frigid Tundra Climate Frigid tundra climates are mainly located on the shores of the Arctic Ocean in Eurasia and North America and are influenced by the perennial polar air masses and polar continental air masses. The winters are long and cold, and the summers are short and warm. This climate has little rainfall, and it is concentrated in the summer. In this cold and humid climate, permafrost develops, and the vegetation is mainly low, dense shrubs, perennial herbs, lichens and mosses. It is also known as the tundra climate.

Frigid-Temperate Coniferous Forest Ecological Landscape This is a type of ecological landscape that is also known as a northern coniferous forest or taiga landscape. It is composed of coniferous woodlands in a cold temperate region. The tree group mainly consists of a single species with straight trunks and a simple and clear community structure. The trees are mainly Picea, Abies, Larix and Pinus. Picea and Abies are more shade-tolerant, so they occupy the darker and closed areas inside the woodland, which were given the name 'dark coniferous forest'. Larix and Pinus are heliophiles, and they are more widely scattered, so it is brighter inside the woodland. This type of woodland has the name 'bright coniferous forest'.

Frost Action This is a type of physical weathering that shapes landforms. In high-latitude areas and mountains at mid-latitudes, where the annual average temperature is below 0 °C, and the annual and diurnal variations are large, frost action splits apart rocks. Landforms sculpted by frost weathering are common in the Qinghai-Tibet Plateau and in mountains more than 1,500 m above sea level.

Frozen Earth *Synonym:* ▶ *Frozen ground landscape*

Frozen earth is a soil layer that contains frozen water in locations where the annual average temperature is below zero. Frozen earth can be short-term (duration of a few

hours or days to half a month), seasonal (half a month to several months) or permanent (several years to tens of thousands of years).

Fuan Baiyunshan National Geology Park, Fujian This geopark is located in Fuan City, Fujian Province. It has an area of 76 km^2 and became a national geopark in 2009. The main geological features of the park are the enormous valley pothole groups, rare incised meanders formed in granite gorges, typical palaeo-volcanic structures and abundant volcanic rocks. Enormous potholes eroded by running water are densely distributed in the park and show the complete development process. Incised meanders formed in Longtingxi Gorge are 18 km long and 400 m deep and have a curvature of 1.9 m^{-1}. Geodes and alkali-feldspar granites are important rocks in the area. The term 'Fuan grotto granite landform' was developed in this geopark.

Frozen Ground Landscape ▶ Frozen Earth

Fuding Mount Taimushan National Geopark, Fujian This geopark is located on the waterfront of Fuding City, Fujian Province, and it integrates the mountains, oceans, rivers, islands, lakes and waterfalls. It covers an area of 61 km^2. It was approved by the Ministry of Land and Resources as the third national geological park in March 2004. The main landscapes include granite peaks and stone egg formations composed of 100-million-year-old granite, more than 100 granite caves formed by tectonics, water erosion and gravity collapse, sea erosion landscapes and coastal beaches. There are also holiday resorts and grasslands for visitors in Daqishan Island, Tianchi and Wanmu.

Fujian Yong'an National Geopark, Fujian Yong'an National Geopark is located 8 km north of Yong'an County, Sanming City in Fujian Province. It lies northeast of the Shaxi River Valley with the Daiyun Mountains to the east, and the western side is part of the southeastern slope of the Wuyi Mountains. It became a national geopark in 2005. The geopark features both Danxia and karst landforms. There are two scenic districts, namely, Taoyuan Cave and Dahu Lake. Karst geomorphologic landscapes are mainly present in Dahu Town and include peak clusters, peaks and stone forests. The Danxia landform includes castles, peaks, pillars, steep cliffs, narrow valleys, stone walls, meandering gorges and collapsed caves.

Fujiyama Volcano Landscape Fujiyama is the highest mountain in Japan and is a world-famous volcano. Located in southern Central Honshu Island, it is 80 km from Tokyo and is part of the Fuji Hakone Izu Park. Fujiyama Volcano is a relatively young dormant volcano. It has erupted 18 times since 800 A.D., most recently in 1770. Volcanic gas emissions are on-going. Fujiyama is made up of eight peaks with 5 lakes formed by volcanic activity in its northern foothills. The mountain is a famous tourist area. It stands above the wilderness and, because of its conical shape and year-round snow cover, it appears sacred and solemn. The area between an elevation of 2,000 m to the foothills is extremely scenic. People in Japan feel a sense of accomplishment when they climb Fujiyama. The crater attracts numerous tourists to climb, as is reflected in a Japanese poem: 'This towering peak is so elegant, like an interesting monument; the eternal wind blows without a break while it looks like a lotus of jade' (Fig. 14).

Fulgurite Fulgurite refers to ornamental stones that get their names from the places where they are produced. Naming a stone based on its production location is a tradition in China; the advantage of this practice is that it is more scientific to name the stone for the production location, rock strata or geomorphic landscape. This name-oriented approach helps the community gain recognition by achieving the objective of 'giving the place the name of the stone while giving the stone the name from the place'. Like Arctic stone, several areas of famous stone production have been coined by the Chinese Ornamental Stone Association as ornamental stone townships or ornamental stone regions (Fig. 15).

Fumarole Landscape This is a landscape that is formed by volcanic gas emissions. In areas of



Fig. 14 Fujiyama Volcano landscape

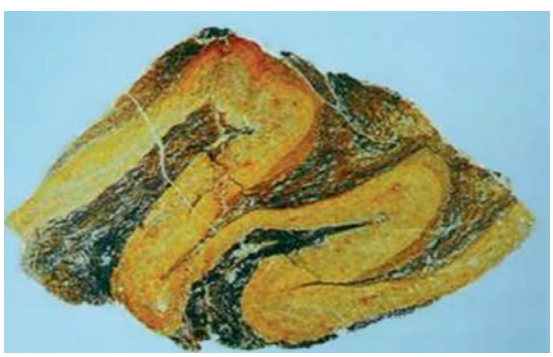


Fig. 15 Fulgurite (slightly twisted phyllite with interbedded thin layers of quartzite)

hydrothermal activity associated with volcanic activity, vapor columns are abundant, and the small holes with emissions of steam or gas are called fumaroles. The emitted gas is mainly steam but can also include hydrogen sulphide, carbonate gas and boric acid. Yangmingshan in Taiwan has a large number of fumaroles, where sulphur vapour condenses to form sulphur crystals that fill the emission holes. Sulphur can be excavated from these holes. Fumaroles are also important for research on the prediction of volcanic eruptions (Fig. 16).

Function of National Mining Parks National mining parks perform a variety of functions, such as the protection of mining heritage, scientific investigations, knowledge dissemination, sightseeing, leisure and entertainment, treatment and restoration of the ecological environment, demonstrations of the functions of mines, and economical and sustainable land use.

Functional Zoning Map of a Geopark or Scenic District Maps showing different parts of the park have different functions. These maps can include the reception area (main entrance or gate), geological landscape areas, cultural landscape areas, natural or ecological areas (e.g., surface and forest), science education areas, geological heritage protection areas, indigenous



Fig. 16 Fumarole landscape in Yangmingshan Volcano, Taiwan

reserves or locations and park management areas. These functional areas can be merged, separated or vacant. When a geopark contains several scenic areas or districts, each should have a separate functional zoning map. Each functional zoning map should have a clear boundary and should correspond to the local government's overall land use plan as a guide for development. Because geological heritage protection areas have their own special maps, this function zoning map should mark the most important protection area or geosite. Other geological heritage protection zones can be grouped into the geological landscape area.

Funiushan Global Geopark, China This geopark is located in the eastern part of the central orogenic system in China and the hinterland of the Funiu Mountain Range in Henan Province. The geopark has an area of 1,340 km^2, and it became a geopark in 2006. The geomorphology is closely related to the orogenic movements, especially the 'Juchiling (Sawtooth Ridge)', 'Yanpanshan (Rock Plate Hill)', 'Wuxingshan' (Five Elements Hill)' and 'Xieheliejie (Unloading cracking)' landscapes are typical related to the granite landform. In addition to displaying different types of granite landforms, its 'plastic rheology' landscape reflects the karst features and heterogeneity of the orogenic belt. The hydrological landscape is represented by the intersection of the Xianchenghe and Houhe Rivers, Heyuan Lake and the associated quasi-plain, the cascades and waterfalls, and the adjacency of waterfalls and knickpoints, demonstrating the close relationship between neotectonics and fluvial geomorphology. The dinosaur egg fossil protection area contains Cretaceous dinosaur egg fossils from 36 species from 12 genera and 8 genera, including the very rare Xixia long cylindrical eggs and the Gobi prism eggs.

Fuping Natural Bridge National Geopark, Hebei This geopark is located approximately 25 km west of Fuping County in Hebei Province. It became a national geopark in 2002. It features a geomorphological landscape that includes the standard profile of the Taigu-YU-Quanping Group and the Tianshengqiao Waterfall Group, which was dated to 2.5 billion years ago. The Tianshengqiao Waterfall consists of nine waterfalls, and the Tianshengqiao Bridge is located at the top of the 112-m-high waterfall. The main rocks are sedimentary rocks that were deposited in a shallow sea 2.5 billion years ago. The rocks have experienced several periods of metamorphism, during which the original rocks were converted to schist, gneiss, granitic gneiss, and mixed lithic granite. In the recent geological past, the rocks were uplifted to the surface and eroded by flowing water to form cliffs, waterfalls, and natural bridges and arches.

Fushan Trachyte Caldera Landscape This is a caldera composed of trachytic volcanic rock that is located in Zongyang County, Anhui Province. The Fushan trachyte is part of the Fushan Formation. It erupted approximately 110 million years ago. It is a typical rock of the late eruption of the volcanic zone in the middle section of the Yangtze River. The erupted rocks in the Fushan eroded caldera have a circular distribution. A bell-shaped mound is located in the centre, which is a product of volcanic activity after subsidence of the caldera. Therefore, the Fushan caldera is a reactivated caldera. Because of the

geological and petrological characteristics of this caldera, features such as overlapping peaks, cliffs, stone corridors, unique rocks, unique caves and natural bridges have formed. They have geological significance and aesthetic value, and they blend with the scenery of the adjacent valleys, streams and lakes. Fushan is one of the five famous mountains in Anhui Province and is also a national geopark.

Fusong Geopark, Jilin This geopark is located in Fusong County, Jilin Province. The geopark has an area of 175 km^2, and it became a national geopark in 2011. It is a uniquely comprehensive geopark because it contains multiple landform units, such as volcanoes, mineral springs, hot springs, and karst. The scattered cinder cones, mostly ice-free mineral springs, rich hot spring resources, unique karst landscapes, peripheral scenic sites, and the volcanic landforms and landscapes of Changbai Mountain add radiance and beauty to one another. As home to a variety of geological features, diverse landforms and landscapes, beautiful natural scenery, long history and profound culture, the geopark is a natural museum for disseminating geological knowledge and a laboratory for ecological and environmental protection.

Fuxin Haizhou Open Cut National Mining Park, Liaoning This park is located in the Taiping District, Fuxin City, Liaoning Province. The pit is 4 km long, 2 km wide, 314 m deep, and covers an area of nearly 8 km^2. The waste dump and coal gangue field cover an area of 14 km^2. It became a national mining park in 2005. The overall layout includes one water park, two pits (a pit and a death pit), three piles (the Haizhou gangue pile, Xinqiu gangue pile, and Sunjiawan gangue pile), four sites (a mine culture corridor, sedimentary strata protection zone, train museum and coal mining area) and five recreational activities (walking into the pit, riding a tramway, riding a small train, climbing a mountain and visiting the mine house).

Fuyun Cocoatuohai National Geopark, Xinjiang This geopark is located in Fuyun County in the Altai Area, which is north of the Xinjiang Uygur Autonomous Region. It is the source of the Eerqisi River. The elevations in the geopark vary from 1,155 to 2,695 m. It became a national geopark in 2005. The unique geomorphologic landscapes of the geopark include typical deposits of rare metals, the Koktokay granite pegmatite, the Erqisi River granite stocks, Gobi (desert), and Kalaxianger earthquake relics. The geopark has two main scenic districts, namely, Ilaymu Lake and the Kalaxianger.

G

Gaia Hypothesis The Gaia hypothesis was proposed by the British atmospheric scientist James Lovelock in the late 1960s. It states that the living organisms and non-living objects on Earth form a complex system in which they can interact. Various species on Earth effectively regulate the temperature and chemical composition of the atmosphere. Various creatures in the biological environment and nature are mainly connected by negative feedback loops, just like the goddess of the Earth (Gaia), to maintain the stability of the Earth's ecology.

Galápagos Islands, Ecuador The Galápagos Islands are located in the equatorial Pacific Ocean approximately 1,000 km from the west coast of Ecuador. After an extension in 2001, its core protection area now covers 140,665 km^2, and it is the second largest protected natural area on the World Heritage List. Its 19 islands and the surrounding marine reserves have been called a unique 'living museum and showcase of evolution'. Located at the confluence of three ocean currents, the Galápagos are a 'melting pot' of marine species. Ongoing seismic and volcanic activity reflects the processes that formed the islands. These processes, together with the extreme isolation of the islands, led to the development of unusual animal life, such as the land iguana, giant tortoise and many types of finches, which inspired Charles Darwin's theory of evolution by natural selection following his visit in 1835.

Galena Galena is an important lead mineral that contains PbS. Its lead content is 86.8%, and it has an isometric crystal structure. Its crystals can be cubic, octahedral or sub-octahedral. Some appear as blocky, granular and fibrous aggregates. The colour and streaks are lead-grey. It has opaque diaphaneity, a metallic lustre, a specific gravity of 7.58, a Mohs hardness of 2.5 and sub-conchoidal fractures. Hydrothermal galena veins usually form when hot fluids rise to the upper crust. Galena often forms with fluorite, quartz, calcite, sphalerite and pyrite. Both galena ore and galena crystal clusters can be crafted into ornamental stones.

Gaolingcun Kaolin Deposit, Jingdezhen, Jiangxi Gaolingcun Village is located in Ehu Town, Fuliang County, Jingdezhen City, Jiangxi Province. It is the source of the kaolin soil and kaolin stone that gives these two geological terms their names. Kaolinite mining in Gaoling Village was active for more than 1,200 years from the Southern and Northern Dynasties until 1969, when the reserves were depleted. During this period, it contributed greatly to the success of Chinese civilisation and the development of the ceramics industry in many ways. The Gaolingcun kaolin deposit is located in a white muscovite and pegmatite weathering belt and in fractures in the Yanshanian Ehu rock mass. The ores are in sandy and lumpy forms. The ore sand comes from weathered muscovite granite, whereas the ore lumps are formed by dissolving and leaching of weathered pegmatites and granites by surface water and groundwater along fractures. The deposit is now a geo-tourism landscape (Fig. 1).

Garajonay National Park, Canary Islands, Spain Garajonay National Park is located in the middle of the island of La Gomera in the western part of the Canary Islands archipelago in the Spanish Atlantic region. It covers an area of 39 km^2. Laurel forest covers approximately 70% of the park. The presence of springs and numerous streams has allowed the development of lush Palaeogene-Neogene vegetation; due to climatic changes, similar vegetation has largely disappeared from southern Europe.

Garamba National Park, Congo Garamba National Park is located in the borderland near southern Sudan in Oriental Province, northeastern Democratic Republic of the Congo. It covers a core protection area of 4,920 km^2. The park's immense savannahs, grasslands and woodlands, which are

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Fig. 1 Gaolingcun kaolin deposit, Jingdezhen

interspersed with gallery forests along the river banks and swampy depressions, are home to four large mammals, namely, elephants, giraffes, hippopotami and white rhinoceroses. Though much larger than the black rhinoceros, the white rhinoceros is harmless; only approximately 30 individuals remain.

Garden Geology Garden geology is also known as landscape geology or scenic geology. The principles of geology are used to explain the formation of scenery in natural parks, which is called garden geology. The aim is to popularise earth science.

Garnet The chemical composition of garnet is $A_3B_2[SiO_4]_3$, where A is Ca, Fe, Mg, and Mn, and B represents Al and Cr. Garnet is a collective term for the garnet family of minerals. Its colour varies from blood red, dark red, reddish brown, brownish yellow, yellowish green, and bright green to black. It has a vitreous lustre, whereas the fracture lustre is greasy. The specific gravity is 3.1–4.3, the Mohs hardness is 6.5–7.5, and it is a typical high-temperature and metamorphic mineral. It is a common gemstone mineral ore. The main gem varieties include pyrope, rhodolite, grossular, almandite, spessartine and andradite. Pyrope and rhodolite have bright red colours, and in Chinese, they are called 'dark purple teeth'. Garnets have a wide natural distribution and are used mainly as gems or for grinding.

Garnet Gem Garnets are a group of silicate minerals, and the major varieties are pyrope, grossular, almandine, spessartine and andradite. All species of garnets are bright pink, and highly transparent pyrope and grossular are excellent gemstones. Almandine, which is deep purple, is also called 'ziyawu', meaning purple black tooth in Chinese. In ancient Chinese customs, garnet jewellery was often used as a talisman of evil. Garnets are common gem minerals that are widely distributed and are often found along the contact zone between igneous rocks and regional metamorphic rocks (Fig. 2).

Gaseous Explosion ▶ Phreatic Eruption

Gea Norvegica Geopark, Norway This geopark is located in southeastern Norway and covers an area of 3,010 km^2. It became a global geopark in 2006. The geopark is characterised



Fig. 2 Garnet crystals

by exceptionally rich geological diversity. Over a long period of geological evolution, a large variety of rock types and geologic deposits formed through numerous processes in distinct geological environments. The park contains geological formations with very different ages and sources. The geological history of the geopark covers one-third of the history of the Earth. In addition, the rocks record two geological events and geological processes that took place during five geological eras and 11 geological periods. The oldest rock in the geopark formed over 1.5 billion years ago.

Gejiu Cassiterite-Polymetallic Sulphide Deposit, Yunnan This is a major tin polymetallic deposit (China's tin capital) located in Gejiu City, Yunnan Province. The Gejiu cassiterite-polymetallic sulphide deposit mainly produces tin ore that is intergrown and associated with other metallic ores, such as copper, tungsten, bismuth, lead and silver. The north-south-oriented Gejiu Fault divides the deposit into eastern and western parts, and the major tin ore fields are concentrated in the eastern part. These include the 5 large ore fields, namely, Malage, Songshujiao, Gaosong, Laochang and Kafang from north to south. The western part contains the Niushipo large tin ore field and tens of small- and medium-size tin and lead ore beds (points). The formation of the deposit was related to a granite intrusion in the middle and late Yanshan period, after which the magmatic tin sulphide and polymetallic ores were deposited in sand on the eroded granite slope at the surface. The deposit has a long mining history. The 'Han Book–Geographic Chronicle' reports that King Wudi consolidated Yunnan five countries into Yizhou County, and mining was conducted for tin at Beicaishan and Wushan in Bengu and for tin and lead in Xiyangshan (note: Bengu is now Mengzi and Gejiu). The 'Zhengde YunnanChronicle' was published in Ming Dynasty, which reports that tin ore was mined from Gejiu Village, Mengzi; and this is where the name 'Gejiu' was first used in historical records. Today, Gejiu City is a major tin and non-ferrous metal industrial base, a shining pearl on the plateau of southwestern China, and China's tin capital.

Gem Gem is a collective generic term for rare and precious natural stone objects. All minerals and rocks that are beautiful, durable, rare and can be made into jewellery or decorative crafts can be called gems. In a narrow sense, gems are mineral crystals that can be used to make valuable jewellery. In a broad sense, gems include jade, coloured stones, organic substances such as pearls, coral and amber as well as artificial gemstones. Approximately 200 known minerals can be made into gems. The most precious minerals are diamond, emerald, jadeite, ruby, sapphire and alexandrite. Others are aquamarine, olivine, tourmaline, topaz, amethyst, turquoise, opal, zircon, garnet, chalcedony, agate and jasper. In the contemporary jewellery market, gemstones can be divided into six types according to the degree of artificial alteration: (1) genuine natural gemstones; (2) artificially modified natural gemstones; (3) synthetic gemstones; (4) artificial gemstones; (5) imitation gemstones; and (6) bonded gemstones. Gemstones are an important tourism commodity and a crucial object for studies of tourism earth science (Fig. 3).

General Planning Map of a Geopark This is a map showing the overall master plan of a geopark. It includes the districts, scenic areas, major attractions, and service facilities such as the main gate, carparks, sign boards, tourist centre, museum, science popularisation



Fig. 3 Various types of gemstones

movie hall, toilets, catering and shopping centres, viewing platforms, and major tourist routes as well as the area, size and direction of transportation facilities. Circles can be used to represent scenic attractions, and squares can be used to highlight service facilities.

General Specification for Tourism Planning To prepare for tourism planning, improve its overall level, achieve scientific, forward-looking, and effective tourism planning and promote the sustainable development of tourism, the National Tourism Administration promulgated the General Specification for Tourism Planning in 2003. This document clarified the definitions of tourist areas, tourist source markets, tourism resources, tourism products and tourism capacity. It also stipulated the principles, procedures and contents of tourism planning and the methods of assessment, and it proposed the composition and requirements of tourism planning personnel and reviewers. It is a normative document for the formulation of tourism development plans at all levels and the planning of tourist areas.

Genetic Classification of Natural Tourism Resources This is a classification scheme that is based on the genetic categories of tourism resources of nature. The resources have a specific location, specific conditions of formation and a historical evolution. The Earth's surface can be divided into the lithosphere (crust), hydrosphere, biosphere, atmosphere, and cultural sphere. Humans are a component of the biosphere. Over the hundreds of thousands of years of human activity, a cultural sphere has been formed within the atmosphere, lithosphere, and hydrosphere. Together with the cosmic space outside the atmosphere, each sphere can become a tourism resource.

Geo Mon Geopark, Wales This geopark is located in the coastal area of Anglesey and has an area of 715 km^2. It became a global geopark in 2009. The park offers visitors many attractions and activities. For example, the Beaumaris Trail, one of a series of local tourism trails, is the first town tourism trail in Anglesey. Tourists can easily reach the Beaumaris Trail through the 201-km-long coastal trail and then follow the trails to explore the coast of Anglesey. Along the Beaumaris Trail, visitors can learn how humans used rocks for a variety of uses, such as for decorative carvings in castles, roofs, roads and houses.

Geochronologic Unit Geochronologic units are also called 'geologic time units' or simply time units. They are time division units for geological periods. From large-scale to small-scale, they can be categorised into eons, eras, periods, epochs, ages and chrons, and the corresponding chronostratigraphic units are

eonothems, erathems, systems, series, stages and chronozones, which are internationally used geological time units. Ages and chrons (stages and chronozones) are adopted both internationally and regionally. A geochronologic unit is not a stratigraphic unit but a time duration unit of the respective stratigraphic unit.

Geographic Information System A geographic information system (GIS) is a computer system that collects, stores, manages, calculates, analyses, displays, describes, and transmits geospatial information with the support of software, hardware, internet and intranet networks. A geographic information system can process and manage a variety of tourism-related geospatial data and their relationships, including spatial positioning, graphics, remote sensing images, and attribute data, to analyse and process the distributions of various phenomena in a tourism area. The current statuses of the process and the tourist area are used to assist and address planning, decision-making and management issues.

Geographical Environment The geographical environment is the surface layer of the Earth that interacts with the lithosphere, hydrosphere, atmosphere and biosphere. The geographical range of human survival extends approximately 10–30 km from the Earth's surface. It can be affected by the structural characteristics, composition and form of the Earth's surface as well as the water and heat conditions. The structure of the geographical environment has obvious zonal characteristics. The geographical environment can be divided into natural, economic, social and cultural environments. They overlap and interrelate each other geographically and structurally to form a unified overall geographic environment.

Geography Geography is the study of the interaction between the natural and human elements of the Earth's surface, its formation and evolution, and disciplines such as the spatial structure, temporal processes, geographical differentiation and human-land relations of the Earth. It mainly includes physical geography, human geography and applied geography. Geomorphology, climatology, hydrology, soil science, environmental geography and biogeography are included in physical geography. Economic geography, urban geography, political geography, population geography, cultural geography, tourism geography, ethnical geography and social geography are branches of human geography. Cartography, remote sensing and geographic information systems are types of applied geography.

Geohazard Tourism Landscape This is a landscape with tourism value that is composed of geological features caused by geological hazards, such as volcanoes, earthquakes, avalanches, landslides, debris flows, land subsidence and land collapse cracks. Numerous geological disasters have left behind geohazard tourism landscapes with value for scenic touring and scientific expeditions. Examples are the volcanic sites in Pompeii, Italy, the large landslide site Xintanzhen, the dangerous rocks at the landslide at Lianziya, Three Gorges, Tangshan, and features left by the Wenchuan earthquake.

Geoheritage Database GIS technology can be used to establish a digital geological heritage management platform. Information about each geological heritage site, including its name, location, outcrops, characteristics, description, maps and pictures, is recorded and put into the database for reference, analysis and planning. The data can also be used for better control and management of the geopark, and they can be shared with geoparks or provincial and national geological surveys for other research.

Geoheritage Sites in Shanxi Province This book was written by the Shanxi Provincial Department of Land and Resources and was published by China Geological Publishing House in 2003. The book, in the form of an album, introduces the geoheritage sites in Shanxi Province with scientific, earth science popularisation and appreciation values. These landscapes include mountains, canyons, rapids, springs, waterfalls, lakes, karsts, strange stone landscapes, and loess.

Geological and Mining Park of Sardinia, Italy This park is located in Sardinia, Italy, and

covers an area of 3,500 km^2. It became a global geopark in 2007. Sardinia has magnificent natural landscapes, such as the coast and inland topography, as well as important caves and archaeological areas of various shapes, all of which have made Sardinia a small but interesting land. Mining activities shaped the landscape and created the ancient culture of the mining nation. The attractions include charming working-class villages, extraction pits, thousands of kilometres of roads and paths, industrial systems, and old railway stations. The history of ancient mining activities and the Sardinian Geology and Mining Park provide tremendous opportunities to develop and attract more tourists from abroad.

Geological Heritage Database The spatial database of a geographic information system (GIS) can be used as the technical platform to establish a geological heritage database. The data include a digitised gallery and a corresponding attribute database. The digitised gallery includes point, line and surface graphics representing the locations of geological relics. The content of the attribute database is consistent with the geological heritage registration form (see "► Geological Heritage Register").

Geological Heritage Protection Plan This plan is focused on protecting important geological heritage and protection zones based on their scientific value and vulnerability to damage. The plan is devised for the effective control and monitoring of protection areas. Different areas with different values and degrees of vulnerability can be classified as special (S), primary (I), secondary (II) and tertiary (III) protection zones. The shapes of these protection zones can be described as point, linear and layered shapes. Special protection zones (S) prohibit the entry of visitors. Primary protection zones have strict limits and controls on the numbers of visitors and cars. Secondary (II) and tertiary (III) zones are open to controlled numbers of visitors with some tourist facilities. No exploration, mining, hotels, rehabilitation centres and resorts are permitted in these geological heritage protection zones.

Geological Heritage Protection Zone These zones are special areas of geological heritage with international, national or regional significance. They are also nature reserves. No activities such as mining, quarrying, sand excavation, logging, land reclamation and waste burning are allowed in these areas. China's geological heritage protection zones are divided into national-level, provincial-level (autonomous regions and municipalities), municipal-level (autonomous prefectures) and county-level protection zones.

Geological Heritage Register Geological heritage data are surveyed, collected, registered and classified according to the required format and content. The data include the geological relic numbers, names, types, geographical location, latitude and longitude, elevation, area, traffic conditions, geography, geological structure, landscape, protection conditions and development status. They also include photographs and brief descriptions. For typical geological sections, the features and parameters should be described according to the geological units and their boundaries and interfaces.

Geological Heritage Resource Type The National Geopark Planning Compilation Technical Requirements issued by the Ministry of Land and Resources in June 2010 classified landscape resources of geological relics into seven major groups, 25 types and 56 sub-types comprising geological sections, geological structures, palaeontology, minerals and mineral deposits, landscapes and water bodies. A geological heritage resource survey report and geopark plan should be completed according to these classification criteria. Other tourism planning or scenic planning activities involving geological heritage of landscape resources can also use this classification (Table 1).

Geological Heritage Survey This term refers to surveys of geological relics of significant scientific, aesthetic, science education and tourism development values. They can be divided into regional geological heritage surveys,

Table 1 National Geopark Planning Compilation Technical Requirements – Types of geoheritage resources

Group	Type	Sub-type
I. Geological section (body, strata)	1. Stratigraphic section	(1) Global Boundary Stratotype Section and Point (GSSP)
		(2) National standard profile
		(3) Regional standard profile
		(4) Area standard profile
	2. Igneous rock section	(5) Typical basic and ultra-basic rock mass (profile)
		(6) Typical intermediate rock mass (profile)
		(7) Typical acidic rock mass (profile)
		(8) Typical alkaline rock mass (profile)
	3. Metamorphic rock profile	(9) Typical contact metamorphic belt profile
		(10) Typical heat dynamic metamorphic belt profile
		(11) Typical migmatisation and metamorphic belt profile
		(12) Typical high- and ultra-high-pressure metamorphic belt profile
	4. Sedimentary rock profile	(13) Typical sedimentary lithic facies
II. Geological structure	5. Structure	(14) Global structure
		(15) Regional (large-scale) structure
		(16) Medium to small structure
III. Palaeontology	6. Ancient humans	(17) Ancient human fossils
		(18) Ancient human activity relics
	7. Ancient animals	(19) Ancient invertebrates
		(20) Ancient vertebrates
	8. Ancient plants	(21) Ancient plants
	9. Palaeontological relics	(22) Palaeontological activity relics
IV. Minerals and deposits	10. Typical mineral origin	(23) Typical mineral origin
	11. Typical deposits	(24) Typical metal deposits
		(25) Typical non-metal deposits
		(26) Typical energy resource deposits
V. Geomorphological landscape	12. Rock and landform landscape	(27) Granitic landscape
		(28) Clastic rock landscape
		(29) Soluble rock landform (karst landform)
		(30) Loess landscape
		(31) Sand depositional landscape
	13. Volcanic landscape	(32) Volcanic structure landscape
		(33) Volcanic lava landscape
		(34) Pyroclastic deposit landscape
	14. Glacial landscape	(35) Glacial erosion landscape
		(36) Glacial deposition landscape
		(37) Periglacial landscape
	15. Fluvial landscape	(38) Fluvial erosion landscape
		(39) Fluvial deposition landscape
	16. Marine erosion and deposition landscapes	(40) Marine erosion landscape
		(41) Marine deposition landscape
	17. Structural geomorphology	(42) Structural landscape

(*continued*)

Table 1 (continued)

Group	Type	Sub-type
VI. Water bodies	18. Spring landscape	(43) Hot spring landscape
		(44) Cold spring landscape
	19. Lacustrine landscape	(45) Lacustrine landscape
		(46) Swamp and wetland landscape
	20. Fluvial landscape	(47) Scenic river
	21. Waterfall landscape	(48) Waterfall landscape
VII. Environmental and geologic landscape	22. Earthquake landscape	(49) Ancient earthquake landscape
		(50) Recent earthquake landscape
	23. Meteorite landscape	(51) Meteorite landscape
	24. Geohazard landscape	(52) Landslide landscape
		(53) Landslip landscape
		(54) Mud flow landscape
		(55) Fissure and ground subsidence landscape
	25. Mining relic landscape	(56) Mining relics

surveys of areas of concentrated geological relics, and geosite surveys. A regional geological survey is a general survey or census of the geological relics in a provincial administrative region. It is intended to locate geological relics that can potentially be included in geological reserves or geological relic protection zones. A geosite survey is a survey of geological relics and landscapes or a group of them to determine whether they are attractive enough to be designated as an independent geosite of scientific, education or tourism importance.

Geological Landscape A geological landscape (geo-landscape) forms through geological processes. These landscapes can be categorised into geological section landscapes, tectonic landscapes, palaeontological landscapes, mineral landscapes, geomorphological landscapes, water body landscapes, environmental geological heritage landscapes, and meteorological landscapes. The major categories can be divided into several sub-categories, types and patterns to form an extensive geological landscape system. Landscapes are the most important natural tourism resources and an important research focus of landscape science.

Geological landscape is also known as geological heritage. A geological landscape is a product of both endogenic and exogenic forces that occur during a geological period. It has significant value for scientific research, science popularisation, education, aesthetics and appreciation. It may include surface and subsurface landforms, underground caves, preserved traces of life and geological structures. The landscape is essential to studies of Earth's evolution and history as well as an important tourism resource.

Geological Map of a Geopark This type of map shows the strata, geological formations, magmatism and mineral distribution in a geopark and the surrounding areas. In principle, a 1:25,000 geological map requires a cross-section across the park showing the strata. Geoparks with important geological relics should compile a map at a larger scale with the geological features and their exact locations clearly marked.

Geological Structure Geological structure refers to the permanently deformed and relatively displaced features of rock. Geological structures are mainly the remnants of crustal movement resulting from crustal evolution, including one-dimensional 'linear structures', two-dimensional 'surface structures', three-dimensional 'structural blocks' and four-dimensional 'structural system'. The most basic geological structures are folds and faults. Based on the deformed relics, the deformation history of a geologic period can be determined,

which in turn can reflect the evolution process and pattern. Typical folds are important geotourism landscape resources.

Geological Structure as Landscape The geological structure of a location controls the types and forms of the natural landscape. Loess plateaus and sandstone and karst peaks form in stable crust and horizontal rock strata. Intense deformation occurs in the fault zones of geosynclines, forming tall mountains, glacial landscapes and canyons, which are excellent nature-based tourism resources. In the depressions formed by deformation of a platform, thick layers of terrestrial sediments can be deposited to form sandstone and conglomerate or be intruded by volcanic or other intrusive rocks to form natural landscapes, such as Danxia landforms and fault-block and granitic mountains.

Geological Tourism Landscape of Mineral Resources This includes mining areas with tourism value such as metal and non-metal mines, coal and oil shale mines, oil and natural gas fields, and brine and geothermal extraction areas. Mines are important geological tourism resources. For example, Australia built a 26-ha park and gold mining museum, which have become a tourism hotspot. Through 2010, China had established 62 national mining parks, which have become a system of mines and mining geotourism sites.

Geological Tourism; Geotourism Geotourism is an emerging type of tourism that focuses on geological and geomorphic landscapes, including the remains of ancient life, minerals, volcanoes, glaciers, earthquakes, deserts, coasts, islands, caves, lakes, rivers, springs, ornamental stones, and gemstones. It is a scientific tourism activity practised to increase the public's awareness of earth science. With the increase in tourists' level of education, some tourists have become interested in exploring the geological background of the landscape. The establishment of numerous geoparks has created destinations for this type of tourism, and the establishment and development of tourism earth science has provided theoretical guidance for geotourism. Geological tourism has gradually become an important type of tourism in China and around the world.

Geology Geology is the science of the formation and evolution of the Earth, its composition, internal structure, external features and the different spheres of the Earth as well as their relationships with the emergence and evolution of life. The study of the Earth's materials and composition includes geochemistry, mineralogy and petrology. The study of crustal movement includes geodynamics, structural geology, geotectonics, geophysics, volcanology, and seismology. The study of the Earth's history encompasses historical geology, stratigraphy and palaeontology. The study of earth resource development includes mineral deposits and energy geology (oil and gas, nuclear energy, and geothermal), hydrogeology, environmental geology, disaster geology, engineering geology and tourism geology. The research skills and techniques applied in geology comprise geological surveys and exploration, geophysical and geochemical surveys and analysis, geological mapping, remote sensing, prospecting, and earth material testing and analysis.

Geomorphology Geomorphology is the study of topography and is an important branch of geography and geology. It involves the study of surface morphological characteristics and their genetic types, internal structure, evolution process and distributions. It can be subdivided into climatic geomorphology, dynamic geomorphology, applied geomorphology, regional geomorphology, quantitative geomorphology, experimental geomorphology and historical geomorphology. Geomorphological analysis is the basis for identifying and locating tourist attractions and planning routes, tourism infrastructure and facilities.

Geopark A geopark is a single unified geographical area with a clear boundary bearing unique scientific significance, rare natural attributes, remarkable aesthetic value and definite geological heritage that is integrated with other natural or cultural landscapes. Geoparks primarily promote earth science but also have sightseeing, leisure resorts, health care and

research purposes. According to the significance of the natural resources and approval authority, geoparks can be divided into international level (approved by UNESCO) and national level (approved by the country's respective authority). In China, national level geoparks are approved by the Ministry of Land and Resources, and there are also provincial and municipal levels that are approved by the provincial and municipal Land and Resources Department or Bureau, respectively. The objectives of geoparks are to protect geological heritage and the natural environment, popularise earth science, enhance national scientific quality, develop sustainable tourism and promote local economic and social sustainable development.

Geopark Bergstrasse – Odenwald, Germany The Global Geopark Bergstrasse-Odenwald is located in southwestern Germany and has a total area of 3,500 km^2. It became a member of the Global Geoparks Network in 2004. The geopark preserves a sequence of 500 million years of Earth's history in central Europe. The region between Rhine, Main and Neckar records globally significant evidence of the Variscan orogeny, which illustrates the continental collision of the Oberrheingraben as part of a European-wide tectonic movement that formed the Alps valleys and the Rhine Graben. This region provides a unique window into Earth's history and displays the dynamic processes of our planet. The typical rock formations, characteristic landscape morphology and agriculture have enabled the development of nature, settlements, agriculture, the economy and present-day life and thus directly connect nature, man and culture in the geopark.

Geopark Guide A guide must comply with the requirements of the *Regulations of the Management of Tour Guides* by passing a qualifying tour guiding examination. He or she must then attend training and workshops on the geological knowledge, concepts of the geopark and geoconservation before being permitted to organise geopark tours and guide tourists in the geopark.

Geopark Harz Braunschweiger Land Ostfalen, Germany This geopark has an area of 11.5 km^2, is located in northern Germany and is surrounded by the Harz Mountains. It became a global geopark in 2005. The motto of the Brownswell Geopark is 'The history of the Earth is the cornerstone of the development of industrial society'. On the northern edge of the Harz Mountains, the Palaeozoic rocks are thrusted over steeply dipping to inverted Mesozoic layered rocks. Due to the many excellent outcrops of thrust faults, the geologic history can be observed clearly. Therefore, the area between Goslar and Harzburg is called a typical geological area of the region and is representative of the entire geopark. In addition, the Harz region had an important historical role in early human history, with the prehistoric Graff wines and famous excavation sites. Neanderthal caves, the "Unicorn Cave" in Salzgitter and the Schöningen spears, the earliest human hunting weapons, are all important cultural relics.

Geopark Location and Traffic Map This type of map depicts the locations and traffic conditions of the geoparks in China at different levels, namely, provincial, municipal and autonomous regions. It also reflects the relationship between the geopark and its associated traffic facilities. It should indicate the nearest airport, railway station, coach station or ferry terminal, the locations of important tourist attractions and important towns, and the routes to the main entrance of the geopark from these places. If possible, it is also helpful to indicate the travelling distance to these areas.

Geopark Management in China In China, global and national geoparks are directly managed by the Ministry of Land and Resources, while the provincial and municipal geoparks are managed by the provincial Departments of Land and Resources but are authorised by the Ministry of Land and Resources to supervise and monitor the performance of geoparks within their jurisdiction. The Ministry has also established a monitoring system of irregular checks of all geoparks and has the authority to

warn (with a yellow card) or delist (with a red card) geoparks with poor performance.

Geopark Muskau Arch, Germany, Poland The geopark is located southeast of Cottbus, Germany, northwest of Dresden and west of Green Mountain, Poland. It became a member of the Global Geoparks Network in 2011. The geopark runs from Poland into Germany across the Nice River, which is the national border. The section in Saxony, Germany, is located in the settlement of Sorbow. The Furst-Puckler Park in the area was listed as a UNESCO World Heritage Site in 2004. In addition, the Nochten mining area has been listed as a geopark based on the advancing moraine landscape. The Muskau Arch is a major scenic site in the park and is shaped like a horseshoe that is 22 km long from east to west and 20 km long from north to south.

Geopark Personnel Training This training includes tour guide training, management training and planner training. In addition to the requirements of the national tour certification, geopark guides should also acquire sufficient geological knowledge through training to introduce visitors to the geological features of interest. They should also have foreign language ability to serve non-Chinese tourists. Management training involves the training of personnel in every aspect of the operation, administration, laws and regulations and the promotion of the associated geoparks. This training is usually in the form of lectures, talks, seminars, workshops and conferences. Planner training involves the geopark staff being trained to design and formulate plans for geopark development. The training is conducted in lectures and seminars.

Geopark Planning Geopark planning is the overall design strategy for the development of a geopark. It requires an investigation, evaluation, protection and utilisation of the geological heritage in the park. Specific plans and measures are developed to ensure the sustainable development of the geopark. The planning can be classified as global, national and provincial. The contents include an overall or master plan, specific plan, detailed plan, and construction and renovation plans.

Geopark Planning Map The Ministry of Land and Resources released the 'National Geopark Planning & Technical Requirements', which require maps showing the geopark location and traffic, geology, park boundary, geological heritage and other natural and cultural resources, geopark planning, geopark (scenic) functional zones, land use, remote sensing images and science field trip guide maps.

Geopark Science Guide Map This type of map helps tourists understand the geological attractions in the geopark and assists them in finding accommodations and transportation in a self-help manner. The map can be converted into a topographic relief map by using a large-scale topographical map or a remote sensing image as a base map. The map integrates the main geological relics, geomorphological landscapes, cultural heritage sites, scenic locations, museums, popular science museums, accommodations, medical care facilities, ambulances and transportation network to make visits easy. It is usually in form of a foldable map for easy storage and transportation.

Geopark Scientific Research The 'National Geopark Planning and Technical Requirements' of the Ministry of Land and Resources include provisions specifying the need for research and research plans. Considering the available resources and management capabilities, problems associated with geopark development must be addressed with short- and long-term research projects. Project proposals with estimated budgets, methodologies, expected results, publications and final applications are available for approval and funding by the local, provincial or national authorities. Every geopark is expected to have one ongoing research project operating throughout the year. The research priorities of newly established geoparks are studies of the formation and evolution of the geology and geomorphology and comparisons with similar locations in other parts of China or around the world. The results of this research can be used to improve the interpretations of the

natural features of the geopark, enabling effective science popularisation.

Geopark Study Geopark studies are a new area of earth science that has grown along with the development of geoparks in the twentieth-first century. The research aims at addressing the problems associated with the establishment, operation and management of geoparks. These can include the classification, evaluation and protection of geological heritage, the formation of the landscape, geological features and phenomena, plans and designs, education and interpretation, visitor perceptions and behaviours, information technology and marketing, geohazard monitoring and control, and the formulation of laws and regulation. There are numerous research opportunities that will allow geoparks to develop better to meet the needs of people and society.

Geopark Swabian Albs, Germany This geopark is located between the Swiss and French Jura. The Swabian Jura (Alb) is the central part of the Jura chain, which extends through central Europe. Bordered by the Black Forest and the Baar region to the southwest, the upper Neckar Valley to the north, the Ries crater to the east and the Danube to the south, the Swabian Alb covers an area of 17,600 km^2. It became a global geopark in 2005. Its geological significance includes the Alliani River Prinsba terrace profile and the Holzmarken, Dortmundhausen Brautov and Nusslingen fossil sites. There are two meteorite impact craters, and the 'Swabian Volcano' contains more than 350 craters. The geopark also contains the oldest sculptural works of art with archaeological value and one of the oldest instruments made by humans. In addition, karst landforms can be found in the geopark, including sinkholes, fossil-bearing reefs, karst springs and caves. The Cretaceous 'Blautopf' spring, which flow rate varies from 290 to 25,750 l/s, and the karst caves, such as the Böttinger marble, are made up of travertine containing plant and animal fossils. The 'water battle in Alwa, Swabia' site is even more impressive. The geopark contains the European water divide, which is the boundary between the watershed of the Rhine River, where water flows to the North Sea, and that of the Danube River, where water flows to the Black Sea.

Geopark Website A website is an effective means of improving the transparency of a geopark and ensuring smooth communication with visitors, the public and other geoparks around the world. The website should provide an introduction to the geopark, including its attractions, accessibility, opening hours, ticket sales, and booking of transportation and accommodations. It is important to maintain and update news about the geopark to enhance its attractions, improve publicity and create a long-lasting positive image.

Geopark, Aboriginal Reserve Areas These reserves are areas used to preserve aboriginal history and culture. They are designated when the area in which aboriginal people live is large, and it is difficult to relocate them. Development is restricted because the main purpose of these reserves is preservation. Assistance is needed to help aboriginals transform from traditional agricultural, forestry, and mining activities to service industries associated with the tourism development of the geopark.

Geopark, Album An album of a geopark is a photo album containing high resolution pictures of the beautiful and representative geological and cultural landscape of a geopark. The difference between this album and other photo albums is that it contains scientific illustrations or descriptions that help readers understand the background of the geopark's iconic geological and landscape features.

Geopark, Audio-Visual Theatre A theatre is a place where multi-media or audio-visual equipment and facilities are used to introduce and demonstrate the significance of the geopark. Movies should demonstrate the evolution and formation of the geological features and landscape of the geopark and their interactions with the local history and culture. 3D, 4D or 5D technology can be used in the theatre to attract the public, especially children. Most geopark theatres in China have more than 80 seats. The

theatre can be located in the geopark museum or separately in an independent building.

Geopark, Boundary Demarcation The demarcation of a geopark is usually set according to the existing boundaries of administrative divisions, major roads (excluding areas occupied by roads), natural terrain such as ridges, valleys, rivers, shorelines, and cliffs, other natural boundaries and the original boundaries of scenic areas. These boundaries require accurate measurement and must be clearly marked by boundary posts or markers.

Geopark, Compilation of Basic Information This refers to the information and results obtained during the planning, survey, and statistical analysis and from major references that are studied.

Geopark, Cultural and Ecological Research This topic focuses on studies of the people, history, cultural relics, historical sites and folklore of the geopark. It involves investigating their types, quantity, distribution, zoning, evolution, evaluation and protection methods. In addition to environmental education, the objective of these investigations is to protect the cultural and biological resources in the geopark and to effectively disseminate knowledge of human history.

Geopark, Cultural Landscape Zone The concentration of cultural landscapes and activities in a certain area of a geopark can be designated as a cultural landscape zone of the geopark.

Geopark, Demonstration System A demonstration system involves the use of GIS technology to recreate the formation and evolution of geological heritage and landscapes. This involves using 3D animation technology and filming of 3D and 4D video. The videos are broadcast in the geopark museum and theatre. They can also be uploaded to the geopark website for sharing with people who are interested in the geopark.

Geopark, Ecological Protection Planning This plan is designed to protect the ecological environment of a geopark. The ecological environment of the geopark and its environmental impacts will be studied and assessed. Based on the research, the pros and cons of having a geopark will be evaluated, and the extents of the impacts will be estimated. Based on the results of the assessment, measures and policies will be formulated to prevent and alleviate the problems to achieve the original goal of protection. The most important protection measures include controlling the numbers of visitors and construction projects, designating ecologically sensitive zones, preventing access to these areas, increasing the forest and vegetation coverage and handling and treating waste.

Geopark, Ecological Zone In a geopark, areas where forest, grassland, wetland and other ecological resources are concentrated can be designated as natural ecological zones of the geopark.

Geopark, Entrance This is the main entrance to the geopark. It includes various facilities, such as car parks, the geopark piazza, a tourist information and service centre, ticket office, waiting and assembly halls, the iconic geopark monument, souvenir and convenience stores, restaurants and cafes. The geopark museum or the science popularisation centre can also be located at the entrance for the convenience of visitors and tour groups.

Geopark, Establishment of Information Systems Modern information technology is essential and important in establishing geoparks. It has been applied in building geological heritage databases, official websites, mobile phone applications, audio-visual and interpretation systems, information sharing and announcements, environmental, geohazard and visitor monitoring, electronic tour guide systems, and management and control centres. Information technology data are easily obtainable, retrievable and responsive to changes. These characteristics help to ensure effective decision-making of management in all aspects of geopark development.

Geopark, Exchange of Scientific Research Results Through the exchange of knowledge and experiences with other geoparks, research results can be shared for the long-term mutual

benefit of all geoparks. Knowledge shared between geoparks includes geological and landform studies, environmental protection, management, organisation of science popularisation activities and promotions, interpretation systems, geopark promotion and tourism development. All geoparks are encouraged to share their knowledge with other geoparks. This knowledge can be shared directly with other geoparks, particularly when they are sister geoparks.

Geopark, Functional Areas The establishment of a geopark requires clear environmental and space planning. In general, these areas can be divided into natural functional areas and artificial facilities areas. Natural functional areas include geological landscapes (e.g., geological heritage protection zones) and natural ecological zones (e.g., water bodies and forests). Artificial facilities include cultural landscape areas, preserved villages and settlements, science education areas, reception areas (or the main entrance) and management areas. The goal of planning is to delineate these areas according to the existing conditions and needs.

Geopark, Functions The three major functions of a geopark include (1) geological heritage and environmental protection; (2) popularisation of geoscience and encouragement of research; and (3) promotion of sustainable economic and social development, fostering tourism activities and improvement of the livelihood of the local people.

Geopark, Funding for Scientific Research All Chinese geoparks assign funding for research, which is usually 2% of the total ticket revenue. Funding is also available from city, provincial and national governments for special scientific research projects, particularly those related to geoheritage protection.

Geopark, Geoheritage Protection Area Protection areas in a geopark can be zoned and classified according to the global, national and regional significance of the geological heritage or geosites that are vulnerable to damage by human activities. Different levels of protected areas should have clear boundaries and be supported by appropriate protection measures. For the classification of geological heritage protection, please refer to 'geological heritage protection plan'.

Geopark, Geoheritage Research Studies of the geoheritage of a geopark focus on the evolution, features, representativeness and aesthetic characteristics of the geology and geomorphology. Studies of the evolution include the formation, development, history and predictions of future development. The ancient geographical environment and other factors are considered and analysed. The aesthetic values are explored, recorded and then translated in a later stage into useful information that can be easily comprehended by the public. The prediction of future development helps in the formulation of safety and protection plans, regulations and laws. Regional, national and global comparative studies also enable the assessment of the scientific value and uniqueness of the geoheritage.

Geopark, Geotourism Area Geotourism areas are located near geological heritage protection areas with interesting geological attractions and well-designed trails and routes. Maps and interpretive signs and boards are used to provide information about the geological and geomorphological features. These are areas for science popularisation and are excellent venues for students to learn about the geopark. Guided tours are typically available with fixed or flexible schedules that suit the needs of visitors with different backgrounds.

Geopark, Information Centre This is a centre for information and data management in the geopark. It is responsible for planning, collection, analysis and synthesis of data. These useful data are prepared in a manner that allows for easy retrieval and reference. They are integrated with other data to form an information platform to serve the long-term planning and development of the geopark. The data can also be exchanged with partners in the local, municipal, provincial and national authorities. The data also provide valuable information to contractors associated with construction and development projects within the geopark.

Geopark, Information Network Please refer to *establishment of information systems in geoparks*.

Geopark, Land Use Plan This plan aims at achieving rational control and sustainable use of the land in a geopark to meet the expectations of the government and people. A detailed investigation and analysis of the available resources of the geopark, zoning and designation of sites is required to meet the objectives of conservation, education and sustainable development. The focus is on the geological heritage, supported by various facilities and the rearrangement of current settlements and agricultural, mining, and industrial activities. Mines and industrial facilities may have to be shut down to create a cleaner and more pleasant environment. Illegal structures are to be demolished, and the area must be restored with vegetation. The land use plan is an integration of many different plans representing balanced interests and objectives.

Geopark, Management Organisation Please refer to *geopark, management structure*

Geopark, Management Research Geopark management research includes research undertaken to ensure the efficient protection of geological heritage and management of the geopark. It can include topics such as the identification and classification of geological heritage sites with different values, conservation and preservation methods, visitor behaviours, routes and interpretation designs.

Geopark, Management Structure Geopark management comprises staff with various backgrounds, such as planning, tourism, geology, biology, history, finance and marketing. However, the Ministry of Land and Resources requires staff with geoscience training, particularly in geotourism. A global geopark requires five to eight geoscientists, and a national geopark requires three to five geoscientists. A member of the senior management staff must have a geoscience background.

Geopark, Management System This is a management system approved and used by the authorities during the application, assessment and development of a geopark. Global Geopark is a programme of the UNESCO Division of Ecological and Earth Science and managed by the Global Geopark Network. The national geoparks in China are supervised by the Geoenvironment Protection and Geohazard Control Division of the Ministry of Land and Resources, while provincial geoparks are managed by the director of the provincial Land and Resources Bureau. A geopark is operated and managed by a management body authorised by the relevant city or local county government in the region of the geopark.

Geopark, Management System and Capacity Building Programmes Geoparks require strong management systems to meet their primary goals of conservation, education and sustainable development. In addition to the need for experienced conservation and education personnel, geoparks must also be run by efficient operational, business and tourism management teams. National geoparks in China are typically required to have 3–5 geoscientists (especially geotourism experts), and each global geopark needs 5–8 geoscientists.

Geopark, Monitoring System This refers to a system that monitors the natural environment, including potential geohazards, the conditions of park facilities, tourist safety and activities, traffic conditions, and illegal developments and activities. Three types of monitoring systems are available in a geopark: geological heritage protection systems, environmental protection systems and tourist management systems. This monitoring equipment is installed at major park entrances, gates, sensitive boundaries, important geosites, key ecological protection areas, forests, assembly venues and potential geohazard sites. They are also used to monitor the weather and environmental changes that may threaten tourist safety and to prevent damage to valuable geological heritage by nature and humans. In recent years, unmanned aerial vehicles (UAVs or drones) have also been used to monitor geoparks, and they are particularly cost- and time-effective in monitoring potential

geohazard areas, plant diseases, illegal developments, and visitor movements and concentrations.

Geopark, Museum A geopark museum should be of a sufficient size to demonstrate the geology and geomorphology of the geopark. A museum is a centre for interpretation, an area for geopark promotion and a training and education centre for science popularisation. It stores and displays the results scientific research projects, academic exchanges and publications associated with the development of the geopark. The displays must be interesting and attractive to visitors to disseminate knowledge. Interactive exhibits that encourage the active participation of visitors are preferred. The contents should comprise the natural and cultural elements of the geopark and the surrounding areas. The iconic and attractive landscape, unique ecological features and local culture are important displays that serve the primary purpose of increasing the interest and appreciation of visitors. In China, the size of a geopark museum is usually larger 800 m^2. Smaller museums and display centres can be set up in individual scenic districts, areas and sites for more focused displays of local natural and cultural characteristics.

Geopark, Narration The narration of a geopark is usually given in the form of a handbook for geopark guides. It contains scripts and information about the geological, ecological and cultural elements of the geopark, including scripts for indoor (e.g., the museum) and outdoor (e.g., along the routes and at the geosites) environments. The information and data must be accurate and cover all aspects of the geopark, and they should be delivered in an interesting and easily understandable form. The writing of the narration can be based on a set of interpretive materials that introduce different aspects of the geopark but can be modified to suit the different backgrounds and requirements of different types of tourists and visitors.

Geopark, Planning Documents These are legal documents guiding the development of geoparks. Based on the requirements of the *National Geopark Planning Compilation Outlines*, the statutory provisions clearly state the required types and quantities of work and the methods to accomplish these tasks. The documents include operational and mandatory guidelines. They consist of 55 articles in 16 chapters: (1) general provisions; (2) nature and development goals of geoparks; (3) landscape assessment of geological heritage; (4) other landscape resources and assessment; (5) overall layout and functional zoning; (6) protection of geological heritage; (7) protection of the ecological environment and cultural landscape; (8) scientific research; (9) commentary system planning; (10) science popularisation action plan; (11) tourism development; (12) information establishment; (13) infrastructure and service facilities; (14) land use; (15) community action plan; and (16) protective measures.

Geopark, Planning Instructions The planning instructions are the results of the planning process. They include (1) the planning basis, guiding ideology, main content and characteristics; (2) preparation; (3) planning objectives, tasks, and major indicators; (4) merging areas with other plans; (5) initial assessment of the provincial Land and Resources Department; (6) opinions and coordination of relevant departments, governments and experts; and (7) other relevant issues.

Geopark, Planning Maps A total of 10 maps are requested by the national authority, including a transportation map, geological map, boundary map, map of natural and cultural resources, geological heritage protection map, overall planning map, map of scenic areas of the geopark, land use map, remote sensing images and a science guidebook. The scales and contents of the maps are based on the requirements of the *Geopark Planning and Technical Requirements*.

Geopark, Popular Science Zone Popularising geoscience is one of the most important functions of a geopark. This zone within the geopark is usually located near an important geological heritage area with a concentration of interesting geological features. It normally

includes a geological museum, science popularisation corridor or hall, multi-media displays, interactive presentations and activity rooms.

Geopark, Practical Transformation of Scientific Research Research results are transformed into practical uses, such as publishing books for the general public and translating them into simple language and expressions for use in the interpretative system of the geopark. The results are also applicable to geological heritage protection and geohazard prevention, environmental pollution, waste and water treatment monitoring and control, tourist management and long-term planning of the geopark development.

Geopark, Principles of Scientific Research Research in geoparks should serve the three major objectives of protecting the geological heritage and environment, popularising geoscience and fostering sustainable local economic development. Research should also be useful in encouraging the sustainable uses of geological, ecological and cultural resources and improving the geopark management system.

Geopark, Publication of Scientific Research Results The results of geopark research are encouraged to be publicised in various kinds of local, provincial, national and international academic journals. The results of studies can also be translated into simpler forms so the general public can read and understand them. They can be published in books, audio-visual materials, magazines and social media networks.

Geopark, Route Planning Route planning includes the use of various types of transportation or walking trails in the geopark to link all or most of the scenic spots with geological, ecological and cultural attractions or geosites for sight-seeing, field study and research. Most geoparks have at least two or more major routes, each of which may require approximately a half day to visit. If the route is too long (usually more than 3–5 km) or the terrain is rough or steep and beyond the capacity of normal tourists (usually more than 300–500 m in elevation), supporting means (e.g., environmentally friendly or battery-operated shuttles, cable cars, and ferries) will be used.

Geopark, Scenery Scenery includes geological and geomorphological landscapes that have tourism value and may or may not be associated with the local culture and history. They form the basic units that make up the geopark.

Geopark, Scenic Districts and Scenic Areas A geopark can typically be subdivided into scenic districts and scenic areas for more effective management. The subdivisions can be based on the spatial distribution and characteristics of certain landscapes or geological heritage, natural landscape boundaries, traffic connections, administration and jurisdiction. Each district contains scenic areas with high concentrations of geological heritage that are accessible to tourists. In principle, the number of scenic districts should be restricted to not more than two, and they should managed by one geopark, although branches can be established in the district for better control and management.

Geopark, Scenic Sites These sites are individual locations of high aesthetic value with unique natural and cultural beauty. The landscapes usually have unique characteristics and attractions. Examples include the 'West Sea Grand Canyon' and the ancient temple 'Ciguang Pavilion' in the Huangshan Geopark.

Geopark, Science Interpretation System Interpretation of science to the general public is one of the main roles of a geopark. The interpretive system usually comprises (1) indoor exhibits, such as a museum and audio-visual theatre; (2) outdoor exhibits, such as interpretive boards and signs that describe the background of the geopark and its attractions, and traffic signs; (3) geopark interpretive messages, scientific guide maps and handbooks, books, audio-visual materials, and printed materials such as maps, booklets, pamphlets and leaflets; and (4) trained interpreters.

Geopark, Scientific Research Topics Scientific research in geoparks mainly focuses on five aspects: geological heritage, environmental protection, resource management, socio-

economic impacts and interpretation. Research on geological heritage includes studies of their formation, evolution, characteristics, aesthetic value and global comparisons. Environmental protection includes the geopark's geodiversity, biodiversity and interactions between its geological and biological components. Studies of the sustainable uses of resources, such as the landscape, water and forest resources, are important for bringing direct environmental and socio-economic benefits and impacts to the local communities. Research on the communication of knowledge and interpretation helps in the design of better interpretation materials, museum displays, digital and audio-visual presentations, tour guide training, guidebooks and maps.

Geopark, Secondary Tablet (or Stele) A geopark can include several scenic districts. Each district usually has a smaller tablet to mark the beginning of a tour or route to view the area.

Geopark, Service Facilities Good tourist facilities will provide a good experience to tourists. The tourist facilities in geoparks in China usually include a bus terminus and stops, assembly areas, an information centre, a ticket office, the main gate, parking lots, medical stations, restaurants, cafes, snack kiosks, toilets, hotels and motels, outdoor performance venues or performance halls and entertainment and shopping centres.

Geopark, Social Regulations and Controls To protect geological heritage and ensure the geopark management, a specific plan is needed to adjust and relocate local residents and people. First, detailed studies of the distribution, scale, and socio-economic conditions of the local residents and the industrial development of the area must be conducted. Based on these studies, feasible resettlement programmes can be formulated (e.g., preservation, compression, relocation, and aggregation plans). Estimates must be made of the number of jobs that could be created and how the geopark management and local industries will be adjusted during and after the establishment of the geopark. These social regulations and controls should be consistent with the local city and town plans, new rural planning and other land use plans.

Geopark, Special Planning Please refer to *geopark, planning*.

Geopark, Specific Reports These reports are some of the results of geopark planning proposed by the *Technical Requirements for Planning of National Geoparks* promulgated by the Ministry of Land and Resources in 2010, which replaced the original *Planning Statement*. They provide more in-depth studies and analysis through research. The preparation of the report is based on the *Outlines of the Compilation of Special Research Report of National Geopark*.

Geopark, Tablet (or Stele) Most Chinese geoparks have a large stone tablet at the entrance that bears the full name and logo of the geopark as well as the national or global geopark logos if they have been approved such status. The tablet is normally made of rocks from the geopark, and it signifies the image and degree of importance of the geopark. The design is preferably based on the iconic natural characteristics of the geopark but must be simple and innovative. It is also labelled with the name of the approving authority, such as the Ministry of Land and Resources or the UNESCO Global Geoparks Network.

Geopark, Tourism Plan A geopark cannot be successfully established without an effective tourism plan. Based on the available tourism resources and clearly set development goals, market research and analysis are conducted to assist in the formulation of a tourism plan. The locations of the geological, ecological and cultural attractions are pinpointed and classified, based on which services and routes are designed to serve the purposes of leisure, study, research and sports activities.

Geopark, Tourist Safety Planning This is a plan for protecting tourists. It includes monitoring, alerting, preventing and controlling the potential dangers caused by geological disasters such as earthquakes, landslides, rockfalls, mudflows, and flooding. They involve designs

for cliff and waterfront safety measures and warning systems, accident and emergency rescue plans, forest and building fire prevention and evacuation plans, electronic and safety monitoring systems and management plans for the entire geopark.

Geopark, Tourist Service Area This is an area where visitors to a geopark can assemble, purchase tickets, hire guides, take shuttle buses, cable cars or boats, make reservations for other activities, and obtain tour and route information or information about the natural, ecological and cultural details of the geopark. Catering, shopping, hiring and toilet facilities are also available for the convenience of visitors. This type of service area is usually called a visitor or information centre, and it is typically located near the main entrance of the geopark or the major scenic attraction, where there is a sufficient flow of people. This area is a basic requirement of geopark planning.

Geopark, Types Geoparks can be classified according to their management, sizes and nature. There are four types of geoparks in China based on their management, namely, global, national, provincial and county (city) geoparks. There are also four classifications based on their sizes, including very large ($\geq$500 km^2), large (100–500 km^2), medium (20–100 km^2), and small ($\leq$20 km^2). The background of a geopark can also be used to determine its type. There are seven types of geoparks based on the park's background and nature, including the stratigraphy, geological structure, mineral and mining, fossils, geomorphology, water bodies and environment.

Geoparks Research This book was written by Yuhui Li and was published by the Commercial Press in 2006. The book introduces the background and development history of geoparks and discusses the theory, knowledge and technology of geopark construction. It provides a relatively systematic discussion of the research on three geoparks in Yunnan Province: Shilin (Stone Forest) Geopark, Tengchong Volcano Geothermal Geopark and Lijiang Yulong Liming – Laojunshan Geopark.

Geosyncline A geosyncline is a banded tectonic unit on the crust that is active, strongly deformed, subject to long-term subsidence, and receiving sedimentary deposits. Geosynclines not only have significant sedimentary deposits but also contain unique rock formations, such as spilite-keratophyre and flysch. Geosynclines are usually uplifted by 'fold inversion' and, due to intense metamorphism and abundant intermediate-acidic igneous activity, form orogenic belts that are characterised by linear folds and thrust nappes.

Geotectonics ▶ Tectonics

Geothermal Groundwater Tourism Resources Under certain geologic conditions, geothermal groundwater influenced by the heat inside the Earth can have different temperatures. Geothermal groundwater can be classified into different types based on the use and temperature, but the standards vary in different countries. From the perspective of recuperation, Japan uses the categories of slightly warm water (25–34 °C), warm water (34–42 °C) and hot water (>42 °C). China currently uses the standard of 25 °C as the lower limit of hot water (according to China's Geothermal Resource Temperature Classification) and categorises water into low-temperature hot water (25–40 °C), warm hot water (40–60 °C), hot water (60–90 °C) and superheated water (>90 °C). According to the geological processes and occurrence, geothermal water can be divided into (1) geothermal water related to volcanic and magma activity; (2) recirculated geothermal water related to fold and fault zones; and (3) subsidence basin-type geothermal groundwater. China has rich underground hot water resources. According to a study by Han Zaisheng, the usable geothermal groundwater resource is 6.8 billion m^3 per day, which is approximately equivalent to the heat from 32.8 million tons of coal per day. This is a huge potential energy resource. Underground geothermal water is the main resource for hot spring resorts. Several hot springs (such as the Old Faithful Geyser in Yellowstone National Park in the U.S.A., which has a water temperature 94 °C and erupts every

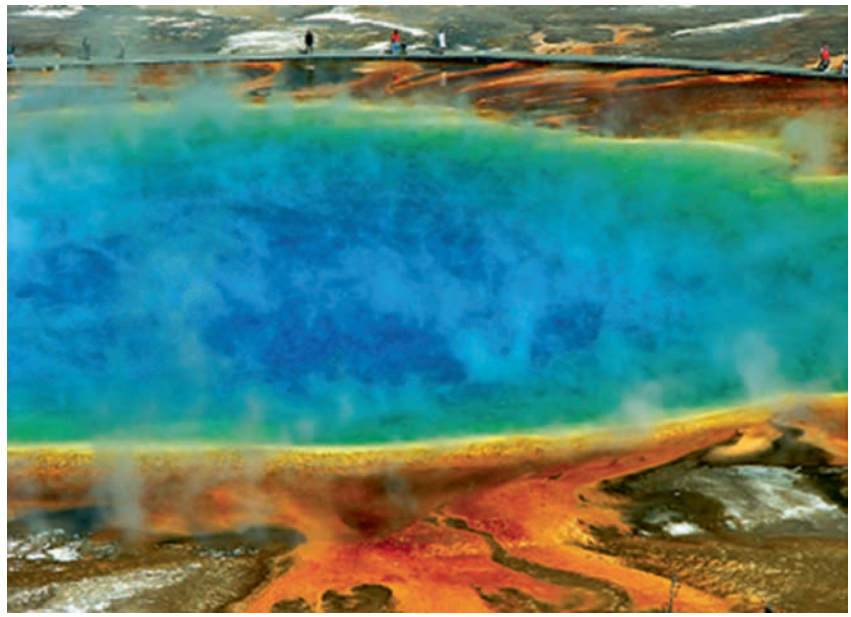


Fig. 4 Geothermal groundwater landscape in Yellowstone National Park, U.S.A

hour for approximately 2–5 min to a height of 40–70 m) have high ornamental value, and it is also a very important tourism resource. With the development of tourism in China that focuses on multiple purposes, including sightseeing, leisure and vacations, the role of underground geothermal water as a tourism resource will become increasingly important (Fig. 4).

Geotourism Resources in China This book was edited by Tianqing Feng and was published by Geological Publishing House in 1998. It systematically introduces more than 30 types and 3,000 geotourism resource and geological heritage sites, their distribution and formation, including mountain landscapes, karsts, caves, rivers, lakes, famous springs, waterfalls, islands, coasts, palaeontological fossils, geological structures and sections. It is a relatively complete database of geological tourism resources.

Germu Mount Kunlun National Geopark, Qinghai Germu Mount Kunlun National Geopark is located in the Kunlun Mountains of Germu. It became a national geopark in 2005. The geopark has high elevations of 5,000 to 6,000 m. It is the meeting point of the main ridges of the East Kunlun Mountains. The rocks are mainly Triassic and Neogene granite and gneiss. The geopark features ancient glacial relics from multiple periods, modern glaciers, mud volcanoes, drumlins and spring water.

Germu Saline Lake National Mining Park, Qinghai This park is located in Germu City in the Tsaidam Basin in Qinghai. It was designated as one of the first group of national mining parks by the Ministry of Land and Resources in August 2005. Because the lake and sky have the same colour, the Chaerhan Salt Lake is known as the 'King of Salt Lakes'. The park includes a salt sculpture park, sightseeing salt pan, water park, and a salt lake history museum. The museum has an area of 2,020 m^2 and is divided into five exhibition areas: a salt lake knowledge area, salt lake development area, potash fertiliser industrial development area, exquisite salt bloom display area and recreation area.

Geyserite Landscape ▶ Siliceous Sinter

Giant's Causeway and Causeway Coast, Northern Ireland The Giant's Causeway and Causeway Coast lie at the foot of basalt cliffs along the Atlantic coast on the edge of the Antrim plateau in the Moyle District Council in Northern Ireland. They cover an area of 0.7 km^2 and consist of approximately

40,000 massive black basalt columns that stick out of the sea. This dramatic landscape name came from the legends of giants walking over the ocean to Scotland. Geological studies of these formations over the last 300 years have greatly contributed to the development of the earth sciences.

Giant's Causeway Basalt Columnar Joint Landscape The Giant's Causeway, located on the northwestern coast of Antrim in Ireland, is a landscape of basalt columnar joints. These regular hexagonal and pentagonal columns formed approximately 50 million years ago, when hot basalt flows cooled gradually and contracted into columns. These basalt columns look like a natural staircase leading to the sea. They are approximately 0.45 m wide and extend 6–12 m above sea level. There are approximately one thousand exposed columns, but some are submerged under the water. The Giant's Causeway is a World Natural Heritage Site. China also has numerous basalt columns in many places, such as Liuhe in Nanjing, Niutou Mountain and Dazhang Mountain in Zhangzhou, Fujian Province, and Tengchong in Yunnan Province (Fig. 5).

Gigantoraptor Erlianensis This is the largest oviraptor found in the world to date. In general, oviraptorosaurs are less than 2 m long, but the Gigantoraptor erlianensis fossil has a length of 7.52 m, a body height of 3.55 m and a head height of 5.21 m, and it weighed approximately 1,400 kg. Its body shape is comparable to the famous Tyrannosaurs. This oviraptor fossil is similar to the fossil birds, and it represents a transitional type of oviraptorosaur. Its femur is similar to that of birds, and its forelimbs might have been covered with feathers. It had no teeth but had a large beak. These bone characteristics clearly indicate that Gigantoraptor erlianensis was an advanced theropod between a dinosaur and a bird (Fig. 6).

Glacial Boulder Landscape This is a landscape comprising large boulders in glacial moraines. The boulders can reach several metres to dozens of metres in diameter. The boulders originally fell onto the glacier and were later transported to the ablation zone and deposited on the ground. The boulders are round with concave surfaces and have glacial striae. Because the boulders are carried from far



Fig. 5 Landscape of Giant's Causeway



Fig. 6 Gigantoraptor erlianensis



Fig. 7 Glacial erratic below the Alps, Switzerland (16 m × 13 m × 6 m)

away, their composition can be used to determine the source area and the glacier's movement direction (Fig. 7).

Glacial Crevasse Landscape This is a landscape composed of cracks on the surface of a modern glacier. During glacial movement, cracks can form on the firn due to stress. Based on the relationship with the glacier flow, they can be divided into transverse crevasses perpendicular to the glacier flow, longitudinal crevasses parallel to the glacier flow, oblique crevasses across the glacier and edge crevasses around the firn basin (Fig. 8).

Glacial Groove Landscape *Synonym:* ▶ *Dorr landscape*
This is a landscape composed of large grooves formed by glacial abrasion. The glacial grooves form from etching of the valley walls by gravels carried by the flowing glacier. The grooves develop better on soft rocks, and they are an evidence of glacial movement (Fig. 9).

Glacial Heritage Protection Glaciers are mostly located in alpine areas, and most of these areas are natural, ecologically sensitive and fragile. Due to the impact of global

warming, the shrinkage of modern glaciers around the world has become significant in recent decades. The protection of glaciers is mainly accomplished by reductions in greenhouse gases, preservation of vegetation and forests and control of soil erosion and desertification. In addition, tourism activities on glacial surfaces, particularly on ancient glaciers, are also restricted or prohibited.



Fig. 8 Glacial crevasse landscape

Glacial Lake Landscape This is a landscape composed of lakes that are formed by glacial action, such as small alpine lakes in glacial regions. Glacial lakes can be divided into erosional and depositional types. The former are lakes that form in armchair-shaped depressions (such as cirques) due to glacial erosion, whereas the latter refers to lakes that form by ponding of water due to blockage of a glacial valley by a glacial moraine. Glacial lakes usually form in alpine glacier areas.

Glacial Lake Tourism Landscape This is an excavated depression formed by the plucking action of glaciers. A glacial lake can be formed by filling of a depression and damming of a glacial moraine. Examples are the cirque lake of Mahu Lake in Luhuo, Sichuan Province, the moraine lake Tianchi on the northern slope of Bogda Peak, and Tianchi Lake in Xinjiang Province. These lakes combine with the glacial peaks in the distance to create a picturesque scenery, and they have become popular tourism spots.



Fig. 9 Glacier groove landscape on the left bank of the Hailuogou glacier trough, western Sichuan



Fig. 10 Modern glacial landform

Glacial Landform See "▶ Glacial Remains Landscape" (Fig. 10).

Glacial Landscape Tourism Resource System This is a landscape resource system with tourism value formed by glaciation. Glaciers are colloquially called 'ice rivers' in Chinese. Quaternary glaciers have a total area of 15.85 million square kilometres, which is approximately 10% of the total land area of the Earth and 3% of the globe. Based on the characteristics and morphology of glacial sites, glaciers can be categorised as piedmont glaciers, alpine glaciers and continental ice sheets and ice caps. Based on their geographical locations, glaciers can be divided into polar glaciers, sub-polar glaciers, temperate glaciers and tropical glaciers. Based on their time of formation, glaciers are classified into glaciers from past ice ages and Quaternary glaciers.

Glacial Pavement Landscape, Abraded Bedrock Surface Landscape This is a glacial erosion landscape. When a glacier flows across the bedrocks, the abraded surface is called a glacial pavement. It is an important evidence of glacial movement. The rock surface appears very smooth to the naked eye, but numerous minute striations can be identified under the microscope. The extent of polishing hinges on the particle size of the materials that act as the abrasion medium (Fig. 11).

Glacial Pothole Landscape Meltwater can percolate into a glacier along crevasses, and when it reaches the bedrock, a layer of pressurised water can form and flow at a maximum speed of 200 km per hour along the contact between the glacier and the rock. The pressurised water washes the rock and forms a vortex loaded with gravel, which swirls and abrades the bedrock. The abrasive action creates deep holes, which are called glacial potholes because they look like rice-grinding mortars (Fig. 12).

Glacial Remains Landscape This is a geomorphic landscape that is formed by erosion and deposition during the life cycle of glaciers. Glacial landforms include glacial erosional features, such as U-shaped valleys, horn peaks, aretes, cirques, roche moutonnees and ice-scoured depressions; glacial depositional features, such as lateral moraines, medial moraines, basal moraines, ground moraines and terminal moraines; and fluvioglacial depositional features, such as drumlins, kames, outwash fans and moulins. All of these landform features are parts of glacial remains landscapes, and studies of these glacial relics can facilitate the understanding of the patterns of ancient glacial activity and climate change. Glacial remains landscapes have high value for scientific studies, research and aesthetics, and they are important tourism resources. There are typical glacial remains landforms in Hailuogou National Geopark, Siguniangshan National Geopark, and Jiuzhaigou National



Fig. 11 Glacial pavement landscape of the Jiuhuping cirque in Shennongga, Hubei (the pencil is aligned with the glacier's movement direction)



Fig. 12 Glacial pothole landscape in the Alps in Lucerne, Switzerland

Geopark in Sichuan Province and in Lushan National Geopark in Jiangxi Province.

Glacial Spillway Landscape This is a landscape composed of a U-shaped notch in a ridge or slope on the side of a glacial valley. When a glacier occupies a U-shaped valley, plucking and abrasion on the ridge or slope can result in a glacial spillway. After the glacier melts, the spillway hangs above the ridge or the valley slope.

Glacial Striae Landscape *Synonym:* ▶ *Drift scratch landscape*

This is a landscape that is created by glacial abrasion. Glacial striae are preserved on the moraine rock surface, sides of the glacial valley and the valley's bedrock surface. The marks look as a T-shaped head with a tail. The large and deep portion points downhills, and the fine linear portion points uphills. The marks form when gravels carried by glaciers



Fig. 13 Glacial scratches on a glacier gravel (quartzite) in Yangbajing, Tibet

scratch each other or abrade the bedrock. The striae are several centimetres to a metre long and several millimetres deep. Glacial striae can help determine the glacier's movement direction (Fig. 13).

Glacial Table Landscape This is a landscape of table-shaped rocks formed by glacial action. On the glacier's surface, the rate of ice melting slows when it is shaded by large boulders. When a boulder on the ice is shaped like a table, it is called a glacial table. The term glacial table also applies to a moraine boulder transported to the top of another boulder (Fig. 14).

Glacial U-Shaped Valley Landscape This landscape is also called a glacial trough landscape, and it is composed of U-shaped valleys that is formed by glacial erosion. This landform is most common in alpine glacier areas. The valleys are wide, flat and straight, and the cross-section looks like a U. They form when a glacier occupies a pre-glacial valley, and the erosive effect of the glacier considerably modifies its form to become deeper and wider with steep valley walls and a flat floor. Polished surfaces and striations often exist on the bedrock of the valley floors and walls (Fig. 15).

Glacial Varve Landscape This is a landscape composed of striped mud layers deposited in glacial melt lakes. Glaciers melt rapidly during the summer, and in the presence of abundant meltwater, large quantities of sand and mud are transported to the lake. The sand or silt grains rapidly sink to the bottom, but the clayey particles float in the water. During the winter, the floating clay gradually settles on the sand, forming a yearly depositional layer of coarse and fine grains. This process repeats every year and forms glacial varves with alternating bands. Varves are also called seasonal mud.

Glacial Well Landscape This is a landscape composed of caves that form from ice melting in the lower portion of a moraine and on the upper part of a modern glacier due to increasing temperature (Fig. 16).

Glaciated Valley-in-Valley Landscape This is also known as a 'glacial valley inside a valley' landscape. When a glacier erodes a pre-glacial valley and deepens the valley floor, a glaciated valley-in-valley landform is formed. When the glacier retreats after forming the glaciated valley, the river erodes the old glacial valley, causing the formation of a V-shaped valley within the U-shaped valley. When the glacier advances later, the existing V-shaped valley is modified into another U-shaped valley, forming a so-called glaciated valley-in-valley landscape as a result of the two consecutive episodes of glacial erosion.



Fig. 14 Glacial table landscape at Gulingjie, Lushan Mountain, Jiangxi



Fig. 15 Ancient glacial U-shaped valley landscape in Wangjiapo, Lushan Mountain, Jiangxi Province

Glaciation in Landscape Formation The movement of glaciers can form various glacial landforms via the processes of pitting, grinding, scouring, plucking, polishing, transportation and deposition.

Glacier At high latitudes and high elevations, the climate is cold. Snow accumulates and recrystallizes throughout the year, and its density increases gradually to form glacial ice. Glacial ice has a degree of plasticity. Under its own gravity, it moves along the ground as a plastic flow and a block-like slide and becomes a glacier. Glaciers are classified as continental ice caps and mountain glaciers. A continental ice sheet is a shield that rises from its edge to its centre. The thickness of the ice often exceeds 1,000 m. In coastal areas, a large ice tongue

often protrudes and breaks when reaching the sea to become a floating iceberg. Mountain glaciers exist at the snow lines of high mountains at middle and low latitudes. China has some of the most well-developed mountain glaciers.

Glacier Debris Flow Landscape This is a landscape that develops in modern glaciers and along firn edges, comprising a unique landform with abundant sand, mud and gravel carried by meltwater or flood water from a glacial lake. As seen in the Zhangmu area of Tibet, the glacier debris flow often starts in the summer and autumn when the temperature starts to rise and increases the amount of meltwater. Glacial debris flows are larger and have longer flows than rainstorm mudslides. The Guxiang mudslide in Bomi, Tibet, is a famous glacier debris flow, and Guxiang Lake is a dammed lake that was formed by the deposition of the debris.



Fig. 16 Glacial well landscape on a modern glacier

Glacier Tongue Landscape When an alpine glacier moves away from the firn basin, the ice body looks like a tongue, so it is called a glacier tongue, and the associated scenery is called a glacier tongue landscape. The glacier tongue is roughly equivalent to the ablation area and is the most active section. It contains water flows and crevasses on the surface and ice caves, ice stalactites and subterranean glacial rivers inside the ice body. The front part of a glacier tongue changes according to the supply of snow and the ablation rate, and the advance and retreat of the glacier also depends on these changes (Fig. 17).



Fig. 17 Glacier tongue landscape of a modern glacier at Yuzhu Peak, Qinghai Province



Fig. 18 Glacier-dammed lake landscape at Guxiangcuo, Tibet

Glacier-Dammed Lake Landscape This is a landscape composed of lakes that is formed by damming of river channels with glacial deposits. A glacier-dammed lake is a type of alpine lake. Examples are the dammed lakes in Bomi County, Tibet, and Tianshan Tianchi in Xinjiang Province (Fig. 18).

Glacio-Lacustrine Deposits Landscape These are sediments deposited in glacial lakes, including sediments in the delta, the lake bottom and along the shores. Compared with ordinary lakes, the sediments in glacial deltas often contain glacial gravels, and the lake bottom sediment contains alternating layers of coarse and fine sediments.

Glass Fragment ▶ Vitric Fragment

Glassy Petrified Wood These fossils are a type of highly silicified and crystallised petrified wood. It has various colours and shapes and high ornamental value (Fig. 19).



Fig. 19 Petrified wood

Glazed Frost Landscape Glazed frost is also known as icicles or 'tree coagulation'. It is a glassy or matted coarse ice layer that forms when super-cooled precipitation comes into contact with the surface of an object whose temperature is zero degrees Celsius or below. Rain that causes the formation of glazed frost is called icy rain. Glazed frost is common in mountains and lake regions. In China, glazed frost generally occurs from December to March. The frequency of glazed frost is higher in

southern China and lower in northern China, and it is higher in moist areas and lower in arid regions.

Global Boundary Stratotype Section and Point (GSSP) This is an internationally agreed-upon reference point on a stratigraphic boundary section that defines the boundary between two stratigraphic units of global standard stratigraphic ages. After detailed investigations of related global stratigraphic sections, the typical section, stratigraphic sequence, and reference point are officially announced, and once a GSSP boundary has been agreed upon, a permanent marker is driven into the geologic section to mark the precise boundary; this marker is known as a 'golden spike'. The GSSPs are defined according to the rules compiled by the International Commission on Stratigraphy (ICS), and the verification process is conducted by respective branch working groups of the ICS in an organized manner. After being selected by the branches, the proposed GSSPs are then submitted to the ICS for voting, and the agreed-upon GSSPs are passed to the International Union of Geological Sciences (IUGS) for formal approval. The selection of GSSPs is a scientific agreement based on the extensive and in-depth research. If there is no dispute, the approved GSSP is permanently effective. If there is a dispute, the adoption procedure can be reactivated 10 years after its approval.

Global Boundary Stratotype Section and Point (GSSP) at Pengchong Village, Bei'an Township, Liuzhou City, Guangxi This GSSP is located at the bottom of Pengchong section 83 south of Pengchong Village in Liuzhou, Guangxi Province. The definition of this boundary aligns with the benthic foraminiferal lineage from the 'Eoparastaffella ovalis group' to the first occurrence of Eoparastaffella simplex. A secondary marker is located five metres above the site, where the conodont Gnathodus homopunctatus first occurs. Thirty metres below it is the uppermost occurrence of Scaliognathus anchoralis europensis. At the end of February 2008, this definition was accepted by the International Commission on Stratigraphy (ICS), with 16 votes (88%) for and two abstentions, and in March it was formally approved by the International Union of Geological Sciences (IUGS) at its 58th executive board meeting in Morocco.

Global Boundary Stratotype Section and Point (GSSP) at the Base of the Permian Leping Series on the South Bank of Penglai Beach, Laibing County, Guangxi This section is located in the Jiangnan Basin between the Yangtze and Cathaysian plates. This area subsided continually in the early Palaeozoic and Triassic and extended south to the Laibin district in eastern Guangxi Province. The boundary is marked by the first occurrence of conodont fossils such as Clarkina postbitteri and is at the bottom of the Laibin marble bed, which overlies Maokou Formation 6 k in the Penglai Beach section (Penglaitian Section), with an evolutionary lineage from C. postbitteri hongshuiensis to C. dukouensis. It is approximately consistent with the middle-upper Absaroka megasequence boundary. The Laibin marble at this site represents continuous deposition of the Maokou Formation and Hesha Formation. This location also records a major extinction and succession of conodonts, brachiopods, corals and ammonoids. This GSSP can be correlated with other GSSPs in continental facies successions.

Global Change Global changes include past, present, and future changes in various components of the Earth's system, such as the atmosphere, hydrosphere, lithosphere and biosphere, under natural and human influences. Studies of global change focus on the entire Earth system to determine the changes and the mechanisms that control them, thus establishing the scientific basis for global change prediction, management of the Earth system, and disaster reduction and prevention.

Global Geopark Expert During the 30th International Geological Congress in 1996 (Beijing) and the 31st International Geological Congress in 2000 (Brazil), a geopark expert committee was established. The committee comprised 14 members, who were mainly members of the International Geological Correlation Programme (IGCP) from Latin

America (2), Africa (2), Asia/Pacific (3) (Xun Zhao was China's representative), and Europe (6). In 2005, the UNESCO Earth Science Division was restructured to become the Ecological and Earth Science Section. Subsequently, a Global Geopark Bureau was established with seven members, including Patrick McKeever, Nickolas Zouros, Guy Martini, Xun Zhao, Ibrahim Komoo, Marie-Luise Frey and Sylvie Giraud. A group of geopark experts was also recruited to assist in the operations of the Global Geopark Network, including site inspections of aspiring geoparks and geoparks being revalidated.

Global Geopark, Application and Approval Applications from the member states are accepted by the secretariat of the UNESCO Global Geopark Bureau. Each member state can only apply for a maximum of two geoparks each year. Countries that have never applied before are allowed to submit three applications. The applicant must be a member of the National Geopark Network of the relevant country. Three digital copies of the application in either English or French are required. The hard copies submitted should not exceed 30 pages. The application shall be signed by the administrative body of the geopark, the National Geopark Network, the National Committee of UNESCO and the local governments. After receiving the application, assessors will be appointed to inspect the geoparks and report to the review committee of the Global Geopark Bureau. When approved, the national geopark will then become a member of the Global Geoparks Network.

Global Geopark, Development History In 1972, UNESCO passed the 'Convention Concerning the Protection of the World Cultural and Natural Heritage', which aimed at developing a list of the world's natural and cultural heritage. By 1995, only a few geological heritage sites had been listed in the directory. During the 30th International Geological Congress in 1996 in Beijing, the UNESCO Division of Earth Science and the International Union of Geological Sciences (IUGS) jointly proposed the initiative of establishing 'world geological parks' with the objective of increasing the protection of geological heritage around the world. As a result, the English term 'geopark' was first used in Beijing. The initiative was immediately supported by more than 30 countries, including China. The European geologists that participated in the Congress discussed the establishment of geoparks in Europe. In November 1997, at the 29th Plenary Session of UNESCO, it was unanimously agreed that a global network of geological heritage with unique geological characteristics should be set up, which paved the way for the development of geoparks around the globe. In April 1999, during the 156th executive board meeting of UNESCO, the Geopark Programme (Global Geopark Plan) was formally launched to establish a Global Geopark Network (GGN). In 2000, European countries began to form their geoparks. At the same time, China also set up its own national geoparks. In May 2002, UNESCO formally promulgated the guidelines of the 'Global Geoparks Network' under 'UNESCO patronage (UNESCO Network of Geoparks)' and began to accept applications from interested countries. In June 2004, the 1st Session of the World Geological Park Conference was held in Beijing, during which the Beijing Declaration was announced, which included the constitution and 'Global Geopark and Geological Heritage Protection'. The first group of 25 global geoparks (eight Chinese national geoparks, including Huangshan) was approved at the meeting. The office of the Global Geoparks Network was set up under the Ministry of Land and Resources in Beijing. In October 2012, the Global Geoparks Network changed its affiliation with the Chinese Academy of Geological Sciences. By May 2017, there was a total of 127 global geoparks in 35 countries around the world, all of which belonged to the Global Geoparks Network.

Global Geopark, Evaluation Forms These forms must be completed to assess the management and qualifications of the geoparks by the Global Geopark Bureau. They include Form A and Form B. Form A comprises six major parts: regional geological and geomorphology,

geoconservation, natural and cultural heritage protection, operation and management, interpretation and environmental education, geotourism and sustainable regional and local development. A total of 254 items are assessed, and the total score is based on the weighted percentage; the maximum score is 100. Form B is the assessment of a geopark's progress and also includes six parts: contributions to the network, management structure and financial status, geoconservation and protection strategy, strategic partnerships, marketing and promotion activities after acquiring global geopark status and sustainable economic development. These forms are used for inspection and references during the required revalidation after 4 years. The results of the revalidation can be either a pass (green card), a request for improvement within 2 years (yellow card) or a failure or disqualification (red card).

Global Geopark, Logo This logo was designed by York Penno. The circle represents the Earth, and the five curved lines represent its five different spheres, including the core and mantle, lithosphere, hydrosphere, biosphere and atmosphere. The logo represents that the Earth is a planet on which humans live in its continuously changing environment. The logo also indicates that under the auspices of UNESCO, global geoparks are selected and protected for sustainable development. No other organisations are allowed to use the logo of UNESCO Global Geoparks Network.



Global Geopark, Revalidation Revalidation of global geoparks refers to the assessment of every global geopark by the executive board of UNESCO Global Geoparks every 4 years. The performance of the geopark is assessed by an expert team assigned by the executive board. A progress report (Form A) and geopark assessment form (Form B) is to be filled out by the geopark authorities and revalidated by GGN. The result can be either a pass (green card), a request for improvement within 2 years (warning or yellow card) or a failure (red card), which means being delisted from the Global Geoparks Network.

Global Geoparks in China China has had national geoparks with global status from UNESCO since 2004. By the end of 2018, there were 37 UNESCO global geoparks in China. The first eight national geoparks, including Huangshan, were approved in 2004 as the first group of global geoparks in the world. Since then, national geoparks have been upgraded to global geoparks every year except in 2007. In 2005, three national geoparks, including Xingwen in Sichuan, became global geoparks, followed by six national geoparks, including Fangshan in Beijing, in 2006. Two geoparks, including Zigong, became global geoparks in 2008, and another two, including Alxa in Inner Mongolia, became global geoparks in 2009. In 2010, an additional two, including Leye-Fengshan, acquired global status, followed by Hong Kong and one other geopark in 2011. Only one geopark in China, Sanqingshan, became a global geopark in 2012. Since 2007, each country has been allowed to nominate a maximum of two national geoparks every year unless it has no global geoparks.

Global Geoparks Network (GGN) In February 2004, during the UNESCO meeting in Paris, 25 members were accepted into the Global Geoparks Network, marking the formal establishment of the UNESCO-supported Global Geoparks Network. Its formal name is the 'Global Geoparks Network' or 'Global Network of National Geoparks', abbreviated 'GGN'. The official logo of the Global Geoparks Network indicates that a national geopark is a member of this global network. Any national geopark can be accepted as a member after being successfully reviewed and receiving a formal approval letter from the GGN Secretariat. The

office of the Global Geoparks Network is located in Beijing, China, in the same building as the Chinese Academy of Geological Sciences.

Global Plate Tectonics Plate tectonics is a means of classifying Earth's geological structures. Global tectonics emphasises that the lithosphere is composed of several relatively hard plates, and the cores of these plates are composed of relatively stable blocks (cratons). Suture zones with unique characteristics form plate boundaries. In 1967, McKenzie categorised these tectonic plates into: I. the Arabian plate; II. the Eurasian Plate; III. the Cocos Plate; IV. the North American Plate; V. the Caribbean Plate; VI. the South American Plate; VII. the Nazca Plate; VIII. the Antarctic Plate; IX. the Pacific Plate; X. the Philippine Sea Plate; XI. the Australian-Indian Plate; and XII. the African Plate. Although academics now have different classifications, the interpretation of the Earth's crust as a whole is the current trend. Plate tectonics is also a method to interpret the development and evolution of different regions from a global perspective.

Global Positioning System; GPS Satellite positioning technology is used to determine the coordinates and elevations of points on the Earth. GPS is a satellite navigation system that was developed by the United States. It can accurately determine the position of a given point and can be used for the navigation of ships, aircraft and cars. GPS is an important technical means for tourist researchers and tourists to obtain their relative position and perform route navigation. China has developed its own global positioning system, called the 'Beidou' positioning system (BeiDou Navigation Satellite System, BDS), which has been used extensively as an alternative to GPS.

Global Warming The average temperatures of the Earth's atmosphere and the ocean have increased in the recent past. In addition to the natural increase in temperatures during the post-glacial period, greenhouse gases generated by the burning of fossil fuels, the destruction of forests and the emission of carbon dioxide are also causes of the changes in temperature. Long-wave radiation has a high degree of absorption and can strongly absorb the infrared rays in ground radiation, resulting in global warming. Global warming will change the global precipitation patterns, accelerate the melting of glaciers and frozen soil, cause sea level rise, and eventually change the balance of natural ecosystems.

Gneiss Gneiss is a deep metamorphic rock with a significant gneissic texture. It generally contains coarse-grained feldspar and quartz (over 50%). The flaky and columnar minerals that make up gneiss are mainly biotite, muscovite, hornblende and pyroxene. Gneiss sometimes contains marker metamorphic minerals such as andalusite, sillimanite, garnet and cordierite. Gneiss is generally named based on the presence of the flaky or columnar minerals plus the feldspar, such as biotite orthoclase gneiss and hornblende plagioclase gneiss. Gneiss can form from igneous rocks, which is known as 'normal gneiss', or from sedimentary rocks or metamorphic rocks, which is known as 'secondary gneiss'. Gneiss can be formed by several processes, and the widely distributed gneiss is a product of regional metamorphism. Contact metamorphism and migmatization can also form gneiss.

Gneissosity Gneissosity is a mode of foliation that occurs in certain metamorphic rocks as a result of the uneven and discontinuous directional alignment of platy or columnar minerals and mineral grains. It is a typical structure of highly metamorphosed rocks.

Gobi Due to strong wind erosion, the fine sand and dust in the original floodplain are removed, and the ground is covered by heavier gravels of various sizes. This landscape is called a 'gravel desert' or gobi. The two main types of gobis are debris stone gobis and gravel gobis. They can be found in the northwestern part of Yumen, the Taklama Basin, Junggar Basin, the edge of the Qaidam Basin, the Hexi Corridor and the western part of Inner Mongolia. The gravels in the Gobi Desert have developed due to the abrasion of sand carried by the wind, which in turn

formed angular aragonite, and the surface is often covered with oily dark brown desert rock paint.

Gobi Landscape This is also known as a 'gravel desert', 'gobi sand beach' and 'gobi desert'. In Mongolian, 'gobi' means a stony desert where vegetation cannot grow. It is a common landform in arid regions. On depositional plains or alluvial fans, the grains of sand on the surface can easily be blown away by strong aeolian erosion, leaving large gravels covering the hard surface and forming a large gravel beach. Only sparse alkali-tolerant grasses and shrubs can survive. In China, gobi can be found in northwestern Inner Mongolia, the margins of the Tarim and Junggar Basins in Xinjiang Province and the Qaidam Basin in Qinghai Province (Fig. 20). (see ▶ Gravel Desert Landscape)

Golden Mountains of Altai, Russia These mountains are located in the border area of the Altai Republic, Siberian Federal District, near the Republic of Khakassia and the Tyva Republic. The park has a core protection area of 16,114 km^2. The Altai Mountains, which are the main mountains in the biogeographic region of Western Siberia, are the sources of such large rivers as the Ob River and Irtysh River. The three independent zones inscribed on the World Heritage List are the buffer zones near the Altaisky Nature Reserve and Lake Teletskoye, the buffer zones surrounding Khara Thun Nature Reserve and Mount Belukha, and the Ukok quiescent area on the Ukok Plateau. The site has the widest vertical vegetation zone in Siberia, including savannah, sylvosteppe, mixed forests, subalpine vegetation and alpine vegetation belts. It is also an important habitat for endangered animals, such as snow leopards.

Goldstone Goldstone is produced at Jishan Mountain in Xingzi County, Jiangxi Province. It gets its name from the pyrite crystals that look like beans and millets and shine with a gold hue like stars in the night sky. Goldstone is a slightly silicified muddy shale from the metamorphic rocks of the Sinian Shuangqiao (Double Bridge) Mountain Group. It has a fine texture and is shiny black. It also has gold stars arranged in the shape of phoenix eyes, gold rings, gold halos, gold flower wavy patterns, fish roe patterns and eyebrow patterns. This inkstone is dark and black like the night sky without a moon and keeps water droplets on the stone. The great scholar Su Dongpo of the Song Dynasty praised this inkstone: 'The stone is as black as lacquer, moist and warm as jade, infused with many gold stars, where the big ones are like beans, able to spread ink in a delicate manner and generates a good sound



Fig. 20 Gobi landscape – Xinjiang Province (after Dong Zhibao)



Fig. 21 Gold stone

when knocked, and it is an excellent grade.' Goldstone is also produced in Fei County in Shandong Province, Wuyuan in Jiangxi Province and Cengong in Guizhou Province (Fig. 21).

Gondwana *Synonym:* ▶ *Gondwanaland*
Gondwana is also known as the southern supercontinent, and it was an ancient supercontinent in the southern hemisphere. It is named after the old kingdom of Gondwana in central India. In the Indian Peninsula, there is a rock unit called the 'Gondwana System', which consists of rocks ranging from 300-million-year-old Carboniferous moraine strata to a 200-million-year-old Jurassic coal system. Similar rock systems and fossils have been found in all of the continents in the southern hemisphere. Based on the similar characteristics and other evidence, this supercontinent was given the name Gondwana. Some scientists have suggested that some parts of this supercontinent are early Palaeozoic or even Mesozoic in age, whereas others insist that it is late Palaeozoic in age. Unique fauna and flora developed on Gondwana, which includes Africa, Madagascar, the Indo-Pakistan subcontinent, Australia, South America and Antarctica. It is generally believed that Gondwana split into many continents after the Palaeozoic Era. Some early geologists postulated that the continent split up due to subsidence in the areas of the Indian Ocean and the South Atlantic Ocean, and this hypothesis led to the assumption of the Gondwana land bridge. Recently, the concept of plate tectonics has indicated that continental drift due to seafloor spreading was the cause of the separation. Laurasia was the supercontinent in the northern hemisphere that was related to Gondwana in the south.

Gondwanaland ▶ Gondwana

Gondwana Rainforests, Australia After its extension in 1994, this site now covers parts of New South Wales and Queensland near the eastern Pacific coast. With a total protection area of 3,700 km^2, the site comprises several protected areas located predominantly along the Great Escarpment.

Gongchangling Iron Deposit in Anshan, Liaoning This is one of the most important iron deposits in China. Located in the Gongchangling District, Liaoyang City, Liaoning Province, the Gongchangling iron deposit covers an area of 38 km^2. Formed by metamorphosed iron sediment from marine volcanoes, it is called an 'Anshan-type iron ore deposit'. The iron-bearing rocks include amphibolite, mica-quartz schist, albite, granodiorite and ferri-quartzite of the Archaean Anshan Group. Low-iron quartzite (iron content of approximately 30%) in bands makes up the majority of the ore. Ancient mining remains are in the area. Local records indicate that melting furnaces were constructed in Gongchangling in the 1200s (Fig. 22).

Goreme National Park and the Rock Sites of Cappadocia, Turkey This national park is located in Nevsehir Province in central Turkey, and it has a core protected area of 95.76 km^2. The Goreme Valley is spectacular and was sculpted by natural wind erosion, and it and the surrounding areas are dotted with refuge



Fig. 22 Gongchangling iron mine

shelters in the rocks. These shelters demonstrate the artistic style of the Byzantine Empire and the post-idol destruction periods. There are also traditional living structures that are from the early fourth century, including simple residences, villages and underground towns.

Gorge Landscape ► Canyon Landscape

Gough and Inaccessible Islands, British Overseas Territory This site is situated in the Tristan da Cunha Islands, a British overseas territory in the South Atlantic Ocean that is far to the southwest of Cape Town, South Africa. After an extension in 2004, its core protection area increased to 79 km^2. The site displays nearly undisturbed island ecology and marine ecosystems in cold temperate zones. The spectacular cliffs on Gough Island and Inaccessible Island stand tall above the sea, protecting the area from the invasion of exotic species, which has enabled it to become one of largest seabird colonies in the world. Gough Island is the habitat for two endemic land birds, gough moorhens and rovia, and 12 endemic plants. Inaccessible Island boasts 2 types of endemic birds, 8 types of endemic plants and at least 10 endemic invertebrates.

Graben A graben is a down-dropped block between two parallel steep normal faults that dip towards each other and formed from extensional movement. Medium-large grabens are not bounded by a single normal fault but by several normal faults with similar bed attitudes in the form of step faults. The two sides of a graben may not develop in the same manner. Grabens are structural geologic features. Fault basins and rift landforms are usually composed of young medium-large grabens. Examples are the Rhine Graben in Europe and the Fenwei Graben in China, which are in the form of long narrow valleys or elongated basins or lakes.

Grand Canyon National Park, U.S.A This famous national park is located in northwestern Arizona near Nevada. It has a core protection area of 4,930 km^2. The national park was carved by the Colorado River to form the

world's largest canyon, called the Grand Canyon, which is 1,500 m deep. Its horizontal strata record the past two billion years of geological history. There are also the remains of prehistoric human adaptation to a particularly harsh environment.

Granite Granite is a widely distributed acidic plutonic rock with a SiO_2 content greater than 66%. Granite is often greyish white or pale red and is mainly composed of quartz, K-feldspar, plagioclase and small amounts of biotite, hornblende or pyroxene. The amount of quartz is approximately 30% and may reach 60%. Dark minerals account for approximately 5%, whereas the K-feldspar content always exceeds the plagioclase content. The total feldspar content ranges from 10% to 65%. Granite is hard and resistant, and it generally forms large mountains. Granite contains well developed joints, and after weathering, several types of distinct features can be formed, which can become tourism resources of high aesthetic value. Granite is widely distributed in China. The Taishan, Huangshan, Tianzhushan, Sanqingshan and Tailaoshan Geoparks all have granite landscapes. The scenic areas of Badaling Ridge, Panshan, Qianshan in Anshan, Fenghuangshan in Dandong, Putuoshan, Gushan, Laoshan, Jigong, Hengshan, the Sky and Sea End in Hainan Province, Gulangyu, Qingyuanshan, Luofushan Mountain, Jinggangshaan and Huashan all contain granite as the landscape theme. Mount Kumgang (Geumgangsan) in North Korea and Yosemite National Park in the United States are also composed of granite.

Granite Bullion This is a granite landscape with rounded shapes like eggs. It is a product of spherical weathering of granite, especially at locations with columnar joints and conjugate joint sets, and they usually form on the weathered surface above the weathered granite crust. When a well-jointed granite body erodes and falls from a granite peak, wall or pillar, the original angular rock experiences physical and chemical weathering, which causes the rock surface layers to peel off and rounds the rock surface until irregular spheroids remain, which are called granite bullions. Granite bullions are smooth and easy to roll, and they will easily scatter on the ground when the landform is flat, subsequently look like residual stone eggs on the planation surface. In mountainous areas, these bullions tend to roll downhills and pile up in the foothills and valleys (Fig. 23).

Granite Canyon This is a valley in a granite area with steep slopes, where the depth of the valley



Fig. 23 Granite bullion landscape in Tianzhushan, Anwei

is greater than the width. They generally develop along tectonic faults in locations of intense uplift. Granite canyons form easily when the rate of uplift is similar to the rate of water erosion. For example, due to uplift associated with neotectonic movements, the Huangshan granite body has reached an elevation of more than 1,800 m. Coupled with the development of faults and strong erosion from abundant rainfall, a group of deep canyons that radiate from the centre of the rock body into the surrounding areas has formed. The Xihai Grand Canyon formed as a result of erosion by water along a NE-SW-trending fault line (Fig. 24).

Granite Cone A granite cone is a product of spherical weathering. It looks like a spike on a small moulding stone, with the sharp end pointing upwards, similar to the pointed top of a smooth granite peak or a granite pillar. It can also look like a cell phone antenna, the legs of an overturned table or a rhinoceros horn. Spherical weathering begins with granite being washed by rain water, followed by rock disintegration and erosion. It can also take place in localised areas with quartz enrichment or by weathering of granite dykes with high concentrations of siliceous materials. Examples are Mobile Phone Rock and Swan Peak in Huangshan and Double Teats Peak and Penguin Rock in Sanqingshan (Fig. 25).

Granite Dyke Wall This is a granite landscape with a wall-like appearance that looks like the screen-like peak but with a greater lateral extent. It forms as a result of rock collapse after weathering along a set of vertical joints. It forms an isolated stone wall, but several parallel stone walls typically extend in the same direction, are upright, and have smooth surfaces. The walls are nearly parallel, and the upper and lower walls have the same thickness, forming a Great Wall-like shape (Fig. 26).

Granite Lattice Some parts of thin granite dyke walls will shatter due to the development of cracks and then form holes as a result of long-term weathering. In contrast, honeycomb



Fig. 24 V-shaped granite canyon landscape in Huangshan



Fig. 25 Granite cone in Huangshan

caves in arid areas form on windward granite slopes. In addition, honeycomb caves subject to further wind erosion will continue to be abraded and form holes; this is also called a granite lattice (Fig. 27).

Granite Mortar The undulating granite hilltop of Daqingshan in Hexigten Banner, Inner Mongolia, contains hundreds of circular, oval, and irregularly shaped caves with large openings and great depths that are shaped like a mortar, a cylinder, a bowl or a dish. Unlike the potholes carved by flowing water along rivers in southern China, there is no indication of water flowing into the cave. They have two main formation mechanisms: congelifraction or wind erosion, but both may occur (Fig. 28).

Granite Moulding Stone This is a granite landscape with a unique shape. Through various geological processes, granite can be carved into shapes that look like a person, an object, an animal or a manufactured product. They can



Fig. 26 Granite dyke wall in Beihai, Huangshan



Fig. 27 Granite lattice in Alxa Right Banner, Inner Mongolia



Fig. 28 Granite mortars in Hexigten Global Geopark, Inner Mongolia

be given an elegant label, an image, or a name, shown to tourists, or become the objects of photographers and painters. Granite moulding stones are an important tourism resource. Tourists do not easily recognise them if they are not labelled with a sign at the scenic site. The quantity of granite moulding stones will tend to as the visitors' ability to appreciate them increases and their imagination grows. The 'Goddess of the Orient' and 'Giant Python Crawling Out of the Mountain' in Sanqingshan, Jiangxi, and the 'Blossoming Brush in Dream', 'Monkey Watching the Sea' and 'Fairies Drying Their Boots' in Huangshan, Anhui Province, are famous examples of granite moulding stones (Fig. 29).

Granite Mushroom In arid areas with strong wind erosion, granite columns protruding from the Earth's surface are abraded by sand grains carried by the wind. This process forms mushroom-shaped rock pillars with slender lower bases, which are known as granite mushrooms. Typical granite mushrooms are common in Haisenchulu in Alxa Right Banner,

Inner Mongolia, and the 'Odd Rock Groove' in Bole, Xinjiang Province (Fig. 30).

Granite Pillar This is a residual columnar structure carved by weathering along vertical joints in granite. Particularly when a granite dyke wall has vertical longitudinal cracks, granite pillars can develop into rows, usually with heights of 10–30 m. Examples are the 'Blossoming Brush in Dream' and 'Fairies Playing Chess' in Huangshan. Granite pillars generally form in periglacial environments in mountains at elevations greater than 1,100 m and in cold areas at high latitudes. At Asihatu in Hexigten Banner, Inner Mongolia, groups of granite pillars are located on flat granite ridges. They formed mainly due to the combined effects of congelifraction, wind erosion and wind abrasion. Marine erosion of granite in coastal areas also forms granite pillars, such as the 'Ban Yang Stone Sail' in Pingtan, Fujian Province (Fig. 31).



Fig. 29 Granite moulding stone in Sanqingshan, Jiangxi – the 'Giant Python Moving Out of the Mountain'

Granite Ridge This is a strip-like ridge of granite with a relatively flat top. Some are slightly inclined, some are undulating, and some are serrated. Unlike granite dyke walls, which are vertical, the slopes of granite ridges are steep.

Granite Shed A granite shed is also known as a stacked stone cave. It is mainly composed of numerous granite blocks piled up haphazardly in a valley. Space remains between the granite blocks, forming caves that can sometimes extend for large distances to form underground passages. Examples include the Granite Block Cave at Tianzhushan (Heaven Pillar) in Anhui



Fig. 30 Granite mushroom in Alxa Right Banner, Inner Mongolia



Fig. 31 Granite pillar of Taimu Mountain, Fuding in Fujian Province

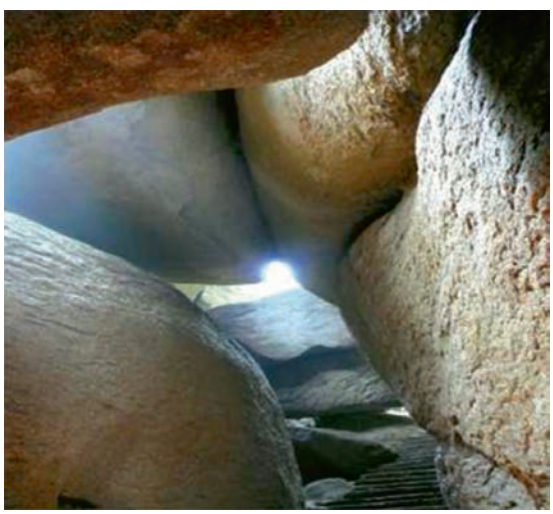


Fig. 32 Granite shed in Tianzhushan, Anwei

Province, the Wanren (Ten Thousand People) Cave and Pingyang Cave in Chayashan, Henan Province, and the Qixing (Seven Star) Cave at Tailaoshan in Fujian Province (Fig. 32).

Granitic Gneiss The composition of granitic gneiss is similar to that of granitic rocks. It is a deep metamorphic rock with a typical gneiss structure. It has many petrological characteristics of gneiss, and there are three genetic types: (1) gneiss that is formed by regional metamorphism; (2) gneiss that is formed by migmatization; and (3) gneiss that is formed by the tectonic stresses from an orogeny. Therefore, studying the origin of granitic gneiss is a key to revealing the tectonic environment and geological evolution process.

Granitization Granitization is the process in which a pre-existing non-granitic rock transforms into granite through migmatization (anatexic migmatization or metasomatic migmatization), which implies that the granite is not the primary magmatic rock but a secondary rock. Granitization is a very common geological process.

Granitoid Landscape This is a geomorphological landscape with tourism value that is composed of granitoid rocks. Granitoid rocks are intrusive igneous rocks composed mainly of quartz, feldspar, mica and a small amount of dark minerals such as hornblende. The main rock types are quartz-rich granite, alkali feldspar granite, granite, monzonitic granite, granodiorite and quartz monzonite. These rocks are distributed throughout China and in all orogenic belts and have ages ranging from Archaean to Cenozoic. China has almost all of the world's identified rock types. China has a great variety of geological formations and climatic belts, which has resulted in highly diverse granite landscapes with higher aesthetic qualities than those in other countries. China has the most abundant granite landscape scenic sites (including World Natural Heritage Sites, Global Geoparks, National Geological Parks, national scenic areas and national tourist areas) in the world. China has been estimated to have more than 10,000 granitoid rock bodies, which have created ample granite landscape, and there is great potential for a substantial future development (Fig. 33).

Granulite Granulite is a regional, deep metamorphic rock characterised by abundant hypersthene. It is composed of anhydrous



Fig. 33 Lianhua (Lotus) Peak, Huangshan

minerals, such as hypersthene, diopside and garnet, and other light-coloured minerals, such as plagioclase, perthite, antiperthite, quartz and sillimanite. Granulite has a medium-fine granoblastic texture and an invisible gneissose structure (or blocky structure). Based on the mineral composition, some people further categorise granulite as acidic granulite and basic granulite.

Grape Agate Grape agate is a precious type of Gobi stone. It gets this name because the agate is covered with bead-shaped spheres shaped like a bunch of grapes. Grape agate is mainly found in the area near the Chinese-Mongolian border north of Suhongtu in Alxa League, Inner Mongolia. Grape agate, wind stone and desert paint stone are known as the 'Desert's Three Superiors'. Grape agate forms as a result of magmatic activity and exists in large crystal cavities near a crater. In a relatively stable environment, hot silica solution condenses into small beads around a particle (e.g., sand, mud or water droplet). This process repeats, and subsequently small beads attach to the earlier bead surface to form features like a bunch of grapes. Grape agate is characterised by: (1) round and moist beads; (2) bright striking colour; (3) excellent texture; and (4) remarkable aesthetics. Red grape agate is the most popular and valuable type (Fig. 34).



Fig. 34 Agate in grape form

Grassland *Synonym:* ▶ *Steppe*

Grasslands are temperate continental zonal vegetation in cold, semi-arid climates that consist of perennial grasses, xeric grasses and



Fig. 35 Grassland ecological landscape

certain bush vegetation. China's grasslands can be divided into four types: meadow grasslands, typical grasslands, desert grasslands, and alpine grasslands. They are mainly located in the western part of Inner Mongolia, the northwestern desert areas and the Qinghai-Tibet Plateau. The grasslands around the world are divided into Eurasian, North American and South American grassland areas.

Grassland Ecological Landscape This is a type of ecological landscape that mainly includes tropical grassland (savanna) and temperate grassland. The grassland landscape structure is simple, the seasonal effects are remarkable, the plant distribution is uniform, and the plant layers are not obvious. The plant types mainly include tussock grass xerophytes with narrow leaves, such as Cleistogees, stipas and Achnatherum, Asteraceae, Fabaceae, Cyperaceae and some rhizomatous grasses. There are few large plants. The grassland animals include herbivorous mammals (including bisons, Connochaetes, antelopes, rhinoceros, elephants, cows, sheep, camels, horses, donkeys and goats) and carnivores, including a variety of canines (wolves), Felidae (lions and cheetahs), hyenas and mongoose (Fig. 35).

Grass Soil ▶ Alpine Meadow Soil

Gravel Gravel is a collection of rock or mineral fragments with a particle size larger than 2 mm that have been transported by water and mixed. Based on the average grain size, gravels can be divided into boulders, coarse gravel and fine gravel. After transportation, gravels are deposited in foothill or piedmont areas and then consolidate into conglomerate or breccia (Fig. 36).

Gravel Desert Landscape *Synonym:* ▶ *Gobi landscape*

Gravity Geological Action in Landscape Formation The Earth's surface is affected by gravity, which helps to form various types of landforms, including gravity sliding and extension. Due to the force of gravity, weathered and crushed rocks on the slopes of mountains, valleys and coasts can be displaced and moved, forming gravitational collapses,

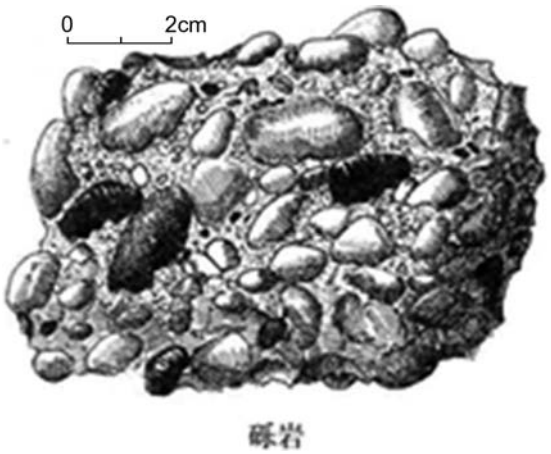


Fig. 36 Conglomerate

landslides, rock fill, colluvium, debris flows and other landscapes.

Great Barrier Reef, Australia The Great Barrier Reef is located in the Pacific along the eastern coastline of Queensland State, northeastern Australia. It has the world's largest collection of coral reefs and includes 400 types of coral, 1,500 species of fish and 4,000 types of molluscs. It is also the habitat for species such as dugong (sea cow) and the large green turtle, which are threatened with extinction. The Great Barrier Reef Reserve is the world's largest natural heritage site and a paradise for marine ecotourism.

Great Smoky Mountains National Park, U.S.A. This park is located along the border between southeastern Tennessee and western North Carolina. With a core protection of more than 2,090 km^2, and this exceptionally beautiful park is home to more than 3,500 plant species, including almost as many trees (130 natural species) as in all of Europe. Many endangered animal species are also found there, probably including the greatest variety of salamanders in the world.

Great Wall The Great Wall is a collective name that refers to a series of military fortifications built during different periods in the central plains of ancient China to resist the invasion of the nomadic tribes from the north. During the Spring and Autumn Period and the subsequent Warring States Period, all states constructed fortifications to protect themselves and linked these fortifications with walls, which became the earliest form of the Great Wall. These works were subsequently enhanced over various dynasties. The Great Wall stretches from the Yalu River in the east to Jiayuguan in the west with a total length of 8,849 km, of which the artificial wall makes up 6,259 km, and the trenches and natural walls make up 2,592 km. Its average height is 6–7 m, and its width is 4–5 m. As a magnificent project, the Great Wall is a symbol of achievement resulted from the hard work of people in the past in applying their knowledge of geological, geomorphological and geographical conditions. It is a valuable legacy of the Chinese nation, and it was designated a World Cultural Heritage Site by UNESCO in 1987. It has long been a famous tourist attraction in China (Fig. 37).

Great Wall Dislocation Relics These are faults that have been formed due to earthquakes that took place near the Great Wall. According to seismic investigations, the 1739 magnitude 8 Pingluo-Yinchuan Earthquake caused seismic displacement on faults that damaged two sections of the Ming Dynasty's Great Wall in Hong Guozhi Gou. The largest vertical displacement on the cracks in the wall was 1.5 m, and the dextral horizontal displacement was 1.45 m. In the mid-1980s, seismic geologists in China investigated the active faults and discovered that they were a branch of an active fault zone in the eastern foothills of the Helan Mountains. There are many other ruins along this fault zone associated with historical and prehistoric earthquakes. Dislocation features associated with the Great Wall were also found in Huangyaguan in Jixian County, Tianjin City. However, these relics were damaged by the repairs performed by the management groups to connect the broken sections of the Great Wall.

Greater Blue Mountains Area, Australia This site is located in eastern New South Wales, Australia. The core protection area covers 10,326.49 km^2 and includes sandstone plateaus, steep slopes, and canyon landforms.



Fig. 37 Great Wall Badaling section

Nearly the entire area contains temperate eucalyptus forests. The eight protected areas covered by the site strongly reflect the unique evolution and species variation of the eucalyptus forest after the separation of the continent from Gondwana. The area contains 91 species of eucalyptus.

Green GDP This is the actual result of economic activities after taking into account the costs of natural and environmental resources such as land, forest, mineral, water, ocean and environmental factors, including ecological, natural and human environments. These costs are deducted from the current GDP, and the result is called the green GDP, which essentially represents the net positive effect of national economic growth.

Green National Account The United Nations and the World Bank have tried to establish a new national accounts system that fully considers environmental issues, which is called the 'Green National Account'. The purpose is to improve the traditional national accounts system, which only considers the gross national product, national production net worth, national income, personal income, and personal disposable income regardless of their impacts on the environment and consumption and therefore their economic impacts.

Greenhouse Effect Solar energy can reach the ground through shortwave solar radiation, but the longwave heat radiation emitted from the surface is absorbed by the atmosphere. This increases the temperature of the surface and the lower atmosphere because it functions like a greenhouse. The excessive carbon dioxide emitted from fossil fuels such as coal and petroleum absorbs heat and prevents it from being released into the outer atmosphere. It is therefore considered a cause of the greenhouse effect.

Greenhouse Gas; GHG In the atmosphere, gasses such as water vapor, carbon dioxide, nitrous oxide, methane, ozone and most refrigerants can absorb solar radiant heat energy reflected by the ground. The greenhouse effect has been more significant in recent history than in the past. The increase in greenhouse gases has exacerbated the greenhouse effect and is a cause of global warming. The UN-initiated 'Kyoto Protocol' recommends measures to reduce greenhouse gas emissions.

Greenish Blue Jade This is a nephrite with a greenish blue colour. The colour hues range



Fig. 38 Greenish blue jade craft

from light cyan-blue, deep cyan-blue, green, greyish green, dark greyish green to emerald green. Tremolite accounts for 93% to 99% of its composition. Of all the soft jade, greenish blue jade is the most abundant type (Fig. 38).

Greenschist Greenschist is a green flaky metamorphic rock produced by the regional metamorphism of basic volcanic rocks. It is mainly composed of green minerals, such as chlorite, epidote, actinolite, and zoisite, as well as plagioclase, quartz, sericite and calcite. It typically has a lepidoblastic texture or a fibroblastic texture of schist. Its nomenclature is based on the main green minerals it contains, such as chlorite schist, epidote schist, and actinolite schist.

Greenway Broadly speaking, a greenway is a linear corridor that connects natural open space. It consists of natural corridors that stretch along rivers, valleys and ridgelines or linear open space along artificial corridors, such as abandoned railway lines, ditches, and scenic roads, used for recreational activities, including natural and artificial landscape routes for cyclists and people. It is an open space that connects parks, nature reserves, famous areas, historical sites, and other places with the densely populated areas.

Grey Desert Soil Grey desert soil develops from loess-like parent material, mainly under desert vegetation in temperate arid zones. The soil is characterised by thin gravel-bearing layers. It has a well-formed crust, irregular cracks on the surface, a high lime content, surface aggregation and salt accumulation. It is common in Xinjiang in Western China. Smaller areas are also found in the northwest corner of the Yinchuan Plain in Ningxia, the Hetao Plain in Inner Mongolia, and west of the Hexi Corridor in Gansu.

Grey-Brown Desert Soil This type of soil develops under the shrub desert vegetation in temperate arid regions. The parent materials have a coarse matrix with a gravel layer and a pore-like crust on the surface. The soil contains lime-coated aggregates and gypsum accumulations, particularly in extremely dry areas. It is classified as between the grey desert soil and brown desert soil, and it is mainly located in the Junggar Basin and Hexi Corridor.

Greywacke Greywacke is also known as mixed sandstone or grey sandstone. It includes a variety of sandstones characterised by their hardness and dark colour. Greywacke forms due to diagenesis and primary metamorphism of angular lithic fragments and quartz and feldspar grains. It always contains some clay matrix materials (approximately 15–40%), which are metamorphosed into illite, chlorite and sericite. Greywacke is rich in Al_2O_3, FeO, MgO, and Na_2O. Greywacke has poor grain sorting and low roundness. It also contains sedimentary structures, such as channel moulds and graded bedding. Greywacke can be divided into lithic greywacke and feldspathic quartz sandstone. In the geological record, greywacke is widespread in older rock strata and is mainly related to marine facies. It is a product of orogenic belts, and it is usually present in stable craton areas. Abundant greywackes can be found in the Cenozoic

continental strata in China. They are rich in volcanic clasts that were mainly produced in the Meso-Cenozoic continental rift lake basins.

Gros Morne National Park, Canada This park is located on the western coast of Newfoundland in eastern Canada, and it has a core protection area of 1,805 km^2. It provides a rare example of the process of continental drift, and rocks of the deep oceanic crust and the mantle are exposed. Recent glacial action has resulted in spectacular scenery, including coastal lowlands, alpine plateaus, fjords, glacial valleys, sheer cliffs, waterfalls and many pristine lakes.

Grotto A grotto is a stone chamber with Buddha statues carved into a mountain wall. This type of Buddhism architecture originated in India and was imitated in China's earliest grotto designs. China's grottoes were built in the Yellow River Basin. The peak period of grotto construction was from the Northern Wei Dynasty to the Sui and Tang Dynasties. The Dunhuang Mogao Grotto and Tianshui Maijishan Grotto in Gansu Province, Datong Yungang Grotto in Shanxi Province and Luoyang Longmen Grotto in Henan Province have been appraised as China's four main grottoes. China's grottoes share similar geological characteristics with those in other countries: (1) All grottoes were carved in rocks with hardnesses below 5 on the Mohs scale. (2) All grottoes are located on isolated mounds. (3) The grotto niches are generally not more than 200 m above the local ground level. (4) Grottoes are generally built on steep cliff walls facing a river.

Ground Crack Landscape; Ground Fissure Landscape Ground fissure landscape is a general term for all types of ground cracks, including cracks of considerable length and width induced by natural processes (e.g., earth movement, hydraulic action) or by artificial causes. The formation of ground cracks is sometimes related to seismic activity, or the crack may be a precursor of an earthquake. Cracks may be a residual deformation feature after an earthquake; these are called seismic cracks. When cracks form in areas of human activities, they can become a geological disaster. For example, due to the excessive extraction of groundwater, a group of cracks formed in Xi'an across an area of approximately 155 km^2 (Figs. 39 and 40).

Groundmass ► Matrix

Groundwater Tourism Landscape This is a landscape resource system with tourism value that is based on groundwater. Groundwater is



Fig. 39 Earthquake avalanche relics landscape



Fig. 40 Ground crack landscape

the water stored in the rocks of the Earth's crust in various forms. Groundwater takes part in the water cycle under the effects of solar radiation, gravity, geothermal energy and tectonics, and in this cycle, the water can form many spectacular landforms, such as various types of springs, subterranean streams inside karst caves, mud volcanoes and calcareous tufa landscapes.

Gu Ban Gu Ban (32–92 AD), also known as Jian Meng, was a historian, geographer and writer during the Han dynasty. He loved reading and field trips. He travelled with the emperor to more than half of the country. His historical masterpiece, the 'Book of Han', was the first annals-biography format about the history of a single dynasty. The 'Treatise on Geography' was the first geography book to use the term geography in Chinese history and the first memoir of its kind to describe the geography of different Chinese territories. Other treatises, such as the 'Treatise on Food and Money' and 'Treatise on Rivers and Canals', contributed greatly to research on economic geography, and the 'Treatise on Astronomy', 'Treatise on Rhythm and Calendar' and 'Treatise on Five Elements' are important for research in history and physical geography. The 'Biography on Western Regions' and 'Biography on Huns' are valuable documents for studying the history and geography of the ancient Chinese frontiers.

Guangde Taijidong Geopark, Anhui This geopark is located in Guangde County (a trans-provincial area of Anhui, Zhejiang and Jiangsu) in Xuancheng City, Anhui Province. The geopark has a total area of 39 km^2, and its main geological features cover an area of 17 km^2. It was designated as a national geopark by the Ministry of Land and Resources in December 2011. The geopark features typical karst landforms. It is a medium-sized geopark with interesting karst caves, dry valleys, tiankengs (sinkholes), springs, karst depressions, collapsed funnels, underground rivers and karst lakes with high scientific and aesthetic value. The complete karst landforms, hydrogeologic features, cave systems and underground water systems have been fully preserved. The concentrated geological heritage landscapes, unique and diverse shapes, magnificent landscapes, karst caves, fault valleys, depressions, lakes and mountains are well-known. The geopark is a natural museum of the typical karst landscapes of eastern China and is worth visiting.

Guangwushan-Nuoshuihe National Geopark, Sichuan This geopark is located in Nanjiang County and Tongjiang County, Bazhong City, Sichuan Province. It has an area of 362 km^2, and it became a geopark in 2009. Its main geological features are karst landforms, gorges, and mountain and water landscapes. The gorges in the geopark are composed of limestone and granite. The longest is more than 10 km long, while the shortest ones are 3–5 km long. The park also has marvellous water features, such as rapids, waterfalls and plunge pools. Deep streams are common and are mostly found in the granite area.

Guanling Biota Fossils of this biota come from the Late Triassic rocks in Xin Pu, Guanling

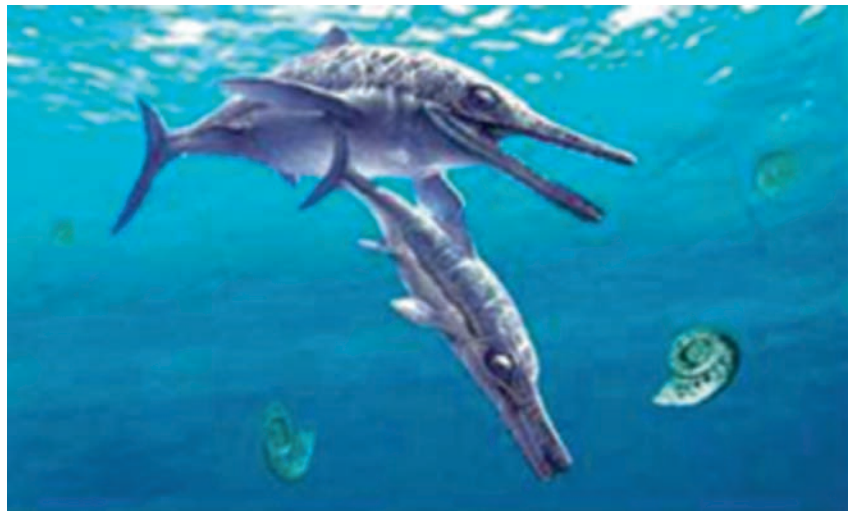


Fig. 41 Guanling biota

County, Guizhou Province. This biota was made up of several phyla of vertebrates and invertebrates, including marine reptiles, such as Ichthyosaurus, Nothosaurus, Thalattosaurus and Phytosaurus, and associated fossils, such as crinoids, ichthyolites, ammonites, bivalves and eophytes. This biota is rich in well-preserved fossils, and it is significant for research in palaeontology, stratigraphy, palaeogeography, palaeoecology and taphonomy. These fossils also have elegant forms and hence high ornamental value (Fig. 41).

Guanling Fossils National Geopark, Guizhou This geopark is located in Guanling County, Guizhou Province, and became a national geopark in 2004. The ancient creatures in the geopark lived in the Triassic waters 200 million years ago. They mainly include ichthyosaurs, sea otters or syngnathus schlegeli, plesiosaurs, aegis and other marine reptiles. There are also a variety of sea lilies and ammonites, bivalves, conodonts, nautilus, brachiopods, and ancient plant fossils. The large number and variety of marine reptile fossils and sea lily fossils are very well preserved and rare, which makes this area one of the most important fossil sites in Guizhou.

Guanshan National Geopark, Henan This geopark is located at the southern end of the Taihang Mountains and borders Jincheng in Shanxi to the northeast. It became a national geopark in 2005. The geopark covers an area of 52 km^2 and includes geological relics and tectonic landforms, such as cliffs, gorges, valleys in Proterozoic quartz sandstone, peak clusters and peak forests on Palaeozoic carbonate rocks and three-stage terraces. The geopark has five scenic districts: Baoquan, Guanshan, Baligou, Huilong, and Wanxianshan.

Guide National Geopark, Qinghai This geopark is located in Guide County, Qinghai Province, Hainan Tibetan Autonomous Prefecture. It became a national geopark in 2009. The main geological features include sandstone peak clusters, Yellow River valley landscapes and wind-erosion landforms. The Ashigong peak clusters are composed of Palaogene and Neogene coloured gravel strata. The Mawuxia Wind-eroded Habitat is spectacular and has several forms. The Yellow River in the Guide region is a braided river system that forms multi-level terraces, diaras, marginal banks, and inverted rivers. The Heerjia section is a typical Pliocene - Pleistocene section with a thickness of 193 m, which contains a continuous set of river and lake deposits. Longyang Gorge is the largest, longest and deepest gorge along the Yellow River.

Guiping National Geopark, Guangxi Guiping National Geopark is located in Guiping City in the Guangxi Zhuang Autonomous Region. It became a national geopark in 2009. The main geological attractions include Danxia

and granite landforms, sandstone peaks and gorges. The collapsing and superimposed granite landforms in the Xishan area have many peculiar shapes. A danxia landscape is developed in the Baishishan scenic area and is one of the typical Danxia landforms in southern China. The strata in Dateng Gorge and Longtan Park are composed of Cambrian and Devonian sandstones with fluvial landforms, sandstone peaks and clusters, pinnacles and gorges.

This geopark is located in Guiping City in the Guangxi Zhuang Autonomous Region. It became a national geopark in 2009. The main geological attractions include Danxia and granite landforms, sandstone peaks and gorges. The superimposed collapse granite landforms in the Xishan area have many peculiar shapes. The Danxia landform is located in the Baishishan scenic area and is a typical Danxia landform of southern China. The strata in Dateng Gorge and Longtan Park mainly comprise Cambrian and Devonian sandstones and have been eroded into fluvial landforms, sandstone peaks and clusters, pinnacles and gorges.

Guizhousaurus The renowned Guizhousaurus fossil fauna was found in Luyin Village of Ding Xiao Town in Xingyi City, Guizhou Province. Xingyi City is known as 'the Land of Dragons' because Guizhousaurus fossils are widespread, and new species have been found. Guizhousaurus are marine reptiles of the Sauropterygia order, Pachypleurosauridae genera. Their bones are black and three-dimensional. The longest Guizhousaurus fossil is 1.55 m long, while the smallest is only a few centimetres long. They all have clear skeletons and hence look alive. Amazingly, larvae were also found inside their bodies, which provide strong evidence that Guizhousaurus were viviparous.

Gulangyu Islet Landscape Gulangyu Islet was previously known as 'Yuanshazhou' (Round Sand Bar) or 'Yuanzhouzai' (Small Round Bar). It is a small island that was formed due to marine erosion of granite. It was given this name because of the sea cave in its southwestern corner, which makes a sound like a drum when impacted by waves. It faces Xiamen City across the 600-m-wide Lujiang River, which takes only 5 min to cross by ferry. It has an area of 1.87 km^2 and a population of approximately 20,000. It is under the jurisdiction of the Xiamen Municipal District. This island has a pleasant climate like spring for the entire year. It is quiet with no vehicles on the island, so it is also called the 'Sea Garden'. The main tourist attractions are Riguang (Sunshine) Rock (a spherical weathered granite rock), Shuzhuang Garden, Haoyue (Bright Moon) Garden, Yu Garden, Circuit Island Road, Gulang (Drum Wave) Rock, museums, the Zheng Chenggong Memorial Hall, Marine World and natural beaches. It is a melting pot for the historical, cultural and natural landscape aspects and is a Chinese National Scenic Area, ranking first in Fujian's 'Top Ten Sceneries'. It is also one of the 35 most famous scenic spots in China (Fig. 42).

Gulf of Porto: Calanche of Piana, Gulf of Girolata, Scandola Reserve, Corsica Island, France This nature reserve is located on the northeastern corner of Corsica Island (France) in the Mediterranean and has an area of 118 km^2. As part of the Regional Natural Park of Corsica, it occupies the Scandola Peninsula, which is an impressive, porphyritic rock mass. The vegetation is an outstanding example of scrubland.

Gunung Mulu National Park, Malaysia This national park is located on the border between Brunei, Kalimantan and northern Sarawak in Malaysia. The core protection area covers 528.64 km^2. Mulu Mountain, which is known for its biodiversity and karst landscape, is a classic example of karst geomorphology in tropical regions. The park includes 17 plantations and more than 3,500 vascular plants. Palm species are unusually rich, with as many as 20 genera and 109 species recorded. At 2,377 m above sea level, the needle-like sandstone peaks of Mount Muroo overlook the park. The cave system that has been explored and developed underground is at least 295 km long and is home to millions of swiftlets and bats. The Sarawak Cave, which is 600 m long,



Fig. 42 Landscape of seashore landforms in Gulangyu

415 m wide, and 80 m long, is the largest known cave in the world.

Guotai Yan Guotai Yan (1953–) earned a doctorate degree in engineering. He is a professor and doctoral tutor in the Landscape Department, School of Architecture and Urban Planning at Tongji University. He is also the director of the Resources and Tourism Spatial Planning Research Centre at the School of Urban Planning and Design, Shanghai Tongji University. He has presided over several scenic site planning, geopark planning and urban planning projects. He is the author of 'Theories and Methods of Tourism Planning' and 'Landscape Resources Science'.

Gupushan-Type Marble Stone Forest Landscape in Hezhou, Guangxi This is a representative type of carbonaceous stone forest landscape composed of Devonian limestone. The Gupushan marble stone forest in Hezhou is a typical example. This landform developed along the contact between Middle and Upper Devonian carbonate strata and granite. It is a skarn-type tin sulphide deposit. The development of vertical joints caused the formation of a large area of dense corrosion trenches, stone pillars and dolines. An iron cap and a weathered laterite layer are interbedded in the strata, forming a layer of secondary placer tin ore that has been mined since the Song Dynasty. As a result of the excavations, vertical and horizontal marble pillars have been exposed. The columns are 10–20 m high, and the highest reaches 30 m. The columns are mainly in conical, columnar, or form sharp peaks. The column surfaces are smooth and rarely have traces of rainwater erosion, but with the characteristics of subsurface karst corrosion. This stone forest is thought to have formed by sulphuric acid dissolution (Fig. 43).

Gurbantunggut Desert Landscape This landscape is located in the central Junggar Basin, east of the Manas River and south of the Ulungur River in Xinjiang Province. It covers an area of 48,000 km^2 and is China's second largest desert. The main features are semi-fixed dunes. The sand ridges in the desert run NW-SE and can be as high as 30–40 m (Fig. 44).

Guzhang Red Stone Forest National Geopark, Hunan This geopark is located in northwestern Guzhang County, Hunan Province. It became a national geopark in 2005. The main attractions are stone forests, gorges, caves, lakes and waterfalls that were formed in the Ordovician red carbonate rocks. The geopark has several scenic districts, namely, the Red Stone Forest karst landscape, Zuolong Stream Valley, and the Qifeng Lake Youshui River water landscape.



Fig. 43 Gupushan-type marble stone forest landscape in Hezhou, Guangxi Province



Fig. 44 Gurbantunggut Desert landscape (after Dong Zhibao)

Gypsum Gypsum mainly contains $CaSO_4.H_2O$ and is a sulphate mineral. It belongs to the monoclinic crystal system, and crystal twinning is common. It also appears in granular form (alabaster) and fibrous form (fibrous gypsum). Rosette gypsum blocks are called 'Desert Rose', whereas radial gypsum blocks are called 'Daisy Gypsum'. It has a wide range of colours from colourless to white, grey, light green, pale yellow, light brown and pale red. It has flaky fractures, transparent to opaque diaphaneity, a vitreous or silky lustre in fibrous gypsum, and a pearly lustre on cleavage surfaces. It exists in the form of evaporite in hot spring areas and in clay layers. It is used for construction, making models and paper, and in the pharmaceutical sector.

H

Ha Long Bay, Vietnam This area is located in Quảng Ninh Province, Vietnam, and is a small bay in the northwestern Gulf of Tonkin. Since its extension in 2000, its core protection area now covers 1,500 km^2. The area has approximately 1,600 islands of different sizes, which form a spectacular karst stone pillar ocean landscape. Because they all have steep slopes, most of the islands in the protected area have not been influenced by human factors, such as settlements.

Hadean Eon The 2018 edition of the International Chronostratigraphic Chart defines the bottom boundary of the Archean Eon as 4 billion years ago and assigns the period from 4.6 to 4 billion years ago as the Hadean Eon or Priscoan Eon (informal nomenclature). Because the rocks collected from the moon have been dated to this period of time, the Hadean Eon is also called the Moon Eon.

Haikou Mount Shishan Volcano Cluster National Geopark, Hainan This geopark is located 15 km southwest of Haikou City between Shishan and Yongxing Towns. It became a global geopark in 2004. The entire area is a typical volcanic rift graben. The geopark is home to one of the few Holocene volcanoes in China (10,000 years old). The area includes 40 volcanoes and more than 30 lava tunnels. The largest, Ma'anling Crater, is a dormant volcano with a height of 222 m above sea level and a 90-m-deep eruptive vent. There are various tropical plants and attractive scenery.

Hailuogou Modern Glacier Landscape This landscape consists of the Hailuogou Glacier in Luding County, Ganzi Prefecture, Sichuan Province. It is a typical marine glacier. It is at the lowest elevation of the glaciers at similar latitudes in China. Its lowest point is 2,850 m above sea level, and it is the only surviving low elevation glacier in the world. This glacier is 14.7 km long, and its tongue extends 6 km into the virgin forest. As a result of the glacier's movement, many glacial features have been created, such as glacial mushroom rocks, glacial terraces, glacial grooves, glacial arches, glacial pearl lakes, glacial crystal palaces, and other ice features in the form of a human or a beast. The Hailuogou glacier contains a large icefall that is more than 1,000 m wide and has a drop of 1,080 m. It starts from Gongga Mountain at an elevation of 7,556 m. Gongga Mountain is mainly composed of granite, and the bedrock is exposed with many glacial erosional features, such as horn peaks, aretes and cirques. There are 159 modern glaciers on its piedmont. Famous examples are the Hailuogou Number One Glacier, Gongba Glacier, Bawang Glacier, Yanzigou (Swallow Ditch) Glacier and Mizigou Glacier. The ice layers are up to 150–300 m high and are spectacular (Fig. 1).

Hailuogou National Geopark, Sichuan This geopark is located in Luding County, Ganzi Tibetan Autonomous Prefecture in Sichuan Province along the southeastern edge of the Qinghai-Tibet Plateau and the eastern slope of Gongga in the middle of the Daxueshan Mountains. It became a national geopark in 2002. The main features include modern glaciers, hot springs, mountains and gorges. The main peak of Gongga Mountain is 7,514 m above sea level, making it the 11th highest mountain in the world. Hailuogou Glacier, which is 15 km long, extends to the original forest area at an elevation of 2,850 m. It is a modern glacier with the lowest elevation at that latitude. Its ice waterfalls are 500 to 1,100 m wide, and the ice tongue is 5.70 km long. Glacier arches and ice cracks can be observed. There are three hot springs with water temperatures between 50 °C and 80 °C, which provide perfect sites for hot baths.

Han Shu (Book of Han): Treatise on Geography This is one of the ten treatises of the first geography book to use the term 'geography' in Chinese history. The author is Ban

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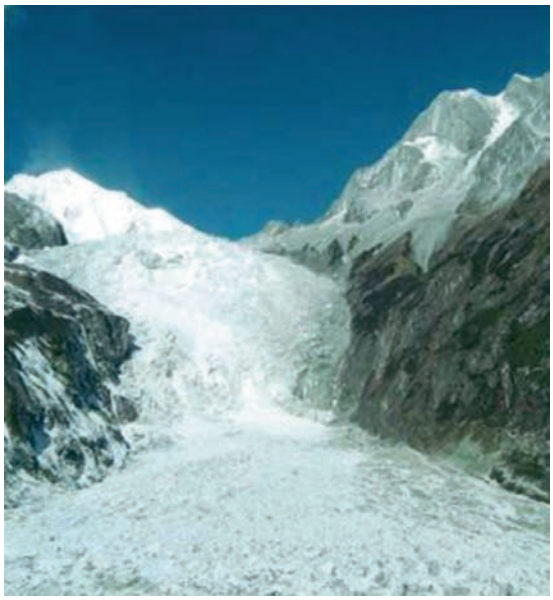


Fig. 1 Landscape of Hailuogou Glacier

Gu (32–92 AD). Its contents include the division and development of Chinese territories and administrative regions before the Western Han Dynasty. The book consists of 3 parts: (1) the changes in the territory from Huangdi (Yellow Emperor) to the beginning of the Han Dynasty; (2) the main body of the book, which describes the administrative and political divisions of the Western Han Dynasty and its mountains, rivers, lakes, water conservancy, produce, folklore, population distribution and evolution; and (3) the relationship between China and several Southeast Asian countries and regions as well as the maritime traffic conditions since the Qin and Han Dynasties. The Treatise on Geography is the revolutionary forerunner of geography and has played a significant role in the development of historical geography.

Hanging Valley Landscape This is a landform consisting of a tributary glacial valley that hangs above the main valley. It forms when the erosion capacity of the tributary glacial valley is much less than that of the main valley (Fig. 2).

Hanging Wall The hanging wall is the rock mass above an inclined fracture plane (fault). Based on the relative direction of movement of the hanging wall and footwall, faults can be categorised as normal faults, reverse faults (thrust faults) and transform faults (strike-slip faults).

Hateg Country Dinosaur Geopark, Romania This geopark is located in central Romania and covers an area of 1 km^2. It became a global geopark in 2005. The area contains numerous glacial lakes as well as mountains more than 2,000 m high, deep canyons, caves, forests, grasslands, orchards and farmland. Its human history extends from the Stone Age to the Roman period and from the Middle Ages to today. The many historic sites include the ancient Roman capital of Dacia Province, several medieval churches and fortresses, modern castle ruins and houses of aristocratic officials.

Hawaii Volcanoes National Park, U.S.A. Located on the island of Hawaii in the U.S., Hawaii Volcanoes National Park has a core protection area of 929 km^2. This park contains two of the most active volcanoes in the world, Mauna Loa (4,170 m high) and Kilauea (1,250 m high), both of which tower over the Pacific Ocean.

Hawaiian Type Volcano This is a type of volcanic eruption named after the Hawaiian volcanoes, which are characterised by gentle flows of dilute basaltic or andesitic magma, usually in the form of lava flows or lava lakes. A particular characteristic is the formation of a lava fountain, and the eruption activity is weak. The lava can be blocky or rope-like, and the volcanic necks are generally filled with lava. The erupted materials include dung-like volcanic bombs and volcanic ash, and these eruptions often form shield volcanoes or parasitic volcanoes (Fig. 3).

Hawaiian Volcanoes The Hawaiian Islands are located in the middle of the Pacific Plate above a mantle hotspot. These islands were formed by volcanic eruptions of basaltic magma. The famous active Mauna Loa Volcano and Kilauea Volcano are still erupting and have become national parks and global tourist attractions. Mauna Loa Volcano has a height of 4,169 m above sea level and is more than 10,000 m high from the seafloor to the peak. It is a shield volcano. Since 1832, this volcano has erupted once every 3 years and has poured



Fig. 2 Glacial hanging valley at Zheduo Mountain, western Sichuan



Fig. 3 Hawaiian-type volcano landscape

out a large amount of lava that has increased the volcano's height and size. As such, it is also called 'the Great Architect'. The eruption in November 1959 lasted for a month and erupted 460 million km^3 of lava. Kilauea Volcano, at 1,247 m above sea level, is the second largest volcano on the islands. In the volcanism literature, pahoehoe lava (translated as string-like

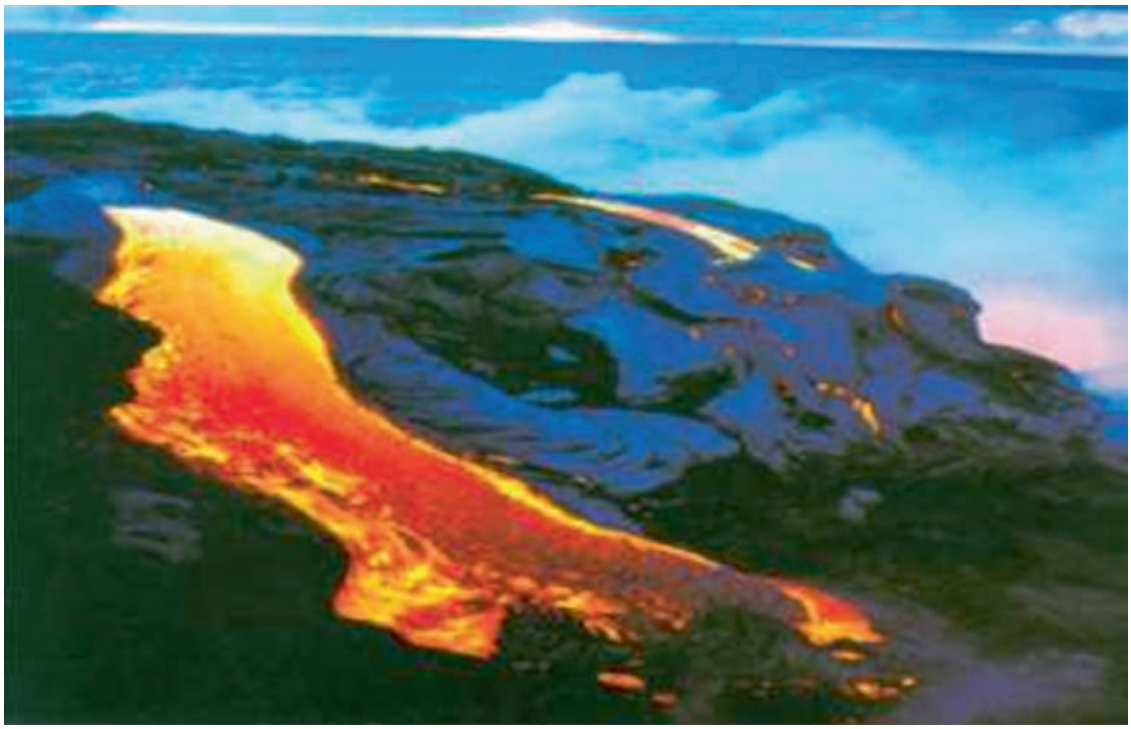


Fig. 4 Hawaiian Volcanoes landscape

lava) and aa (translated as blocky lava) are local names used by native inhabitants for these features. This volcano erupted 17 times from 1983 to April 1984. At that time, the lava temperatures rose to 1,100 °C–1,200 °C, lava fountains erupted upwards, lava flows moved like red rivers, and the flow rate reached nearly 321 m per second (Fig. 4).

Headland Landscape ▶ Promontory Landscape

Heard and McDonald Islands, France These islands are located in the southern Indian Ocean approximately 4,100 km from Perth, Western Australia, and approximately 600 km from the Kerguelen Islands, and they are an extraterritorial district of France. As the only active volcanic islands in the sub-Antarctic area and a 'window to the earth's heart', the site provides a unique location for scientists to observe the evolution of landforms and study glacier dynamics. Heard and McDonald Islands boast one of the few primitive island ecosystems completely free from the invasion of exotic animals and plants. In addition, they have not been affected by human activities. Therefore, they have unique natural protection value.

Heart-Shaped Sand Bar Landscape ▶ River Island

Hegang National Mining Park, Heilongjiang This park is located in Hegang City, Heilongjiang Province. The Heilongjiang Hegang National Mining Park has an area of 6.66 km^2 and was approved as one of the first group of national mining parks in 2005. It has four scenic areas: a mining history museum, together with the Wanrenkiang (Ten Thousand People burial ground), Xinyi Mine, Lingbei outdoor mining area, and the 'Langwo' Japanese secret underground fortification area. The green area of the park accounts for 57.1% of the total area of the city, and the forest coverage rate is 42.1%, which allows it to serve as a forest park. The main scenic site in the park highlights mining relics, the slope of the open pit, the clear distribution of geological structures, and the coal seam.

Heihe Handaqi National Mining Park, Heilongjiang This park is located in the

Aihui District, Heihe City, Heilongjiang Province, and it covers an area of 698 km^2. It became a national mining park in 2010. The park is located in the transition zone between the two level structural units in the Greater Khingan Mountain Basin system and the Lesser Khingan Mountains-Zhangguangcai Basin and Range system, in the transition zone between the older topography of the Greater Khingan Mountains and the older topography of the Lesser Khingan Mountains, and between the cryolithozone and the non-cryolithozone. The placer gold deposits are located in a unique structure. The Handaqi Rift Valley, which runs through the park, is the only early Palaeozoic rift valley on the eastern continental margin of the Eurasian Plate. It formed due to the subduction of the Pacific Plate below the Eurasian Plate in the early Palaeozoic, and it has great value for studying plate movements, the subduction of the Pacific Plate and the geologic processes along the continental margin. The placer gold deposits in Heihe are typical of alluvial river valley placer gold deposits. The placer gold mining technologies and mineral processing process in the Heihe gold mines, especially the design and manufacturing technologies of gold dredgers, have a leading position in China's gold industry.

Heilu Soil Heilu soil is characterised by a thick black clay layer. It develops on loess parent material under the semi-arid grassland vegetation on the Loess Plateau, and it contains a dark and thick layer of organic matter and a pseudomycelium calcium deposit. There is always a top layer on the soil profile, and the entire section is calcareous. Heilu soil is the remnant soil upon cultivation on the parent loess, and it is mainly found in northern Shaanxi, northwestern Shanxi, eastern Guizhou and central Yunnan.

Helan Inkstone This inkstone is simply called Helan stone, and it obtained its name because it is produced in the Helan Mountains in Yinchuan, Ningxia Province. The rock is silty sericite slate that was deposited at the bottom of the Proterozoic Changcheng Series Huangqikou Group. It is dark purple, greyish purple or light brown, and its main minerals are sericite, quartz and illite. The Helan inkstone has a combination of green and purple colours and a fine texture like jade. Some have jade-like strips, cloud patterns, brow patterns, silver lines and stone eyes. The stones always have patterns like clouds, the moon, water or mountains, which are interesting and natural. This inkstone does not absorb water, and it is easy to spread ink on it. It is wear-resistant, and when covered, the ink remains moist and does not become smelly after several days. It is an excellent inkstone material and can also be used for other types of stone crafts, such as high-quality grinding stones and oil stones (Fig. 5).

Heliotropic Stalactite Landscape Plants absorb carbon dioxide from water droplets on the cave roof through photosynthesis, and the water eventually becomes saturated and is deposited to form stalactites. Heliotropic stalactites are common at cave mouths, where light can reach. Algae and other organisms attach to the stalactites near the cave mouth. Because these organisms are phototropic, the stalactites tend to grow towards the outside part of the cave mouth. This is a type of biokarst landform. Similar sedimentary landforms form on both sides of some karst canyons in the south. Similar stalactites can form when a solution seeps from cracks; these features are called external stalactites (Fig. 6).

Heluo Stone Heluo stone is a type of egg-shaped Yellow River (Huanghe) pebble found in Xin'an County and the Mengjin section of Huanghe, Henan Province. It includes clastic rocks, dolomite, limestone, gneiss, quartzite, granite and volcanic rocks that have complex causes of formation. Typical Yellow River Sun and Moon ornamental stone is from Carboniferous, Permian and Triassic sedimentary rocks. Heluo stone can be divided into pebbles and mountain stones, of which the Heluo painting stone is most attractive. Heluo stone has various colours, including red, orange, yellow, green, cyan, blue and purple, interesting patterns with fine textures, such as landscapes, flowers and birds, characters, animals, and

Fig. 5 Helan ink stone





Fig. 6 Phototropic stalactite landscape



Fig. 7 Heluo stone with iron oxide patterns

Chinese characters, which are rare and peculiar, and numerous types, such as peony stones, purple clay stones, plum stones, chicken liver stones, moire stones and snowflake stones (Fig. 7).

Hematite Hematite is commonly known as 'red iron ore', and it is composed of Fe_2O_3. It contains 70% iron and belongs to the trigonal system. The crystals are blocky or rhombic and sometimes have columnar or conical shapes. The blocky crystal aggregates form a rosette pattern that is called 'iron rose'. Haematite crystals are mainly platy, dense, columnar, fibrous, reniform, botryoidal, stalactitic, dendritic or granular. When hematite is reniform, it is called 'kidney ore'. It has several colours, such as light brown, bright red, blood red, brownish red, grey and iron black. It has brownish red streaks, opaque diaphaneity, a metallic to dark lustre, a specific gravity of 5.26, a Mohs hardness of 5–6, and uneven to

sub-conchoidal fractures. It usually forms in hydrothermal metasomatic ore deposits and can also be a secondary mineral that forms in igneous rocks. Haematite is an important raw material for iron smelting. Ores with bright colours can become good ornamental stones.

Henderson Island, British Overseas Territory Henderson Island, which is in the Pitcairn Islands in the eastern part of the southern Pacific Ocean, is a British Overseas Territory. It covers a core protection area of 37 km^2. It is one of the few atolls in the world which ecology has been nearly untouched by humans. Its isolated location provides an ideal site for studying the dynamics of insular evolution and natural selection. It is particularly notable for the 10 plants and four land birds that are endemic to the island.

Hereynian Movement The Hereynian movement is also known as the Variscan movement, which occurred in the late Palaeozoic in Europe. This movement had global significance. In China, the main events were mainly associated with the extensive crustal movement between the Carboniferous and Permian Periods. The Tianshan-Xingan orogenic belt is a typical Hereynian (Variscan) orogenic belt, and it is more than 300 million years old.

Heritage Tourism Heritage tourism is a type of tourism that attracts people to visit heritage sites to appreciate the natural heritage and experience or learn about the cultural heritage. It is a high-end field of tourism that focuses on nature and history. China has some of the richest natural and cultural heritage in the world and has established more than 30 world heritage sites. The successful application of the Danxia Landform World Heritage Site in 2011 and the establishment of 38 global geoparks (by May 2018) have greatly enhanced the status of China's natural heritage tourism around the world.

Heshan National Mining Park, Guangxi This mining park is located in Heshan City, central Guangxi Zhuang Autonomous Region, and has a total area of 18 km^2. It was accredited as a national mining park in 2010. The development of the Heshan coal resources has a history of over 100 years and began in the 31st year of the Qing Emperor Guangxu (1905). The park's geological heritage includes the Heshan Formation (Heshan coal measures), Hefei Formation of the Upper Permian Hefei Formation, the profile of sedimentary facies (Matan profile), Permian patterned oysters and fossils of Pseudotirolites cf. laibinensis. The park preserves numerous mining relics, including the lanes and ravine sites represented by the 'Heishan No. 1 Mine', well and lane systems, inclined shafts with hoisting systems, ground transportation, mine production equipment, ventilation, supports, production assistance systems and supporting facilities of the Heshan Coal Mine Company.

Hetao Man Site The Hetao Man site is a site of ancient human fossils on both banks of the Salawusu River in Wushen Banner, Mu Us Desert, Ordos Plateau, Inner Mongolia Autonomous Region. This site is also called the Relic of the Ordosian People. Between 1922 and 1980, several late Homo sapiens fossils, abundant stone artefacts and mammal fossils have been discovered in the 70-m-thick fluviolacustrine gravel-sand-clay layer in the river terraces along the Salawusu River. The sediments contained 23 pieces of human fossils, including a frontal bone, parietal bone, lower jaw bone, vertebrae, humeri, tibia, femur, fibula and a single incisor tooth. More than 400 artefacts were also found. The fossil fauna indicates that 35 species of mammals lived with the Hetao Man. The Hetao Man and the Salawusu fauna have been dated to 37,000 to 50,000 years ago by uranium dating.

Hetian Jade (Hetian Jade, Khotan Jade) Hetian jade is a nephrite that is famous in China. It gets its name because it is mainly produced in Hetian in Xinjiang Province. It comprises mostly massive microcrystalline to cryptocrystalline felted amphiboles of the tremolite-actinolite series. The original mineral resources are in the contact zone of acidic igneous rocks containing magnesium carbonate. Transported by river water, the nephrite rocks became polished pebbles called Hotian

jade. The Palace Museum displays a large Hetian jade stone weighing 5,350 kg. The original stone was mined at Mileta Mountain in Xinjiang during the Qianlong period of the Qing Dynasty. It was delivered to Beijing within 3 years and later moved to Yangzhou to be carved by the most famous craftsmen. Hundreds of craftsmen spent more than 6 years carving it and eventually completed a relief with the theme of 'Flood control by King Yu'. Hetian jade can be divided into white jade, green jade, black jade and yellow jade according to the colour. A type of red jade has been described, but no actual object has been found (Fig. 8).

Hexigten Global Geopark, China This geopark is located in the territory of Keshiketengqi in the Neijiagu Autonomous Region, and it covers an area of 1,343 km^2. It was granted the global geopark status in 2005 as one of the second group of approved global geoparks. It consists of nine scenic districts, namely, Darinor, Qingyuan, Asahout, Hunsindake, Xilamulun, Hottang, Huanggangliang, Pingdingshan and Wulanbutong. It is characterised by a Palaeozoic granite landscape and was the earliest designated area of the 'Keqiu-Shizhuqun granite landscape'. Other geological features include Quaternary glaciers, granite, demarcation lines of the Tatai Formation, Ebara Lake, volcanic landforms, deserts, grasslands, hot springs, and the Sasahara Wetlands. Lake Darinol is located in the deep fault zone along the Xilamurun River. It is an inland lake that was formed in a fault depression and was filled by basaltic rocks. The Dali Nuoer volcanic group is located to the northwest of Dali Lake and has many volcanic cones. It is a diverse, well-preserved and typical volcanic region of eastern China. The Pingdingshan Scenic District contains a cluster of Quaternary cirques.

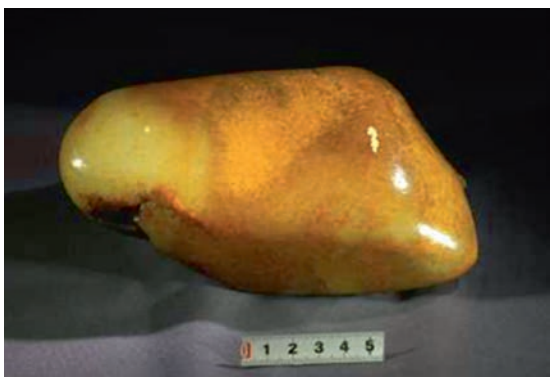


Fig. 8 Hetian jade

Hexigten National Geopark, Inner Mongolia See ► Hexigten Global Geopark, China.

Heyuanoceras or Heyuan Ammonite The heyuan ammonite is a type of Ladinian ammonite fossil (late stage of the Middle Triassic). These fossils have been mined in Zeng Keng Village in Shuangjiang Town, Dongyuan County, Heyuan City, Guangdong Province. The fossils excavated in Zeng Keng generally have sizes of approximately 1–10 cm, but the largest was 42 cm in diameter and was appraised as China's best fossil of this kind. The ammonite fossil mine relics at this site cover an area of approximately 20 m^2, Coroniceras is the main fossil type, and Paracoroniceras is the secondary type.

Hezheng Fauna This fauna is the fossil group located in the Neogene red beds in Hezheng, Guanghe, Dongxiang, Linxia, Kangle, and Jishishan Counties in Linxia Hui Autonomous Prefecture, Gansu Province. The fauna can be divided into 3 age groups: (1) Platybelodon fauna (approximately 12 million - 15 million years ago), (2) Hipparion fauna (approximately 7 million–10 million years ago), and (3) true horse fauna (approximately 2 million years ago). These fossils belong to 6 orders and approximately 70 genera and species of Reptilia and Mammalia. The main fossils include Platybelodon, Kubanochoerus, giraffes, Hezhengia, Hipparion and Testudinidae. These fossils have important scientific significance for research on the evolution of Palaeogene biota and the climate distribution and change in northwestern China (Fig. 9).

Hezheng Paleo-Organism Fossils National Geopark, Gansu This geopark is located in Linxia Hui Autonomous Prefecture, Gansu Province. In August 2009, the Ministry of Land and Resources approved it as one of the 5th batch of national geoparks. It is



Fig. 9 Hezheng fauna

characterised by palaeo-organism fossils in Late Cenozoic strata. More than 80 sites with vertebrate fossils have been found in the Hezheng area. The fossils belong to four types of Late Cenozoic vertebrate fauna. From bottom to top, they are Paraceratherium fauna buried in Late Oligocene red gravels (approximately 30 million years old), Platybelodon fauna buried in Middle Miocene grey fluvial-lacustrine sandstones (approximately 12 million years old), Hipparion fauna buried in Late Miocene red mudstone (approximately 10 million years old) and Equus fauna buried in Early Pleistocene loess deposits (approximately 2 million years old).

Hiatus *Synonym:* ▶ *Depositional break*

A hiatus is sometimes called a 'break' and is a small-scale, relatively short-duration interruption during sedimentation. A hiatus is different from a lacuna because it only represents a short duration of absence of deposition, and denudation rarely or never occurs before sedimentation resumes. Hiatuses are common in conformable rock strata and are generally not easy to identify; however, because discontinuities in organism types often indicate discontinuous sedimentation or a depositional break, biostratigraphic techniques are commonly employed. For example, missing fossil zones can be used to identify a break in deposition.

Hierapolis-Pamukkale, Turkey This site is located in the Denizli Province in southwestern Turkey. The total area of the heritage site is 10.77 km^2. The 200-m-high cliffs overlook plains with springs running through the limestone landscape. The Pamkalay (cotton palace) section creates a natural wonder composed of calcium carbonate deposits. There are mineral forests, petrified waterfalls and a series of terraced basins. At the end of the second century AD, the Kings of Pajara of the Atalides Dynasty built the Hierapolis geothermal spa resort. There are also historical hot spring baths, monasteries and other Greek relics.

High Coast/Kvarken Archipelago, Sweden/Finland This archipelago is located in the Gulf of Bothnia between Sweden and central Finland, and the core protected area covers 1,944 km^2. The Gulf of Bothnia extends northward from the Baltic Sea. The Kvarken Islands (Finland) is a group of 5,600 islands. The main geomorphological feature is the De Greer hailstone, which formed from the melting of the continental ice sheet 24,000 to 10,000 years ago. The theory of glacial isostacy states that land that subsides due to the weight of glaciers will rise again after the glaciers retreat. Due to this process, numerous islands have emerged, and they continue to grow larger due to the ongoing uplift. The peninsula has thus continued to expand, and some areas of the sea have evolved into lakes. Since the last glaciers retreated 9,600 years ago, the High Coast has rebounded by 294 m, which the world's largest amount of glacial rebound.

High Mountain and Frigid Karst Calcareous Pool Landscape This is a landform composed of colourful calcareous pools formed by spring precipitation in an alpine region. Jiuzhaigou in Sichuan Province is a typical representative. The Jiuzhaigou region is located at elevations greater than 3,000 m, where the average annual temperature is

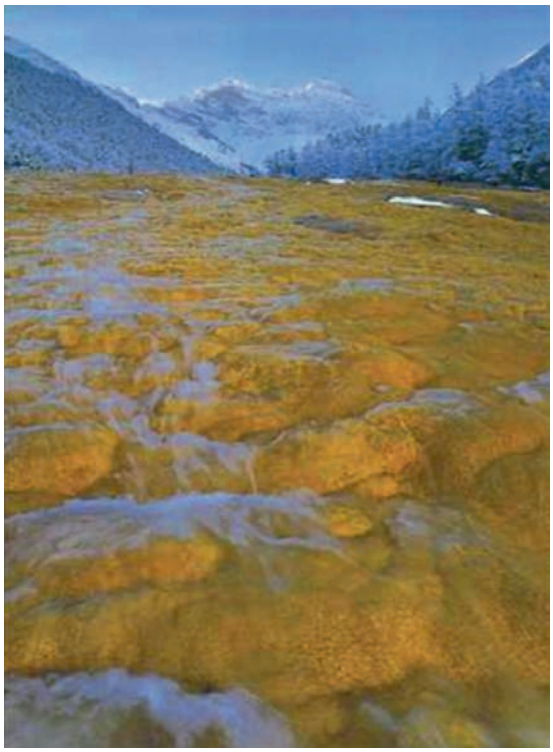


Fig. 10 High mountain and frigid karst calcareous flow landscape – Huanglong, Sichuan Province

lower than 5 °C. Calcareous springs run down glacial valleys. Calcium precipitation from these springs has created a series of stone embankments that pool water of various colours, forming a landform of magnificent calcareous pool clusters. This site is now a national geopark and World Natural Heritage Site (Figs. 10 and 11).

High Mountain Karst Travertine Flow Landscape This is a type of landform of spring precipitation that forms a flow of elongated calcareous tufa in regions of high elevation and high latitude. Huanglong in Sichuan Province is a typical example. In Huanglong, golden-coloured tufa extends for 2.5 km with a width of 10–170 m. It looks like a golden dragon when viewed from a distance. It has high scientific, aesthetic and ornamental value and has become a national geopark and World Natural Heritage Site.

High Swamp Landscape This is a type of swamp landscape that is also known as an oligotrophic swamp. It is a swamp in an advanced stage. These swamps are mainly located in flat watersheds at high elevations, and the water is supplied by precipitation. The plants lack nutrients, and the peat ash content is less than 4%. These swamps are dominated by oligotrophic plants such as Sphagnum moss. In China, high swamps are mainly located in the Daxing'anling, Xiaoxing'anling, Changbai Mountain and Shennongjia areas.

Hill A hill is an undulating terrain with topography that is rounded at the tops, and with slopes and an inconspicuous slope line. Hills generally have relative heights less than 200 m. Low hills have reletive heights less than 100 m while high hills are 100–200 m high. Examples are the Liaodong hills, Shandong hills, southern hills and Zhegan hills.

Hillock Moraine Landscape ▶ Moraine Hills

Himalayan Movement The Himalayan movement is the orogeny that has occurred in Asia and the surrounding regions since the Cenozoic Era. It is composed of multiple episodes. The Himalayan movement caused the ocean to retreat from the Qinghai-Tibet Plateau, and the subsequent extensive uplift formed the highest mountains in the world. It created the Himalayan orogenic belt and caused strong folding, large-scale thrust-nappe tectonics, extensive igneous intrusions and regional metamorphism. The Himalayan movement created the modern landscape in China and has had a significant influence on the recent changes to the geologic environment, seismic activity and crustal stability.

Hinggan-Mongolian Orogenic Belt This belt is part of the Central Asia Orogenic Belt in China, including the Xianganling Range in the northern and western Songliao Basin and the orogenic belt in eastern Inner Mongolia. Orogenic belts of different periods also formed during the early and late Palaeozoic. The Mongolian-Okhotsk Orogenic Belt is located to the north, and the Sino-Korean Platform is located to the south, and there was a Palaeozoic ocean that divided the Siberian and Sino-Korean palaeocontinents prior to the orogeny.

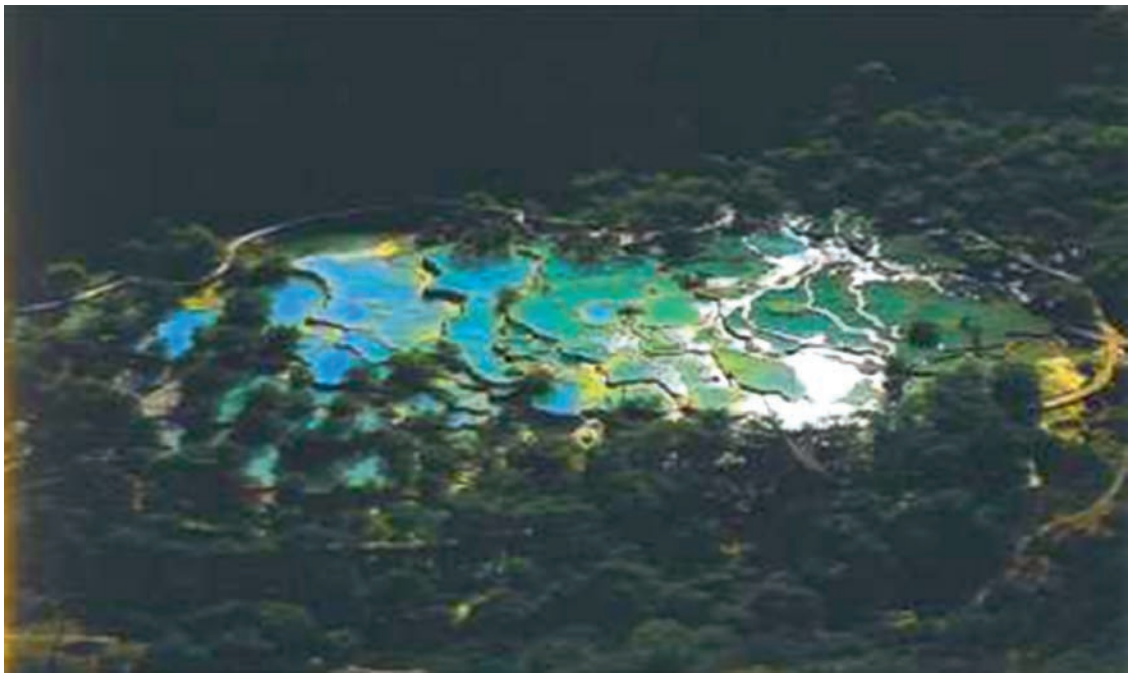


Fig. 11 High mountain and frigid karst calcareous pool landscape – Jiuzhaigou

Historic Sanctuary of Machu Picchu, Peru This famous site is located in the province of Cuzco in southeastern Peru, and it has a core protection area of 325 km^2. Machu Picchu, located at an elevation of 2,430 m in the tropical forest, is probably the most amazing city complex left by the Inca Empire. Huge walls, terraces and ramps were built on rocks surrounded by cliffs. The area is near the eastern slopes of the Andes and is in the upstream part of the Amazon Basin, and it has very rich biodiversity.

Historical Geography Historical geography is a branch of human geography. It studies the geographical environment and its evolution during historical periods. It can be subdivided into historical physical geography, historical human geography, regional historical geography and historical cartography. The term 'historical period' applied in historical geography usually refers to a period in the Holocene, which began approximately 10,000 years ago while the primitive agriculture first appeared and the human activities started to make impacts.

Historical Geology Historical geology is the study of the history of the Earth based on the theories and methodologies of palaeontology, stratigraphy, geologic chronology and palaeogeography. It covers studies of the palaeogeography of each geological period, changes in the palaeosedimentary environment, characteristics of magmatic activities and tectonic movements, distribution and evolution of ancient life, metamorphic events and metamorphism, which are used to interpret and summarize the general processes of crustal tectonics and evolution.

Historical Maps of Consecutive Dynasties This is a collection of historical maps compiled and edited by Shoujing Yang (1839–1915). The first volume was issued and circulated in 1906, and the final volume was completed in 1911. The map collection comprises 34 volumes, which are divided into 44 series according to each country or dynasty consecutively from the Spring and Autumn Period (770–476 BC) to the end of the Qing Dynasty (1911); thus, it is also known as 'Historical Geography Maps of Changes and

Developments'. The names of places in the Spring and Autumn Period map are those from the historical book 'Zuo Zhuan' (i.e., 'Commentary of Zuo'), while the names in the Warring States map are those stated in the book 'Zhan Guo Ce' (i.e., 'The Intrigues of the Warring States'), and the maps of the Han Dynasty and after are based on the 'Treatise on Geography' of each dynasty or country; the place names are those above the county level and the first level administrative divisions. All of the famous mountains and major rivers are listed in the maps. The collections are based on the 'Complete Geographical Map of the Great Qing Dynasty', and they include both the ancient and prevailing names printed in red at a larger scale, so they are much more accurate and detailed. Most of the maps before the Sui Dynasty include prefaces, tables and annotations.

Hogback A hogback is a unique type of cuesta that comprises a monocline with a steep dip. It is a ridge with two steep slopes resembling the back of a hog. In general, the dips are greater than 45°. The backslope, which hinges on the structural plane, is symmetrical to the front slope formed by erosion. Hogbacks are generally composed of hard rocks with a gentle dip. They are often located on the margins of tectonic basins with tilted rock strata (Fig. 12).

Holiday Tour ► Vacation Tour

Holiday Tourism Holiday tourism is a type of tourism in which people stay in destinations away from home for periods of time to relax, enjoy and keep themselves fit and healthy. Holiday tourism commonly includes hot spring tours, alpine skiing tours and seaside resorts.

Holostratotype A holostratotype is the original stratotype used to designate a stratigraphic unit or boundary.

Homalocephale Homalocephale is also known as the 'Manchu Dragon'. It is a large Hadrosaurus that was 8 m long and 4 m high with a flat triangular palatine bone. It was an advanced type of ornithopod dinosaur. It was herbivorous and lived along the shallow margins of lakes in the Late Cretaceous. This fossil was excavated in 1902 in Jiayin County, Heilongjiang Province, and was the first dinosaur fossil found by Russians in China. At the time of its discovery, it was called 'China's Number One Dragon" (Fig. 13).

Homo Erectus Lantianensis Site *Synonym:* ► *Lantian Man site*

Homo erectus lantianensis is also called the 'Lantian Chinese Ape'. A lower jaw bone and a skull were discovered in 1963 and 1964, respectively, in different locations in Lantian County, Shaanxi Province. A lower jaw bone



Fig. 12 Hogback (Credit: Science Photo Library)



Fig. 13 Tarbosaurus homalocephale

of an old woman was unearthed in the light reddish soil layer in the Middle Pleistocene Xiehu Formation in Chenjiawo. A skull of a 30-year-old female was discovered in a calcium nodule in the yellowish red loess-like sandstone in the lower part of the Xiehu Formation in Gongwangling. The lower jawbone is approximately 650,000 years old, while the skull is approximately 1.1 million years old as determined by palaeomagnetic dating. The research of Wu Ru Kan indicates that the Lantian Man is more primitive than the Peking Man, and the more prominent skull supports this interpretation (Fig. 14).

Homo Erectus Pekinensis Site or Peking Man Site This site is located in a limestone cave on Long Gu Mountain in the Ordovician Majiagou Formation to the west of Zhoukoudian Town, Fangshan, Beijing. The cave contains more than 40 m of deposited material, which dates from the late stage of the Early Pleistocene to the Middle Pleistocene and contains 17 layers. From the first layer at the top to the 11th layer at the bottom, ancient human fossils and numerous stone tools, bone tools, traces of fire, animal fossils and plant fossils have been found. Two tooth fossils



Fig. 14 Homo erectus lantianensis

were first discovered at the Peking Man site by Andersen from Sweden in 1921 and 1923. On 2 December 1929, Pei Wenzhong took charge of the excavation of the first complete

Peking Man skull, which became famous around the world. From 1927 to 1937, five Peking Man skulls, 147 teeth, facial bones, lower jaw bones, femurs and humeri were found. Unfortunately, these fossils were lost by the Americans in 1941 during the Japanese invasion of China after the outbreak of the Pacific War. According to uranium fission, thermoluminescence and palaeomagnetic dating methods, Peking Man lived in the Pleistocene Era between 230,000 and 500,000 years ago (Fig. 15).

Homo Erectus Yuanmouensis Site *Synonym:* ► *Yuanmou Man site*

This is the earliest site of human relics in China. The teeth of Homo erectus yuamouensis were found on 1 May 1965 in the lower part of a brown layer of the Pleistocene Yuanmoa Formation in northwestern Bang Village, Shang Na, Yuanmou County, Yunnan Province. Identified by Hu Chengzhi, the two incisors are considered to be comparable to that of the Peking Man, but they are more primitive. The age of Yuanmou Man was first determined in 1976 as approximately 1.7 million years old based on palaeomagnetic dating methods. Yuanmou Man is the earliest human fossil identified in China. The history of the Chinese race started with Yuanmou Man. In the 25th layer of the Yuanmou Formation, where the tooth fossils were unearthed, 17 pieces of stone artefacts were also excavated, in addition to bone pieces with human traces and a chicken nest-shaped charcoal layer. These features are evident to indicate that Yuanmou Man used fire (Fig. 16).

Honeycomb Granite and Tafoni Granite honeycomb stone and rock tafoni mainly develop in arid areas of intense wind erosion. Wind erosion and abrasion by sand grains on the windward sides of steep granite slopes cause the formation of small irregular oval holes and pits. Some are sporadically scattered, and some cluster to form honeycomb-shaped features. Large granite honeycomb stones are also called rock tafoni. Haisenchulu in Alxa Right Banner, Inner Mongolia, is a typical area with this landscape. When this phenomenon occurs along a granite coast, the foot of the steep cliffs facing the sea is subject to marine erosion and wind erosion, which can result in the formation of grooves with depths less than their width. These features are called wave-cut notches, and they are common in the granite area on Pingtan Island, Fujian Province (Fig. 17).

Hong Kong Global Geopark, China The idea of setting up an urban geopark was initiated and promoted by Wu Zhenyang (Young Ng) and volunteers of the Association for Geoconservation of Hong Kong in 2006. The geopark is located in northeastern Hong Kong and covers an area of 100 km^2. It became a global geopark in 2011. It comprises Sai Kung Volcanic Rock Geoarea and the Northeast Sedimentary Rock Geoarea with a total of eight scenic sites. The four scenic sites in the Sai

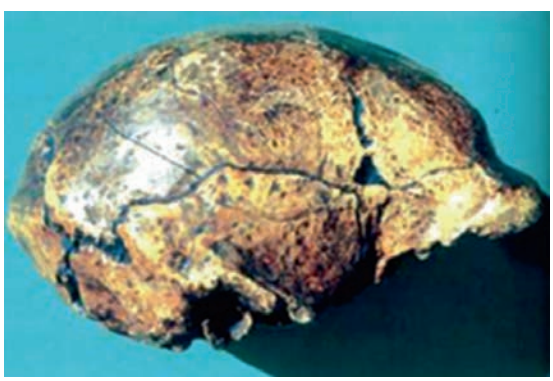


Fig. 15 Homo erectus pekinensis



Fig. 16 Teeth fossil of Yuanmou Man



Fig. 17 Tafoni in Alxa Right Banner, Inner Mongolia

Kung Volcanic Rock Geoarea include High Island, Uk Kong, Ninepins Islands and Sharp Island. The geological features include Cretaceous hexagonal columnar joints in acidic volcanic rocks and stunning coastline and waters. The Northeast Sedimentary Rock Geoarea comprises four scenic sites, including Tung Ping Chau, Yan Chau Tong and Tolo Harbour/Port Island. This area features Devonian, Permian, Jurassic, Cretaceous and Palaeogene strata, palaeontology, and sedimentary and structural geological relics. Hong Kong Global Geopark was built on the basis of Hong Kong's countryside parks, marine parks and special protection areas. It is managed by the Agriculture, Fisheries and Conservation Department under the Bureau of Environment. Precious geological heritage, marvellous island and coastal scenery and the local Hakka culture make the urban geopark a unique and interesting place to visit.

Hong Kong National Geopark, Hong Kong See ▶ Hong Kong Global Geopark, China.

Honghu Lake Landscape Honghu Lake is one of China's largest freshwater lakes and is the largest lake in Hubei Province. It is located in a depression in southern Hubei Province between the Changjiang (Yangtze River) and Dongjing River. The lake has a depth of 25 m and an area of 413 km^2. Its eastern and western sides are connected to the Changjiang (Yangtze River). Honghu Lake is shaped like a polygon with straight shores and a flat bottom. The lake contains extensive lush aquatic plants and abundant fish and shrimps. It is China's most important freshwater fish habitat. There are 84 fish species and 92 plant species, which contribute to the export of 200,000 kg lotus seeds annually. The lake is also home to many migratory birds, such as wild ducks and wild geese. There are 39 species of wintering birds, including 18 species of wild ducks. In addition to the rich aquatic produce, Honghu Lake is also famous for its spectacular scenery. In November 2006, it was awarded the 'Best Conservation Practice Award for Life Lake' by the World Wildlife Fund (Fig. 18).

Hongqiqu Linlushan National Geopark, Henan This geopark is located in Linzhou City, Henan Province, and was approved as one of the fifth group of national geoparks by the Ministry of the Land and Resources in August 2009. The main geological heritage in the geopark is the Linlushan Grand Canyon, which formed in Proterozoic quartzite and contains a well-developed N-S-trending fault on Taihang Mountain ridge. The formation of numerous gorges, cliffs, and springs can be attributed to erosion by many rivers in the Shanxi hinterland. The Hongqi Canal, which was constructed in a cliff at Linlushan, is an important man-made river and an important water conservancy project.



Fig. 18 Lake Honghu landscape

Horizontal Bedding Bedding in sedimentary rocks is parallel to the attitude of the strata. Bedding that is oriented horizontally is called 'horizontal bedding'. It indicates minimal movement of materials during sedimentation in a calm environment, and these conditions are common in sedimentary rocks (Fig. 19). For example, carbonaceous shale and black shale often have horizontal bedding. These rocks generally form in lacustrine or marine environments in quiet deep water. Some limestone strata also have horizontal bedding, which indicates that they are formed in a deep carbonate basin. High-quality bedding is present in many geoparks, resulting in distinctive natural scenery. For example, horizontal bedding is widespread in Yuntaishan Global Geopark. The Hukou Waterfall in Huanghe (Yellow River) was formed when the river cut through the horizontal bedding in Triassic rocks, resulting in a splendid landscape (Fig. 20).

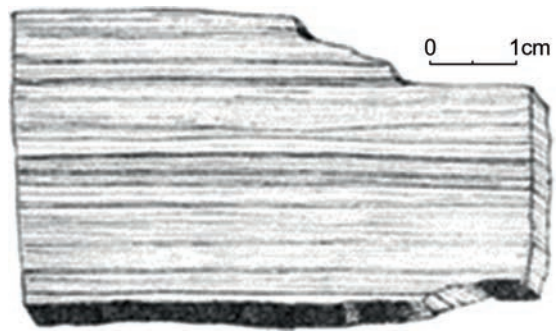


Fig. 19 Horizontal bedding

Horizontal Crustal Movement Horizontal crustal movements include the drifting, sliding or horizontal translation of the Earth's crust. Large amounts of evidence have confirmed that since the Permian, extensive horizontal crustal displacements have been caused by continental drift and seafloor spreading. The geological phenomena associated with the Benioff subduction zone, the global mid-ocean ridge zones, continental orogenic belts and continental rift belts can be reasonably associated with the horizontal crustal movement hypothesis. Plate tectonics holds that the movements of large plates are driven by horizontal movements. Geomechanics holds that all megatectonic systems are formed due to horizontal movements. Both plate tectonics and geomechanics emphasize the dominance of horizontal crustal movements, whereas vertical movements are caused by horizontal movements.

Horizontal Zonality As the amount of heat varies from north to south and the degree of moisture varies from east to west, natural elements, such as the climate, vegetation, soil, hydrology, and their interactions, form a



Fig. 20 Horizontal bedding

striped distribution on the Earth's surface. Zonality includes north-south, east-west, and vertical components. The north-south and east-west components make up horizontal zonality.

Horn Peak Landscape This is a landform composed of a sharp pyramidal hill that is formed by glacial erosion. The sharp peak is carved by the development of three or more cirques. It gets its name because the peak has a very sharp point like a horn (Fig. 21).

Hornblende The composition of hornblende is $NaCa(Mg,Fe,Al)_2[(Si, Al)4O_{11}]_2(OH)_2$. It crystallizes in the monoclinic crystal system. Its cross-section is nearly rhombic hexagonal, and crystal twinning is common. The aggregates are usually blocky with dense, granular, columnar, bladed and fibrous forms. The colour is green, greenish brown or black with white or grey streaks. Its diaphaneity is translucent to opaque, and its lustre is vitreous. The two cleavage angles are 60° and 120°. The specific gravity is 3.28–3.41, the Mohs hardness is 5–6, and the fractures are uneven. Hornblende is a major rock-forming material of intermediate igneous rocks, hornblende schist, amphibole gneiss and amphibolite. It is also found in granite, gabbro and alkaline rocks.

Hornito *Synonym:* ► *Driblet cone landscape* This is a lava landscape that consists of small cones made up of small overlapping pieces of basalt. The upper part of the cone is small, and the basal part is large. The cone contains a cavity with lava spines and lava stalactites on the inner walls. There are openings at the top. More than 5,000 driblet cones of various sizes occur in groups in Wudalianchi. It is generally believed that they were formed in connection with vapour emissions. As hot magma flows, vapour is released intermittently when air accumulates inside the lava or when the lava encounters surface water. The emitted gas carries small lava fragments, which eventually accumulate in layers around the centre to form driblet cones (Fig. 22).

Horst An uplifted block between two normal faults that dip away from each other is called a horst. A horst forms as a result of the extensional movement on two parallel steeply dipping normal faults that dip away from each other. A horst can have a single bedding orientation or be bounded by several normal faults with multiple bedding attitudes, which are called terraced step faults. Horsts are structural geologic features. Block mountain landforms are usually made up of medium and large young horsts.

Hot Lake Landscape This is a hot spring landscape consisting of a large depression composed of thermal springs of considerable depth. A typical example is the Yangbajing Hot Lake in Damxung County, Tibet (Fig. 23).

Hot Pool Landscape This is a landscape consisting of a hot water pool that is smaller than a hot lake but larger than a hot spring



Fig. 21 Matterhorn Peak landscape in the Alps, Switzerland



Fig. 22 Driblet cone landscape, Wudalianchi



Fig. 23 Hot lake landscape in Yangbajing

channel. Its surface is round or oval with a depth of 1 m to several metres and an aerial surface of tens to dozens of square metres. It is called a boiling pool when the water temperature reaches the boiling point. Some hot pools do not leak water, and due to evaporation, the mineral salts in the hot water gradually precipitate from the pool edge towards the centre, causing the pool to shrink and eventually forming a hot pool with a wide centre but a small mouth.

Hot River Landscape This is a landscape consisting of rivers with hot water. The hot river water mainly comes from thermal springs with large flow volumes or from the convergence of groups of small thermal springs along a valley. It is called a hot stream when the water flow is small and a hot river when the flow volume is large. Typical examples include the Quzhen Hot River in Zhag'yab County and Sobucha Hot River in Nagqu County, Tibet. Their flow volumes are more than 500 l/s. In Central America, the hot river in Ahuachapan has a water temperature of approximately 56 °C (Fig. 24).

Hot Spring *Synonym:* ► *Thermal spring*
A thermal spring refers to a flow of geothermal water with a temperature higher than 45 °C at the outlet but below the local surface water boiling point (Fig. 25).

Hot Spring Resort Tourism Hot spring resort tourism is a type of tourism that focuses on experiencing hot spring culture, health maintenance and healing. Hot springs in different geological areas can have remarkable differences in terms of the quality, temperature and quantity of water. Before creating a tourism product based on a hot spring, detailed investigations and tests must be carried out on the quality and quantity of the spring water, and clinical experiments must be performed on the water's healing effects to determine the scale and category of the tourism product. Hot springs used to be used only for



Fig. 24 Hot river landscape in Rucheng County, Hunan

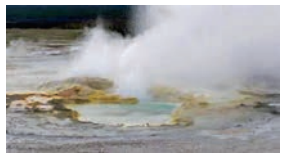


Fig. 25 Hot spring landscape in Yellowstone National Park, U.S.A

healing, but a trend is emerging to elevate them to a cultural and spiritual, health-keeping, leisure and fashionable tourism activity that caters to the needs of modern consumers.

Hot Spring Tourism Landscape This is a distinctive natural landscape formed due to the geothermal energy in the Earth's crust with hot groundwater and gases that flow to the surface. The unique physical properties and chemical compositions of hot springs have significant tourism and medicinal value. The fumaroles and hot springs in Yellowstone National Park, USA, have become a renowned tourism landscape around the world. In China, the fumaroles in Tengchong in Yunnan Province, the Yangbajing Hot Spring in Tibet, Xiaotangshan in Beijing and Huaqingchi in Lingtong are important tourism attractions for recreation, health rehabilitation, sight-seeing and leisure.

Hot Spring Tourism Resources When hot geothermal water flows to reach the ground surface, it is called a hot spring. Based on the formation process, hot springs can be classified into natural hot springs and artificial hot springs. Artificial hot springs can be further divided into borehole hot springs and mining tunnel hot springs. According to the pressure of the groundwater, hot springs can be divided into non-pressurised and pressurised hot springs. Based on the pH of the water, hot springs can be categorised into acidic hot springs (pH <3), weakly acidic hot springs

(pH 3–6), neutral hot springs (pH 6–7.5), alkaline hot springs (pH 7.5–8.5), and strongly alkaline hot springs (pH >8.5). Based on the content of chlorine ions, carbonate ions and sulphate ions, hot springs can be divided into chloride hot springs, bicarbonate hot springs and sulphate hot springs. According to the temperature (Chen Yanbing et al., from the perspective of medical therapy), hot springs can be divided into low-temperature hot springs (25–33 °C), medium-temperature hot springs (34–37 °C), hot springs (38–42 °C) and high-temperature hot springs (>43 °C). Usually, temperatures of 37–42 °C are most appropriate for bathing. The formation of hot springs requires the following 3 conditions: (1) the existence of geothermal groundwater; (2) the existence of different static water pressures for hot water upwelling; and (3) the existence of deep fissures in the rock for hot water to reach to the surface. China has approximately 3,000 sites with natural hot springs, and 100 are famous, such as Lishan Hot Spring in Shaanxi Province, Xiaotangshan Hot Spring in Beijing, Changbai Mountain Hot Spring, Chongqing South Hot Spring, and Conghua Hot Spring in Guangdong Province, Tengchong Hot Spring in Yunnan Province, and Huangshan Hot Spring and Beitou Hot Spring in Taiwan. Due to the limited resources of natural hot springs in China, drilled artificial hot springs have become an important resource for tourism (by 2004, 2,239 artificial hot springs had been drilled). This resource is expected to have a bright future for development.

Hot Springs Resource Protection This term involves protecting forest vegetation and the ecological and geomorphological environment based on the local conditions to form a protected area large enough for water supply, runoff and drainage. Construction projects that affect, destroy and pollute water resources and water environment are prohibited. Based on the amount of water resources and the environmental carrying capacity, exploitation is restricted to prevent over-exploitation caused by water browning and deterioration of the hydrogeological environment.

Hotan Jade Occurrence, Xin-Jiang The Hotan jade occurrence is a contact metasomatic deposit and is the most famous source of jade in China. The ore bed of the deposit is located along a stream in the Alamas Valley, a tributary of the Keriya River in the Kunlun Mountains, approximately 80 km south of Hotan County, Xinjiang Uygur Autonomous Region. The primary ore bed is located on the contact zone between Late Hercynian granodiorite and altered dolomitic marble associated with metamorphic clastic-carbonate rock of the Proterozoic Pixian System, which has obvious metasomatic alteration and zonation. The Hotan jade ores are located in the marble zone of the deposit. The mineral composition of Hotan jade is tremolite. The Hotan jade can be classified according to its colour, such as opaque white, greenish white, and green. High-quality Hotan white jade is world-famous. Currently, Hotan jade mining is performed by collecting water-polished jade pebbles from a secondary ore sand. Hotan jade was mined from the streams in the valleys as early as the Qianlong Period of the Qing Dynasty. Because it is collected mainly from streams, Hotan jade is called ‘Aqueous White Jade’.

Huaibei National Mining Park, Anhui This park is located in northern Anhui Province on the borders with Jiangsu Province and Henan Province. It became a national mining park in 2005. There are abundant remains of mining activities, including large coal mines that were built and put into production after the establishment of the modern China in 1949, small coal pits exploited by local enterprises and small abandoned coal pits from ancient coal mining activities. The park can be divided into three parts, namely, the Xiangcheng Coal Culture Scenic Area, Xiangshan Earthquake Remains and Nanhu Subsidence Site Recreational Zone. The Xiangcheng Coal Mine is the core scenic site, and it mainly includes mine remains, the main telphers and the main haulage roadway.

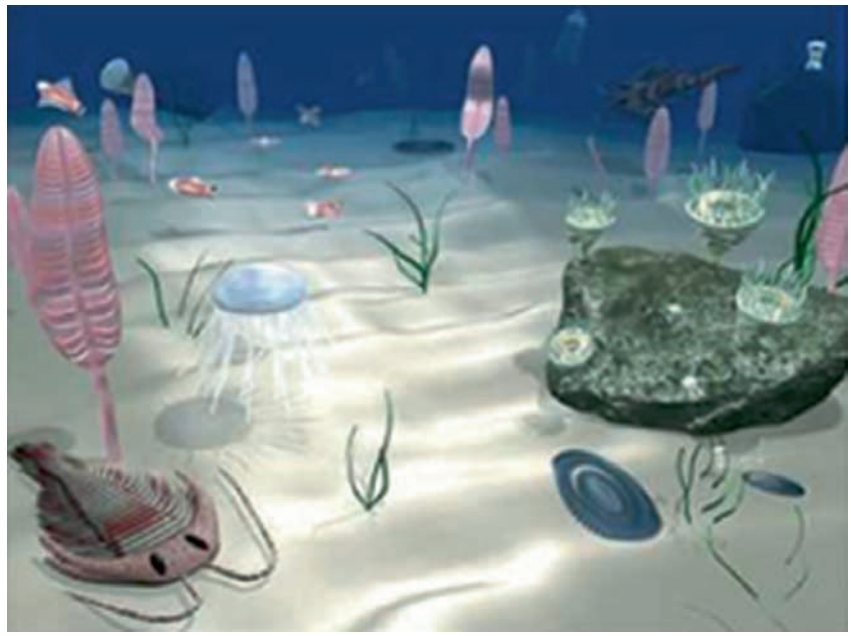


Fig. 26 Huainan biota

Huainan Biota Fossils of the Huainan biota were found in the Liulaobei Formation in the lower part of the Sinian Huainan Group below Bagong Hill, Huainan, Anhui Province. The biota lived 750–800 million years ago. The biota is characterised by animals with no hard shells; hence, the fossils are mostly preserved prints and traces of activity of soft animals, mainly combinations of worms, desmids and acritarch micro-plants. A notable characteristic of the Huainan fauna is that although many types of metazoans had appeared by that time, these animals have only primary features in terms of quantity, geographic distribution and the structure of the organisms. The discovery of these fossils was significant because it indicated that the earliest metazoans were naked and that their bodies had not developed the ability to build hard shells or bones through secretion (Fig. 26).

Huainan Datong National Mining Park, Anhui This park is located in Huainan City in northern Anhui Province and has a planned area of approximately 22.20 km^2. It was designated as a national mining park in 2010. The Datong Coal Mine is the place where the Huainan coal originates. Records indicate that coal mining occurred as early as the Wanli Regime in the Ming Dynasty (1573–1620). The mine was established for exploitation in 1903 and was shut down in the late 1970s due to resource exhaustion, and the shaft mouth, headframe, gangue heaps and other features of mining activity remain. The 'Wanren pit' (a pit that can hold 10,000 people), water dungeon, post-war blockhouses and Yaoshen Temple, which are related to the mining activity, are evidence of the Japanese invasion of China. The park is divided into four areas: a mining heritage conservation area, patriotism education area, ecological restoration area and coal museum.

Huainan Mount Bagongshan National Geopark, Anhui This geopark is located in Huainan City, Anhui Province, and is characterised by a section of Lower Cambrian strata that was formed in the area approximately 540 to 511 million years ago, in which fossils have been found. It became a national geopark in 2002. The geopark is mainly a hilly area with mountains stretching from north to south. The Huai River flows around the mountains in the northwestern part of the geopark, which forms a unique landscape where the mountains and water are closely correlated to each other. Due to the unique geographical and geological conditions, karst landforms and unique peaks and

rocks are spreading throughout the region. The lower, middle, and upper Cambrian strata are rich in fossils, forming good outcrops and are not altered or deteriorated.

Huairou Yuanjinmeng National Mining Park, Beijing This park is located in Liulimiao Town, Huairou District, northeast of Beijing and covers an area of 5.56 km^2. It became a national mining park in 2010. The core mining heritage in the park is the Yuanjinmeng Scenic Area, which is the only gold science popularisation and sightseeing scenic area in China. The park was created from a gold mine that was closed in October 2000. The park includes rich mining heritage, including a gold orebody, prospecting features (gossans, secondary quartzite belts, and dolomite marble peaks), index minerals, structural geologic features, mining features, and mining methods and production heritage, including open-pit mining, mining chambers and mining production structures. Geological investigations, tools and equipment dating back to 1970 as well as Jinzhuan, which was the end product of the Qifengcha gold mine, can also be found in the park. A mining and transportation production system with an elevation difference of 400 m is the only surviving complicated underground mining transportation system in China's gold mines. The gold science popularisation museum and an on-site alchemistic demonstration illustrate the entire gold production process. Gold washing and gold souvenirs highlight the cultural connotations of gold.

Huaiyang Shield Originally, the Huaiyang Shield referred to the main area of the Daibie Mountains between Wuhan along the lower course of the Yangtze River and Nanjing. The term was coined by Huang Jiqing in 1945. The Precambrian crystalline rocks in the area are extensively exposed, and this shield is considered to be a continually uplifted tectonic unit. Its eastward extension is truncated by the Tanlu fault. Later studies revealed that the other side of this 'shield' is the eastward extension of the Qinling Mountains. A thrust system was identified in the Dabie Mountains, which generated debates about the formation of this 'shield'. Numerous Mesozoic granite intrusions are also present in this area. Features associated with the Mesozoic thrust fault system indicate strong Mesozoic intracontinental tectonic activity in the area. These features have facilitated the formation of many scenic geological parks, such as the famous Tianzhushan Global Geopark in Anhui Province and the Dabieshan National Geopark in Hubei Province.

Huanghe Hukou Waterfall National Geopark (Shanxi, Shaanxi) This national geopark is trans-provincial in nature and extends across Shanxi and Shaanxi provinces with an area of 29 km^2. It became a national geopark in 2002. The Hukou Waterfall is the largest waterfall on the Yellow River. It is 20 to 30 m wide, more than 20 m long and has a flow rate of 1000 m^3/s. The falling water generates massive waves tens of metres long that create the roaring sound of 'the thunder of valley'. Shili Long Groove' is the narrowest part of the Yellow River. It is 4,200 m long and 30 to 50 m wide. It is the result of the erosion of the waterfall towards the source. The undercutting effects of the river are very strong. Numerous potholes caused by water erosion have formed in the bedrock. The bedrock that forms the Hukou Waterfall is mainly interbedded sandy shale, soft mudstone and shale, and hard thick sandstone of the Triassic (approximately 200 million years ago) Zhifang Formation. The waterfall is magnificent because of its powerful flowing water.

Huanglong National Geopark, Sichuan This geopark is located in Songpan County in the Aji Tibetan and Qiang Autonomous Prefecture, Sichuan Province. It became a national geopark in 2004. The park is characterised by cold and karst landscapes. The main peak is Minshan, which has a height of 5,588 m above sea level. The karst deposits in the middle of the valley led to the formation of more than 3,400 Yushancai pools with a total area of more than 80,000 m^2, a length of 3.6 km and a width of 30 to 170 m. These pools are arranged

like a 'golden dragon'; therefore, Huanglongou is the Chinese name. These features, in addition to five karst waterfalls and four stalactite caves, create a unique and representative temperate highland karst and travertine landscape.

Huanglong Scenic and Historic Interest Area See ► Huanglong National Geopark, Sichuan, ► Jiuzhaigou Valley Scenic and Historic Interest Area.

Huangshan Geopark Granite Geology and Geomorphology Symposium The Huangshan Geopark Granite Geology and Geomorphology Symposium was held in Huangshan on 4–9 April 2009. It was organised by the Chinese Academy of Tourism Earth Science and Geopark Research, Geological Society of China, and included more than 80 participants. The main theme was a review of research results on the formation and evolution of Huangshan granite geomorphology and landscapes. This was the first special research project on granite geomorphology and landscapes by the Academy. The 'Huangshan Granite Geology and Geomorphology Proceeding' was published.

Huangshan Global Geopark, China *Synonym:* ► *Huangshan National Geopark, Anhui*

This geopark is located in Huangshan City, Anhui Province. It has an area of 160 km^2. It was one of the first geoparks approved by the Global Geoparks Network in 2004. The geopark has nine scenic attractions, including hot springs, Yuping, Beihai, Yun Valley, Pine Valley, Diao Bridge, Yang Lake, Floating Creek and Fugu. It is geologically characterised by a granite landscape and is enriched by outstanding geological relics and ecological objects of interest, such as Quaternary glacial relics, water landscapes and rare fauna and flora. Huangshan is well-known for its high peaks with distinctive shapes, with 72 peaks with heights over 1,000 m and three major peaks. Lotus Peak (1,864 m above sea level) is the highest peak in Huangshan Geopark and the highest peak in East China. Guangming Ding, the second highest peak in Huangshan, has an elevation of 1,840 m, and the third highest is Tiandu Peak, which is 1,810 m above sea level. Numerous U- and V-shaped valleys radiate from the centre of Huangshan, where numerous granite pinnacles are located. The main geomorphological features include dome-shaped, cone-shaped, ridge-shaped, columnar and box-shaped peaks. It is where the 'Mount Huangshan - Sanqingshan Type' granite peak landscape was named.

Huangshan National Geopark, Anhui See ► Huangshan Global Geopark, China.

Huangshan Stone This is a type of rock with ornamental value produced in the Huangshan area. Mount Huangshan stone can be divided into water-washed stones and mountain stones (dry stones). The varieties that have been mined are the yellow wax stones, pearl stones, Machuan stones and drum nail stones, all of which are water-washed stones. Yellow wax stones and pearl stones can be either water stones or dry stones. Some have very high ornamental value (Fig. 27).

Huangshan, Anhui Huangshan is located in Huangshan City, Anhui Province. It covers an area of 160 km^2. It is a scenic attraction with granite peaks, fault-block mountains and Quaternary glacial relics. The three iconic peaks, namely, Lotus Peak (1,864 m above sea level), Tiandu Peak and Guangming Peak, are famous for their exotic pines, unique rocks, clouds and hot springs. The famous scenic sites include Er



Fig. 27 Huangshan yellow wax stone

Lake, San Waterfall, Twenty-four Stream, and Seventy-two Peaks. Xu Xiake exclaimed 'After seeing the Five Mountains, there is no need to see any other hills. After seeing Huangshan, there is no need to see the Five Mountains'.

Huangshi National Mining Park, Hubei This park is located in Huangshi City, Hubei Province. It covers a total area of 30 km^2 and was approved as one of the first group of national mine parks in August 2005. It contains three mine geological relics, three mine production sites and two mining activity sites. There are eight landscapes: Oriental Sunrise Square, a mine exhibition centre, an underground exploration area, Stone Sea and Oasis, Millennial Apricot, Saint Mountain and Ancient Temple, Zhishan Misty Rain and Nine Dragons Cave.

Huascarán National Park, Peru This park is located in the Pacific coastal province of Ancash in central Peru. It consists of the antiquities of a world cultural heritage site and protects an area of 3,400 km^2. Mount Huascarán, which is in the world's highest tropical mountain range, the South American Cordillera, rises to 6,768 m above sea level. The park is also home to such species as the spectacled bear and the Andean condor.

Huguan Mount Taihangshan Gorge National Geopark, Shanxi This geopark is located in the central and southern parts of Mount Taihangshan. It became a national geopark in 2005. The terrain is gentle in the northwest and steep in the east. There are more than 150 peaks and 3,400 ravines and gorges of different sizes around Huguan Taihangshan Canyon. These gorges intersect to form grand and steep precipices over 100 m high. The elevations of most peaks range from 1,000 to 1,300 m with an average elevation of 1,252 m, and the maximum elevation is 1,822 m. The geological landscapes feature deep gorges cutting through Palaeozoic carbonate rocks. The geopark consists of six scenic spots, including Wangmang Gorge, Baquan Gorge, Qinglong Gorge, Wuzhi Gorge, Hongdou Gorge and Wanfo Mountain.

Huguangyan Maar Lake Landscape, Zhanjiang Huguangyan in Zhanjiang is a crater lake. This type of lake is composed of a low flat crater that forms during a phreatomagmatic eruption induced by the interaction of hot magma with groundwater. This type of lake is also known as a maar. Huguangyan has an area of 2.3 km^2 and a water depth of 22 m. It is one of the maars of the Leiqiong volcanic zone. It never dries up and has a self-cleansing ability (Fig. 28).

Hukou Waterfall Landscape of the Yellow River Located east of Yichuan County in Shaanxi Province and west of Ji County in Shanxi Province, the Hukou Waterfall is a natural waterfall where the middle course of the Yellow River flows through the Shaanxi-Shanxi Canyon. The fall width is 50 m, the depth is approximately 50 m, and the largest fall surface has an area of 30,000 m^2. This waterfall is located at the spot where the river, which is more than 300 m wide, is suddenly bound by the river banks and drops 50 m in a gap with a wide top and a narrow bottom. The flow roars and looks like water pouring from a pot, which is why it was given the name 'Hukou (Tea Pot Mouth) Waterfall'. The ancient book Yu Gong states: 'the river flows out in a vortex like water being poured from a pot', and this description vividly captures the scenery (Fig. 29).

Human Geography Human geography is one of the two main branches of geography. Based on the regional system of human-earth relations, this field focuses on the distribution and evolution of surface human phenomena, the formation and characteristics of their spatial structures, forecasts of their development and the patterns of changes. Sociality, regionality and comprehensiveness are the basic characteristics of this discipline. The identification and analysis of human geographic factors are the basis for conducting surveys of tourism resources and preparing tourism plans.

Human Living Environment The various natural and social environments that affect human survival are the sum of various natural and



Fig. 28 Maar-type crater landscape at Huguangyan, Zhanjiang



Fig. 29 Hukou Waterfall landscape of the Yellow River

social factors that affect human survival and development. The human living environment is a complex system that interacts with humans and geography and is the basis for the sustainable development of human society. It is also a general term for natural and artificially modified natural factors.

Hupao Spring Landscape This is a spring landscape consisting of Hupao Spring, which ranks first among the springs in West Lake. It is located next to the Huizen (Wisdom of Zen) Monastery below Baihe (White Crane) Peak on Daci (Great Mercy) Mountain, southwest of Hangzhou. It has been ranked as the 4th most

historic spring in China. The name came from the legend that the spring water flowed after two tigers ran across the ground. The spring water actually comes from an aquifer that was cut by the Daci Mountain Fault, and the water seeps from the sandstone along the fault to form a subsidence spring. The spring has a flow volume of 43.2–86.4 m^3 per day. The water is crystal clear and has a sweet taste. It is excellent for making tea; hence, it has become an important tourist attraction in West Lake.

Hurricane Hurricanes occur in the eastern Pacific Ocean, the Atlantic Ocean and the Caribbean. They are tropical cyclones with winds exceeding magnitude 12 (maximum wind speeds of 32.7 m/s). An eye is located at the centre of a hurricane. The smaller the centre is, the stronger and destructive it will be.

Hushan National Geopark, Jiangxi See ▶ Longhushan Global Geopark, China.

Hutiao Gorge Landscape The Hutiao Gorge is located along the upper course of the Jinsha River northeast of Shigu in Lijiang Naxi Autonomous County, Yunnan Province. Its total length is 18 km, and it is divided into 3 sections, Upper Hutiao, Middle Hutiao and Lower Hutiao, which stretch circuitously for 25 km. Yulong Snow Mountain is to the east, and Diqing Haba Snow Mountain is to the west. The upper gap of Hutiao Gorge is at an elevation of 1,800 m, and the lower gap is at an elevation of 1,630 m. The height difference of the canyon is 3,790 m. There are seven consecutive headcuts along the gorge with a drop of 170 m. The river flow is torrential, and its roar can be heard miles away. It is one of the world's deepest gorges. The narrowest part of the channel is slightly more than 30 m wide. A local legend states that in the past, a tiger from the mountains jumped to the opposite bank, which is why this gorge is called Hutiao (Leaping Tiger) Gorge. The gorge contains abundant rock pillars, 21 shoals with dangerous rapids, seven drops more than 10 m high and 10 waterfalls (see plate of the Hutiao Gorge landscape) (Fig. 30).



Fig. 30 Hutiao Gorge landscape

Huzhu Mount Beishan National Geopark, Qinghai Huzhu Mount Beishan National Geopark is located in the eastern Qilian Mountains. It is in the northeast mountainous areas of Huzhu County, Qinghai Province, along the downstream section of the Datong River and along the border between Gansu and Qinghai Provinces. It became a national geopark in 2005. The elevations of the geopark range from 2,100 to 4,308 m, and it has a unique plateau climate with temperatures that range from 0 °C to 3.8 °C. It has a pleasant and cool summer with abundant sunlight and high atmospheric transparency. It has abundant light resources contains crisscrossing ravines and gullies and a well-developed river system. It is a comprehensive geopark that features high-elevation karst landscape relics, Quaternary glaciers and red beds.

Hydrogen Sulphide Spring This is a hot spring that contains hydrogen sulphide. It is also called a sulphur spring. Bathing in this spring

water can cure skin diseases. A notable feature is the smell of bad eggs. The main health care effects are skin softening, dissolving cutin, sterilisation and insecticidal effects. The water is remarkably effective for treating skin diseases. It can repair a damaged nerve system and can be applied to patients with nerve injuries, neuritis and muscle paralysis. Hydrogen sulphide springs are suitable for treating chronic joint diseases because the water can promote the absorption of lubricants and alleviate tension in ligaments. Because sulphur springs contain minute colloidal sulphur molecules, which can easily enter the body and act as catalysts to discharge waste from the skin and kidneys, they have certain effects on metabolic diseases.

Hypersthenite Hypersthenite contains 30–50% $Fe_2Si_2O_6$, and the remainder is $Mg_2Si_2O_6$. It belongs to the clinopyroxene family, crystallizes in an orthorhombic crystal system and occasionally forms columnar crystals. It often appears in bladed or platy aggregates and is brownish green or black with brownish grey streaks. Its diaphaneity is translucent to opaque, and it has a submetallic lustre, a specific gravity of 3.4–3.8, a Mohs hardness of 5–6 and serrated fractures. It forms in ultramafic and mafic rocks.

Hypostratotype A hypostratotype is a stratotype proposed subsequent to the designation of a specific holostratotype (and parastratotype) to extend its coverage to other geographical localities.

I

Ibiza, Biodiversity and Culture Ibiza, Biodiversity and Culture, Spain This area is located in the southwestern part of the Balearic Islands in the Mediterranean east of Spain. The core protection area covers 85.64 km^2. Ibiza is an excellent example of the interaction between marine and coastal ecosystems. An important indigenous species that can only be found in the Mediterranean Basin, Posidonia seagrass, covers dense submarine grasslands, which support marine biodiversity. Ibiza also has well-preserved historic sites. The archaeological site of the Sa Caleta and Quebec-Pylos Moulins (Windmill Hills) cemeteries are from prehistoric times when the Phoenicians and the Carthaginians were active. The island played an important role in the Mediterranean regional economy. The fortification complex (Alta Villa) is an outstanding example of a Renaissance military installation. As the Spanish settled in the New World, it had a profound impact on the development of military defence facilities.

Ice Bar ▶ Cross Wall Landscape

Ice Cap This is also known as an ice hat or ice dome. It is a cover-type glacier that is smaller than an ice sheet with a similar form but a more pronounced dome shape. Due to differential pressure, the ice inside the ice body flows in a radial pattern. It is a transitional type of glacier between an ice sheet and a mountain glacier. Ice caps are mainly found in plateaus and on islands at high latitudes; therefore, they can be further divided into plateau ice caps and island ice caps (Fig. 1).

Ice Cascade Landscape This is a landscape composed of waterfall-like glacial ice on modern glaciers. When a glacier reaches a steep slope, the glacial ice will fall or slip like a waterfall, which has led to the name ice cascade. Many cracks are located above the ice cascade, whereas fallen ice is abundant below. Ice cascades can form in the middle of a glacier or in the ice tongue (Fig. 2).

Ice Cavern Landscape This is a landscape with empty cavities in a modern glacier. An ice cavern is a product of ice ablation inside an ice body. Water on the ice surface can flow into the glacier along crevasses and cause internal ice ablation, which can form many glacial karst features, such as glacial funnels, glacial wells, glacial tunnels, glacial caverns and glacial windows (Fig. 3).

Ice Column Landscape Due to the undulating glacier bed, the hard and brittle ice in the upper layer of a moving glacier will develop crevasses under tension. A column-like or peak-like ice body can form between two crevasses; this type of landscape is called an ice column landscape (Fig. 4).

Ice Cone ▶ Icicle

Ice Mushroom Landscape This is a landscape composed of mushroom-like glacial features. An ice mushroom forms when an ice pillar is covered by a rock, causing differential ablation that results in a shape similar to that of a mushroom. When the surrounding ice melts, the ice beneath the rock remains due to the shadow of the rock. Ice mushrooms can have various sizes (Fig. 5).

Ice Sheet An ice sheet is also known as a continental ice cap. It is called an ice sheet when the total area is more than 50,000 km. An ice sheet is very thick and has a shield-shaped surface that flows from a central ice layer up to 2–3 km thick to the surrounding area. The ice sheets in Antarctica and Greenland are typical examples (Fig. 6).

Ice Tower Forest Landscape This is a landscape of ice towers on the surface of a modern glacier. A tower-like ice body left behind at the glacier's end is called an ice tower, and a cluster of ice towers is called an ice tower forest. Ice towers are generally separated from the ice tongue. Dense moraines always lie between the ice towers, and the moraines always contain dead ice (Fig. 7).

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Fig. 1 Glacier remains landscape of the Pleistocene Baiyu icecap, northern Shaluli Mountains, western Sichuan (with a group of ice-scoured lakes and glacial erratic clusters, approximately 3,000 km^2)

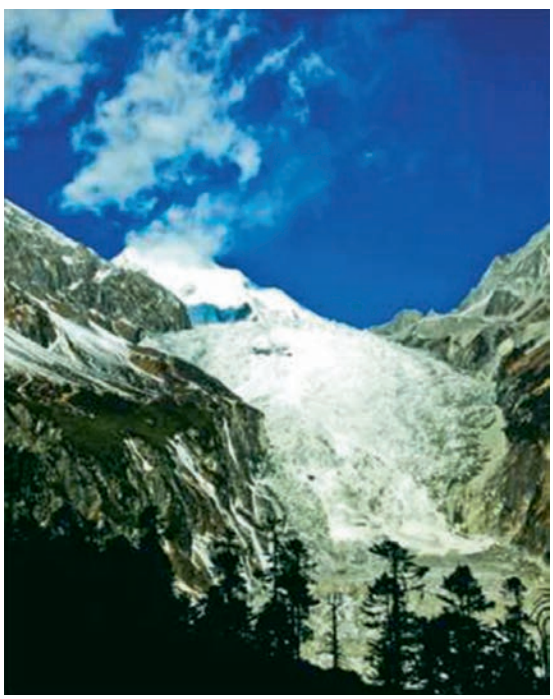


Fig. 2 Ice cascade landscape at Hailuogou glacier, western Sichuan

Ice Wedge Landscape This is a landscape consisting of an ice body formed by melted ice in the summer that tapers downwards through the active layer of permafrost. When the temperature drops during persistent cold weather, the water in cracks in the rock freezes. The ice layers grow through continuous freeze-thaw action, deepening and widening the cracks and putting pressure on the surrounding rock. When the ice penetrates through the active layer and wedges into the permanently frozen layer, the ice does not melt in the summer and forms an ice wedge (Fig. 8).

Iceland Spar Iceland spar is a colourless transparent calcite with the composition of $CaCO_3$. Transparent Iceland spar has a very high birefringence, so it is mainly used in the manufacturing of special optical instruments. High-quality Iceland spar forms in calcite and zeolite veins in basalt because its formation is related to hydrothermal processes. Iceland spar can also be found in limestone, but the crystal quality is comparatively low.

Ice-Scour Lake Landscape This is a type of glacial lake landscape consisting of lakes that is created by glacial erosion. When a glacier flows down a valley due to gravity and pressure, it carries abundant debris that abrade the bedrock surface. A depression can form, or the glacier may scour an existing depression into a lake basin. When the glacier melts, the outlet may be blocked by debris, which can prevent water from flowing out and forms a lake. These



Fig. 3 Ice cavern landscape in Hailuogou glacier, Western Sichuan



Fig. 4 Ice column landscape, Tibetan Plateau

lake basins have elongated shapes and gentle shores. Drift gravels often remain. The bedrock surface of the basin wall and basin bottom often have glacier-polished surfaces and striation marks. Many lakes in the Tibetan Plateau, Kanas Lake in Xinjiang Province, Xinluhai Lake in Dege County, Sichuan Province, and the Taibai Pool in Taibai Mountain, Shaanxi Province, are ice-scour lakes.

Ice-Scoured Lake Landscape This landscape is composed of water-filled depressions that is formed by glacial erosion. In alpine or high-latitude areas, abrasion and plucking create depressions that, when filled with water, form ice-scoured lakes. In general, the lake basins are made up of hard bedrock, and the basin's walls and bottom often have polished surfaces, deep glacial striations and scars (Fig. 9).

Ichkeul National Park, Tunisia Ichkeul National Park is located in the coastal area of northern Tunisia near the Mediterranean Sea. It has a core protection area of 126 km^2. The Ichkeul Lake and wetlands are a major stopover point for hundreds of thousands of migrating birds, such as wild ducks, wild geese, storks and

flamingos, which come to feed and nest. Ichkeul is the last remaining lake in a chain that once extended across North Africa.

Ichnofossil *Synonym:* ▶ *Trace fossil*

An ichnofossil is a geological record of the traces of living creatures during their life, such as footprints, trails, dwelling caves, foraging trails, and working tools or decorations of ancient humans.

Ichthyosauria; Ichthyosaurs (Ichthyosaurus)

Ichthyosaurus was a type of reptile which returned to the sea from land. It was not dinosaur. It lived during the Triassic and Jurassic. China's ichthyosaurus fossils are mainly located in the Upper Triassic Series in Anhui, Hubei and Sichuan Provinces and the Triassic Series in Guizhou Province and Tibet. The primitive ichthyosaurus fossils found in the rocks of the late stage of the Early Triassic in Yuan An, Hubei Province, and Chaohu, Anhui Province, are recognised as one of the world's oldest ichthyosaurus. The abundance and ideal preservation conditions of the ichthyosaurus fossils found in Guanling National Geopark in Guizhou have made this location a top site of this kind. China's most famous ichthyosaurus fossil is the 160-million-year-old 'Himalayasaurus', which was found in the 1970s at an elevation of 4,800 m on the southern slope of the Himalayas. This fossil is more than 10 m long and contains more than 600 teeth (Fig. 10).



Fig. 5 Ice mushroom landscape at Tuomoer glacier, Xinjiang

Icicle *Synonym:* ▶ *Ice cone;* ▶ *Pingo landscape*

An icicle landscape is also known as a spring ice cone landscape. When pressurised water flows through the ground and spills out from the ice layers into rivers and lakes, the water freezes to become ice layers or cone-like ice bodies that point upward. These cones are called icicles, which are different from ice mounds. The former are frozen ice on the ground, whereas the latter are ice nuclei that froze underground.



Fig. 6 Greenland ice sheet



Fig. 7 Ice tower forest landscape at the Rongbu Temple glacier below Mount Qomolangma



Fig. 8 Ancient ice wedge landscape at Lulin, Lushan Mountain, Jiangxi Province

Igneous Rocks See ► Magmatic Rocks (Fig. 11).

Ignimbrite *Synonym:* ► *Welded tuff*
Volcanic eruptions generate hot gases and fluids that mix with clastic materials and then flow along the ground surface. An ignimbrite is a volcaniclastic rock formed by the consolidation of these materials and has a pyroclastic structure. It is characterised by the presence of plastic fragments (magma fragments), and after consolidation, it appears as flame-like lava banding (called fiamme) and has a flow-like structure.

Iguazu National Park, Argentina Iguazu National Park is located in northeastern Argentina near the borders with Paraguay and Brazil. It has an area of 550 km^2. The semi-circular waterfall at the heart of the park is 80 m high and 2,700 m in diameter, and it is situated on a basaltic



Fig. 9 Ice-scoured lake in the Daxueshan area, Western Sichuan





Fig. 10 Ichthyosauria

line along the border between Argentina and Brazil. The park is made up of many cascades that produce vast sprays of water and has one of the most spectacular waterfalls in the world. The surrounding subtropical rainforest has more than 2,000 species of vascular plants and is home to the typical wildlife of the region, including tapirs, giant anteaters, howler monkeys, ocelots, jaguars and caimans.



Fig. 11 Formation of igneous rocks. 1. Batholith, 2. Lopolith, 3. Sill, 4. Cupola, 5. Weathered Hypabyssal rock body, 6. Stock, 7. Lava dome, 8. Pluton, 9. Dyke and apophysis, 10. Xenolith, 11. Volcanic ash layers, 12. Ash plume, 13. Cinder cone, 14. Lava flow, 15. Lava plateau

Ilulissat Icefjord, Greenland This site is located in the Danish territory on the west coast of Greenland, approximately 250 km north of the Arctic Circle, and it has a core protection area of 4,024 km^2. Ilulissat Ice Bay is the end of the Sermeq Kujalleq glacier, which is one of the few glaciers originating in the Greenland ice cap that reaches the ocean. The Sermeq Kujalleq Glacier is also one of the fastest-moving glaciers in the world (19 m/day). It releases ice into the ocean at a rate of 35 km^3 per year, which is equivalent to 10% of Greenland's ice every year; this is more than any glacier outside of Antarctica. The protected area contains large ice sheets and rapidly moving glaciers. The icebergs make loud noises when they move, which is a fascinating natural phenomenon that attracts tourists.

Image Stone The image stone is also known as pictographic stone and is a common type of ornamental stone. It usually refers to stones with peculiar shapes that resemble the natural landscape, animals and plants, humans or the abstract concepts. It is also a type of ornamental stone associated with a higher level of traditional Chinese stone culture and research and a more comprehensive coverage of theory. In March 1921, Hongyi Zhang, the first president of the Chinese Geological Society, proposed the term 'image stone' in the monograph 'Shi Ya' (Stone Elegance); in which he stated 'natural lives are endowed with their own shapes, which do not fully cover their entire bodies but manage to leave their images.' The encyclopaedia follows this naming convention, and the stones are generally rocks with simple mineral compositions (e.g., carbonate rocks and siliceous rocks). Due to internal and external geological processes, ornamental stones of various shapes can form. In the past, the rock characteristics of 'slimness, wrinkliness, leakage and penetrability' were considered beautiful in a stone, and emphasis was put on the essence, qi (air) and spirit. Today, the shape, colour, quality and rhyme have become the top criteria. In addition, the actuality, completeness and likeliness of the image are crucial factors for appreciation and enjoyment of beauty. The general trend is to seek a common ground to improve the level of appreciation to satisfy people's needs for ornamental stone aesthetics (Fig. 12).

Incentive Tourism Incentive tourism is a way to reward employees in companies. A modern management technique is to award employees who have achieved certain goals with special holiday tours. Incentive tourism can also include tours for potential clients arranged by businesses whose ultimate goal is to develop a market and secure customers. Cities in China with rapidly developing incentive tourism markets are Guangzhou, Beijing and Shanghai.



Fig. 12 Image stone

Incised Meander Landscape This is also known as an embedded meander landscape and comprises meanders that have deeply incised into the bedrock in mountainous areas. If the land is uplifted after the formation of a meander and the incision rate is equal to the uplift rate, the meander maintains its original form and continues to cut into the bedrock to form an incised meander. An incised meander has similar characteristics of a mountain valley. Typical incised meanders are located in the mountainous sections of the Jialing River, Yongding River and Hutuo River. When an incised meander continues to develop, it can cut off the river, leaving behind an isolated raised bedrock knoll between the straightened river course and the bend. This raised knoll is called a meander core (Fig. 13).

Indian Plate The India Plate is also known as the Indo-Australian Plate. This plate includes Oceania, the Indian subcontinent and the northern and eastern parts of the Indian Ocean. Its southern boundary is the oceanic ridge in the southeastern Indian Ocean, which separates it from the Antarctic Plate. A deep trench separates its eastern side from the Pacific Plate. It is bounded to the north by the suture zone between the Java Sea Trench and the Yalung Zangbo Plate. The western boundary is composed of the oceanic ridges in the central Indian Ocean, which separate it from the African Plate.

Indosinian Movement The Indosinian movement was an episode of crustal movements that lasted for the entire Permian Period, including several tectonic movements between 250 and 203 million years ago. The main events occurred during the late Triassic Epoch. The Kunlun-Qinling orogenic belt had previously experienced several ancient orogenic events and was completed during the Indosinian movement. The Indosinian movement was an important period of tectonic deformation, magmatic activity, metamorphism and regional mineralization in China, and it was also a remarkable period in the transition of China's continental tectonic pattern and dynamic system. It played an important role in China's geological history and tectonic evolution.

Industry Tourism Industry tourism includes tourism activities at industrial sites. Industrial and mining enterprises can integrate or re-develop their resources to highlight their attraction and turn them into tourist attractions. In recent years, industrial tourism has developed rapidly in China. Several cities have successively developed effective industrial tourism products and formed numerous outstanding industrial tourism projects, including Shanghai Bao Steel, the Haier Industrial Park, and the Three Gorges Project. A new type of industrial tourism is the establishment of parks in mines after remediating the waste and highlighting the geological resources and mining activities to visitors.

Injection Injection is the process in which foreign substances penetrate into the parent rock via schistosity or fissures. A common injection process is the intrusion of granite into the schistosity and fissures of metamorphic rocks to form new feldspar or quartz with banded, augen or dendritic distributions to form 'injection gneiss'. During the injection process, metasomatism is insignificant.

Inkstone *Synonym:* ► *Ink-slab*

Inkstone is a kind of stationery associated with ink grinding and brush writing. In general, four types of stone materials are used to make inkstone: argillaceous rocks, slate, phyllite and carbonaceous rocks. Like paper, writing brushes and ink, inkstone has played an



Fig. 13 Meander landscape

important role in the spread of Chinese civilisation and the development of Chinese art and culture. Inkstone is also the most popular collectible of these four writing tools. The stone materials for inkstone must have a fine texture and be able to hold moisture and facilitate ink grinding. Therefore, the stone should have the characteristics of (1) a suitable hardness (Mohs scale of 3–4) that is ideal for ink grinding; (2) an appropriate grain size in the range of 0.01–0.001 mm, which can facilitate grinding of the ink particles to the correct size to form an oily ink solution; and (3) a suitable mineral flake array with a particular angle to the inkstone surface to ensure proper grinding and water retention to reach a state where the water does not dry and the brush can move smoothly. Inkstone production has a long cultural history in China. A primitive form of inkstone, a stone grinder, existed during the Yanhshao cultural period, approximately 6,000 years ago. The Tang Dynasty was the peak period for making inkstone with the continuous development of stone relief carvings. During that time, four major inkstones, the Duan inkstone, Xi inkstone, Tao inkstone and Red Silk inkstone, were developed. During the Ming and Qing Dynasties, the inkstones were of exquisite quality and in line with the pursuit of natural beauty, reaching a level of perfection in stone quality and art design. Different inkstones have different characteristics in terms of the stone quality and patterns because the stones have different mineral compositions. In addition to these major stones and the Helan stone and Juque stone, there are also many other famous types.

Ink-Slab ► Inkstone

Inland Lake An inland lake is the water body at the end of an inland river or an inland catchment area that forms the lake itself. Inland lakes in China are mainly located in Inner Mongolia, Xinjiang Province, Gansu Province, Qinghai Province and Tibet, such as Qinghai Lake and Lop Nur. Areas of inland lakes are far from the ocean and have dry

climates. The replenishment of the lake mainly comes from runoff, but water loss is mainly through evaporation of the lake water. Some lakes have no outflow, and all of the water is evaporated. Some inland lakes have only a limited water supply but intense evaporation, causing them to shrink gradually and eventually become a saltwater lake or salt lake. As a result of drought and increasing water consumption in the upper courses, many inland lakes are shrinking or drying up. Typical examples are Juyanhai Lake and Lop Nur, which have already dried up (Fig. 14).

Inner Mongolian Axis This axis is an elongated uplifted tectonic structure along the northern margin of the North China Platform. The name was coined by Huang Jiqing in 1945. It runs east from Alashan in the west via Daqingshan Mountain in Inner Mongolia to Yanshan Mountain in Hebei. Its total length is approximately 2,000 km, and it is approximately 300 km wide. Precambrian crystalline basement outcrops are extensive in the region, which are overlain by Mesozoic and Cenozoic basin sediments. There is a lack of Palaeozoic sedimentary cover. For a long time, this structure was considered a palaeo-uplift separating the North China Platform from the Xingmeng Sea Trough to the north during the Palaeozoic Era. However, later research suggested that it might have formed due to Mesozoic thrusting and subsequent exposure of the Cambrian System and that it was not an uplifted area in the Palaeozoic.

Insect Fossil Insects are a class of Arthropoda. Their sexes are separate, and they mainly develop by metamorphosis. They first appeared in the late Devonian, and they have lasted until the present. Insects account for 80% of all animal species. China's insect fossils are mainly found in Late Jurassic-Early Cretaceous and Neogene shale. Examples are the fossils of Ephemeropsis, split-tail shrimp, dragonflies and bees discovered in the dense



Fig. 14 Qinghai Lake landscape



Fig. 15 Insect fossils

greenish brown shale in the Upper-Lower Jurassic strata in eastern Hebei, western Shangdong and western Liaoning Provinces. Other examples are the fossils of mosquitoes, midges, flies and ants preserved in amber mined in the lower Palaeogene rocks in the Fushun Coalfield in Liaoning Province and the amber containing mosquitoes, flies, ants and moths found in the lower Palaeogene paper-like diatomaceous shale in Linqu, Shangdong Province. Insect fossils inside well-preserved amber are most valuable. China's prime sites for excavating insect fossils are in Laiyang, Shangdong, where there is a wide range of abundant and intact insect fossils (Fig. 15).

Intangible Cultural Landscape Tourism Resource System This is a landscape created by humans that is related to the spiritual aspects of a civilisation. For example, the oral literature, performing arts, social customs, traditional handicrafts and other non-material cultural features constitute a rich non-material cultural landscape tourism resource system that is tangible but immaterial. It is maintained by human beings, and it is also a comprehensive representation of mankind's productivity, lives, science, technology and artistic creativity. It has important travel and tourism value.

Interlobate Moraine Bar Landscape ▶ Medial Moraine Bar Landscape

Interior River ▶ Internal River

Intermediate Rocks Intermediate rocks are another large group of igneous rocks. The rocks contain 53–66% SiO_2. The main mineral is feldspar, often with a small amount of quartz. Intermediate rocks contain more dark minerals, such as hornblende and pyroxene (usually approximately 30%), than acidic rocks. Common intrusive intermediate rocks include diorite and quartz diorite, and common extrusive intermediate rocks include andesite and dacite.

Intermittent Spring Landscape This is a spring landscape consisting of springs in a modern volcanic area with periodic water or vapour eruptions. The eruption height can reach several metres to dozens of metres. The springs are generally alkaline, often contain silica and carbon dioxide, and sometimes contain boric acid. Typical examples are the Old Faithful Geyser in Yellowstone National Park in the United States and the Yangbajing Hot Spring in Tibet, China.

Internal River *Synonym:* ▶ *Interior river;* ▶ *Endorheic river*

Rivers that do not flow into the ocean but rather into an inland lake or are lost in the desert are called endorheic rivers. These rivers are mainly located in arid and semi-arid areas with sparse rainfall or in closed mountain plateaus, basins and low-lying areas.

They usually have sparse, small and short tributaries, and most flow into the basin alone, lacking a complete fluvial system. They generally have small water volumes, and most are seasonal intermittent rivers. The longest endorheic river in China is the Tarim River, which is 2,197 km long and has a river basin of 198,000 km^2. This river is the lifeline of the oasis economy, natural ecology and people's livelihood in the Tarim Basin.

Interpretative Panels and Boards, Upgrading All interpretive panels and boards must be reviewed and updated on a regular basis, usually every 1 or 2 years, for various reasons. One is the fading of the colour of the printing due to UV light as a result of the continuous exposure to sunlight, ageing, graffiti or damage by vandalism. In addition, the materials of the panels and boards, such as steel, may rust due to wet conditions. Other reasons include improvements and updates to the content to make it more accurate, easy to understand and interesting to visitors.

Interpretive Panel and Board at Scenic Sites These are part of the outdoor interpretation system of a geopark. They use easy-to-understand words and expressions, pictures and diagrams to explain the scientific, ecological, cultural and historical significance of the scenic features. They are usually bilingual in Chinese and English but can also be in other languages, such as Korean, Japanese and Spanish. The panels and boards are set up at safe and convenient locations, usually on major walking trails, where tourists can gather and rest.

Introduction to Geopark Planning This book was written by Tongde Li and was published by China Architecture and Building Press in 2007. The book briefly introduces the history of geopark development and systematically discusses the concepts, principles, methodologies and structures of geopark planning. It also provides an in-depth analysis of the common problems encountered in the planning and design of nature-based scenic parks and areas. The book includes attachments with detailed planning examples as well as documents and practical data related to geopark planning.

Introduction to Landscape Science This book was written by Wenkui Ding and was published by Shanghai Science and Technology Education Publishing House in 1993. The book has a total of 226,000 words. The content is divided into four parts: 1. discussion of the system of landscape science; 2. analysis of landscape resources; 3. systematic summary of scenic area planning over the past 13 years; and 4. a proposal of the guiding theory and new ideas in landscape design.

Introduction to Tourism Earth Science This book was written by Guizhen Pang et al. and was published by Shaanxi Science and Technology Press in 2006. The book provides greater detail about the basic knowledge, principles and methodologies of tourism earth science. It covers the studies of tourism, geology, geography, hydrology, geophysics, environmental geology, astronomical geoscience, rock technology and management. The three major characteristics of tourism earth science (i.e., practicality, comprehensiveness, and science popularisation) are highlighted.

Intrusive Body; Intrusion Intrusive body is a general name for a rock mass that is formed by the cooling of magma that intruded into the crust. Intrusive rocks have several modes of formation. For example, sills, laccoliths and lopoliths intrude along the surrounding rock layers, whereas dykes, stocks, bosses and batholiths intrude oblique to or cut across the layers of the surrounding rock.

Intrusive Contact Intrusive contacts are the surfaces between the surrounding country rock and an intrusive magmatic body that cools after the intrusion. The edge of the intrusive rock mass contains fine crystalline minerals due to the rapid cooling and forms a chilled margin. The country rock responds to the high heat and fluid dynamics from the intruding magma to form a contact metamorphic zone by recrystallization. The primary flow surface

structure of the rock mass is consistent with the contact surface. Intrusive contacts are important evidence for determining whether a rock mass is an intrusive body and to identify the sequence of intrusion.

Intrusive Rocks Intrusive rocks are rocks that form when magma solidifies in the Earth's crust. Magma cools slowly in the subsurface, and the rocks are composed of crystalline minerals. Based on their depths, intrusive rocks can be divided into (1) plutonic rocks, which are generally located at depths greater than 3 km, (2) hypabyssal rocks, which form at depths of approximately 1.5–3 km, and (3) ultra-hypabyssal rocks, which form near the surface. The crystals of plutonic rocks are relatively coarse, whereas those of ultra-hypabyssal rocks are relatively small.

Inverted River An inverted river, called Daotanghe in Chinese, refers to a river that originates in the Qagan prairie at the piedmont of Riyue (Sun and Moon) Mountain and flows from east to west into Qinghai Lake. This river is at an elevation of 3,300 m and is 40 km long. Daotanghe originally flowed east into Huanghe (Yellow River) with the Buha River and Luohantang River. After the uplift of Riyue Mountain due to tectonic movements, the river changed direction to become an inverted river that flows west into Qinghai Lake. It is the smallest portion of the Qinghai Lake system. At high tide, water from Qinghai Lake flows back into the river, which is another reason that this river was given its name.

Involution Landscape ▶ Brodelboden Landscape

Iodine Spring This is a spring where the iodine ion (I1-) content is greater than 5 mg/L.

Iodine Water This is hot mineral water that contains iodine. Its occurrence and distribution are similar to those of bromine water, and it is usually found in the deep parts of sedimentary basins containing salts and hydrocarbon. The iodine content of hot mineral water and hot brine is lower than the bromine content. Based on its usage, iodine water can be divided into industrial iodine water, medical iodine water and drinking iodine water. Iodine water is mainly applied to the treatment of diseases such as arteriosclerosis, hyperthyroidism and rheumatoid arthritis.

Iron Spring This is a spring where the content of iron cations (Fe^{2+}+Fe^{3+}) is greater than 10 mg/L. The anions are mainly sulphate or bicarbonate ions. When the ions combine, a hot spring with ferrous sulphate, ferric sulphate or ferric carbonate can form.

Is-Chigualasto/Talampaya Natural Parks, Argentina These two natural parks are located in the desert along the border between the provinces of San Juan and La Rioja in western Argentina. This area is along the western edge of the Pampas Mountains in central Argentina and covers an area of 2,753 km^2. It contains the most complete record of the continental fossils from the Triassic (245–208 Ma). The fossils of dinosaurs and ancient plants have revealed the characteristics of numerous Triassic vertebrates and natural environments. The park also contains numerous mammals.

Island Landscape This is a landscape of islands in oceans, lakes or rivers. Islands can be large and small. Small islands are called islets (in Chinese, 'Yu'), such as Gulangyu, Huapingyu and Chiweiyu in China. Land surrounded by water on three sides is called a peninsula. An area with two or more islands in a group is called an insular group. A large-scale insular group can be called an archipelago, whereas islands arrayed in a linear or arch-shaped arrangement are called a chain of islands. Based on the causes of formation, islands can be divided into (1) continental islands, which form due to crustal movement induced by land subsidence or sea rise, causing part of the land to be separated from the main continent; typical examples are Taiwan Island and Hainan Island in China; (2) oceanic islands, which form by the accumulation of erupted materials (mainly lava) from underwater volcanoes or by the accumulation of coral or remains of coral in coral reefs; the Hawaiian Islands are examples of the former, while



Fig. 16 Landscape of the Zhoushan Islands in Zhejiang Province

China's Xisha Islands are an example of the latter; and (3) alluvial islands, which form by the accumulation of mud from rivers and lakes, such as Chongming Island in Shanghai (Fig. 16).

Island Tourism Landscape An island landscape can have high tourism value. Based on the factors that affected its formation, these landscapes can be divided into the following categories: (1) alluvial island landscapes, which are generally found near estuaries along the coast, such as Caofeidian at Bohai and Chongming Island in the Changjiang estuary; (2) continental island landscapes, which is formed by marine erosion and transgression of the continental plates or by the uplift of the continental shelf, such as the Zhoushan Islands and the Changshan archipelago in the Gulangyu tourism area in Xiamen Province; (3) oceanic island landscapes, which are located in the middle of the ocean and are composed of islands that formed by tectonic uplift, volcanic eruptions or biological processes, such as the Hawaiian Islands, Fiji Islands and Tonga Islands; and (4) tombolo landscapes, which form when islands are linked by sand bars or sand spits, such as Bijia Hill in Huludao City, Liaoning Province, Zhifu Island in Yantai, Shandong Province, and Dahao Island in Shantou, Guangdong. For example, the land of Bijia Hill is connected at low tide but is separated into several islands at high tide; and this interesting feature has become a tourist attraction.

Islands and Protected Areas of the Gulf of California, Mexico These islands are located in the Gulf of California in northwestern Mexico. The heritage site extends across Baja California, Baja California Sur, Sonora, Sinaloa and Nayarit. The area includes 244 islands and extensive portions of the coast. The Sea of Cortez and its islands are recognised as natural laboratories for research on species formation. Almost all types of marine physical and biological processes on Earth can be found in the region, as well as 695 vascular plant species and 891 species of marine fish, of which 90 are endemic fish species. The area breeds 39% of

the world's marine mammals and 1/3 of the world's mussel species.

Isole Eolie (Aeolian Islands) This site is located in the Mediterranean Sea, 50 km north of Sicily, Italy, and has a core protected area of 12.16 km^2. The Aeolian Islands are a classic example of the formation, evolution and destruction of volcanic islands. Research on the archipelago can be traced back to at least the eighteenth century and led to the identification of two typical eruption patterns in volcanology – Vulcanian and Strombolian eruptions.

Isotopic Age ► Absolute Age

Itoigawa Geopark, Japan This geopark is located in the centre of Honshu Island and has an area of 746 km^2. In 2009, it became a member of the Global Geopark Network. The geopark contains 24 geosites. The main highlights are the Shiyuchuan-Shizuoka Tectonic Line, the Yanhe Road geological relics, and the 'Jiaochuanchuan Yushixia' geological relics. At the site of the 'Yinuchuan-Shizuoka Tectonic Line and Salt Road Geological Remains', tourists can observe the challenging conditions and understand the human history and culture of this site, where jade, the typical oriental gemstone, is an important part of the land. The jade is a product of crustal movement during the island arc period and formed in the deep subduction zone during the Palaeozoic. It was then brought to the surface by tectonic events and was eventually transported to various locations by rivers and the sea. The Shiyuchuan area retains the traditional human life, history, and culture of the island arc and displays it vividly to the world.

J

Jade Jade is a collective term for stone objects with exquisite textures, warm and moist colours, and toughness to withstand abrasion. In mineralogy, jade can be divided into soft jade (nephrite) and hard jade (jadeite). Hard jade specifically refers to feicui (jadeite), which is considered a precious gemstone. The term jade more commonly refers to soft jade, or nephrite. Nephrite is a silicate of water-containing calcium and magnesium. It has a Mohs hardness of 6.5 and excellent toughness, is translucent to opaque, and is composed of fibrous microcrystalline aggregates. China's famous jade includes the nephrite produced in Hotian in Xingjiang Province and the Dushan jade produced in Nanyang, Henan Province. From the arts and crafts perspective, any high-quality stone that can be used to make jewellery can be called jade. Examples are the Xiuyan jade, which is serpentine mined in Xiuyan, Liaoning Province, and the Zhangye jade, which is a serpentine mined in Zhangye, Gansu Province. China was the first country in the world to mine and use jade. A nephrite jade block unearthed from an archaeological site in Fuxin City, Liaoning Province, is approximately 8,000 years old (early Neolithic period). This block is the earliest known true jade artefact in the world. The written record of the Zhou Dynasty (256 B.C. to eleventh century B.C.) shows that jade was used for utensils. During the Spring and Autumn Period, the king of Zhao owned a precious jade block called 'He Jade'. The king of Qin learned about it and offered to exchange it for 15 cities. This incident reflects the value of jade at that time. In 1995, a Xiuyan jade stone with a height of 25 m, a maximum diameter of 30 m, a volume of 20,000 m^3 and a total weight of 60,000 t was discovered in Yushi (Jade) Village in Xiuyuan County, Liaoning Province. It is the largest piece of serpentine jade in the world and is an extremely precious gemstone. In 1997, a jade stone was excavated 300 m underground in Xiuyan County. It weighs 12.6 t and is by far the largest jade stone piece excavated from a mine shaft. This stone was given the name 'king of the mine shaft'. The Hotian jade, Xiuyan jade, Dushan jade and turquoise are considered China's four famous jades (Fig. 1).

Jadeite In mineralogical terms, feicui is a jadeite composed of microcrystalline aggregates of sodium aluminosilicate pyroxene. It is opaque or translucent with a Mohs hardness of 6.5–7 and a density of 3.25–3.4. Based on the green hue, brightness and saturation, jadeite can be divided into emerald green, apple green, shallot green, spinach green, oily green and greyish green. It is a precious gemstone and can be divided into grade A jade (all natural, without artificial colour), grade B jade (impurities have been removed through bleaching and filled with resin; it is subject to ageing, discolouring and cracking easily upon heating), grade C jade (dyed colour but no filler) and grade B + C jade (with filler and dyeing agents in cracks or grain pores). Tourists should be cautious in differentiating these types when purchasing jadeite (Fig. 2).

Jalai Nur Man Site The Jalai Nur Man site is a site of ancient human fossils located in the upper part of the open coal mine in eastern Zhalainuoer, southeastern Manzhouli City, Inner Mongolia Autonomous Region. Skulls of ancient indigenous human beings have been unearthed with cultural relics, including microliths, stone arrowheads, Jomon pottery fragments, bone cones, bone needles and jade twigs. Hence, the Jalai Nur Man is a new modern man from the early stage of the Neolithic. The mammal fossils include Late Pleistocene and Holocene species, such as marmots, Ochotonidae, wolves, Mammuthus sungari, Coelodonta antiquitatis, deer, horses, Capreolus pygargus, Procapra przewalskii and Bison exiguus.

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Fig. 1 Jadeite



Fig. 2 Jadeite craft (red is called fei, green is called cui)

Jasper *Synonym:* ► *Jasperite*

Jasper is also known as 'bluish green stone'. It is a low-grade gem. Jasper generally refers to: (1) all bluish green or cyan precious or semi-precious stones; and (2) high-quality bluish green silicalite with other colours (e.g., green, red, orange, yellow and black) composed of quartz, chalcedony and iron oxide. The iron oxide and clay content can reach 20% or more, and it has a glassy and greasy lustre, can be opaque, slightly transparent to translucent, and has a Mohs hardness of 6.5–7, a density of 2.6 g/cm^3 and several colours, such as dark red, green and mixed colours. Based on its colour and lustre, jasper can be divided into green jasper, yellow jasper, banded jasper, egg white jasper, agate jasper, sheep liver jasper and pig liver jasper. It is sometime described according to its unique patterns and colours, such as landscape jasper and blood drop jasper. Jasper is mainly a surface deposit of silica with several impurities. Some jasper is related to submarine volcanic eruptions. Jasper has been found in Xinjiang Province, Gansu Province, Inner



Fig. 3 Jasper stone

Mongolia, Henan Province, Hubei Province, Guangxi Province, Tibet, Jiangxi Province, Zhejiang Province, Jiangsu Province and Fujian Province in China (Fig. 3).

Jasperite ▶ Jasper

Jehol Biota This biota is mainly located in several Mesozoic terrestrial sites in western Liaoning Province, northern Hebei Province and Inner Mongolia. The Mesozoic terrestrial facies strata are well developed and contain abundant fossils, such as Estheria, insects, bivalves, fish, amphibians, reptiles, birds and various mammals and plants. The phyla are complete, and the fossils are well preserved. This fossil group is known as the Jehol biota. With the recent discovery of fossils of feathered dinosaurs, birds, primitive angiosperms and mammals, this biota has become the focus of palaeontologists and geologists in China and around the world. This biota has provided adequate fossil data for identifying the origin of birds, angiosperms and mammals, which makes this site a treasure trove of rare terrestrial Mesozoic biota of significant academic and scientific value (Fig. 4).

Jeju Island Geopark, Korea This geopark is located on Jeju Island, South Korea, and covers an area of 2,368 km^2. It became a global geopark in 2010. Its main attractions include Halla Mountain, Seongsan Sunrise Peak, Manjan Grottoes, Seogwipo Shellfish, Cheonjiyeon Waterfall, Chinese Dapu Coastal Column Joints, Shanfang Mountain, Longtou Coast, and Shuiyue Peak. Jeju Island, which is Korea's largest island, is a volcanic island. It has important academic value and provides beautiful natural landscapes for visitors. It is Korea's premier world-class resort and recreation area.

Jeju Volcanic Island and Lava Tubes, Korea This site is located on the southwestern corner of the Korean peninsula approximately 90 km from the coast. It has a core protected area of 94.7 km^2. The heritage site comprises three sites with a total area of 188 km^2. The pure black lava cave is considered to be the best-preserved lava tunnel in the world, and Sunrise Peak is a cone-shaped peak composed of tuff. The highest peak in Korea is Halla Mountain, which has waterfalls, several types of rocks and crater lakes.

Jet Jet, also known as coal jade, is a type of lignite. It is an organic gemstone composed of organic matter (C, H, O, N, and S) and sometimes contains impurities of quartz and clay. Jet has a dense but light body and is black. It has a metal-like lustre upon polishing. It is a fossilised organic material that is transformed after prolonged burial. In Europe, jet has been used as a gemstone for almost a thousand years. In China, jet artefacts have been found in the Neolithic cultural relics in



Fig. 4 Jehol biota

Fig. 5 Jianghanichthys



Liaoning Province. The major production areas of high-quality jet are Britain, France, Czech Republic, Italy, Russia and China.

Jianghanichthys Jianghanichthys is a type of fish fossil found in the Jianghan area. It is flat, from oval to round in shape, and 6–8 cm long. The fish head is relatively small with a convex back, and the dorsal fin is in the middle of its body, nearly symmetrical to the pelvic fin. The caudal peduncle and caudal fin are short and orthomorphic. The fish fossils are brownish black with round scales. They have been discovered in the Palaeogene and Neogene greenish grey to grey shale and calcareous shale in Songzi, Hubei Province (Fig. 5).

Jianghe Coal National Mining Park, Sichuan This park is located in Shiniugou, Xiema Village, Fuxing Town, Beibei District, Chongqing City, and it covers an area of approximately 1.8 km^2. It became a national mining park in 2010. It has a long mining history that dates back to 1810. It is a unique mine that is facing a resource crisis and was the first high-quality coal demonstration base whose ownership was obtained through a court case against British businessmen. Numerous geological features and remnants of coal production and life left behind from the construction and production remain in the park. Its resource exploration, geological survey, mining technology, means of production, social life and means of transportation have been systematically preserved. With rare and valuable mining heritage, the Jianghe Coal National Mining Park is an

important base in southwestern China for training, mining experiments and technological demonstrations of thin seam mining.

Jiangjunmiao Gobi Wood Fossils This fossil site is located in the Jurassic rocks in the Gobi Desert at Jiangjun Miao, Qitai County, Changji Hui Autonomous Prefecture, Xinjiang Province. Most of the silicified wood is more than 100 cm in diameter, and the largest can reach 200 cm. The wood with a diameter of more than 2 m is estimated to have been at least one thousand years old. The wood fossil pieces or trunks either lie parallel to the ground intact or are broken into segments. There are more than 20 vertical trunks with diameters of 200–250 cm with residual heights of 1–2 m. These petrified wood trunks are mainly of coniferous cypress species as well as ancient spruce, Araucaria, and lush fern bushes. The famous Dinosaur Ditch is located 5 km to the east of this site. Since 1984, six complete dinosaur skeletons have been unearthed at this site. One Mamenchisaurus is 30 m long, 10 m high, and weighed approximately 50 t, which is the largest dinosaur fossil found in Asia and the second largest in the world.

Jiangning Tangshan Fangshan National Geopark, Jiangsu Jiangning Tangshan Fangshan National Geopark is located in Jiangning District, Nanjing City. It became a national geopark in 2009. The main attractions of the geopark are the Tangshan ape-man cave, the geological section, the hot springs and the Neogene volcanoes. Nanking Man fossils were discovered in the karst cave, and the mammal oryctocoenose was found in the Tangshan Karst Cave. This geopark is also called a geological corridor because of the exposures of Ordovician, Silurian, Devonian, Carboniferous, Permian and Triassic rocks. The Neogene shield volcano and the Tangshan Hot Spring also make the geopark unique.

Jiangyou National Geopark, Sichuan Jiangyou National Geopark is located northwest of Jiangyou City, Sichuan Province. In August 2005, it was approved by the Ministry of Land and Resources as one of the fourth group of national geoparks. It is consists of four scenic areas, namely, Doutuan Mountain, Buddha Cave, Guanwu Mountain and Wujiahoushan Mountain. The peak of Tuandou Mountain is surrounded by three mountains, namely, Shenfu Mountain, Feixian Mountain and Wenyue Mountain. The distance between the three mountains ranges from 13 to 45 m, and the relative height between the peaks is 53 m. Iron cables link the three mountains. Danxia geomorphologic landscapes can be observed in the geopark, including stone pillars, stone doors, stone walls, isolated peaks, and camelbacks. Guanwu Mountain, Wujiahoushan Mountain and Buddha Cave have landscapes such as peak clusters, depressions, karst dolines, tiankengs, clints, karsts and gorges.

Jianjun Jiang Jianjun Jiang (1957–) is a native of Ning County, Hunan Province, and is a doctor, professor, and doctoral tutor at China University of Geosciences. He has served as the deputy director of the Technology Department of the Ministry of Geology and Mineral Resources, the deputy director and director of the Department of Geological Environment of the Ministry of Land and Resources, and the director of the Department of Science and Technology and International Cooperation of the Ministry of Land and Resources. He once served as the vice chairman and secretary-general of the China Ornamental Stone Association and director at the Chinese Academy of Tourism Earth Science and Geopark Research, Geological Society of China. He actively promotes the use and conservation of geoheritage, the construction of national geoparks and mining parks, the improvement of the mining environment, and the popularisation of earth science. He has published 'Earth and People', 'China Mine Environmental Protection Manual', 'Geoheritage Resources and Management in China', 'Global Geoparks of China', 'China Geoparks Construction Guide', 'China Mining Park Construction Guide', and more than

30 academic papers. He has contributed greatly to the development of tourism earth science through the close integration of geopark activities with tourism earth science.

Jianrong Xin Jianrong Xin (1946–) is a university professor. In 1970, he graduated from the Beijing Institute of Geology (now China University of Geosciences), and he began to study tourism earth science in 1984. In 1986, he founded the Hubei Tourism Earth Science Research Institute and served as secretary-general. In 1993, he established the Department of Tourism at China University of Geosciences (Wuhan) and served as the department head. He once served as a committee member of the Chinese Academy of Tourism Earth Science and Geopark Research, Geological Society of China, vice chairman of the Tourism Association of Hubei, and executive director of the Geographical Society of Hubei. He mainly engages in teaching and research of tourism, tourism earth science, and tourism planning and management. He is the author of 'The Principles of Tourism Earth Science', 'Tourism Earth Science', 'Planning and Management of Tourism Sites', and other training materials and has published more than 40 papers.

Jianzha Kanbula National Geopark, Qinghai This park is located in the Yellow River Gorge in Jianzha County, Qinghai Province. It became a national geopark in 2004. The main geological heritage features include red sandstone landscapes, Cenozoic stratigraphy, erosion terraces and gorges along the Yellow River, dams, Lijiaxia landslide relics, and Shenbaoshan glacial landform relics.

Jiaojia Gold Mine, Zhaoyuan, Shandong The Jiaojia gold deposit is an important and famous gold deposit in China. It is composed of more than 10 medium and large gold mines within a 60 km^2 area between Zhaoyuan City and Laizhou City, northwestern Jiaodong Peninsula. It has proven gold reserves of several hundred tons. The Jiaojia gold mine is the biggest of the mines. Shandong has a long gold mining history. The 'Song History–Commodities Chronicle' (1023–1032) reports that gold mining in Tiansheng, Deng (now Penglai County) and Lai (now Ye County) amounted to several thousand taels of gold production annually. Gold mined from the deposit accounts for 89% of the gold production of the entire country. The discovery of the Jiaojia gold deposit and the understanding of its formation characteristics have facilitated the development of gold mineralisation theories, led to a booming period of gold exploration, and greatly enhanced gold mining and production in China.

Jiaozuo Fengshan National Mining Park, Henan This park is located in Baizuo, Baijiangfang, Jiulishan and Fangzhuang in northern Jiaozuo, Henan Province, and covers an area of 10.2 km^2. It was designated as one of the second group of national mining parks by the Ministry of Land and Resources in May 2010. The park has rich mining heritage resources, including five major categories: mining geological heritage, mining production heritage, mining product remains, mining social life heritage, and mining development literature and historical records. Among them are nine rare mining features and over 50 important mining features. The park contains typical ore-bearing stratigraphic sections, mine and coal seam structural profiles, and complete profiles of the coal field strata. Fenghuangshan Mountain, gullies, river valleys, the Fenghuangling faults, fault scarps and other geological landscape features as well as surface collapses, ground fissures and other geohazard features have high scientific research value.

Jiayang National Mining Park, Sichuan This park is located in Jianwei County in southern Sichuan Province and covers an area of 38 km^2. It became a national mining park in 2010. Boasting a long mining history, the Jiayang coal mine has preserved large amounts of mining geological heritage and typical mining production heritage, such as an outcrop of the Huangcun underground coal seam, Huangcun silicified wood and syngenetic sedimentary concretions. Jiayang Laojin and the

Bajiao Industrial Ancient Town were important bases that supplied coal during the Anti-Japanese War and the early days of the liberation of China. Bagou Town, which was established during that period, integrates the architectural styles of many countries and is a location of peace and happiness.

Jiayin Dinosaur National Geopark, Heilongjiang This geopark is located in western Jiayin County, Heilongjiang Province, between the Taipinggou Estuary and No. 2 Liangzi on the right bank of the Heilongjiang River. It is approximately 11 km long and faces Buschovo in Russia across the river. It was approved as a national geopark by the Ministry of Land and Resources. Late Cretaceous (88–65 million years old) dinosaur fossils and additional plant and animal fossils are the main geological relics, including fossils of dinosaurs, fish, turtles, gastropods, insects, and plants. The stratigraphic profile and the sequence are complete and continuous. The fossil of the flat-headed duck-billed dinosaur found in the early twentieth century was the earliest such dinosaur fossil found in China. In addition, carnivorous Tyrannosaurus and Jiayin plant fossils have also been discovered.

Jiayin Wulaga National Mining Park, Heilongjiang This park is located in Wulaga Town, Jiayin County, Yichun City, Heilonjiang Province. It covers a total area of 155 km^2 and was approved as one of the first group of national mining parks in 2005. The main mining remains are the Wulaga Rock Gold Mine, the large porphyry gold deposit and Late Cretaceous dinosaur remains. The mineral deposit is a large porphyry gold deposit. The mineralisation and alteration of the deposit is clear, and the structural control of the ore is obvious. It is a large modern gold mine that uses modern equipment and advanced smelting techniques, and it also preserves typical and rare mining equipment.

Jicheng Yin Jicheng Yin (1936–) is a native of Xinghua City, Jiangsu Province. He is a professor in the School of Earth Sciences at Chengdu University of Technology, director of the academic committee of the Institute of Tourism and Urban Planning of Chengdu University of Technology, and executive director of the Sichuan Tourism Earth Science Research Institute. He has edited and co-edited eight books, three translations and published more than 50 papers. He is the first person to earn a master's of tourism earth science and is a doctoral tutor.

Jigang Bao Jigang Bao (1964–) is a travel geographer. He graduated from Peking University and is now a professor and doctoral supervisor of Sun Yat-sen University. He is also the dean of the Institute of Tourism at Sun Yat-sen University, deputy director of the Geographical Society of China, and chairman of the Tourism Geography Professional Committee. His major publications include 'Tourism Geography', 'Tourism Geography of Beijing', 'Research on Theme Park Development and Its Impact' and 'Tourism Resources Development of Karst Caves'.

Jigzhi Nyanboyeshizer National Geopark, Qinghai This geopark is located 40 km southwest of Jigzhi County, Guoluo Tibetan Autonomous Prefecture in Qinghai Province. It became a national geopark in 2005. Glacial and moraine landforms are the main features, particularly those located 4,000 to 4,500 m above sea level. Glacial melting and glacial erosion at different times developed numerous glacial erosion landscapes, such as steep cliffs, peaks forests and valleys. The Omutso Glacier Valley in the geopark retains the periglacial landforms left over from the Quaternary Ice Age in the hinterland of the Qinghai-Xizang Plateau.

Jilin Baishan Slate National Mining Park, Jilin This park is located 8 km north of Baishan City, Jilin Province. The Jilin Baishan Slate National Mining Park was one of the first group of mining parks approved by the Ministry of Land and Resources in 2005. The park has six scenic areas: the beneficiation area, tailings pond, Shangqing, Bangchui, Xizhenzhumen (Western Pearl Gate area) and Kucanggou. Featuring geology, landforms and mining development, it is a comprehensive

scenic park that includes karst and fault scarp landforms, Songhua stone landforms, slate, structural geology and the iron ore extraction process.

Jinbu Zhou Jinbu Zhou (1944–) is a professor at Zhejiang University. He was a postgraduate student at Sun Yat-sen University in 1981. He is the author of more than 60 articles, including 'Tourism Geography of China', 'Tourism Geography', and 'Modern Tourism Geography of China'. 'Tourism Geography of China' was one of the earliest publications of its kind in China.

Jinchang Gold Ore National Mining Park, Gansu This park is located in the Jinchuan District, Jinchang City, Gansu Province, and covers an area of 568 km^2. It became a national mining park in 2010. The park consists of the Longshou Mine Scenic Area, a science park scenic area and the Chengbei Scenic Area. It has attractions such as the Longshou Mine open mining pit, Longshou Mine western slope ramp, no. 1 tailings reservoir, Longshou Mine new no. 1 hoisting shaft and other mining production features as well as mining models, tools, loading and transportation equipment, dressing and smelting technological processes, environmental protection, ecological construction engineering and other mining heritage.

Jinchuan Copper-Nickel Mine The Jinchuan copper-nickel mine is one of China's three major polymetallic ore fields. Nickel is the main ore. Located in Jinchang City, Gansu Province, the ore field was discovered in 1958. The mineral deposits are mainly located in the Jinchuan ultramafic rock mass. The deposit is a deep melting-compound penetration-type deposit. Based on its composition, the ore body is divided into four types: in situ magma melting, deep magma melting and penetration, late-stage magma penetration and contact metasomatism. This field mainly contains nickel ore; its nickel sulphide reserves rank second in the world. There are also 18 other kinds of non-ferrous and rare metals. This mine ranks first in the country in nickel and cobalt production and is also China's main platinum production field (Fig. 6).

Jinding Lead-Zinc Deposit, Yunnan This is currently the largest surveyed lead-zinc deposit in China. Discovered in 1959, the Jinding lead-zinc deposit is located in Lanping County, western Yunnan Province. It is a 'multi-genetic stratification-controlled and hot brine mineralisation-dominated deposit'. The lead-



Fig. 6 Jinchuan copper-nickel mine

zinc ore body formed in the limestone breccia and limestone-sandy breccia strata of the Palaeocene Yunlong Formation and the calcareous quartz sandstone strata of the Lower Cretaceous Jingxing Formation. The mining areas can be divided into seven districts, namely, Beichang, Jiayashan, Fengzishan, Xipo, Nanchang, Baicaoping and Paomaping. The deposit has a long mining history. In the Ming and Qing Dynasties, miners had already begun mining and refining silver ore, leaving several caves. Several slag piles can still be seen around Paomaping today (Fig. 7).

Jinduicheng Molybdenum Deposit, Shaanxi This is a molybdenum deposit in Jindui City, Shaanxi Province. It is located on the southern slope of Huashan in the eastern Qinling Mountains. The Jinduicheng molybdenum deposit is under the jurisdiction of Jindui Town in Hua County, Shaanxi Province. The deposit sits on the concave Jinduicheng platform in the West Henan upfault zone, which is located on the southwestern margin of the Sino-Korean paraplatform. The exposed rock strata are part of the Proterozoic Xionger Group and Gaoshanhe Formation. The discovery of the Jinduicheng molybdenum deposit had tremendous political and economic significance for the young People's Republic of China when its economy was still in its initial stage of growth (Fig. 8).

Jingbohu Global Geopark, China This geopark is located in the inner area of Ning'an City in southeastern Heilongjiang Province. It covers an area of 1,400 km^2 along the middle and upper reaches of the Mudanjiang River. It became a global geopark in 2006. It has a total of nine scenic districts; seven are geological heritage sites, and the others are the ancient Bohai scenic district and the donkey riding exploration district. Several volcanic eruptions occurred from before 12,000 to 5,140 years ago, and lava blocked the Mujiang River to form the current Jingpohu (called Jingpo Lake), which is the world's largest lake formed by lava. The geopark preserves typical geological heritage such as gorges and wetlands. The main geological attractions available for tourists include: (1) volcanic geological remains, such as craters, lava flows, lava tunnels, pyroclastic materials, and



Fig. 7 Jinding lead-zinc mining site



Fig. 8 Jinduicheng molybdenum mine

volcanic rocks; (2) water body landscape features, such as Jingpo Lake, Diao Shui Lou Waterfall, Xiaobei Lake, Zhuoxin Lake, Dianchi Lake, and Ziling Lake; and (3) granite geological remains, such as Taoist Mountain, Pearl Gate, Xiaogushan, Dagu Mountain, City Wall Gardenia, Baishi Gardenia, Luyuan Island, Maogong Mountain, and Granite Canyon (Gengbo Canyon).

Jingdezhen Gaoling National Mining Park, Jiangxi This park is located in Gaoling Village, Yaoli Town, Fuliang County, in the northeastern part of Jingdezhen City (the Porcelain Capital) in Jiangxi Province. It has dozens of ancient mine caves and the remains of elutriation equipment, and it became a national mining park in 2005. The park can be divided into six parts: a service centre, commerce dock, ancient mine remains, an ecological tourism zone, a mineral customs area and the Gaoling Research and Study Centre.

Jingkou Sinkhole Cluster Landscape, Wulong, Chongqing This is a landscape of erosional tiankeng (sinkhole) clusters. This landform is located in Houping Village in Wulong County, Chongqing City, and it is a part of the Wulong World Heritage Site. The lithology structure is binary. Sandy shale is widely distributed at the surface, and it overlies thick Cambrian and Lower Ordovician limestone. This karst hydrological and geomorphological system consists of sinkholes, shafts, avens, ground seam-type blind valleys, large fossil caves, subterranean rivers and karst springs. The Jingkou sinkhole cluster is composed of five sinkholes: the Jingkou sinkhole, Shiwang sinkhole, Daluodang sinkhole, Tianpingmiao sinkhole and Niubidong sinkhole. The Jingkou sinkhole has a diameter of 250 m and a depth of approximately 300 m. Of the 75 sinkholes found around the world, only the Jingkou sinkhole is an erosional-type, whereas the others are collapse-type (Fig. 9).



Fig. 9 Jingkou sinkhole cluster landscape, Wulong, Chongqing

Jingpohu National Geopark, Heilongjiang See ► Jingbohu Global Geopark, China.

Jingtai Yellow River and Stone Forest National Geopark, Gansu This park is located on the banks of the Yellow River in southeastern Jingtai County, Baiyin City, Gansu Province. It became a national geopark in 2004. Its main geological features include sandstone-conglomerate landforms (which belong to the forest landscape series) and extensive gravels of the Yellow River as well as the dynamic and static processes of the river. Other attractions include the Longwan Oasis, dam beaches, gobi and sand dunes.

Jingyu Volcano-Mineral Water National Geopark, Jilin This geopark became a national geopark in 2004. It is located in Jingyu County, Baishan City in Jilin. It has three major scenic attractions: the Longgang volcano cluster, mineral springs and the primitive ecology. Longgang contains 72 volcanic cones of different sizes and shapes distributed across a 20 to 100 km long basalt lava platform. Other volcanic features include well-preserved lava flows, volcanic cones, craters, maar lakes and large well-preserved dammed lakes. There are 18 mineral springs in the northeastern part of the geopark, which have a daily water output volume of 150,000 t.

Jinjiang Shenhuwan National Geopark, Fujian This park became a national geopark in 2004. It is located on the southern coast of Jinjiang City, Fujian Province, and is separated from Kinmen Island by 6 nautical miles. There are 44 major geosites in the geopark, including five fossil sites, 29 geomorphological sites and 10 typical geological profile sites, within an area of 20 km^2. It is divided into three scenic districts: Shenhu Bay, Longhu, and Waitou. The area is characterised by the symbiosis between ancient submarine forests that are between 7,000 and 8,000 years old with well-preserved remains of ancient oyster reefs that are between 15,000 and 25,000 years old. The park preserves various types of coastal

landforms, such as sandy shores, red clay shores and bedrock coasts.

Jinning Movement The Jinning movement was the folding tectonic event that occurred between the middle Neoproterozoic Era (Nanhuan Period) and the early Neoproterozoic Era (Qingbaikouan Period) more than 800 million years ago. It formed an extensive regional angular unconformity. The Jinning movement formed the Yangtze Platform and the base of the Tarim Platform. It was an important crustal movement in China's geologic history.

Jiqing Huang Jiqing Huang (1904–1995) was a native of Renshou County, Sichuan Province. He was a geologist. He was the director of the Central Geological Survey of China, academician of Academia Sinica and professor of geology at Peking University. After the founding of the People's Republic of China, he served as the director of the Southwest Geological Survey, the director of the Southwest Geological Bureau, the chief engineer of the Petroleum Geological Bureau of the Ministry of Geology, the vice president of the Chinese Academy of Geological Sciences, and the director of the Geological Society of China. He was one of the founders of Chinese geotectonics and established the theory of multi-cycle tectonic movements. He made significant contributions to the study of tectonics in China, the compilation of geological maps and the development of petroleum geology. His main works were 'Permian Stratigraphy in Southern China', 'Major Geological Structural Units in China', and 'Several Types of Neotectonic Movement in China'. He was the first honorary president of the China Tourism Earth Science Research Institute (Organising Committee) and prefaced the outline of 'An Introduction to Tourism Earth Science', which provided important support for the development of tourism earth science.

Jiufujiang National Geopark, Hunan This geopark is located in eastern Youxian County, Hunan Province. The geopark lies on the western side of the middle part of the Luoxiao Mountains along the border between Hunan and Jiangxi. It was designated as one of the fourth group of national geoparks by the Ministry of Land and Resources in August 2005. Its major geological features include karst caves, underground rivers, tiankengs (sinkholes), canyons, natural bridges, waterfalls and fossils in Palaeozoic carbonate rocks.

Jiuxiang Canyon and Cave National Geopark, Yunnan This geopark is located in Yiliang County, Yunnan Province, and covers a total area of 53 km^2. It became a national geopark in 2009, and it features karst caves and canyons that developed in Proterozoic carbonates as well as ancient human remains. Jiuxiang Karst Cave is an assemblage of vertical, inclined and horizontal caves. Six sets of karst caves are located along the longitudinal profile of the cave, including the Bikedashaba Caves, Sanjiaodong Caves, Huangjiamaidichong-Tiansheng Bridge Caves, Maitian-Dadong Caves, Diehong Bridge Caves and Mangyudong Caves. Numerous excavations in Zhangkou Cave have uncovered more than 40 tooth fossils of homo sapiens, nearly 2,000 fossils of 33 mammal species, more than 1,800 pieces of stone artefacts and a host of carbon shavings.

Jiuzhaigou National Geopark, Sichuan This geopark is located in Jiuzhaigou County, Axian County, Sichuan Province, and it covers an area of 729.6 km^2. It is situated at the edge of the Qinghai-Tibet Plateau at elevations between 2,000 and 3,000 m above sea level. It is characterised by a cold karst travertine pool. In March 2004, the Ministry of Land and Resources approved it as one of the third group of national geological parks. The main landscape is more than 80 km long. It consists of the Mizoguchi-Nori-Rang-Chang-Hai and Nori-Lang primeval forests, and it includes the six wonders of Changhai, Jianyan, Nuorilang, Shuzheng, Zharu and the Black Sea. More than 100 lakes are scattered between the narrow valleys, with clear water and colourful travertine dams and pools. There

are also large streams and waterfalls formed by tufa. Jiuzhaigou is typical of the geology and landscape of the lacustrine craters in the Hutuo karst area.

Jiuzhaigou Valley Scenic and Historic Interest Area Jiuzhaigou is located at the northern foot of the Minshan Mountains in Huanglongsi, Sichuan Province. The Huanglong Scenic Area has a total area of 1,830 km^2, and the Jiuzhaigou Scenic Area has an area of 720 km^2. These areas are well-known for their highland karst landforms that was formed by redeposition from saturated calcareous water on the surface. Huanglongsi Valley contains more than 300 coloured tufa pools due to sedimentation from flowing water. Its travertine beaches cover an area of 80,000 km^2. With its five major karst waterfalls and four karst caves, the area is a distinctive outdoor karst scenic site. Jiuzhaigou is composed of two tributaries; one flows from Goukou, Norilang to Changhai, and the other flows from Norilang to the Primitive Forest. Its six scenic areas are Changhai, Jianyan, Norilang, Shuzheng, Zaru and the Black Sea.

Jixi Hengshan National Mining Park, Heilongjiang This park is located in the Hengshan District, Jixi City, Heilongjiang Province. It covers an area of 21 km^2 and was approved as one of the first group of national mining parks in August 2005. It was built on a coal mine subsidence area, and it highlights coal history and culture. The park has several scenic areas, including Hongqi Lake, an underground adventure scenic area, the Dahengshan Coal Mine, the Nanshan Forests and Huoshaoshan Mountain. The park has a buffer zone for developing tourist facilities, which has a coal-mining theme area in the centre and eight functional areas around it, including the Coal Mine Culture Exhibition, entertainment and adventure scenic area, romantic scenic area, miner recuperation resort, bird's-eye view scenic area and a folk customs and food area.

Jixian National Geopark, Tianjin This national geopark is located in northern Ji County, Tianjin. The main geological features are the Neoproterozoic stratigraphy and palaeontological fossils. It became a national geopark in 2002. The Neoproterozoic section in Songxian County is famous for its complete rock formations, continuous outcrops, well-preserved and simple structures, clear top and bottom boundaries and low metamorphism. The stratigraphic section is located north of Changzhou Village (Jiushanding) in Xiaying Town at the foot of the Great Wall and extends to Junjunshan in the county town to the south, with a length of 24 km and an average width of 350 m from east to west. It represents the period from 1.8 billion to 800 million years ago. The complete sequence of continuous deposition is a national standard profile. Fossils are abundant in the strata, especially macro-algal multicellular fossils, the discovery of which increased the age of the development of multicellular organisms from the internationally recognised 900 million years ago to 1.7 billion years ago.

Jixianian Period The Jixianian Period is the second geologic period of the Mesoproterozoic Era in China. It extended for 400 million years, from 1.4 billion to 1 billion years ago. The Jixianian System includes the rocks that formed during the Jixianian Period. The standard section of the system is located in Jixian County, Tianjin.

Joggins Fossil Cliffs, Canada This site is located on the Atlantic coast of Nova Scotia, Canada, and has a core protection area of 6.8 km^2. The rich Carboniferous (350 to 290 million years ago) fossil species have led the site to be hailed by the palaeontology community as the 'Galapagos of the Carboniferous'. The rock specimens at the site are regarded as textbooks of Earth history. The Pennsylvanian strata (318 to 303 million years ago) contain the world's thickest and most abundant fossil records from that time period. The 14.7-km-long coastal cliffs, rocky mesas, and low-lying beaches have three types of ecosystems: estuarine bay, floodplain rainforest and floodplain

freshwater lake ecosystems. Three kinds of palaeoecological remains have been unearthed from 96 genera and 148 different fossil specimens, and there are also 20 fossil footprints.

Joint A joint is a small fracture that lacks any measurable displacement. Based on the time of formation, joints can be categorised as primary joints that formed during rock formation and secondary joints that formed after the rock had formed. Based on the causes of formation, they can be categorised as structural joints and non-structural joints. According to their mechanical properties, joints can be divided into tensional joints and shear joints. Based on the bedding attitude, joints can be divided into strike joints, dip joints, diagonal joints and bedding joints. Based on the form of the joints and the shape of the rock blocks after being cut by joints, they can be categorised as rhombic joints, columnar joints, plate joints, radial joints, brush joints and torch joints. Joints are the result of tensile stresses, and the distribution of joints is closely related to folding, which is indicative of the mode of the tensile stresses (Fig. 10).

A joint is a fracture in rock that lacks any visible movement. Based on the mode of formation, joints can be divided into tectonic (structural) joints and nontectonic (non-structural) joints. Based on their relationship with the rock formation process, joints can be divided into primary and secondary joints. Due to the forces that caused the cracking, joints can be divided into expansion joints and shear joints. Based on the relationship between the joints and the attitude of the rock strata, they can be divided into strike joints, cross joints, angular joints and bedding joints. Unlike faults, joints are fractures along which there is an absence of physical displacement. Weathering and erosion commonly occur along joints because they are weak zones in rocks; as a result, they can form unique landforms. Many famous landscape features are related to weathering of rocks along joints, such as the sharp peaks of Sanqingshan and the tall stone pillars in Zhangjiajie. Joints are also an important landscape feature, such as the basalt columnar joint sets in Penghu.

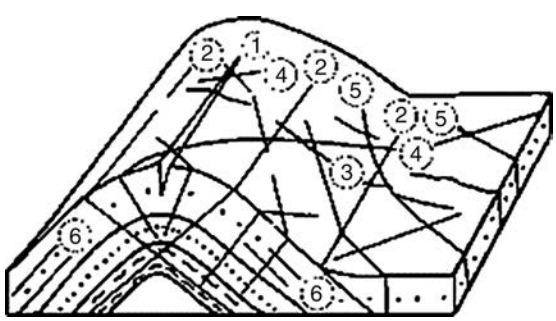


Fig. 10 Relationship between joints, bedding attitude and fold structures. 1: dip joint or cross-joint. 2, 3: strike joint or longitudinal joint. 4, 5: diagonal joints. 6: bedding joint

Junggar Block The Junggar Block is located between the Altay and Tianshan orogenic belts and is geographically part of the Junggar Basin. This block is almost completely overlain by Cenozoic rocks, although some Mesozoic and Palaeozoic outcrops are located along the margins. There is currently no agreement on the composition of its base. Some scientists materials consider it to be Precambrian materials, but some believe that it is composed of materials derived from the Palaeozoic oceanic crust. After the Permian, this area became a large inland basin and received more than ten thousand metres of terrestrial sediments. The presence of abundant land-vergent thrust structures indicates that it was a foreland basin subject to compression during the Cenozoic Era.

Juque Inkstone The Juque inkstone, also known as golden sand inkstone, comes from the cliffs at Dalongtan Village in Renhe district, Panzhihua City, Sichuan Province. This area was called 'Juque', which is where the stone obtained its name. It is a sericite-chlorite-dolomite shale that also contains quartz, rutile and pyrite. Juque inkstone has many varieties, such as blue eye, cyan flower, frozen fish brain, banana leaf white, purple sand, chicken blood, gold line and silver line types. In particular, round or oval stone eyes can be distributed in the stone, which look like red and gold pupils and cat's eyes. These features are unique characteristics of this stone. It is rather low in hardness and mainly has various colours such

as bright green, earth yellow, purplish grey, purplish brown or purplish black. There are three major production sites. The first is the Pingdi (Flatland) pit, where the stones often have stone eyes and are bluish green with rounded stone blocks that are mainly greenish yellow. The second is the Dabaoshao (Big Treasure Whistle) pit, which mainly produces stones with eyes. The third site is the Huapengzi (Flower Shed) pit, which produces purple stones with a fine texture. The ink slabs made from this stone make no noise when the ink stick is ground, spread ink like oil, prevent the ink from decomposing, are resistant to abrasion, give a cool feeling when touched, make a metallic sound when struck, and also generate a smooth feeling like touching the baby's skin (Fig. 11).



Fig. 11 Juque ink stone

Juramaia Sinensis Juramaia is a fossil of an eutherian. The fossil was discovered in 2011 and contains preserved skulls, soft tissue marks and a complete set of teeth and forefoot bones, including three molars and five molars. The fossil teeth have all of the characteristics of eutherians. Hence, Juramaia sinensis was a placental mammal of the class Eutheria. Its forearm structure indicates that it was skilled at climbing trees. It lived in trees, preyed on insects and weighed approximately 15–17 grams. It lived approximately 160 million years ago (Fig. 12).

Jurassic Period The Jurassic Period is the second period of the Mesozoic Era. It lasted from

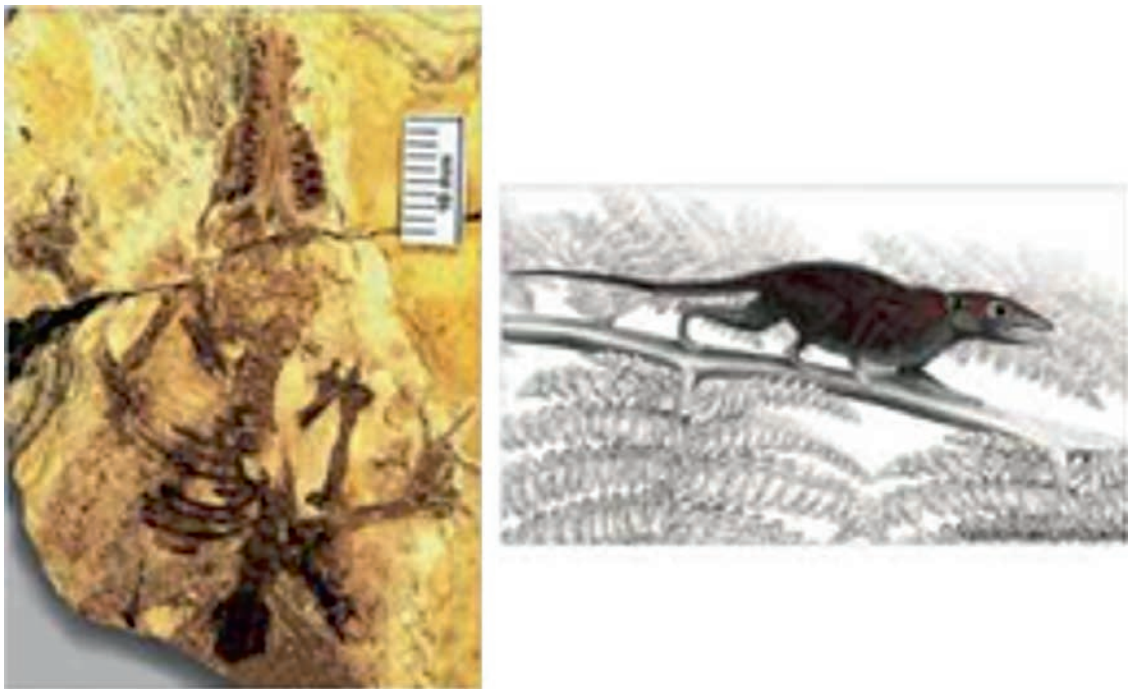


Fig. 12 Juramaia sinensis

199.6 to 145.5 million years ago, a duration of 54.1 million years. The Jurassic System includes the rocks that formed during the Jurassic Period. The name originates from the Jura Mountains on the border between France and Switzerland. Starting in the Jurassic Period, the main ancient Chinese mainland was in a terrestrial environment, and the pre-Triassic palaeogeographical pattern in the eastern regions, consisting of marine sedimentation in the south and terrestrial sedimentation in the north bounded by the Qinling-Daibeishan line, ended. Southern China, northern China and northeast China were linked by numerous sedimentary basins of different sizes. Because of the oblique subduction between the ancient Pacific Plate and the eastern edge of the ancient Asian continent, strong tectonic movements and magmatic activity occurred in the areas east of the Xing'anling-Taihangshan-Wulingshan line, in contrast to the large-scale stable inland basins in the west. This has caused the ancient Chinese mainland to acquire a macro-scale pattern of varying crustal movements between the east and west since the Jurassic Period. During the Jurassic Period, the Chinese mainland typically had a tripartite palaeogeographical character: (1) the southeast coastal areas mainly contained small faulted basins with sedimentary and volcanic rocks; (2) in Sichuan Province, Yunnan Province and the northwest region, the main features were large basins (mainly lacustrine sedimentary basins) and mountains; and (3) the Qinghai-Tibet areas, western Yunnan Province, part of Guangdong Province, and the northeast Nadanhada Range area were still in marine environments. Currently, the Jurassic System is divided globally into 3 series and 11 stages. The Jurassic System is widely distributed in China, and comparisons of the marine facies and the terrestrial facies of various stages is an important topic of research.

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Kahuzi-Biega National Park, Congo Kahuzi-Biega National Park is located along the border between North Kivu Province and South Kivu Province in eastern Democratic Republic of the Congo. It has a core protection area of 6,000 km^2. It has a vast area of primary tropical forest dominated by two spectacular extinct volcanoes, Kahuzi and Biega. The park has diverse and abundant fauna. One of the last groups of eastern lowland (graueri) gorillas (consisting of only approximately 250 individuals) lives between 2,100 and 2,400 m above sea level.

Kakadu National Park, Australia This park is located along the coast of Northern Australia adjacent to Van Diemen Gulf. It was expanded in 1987 and 1992, and the total area is 19,804 km^2. It is a unique area of archaeological and ethnological protection that has been the home of indigenous people for more than 40,000 years. Cave paintings, rock carvings and archaeological artefacts record the lifestyles of the prehistoric hunter-gatherers.

Kamchatka Volcanoes Landscape This is a cluster of volcanoes located on the Kamchatka Peninsula in the Russian Far East. There are a total of 127 volcanoes, 22 of which are active. The most famous is the Klyuchevskaya Sopka, which is 4,750 m high. Over the past 30 years, more than 50 eruptions have occurred. Currently, smoke still rises from the peak. Avachinsky Volcano lies at an elevation of 2,741 m and is also an active volcano. The Kamchatka Peninsula volcanoes, together with the 16 volcanoes of the Kuril Islands in its southeast corner, form one of the most active volcanic groups on the Pacific Rim. There are hundreds of fountains and hot springs on the island. The Death Valley on the peninsula lies in the foothills of the Kihainech Volcano. Several weasels and black bears came here to search for food but died when they inhaled toxic fumes. This place is only safe for animals when easterly or northerly winds dilute the poisonous gases (Fig. 1).

Kame Landscape This is a glacial hilly landform composed of flat-topped circular to elongated mounds. The mounds have diameters of 0.1–2 km and heights of 5–70 m with steep slopes. They always occur in groups with a chaotic pattern near the terminal moraine of alpine or continental glaciers. Kames are composed of sandy loam, sand and fine gravel with obvious bedding in various forms. Lenses of gravel kame moraines are often sandwiched inside a kame, and most kames are covered with moraine materials.

Kame Terrace Landscape This type of landscape is composed of kame terraces along the sides of a glacial valley or at the edge of a highland. When a glacier retreats, the meltwater along both sides of the glacial valley creates streams, and the flowing water accumulates layers of glaciofluvial deposits between the valley wall and the glacier. When the entire glacier has melted, the front of the deposit (the contact surface of the glacier) collapses due to the absence of glacier ice as a support, forming a scarp. This feature is similar to a river terrace and thus is called a kame terrace. Kame terraces look like elongated strips and lie along both sides of the glacial valley. They gradually become flatter down the valley and eventually link up with the outwash fan.

Kanawinka Geopark, Australia This former geopark extended across southwestern Victoria and southeastern South Australia and covered an area of approximately 26,910 km^2. It became a global geopark in 2008 but was delisted from the Global Geoparks Network in 2012. The park contained 58 geosites, mainly including volcanic craters, limestone landscapes, shores and caves, lava cones, waterfalls, lakes and wetlands. Lakes and craters occupied the eastern part of the Kanawinka Geopark, including a significant number of important volcanic sites and lakes formed by volcanic activity. The lava flow area was

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Fig. 1 A volcano in Kamchatka

characterised by a series of volcanic systems, with numerous volcanic cones and a wide distribution of lava flows. The Byaduk Cave is the largest and most accessible lava cave in Australia. The caves formed only 8,000 years ago, so they have not been weathered and are in a natural state.

Kang Guo Kang Guo (1936–2012) was a native of Pingyao County, Shanxi Province. In 1962, he graduated from the Department of Geology and Geography at Lanzhou University. He was a research fellow at the Institute of Geographical Sciences, Hebei Academy of Sciences and a director of the Tourism Research Office of the Institute. He published more than 70 papers and was involved in writing 'An Introduction to Tourism Earth Science'. He was the author of seven monographs, including 'Zhang Shiyan Landform' and 'Tourism Development Research'. He made important contributions to the development of tourism in Hebei Province.

Kangdian-Yunnan Axis This axis originally referred to the area with exposed Precambrian metamorphic rocks extending north-south from Kangding, Sichuan Province, to Honghe, Yunnan Province. The name was coined by Huang Jinqing in 1945. It was thought to be a continuously uplifted region since the Phanerozoic Eon. Tectonically, it was grouped as a secondary positive tectonic unit on the western border of the Yangtze Platform. However, recent studies suggest that the metamorphic rocks in this area are Mesoproterozoic and Neoproterozoic in age. Strong rifting with intense volcanic activity occurred in the late Neoproterozoic; hence, this term is now seldom used.

Kaolinite The composition of kaolinite is $Al_4[Si_4O_{10}](OH)_8$, and it is an important mineral ore for making ceramics. It gets its name because it was first discovered in Gaoling (Kaolin) Village in Jingde Town, Jiangxi Province. Kaolinite belongs to the monoclinic crystal system and appears as small pseudo-hexagonal or scale-like plates or as blocky, dense, earthy or clayey aggregates. It is white, colourless, light yellow, light brown, light red or light blue with white streaks. It also has transparent to translucent diaphaneity, a pearly to dark earthy lustre, a specific gravity of 2.6–2.63, a Mohs hardness of 2–2.5, and uneven fractures. It is mainly found in weathered feldspar and other alumina-rich silicate minerals, especially in hot and humid areas where the feldspar in granite can weather into loose white kaolin clay.



Fig. 2 Karez in Turpan

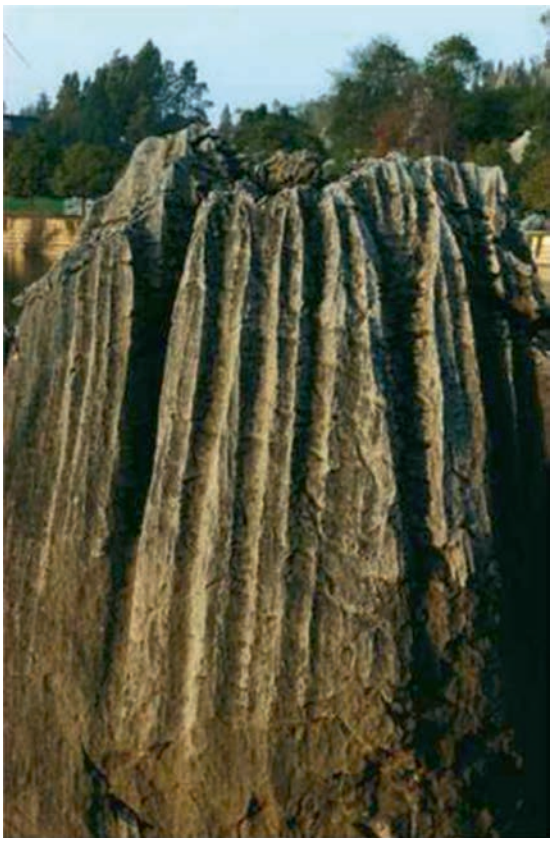


Fig. 3 Karren – Shilin, Yunnan

Karez A karez is an ancient horizontal water collection structure for the collection of groundwater. This type of structure is used on piedmonts and alluvial fans where people can tap groundwater for irrigation and daily consumption. Karez are mainly distributed in the Turpan Basin in Xinjiang Province, where there are nearly a thousand with a total length of approximately 5,000 km. A karez is composed of a shaft, an underground channel, a surface channel and a 'waterlogging dam' (a small storage pool). At Bogda (Bogeda) Mountain in the northern Turpan Basin and Kalawucheng Mountain in the western Turpan Basin, abundant meltwater and rainwater flow down to the valleys in the spring and summer and then into the aquifer under the Gobi Desert. The Xinjiang people developed the skill to make use of the natural gradient of the proluvial fans and diverted the groundwater via the karez for farm irrigation (Fig. 2).

Karez and Kanat Tourism Landscape This is a method for transporting groundwater in arid areas. Karez irrigation includes vertical wells, underground canals, surface canals and sand banks. The spacing between the vertical wells is 25–30 m, and the deepest can reach a depth of 70 m. The underground canals are 1.5–2.0 m high, 0.6–0.7 m wide and generally 2–3 km long, though the longest can be 10 km or longer. The system facilitates the collection of groundwater and prevents its evaporation. Karez wells are a brilliant invention of the Xinjiang people in China for the utilisation of groundwater in arid regions. Every year, these wells attract many tourists for studying and sight-seeing purposes.

Karren (Solution Fissure, Lapies, Lapiaz) Landscape When surface water continuously erodes soluble rocks along joints, grooves form on the rock surface, which are collectively called karren or lapies. The bottom is often filled with dissolved residual soils and gravels deposited by water. Karrens are generally 10 cm to more than 2 m wide and tens of centimetres to several metres long and deep. Karrens (lapies) usually form in a criss-cross pattern (Fig. 3).

Karst Cave or Cavern Landscape This is a type of cave that is formed by the weathering and

dissolution of soluble rocks. Karst caves include carbonate caves, gypsum caves and rock salt caves. Carbonate caves are the most common type in China and are most extensively distributed. They are mainly limestone caves. According to the nature of the caves, they can be divided into dry caves, water caves and cultural caves. There are approximately 100,000 karst caves in China, and more than 400 have surveyed lengths greater than 500 m. In June 2008, 78 caves with lengths greater than 5 km had been surveyed in China, and 25 were longer than 10 km. For example, the Bailang Cave in Leye, Guangxi Province, has been surveyed 75 km long, and the Tenglong Cave has been measured 52.8 km long. There are 60 caves with depths (vertical extent) greater than 250 m, and 17 are deeper than 400 m. There are 22 caves with cave chamber areas exceeding 20,000 m^2. Most of these large caverns are located in southwestern China. They are important tourism resources.

Karst Cave Tourism Landscape Cave landscapes formed by dissolution are attractive to tourists. A karst cave is a complex hollow formed by the dissolution of carbonate rocks or other rock layers composed of soluble salts. Inside the caves, features such as stalactites, stalagmites, stone pillars, stone flags, stone drapery, stone flowers and relics of ancient human, palaeobiotic and cultural activities make up the karst cave tourism landscape. Karst caves usually develop along a specific rock layer and faults and fracture zones, and they form due to dissolution and corrosion by groundwater flow. The caves can be horizontal, inclined, near-vertical, multi-layered and inter-connected, and they include small, medium and large chambers. Some caves are dry and are above the groundwater level, while others have subterranean streams, underground waterfalls, or are completely submerged below the groundwater level. The caves and cave systems can vary from dozens of metres to several tens of kilometres long, and some are hundreds of kilometres long. The caves can range in volume from several cubic metres to tens of thousands of cubic metres or more.

Karst Collapse Landscape This is a landform that forms by ground collapse in karst areas. It can be divided into bedrock collapses and overlying strata collapses. The former are caused by the collapse of a cave roof due to cave enlargement, and the latter form by sinking of the overlying rock layer due to a loss of balance induced by natural or artificial factors. Bedrock collapse caves are always associated with bore-like collapse dolines with depths of tens to hundreds of metres. A cave is called a 'tiankeng' or ceiling pit if the width and depth are more than 100 m. When a collapse occurs in soil layers, circular, saucer-shaped, pot-shaped or cone-shaped collapse dolines can form. Karst collapse landforms are widespread in China and include tens of thousands of sunken pits. They can be either ancient or modern and may have formed under natural conditions, but some are caused by human economic and engineering activities (Fig. 4).

Karst Column Landscape Residual rock columns with similar upper and lower sections caused by the erosion of carbonate rocks along vertical fissures can form a karst column landscape. The columns are generally more than 5 m tall and can be up to tens of metres tall, and the relative height is greater than the column diameter. Few columns form in isolation, and most are in clusters. They are usually located along the margins of karst peak clusters or along the banks of karst canyons. Typical examples are the Yunnan Stone Forest, Guan Mountain in Xinxiang, Henan Province, Baishishan in Laiyuan, Heibei Province, Chaibuxi in Qingjiang and Yunlong River Canyon, Hubei Province (Figs. 5, 6, 7, and 8).

Karst Foot Cave Landscape This is a landform of horizontal karst caves that develop along the groundwater surface. These caves are formed by erosion due to frequent flooding along the foot of rock peaks in karst peak plains and karst valleys. The cave walls are often marked by side troughs, flow marks and shell-like ripple marks. The caves often have channel shapes, which are a typical form of water karst. Guilin in Guangxi Province and Dushan in Guizhou Province are examples of this kind of landform (Fig. 9).



Fig. 4 Karst collapse landscape – Hezhou, Guangxi Province



Fig. 5 Karst column landscape – Guanshan, Henan

Karst Gorge Landscape This type of karst valley has steep walls on both sides and a very narrow bottom (sometimes only a few metres to dozens of metres), and the depth far exceeds the width, which forms a unique landform. This type of valley is widely distributed in limestone regions subject to deep erosion by water associated with rapid crustal uplift. Karst



Fig. 6 Mushroom-shaped column landscape – Shilin, Yunnan

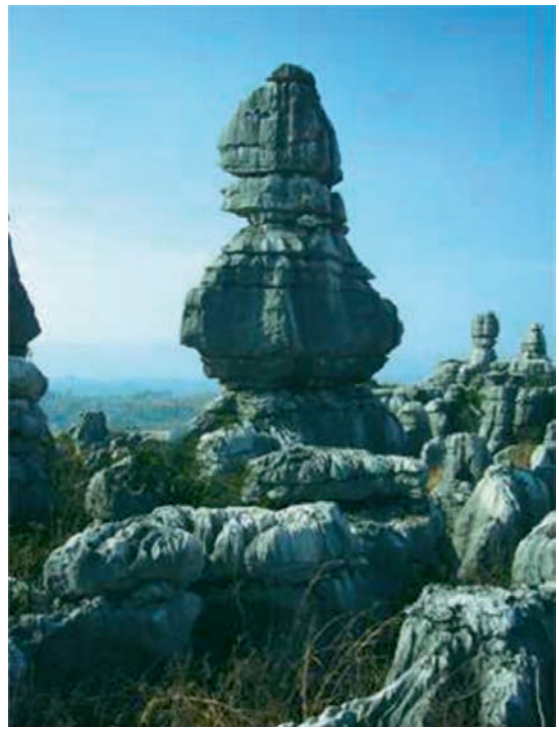


Fig. 8 Barrow-shaped column landscape – Shilin, Yunnan



Fig. 7 Pagoda-shaped column landscape – Shilin, Yunnan

gorges are often suitable for rafting and hence are an excellent tourism resource for participatory activities. The Maling scenic area in Xingyi National Geopark, Guizhou Province, is a typical example (Figs. 10 and 11).

Karst Hanging Valley Landscape This is a dry U-shaped valley hanging on the main valley slope in a karst area. It forms as a result of neotectonic uplift. The term hanging valley originates from glacial landforms, but it has been applied to river valley landforms to signify a tributary valley that hangs over the main valley slope.

Karst Hills Landscape This is a landform formed by the combination of mounds and unenclosed karst depressions. The mound tops are round with gentle slopes, whereas the bottoms are wider than their heights, with relative height differences of 100–150 m. This landform is mainly located in subtropical areas with muddy, siliceous, dolomitic limestone. Dissolution of this type of carbonate rock is relatively slow. This



Fig. 9 Karst foot cave landscape – Guilin, Guangxi Province



Fig. 10 Karst barrier valley landscape – Qutang Gorge

landform is well developed in dolomitic limestone outcrops in central China, western Hubei Province and northern Guizhou Province (Fig. 12).

Karst Ice Cave Landscape This is a landform of karst caves with perennial ice. The average temperature inside some portions of these caves is lower than 0 °C; thus, they are permanently or seasonally frozen. The Shennongjia Ice Cave in Hubei Province and Ningwu Ice Cave in Ningwu County, Shanxi Province, are typical examples. Ningwu Ice Cave developed in limestone of the Ordovician Majiagou Formation. The cave mouth is 2,220 m above sea level, and it is a vertical cave with a depth of 85 m. The walls inside the cave are wavy undulating layers of ice with naturally formed ice pillars, ice curtains, ice cascades, frost

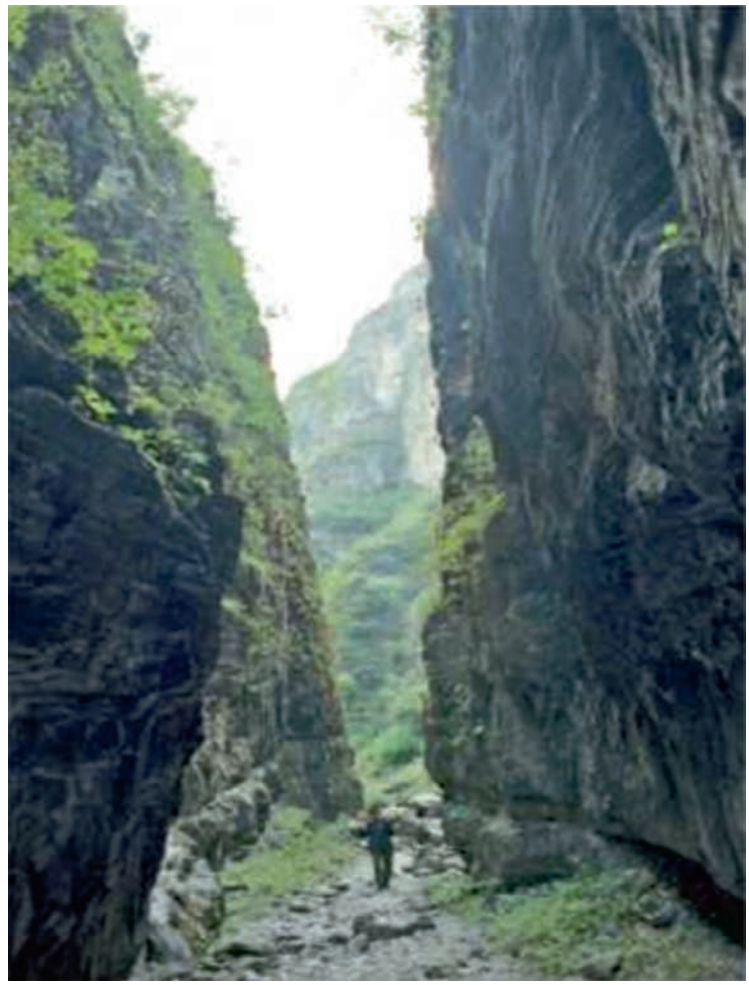


Fig. 11 Karst barrier valley landscape – Yesanpo, Hebei Province

flowers, icicles, ice stalactites and ice stalagmites (Fig. 13).

Karst Isolated Peak Landscape This is a landform with isolated peaks on a karst plain or basin. The peak walls are steep, typically over 60°. They generally cover areas of 0.01–0.05 km^2, and they are round in map view. They range in height from dozens of metres to more than 100 m. The peaks can have pagoda-like, conical and river snail-like forms, and they stand alone on the karst plain. They are features of the late stage of karst landform development. They are distributed along the banks of Guijiang and Liujiang in Guangxi, in the Binyang and Laitong areas and in several other karst regions (Fig. 14).

Karst Lake Landscape This is a landscape composed of groups of lakes in karst areas. A karst lake specifically refers to a large perennial water body in an enclosed karst depression. Typical examples are Xitang Karst Lake in Yangshuo County in Guilin, Huaying Mountain Tianchi (Heavenly Lake) in Sichuan Province, Dalong Pool in Liuzhou, Lingshui Lake in Wuming and Dun Lake in Xin City. These karst lakes can form under different conditions. Some form by the blockage of dolines or sinkholes, some are directly associated with the underground aquifer that supplies water for the entire year, and some are supplemented by water from karst springs. In a broad sense, karst lakes include artificial ponds and reservoirs constructed in karst areas. Hongfeng Lake, which was constructed along the Tiaomao River, and several large reservoirs built along the Hongshui River in Guizhou



Fig. 12 Karst hills landscape – Lichuan, Hubei Province



Fig. 13 Ice cave, Ningwu, Shanxi

Province are important examples. Many karst lakes have been used for tourism, and some have become national scenic areas (Fig. 15).

Karst Lake Tourism Landscape These are lakes that form in depressions or funnels in karst regions. They are generally small, but coupled with the unique karst geomorphic landscape, they have prominent tourism value. Examples are the Sword Pool in the Stone Forest, Yunnan, and the Grass Sea (Caohai) in Guizhou Province.



Fig. 14 Karst isolated peak landscape – Yangchun, Guangdong Province



Fig. 15 Karst lake landscape – Dalog Pool, Liuzhou, Guangxi Province

Karst Landform See ▶ Karst Landscape Tourism Resource, ▶ Loess Landscape (Figs. 16 and 17).

Karst Landform and Landscape Resource This is a geomorphic resource with the tourism value composed of soluble rocks. The main soluble rocks are limestone, dolomite, gypsum, anhydrite and rock salt. Unique karst surfaces and underground caves can form through dissolution and transformation by groundwater and surface water. The surface landscape can be divided into positive and negative landforms. The major positive landforms are clints, stone pillars, stone forests, isolated peaks, peak clusters, remnant mounds,



Fig. 16 Karst landscape



Fig. 17 Loess landscape in Shaanxi

natural bridges, travertine pools, travertine flows and travertine mounds. Negative landforms include avens, sinkholes, funnels, shafts, blind valleys, dry valleys, depressions, polje valleys and karst canyons. Underground caverns can be divided into dry caves, wet caves, cultural caves and various cave sediments. Water bodies inside caverns include subterranean rivers, underground lakes and underground waterfalls. Soluble rock (especially limestone) outcrops are widespread in China. Compounded by the complex geological structures and climate conditions, the resultant landform types are varied and widely distributed. They have high ornamental value, and some have qualified as world wonders and have become world heritage sites as global geoparks. Karst (Yangrong) landforms are one of China's important tourism resources and are a major supporter of China's tourism industry.

Karst Landscape Tourism Resource This landscape gets its name from a location on the Istria Peninsula in Slovenia, where limestone forms a unique landform with distinct peaks and caves. In 1893, the Yugoslavian scientist J. Cvijic studied the geological and geomorphic landscape of this area in detail and used the name of the site 'karst' as a general term for this limestone dissolution landform. Since then, 'karst' has become a universal term for dissolution landforms in limestone areas.

Because this term was considered to be not sufficiently popular, at the National Symposium on Karst held by the Chinese Geological Society in 1966, it was proposed that the Chinese term for this landscape be replaced by 'Yangrong', which means rock dissolution. This is because the distinctive peak and cave scenery is formed by the dissolution of rock by water; hence, it is easy to understand how 'Yangrong' reflects this process. Since then, 'Yangrong' has generally been used by Chinese academics, but some continue to use 'karst' because it continues to be used in translations of texts into foreign languages. In 1981, several participants at the Symposium on Northern Karst proposed resuming the use of the term 'karst', and it was agreed that both 'karst' and 'Yangrong' could be used and that these two terms were identical in context and meaning.

Karst Landscapes on Yongxing Island and Shidao Island in the South China Sea Yongxing Island is the largest island of the Xisha Islands group and is also the largest island in the South China Sea. It is China's most important karst landform associated with coral reef islands. It has an east-west length of approximately 1,850 m, a north-south width of approximately 1,160 m and an area of approximately 2.1 km^2. Shidao (Shi Island) lies 1,130 m northeast of Yongxing Island on the same atoll. At low tide, Shidao is accessible to Yongxing Island by foot. Shidao is the only rocky island in the early stage of diagenesis. It has an area of approximately 0.08 km^2, and the highest point is 15.9 m above sea level, which is also the highest point on the Xisha Islands. It is mainly composed of bioclastic limestone that is subject to strong karst dissolution and marine erosion. Reef caves are common near the ocean surface. A 3-m-high piece of coral reef stands upright and looks like a dissected aged loofah melon with pulp. A unique karst landform, solubilisation tubes (rhizoliths), are located on the cliff above the high tide mark. The tubes are in a criss-cross pattern, spread vertically, or are sometimes at an oblique angle from the cliff. They have varying diameters and lengths. There is no relic of organisms inside the tubes, and the tube centres are tiny hollows from which concentric layers extend. These layers are similar to those of stalactites but without a radial pattern. There is currently no consensus on their formation. Uranium dating of the limestone reef at a location 19 m below sea level indicates an age of 130,000 years. To the southwest of Yongxingdao, there are seven additional coral reef islands of different sizes and shapes. They are linked together, so they are called the Seven Linked Islands, and they form an important karst landform in the South China Sea (Fig. 18).

Karst Lateral Cave Landscape This is a landform of karst caves created by lateral water flow in which the cave channel extends horizontally or nearly horizontally. Most form in the shallow saturated water zone or the aquifer zone. They are most common in karst plains. Based on the shape, karst lateral caves can be divided into channel-type (single, dendritic and labyrinth shapes), chamber-type and composite channel-chamber type (Fig. 19).

Karst Mixed Cave Landscape This is a composite cave landform consisting of superimposed lateral and vertical caves. This kind of cave has both horizontal and vertical structures and characteristics, and they generally form when vertical caves link layers of lateral caves. They mainly develop in karst mountainous areas. The caves are generally large and have complex forms.

Karst Natural Bridge Landscape When the roof of a subterranean river collapses, the ends remain connected and touch the ground, forming a suspended bridge-like feature called a karst natural bridge. Although the term karst natural bridge has been commonly used, its definition is not completely consistent. Practically, it is difficult to make a strict distinction between a karst natural bridge and a light-through cavity (subsurface flow). Therefore, some academics suggest that a karst natural bridge should be defined based on the condition that sunlight can reach the entire channel.



Fig. 18 Coral island landscape on Yongxing Island, South China Sea



Fig. 19 Karst lateral cave landscape – Chuanshan rock, Guilin

Based on this standard, the channel length of the cave beneath a karst natural bridge (which equals the width of the bridge surface) should be limited to a maximum of 180 m. Karst natural bridges are common in southwestern China. The bridge across the Buliu River in Leye County, Guangxi Province, has a thickness of 78 m, an arch height of 67 m, an arch span of 177.14 m and a bridge width of 19.3 m, and the ridge height is 145 m. Along 1.5 km of



Fig. 20 Karst natural bridge landscape – Xiangqiao, Luzhai, Guangxi Province

the Yangshui River in Wolong, Chongqing City, there are three sets of karst natural bridges that form a single large-scale subterranean cave system. This landform is rare and has been put onto the World Natural Heritage directory (Fig. 20).

Karst Perforated Rock Landscape *Synonym:* ► *Light-through cavity landscape*
This is a karst landform consisting of residual karst channels, both ends of which are open to allow light to enter, and the cavity is above the groundwater level and is located in the upper part of the hill. These features are common in Guizhou and Guangxi Provinces, and the Through the Mountain Moon Rock in Guilin and the Moon Mountain in Yangshuo are most famous. The Through the Mountain Moon Rock is a large open cavity aligned north to south. The cavity is located in the middle of a hill, is approximately 10 m high, 20 m wide and 70 m long, and can accommodate several hundred people. Viewed from a distance, this cavity looks like a bright moon hanging high in the sky; hence, it was previously called Empty Bright Rock. Yangshuo's Moon Mountain is 411 m above sea level and has a relative height of approximately 300 m. The cliff on the upper hill looks like a screen with a hole in the middle, resembling a luminous moon in the sky. Hence, it is called Luminous Moon Peak or more commonly Moon Mountain (Fig. 21).

Karst Plain Landscape This is a landform that forms in flat and wide karst areas near the water surface. It is a bedrock plain that forms by river and groundwater erosion combined with the abrasion of sand and gravel carried by water. Karst plains often form near the contact between soluble and non-soluble rocks; therefore, they are called a karst margin plain. In humid tropical and subtropical areas, dissolution is strong because of frequent river flooding, so karst plains can form easily. The area of the plain can reach hundreds of square kilometres. Examples are the plains in Liuzhou, Laibin, Litang and Guiyang in central Guangxi Province.

Karst Spring Landscape This is the natural outflow of underground karst water and is the phenomenon of groundwater flowing from the spot where the aquifer or water channel intersects the ground surface. A karst spring



Fig. 21 Karst perforated rock landscape – Yangshuo Moon Hill, Guangxi Province

signifies the characteristics of the water volume, water quality and movement of the karst groundwater. According to their properties, karst springs have various classifications: (1) rising springs and descending springs, which refer to the spring's hydrodynamic properties; (2) constant flow springs, intermittent springs or seasonal springs, erratic springs or sinkhole springs, overflow springs and periodic springs, which refer to the spring's dynamics; (3) dissolution fissure springs, karst cave springs, rising shaft springs and dissolved pool springs, which refer to the springhead shape; (4) riverbed springs, valley edge springs, coastal springs, seabed springs, fault springs and suspension springs; and (5) external source springs and internal source springs, which refer to the spring's supply (Figs. 22 and 23).

Karst Valley Landscape In karst areas, valleys with steep cliffs can form due to uplift during neotectonic movements and strong erosion, dissolution and gravitational collapse by water flow. This type of valley is deeper than its width and is commonly called a karst valley landform. It is characterised by steep or near-vertical walls on both sides and numerous grooves and small caves on the walls just above the water level. Based on the mode of formation, they can be divided into V-shaped valleys, gorges, box-shaped valleys and fissure-type valleys. The Three Gorges is the most famous karst valley and has a total length of 124 km. Fissure-type karst gorges are represented by the famous Tianjing Canyon in Fengjie, Chongqing City, which has a length of 6,162 m, a bottom width of 1–15 m and a vertical depth of 80–229 m (Fig. 24).

Karst Waterfall Landscape A waterfall is a flow of water that pours down from the longitudinal section of the steep slope of a riverbed or from a hanging cliff. A waterfall in a karst area is called a karst waterfall, and the associated landform is known as a karst waterfall landscape. In addition to waterfalls that form along the cliffs along rivers, karst areas contain waterfalls that form from underground rivers or karst springs. The permeabilities of different carbonate rock strata are different. Non-soluble rock layers are sometimes located between the layers of carbonate rock. Due to



Fig. 22 Double karst spring landscape – Fengshan, Guangxi Province

the abundant rainfall and active tectonic movements, there are numerous fissures; hence, karst waterfalls in southwestern China are particularly well developed. The Huangguoshu Waterfall clusters in Guizhou Province and the Detian Waterfall in Daxin County, Guangxi Province, are the most famous. The Large and Small Cascade Waterfalls in Shilin County, Yunnan Province are equally well known (Fig. 25).

Karst Window Landscape This is the roof of an underground river or a cavern that is connected to the ground surface and allows sunlight to shine in. It is usually a vertical shaft-like channel that reaches the ground surface. Viewed from the cavern bottom, this feature looks like a transparent skylight akin to that in a house. Karst windows vary in size and form. The karst window of the Fuming Cave in the Dashiwei karst window cluster in Leye, Guangxi Province, has an area of 16.5 m^2 and a depth of 365 m. Sunshine can reach the cave chamber, so it is also called 'Sunshine Hall'. In the Sanmen karst window cluster in Fengshan, Guangxi Province, there are four windows along a 690-m stretch along a subterranean river, and three are accessible by boat. Therefore, this site is also called the 'Sanmen (Three Doors) Sea' (Fig. 26).

Kastanozem *Synonym:* ▶ *Chestnut soil*

This soil forms by weak humus accumulation, clayification and intense calcification under temperate semi-arid steppe vegetation. The upper part of the section is chestnut in colour, and the lower part contains mycelium-like, plaque-like or reticular calcium deposits. Additional features include salinization, alkalization, and meadowization.



Fig. 23 Baotu Spring landscape – Jinan, Shandong Province



Fig. 24 Karst valley landscape – Furong River, Wulong, Chongqing

Kastanozems are the main soils in grasslands in China. They are mainly located in the eastern and central parts of the Inner Mongolian Plateau, the eastern Ordos Plateau, the Datong Basin and the foothills of the southeast Daxing'anling Mountains.



Fig. 25 Karst waterfall landscape – Huangguoshu Waterfall, Guizhou Province



Fig. 26 Karst window landscape – Maoqi Cave, Leye, Guangxi Province

Katla Geopark, Iceland This geopark is located in Iceland's Eyjafjallajokull volcano area and covers an area of 9,542 km^2. It was accepted as a member of the Global Geopark Network in 2011. The park is characterised by volcanic landforms, such as volcanic vents, eruption

cracks, lava rocks, lava ridges and tuff. The glaciers stand out in the landscape of the park, covering beautiful mountains. There are several smaller glaciers, glacier rivers and glacial landforms, such as hailstones and glacial lakes, near the glaciers. In addition, glaciers were generated by volcanic eruptions under ice-break floods, forming ice-water sedimentary plains in the lowland areas. Other fascinating features in the area include fossil-bearing xenoliths, false craters, and volcanic dust, which are helpful for the identification of geologic time. Geotourism is a driving force for sustainable development in this region, where the residents' daily lives are strongly affected by volcanic activity.

Katmai Type This is a type of volcanic eruption named after the Katmai Volcano in Alaska. The magma viscosity is very high. The magma is usually rhyolitic, andesitic or trachytic and is characterised by the formation of a large thick hot volcanic ash flow, in which the clastic materials have various sizes and are unsorted. An example is the ash flow of the 'Million Smoke Valley' near Katmai Volcano, where a volcanic crater formed by the eruption of abundant magma.

Kaziranga National Park, India Kaziranga National Park stretches along the banks of the Brahmaputra River in eastern India and covers an area of 429 km^2. In the heart of Assam, this park is one of the last areas in eastern India that is undisturbed by humans. It is inhabited by the world's largest population of one-horned rhinoceroses as well as many mammals, including tigers, elephants, panthers and bears, and thousands of birds.

Keketuohai No. 3 Pegmatite Deposit, Xinjiang This is a large rare earth element-bearing granite pegmatite ore bed containing lithium, rubidium, caesium, beryllium, niobium and tantalum in a Hercynian hornblende gabbro rock mass. It is located in Keketuohai, Fuyun County, Xinjiang Province. Twenty-five granite pegmatite veins have been found in this area, six of which contain rare earth element reserves. The Keketuohai No. 3 pegmatite deposit is the largest and the most typical granite pegmatite vein; it is 2,250 m long, 1,500 m wide and 20–60 m thick. There are nine zones from the edge to the centre, namely, (1) a graphic-textured and deformed graphic-textured quartz microcline zone, (2) a sugar-crystal albite nest zone (mainly containing beryllium ore), (3) a plagioclase block zone, (4) a muscovite-quartz aggregate zone, (5) spheroidal albite-spodumene zones (lithium-bearing belts containing beryllium and niobium), (6) a quartz-spodumene zone (combined with (5) to form a beryllium-tantalum-niobium lithium host ore), (7) a muscovite flaky albite zone (with lithium, beryllium, niobium, and tantalum ore), (8) a flaky albite-lithium mica zone (with niobium, tantalum and lithium ore), and (9) a quartz block zone. The No. 3 vein is large, has a fine internal structure with perfect sub-zones, and contains a wide variety of rare earth element minerals in coarse-crystal form. Given its relatively large variety, concentrated mineral mass and characteristics that differ from other granite pegmatite mines, the Keketuohai No. 3 pegmatite deposit is considered an atypical pegmatite deposit (Fig. 27).

Kenya Lake System in the Great Rift Valley, Kenya This heritage site is located in the East Rift Valley of Kenya and covers a total area of 320 km^2. Its outstanding features include three interconnected shallow lakes, Lake Bogogna, Lake Nakuru and Lake Elmentetta. The Lake District is home to 13 globally endangered species and is one of the richest areas for bird species in the world. It is the most important foraging ground for small flamingos as well as the nesting and breeding base for great white pelicans. The heritage area also has large populations of large mammals, such as black rhinoceroses, Rothschild giraffes, twisted antelopes, lions, cheetahs and wild dogs, which have important scientific value for studies of major ecological processes.

Keoladeo National Park, India Keoladeo National Park is located 50 km west of Agra City in the northeastern corner of Rajasthan in northwestern India. It protects an area of 28.7 km^2. This former duck-hunting reserve of the Maharajas is one of the major wintering



Fig. 27 Keketuohai No. 3 pegmatite mine

areas for large numbers of aquatic birds from Afghanistan, Turkmenistan, China and Siberia. Approximately 364 species of birds, including the rare Siberian crane, have been observed in the park.

Kilimanjaro National Park, Tanzania This park is located in the borderland of Kilimanjaro, Tanzania, near Kenya. The park covers a core protection area of 753 km^2. At 5,895 m, Kilimanjaro is the highest point in Africa. This volcanic massif stands isolated above the surrounding plains, and its snowy peak looms over the savannah.

Kilimanjaro Volcano Landscape This is a dormant volcano in northeastern Tanzania near the Kenyan border. Known as the shining mountain, its foothills have a tropical climate, but the summit is alpine. Kilimanjaro Volcano includes three peaks, which formed during volcanic eruptions approximately two million years ago. The peak has a crater that is approximately 1,800 m in diameter, which erupted 1,000 years ago. It is now dormant, and the crater is filled with ice and snow with icicles on the edges. Fumes are occasionally emitted near these icicles. The foothills are covered with tropical forests that are populated by wild animals; hence, they are called the world's zoo for wild animals. The temperature decreases by 6 °C with every 1,000 m increase in elevation, and the areas with temperatures below 0 °C have permanent snow cover. The mountain also has the name 'Snow White of the Equator'. People who live below the foothills regard this mountain as their god and the origin of all life. At the Copenhagen Climate Conference, some people pointed out that with global warming, this 'Snow White of the Equator' will disappear in a few years.

Kimberlite Kimberlite is an ultramafic rock which contains diamonds. It gets its name from the township of Kimberley in South Africa, where diamonds were discovered. Kimberlite is a breccia mica peridotite that is dark green or grey and is composed of minerals such as forsterite, phlogopite and pyrope. It often contains xenoliths that come from the mantle, deep crust or shallow country rocks. It often appears in a volcanic pipe, volcanic neck dyke or vein. Since diamonds are usually found in association with kimberlites, this rock has received much attention. In China, diamonds are mined in kimberlites in Liaoning and Shandong Provinces.

Kinabalu Park, Malaysia The park is located on the edge of Kalimantan, Malaysia, in northern Sabah. The core protection area covers 753.7 km^2. At 4,095 m above sea level, Mount Kinabalu is the most beautiful peak between the Himalayas and New Guinea. The park displays a wide variety of animal and plant habitats, including lush tropical lowland

and mountain rainforests, tropical forests, low forests, and the Shushan bushes. The park was designated as a Southeast Asian Plant Diversity Conservation Centre and contains plants from the Himalayas, China, Australia, Malaysia, and other tropical vegetation areas.

Klippe A klippe is an isolated remnant of an exotic rock body sitting on an in situ rock body. Klippes form by the erosion of a nappe or an overthrust. Klippes are generally surrounded by younger rocks and separated from them by a fault.

Kluane/Wrangell-St. Elias/Glacier Bay/Tatshenshini-Alsek, Canada and U.S.A. Kluane/Wrangell-St. Elias/Glacier Bay/Tatshenshini-Alsek is the first cross-border heritage site added to the World Heritage List after the World Heritage Convention took effect. After extensions in 1992 and 1994, the site now comprises four federal and provincial reserves, namely, Kluane National Park (Yukon Territory, Canada), Tatshenshini-Alsek Provincial Park (British Columbia, Canada), Wrangell-St. Elias National Park and Preserve (Alaska, U.S.) and Glacier Bay National Park and Preserve (Alaska, U.S.). These parks have a core protection area of 98,391 km^2 and form the largest land reserve system in the world heritage network. The spectacular natural landscapes protect the largest non-polar icefield in the world and are home to many grizzly bears, caribou and Dall's sheep.

Knickpoint A knickpoint is the break between the steep and gentle slopes of a river profile caused by erosion induced by a rejuvenated river, tectonic uplift of the riverbed or a change in lithology. On stable ground, a riverbed will tend to be a smooth surface with a gentle gradient. The Earth's movement can cause uplift of the riverbed or drastic lowering of the erosional datum (i.e., ocean or lake surface); as a result, the river resumes downward erosion at the river mouth and headward erosion upstream. The break point between the new and old river courses is the knickpoint, which often appears in the form of a rapid, turbulent shore or waterfall. River terraces often correspond to the formation of knickpoints.

Komodo National Park, Indonesia This park is located in the northwestern corner of East Nusa Tenggara, Indonesia. The core protection area covers 2,193 km^2. The volcanic islands are the habitat for more than 5,700 giant lizards. Because of their unique appearance and aggressive nature, they are also known as Komodo dragons. Because no similar species can be found anywhere else in the world, the giant lizard attracts scientists who study evolution.

Kuantzuling Hot Spring Landscape This is a landscape consisting of a hot spring associated with oil and gas fields. It is located in the northern foothills of the Kuantzuling Range approximately 8 km east of Baihe Town in Tainan County, Taiwan. The spring flows along the valley in the upper course of Baishiu Creek 2 km northeast of Zhentou Hill. The spring has two sources: (1) water that flows from the fissures in the bedrock; the springs are located west of the Central Mountain Range, which contains marine facies muddy sandstone layers; and (2) water that flows from oil and gas fields, which is greyish black and collected in a square pool. Natural gas is associated with the spring water that flows from the cracks in the rock, and it can be lit to form a one-foot-tall flame, creating a scenery of 'Merged Water and Fire'. The spring water has a temperature of 84 °C with a salt concentration of approximately 10 g/L, and the highest concentration can exceed 20 g/L. The hot water is moderately alkaline (pH 8.2) and is a bicarbonate sodium chloride-type water. It also contains 136 mg/L of boron. This spring water is effective at treating various skin diseases and rheumatoid arthritis (Fig. 28).

Kuiyuan Tao Kuiyuan Tao (1934–) is a researcher at Nanjing Institute of Geology and Mineral Resources, Ministry of Land and Resources and a doctoral tutor and major in volcanism research. His main publications are 'Volcanic Lithofacies Tectonics', 'Basement Structure of the Southeast Coast of China', and 'Intrusive Igneous Rocks and



Fig. 28 Kuantzuling Hot Spring landscape, Taiwan

Mineralization'. Since 1996, he has engaged in studies of tourism earth science, geopark planning and earth science popularisation. He has compiled 8 tourism earth science books for people at different levels and has published more than 30 tourism earth science papers.

Kunshan Stone Kunshan stone was given its name because it is mined at Yu Feng Mountain (called Ma'an Shan in the past) in Kunshan, Jiangsu Province. This stone is Cambrian marine dolomite. Kunshan stone is characterised by its white colour and abundant pores, and it is also known as 'Linglong (exquisite) stone'. It has various shapes and famous varieties, such as chicken bone, walnut, snowflake, red bayberry and lotus leaf wrinkle. This stone is an excellent material for interior decoration and landscape gardening (Fig. 29).

Kuo Shen Kuo Shen (1031–1095), nicknamed Cunzhong, was a native of Qiantang in Hangzhou, Zhejiang Province. He was a scientist during the Northern Song Dynasty. He studied loess in North China and Shaanxi Province and fossil oil in northern Shaanxi. He wrote the



Fig. 29 Kunshan stone

26 volumes of 'Meng Xi Bi Tan (Dream Pool Essays)'. He performed in-depth studies of astronomy, geography, geology and medicine. He studied astronomy, drew numerous astrological maps and promulgated a new calendar. In his studies of physics, he discovered the existence of geomagnetic declination 400 years before the Europeans. Based on his studies of geology, he inferred the changes of the sea and land from the presence of fossils in the rocks of Mount Taihang. He was the first person to use the term fossil oil. He explained the process of water erosion 600 years earlier than J. Hutton in England. He wrote many books that survive today, including 'Dream Pool Essays', 'Bu Bi Tan (Supplement to Dream Pool Essays)', 'Xu Bi Tan (Continuation of Dream Pool Essays)', 'Changxing Collection', 'Yi Mao Ren Guo Zou Qing (Petition of Foreign Countries in the Year of Yi Mao)', 'Ren Guo Bie Lu (Records of Foreign Countries)', and 'Su Shen Liang Fang (Su Shen Effective Prescription)'.

Kuqa Canyon National Geopark, Xinjiang This geopark is located in Kuche County, Aksu District, Xinjiang, and was included in the fifth group of national geoparks in August 2009. The geopark is characterised by the red-sandstone canyon that formed in the Cenozoic. It is dominated by Quaternary glacial remains and yardang landforms. The geopark also boasts a 'kuqa landscape' that is mainly composed of red sandstone and features maze-like canyons and castle-like mountains. This landscape is composed of folded terrestrial Cenozoic conglomerates, sandstones and mudstones that have been eroded by seasonal water flows, arid climatic conditions and collapses. The park also has various glacial landforms, including dammed lakes, moraine platforms, U-shaped valleys, and diverse yardang landforms in the shape of belts and pyramids.

Kyanite; Cyanite The composition of kyanite is $Al_2[SiO_4]O$. It belongs to the same series as the polymorphs andalusite and sillimanite. It has a trigonal crystal structure, and the crystals are flat and prismatic with curved crystal surfaces. The aggregates are blocky or fibrous. It can be blue, white, grey, green, yellow, pink or nearly black. Single crystals can have many colours. It has transparent to translucent diaphaneity, a vitreous lustre, a pearly cleavage surface lustre, a specific gravity of 3.52–3.67, a Mohs hardness of 5.5–7 and uneven fractures. Kyanite is mainly found in crystalline schist in regional metamorphic zones because it forms from clay rocks subjected to regional metamorphism. Kyanite with elegant colours can be used as gems.

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La Niña La Niña occurs when the water temperatures in the eastern and central equatorial Pacific Ocean are 0.5 °C lower than normal for six consecutive months. It is the opposite of the El Niño phenomenon, and it means 'girl'. It is also called the 'Anti-El Niño'. The La Niña phenomenon occurs approximately once every 3–5 years, and its appearance has a large influence on the regional and global climate.

Lacuna *Synonym:* ► *Stratigraphic gap*

A lacuna, which is sometimes called a 'gap', is a large and obvious discontinuity in a rock formed by a disconformity or unconformity. If a lacuna forms due to an unconformity, when deposition stops, the erosion of the old strata also stops. This implies the end of deposition of new rock layers and the partial denudation of the old rock layers. For example, the parallel unconformity between the North China Middle Ordovician Series and the Middle Carboniferous Series lacks the Upper Ordovician Series, the Silurian System, the Devonian System and the Lower Carboniferous Series. This lacuna shows not only that the deposition of several systems did not occur and that some of the Ordovician strata had been eroded.

Lacustrine Facies *Synonym:* ► *Lake facies*

Lacustrine facies are deposits that is formed by geological processes in lakes. They are the most widely distributed type and one of the main types of terrestrial facies. Ancient lacustrine facies can be divided into freshwater lake facies and salt lake facies. In map view, freshwater lake facies are often banded in rings, where the sediment particles vary from coarse to fine from the lake edge to the centre, and the sand bodies become more well connected. Freshwater lake facies also contain freshwater biota and biological material and are usually composed of mudstone, siltstone and sandstone, sometimes with marl, diatomite and other deposits. Salt lake facies form under dry continental climatic conditions and mainly consist of various kinds of salt deposits, such as gypsum, rock salt, potassium salt, and bauxite with fine clastic rocks, limestone and dolomite. Horizontal bedding is developed and contains cracks, raindrop imprints and markers of biotic activity. In China, lacustrine facies are widespread in Mesozoic and Cenozoic strata; the large facies can cover hundreds of thousands of square kilometres. Lacustrine facies are often closely related to oil and gas reservoirs.

Lagoon Landscape A lagoon landscape is a landscape comprising a coastal zone separated from the ocean by sand spits, sand bars or coral reefs. The lateral movement of sediments in the coastal zone can form an offshore bar-lagoon landform. When the waves move landward, sand and mud accumulate parallel to the coastline and form an offshore bar that is higher than sea level. The bar eventually separates the water from the open sea, forming a semi-enclosed or enclosed lagoon on the landward side. Based on the materials that form the embankment, lagoons can be categorised into coastal lagoons and coral lagoons. Coastal lagoons are widely distributed around the world, accounting for 13% of the total coastline, and are mainly in areas with small tidal ranges, low wave energy, and adequate sediments to form bars to protect the coastline. Coral lagoons are mainly located in the extensive seas in the tropics, which are suitable for coral to grow, mainly in regions below 25° latitude. The West Lake in Hangzhou in China is thought to have originally been a lagoon.

Lagoon Tourism Landscape This is a landscape composed of a water body surrounded by sand bars in a coastal area. It is separated from the sea at low tide but is connected to the sea at high tide.

Lagoons of New Caledonia, France These lagoons are located northwest of New Caledonia in the southwestern Pacific, and they have a

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core protected area of 15,743 km^2. The Lagoon Conservation Area contains six marine biomes that demonstrate the diversity of coral reef resources and related ecosystems in New Caledonia. It is also one of the three largest coral reef ecosystems in the world. The lagoon is home to a variety of corals and fish, and it is the most concentrated area of coral reefs in the world. In addition, several marine habitats are fully developed, including mangrove forests and seaweed habitats.

Laishui Yesanpo National Geopark, Hebei This geopark is located 90 km east of Beijing and 145 km northwest of Baoding. It became a national geopark in 2004. It is characterised by a karst valley landscape. The park is located along the southern branch of the Taihangshan Fault Zone and at the northern end of the Zijingguan Fault Zone, which is indicative of intense tectonic activity. The 52-km-long Bailixia Gorge and the river erosional landscape are the most spectacular attractions of the geopark.

Laixi Guo Laixi Guo, (1934–) is a native of Shangcai County, Henan Province, and is a human, economic and tourism geographer. He graduated from the Department of Geography, Nanjing University and is one of the pioneers of Chinese tourism geography. He is a researcher at the Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, and a doctoral tutor. He once served as the chairman of the Human Geography Professional Committee of the Geographical Society of China, director of the Geographic Research Institute of Yunnan, and deputy chief editor and executive editor of the 'China Human Geography Series'. His major works include 'Development and Distribution of Light Industry in Southwest China', 'Economic Geography of Hulunbuir', 'Research on Comprehensive Development of Meizhou Bay Region', 'Tourism Geography', 'Development and Research of Gold Coast in China', 'Classification and Evaluation of Tourism Resources' and 'China's Ecotourism: The Cornerstone of Sustainable Tourism'. He presided over the tourism planning of five provinces, namely, Jiangxi, Qinghai, Hebei, Ningxia Hui Autonomous Region and Xinjiang Uygur Autonomous Region, as well as the master planning of dozens of local areas. He is still in charge of tourism planning and has made significant contributions to the development of China's tourism industry.

Laiyang Cretaceous Geopark, Shandong This geopark is located at the heart of the Jiaodong Peninsula, Shandong Province, and covers a total area of 104 km^2. It is adjacent to the Yellow Sea to the south and is separated by the sea from the Liaodong Peninsula, the Korean Peninsula and the Japanese Archipelago. It became a provincial geopark in 2010 and a national geopark in 2011. The geopark consists of two areas, namely, Jingangkou and Phoenix Mountain. With the concentrated, successively deposited and well-exposed Cretaceous strata, the geopark is where the names of the Laiyang Group, Qingshan Group and Wangshi Group come from. It is also the location where dinosaur fossils and pterosaur fossils were first discovered in China. The world's only complete Tsintaosaurus spinorhinus fossils and numerous dinosaur egg fossils were also found here. Research on the dinosaur egg fossils in Laiyang led to the establishment of the internationally recognised and universal dinosaur egg classification and naming system. In addition, entomolites were first found and studied here, including the 'Laiyang biota', which includes insects, conchostraca and lycoptera.

Laiyuan Baishishan Mountain-Type (Tower Peak) Stone Forest Landscape, Hebei This is a representative type of carbonate rock stone forest landscape. It is composed of Proterozoic siliceous dolomite strips. It is a typical pagoda-like stone forest landscape in the Baishi (White Rock) Mountains in Laiyuan, Hebei Province. This landscape is characterised by a combination of clustered columns (peaks) that look like pagodas standing along the valley edge or on the ridgeline. They look like a pagoda forest when viewed from a distance. The column edges are angular, which is an indication of weak dissolution but strong gravitational



Fig. 1 Baishishan Mountain-type (tower peak) stone forest landscape, Hebei Province

disintegration. Baishi Mountain in Laiyuan, Hebei Province, is a typical karst stone forest in a semi-arid area in northern China. The Baishi Mountain area of China's Fangshan Global Geopark is composed of this landscape (Fig. 1).

Laiyuan Baishishan National Geopark, Heibei This geopark is located in southern Wuyuan County, Hebei Province, and it includes the source of the Jumayuan Spring and Baishi Mountain in Liyuan County. It has a total area of 60 km^2, and it became a national geopark in 2002. It is characterised by landforms formed by the Baishishan dolomite marble, which was named the 'Shilin-style (Taifeng) Stone Forest Landscape'. The park also contains the Shipuxia rich granite landscape and geological relics of the waterfalls and the Jumayuan Spring Formation. The Baishishan dolostone marble was baked by hot lava and metamorphism. The upper dolomite caprock formed in a marine environment one billion years ago. The deformation of the dolomite created more than two sets of vertical joints. Weathering allowed expansion of the joints to form columnar peaks with towering pillars, creating a 'white stone mountain landscape'.

Lake A lake is a large body of water on the land surface. Lakes account for approximately 1.8% of the total land area of the Earth. The largest numbers of lakes are in Northern Europe and North America. There are more than 2,800 natural lakes in China with areas greater than 1 km^2. They are mainly distributed in the eastern plains, the Qinghai-Tibet and Yunnan-Guizhou Plateaus, and the Mengxin region. Lakes can be classified into different types based on their formation, including structural lakes, furiotile lakes, lagoons, crater lakes, barrier lakes, erosion lakes, glacial lakes and artificial lakes.

Lake Baikal, Russia This lake is situated on the border between the Republic of Buryatia, southwestern Siberian Federal District, Russia, and Irkutsk Oblast, and it covers an area of 88,000 km^2. The surface of Lake Baikal covers 31,500 km^2, and it is the oldest (25 million years) and deepest (1,700 m) lake in the world. It contains 20% of the world's unfrozen fresh water reserves. Its age and isolated location have allowed it to grow into the 'Galapagos Islands of Russia'. Therefore, it is home to the world's richest and most unusual freshwater animals and has irreplaceable value for research on the theory of evolution.

Lake Basin A lake basin is a natural depression on land that contains water. It includes the lake shore zone and the lake bottom area. Based on the crucial factors during its formation, lake basins can be classified into the following: (1) tectonic (such as faulting and folding) lake basins; (2) glacial lake basins, which are formed by glacial advance or retreat, ice fracturing or uneven warming of the ice surface; (3) volcanic crater lake basins, which form in dormant volcanoes after their eruption; (4) barrier lake basins, which are a result of landslides or blockage of river valleys by erupted materials; (5) fluvial lake basins, which are formed by water erosion; (6) aeolian lake basins, which are formed by wind erosion; and (7) meteorite lake basins, which form due to the impacts of meteorites on the ground. When a lake basin fills with water, it becomes a lake (Fig. 2).

Lake Cliff Landscape This is a type of lacustrine erosion landscape consisting of steep cliffs facing a lake that are formed by the scouring of lake waves on bedrock. Due to the continual impact and abrasion of waves along the lake shore, rocks near the lake surface are scoured to form concave cavities with overhanging rocks. Upon further erosion, the hanging rocks fall to form vertical cliffs. Their formation is similar to that of marine cliffs but at a smaller scale. The study of the spatial distribution of lake cliffs is a key to understanding the development of lake landforms and the related neotectonic movements (Fig. 3).

Lake Erosion Groove Landscape This is a type of lacustrine erosion landscape. These grooves form due to wave erosion of a lake cliff, and they are distributed continuously at the same elevation.

Lake Facies ▶ Lacustrine Facies

Lake Landscape This is a landscape consisting of landforms formed by lacustrine erosion or deposition. The main erosional features are lake erosion cliffs, lake erosion columns, lake erosion grooves and lake erosion benches. In the context of tourism landscape resources, lake landscapes also include water bodies. Lakes can be classified into tectonic lakes, fluvial lakes, glacial lakes, volcanic (crater) lakes, aeolian lakes, barrier lakes and artificial lakes. Lake landscapes are important tourism resources. For example, Qinghai Lake, Dongting Lake, Dianchi Lake, Erhai Lake, the modified West Lake in Hangzhou, Nanjing Xuanwu Lake, Wuhan East Lake, and Zhejiang Qiandao Lake are all important tourist destinations.

Lake Landscape Tourism Resource System Lakes are composed of water that accumulates in depressions on land. Water bodies and lake shores are important tourism



Fig. 2 Lake basin landscape



Fig. 3 Cliff landscape in Dalinuoer, Inner Mongolia

resources for human activities. Based on whether a lake is connected to the sea, lakes can be classified into inland lakes and external lakes. Based on the salt content of the water, lakes can be divided into saltwater lakes and freshwater lakes. Lakes have a total area of approximately 2.0587 million square kilometres, which accounts for 1.5% of the total land area of the Earth. The total volume of lake water is approximately 176,400 km^3, which is 52% of the freshwater reserves. Lakes with different formation processes, sizes, and locations and environments have formed an extensive lake landscape tourism resource system.

Lake Malawi National Park, Malawi Lake Malawi National Park is located in eastern Malawi across the lake from Mozambique. It has an area of 94 km^2. Located at the southern end of Lake Malawi, the national park is home to hundreds of endemic fish species. Their importance for studying evolution is comparable to that of the finches of the Galapagos Islands.

Lake Turkana National Parks, Kenya These parks are located in northwestern Kenya near the southeastern corner of Sudan and the southwestern corner of Ethiopia. It has a core protection area of 1,614 km^2 after its extension in 2001. As the saltiest of the large lakes in Africa, Lake Turkana provides a unique laboratory for studying flora and fauna. The three connected national parks, which provide a transfer station for migratory water birds, are breeding sites for Nile crocodiles, hippopotami and various venomous snakes.

Lakes of Ounianga, Chad These lakes are located in northwestern Chad and cover an area of 628 km^2. They include 18 interconnected lakes in the Ennedi region in the Sahara Desert. Beautiful colours and shapes form a magnificent natural landscape. Saltwater lakes, brackish lakes and freshwater lakes are all supplied by groundwater. Two groups of lakes are separated by 40 km. The Uyuniga-Kebir Lake group consists of four lakes, the largest of which is Lake Yoan, with an area of 3.5 km^2 and a depth of 27 m. Because of the salinity of the water, the Lake District can only support algae and certain micro-organisms. The second group, the Uyuniga-Serrill Lake group, consists of 14 lakes separated by sand dunes. Floating reeds cover nearly half of the lakes, thus reducing evaporation. Tie Li Lake covers an area of 4.3 km^2 and is the largest lake, but it is only 10 m deep. The excellent quality of the fresh water supports numerous aquatic animals, especially fish.

Lamprophyre A lamprophyre is basic dyke rock that is rich in dark minerals. It usually has a

porphyritic structure, and biotite and hornblende are the common dark minerals, followed by pyroxene and olivine. A euhedral structure is common. The light-coloured mineral is usually feldspar.

Land Bridge A land bridge is a narrow strip of land that links different land areas separated by seawater. Based on fossil studies, palaeontologists have postulated that the spread of ancient horses from North America to Eurasia and ancient elephants from Eurasia to North America occurred across the 'Bering land bridge' at the location of the present Bering Strait.

Land Management Law of the People's Republic of China The Land Administration Law was passed and promulgated on 28 August 2004 during the 11th meeting of the Standing Committee of the Tenth National People's Congress. The law has the following chapters: Chapter I, General Provisions; Chapter II, Land Ownership and Right of Use; Chapter III, General Plan of Land Use; Chapter 4, Arable Land Protection; Chapter V, Construction Land; Chapter VI, Supervision and Inspection; Chapter VII, Legal Responsibility; and Chapter VIII, Supplementary Provisions. This law stipulates that land will be divided into agricultural land, construction land and unused land. It strictly limits the conversion of agricultural land into construction land. It controls the total amount of construction land, implements special protections for cultivated land, and outlines the requirements for the comprehensive management, development and utilisation of rivers and lakes and the linkage with overall land use planning. It also prohibits the destruction of forests and grasslands as well as encroachment of cultivated fields on river banks.

Land Planning Land planning is the rational development and utilization of resources such as land, water, minerals, climate, oceans, tourism and labour. It determines the economic layout of a region, coordinates the relationships between economic development and the population, resources, and environment, and defines the resources. It helps to determine the direction, goals, priorities and steps for formulating comprehensive plans for land development, utilization, governance, and conservation. Tourism area development and planning should be guided by a national land plan and be consistent with the corresponding land planning goals of the area. This allows effective coordination of the rational allocation of tourism resources and other associated elements.

Land Resources Land resources can be defined as resources (e.g., natural resources, human resources, and other socio-economic resources) that are under the jurisdiction of a sovereign state, including territories, territorial seas, territorial airspace, continental shelves, and exclusive economic zones. They can also be defined as the natural resources within the jurisdiction of a sovereign country. Land resources are characterized by integrity, regionality, limited extents, and variability. The various resources of tourist areas are land resources and therefore have regional and sovereign characteristics.

Land Type Based on the natural attributes and utilization of land, decentralized land units can be summarized as a land system with a hierarchy of affiliations. Land types reflect the quality of the land and the types of development and utilization. Land type research is an important prerequisite and foundation of tourism planning and development. A land type in the general physical and geographical sense refers to a small-scale natural complex.

Land Use For the proper development of society and the economy, humans carry out long-term, short-term and periodic plans based on the natural characteristics of the land and the practical needs of society. Tourism development and tourism management activities are also a form of land use.

Land Use Planning of Tourism Areas Land use planning of tourism areas involves developing plans for land use in tourism areas. It aims at providing reasonable planning and layouts for tourism infrastructure, service facilities, project development, transportation, environmental protection, residents, agriculture, forest lands, grasslands, water areas and retained lands to ensure the development of tourism, the reasonable coordination between urban

and rural development and other purposes in tourism areas. It is a forward-looking plan for land use. It includes comprehensive technical and economic measures to allocate land resources and rationally organize land use in time and space based on the regional social and economic development and natural history. Land use planning should meet the needs of tourism industry development in terms of the functions and the reasonable planning and layout for tourism infrastructure, service facilities, project development, environmental protection, urban and rural residential lands, agricultural development, and commercial and cultural lands.

Landerite *Synonym:* ▶ *Field yellow stone*
Field yellow stone is also called 'Tian Huang' or 'Tian Shi'. It is a fine variety of Shoushan stone. High-quality Tian Huang is extremely valuable, and there is a saying that a tale of Tian Huang equals three tales of gold. It is mainly composed of minerals of the kaolinite family, such as dickite and kaolinite, and several other minerals, such as quartz, pyrite and stibnite. Tian Huang stone is mainly found beneath the paddy fields around Shoushan Creek in Fuzhou; the higher quality stones come from the middle field because they have a yellowish colour like loquat, so they were given the name 'Tian Huang (field yellow)'. These stones were originally mountain stones that were transformed through transportation, abrasion, and gradual acidification. Tian Huang often has a shell (stone skin) with different colours. It appears as fine and dense cryptocrystalline blocks with a greasy lustre, is translucent to opaque, and shows white fluorescence under ultraviolet light. The stone is used for making high-end ornamental decorations and seals (Fig. 4).



Fig. 4 Tian Huang stone

Landforms Landforms are the results of endogenic and exogenic forces of the Earth under the influences of tectonics, water, wind, glaciers, waves and time. They are the basis of physical and natural geography. Basic landforms include mountains, hills, plateaus, plains and basins. Landforms can also be divided into tectonic landforms and climatic landforms. Landforms are the frameworks of landscapes. Different scales and types of landforms can constitute different landscapes in the natural and geographical environment. They can also affect the climate and the redistribution of surface water and groundwater as well as the composition and distribution of biological communities. Landforms and the diversity of natural landscapes are important for providing tourism resources and for tourism earth science research.

Landmass A landmass is an area of land elevated above sea level during a geologic period that was subject to erosion. Based on the characteristics of the strata, coastline changes and sediments produced by denudation, the existence of the landmass can be determined. A landmass can be a microcontinent or a continent.

Landscape Landscape is a general term for everything that can be observed and perceived. Different disciplines have different definitions

of landscape. Geography interprets it as the appearance of the surface of the Earth, including the natural landscape, the natural complex and the human landscape, which means the characteristics of the surface in a certain area that are different from those in other areas. Landscape ecology explains it as 'a heterogeneous mosaic of an ecosystem'. In gardens, it is often regarded as 'scenery'. Tourism earth science uses landscape as a general term for all natural and human phenomena that can be observed and felt on the Earth. Landscapes can be categorized into two types: natural landscapes and human landscapes. Landscapes, which are the research focus of tourism earth science, are believed to have resource attributes and can be used to develop a tourism industry.

Landscape Design Landscape design is the design of a specific landscape for a particular site. Landscape design provides an overall plan and drawings that serve as guidance for the renovation activities that bring ecological, social, aesthetic, economic and other values to an area and the related ground features. The design includes two parts: the overall design and the specialized design. The overall design of a scenic site provides a comprehensive design for the division of functional areas or scenic areas, landscape concepts, scenic area settings, entrance and exit locations, garden road systems, the water system connecting rivers and lakes, plant layout, locations, sizes and shapes of buildings and structures, and the professional engineering pipeline system based on the requirements of the plan approved by competent departments or clients. The specialized design refers to the landscape design of the artificial facilities, including landforms and earthworks, rocks and revetments, roads and paved areas, plantings, structures and buildings, water supply and drainage engineering, electrical engineering and sports and playground equipment based on the requirements of the general landscape plan.

Landscape Ecology The concept of landscape ecology was proposed by the German geographer Carl Troll (1899–1975). It considers the entire landscape as an object and uses the principles of ecosystems and systematic methods to study the landscape's structure, function, dynamic changes and associated interaction mechanisms. It also studies the beautification of landscape patterns, structural optimization, rational use and protection. It is an emerging cross-disciplinary research area in ecology and geography. It involves studies of the transmission and exchanges of material, energy, information and value in landscapes, the associated biological and non-biological components and their interactions with humans.

Landscape Element A landscape element is an individual component of the landscape. Elements include rocks, water, the atmosphere, plants, animals, architecture, music, and art. These are visible materials and thus can be objectively described and quantified.

Landscape Engineering Landscape engineering refers to outdoor projects (except garden building projects) in gardens, urban green areas and natural scenic sites that are characterized by the use of engineering techniques to shape the image of garden art. It includes earthworks that embody the creation of garden landscapes, hill-making projects in gardens (e.g., rock techniques, man-made rockwork, and stone arrangements), the water projects in gardens (e.g., revetments, slope protection, and fountains), garden roads and paving projects, and planting projects (e.g., tree planting, flower beds, and lawns).

Landscape Formed by Endogenic Geological Processes Landscapes can form by endogenic geological processes such as crustal and tectonic movements, magmatism, metamorphism, volcanoes and earthquakes.

Landscape Formed by Exogenic Geological Processes External energy, such as solar radiation, gravity and lunisolar attraction, are external geological forces that play significant roles in shaping the topography of the Earth's surface. These forces include weathering and erosion caused by water, currents, waves, groundwater movements, corrosion, glaciers

and wind as well as the transportation and deposition of sediments. The vast majority of natural landscapes for tourism have been formed by the interactions between these internal and external geological forces.

Landscape Formed by Physical Geography Physical geography is an integral factor that forms landscapes. It includes climate, hydrology, soils, flora and fauna. All of these elements are interdependent, related and systematically interact to form a natural physical geographical environment. The formation of a nature-based tourism resource is dependent on such integration. Huangshan is an example. Its four unique features, including unique pines, strange rocks, clouds, and hot springs, are dependent on the vertical joints in the granite, the warm and humid climate, the dense vegetation and the specific hydrological conditions of the area.

Landscape of Arch of Volcanic Rocks An arch of volcanic rocks is a bridge-like landform with two ends connected to a mountain to form a suspended arch. The rhyolite Fairy Bridge in Yandangshan, Zhejiang Province, is a typical example; it has a span of 37 m and an average width of 8 m. The arch is from 20–25 m high. Another type of volcanic natural bridge is related to basalt tunnels, which are formed by the collapse of a lava tunnel. Basalt bridges are located at the entrance to the lava tunnel at Haikou's Seventy-Two Caves (Fig. 5).

Landscape of Overlapping Screen-Like Peaks of Volcanic Rocks This is a volcanic landform that is shaped like a screen wall. The term 'overlapping screen-like peak' was first proposed by Xiake Xu after his tour of Yandangshan. In the geological context, 'overlapping screen-like peaks' are composed of ruptured and disintegrated steep cliffs of superimposed rhyolite layers that formed from multiple lava flows (Fig. 6).

Landscape of Rain over the Lijiang River (Guilin) The Lijiang River is the most essential part of the landscape of Guilin. On rainy days, drizzle falls like smoke and mist, the mist rises from the river surface, making the mountains only partially discernible. The falling rain covers all of the mounds and rivers like a veil, creating a mood like an elegant Chinese ink landscape painting.

Landscape of the Three Parallel Rivers This is a landscape composed of the parallel flows of the Nu River, Jinsha River and Lancang River. The Nu River, Jinsha River (upper Changjiang River) and Lancang River (upper Mekong River) originate in the Qinghai-Tibet



Fig. 5 Rhyolite bridge - Yangdangshan, Zhejiang Province

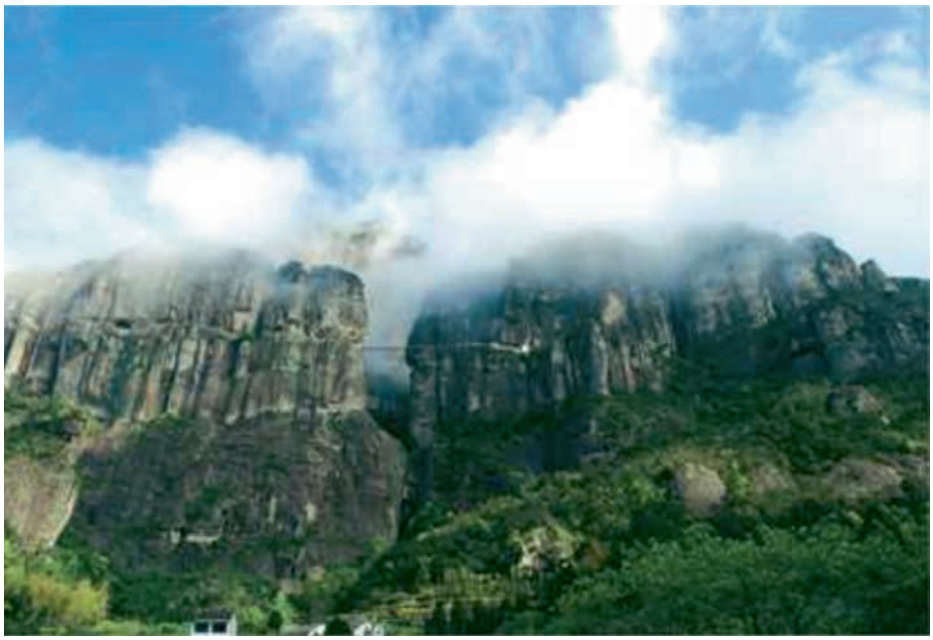


Fig. 6 Screen-like peaks of volcanic rocks in Yandangshan, Zhejiang Province

Plateau and pass through the Hengduan Ranges, Yun (Cloud) Ridge, Nu Mountain and Gaoligong Mountain in Deqe Tibetan Autonomous Prefecture and Nujiang Lisu Nationality Autonomous Prefecture in Yunnan Province. They form spectacular scenery composed of three deep river gorges that run parallel for several hundred kilometres. This is by far the largest World Natural Heritage site in China.

Landscape of Volcanic Rocks This is a collective term for landforms of volcanic rocks. Volcanic rocks of different ages are present in China, and Mesozoic volcanic rocks are widely distributed. Due to external dynamic geologic processes, volcanic rocks can form a variety of landforms with ornamental value, such as peaks, caves, valleys and mesas, which have become famous scenic locations. Examples are Yandangshan and Wenling Mesa in Zhejiang Province and Baishuiyang in Fujian Province.

Landscape Planning Landscape planning refers to planning of a region or a project based on the principles of landscape science. It provides policy makers, land managers, and land users with principles and strategic plans for transforming, protecting, restoring, or developing the landscape in a certain area. Landscape planning must ensure sufficient degrees of freedom for people to adapt actions to new economic needs or social changes as it is applied. Landscape planning emphasizes the coordination between humans and nature, including not only land utilization but also the superposition and integration of land utilization in particular. To achieve harmony between natural and artificial construction, it is necessary for many roads, water conservancy projects, towns, and even industrial and mining projects to perform landscape planning before construction.

Landscape Science Landscape science is a discipline that studies landscapes and is one of the supporting theories of tourism earth science. Landscape science includes landscape resources, landscape aesthetics, landscape ecology, and landscape design. The research mainly focuses on the classification of landscapes, aesthetic appreciation, natural landscape transformation, cultural landscape design, landscape construction

and conservation. Landscape science is an extension of landscape design and interacts with many disciplines, such as geology, ecology, environment, landscape, architecture, planning, aesthetics, art, and sociology. It is an applied science based on natural and human sciences. Its core objective is to coordinate the relationship between man and nature. See ► Tourism Earth Science.

Landscape Tourism in Heilongjiang Province This book was written by Jiesheng Gong and was published in 1998 by China Environmental Science Press. It introduces the unique landforms, natural landscapes, characteristics and classification of tourism resources, zoning and tourism industry in Heilongjiang Province. It also discusses several problems that have been encountered in geotourism studies in Heilongjiang Province and opines on the development of tourism resources. The material popularises earth science and serves as a guidebook on landscape tourism in Heilongjiang Province.

Landscape Tourism Resource of a Geological Section These are tourism resources composed of geological sections that have recorded various stages of Earth's history. They have important scientific research value and form the basic components of various kinds of geological parks and natural parks. For example, the Jixian County Global Geopark is composed of continuous Neoproterozoic geological sections (0.5–1.8 billion years ago) of various ages. The Songshan Global Geopark is composed of five rock strata from the Archaean, Proterozoic, and Palaeozoic Eonothems and the Mesozoic and Cenozoic Eras and has been labelled the 'Five Generation Sections'. The Dai Mountain Geopark in Zhejiang contains the Golden Spike–Huangnitang Geological Section (Middle Ordovician Darriwilian Stage, 455–460 million years ago). The Luo Chuan Loess Geopark in West Shanxi is composed of the Quaternary Heimugou Loess Section (2.5 million years ago). Almost every geopark and natural scenic site has stratigraphic sections of various stages, some with global significance and others of national or local importance. These geological sections can be interpreted as stories of the Earth and can attract the attention and arouse the appreciation of tourists. They are therefore important tourism resources with high scientific and education value.

Landscape Tourism Resources of Geological Structures Geological structures are features left behind from crustal movements, such as faults, folds, joints, tectonic plates, suture zones, rift valleys, volcanic arcs, back-arc basins, platforms, grabens, horsts, blocks, tension faults, shear faults, compressional faults, latitudinal structures, longitudinal structures, Cathaysian and neo-Cathaysian structures, xi-type structures, epsilon structures, chess board structures and flower structures. All of these structures form important geological features in geoparks and have become attractive landscape tourism resources.

Landscapes for Geotourism The factors that affect the formation of the landscape by geological and geographical factors can be summarised as: 1. material – rocks, soil, water and air are the basic components of any landscape; 2. dynamics – crustal movements, volcanic activity, earthquakes, metamorphism and other endogenic or internal forces and erosion, transportation, deposition and other exogenic or external geological forces; 3. geological structure –the background of the landscape as well as the rock strata and characteristics (e.g., horizontal, inclined or folded); 4. geography –the location, latitude, elevation, climate, temperature, humidity, rain, wind, sunshine and vegetation; and 5. time – the time of the formation of the rocks that form the landscape. Tourism earth science can be complicated because it is an integration of numerous geological and geographical factors.

Landscaping: Principles and Practices This was written by Jack E. Ingels, translated by Juan Cao, Jiaqin Wu and Xuan Lu et al. and was published by China Forestry Publishing House in 2008. The book has a total of 697,000 words and provides comprehensive explanations of three areas of landscaping practice:

design, contracting, and maintenance and management. The contents include the basics of cartography, site analysis, plant materials, design principles, project implementation procedures, tender contents, budgets, costs, construction contents, and ongoing management and maintenance after the completion of the project.

Landslide Landscape *Synonym:* ▶ *Landslip landscape*, ▶ Soil Fall Landscape

A landslide, also known as a landslip landscape or rupture landscape, is a type of environmental geologic landscape. After being saturated by water or when the stability is disturbed, a rock mass or clastic deposit may slide down a slope due to gravity. This process is a landslide. The components include the landslide mass (the entire sliding part of the landslide), landslide scarp (i.e., the rupture wall, which is the exposed boundary between the landslide mass and the stable mass), landslide step and landslide ridge (landslide steps form due to the differences in the sliding velocities of various soils, and landslide ridges form when the steps are rotated or inclined), sliding zone (the crumpled or sheared zone, which can be a few centimetres to several metres thick at the upper part of the sliding surface), slide tongue (i.e., slide front), landslide drumlins (small mounds uplifted by friction at the slide front), enclosed depressions (depressions surrounded by higher ground that form when the area between the slide mass and slide wall is pulled apart), and landslide cracks (which can be divided into four types according to the state of stress: tensile cracks, shear cracks, bulging cracks and fan cracks). Landslides are hazardous in open-pit mining, water conservancy, railways and highway projects; therefore, they are a major aspect of geotechnical surveys (Figs. 7 and 8).

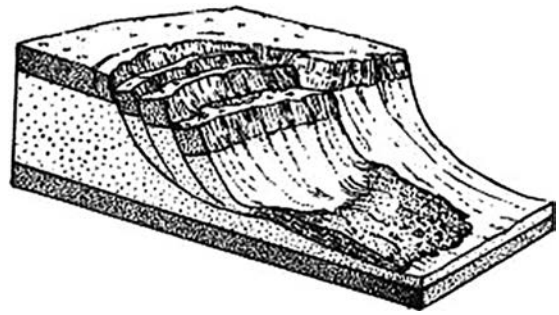


Fig. 7 Diagram of a landslide

Landslip Landscape ▶ Landslide Landscape

Langao Mount Nangongshan National Geopark, Shanxi This geopark is located in Langao City, Shaanxi Province, and it has an area of 72 km^2. It became a national geopark in 2009. Geologically, it is dominated by basic volcanic brecciated lava from a series of ultrabasic-basic-neutral volcanic complexes extending NWW for approximately 50 km that are an average of approximately 2 km wide. The volcanic facies in Nangongshan Geopark can be divided into explosive volcanic breccia lava, volcanic agglomerate lava, volcanic lava and tuffaceous facies, most of which originated from an alkaline-basic volcanic complex. The volcanic activity included two typical phases, and the later eruption was the main phase. The landforms include volcanic peaks, clusters, columns and cliffs.

Langkawi Geopark, Malaysia This geopark is located on the island of Langkawi in Malaysia. It has an area of 478 km^2, and it became a global geopark in 2007. It was the first geopark in Malaysia and in Southeast Asia. The Machincang Formation, a 550-million-year-old sequence of interbedded sandstone and shale in Datai Bay in the northwestern part of the island, is the oldest rock in the country. The Chuping Limestone at Pulau Dayang Bunting and the northeastern part of Langkawi forms beautiful limestone outcrops. These features indicate that the sedimentary environment at that time was a river delta and shallow sea environment. The landscape diversity of the Machingcang Formation is also reflected in the numerous beautiful coast types: rocky beaches, sandy beaches, pebble beaches, abrasive platforms, sediment platforms, gravel dams, caves, and islands. The Ma Qingchang Formation is one of the most important geological heritage resources in Southeast Asia. It illustrates the coastal landscapes associated



Fig. 8 Landslide landscape

with sedimentary rocks. The different landscapes in the area provide a good basis for research and tourism education.

Lantian Man Site ▶ Homo Erectus Lantianensis Site

Lapilli Lapilli are spherical volcanic debris in volcanic tuff. They form in a two-step process: (1) during a volcanic eruption, small volcanic fragments adhere to falling raindrops and grow due to the air stream to form lapilli; and (2) volcanic debris adhere to a nucleus or a particle and then roll and accumulate on the surface of loose volcanic cones due to the wind or gravity. The sizes of such volcanic ash spheres can range from several millimetres to dozens of millimetres. The inner part of the sphere has a fine structure with a granular gradation to finer particles towards the outer part, forming a concentric layered pattern. Volcanic ash spheres are often called accretionary lapilli abroad.

Lapis Lapis is a type of gemstone composed of lapis lazuli, sodalite, hauynite, calcite, and pyrite. It is blue or purplish blue with patches of copper-coloured pyrite, white calcite and other dark minerals. In ancient feudal China, lapis was considered a symbol of power and social status, so it was treasured by dignitaries. In the Qing Dynasty, court officials in the fourth rank had to wear Lapis with their court uniforms. Lapis is also a natural dye. It is mainly mined in Afghanistan, the Lake Baikal area of Russia, the Chilean Andes, Myanmar and California in the United States (Fig. 9).

Laponian Area, Sweden This area is located in the Arctic region of Sweden in northern Borcht near the border with Norway. The core protection area covers 9,400 km^2. It is the traditional home of the Sámi people (or Lapu people). It is the largest (and last) human settlement in the world that still uses ancestral methods of carrying out seasonal migrations of herds. Every summer, the Sami people drive large groups of reindeer into the mountains. Visitors can clearly observe the historical evidence and the evolving geological processes of the moraine landscape and changing rivers.

Large-Scale Atmospheric Tourism Resource System The Earth's atmosphere can serve as an important tourism resource system. The lower limit is bounded by the water and land on the Earth's surface, and the upper limit is approximately 2,000–3,000 km high. Based on the temperature, density and other physical properties, the atmosphere can be divided into several layers, including the troposphere, stratosphere, mesosphere, the thermal layer (ionosphere) and the outer sphere. The total mass of the atmosphere is 5.14×10^{18} kg.



Fig. 9 Lapis

Due to the influences of solar radiation, X-rays and ultraviolet radiation, the atmospheric temperature, density, and pressure vary, and such variation causes air to rise and fall to form convection and atmospheric circulation. Meteorological features such cold and hot spells, dry and wet weather, wind, clouds, rain, snow, frost, fog, lightning and scintillation create different types of weather and climate. These features are important tourism resources based on meteorology and clean air that form the large-scale atmospheric tourism resource system.

Lateral Moraine Bar Landscape This is a landscape composed of embankment-like features formed by moraines along both sides of a glacier. Glacial erosion and the disintegration process along the glacial valley walls cause the accumulation of abundant debris along both sides and on the surface of the glacier. When the glacier melts, these materials are deposited on both sides of the valley, forming an embankment-like feature parallel to the glacier. This feature is called a lateral moraine bar (Fig. 10).



Fig. 10 Lateral moraine bar landscape of a late Pleistocene glacier in the northern Shaluli Mountains (ridge at left)

Latosol Latosols form in tropical rainforest and monsoon forest environments by strong desilication and bio-enrichment. They are highly acidic and dark red soils with abundant iron-aluminium oxides. In China, they are mainly located in the Leizhou Peninsula, Hainan Island, and parts of Yunnan, Guangxi, and southern Taiwan. They are located along the northern margin of the tropical zone south of 22°N latitude. The soils have high viscosity and high acidity but are poor in nutrients.

Latosolic Red Soil This is a type of transitional soil between red earth and latosol soil that is formed by desilication, aluminization and bioaccumulation under high temperature and high humidity conditions in South Asia. It is a typical soil type in South China's subtropical zone. The surface has a deep red weathered layer, and the soil is acidic. This soil is mainly located in the hills and terraces of western Guangdong, southeastern Guangxi, southwestern Guangxi, southern Fujian, southern Taiwan, and southwestern Yunnan between approximately 22 and 25°N at elevations of approximately 450 m.

Laurasia Laurasia is also known as the 'northern supercontinent' and was a supercontinent that existed in the northern hemisphere. Laurasia was a combination of Laurentia (North America and Europe) and Asia. It was separated from the southern supercontinent (Gondwana) by the Mediterranean Sea (Tethys Ocean). Over the past 150 million years, Laurasia was reorganized and due to the growth of the Atlantic Ocean, North America split from Laurasia, but a block that split from Gondwana that included Indo-Pakistan, Qinghai-Tibet, Iran and Turkey merged with Laurentia to form the present continent of Eurasia.

Laurisilva of Madeira, Portugal This site is located on Madeira Island, a Portuguese archipelago in the North Atlantic Ocean approximately 800 km west of the central coast of Morocco, Africa. It has a core protection area of 150 km^2. It is an outstanding representative of the remaining laurel forests that were once widely distributed on the island, and 90% of the park is considered a primitive forest landscape. It is also a habitat for unique animals and plants that nurtures numerous endemic species, such as the Madeira long-toed pigeon and 66 types of vascular plants.

Lava Lava is a rock that solidifies from the cooling of molten magma erupted onto the ground surface. Based on the SiO_2 content of the bulk rock, lava can be categorised as rhyolite, andesite, basalt, and komatiite. The Yandangshan landscape in Zhejiang Province formed in rhyolite, while Wudalianchi in Heilongjiang Province is composed of basalt from volcanic eruptions.

Lava Cascade Landscape This is a lava flow landscape resembling a waterfall. As lava flows on the ground surface, the lava can meet steep humps and cools. The solidified downward flow looks like a cascade. Examples are China's Wudalianchi in Heilongjiang Province and the Hawaii Lava Cascade in the United States (Figs. 11 and 12).

Lava Flow and Lava Sheet Landscape A lava flow is a flow of molten magma like a lava river for a period of time, which eventually forms a landscape of molten lava. Its length is greater than its width. A lava sheet is characterised by a large coverage area, usually appears isometric in map view and can form through the stacking of numerous lava flows. The lava is usually relatively thick. The associated low-viscosity basaltic magma moves on the ground surface at velocities of several metres to tens of kilometres per hour. The lava in Hawaii can reach a velocity up to 60 km per hour. Wudalianchi in China has an intact lava flow landscape that is locally called a lava river or stone dragon.

Lava Flow Unit Numerous lava flows are generated by volcanic eruptions. Each flow of lava is an individual unit, which is called a flow unit. Whether it is a basalt flow (such as at Wudalianchi) or a rhyolite flow (such as at Yandang Mountain), lava flows come from repeated eruptions.



Fig. 11 Lava cascade landscape, Wudalianchi



Fig. 12 Sketch of a basalt lava cascade at Kilauea Volcano, Hawaii (Courtesy: Forbes)

Lava Lake Landscape A lava lake, also known as a magma lake, is a landscape consisting of an unconsolidated lake of magma in a crater before the eruption has finished. Lava lakes often exist in the volcanic craters of tranquil eruptions, such as in Hawaii. The presence of lava lakes greatly facilitates studies of the origin and characteristics of magma; hence, this landform has both ornamental and scientific value (Fig. 13).

Lava Plateau Landscape This is a platform-like landscape of volcanic lava. Basalt has a low viscosity, and when it flows from a crater, the flows overlap to form a flat lava landscape.



Fig. 13 Lava lake landscape in Hawaii Crater

Pingding Mountain in Xilinhaote, Inner Mongolia, is a typical example.

Lava Pool Landscape This is a lava landscape. When lava flows on the ground surface, gas is released due to the accumulation of the gas in the lava or the lava encountering a small amount of water. As a result, the lava continues to flow and forms a small emission hole with no base, which is a lava pool. The lava cools around this secondary emission outlet to form circular or radial fissures. There are small lava pools in the volcanic basalt flow at the Fenglu Ridge Volcano in Haikou and the pool clusters in the volcanic basalt lava in Zhangzhou Littoral National Geopark in Fujian Province (Fig. 14).

Lava Spine Landscape This is a thorn-shaped lava landscape that is formed by a small amount of magma spilling out of small fissures. They usually form at the top of the lava tunnel, the inner walls of lava gas holes and driblet cones or the gaps between two lava flows (Fig. 15).

Lava Stalactite Landscape This lava landscape consists of stalactite-shaped features that form on the roof and walls of a lava tunnel (Fig. 16).

Lava Tube Landscape ▶ Lava Tunnel

Lava Tunnel *Synonym:* ▶ *Lava tube landscape* This is a volcanic landscape composed of tunnel-like tubular caves that form when lava flows. A shell forms when the lava flow surface meets the air and cools, while the interior remains molten and mobile for a long time. As long as new lava from the crater continues to erupt, it continues to flow. When the molten core eventually empties, a lava tube is left behind, which looks like a tunnel. In the USA, many lava tunnels in the Lava National Museum in NE California and the Craters of the Moon National Monument in southern Idaho are open to visitors. In China, a gigantic lava tunnel is located in the Quaternary basalt in the Shishan Volcanic Cluster National Geopark, Haikou. There are also lava tunnels in Wudalianchi and Jingpo Lake. These tunnels formed when flowing molten lava dripped slowly from the solidified top or from the cave wall. Most of the slender lava stalactites that formed from the roof and from wall remelting are hollow and may reach a length of 1 m. Not all lava stalactites inside the lava cave are composed of lava; some are made up of sulphur or opal (Fig. 17).

Lazurite Lazurite, which has the composition $(Na,Ca)_8[AlSiO_4]_6(SO_4,S,Cl)_2$, is a mineral

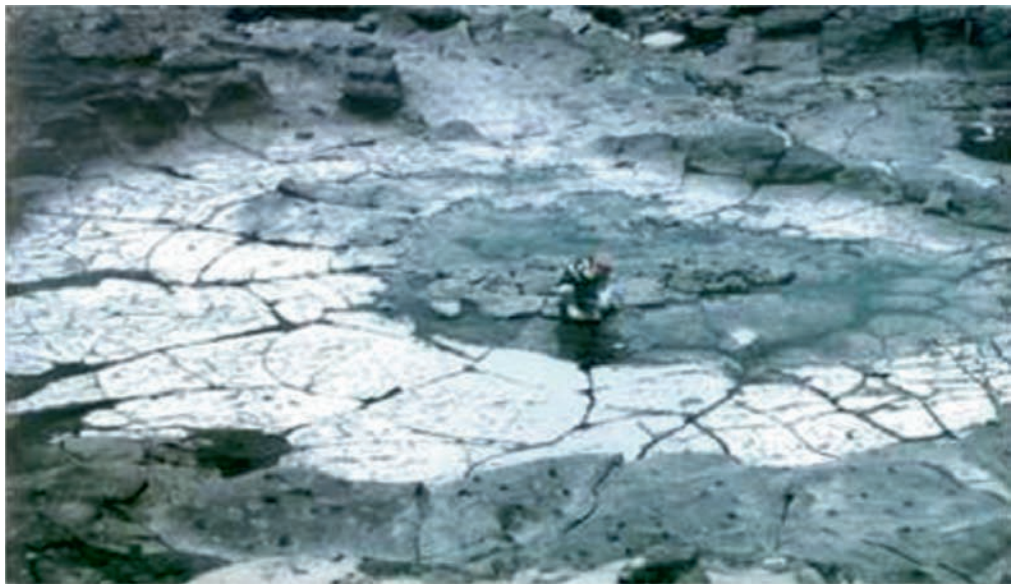


Fig. 14 Small basalt lava pool landscape in Zhangzhou Binhai Volcano National Geopark, Fujian Province

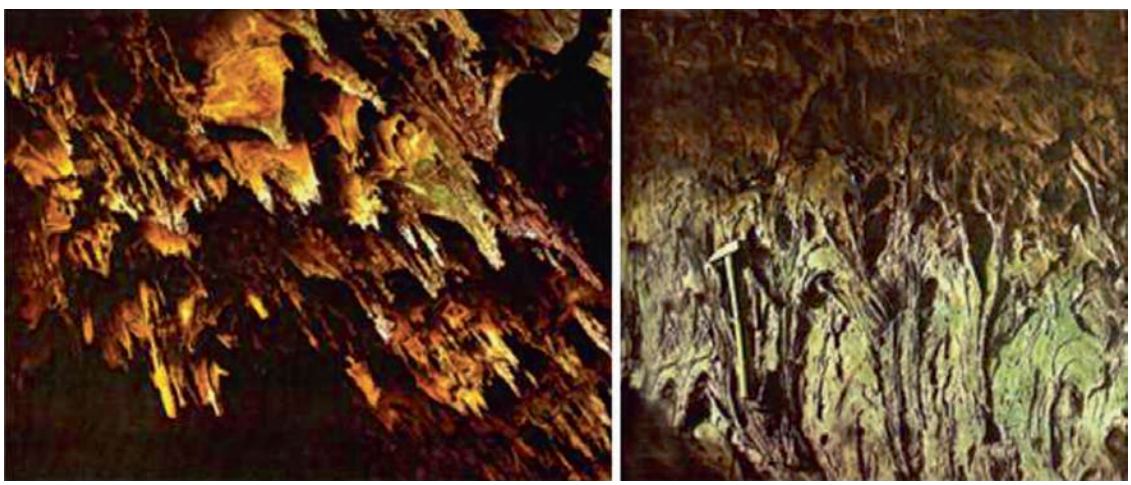


Fig. 15 Lava spine landscape inside a lava tunnel, Wudalianchi

used as jade and in pigment-making. It belongs to the isometric crystal system and has a vitreous-waxy lustre, a granular structure, a dense texture, a Mohs hardness of 5–6, a specific gravity of 2.4–2.9, a refractive index of 1.5 and opaque to slightly translucent diaphaneity. Lazurite has a bright blue colour. Its complex colour hues and gold star flash make it a precious type of jade. As a pigment, it is called 'gold spirit', 'Fu blue', 'Muslim blue' or 'cluster blue'. It was often used in ancient murals. Based on its composition and colour pattern, lazurite is categorised into four types in Chinese: (1) pure blue and gold stone; (2) blue gold; (3) gold wave; and (4) parturition stone. Lazurite mainly forms in contact zones between alkaline and carbonate rocks.

Leefructus mirus Leefructus mirus is directly related to modern angiosperms. This plant was 16 cm long, and the fossil specimens are approximately 1 cm thick. Two fish fossils, called 'Lycoptera dividi', are located on each



Fig. 16 Lava stalactite landscape inside a lava tunnel, Wudalinchi



Fig. 17 Lava tunnel landscape in Seventy-Two Caves, Haikou Shishan Volcano National Geopark

side of the plant. The fish fossils are one of the three representative fossils of the famous Jehol Biota. Leefructus mirus might have grown in a wetland or swampy environment. This plant is similar to the modern Ranunculaceae plants, and its morphology resembles the modern Clematis or Delphinium grandiflorum. Fossils of Leefructus mirus have been collected from the Yixian Formation, which is from the early and middle periods of the Early Cretaceous, and this is the earliest occurrence of a dicotyledonous angiosperm fossil. Therefore, Leefructus mirus is China's and perhaps the world's earliest angiosperm fossil that is directly connected

to modern angiosperms; in other words, it is a close relative of flowering plants.

Leiqiong Global Geopark, China This geopark is located on both sides of the Qiongzhou Strait. It has two major scenic districts: Haikou in Hainan Province and Zhanjiang in Guangdong Province. It became a global geopark in 2006. The Haikou Scenic District contains 101 volcanoes of different types, including almost all types of basaltic and steam magma volcanoes, such as lava cones, scoria cones, composite cones and maar volcanoes. It is the largest volcanic cluster in China and has well-preserved examples of many shapes and forms of volcanoes along the Quaternary volcanic belt. The Huguangyan, Tianyang and Qingtongyang geosites in the Zhanjiang Scenic District and Shuangchiling and Yanghualing in the Haikou Scenic District are famous typical maar volcanoes. The maar lakes in China were first studied at Huguangyan, and it is a base for cooperative research projects for Chinese and German scientists. The two scenic districts also have interesting local culture that coexists with the natural volcanic environment.

Leisure Leisure is activity for rest and relaxation when one is not working. It is a lifestyle and attitude in the post-industrial age as well as a process of self-development and self-fulfilment. Leisure is a state of mind and a way of living. It helps people to fully realize their value and freely develop themselves. Travelling is a form of leisure, and leisure activities cover a much wider group of activities.

Lekolith This is a landscape consisting of rounded disc-like lava pits called lekoliths. The formation of a lekolith is similar to that of a driblet cone. The diameter is generally 0.5–2 m, and the base diameter is 1.5–3.5 m. Large lekoliths can reach 5 m in diameter and are approximately 1 m tall. Lekoliths are an elementary form of driblet cone. They have a lower frequency of intermittent gas emissions and lava eruptions, usually only three to four times; hence, there is only three to four layers of lava (Fig. 18).

Lena Pillars Nature Park, Russia This park is located on the Lena River in central Sakha (Yakutia) in the Russian Federation. The park is known for its spectacular rock pillars that are approximately 100 m tall that are the product of the extreme continental climate in the region, which has a local annual temperature range of nearly 100 °C (−60 °C in the winter,



Fig. 18 Lekolith landscape, Wudalinchi

+40 °C in the summer). The deep and steep gullies that separate the rock columns are formed by frost crushing along the joints that divide the rock columns. The infiltration of surface water contributes to the cryogenic (freeze-thaw) process and causes further expansion of the gullies between the pillars. River processes are also an important factor in the formation of pillars. The heritage site also contains numerous Cambrian fossils, including several unique species.

Leopard Limestone Leopard limestone is a limestone with yellow or reddish brown irregular stripes, and it gets its name from this leopard skin-like pattern. It forms due to dolomitization during its formation. This rock is common in the Cambrian and Ordovician strata in China. Leopard limestone usually has a high dolomite content, and the matrix materials are mainly microcrystalline or cryptocrystalline calcite.

Levee Landscape ► Natural Levee Landscape

Leye Karst Sinkhole Cluster Landscape, Guangxi This is a landscape that formed from a tiankeng cluster composed of an exceptionally large tiankeng group and another large tiankeng group. This cluster is located in western Leye County, Guangxi Province. Nearly 30 tiankengs have been found, of which the one in Dashiwei is exceptionally large, and others in Chuandong, Datuo and Dengjiatuo are also very large. The vadose zone of the karst aquifer in this tiankeng cluster area is 400–800 m thick. The associated rocks are thick Carboniferous and Permian limestone and dolomite with gentle dips. This topography mainly contains a large area of deep peak cluster depressions at elevations of 1,300–1,500 m. The Dashiwei Tiankeng is pear-shaped with a length of 600 m from east to west and a width of 420 m from north to south. Its perimeter is 1,580 m, and its greatest depth is 613 m. It is surrounded by steep cliffs, and its bottom is covered by gravels that are estimated to be 100–150 m thick. This tiankeng is covered by a lush subtropical evergreen quasi-virgin forest that is a relatively independent ecosystem. There is an underground river at the bottom of the western margin of this tiankeng (Fig. 19).



Fig. 19 Leye Dashiwei sinkhole landscape, Guangxi Province

Leye-Mount Fengshan Global Geopark, China This geopark is located in Baise, Guangxi, and covers an area of 930 km^2. It was given the global geopark status in 2010. It is divided into the Leye Park and Fengshan Park Districts. The main geological sites in the Leye Park are tiankengs (sinkholes), caves, gorges, underground rivers and arches. There are 26 tiankengs, include two very large tiankengs with capacities of more than 5,000 m^3, and more than 200 smaller depressions in Luomei Cave with a maximum diameter of 9.2 m. The natural arch is 280 m long and 145 m high. Fengshan Park has the world's largest cave tunnels, cave halls, underground rivers, skylights and important secondary cave deposits.

Liancheng Mount Guanzhaishan National Geopark, Fujian This geopark is located in Lianchen County, Fujian Province. It became a national geopark in 2009, and the main geological attractions are geohazard sites and Danxia and karst landforms. The red sandstone and conglomerates of the Danxia landform were formed from alluvial-colluvial fans in the inland basins during the Late Cretaceous. The landform dips shallowly at 15°–25°. It is characterised by cliff walls and gorges and is also known as a monoclinic Danxia landform. Karst geomorphologic features are located in the Laiyuan scenic area, including karst peak clusters, solitary peaks, karst caves and secondary chemical deposits.

Liangshan National Geopark, Hunan This geopark is located in Xinning County in southwestern Hunan province. It features a Danxia landform and became a national geopark in 2002. It contains five scenic districts: Zixia Temple, Fuyi River, Camel Peak, Niuzone Village and Bajiao Village. There are many types of Danxia landforms in Kunshan, such as steep cliffs, wedge-shaped strips, segmented blocks, sloped walls, intersecting lines, scattered columns, arches, holes and caves. Among them, the wedge-shaped landscape arranged in rows and the prominent peaks and valleys between them are most striking. It is a large 'Danxia landform' museum.

Liaoyuan National Mining Park, Jilin This park is located in Liaoyuan City in south-central Jilin Province and covers an area of 120 km^2. It was designated as a national mining park in 2010. The coal resources in Liaoyuan have been exploited since 1911. Large amounts of mining geological heritage, mining production heritage, mining product remains, mining social life heritage, mining development literature and historical records as well as natural and human landscape resources can be found in the park.

Libo Peak Cluster Landscape, Guizhou This area of peak clusters is a World Natural Heritage site. The main component of this landscape is the cone-like karst, which includes drumholder-like or penholder-like peak forests that are scattered on the flat bedrock surface. The cluster-like peak bases are connected and developed together with underground flows, subsurface streams, caves and cave sediments. The cone peaks have relative heights from 100 to 250 m, and the peak tops are uneven. The related depressions are deep and are having cylindrical, funnel or pot shapes of different sizes. The bottom heights vary with the exposure of the bare rocks and are associated with developed dolines and sinkholes. The height difference between the peak and depression is generally 180–300 m. As a type of peak cluster valley (polje), this valley generally has narrow but unobstructed passages. The valley bottoms are relatively flat, and there is generally no surface river. Most rocks are bare, and a few are covered with residual and slope deposits. Dolines and sinkholes are well developed. This type of valley is formed by rapid cutting of the main river course by several hundred metres caused by substantial late stage uplift of the plateau. The valleys are narrow, and the flow is rapid. The drops are substantial, and alluvial deposition is not pronounced. The valleys have steep slopes and are deeply cut to form a V-shape, a box shape or even rift shape. Many caves are distributed in this area. The Daqikong (Big Seven Holes) underground river cave system is 11.2 km long (Fig. 20).



Fig. 20 Peak cluster landscape, Guizhou – Libo, Guizhou Province

Light of Buddha ► Buddha's Halo

Light-Through Cavity Landscape ► Karst Perforated Rock Landscape

Lijiang Jade Dragon (Yulong) Snow Mountain and Glacier National Geopark, Yunnan This geopark is located in Lijiang, Yunan, and it covers an area of 340 km^2. It became a national geopark in August 2009. It is representative of modern and ancient glacial landforms, with intact remnants of modern glaciers and traces of multiple glacial movements. It also contains landforms of fluvial erosion and deposition, which are mainly distributed along the Jinsha River and at Daju Dam. It is a typical alpine vertical zone segmented by snow, forest and cloud lines.

Lily Pad Landscape A lily pad, also called a cloud pad, is a karst cave depositional feature like a lotus flower. It is a composite deposit of water dripping sedimentation. It can grow alone or connect with other pads. Single lily pads are approximately round with a diameter larger than 1 m, and the largest can reach 9 m in diameter and dozens of centimetres high. Lily pads are usually elongated, but a few are semi-circular and grow close to cave walls. Single lily pads have a concentric centre, and most are related to stalactites at the cave roof. Conjoined lily pads have several irregular concentric centres with numerous cave beads inside and outside the pad. A crucial condition for lily pad development is a flat cave bottom that can facilitate the formation of a shallow pool. When large amounts of water drip from the cave roof, the pool will grow simultaneously with the lily pad. China's earliest discovery of a lily pad was in the Lotus Cave in Xingping, Yangshuo. Since then, pads have been found in many caves. The Luomei Cave in Leye, Guangxi Province, contains 296 lily pads, one of which is 9.2 m in diameter and can be called 'the World's Lily Pad King' (Fig. 21).

Liman Coast A liman coast is a coast composed of silty sand and silt with a flat coastline, a gentle slope, and a wide shoal. Liman coasts are mainly located in relatively sheltered sedimentary coastal areas near estuaries with an abundant sediment supply. Examples include the coastal section of the Dahe River, which is a subsidence area that is sheltered by sandbars



Fig. 21 Lily pad landscape – Yizhou Lizhi Cave, Guangxi Province

where large amounts of sand and silt are deposited. The three types of liman coast are the plains type, which are found along the northern Jiangsu coast, the fortress type and the harbour type.

Limestone Limestone is a carbonate sedimentary rock mainly composed of calcite and sometimes dolomite, clay minerals and clastic minerals. It can be grey, greyish black, greyish white, pale red or reddish brown. It is usually soft and will fizz in diluted hydrochloric acid. Limestone has a complex structure, and there are two main kinds of structure: clastic and crystalline grain structures. Because limestone is soluble, it often forms graceful landscapes consisting of various forms, such as stone forests, peak clusters, peak forests, natural bridges, sinkholes, and karst caverns. The extensive limestone landforms in Guizhou, Guangxi, Yunnan and Hunan Provinces have become valuable tourism resources in China.

Lincheng National Geopark, Hebei Lincheng National Geopark is located in Lincheng County in Xietai City, southwestern Hebei Province, along the eastern border of Taihang County. It covers an area of 54 km^2, and it became a national geopark in 2005. The western parts of the geopark are mainly moderate and low mountains. The elevations are above 500 m, and the highest peak is 1,508 m tall. The middle part of the park is a low and flat hilly platform with the central Hebei Plain to the east. The geopark is mainly composed of the karst cave called White Cloud Cave on Mount Kong, which formed in Cambrian limestone. Other attractions include Tiantai Mountain, which is composed of Proterozoic quartz sandstone.

Lineation Lineations are small-scale penetrative linear features in a rock. Based on the time of formation, lineations can be categorised as primary lineations (lineations that formed during rock formation, such as lineations and flow planes in igneous rock and bedding in sedimentary rock) and secondary lineations (lineations that formed after rock formation, such as cleavage, schistosity and stretching lineations). Based on the relationship with the direction of movement, lineations can be divided into A-type lineations (parallel to the movement direction, such as stretching lineations and mineral growth lines) and B-type lineations (perpendicular to the movement direction, such as crenulation lineations).

'Line-Like Sky' of Granite ▶ 'One-Line Sky' of Granite

Lingbi Stone Lingbi stone is a carbonate rock mined in 'Lingbi' (an ancient county) in Anhui Province. Some contain algae fossils, and because they were found along the Sishui

River, they were given the name 'Sibi Fuqing (Floating Chimes of Sishui Shore)'. High-quality Lingbi stone generates a chime sound when struck, and in the past, it was used as a musical instrument called 'Qing', which, along with 'You (the old name for bell)', was a key instrument for the court. Lingbi stone looks slim, wrinkled, leaky and permeable and has an elegant shape, pleasing colour, multiple patterns and good sound. It is considered a high-quality ornamental stone. Large specimens are considered to contain numerous features of the world, enabling it to become an ideal ornamental specimen for landscape gardens. Small specimens can give the impression of a landscape of a thousand rocks and thus are ideal for indoor displays. There are a wide range of Lingbi stones with different characteristics, but most are limestone. There are more than 400 varieties based on the impurities (Fig. 22).

Lingchuan Wangmangling National Geopark, Shanxi This geopark is located in Lingchuan County, Shanxi Province, and it has an area of 62 km^2. It became a national geopark in 2009. The geopark mainly features karst peaks, gorges, and underground karst caves. The gorge is nearly 900 m high, and the valley in Xiyagou is an icon of the geopark. Its upper part is the Cambrian karst canyon, which is 500–800 m deep and has a relatively wide and flat bottom. The lower part is a barrier valley composed of quartzite of the Changchengian System that is tens of metres wide. Enormous karst caves formed in the brecciated limestone and dolomite of the Majiagou Group and the lower part of the Liangjiashan Group. The most representative karst cave is the Huangweiling hole, which is large and contains large amounts of sediments.

Lingqu Canal The Lingqu Canal is by far one of the best-preserved ancient water conservancy projects in the world. It shares this honour with Dujiangyan in Sichuan Province and the Zheng Canal in Shaanxi Province; together, they are called the 'three major water conservancy projects of the Qin Dynasty.' The Lingqu Canal is located in Xing'an County, 60 km northeast of Guilin, and has a total length of 37 km. Its construction was completed in Emperor Qinshihuang's Year 33 (214 B.C.), and it comprises Huazui (Spade inlet), Daxiao Tianping (Large and Small Balance), Nanqu (South Canal), Beiqu Tianping (North Canal Balance) and Doumen (Steep Gate). The design is sophisticated and scientifically effective. Huazui separates the Xiangjiang River into two flows, one of which contains approximately 30% of the water volume and flows south into the Lijiang



Fig. 22 Lingbi stone



Fig. 23 Xing'an Lingqu, Guangxi Province

River, while the other contains approximately 70% of the water volume and flows north into the original Xiangjiang River. This canal links the Changjiang (Yangtze River) system with the Zhujiang (Pearl River) system (Fig. 23).

Lingwu National Geopark, Ningxia This geopark is located in Lingwu City, Ningxia Hui Autonomous Region. It became a national geopark in 2009, and the main geological attractions are fossil remains, ancient human activity sites and interesting stratigraphy, geomorphology and hydrology. Fossils of eight dinosaurs, including skulls, teeth and scapulas, were excavated on the southern side of the hill in Ciyaobao, Ningdong Town in Lingwu City. These dinosaurs were large herbivorous sauropods and were found in the Jurassic Yan'an Formation, which is approximately 160 million years old. An ancient human site is located in Shuidonggou, which contains evidence of human activity during the Late Palaeolithic, approximately 250,000 years ago.

Lingyun Xie Lingyun Xie (385–433) was a native of Yangxia in Chen County (now Taikang, Henan Province) and subsequently moved to Huiji. He was a poet that focused on the landscapes in the Southern and Northern Dynasties. He was fostered when he was a child; thus, his alias was Ke'er or Xie Ke (guest). His poems were mainly about the landscape scenery in Huiji, Yongjia and Mount Lu. He exceled at depicting natural scenery and was the founder of the school of Chinese landscape poetry.

Linhai National Geopark, Zhejiang This geopark is located in the coastal zone approximately 50 km east of Linhai City in eastern Zhejiang Province and was approved as a national geopark in 2002. It is characterised by a geomorphic landscape composed of intrusive and extrusive volcanic rocks dating from approximately 95 million to 65 million years ago. The main strata in the park are the Upper Cretaceous Tiantai Group, which is part of the Late Mesozoic volcanic belt along the eastern coast of Zhejiang. The volcanic activity was dominated by eruptions of acidic magma accompanied by magmatic intrusions. The park is composed of layered volcanic rocks, faulted structures and vertical columnar joints that form a unique landscape of lava tables and peaks.

Linhai Rhyolitic Stone Column Landscape This type of landscape, known geologically as columnar joints, is located in Taizhou City,



Fig. 24 Linhai rhyolitic stone column landscape

Zhejiang Province. Columnar joints commonly occur in areas of basalt, but the volcanic columns in the Dakantou area in Taozhu, Linhai, are mainly rhyolitic rocks (porphyroclastic lava), which is the reason for the landform's name. These columns were discovered in the 1970s and are distributed over an area of 4 km^2. The columns have regular hexagonal shapes with exposed outcrops from 1 m to 10 m high. They constitute stunning landforms called peaks of 10,000 pillars, rocks of a thousand pillars, stone pillar valleys and stone pillar waterfalls. Dakantou has been established as the Linhai Taozhu National Geopark (Fig. 24).

Linxi Dajing National Mining Park, Inner Mongolia This park is located in Dajinzi Town, Linxi County, northern Chifeng City, and it covers an area of 2.5 km^2. It was designated as a national mining park in 2010. The park consists of ancient copper ore sites dating to more than 2,800 years ago and modern mines. It is divided into four scenic areas: a mining heritage scenic area, modern production scenic area, mining culture scenic area, and ecological experience area. With rich and representative mining heritage, the park is the largest and earliest copper mine in northern China, where the complete processes of large-scale mining, smelting and casting can be found.

Linyi Guilaizhuang Gold Ore National Mining Park, Shandong This park is located in Pingyi County, Shandong Province, and covers an area of 3.7 km^2. It was designated as one of the second group of national mining parks by the Ministry of Land and Resources in May 2010. Boasting a long history, the Guilaizhuang gold ore is one of the three major geological prospecting discoveries made during the Seventh Five-Year Plan in China. It has been developed into a modern gold mine that integrates mining, processing and smelting. The unique metallogenic conditions in the park contributed to the formation of the gold ore crypto-explosive breccia profile and the structure that has controlled the formation of the gold ore – the Guilaizhuang Fracture. The open mining has resulted in a pit that is 550 m long, 380 m wide and 160 m deep. The unique mining and geological heritage resources are fully manifested in such mining production structures as dressing and smelting fields, mine houses, soil sediments as well as mining activities such as prospecting, mining and smelting.

Linyi Mengyin Diamond National Mining Park, Shandong This park is located in Liancheng Town, Mengyin County, Shandong Province, at the northern foot of Mengshan Mountain, and it covers an area of 30 km^2. It became a

national mining park in 2005. It can be divided into five zones in accordance with their functions, including a mine tourist zone, special landscapes zone, camping zone, the Yixin Leisure and Recuperation Area and the Jinboli Entertainment Zone. Linyi is a famous old revolutionary base as well as the seat of party, government and military organisations. It contains more than 30 Red revolutionary sites and is a base to promote Red revolutionary education.

Lishan Hot Spring Landscape This is a famous spring resort in China and has long been considered 'China's top spring'. It is located in the foothills of the Lishan Mountains in Lintong, 30 km east of Xi'an. As early as the Zhou Dynasty, the springs in this district had been discovered and were called the Star Spring. King You built his Li Palace here, and Emperor Qin Shihuang later constructed a stone pool that was called the Lishan Pool or Shennu (Goddess) Pool. The expansion and renovation continued through the Han, Sui and Tang Dynasties. By the time of Emperor Xuanzong, the palace had been extended to incorporate the spring pool, and the palace was then named Huaqing Palace. Since then, this pool has been called the Huaqing Pool. Huaqing Pool Hot Springs has four sources. One was discovered in the Zhou Dynasty in approximately the eleventh century B.C., and the others were developed after the founding of the People's Republic of China. The spring water contains many types of minerals and organic substances, rendering it suitable for bathing and for treating arthritis and skin diseases. From 747 to 757 A.D., Emperor Xuanzong of the Tang Dynasty came to Huaqing Palace every October and stayed until the next spring with his concubines, the Yang sisters. Because of this, Huaqing Pool was given the name 'Oriental Sacred Spring' and became as famous as the Caracalla Therme in ancient Rome and the Bath Spa in Britain. The striking modern historical event 'Xi'an Incident' was staged here (Fig. 25).

Lishi Loess This is the name for the Pleistocene loess layer that was proposed by Liu Dongshan and Zhang Zonghu in 1962. This loess layer is 95.5 m thick. The typical profile is located in Chenjiaya in Wangjiagou Village, Lishi County, Shanxi Province. Based on the lithology, this profile can be divided into two sections: (1) The lower section conformably overlies the Wucheng loess. It is composed of yellow-light yellow clay with a dense and uniform texture, no bedding and large pores, and it contains 14 palaeosol layers. (2) The upper section is composed of grey yellow-yellow loess with a loose soil structure, vertical joints and seven thick layers of palaeosols. Dating of S5 indicates that the palaeosols formed 500,000 years ago under extremely warm climatic conditions. The Lishi loess is generally 60–80 m thick, but it can be up to



Fig. 25 Landscape outside Lishan Hot Spring, Xi'an

250 m thick in Lanzhou, where it forms the base of the Loess Plateau.

List of World Heritage in Danger Noting that the heritage of global citizens is increasingly threatened with destruction, Article 11 of the World Heritage Convention prescribes that "the World Heritage Committee shall establish, keep up to date and publish, whenever circumstances shall so require, under the title of 'List of World Heritage in Danger', a list of the property appearing in the World Heritage List for the conservation of which major operations are necessary and for which assistance has been requested under this Convention". Since 1984, a new version of the 'List of World Heritage in Danger' has been published almost every year, which has provided not only good news about the termination of danger but also alerts of new additions to the list. In May 2018, 54 sites around the world were listed as being in danger and were required to take immediate actions to rectify and improve their situations.

Lithic Fragment *Synonym:* ▶ *Rock fragment* During a volcanic eruption, magma rises through the volcanic channel and breaks through the overlying strata or older rocks, which breaks these rocks into fragments of varying sizes. When the diameter of a rock fragment is less than 2 mm, it is called a lithic fragment.

Lithium Water This is hot mineral water that contains lithium. According to the National Medical Hot Mineral Water and Natural Drinking Mineral Water Quality Standard, water with lithium contents over 5 mg/L and 0.2 mg/L can be classified as medical lithium water and drinking lithium water, respectively. The standard for natural drinking mineral water used in Europe limits the lithium content to 1 mg/L or above, which is much higher than that in China. Because lithium is difficult to concentrate in groundwater, lithium water or lithium-containing water is rare in nature. Only a few places in China have lithium water. The highest standard for drinking lithium water is used in the Vichy area in France, which is 4.9 mg/L. Lithium has a moderating effect on the central nervous system. It has a calming effect and can be used in the treatment of manic depression. Lithium also stimulates the blood and can improve haematopoiesis. European countries use water with a high lithium content to treat kidney stones and rheumatism.

Lithostratigraphic Unit Lithostratigraphic units are bodies of rocks in three-dimensional space that are defined based on their observable consistent lithographic properties (or lithologic composition), by the extent of metamorphism or structural characteristics, and by their stratigraphic relationships with the adjacent rock strata. A lithostratigraphic unit may consist of one or more types of sedimentary rocks, extrusive rocks or related metamorphic rocks. The requirement for identifying a unit is the consistency of the rock characteristics. In defining a lithostratigraphic unit, factors such as time, origin, climate, environment or events are not critical factors, but the units themselves are the physical basis for inferring these factors. Lithostratigraphic units are the basic units of geologic mapping, especially in large-scale mapping. They are also primary aspects of regional lithostratigraphy. The customary lithostratigraphic units applicable to a certain geographical area are as follows: (1) Group – two or more formations; (2) Formation – the basic unit of lithostratigraphy; (3) Member – a named lithologic subdivision of a formation; and (4) Bed – a named distinctive layer in a member or formation. There is no corresponding relationship between lithostratigraphic units (groups, formations, members and beds) and chronostratigraphic units (erathems, systems, series and stages). Therefore, the former can cross the boundaries of the latter. Lithostratigraphic units and biostratigraphic units have different parameters, and they can either be consistent with each other or cross each other.

Liujia Gorge Landscape of the Yellow River Located in Yongjing County in Gansu Province, approximately 80 km from Lanzhou City, the Liujia Gorge is a deep valley along the upper course of the Yellow River (Huanghe). The Yellow River runs west from here in a large curve, and Liujia Gorge is one of the nine bends in the Yellow River. In 1969, the Liujiaxia



Fig. 26 Yellow River Liujia Gorge landscape

hydropower dam was completed; it has a height of 147 m, a length of 84 m and a top width of 16 m. The reservoir formed by the dam has a capacity of 5.7 billion m^3, which reflects the enormous size of the gorge (Fig. 26).

Liujiang Man Site The Liujiang Man site is a site of ancient human fossils that was discovered in September 1958 in a small limestone cave adjacent to Tongtian Rock in Xingxingling Farm, Liujiang County, Guangxi Province. The human fossils include a complete fossil of a middle-aged man, including a skull, four thoraxes, five lumbars and sacrums. There are also hips and femurs that may belong to the same individual. The skull of Liujiang Man bears several primitive features of modern man; therefore, Liujiang Man should be a fossil of late Homo sapiens. The cave contains a 1.5-m-thick deposit, the upper part of which is composed of grey and yellow sandy soils with rare fossils. The middle part of the deposit is a lamellar calcium layer, and bottom part is yellow sand clay mixed with limestone breccias and cherts that contain human fossils. The Liujiang Man lived in the Late Pleistocene. Uranium dating of the cover layer gives dates of 67,000 ± 6,000 years. The cave also contains mammal fossils.

Liujiaxia Dinosaur National Geopark, Gansu This geopark is located on the northern bank of Taiji Gorge and Taiji Lake in Yongjing County, Gansu Province. It became a national geopark in 2002. The geological remains are dominated by clusters of dinosaur footprints, which are very complete and clear with good three-dimensionality. Dinosaur sleeping prints, tail trails, and manure trails are also present in the same rock formation. Thirty sets comprising 270 footprints of eight types of dinosaurs have been discovered in the 710 m^2 of rock that has been excavated, including at least two types of giant sauropods, two types of theropods, a similar bird dragon, and three other types that have not yet been assigned.

Liupanshui Mount Wumengshan National Geopark, Guizhou Liupanshui Mount Wumengshan National Geopark is located in Liupanshui City, which is in western Guizhou Province. It acquired national geopark status in 2005. The peak and the plateau karst landscape on the eastern slope of Mount Wumengshan are the major features. The core area of the geopark is the Beipan River and karst valleys. The limestone landform is from the Cenozoic, and it is unique to the eastern slope of the Yunnan-Guilin Plateau. It has two scenic districts, namely, the Beipan River Grand Canyon and the Biyun Caves. The former is characterised by the Beipan River grand karst canyon, which links several

unique geomorphologic landscapes, including karst shafts, giant collapse dolines, subterranean rivers, plateau karsts and mountain plateaus. The latter feature karst caves and mountains near Chengguan Village in Panxian County.

Liuyang Mount Dawei Geopark, Hunan This geopark is located in northeastern Liuyang (a county-level city) in Changsha, Hunan Province. The geopark covers an area of 114 km^2, and most of the geological features are concentrated in an area of 85 km^2. It became a national geopark in 2011. Quaternary glacial relics are the major components of the geopark. Other attractions include granitic landforms, faulted landforms, waterfalls and springs at the source of the Liuyang River. It is a comprehensive geopark that integrates attractive natural landscapes and cultural landscapes. It also serves multiple functions, such as scientific research, science popularisation, geotourism and adventure.

Local Education and Science Activities A geopark has the responsibility to popularise science to students in the local communities. It also encourages the understanding of the value of local land and resources. It usually works jointly with local education departments to design and develop teaching materials of science and culture by adding these materials to the students' curriculum. The general theme of these activities is to cherish the Earth and encourage students to learn about their environment. Through these activities, students should be able to show interest in earth science, nature conservation and the surrounding environment.

Location The term location comes from the German 'standort', which means a location or venue. In general, location refers to the position of a thing or item or its spatial relationship with other things or items. The extended location theory is one of the core theories of economic geography. Location analysis of tourism sites is an important scientific basis for tourism planning and site and destination development.

Lochaber Geopark – Scotland, UK This former geopark was located in the Scottish Highlands and became a global geopark in 2007. The park stretched north-south across Lairigmor and Glencoe, and from Loch Leven in the east to the those small islands such as Isle of Eigg, Isle of Rum, Isle of Muck and Isle of Canna in the west. The Lochaber area is famous for its spectacular scenery. The Lochaber Geopark contained geological features that were of national and international importance, including deeply eroded volcanoes in the western part of Rum and the parallel path of the stunning Glenroy in the east. These unique geological features led the Lochaber region to be officially granted the status of European and Global Geopark in April 2007. However, such status of the park was cancelled at the time of assessment.

Loess Loess is an aeolian sediment with visible pores that forms by the accumulation of windblown yellow silt (over 50% content) that has not experienced secondary disturbance and is rich in calcium carbonate. In China, loess covers an area of approximately 630,000 km^2, which is the world's thickest and largest deposit and is mainly distributed in the Loess Plateau in northwestern China. Loess is important in agricultural production and played a key role in the emergence of Chinese civilisation. Loess records a large amount of information about the changes on Earth since the Quaternary. Loess-palaeosol profiles, together with polar ice cores and deep-sea sediment charts, have become the three 'bibles' for revealing the changes in the Earth's environment since the Quaternary. The Luochuan Loess National Geopark in Shaanxi Province has a typical loess profile that records information about the environmental and climatic changes over the past 2.5 million years (Fig. 27).

Loess Bridge and Arch Landscape This is a loess erosion landscape. When the area between two loess collapse holes is cut through by subterranean water, a bridge-like or arch-like landform is created. The landform is called a loess bridge when water flows beneath it, and it is called a loess arch when there is no water below (Fig. 28).



Fig. 27 A loess profile in Luochuan Potou, Shaanxi Province

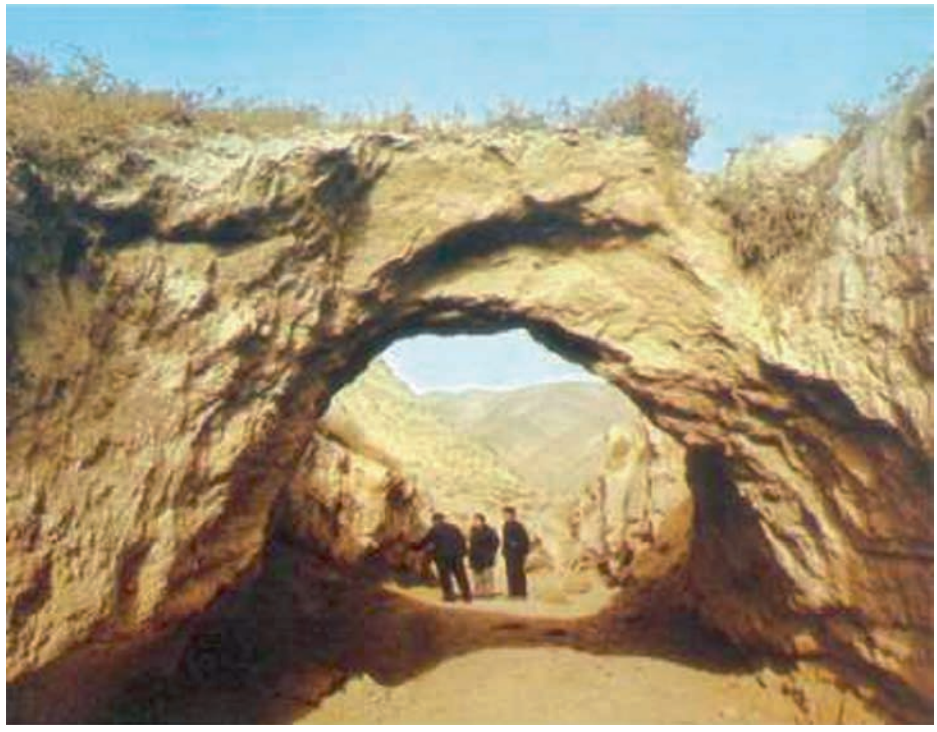


Fig. 28 Loess arch landscape – Luochuan, Shaanxi Province



Fig. 29 Loess cave landscape

Loess Cave Landscape This is a loess erosion landscape. A loess cave is a type of cave that forms when atmospheric precipitation flows into a gully after entering a loess sinkhole (Fig. 29).

Loess Column Landscape This is a loess erosion landscape consisting of residual loess columns formed by erosion and dissolution along vertical joints. When they appear in a cluster, they are called a loess forest. Loess columns often form at the edge of a gully or gorge (Fig. 30).

Loess Dissected Valley Landscape This is a loess erosion landscape consisting of small gullies cut by erosion of the loess by water. These gullies or valleys commonly form on steep loess liang and mao slopes. Typical loess dissected valleys are V-shaped, 3–6 m wide, 2–4 m deep and appear in clusters. They are the result of early-stage erosion (Fig. 31).

Loess Fissure Landscape This is a landscape consisting of surface fissures in loess regions. These fissures can be related to diagenesis cracks, tectonic cracks or stress-release cracks. Vertical joints in loess areas tend to develop into diagenetic fissures, which are often the causes of landslides and land collapses (Fig. 32).

Loess Flat Landscape This is a loess landscape consisting of small pieces of a residual loess terrace or a wide and flat loess gully bed. Loess flats are usually high-quality farmland. Wangjiaping in Yan'an, Shaanxi Province, where the Central Military Commission was located during the anti-Japanese war period, is a typical example of this landform (Fig. 33).

Loess Flat Ridge Landscape This is also called a 'loess liang landscape' and is characterised by erosion of loess along elongated strips of highlands parallel to the adjacent gullies and valleys. A liang is often the remnant of a yuan that has been eroded further. Due to backward erosion, the gullies on both sides of a liang tend to extend through the liang ridge, forming a narrow saddle. Loess liangs vary in width from less than 1 km to tens of kilometres. A wide laing can be more than 100 m wide, and its ridge is called a 'yaolian'. Typical liangs can be found in Yan'an, Ansai and Baiyu Mountain in northern Shaanxi Province and in eastern Gansu Province (Fig. 34).

Loess Funnel Landscape Surface runoff around loess washes away the particles through percolation and can form loess funnels. These funnels are round or subrounded with diameter of 1 m to several metres and depths of 2–5 m (Fig. 35).

Loess Gorge Landscape This is a loess erosion landscape consisting of a type of linear loess landform of a certain height with vertical walls and a narrow width. Loess gorges are characterised by vertical valley walls, narrow widths of 1–2 m, heights ranging from several metres to dozens of metres and an extremely narrow skyline viewed from the gorge bottom, which gives this landform its Chinese name 'one-line-sky'. The gorges form along faults and are enlarged by water erosion along vertical joints. This landform has significant ornamental value (Fig. 36).

Loess Gully Landscape This is a loess landscape with gullies formed by the erosion of transient linear currents. It is an important form of loess



Fig. 30 Loess column landscape – Luochuan Loess National Geopark



Fig. 31 Loess dissected valley- Yanan, Shaanxi Province



Fig. 32 Loess vertical fissure landscape – Jingyang, Shaanxi Province



Fig. 33 Loess flat landscape – Yan'an, Shaanxi Province



Fig. 34 Loess liang landscape – Yanchuan, Shaanxi Province



Fig. 35 Loess funnel landscape – Luochuan, Shaanxi Province



Fig. 36 Loess gorge landscape – Shaanxi Province

erosion that is characterised by deep grooves, steep walls and obvious backward erosion. The gully depths range from several metres to more than 10 m, and the lengths vary from hundreds to thousands of metres. The gully bottoms are narrow with V-shaped cross-sections and steep walls. The gully bed gradient is high; therefore, the water and gravity erosion are strong. Water erosion will cut the ground into a network of gullies, reflecting the power of external geological forces (Fig. 37).

Loess Hanging Valley Landscape This is a loess erosion landscape consisting of steep semi-cylindrical gullies that hang on loess slopes. When surface runoff on loess yuan and liang converges at the edge of a steep slope, the rapid downhill flow erodes the slope surface and forms loess hanging valleys (Fig. 38).

Loess High Tableland Landscape This is one of the landscapes of loess accumulation. It is a high tableland with extensive coverage (dozens to hundreds of square kilometres) and a flat top that is dissected by gullies.



Fig. 37 Loess gully landscape – Yan'an, Shaanxi Province



Fig. 38 Loess hanging valley landscape – Luochuan Loess National Geopark



Fig. 39 Loess high tableland in Luochuan, Shaanxi Province

It is locally called 'yuan', which means high tableland. Famous examples are Dongzhi Yuan and Baicao (White Grass) Yuan in eastern Gansu Province and Luochuan Yuan in northern Shaanxi Province (Fig. 39).

Loess Landscape Loess landscape is the collective term for all natural geographical



Fig. 40 Loess liang (flat ridge), mao (round hillock), and mounds and depressions in Yan'an, Shaanxi Province

landforms in loess regions. Loess geomorphological landforms mainly include features such as yuan (tablelands), liang (flat ridges), mao (round hillocks), gou (ditches), loess pillars, ping (plains), die (basins), walls, holes and hollows. Loess landforms have important scientific research value and aesthetic and ornamental value, and they are an important tourism resource. The Luochuan Loess National Geopark and Yanchuan National Meander Geopark on the Yellow River in Shaanxi Province have spectacular landscapes of loess mounds and depressions (Fig. 40).

Loess Mao Landscape or Loess Round Hillock Landscape This is a peculiar and unique loess landscape of erosion consisting of isolated dome-shaped mounds that look like buns. Most mounds are the result of the erosion of the loess layer, but some form when the loess sediments cover ancient mound-shaped highlands. Loess maoes and liangs often appear together to form so-called liang-mao landforms. The relationship between loess yuan and liang represents the geomorphological evolution process associated with the erosion intensity of water on the loess deposits. On the vast Loess Plateau, circular loess maoes look like numerous buns dotting an 'ocean' of loess and hence add much interest to the unique landscape (Fig. 41).

Loess Plateau Landscape This is a unique geomorphic unit of a plateau landscape composed of thick layers of loess. China's Loess Plateau has an area of 440,000 km^2, and the elevations are generally 1,000–2,000 m. It is located to the west of the Taihang Mountains, east of Riyue (Sun and Moon) Mountain, south of the Great Wall and in the vast area north of the Qinling Mountains, including four geographical regions: the Longxi (West Gansu) Plateau west of Liupan Mountain; the Longdong (East Gansu) Plateau between Liupan Mountain and Ziwu (Meridian) Ridge; the Northern Shaanxi Plateau between Ziwu Ridge and the Luliang Mountains; and the Shanxi Plateau between the Luliang Mountains and the Taihang Mountains. The Loess Plateau is an important agricultural and energy resource base. More than one million years ago, the Lantian ape-man lived and flourished in this region. Since then, China's farming culture has developed in this area, which



Fig. 41 Loess mao landscape – Baiyu Mountain, Shaanxi Province

became the cradle of Chinese civilisation. However, the loose soil structure of loess easily results in soil erosion; hence, China's Loess Plateau is the most serious area of soil erosion in China or even around the world, causing the section of Huanghe (Yellow River) that flows through this region to become heavily sediment-loaded, which has formed a unique landscape of an 'above ground river'.

Loess Plunge Cave Landscape This is a loess erosion landscape. Due to rainwater percolation, loess funnels and loess collapse holes can evolve into pits deep enough to reach the water table. These pits are called loess sinkholes, which are a large type of loess collapse hole. They are also called 'heavenly wells' and form a peculiar ornamental micro-landform.

Loess Sinkhole Landscape or Loess Collapse Hole Landscape This is a loess subsidence landscape. Dish-like depressions develop in loess and subside, forming loess collapse holes of great depth and width. This landform results from the combination of dissolution and mechanical erosion. Based on the form, loess collapse holes can be divided into shaft-like, funnel-like and beaded string-like holes. The diameter of a shaft-like hole's mouth can reach several metres, and the depth can be up to 20–30 m. Funnel-like holes have larger mouths but small bottoms, like a funnel, and can be several metres deep. Beaded string-like holes contain several collapse holes connected by subterranean tunnels. These tunnels are straight with a gentle gradient and some are also temporary waterflows. When subject to further erosion and the effects of gravity, beaded string-like sinkholes can evolve into loess gullies. Loess collapse holes are a spectacular loess micro-landform (Fig. 42).

Loess Wall Landscape This is a loess erosion landscape. Loess can stand upright due to vertical joints, and when the standing loess is surrounded by two gullies, it can collapse with further erosion, forming a residual wall-like feature that is called loess wall (Fig. 43).

Longhushan Global Geopark, China This geopark is located in Yingtan City, Jiangxi Province, and covers a total area of 928 km^2.



Fig. 42 Loess sinkhole landscape – Yongdeng, Gansu Province



Fig. 43 Loess wall landscape – Pinglu, Shanxi Province

It became a global geopark in 200. It comprises three scenic districts, including Longhushan, Guifeng and Xiangshan. It is mainly composed of a Danxia landform with volcanic and tectonic landforms. The Danxia landform is representative and integrated with rich cultural elements, such as Taoist and Buddhist temples and cliff tombs. It is a comprehensive geopark with interesting history and culture in addition to the scenic environment.

Longitudinal Dune Landscape A longitudinal dune is an elongated sand ridge with an axis parallel to the dominant winds. It is a type of composite dune that is much larger than typical sand dunes. Sand ridges are normally flat or undulating in a wavy pattern. The surface of a sand ridge is stacked with many crescent-shaped sand dunes and dune chains. The longitudinal dunes of Mingshashan (Mingsha Mountain) in Dunhuang, Gansu Province, are 130 m high. The sand ridges in the Qaidam Basin, Qinghai Province, are 10–20 m high, the tallest can reach 40 m, and they are several hundred to several thousand metres long. Longitudinal dunes form due to the interaction of wind forces, which push a wing of a barchan dune forward, or by the transformation of sand dunes with vegetation cover. The entrance to the Taklimakan central composite longitudinal dune area, which contains groups of longitudinal dunes, is located 130 km south of the Southern Xinjiang Desert Highway in Xinjiang Province (Fig. 44).

Longitudinal Valley Suture of Eastern Taiwan This suture zone is located in the longitudinal valley in eastern Taiwan. This zone is oriented NNE and is 150 km long. The valley, which is a fault zone, is approximately 5–7 km wide, and both sides are composed of straight faults. This fault zone is sinistral (strike-slip with left-lateral motion), and the coastal ranges to the east have moved at least 170 km north. The eastern basin also has characteristics of westward thrusting. This fault zone is an active seismic zone. The geological and geophysical features on both sides of the fault zone are significantly different, indicating that they are composed of different types of crust. Glaucophane schist, which is an indicator of high-pressure metamorphism, is present in this fault zone. Melange (Lichi Formation) is also present, and scientists agree that it is a typical



Fig. 44 Longitudinal dune landscape – Kumutage Desert, Xinjiang Province (after Dong Zhibao)

suture zone that serves as the boundary between the Eurasian and the Philippine Sea Plates. A series of geological relics associated with the suture zone are available for touring along the east coast of Taiwan, including the area from Taroko to Lichi, where landforms related to compressional faults, glaucophane schist, ophiolite and mélange can be seen (Fig. 45).

Longmen Grottoes The Longmen Grottoes are one of the four famous grottoes in China and are also a World Cultural Heritage Site. They are located on the cliffs along the banks of the Yi River, 12 km south of Luoyang City, Henan Province. These grottoes experienced 400 years of consecutive development starting in the Northern Wei Dynasty and extending to the Song Dynasty. To date, more than 2,100 caves have survived with more than 100,000 statues and over 3,600 carved inscriptions om the stone. Their quantity ranks first among all grottoes in China. The middle and lower portions of the western Longmen mound (except the areas south of Huoshao Cave) are mainly composed of limestone and dolomite, both of which are high-quality stone suitable for grotto excavation. These characteristics are why most of the grottoes were built in this area (Fig. 46).

Longmenshan Nappe Structure This nappe structure is located on the northwestern margin of the Sichuan Basin and has a NE trend. It starts in the southeast near Luding and extends northeast through Guanxian County, Wenchuan, and Mian County in Yangping, where it enters the Qinling Mountains. Its total length is approximately 600 km, and it forms an important geological demarcation line between eastern and western China. It is also associated with an obvious gravity gradient. The tectonic movements have been strong since the Mesozoic, resulting in an overthrust-nappe belt more than 30 km wide that forms the eastern border of the Qinghai-Tibet Plateau.

Longmenshan Tectonic Geology National Geopark, Sichuan This geopark is located in the Longmenshan area near Mianzhu in Pengzhou, Sichuan Province. It covers an area of 251 km^2 and became a national geopark in 2001. The main geological heritage includes nappe tectonics ('flying peaks'), glacial boulders, stratigraphic profiles, fossils, various



Fig. 45 Longitudinal valley suture of eastern Taiwan



Fig. 46 Longmen Grotto

tectonic features associated with nappe tectonics, mountains and valleys, hot springs, mineral water, granite peaks and earthquake sites. Longmenshan therefore has very rich geodiversity. Additional attractions include the primeval forests, streams, waterfalls, clouds, sunrises and flammules. The region is home to giant pandas, red pandas, wildebeests, golden monkeys and the three living fossils: sycamores, metasequoia, and ginkgo.

Longshan Culture (Black Pottery Culture) The Longshan culture site is a Neolithic relic site in the middle and lower courses of Huanghe (Yellow River). The Longshan culture, which existed 4,000–5,000 years ago, developed following the Yangshao culture. Unlike the Yangshao Painted Pottery Culture, this culture was characterised by black and grey pottery, which was where it gets the name 'Black Pottery Culture'. The Longshan culture belongs to the Neolithic period in China. The Qijia culture in the upper course of Huanghe, the Laohushan (Tiger Hill) culture in Inner Mongolia, the Kano relic site in Changdu, Tibet, and the Liangzhu culture south of the Yangtze River are equivalent to the Longshan culture. Agriculture in the Longshan culture was more prominent and intense than the previous one. Stone tools advanced with the manufacturing of jade and copper tools. In addition to domestic animals such as pigs, dogs and chicken, sheep and horses that came from the west were also raised. This is a strong proof of frequent cultural interactions and bartering trade between the eastern and western China during that period. More importantly, abundant townships and castles were established, and wells began to be dug. In addition to stone tools and pottery, numerous unique and elegant jade ritual artefacts, decorations and lacquer wood implements were also found at the Taoist relic site (Fig. 47).



Fig. 47 Jadeite

Lope-Okanda Ecosystem and Relict Cultural Landscape, Gabon This area is located along the southwestern border of the province of Ogooué-Ivindo and the northwestern border of Ogooué-Lolo Provinces in Gabon. The core protection area covers 4,912 km^2 and is located at the transition between the dense and well-preserved tropical rainforests and the savannah. The landscape areas exhibit diverse exotic species, large endangered mammals and their habitats. The site illustrates the adaptation of different species to the ecological changes during post-glacial climate change as well as the disappearance of various ethnic groups. These groups left relatively well-preserved cultural sites in the area, such as peaks, caves, and natural shelters, smelting workshops and 1,800 rock carvings. Neolithic and Iron Age cultural relics and rock art reflect the major migration routes of the Bantu people and other West African nations. This cultural migration determined the historical development of sub-Saharan Africa.

Lord Howe Island Group, Australia The Lord Howe Island Group is located in the Pacific Ocean 700 km northeast of Sydney, New South Wales. The site consists of Lord Howe Island and the nearby ocean area, which is dotted with coral reefs. It has an area of 1,463 km^2. Boasting a unique oceanic topography generated by volcanic activity at depths of more than 2,000 m, these islands are home to numerous endemic species, especially birds.

Lorentz National Park, Indonesia This park is located in the coastal area of Papua Province (the former Irian Jaya Province) in far eastern Indonesia near Arafura Se. It has a core protection area of 25,056 km^2. It is the largest protected area in Southeast Asia and the world's only area that continuously protects ecological systems from snowy mountains to tropical oceans, including low-elevation wetlands. Located in the collision zone between two continental plates, the area has complex geological conditions with active orogeny and traces of important glacial actions. Unearthed fossils illustrate the evolution of life in New Guinea. The large numbers of endemic animals and plants highlight the rich biodiversity in the region.

Los Glaciares National Park, Argentina The Los Glaciares National Park is located in the southwestern corner of Argentina near the border with Chile. It is an area of exceptional natural beauty with rugged, towering mountains and numerous glacial lakes, including Lake Argentino, which is 160 km long. At its farthest end, three glaciers meet and deposit material into the milky grey glacial water, forming massive icebergs that drift into the lake.

Los Katíos National Park, Columbia This park is located in the borderland of the Chocó Department in northwestern Columbia near Panama, and it protects a core area of 720 km^2. The main landforms of the park are low hills, followed by piedmont plains. Because it is located in a tropical zone with humid weather and thick forests, the park is inhabited by diverse flora and fauna. It nurtures many types of endangered animals and provides a sanctuary for numerous endemic plants.

Loud Sand Loud sand is also called 'singing sand'. This is a natural phenomenon where dry loose sand, in a specific natural environment, generates sound, or when the sound sound is caused by an external force. This phenomenon often occurs in sand dunes along lakes, ocean coasts and large deserts. Some people call this phenomenon along lakes and coasts 'loud sand' and the phenomenon in the desert 'singing sand'. There are numerous explanations for the cause of the sound, including air vibration theories, such as the resonance box hypothesis, the air cushion hypothesis, the friction shear hypothesis, the surface structure hypothesis, the sand dune sliding hypothesis and the quartz piezoelectric hypothesis. Mingshashan (Singing Sand Mountain) in Dunhuang, Gansu Province, Shapotou Mingshashan (Shapotou Singing Sand Mountain) in Zhongwei, central Ningxia, Xiangshawan (Loud Sand Bay) in Baotou, Inner Mongolia, Xiangshawan (Loud Sand Bay) in Ordos, and Mingshashan (Singing Sand Mountain) in Badain Jaran are famous 'singing sand' landscape. Badain Jaran is China's largest known area of 'singing sand'. In an area of 1,000 m^2, eleven 'singing sand' mountains have been identified. 'Singing sand' landforms are also located in other countries, such as Long Island and Massachusetts Bay in the United States, Bornholm Island in Denmark, Fort Cole in Poland, Brazil and Chile.

Low Swamp Landscape This is a type of swamp landscape that is also known as a eutrophic swamp. They mainly develop in flats and low depressions, basins or floodplains with the continuous replenishment of surface water and groundwater. The peat content is generally 18%, and there are eutrophic plants such as Carex and reeds. In China, low swamps are mainly sedge swamps, grass swamps and mixed swamps. Low swamps are common in the Sanjiang Plain and Ruoergai Plateau in China.

Low-Velocity Zone See ▶ Asthenosphere.

Lower Triassic (Induan-Olenekian) Global Boundary Stratotype Section and Point (GSSP) Southwest of Pingding Mountain, Chaohu Lake, Anhui The outcrop of this GSSP extends from the Middle Permian Gufeng Formation to the middle portion of the Nanlinghu Formation in the Lower Triassic Series. The more intact section extends from the upper part of the Lungtan Formation of the Permian Series to the lower part of the Nanlinghu Formation. The sequence of the Lower Triassic Series and its associated lithological cycles are very clear. Notwithstanding the steep terrain, the rock strata are aligned and have a constant thickness. The mudstone in the upper part of the Yinhang Formation and the Lungshan Formation strata include prominent sequences than can be correlated with those in the Majiashan area. This section is the most representative marker of the middle and lower strata of the Lower Permian Series in this region. The research on the Induan-Olenekian boundary is more precise and has led to more accurate records. The Lower Triassic Series in the Chaohu area clearly contains eight conodont and ammonite zones that have regional and even global significance for geological correlations. The Lower Triassic ammonite

biostrata at Chaohu can also be divided into six ammonite zones.

Lufeng Dinosaur National Geopark, Yunnan This geopark is located in Lufeng County, central Yunnan Province. It became a national geopark in 2004. The main geological remains are fossils, including dinosaurs and Rama Gulan fossils, which are well-known around the world. There are also Lufeng Dragons (Dilophosaurus) from the Middle Jurassic and fossils of the Lufeng Archaeopteryx (apes) from the Late Miocene. In addition, the geological structures, geohazard sites, and mineral ore deposits are interesting and record the early interactions between humans and nature.

Lufengosaurus huenei Lufengosaurus huenei is a Saurischian fossil that was found in Lufeng County, Yunnan Province. It is 2.6 m tall, 4.5 m long and 1.55 m wide. These animals lived from the Late Triassic to the Early Jurassic. They had small heads, long necks, saw-like teeth and long, strong tails. They walked with their hind limbs, which were longer than their forelimbs. Lufengosaurus mainly fed on plants. It is one of the oldest dinosaurs that have been found in China and was the first dinosaur fossil excavated, studied and assembled by Chinese scientists alone; therefore, it is called 'China's First Dragon'. It is similar to the fossils discovered in the Late Triassic strata in western Europe (Fig. 48).

Luliang Movement The Luliang movement was an intense crustal movement that occurred between the Palaeoproterozoic Era (Hutuo Group) and the Proterozoic (Changcheng Group) 1.8 billion years ago. Strong folding, fracturing, extensive magmatic activity, regional metamorphism and mixed lithologies caused the formation of a significant unconformity. The Luliang movement eventually formed the base of the North China Platform and the unified North China Platform. The Luliang movement was an important tectonic movement in China's geologic history.

Luliang-Type Multi-coloured Sand Forest Landscape This is a representative type of sandstone landform found in Neogene



Fig. 48 Lufengosaurus huenei



Fig. 49 Luliang-type multi-coloured sand forest landscape – Luliang, Yunnan Province

lacustrine facies variegated semi-consolidated silty sandstone and shale. It is formed by rainwater erosion on loose rocks and results in a badland landform with features such as irregular penholder-like residual mounds composed of purple, red, yellow, blue, green and black sandstone and shale. These features look like dead tree branches or a withered woodland, and such spectacular landforms have ornamental value. This landform was first discovered in Luliang in Yunnan Province, so it was called the 'Luliang-type multi-coloured sand forest landscape'. This landform type is fragile, and the topography continues to change because of erosion from the heavy rain every year (Fig. 49).

Luochuan Loess National Geopark, Shaanxi This geopark is located in Luochuan County, Yan'an City, Shaanxi Province. It has an area of 8 km^2 and became a national geopark in 2002. It features loess sections and yellow land landscapes. The section of the loess strata within the park is continuous and complete with good exposure. It records important geological events and geological information about the climate, environment, and biology since the Quaternary period. It is the most typical site for studying Quaternary geological events in mainland China and even in Eurasia. The highest loess elevation near the park is 1,136 m above sea level, and it is a typical area for the development of loess landforms in loess areas in China. The valley is 80–140 m deep and has steep slopes of 30°–60°. Due to gravity, surface water, and groundwater, loess landslides and collapses are common in the valley.

Luoning Shenlingzhai National Geopark, Henan Luoning Shenlingzhai National Geopark is located 26 km southeast of Luoning County in Henan Province, and it covers an area of 101 km^2. It became a national geopark in 2005. Granite landforms are the main features of the geopark, which represent the 'Luoning Low Mountain Dome Granite Landscape'. The geopark has two scenic districts, namely, the Shenlingzhai Scenic Area and Lotus Peak Scenic Area. The Shenling Gorge stretches for 10 km, and the elevation varies by more than 300 m. The gorge is deep, the riverbank is narrow, and water flows throughout the year. On both sides of the gorge, granite domes

with washout grooves create stone waterfalls, particularly during the rainy season. The Lotus Peak Scenic Area is in the eastern part of the geopark and consists of Majian Canyon, Lotus Peak Middle Mountain Wetland, and Peach Blossom Ridge.

Luoping Biota Geopark, Yunnan This geopark is located in the southern foothills of Wumeng Mountain and on the slope of the Eastern Yunnan Plateau at the junction of Yunnan, Guizhou and Guilin Provinces. It extends to the southwestern Yunnan Plateau and is known as 'the Gate to Eastern Yunnan'. It became a national geopark in 2011. Luoping County has typical karst landforms with a strong ethnic culture. Large and diverse fossils are well-preserved in Luoping. This area is called the 'Triassic Marine Biological Fossil Repository of China' and has significant scientific research and popularisation value. The great traveller Xu Xiake from the Ming Dynasty once wrote that 'Luoping is famous in East Yunnan'.

Lushan Global Geopark, China This geopark is located in northern Jiangxi Province and south of Changjiang (Yangtze River) in eastern China, and it covers an area of 500 km^2 with outstanding geological landscapes and stratigraphic outcrops. The horst block (uplifted fault block) mountains, Quaternary glacial features, and stratigraphic sections of Quaternary glaciers and the Lower Proterozoic Xingzi Formation are geologically valuable. More than 100 important glacial geological sites have been discovered at Lushan Mountain, which record the entire process from niveal accumulation, glacier formation, glacial motion, erosion and transportation to sedimentation of clay and boulders. These features provide evidence of palaeo-climatic changes and represent the geological characteristics of eastern China. Their similarities with the Quaternary glacial features in the European Alps and North America provide great opportunities to study regional and global palaeo-climatic changes and geological evolution. The fault-block mountain that formed from tectonic movements, glacial erosion and flowing water form a composite geomorphologic landscape that is characteristic of Lushan Mountain. Its vegetation and biological diversity jointly form the magnificent and beautiful scenery of Lushan Mountain and demonstrate the extreme aesthetic value of geoscientific landscapes. Lushan Mountain is also culturally and historically important as it was the cradle of China's landscape culture, and hundreds of famous poets have written about it over the past two thousand years. Lushan architectural culture is represented by the villas built by people from more than 20 countries from the end of the nineteenth century to the 1930s; it is a renowned combination of Chinese and western cultures and has been called the 'Park of All Nations' and the 'World Village'.

Lushan National Geopark, Jiangxi See ▶ Lushan Global Geopark, China.

Luxi Alu Geopark, Yunnan This geopark is situated in Luxi County, Hani-Yi Autonomous Prefecture of Honghe, Yunnan Province, and it has a total area of 38 km^2. It was approved as a national geopark by the Ministry of Land and Resources in December 2011. The geological heritage of the geopark includes the multi-phased plateau, peak clusters, basin valleys, cave groups, cave and karst landscapes, multi-phase cave landscapes, surface karst landscapes, ancient planation surface features, relics of tectonic activity and palaeoenvironmental evolution, fossils, hominid sites, cave culture landscapes and geological engineering landscapes. The park systematically illustrates the evolution of multi-phase plateau peak clusters, basin valleys and cave groups and shows the linked evolutions of surface and underground karsts.

Luzhai Xiangqiao National Geopark, Guangxi This geopark is located in Luzhai County in central Guangxi and is 36 km from the county town. The geopark is a transitional zone of karst peak clusters and tower peak forests, and it contains characteristic karst landform landscapes formed by Carboniferous limestone and dolomite. It was designated as one of the fourth group of national geoparks by the



Fig. 50 Lycoptera

Ministry of Land and Resources in August 2005. The karst landscapes mainly include tower peak forests, stone forests, arches, sinkholes and karst caves. The typical subtropical karst landscapes from different development stages are concentrated in an area of less than 40 km^2.

Lycoptera Lycoptera is a genus of the Osteichthyes. Lycoptera species were small freshwater fish (approximately 5–12 cm long), and the head's length and height were similar. They had large eyes, and their dorsal fins were close to the back with 43–50 spine segments. The tails were orthomorphic, and their caudal vertebras pointed upwards. Lycoptera fossils have mainly been found in the Late Jurassic lacustrine sedimentary rocks in Liaoning Province, Inner Mongolia, Hebei Province, Shandong Province and Gansu Province. These fossils often appear in a group in the same layer of shale. Collectors put higher value on fossils in swarms with natural forms, in regular arrays, with clear structures and contrasting colours with the surrounding rocks. Lycoptera fossils have additional value if they are in a symmetrical pair made up of both the fossil and the cast (Fig. 50).

M

Maar Landscape A maar landscape is a low flat crater landscape with no volcanic cone but only a wide flat crater. It is a type of volcano that forms during an eruption caused by the interaction between cold water and hot rising magma. This type of volcano is characterised by a wide crater that extends underground or cuts into the surrounding rock mass. The crater edge curves upward with a gentle slope. There are numerous maars in the Eifel area in Germany; many are filled with water and hence are called 'mare', which literally means 'sea'. In studies of volcanoes, this type of structure is called a maar. There are maars in the Haikou, Zhanjiang and Huinan areas of China (Figs. 1 and 2).

Maba Man Site The Maba Man site is a site of ancient human fossils that is located in a limestone cave in Shi Zi Hill (Lion Hill) in Maba Village, Shaoguan City, Guangdong Province. It was discovered in June 1958 by a local farmer, who found a broken human skull and several animal fossils. The skull contains the parietal bone, frontal bone, a large portion of the nasal bone and the right orbit. The Maba Man is an early Homo sapiens. Morphologically, the Maba Man is similar to the Neanderthal Man. His frontal bone is lower than that of modern human beings but higher than that of Peking Man. Fossils of 17 species of animals living together with the Maba Man have been found, including pandas, stegodons, rhinoceros, and Crotuta ultima. The uranium dating resulted in dates from the Late Pleistocene, $120{,}000 \pm 10{,}000$ ago.

Macquarie Island, Australia This island is located in the Southern Ocean and has a core protection area of 170 km^2. It is located 1,500 km southeast of Tasmania, Australia, between the Pacific and Antarctica. Formed by the emergence of the Macquarie Ridge above the water, it is the result of the collision between the Indo-Australian Plate and the Pacific Plate and the subsequent uplift. As the only existing example of the zone of activity of mantle rocks (more than 6 km below the ocean floor) that is exposed above sea level, it has important geological preservation value. Among the features exposed at the surface are perfect pillow basalts and other forms of extrusive tuffs and lava.

Macrosystem of Hydrosphere Tourism Resources This is a landscape resource system with tourism value composed of water bodies. The hydrosphere is a collective term for all water bodies. During the formation and evolution of the Earth, the hydrosphere, which includes the oceans, rivers, lakes, swamps, glaciers and groundwater, formed between the atmosphere and the lithosphere. The hydrosphere has a mass of 145×10^{16} metric tons. Oceans cover 72.8% of the Earth's surface and contain 97.1% of the total water volume of the hydrosphere, whereas the land contains less than 3% of the water, and the air contains 0.001%. The water volume of the ocean is 33 times that of the land, and the total mass is 134.99×10^{16} metric tons. Glaciers and the polar ice caps represent 77% of the water mass on land, and the remainder is in rivers, lakes and groundwater. The hydrosphere, atmosphere, biosphere, and the upper layer of the lithosphere are interconnected. Therefore, due to the effects of solar radiation, lunar gravity and other physical and chemical processes, the water cycle continuously causes substantial exogenic geological effects, which have resulted in the formation of various water landscapes that make up a valuable hydrosphere tourism resource system.

Macrosystem of Lithosphere Tourism Resources This refers to all tourism resources in the lithosphere of the Earth. The lithosphere includes the Earth's crust and upper mantle. The solid part of the Earth's outer layer is the host of all tourism resources. The scenery composed of the stratigraphic layers, palaeo-biotic elements, minerals and structures of different geological ages forms tourism resources, and the geomorphological features on the

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Fig. 1 Maar landscape in Shuangchi Ridge, Haikou



Fig. 2 Maar landscape in Luojingpan, Haikou (the crater has become farmland)

lithosphere have become a geomorphological tourism resource. Another resource is the caves below the Earth's surface. These three types of tourism resources make up the Earth's macrosystem of lithospheric tourism resources.

Macrosystem of Tourism Resources of the Biosphere This is a resource system with tourism value that consists of a variety of living creatures.

Living organisms began to exist on Earth more than three billion years ago. Since then,

they have become increasingly complex and sophisticated, have moved from marine environments to terrestrial environments, and have occupied every corner of the ocean, land and the lower part of the atmosphere, forming the biosphere. In every geographical landscape or tourism area, living creatures are the most eye-catching features. Therefore, the landscape of biological creatures (especially vegetation) and other natural tourism resources, together with the cultural tourism resources, comprise various tourism areas. Different flora and fauna tourism resource landscapes under different natural geographical conditions have made up the extensive system of tourism resources of the biosphere.

Macrosystem of Tourism Resources of the Cultural Sphere The cultural sphere is also called the human sphere or intelligence sphere. Over the long history of mankind, humans have created many material and non-material landscapes, forming an extensive system of tourism resources in the cultural sphere that is characterised by abundant elements, complex structures, prominent regional significance and obvious historical features. This system can be further sub-divided into a material cultural landscape tourism resource system and a non-material cultural landscape tourism system.

Madonie Natural Park, Italy This geopark is located in Sicily, Italy, and covers an area of 400 km^2. It became a member of the Global Geoparks Network in 2004. The geopark contains unique geological heritage (magnificent, smoke-filled volcanoes), archaeological remains, magical landscapes and wildlife conservation areas. The natural history of the area began 200 million years ago with the deposition of terrestrial sediments in the current sea basin near Sardinia. Approximately 150 million years ago, the basin began to rise and fall, causing a variation in the elevation of the basin. Terrestrial sediments, evaporates and carbonates were deposited in the sea and were later covered with coral reefs and salt deposits.

Maestrazgo Cultural Park, Spain This geopark is located within 7 km of Aliaga and has a total area of 2,700 km^2. It was selected as a member of the Global Geoparks Network in 2004. The geopark is a beautiful natural scenic area as well as a unique field laboratory that explores the evolution of the Iberian Plate in the Mesozoic and Palaeogene. Spectacular strata and structures and their unforgettable landscapes are of great value for science and education activities. The geopark is also an important site for ancient creatures. The site was researched and excavated by Fundacion Conjunto Paleontologico de Teruel. A large museum in Teruel and a network of small exhibition centres across Teruel Province are located in Maestrazgo. The first visitor centre is located in the small village of Galve, where visitors can see important dinosaur fossils such as dinosaur footprints and a reproduction of the most representative specimen of the original dinosaur. The second centre is located near Castellote, where Cretaceous petrified wood has been found.

Magma Magma is a hot, viscous, volatile molten silicate (melt) in the upper mantle and the deep crust. The main components are silicates and volatiles (mainly water), which make up 60–69%, and the remainder is CO_2, SO, CO, N_2, H_2, NH_3, NH_4, HCl, HF, $B(OH)_2$, KCl, and NaCl. The temperature of magma is generally between 500 °C and 1,300 °C. Its viscosity depends on the SiO_2 content, and the volatile content is related to the magma temperature.

Magma Fragment ▶ Fiamme Pumice

Magma Geopark, Norway This geopark is located in southwestern Norway and has an area of 2,329 km^2. It became a global geopark in 2010. The geopark has 46 geosites that are open to the public, including the serpentine rocks of St. Olav, a fascinating glacier ridge of long rolling hills; the Gloppedal rock debris heap, which is one of the largest landslides in Europe; the Eigerøy lighthouse and the coastal landscape area, which includes a walk through a large magma chamber; the Blåfjell ilmenite waste; and Hellersheia, which is an anorthosite landscape with boulders and caves. At Storeknuten, visitors can see the magma that has formed Europe's largest stratospheric

landscape as well as the Ørsdalen tungsten mine, Gursli waste molybdenum, large coastal caves and the waste railway at Flekkefjord. Although the magma has cooled and consolidated and the mountains have been eroded, the foundations of the ancient mountains can still be seen. The geopark contains anorthosite, which is more common on the moon than on Earth. The area has very high regional, national and international significance.

Magmatic Rocks Magmatic rocks are also known as igneous rocks, and they are formed by the cooling and consolidation of magma in the subsurface or at the surface. The types of magmatic rocks, such as intrusive rocks, subvolcanic rocks and volcanic rocks, are related to the environments in which they cool down and are affected by the magma's chemical composition, temperature, pressure, and rate of cooling. China's famous geoparks, such as the Huangshan, Sanqingshan, Yandangshan and Wudalianchi Geoparks, are all composed of magmatic rocks.

Magnetite Magnetite is an important iron mineral that contains Fe_3O_4. The crystal shape is octahedral or dodecahedral, and it also appears as blocky or granular aggregates. Its colour and streaks are black. It has opaque diaphaneity, a sub-metallic lustre, a specific gravity of 5.2, a Mohs hardness of 5.5–6.5, and sub-conchoidal to uneven fractures. It mainly forms in magmatic rocks and sometimes in metasomatic mineral ores and metamorphosed iron ore beds (Fig. 3).



Fig. 3 Magnetite

Magnetostratigraphic Polarity Unit A magnetostratigraphic polarity unit is a stratigraphic unit subdivided according to the variations (e.g., reversals, deviations) of the remnant magnetization in the rock strata. At the time of formation, a rock is magnetized in the same direction as the Earth's magnetic field, and these magnetic properties are recorded in the rock. Over geologic tine, the polarity of the Earth's magnetic field has changed and reversed. Hence, the direction of the remnant magnetic polarity recorded in a stratigraphic sequence can be used as the basis for subdividing the sequence into units characterized by their magnetic polarities, which are called magnetostratigraphic polarity units. The time interval represented by a magnetostratigraphic unit is called a 'magnetic chron' or 'magnetozone'. For example, the Institute of Geomechanics, Chinese Academy of Geological Sciences, has categorized the Quaternary Period from top to bottom into the 'Brunhes normal chron', 'Matuyama reverse chron', 'Gauss normal chron' and 'Gilbert reverse chron'. When a rock unit lacks fossils or isotope samples, the magnetostratigraphic technique is a suitable method to determine its age.

Maijishan Grottoes The Maijishan Grottoes are one of China's four major grottoes and are a key protected cultural feature. They are also a world-renowned art treasure. The Maijishan Grottoes are located on Maiji Mountain southeast of Tianshui City, Gansu Province. The associated caves are arranged like a hive. There are 194 caves with overhanging plank paths, constituting a spectacular 3-dimensional architectural building group. Maiji Mountain is composed of Palaeogene muddy and sandy conglomerate that has a loose structure and is not suitable for fine carving. Therefore, Maiji Mountain became famous because of its exquisite clay sculptures. Over a period of 1,600 years from the initial work, which was conducted in the Late Qin Dynasty of the Sixteen States period, through the West Qin, North Wei, West Wei, North Zhou, Sui, Tang,

Fig. 4 Maijishan Grotto



Song, Yuan, Ming and Qing Dynasties, the carvings and renovation of the Maijishan Grottoes had never stopped (Fig. 4).

Malachite Malachite is a copper mineral with a chemical composition of $Cu_2[CO_3](OH)_2$. Its copper content is 57.4%, and it belongs to the monoclinic system. The crystals are acicular or columnar, often with shell-like and concentric strip blocks. It has a slightly transparent to translucent diaphaneity, silky lustre, conchoidal fractures, a Mohs hardness of 3.5–4.0, a specific gravity of 3.6–4.0, a refractive index of 1.655–1.909 and a birefringence of 2.5. It foams in acid, is brittle, and is green or peacock green. It is a common material for crafting and for making pigments (Fig. 5).

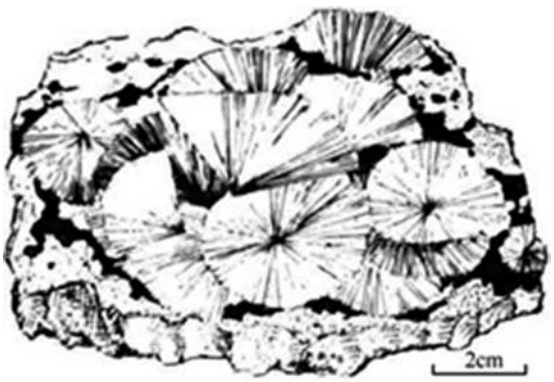


Fig. 5 Malachite

Malan Loess This is the name for the Late Pleistocene loess layer proposed by Liu Dongshan and Zhang Zongji in 1962. The typical profile is on the second terrace along the right bank of the Qingshui River in Zhaitang, Beijing. It mainly consists of loose, porous silt with a homogeneous texture with vertical joints and a few scattered small calcareous nodules. The soil layer also contains a dark loessal palaeosol with fossils of rodents and ostrich eggs. The profile thickness varies from 2 to 5 m in the northern foothills of the Qinling Mountains and up to 59 m in the Lanzhou area. The 70–80-m-thick Malan loess of Mangshan in Zhengzhou and the 35-m-thick Malan loess in the Luochuan Loess National Geopark in western Shaanxi Province are impressive. They have recorded two dry cold climate periods 10,000–20,000 and 50,000–70,000 years ago (Fig. 6).

Malpelo Fauna and Flora Sanctuary, Columbia This sanctuary is located in the Pacific Ocean approximately 506 km from the west coast of Colombia. The island has an area of only 3.5 km^2, but its peripheral marine



Fig. 6 Section of the Malan loess – Jingyang, Shaanxi Province

protection area covers 8,571 km^2. This large marine park is the largest closed fishing reserve in the tropical eastern Pacific Ocean and provides an important habitat for internationally endangered marine species. The abundant nutrient resources have laid a solid foundation for the enrichment of marine biodiversity. It is a unique 'gene bank' for sharks, giant groupers and long-billed fish, and it is one of the few places in the world where short-nosed rough-toothed sharks and deepwater sharks can be found. The environment created by steep cliffs, natural caves, and deepwater resources nourishes large groups of marine predators and pelagic fish. Because there are no traces of human interference, the marine animals maintain their natural behavioural patterns. This sanctuary is therefore also recognised as the world's top diving destination.

Mamenchisaurus hechuanensis This is a Saurischian fossil that was found in the Xian Miao Formation in Shangxi, Hechuan County, Chongqing City. It is 22 m long, 3 m wide and 6 m tall. Its head is small, and its neck is 9 m long, approximately three times that of a giraffe. Some scientists believe that it had two hearts. It lived on land during the Late Jurassic, and it was active, herbivorous and a type of quadruped. When attacked by carnivorous dinosaurs, several would gather together to fight back with their bony hammer-like tails (Fig. 7).

Mammal Fossil Mammal fossil is a collective term for fossils of the phylum Mammalia. Mammals have a wide range of sizes from as small as a mouse to as large as an elephant. They are warm-blooded and viviparous animals. The identification of the species, genus and even upper classifications of mammals relies on the tooth forms and array characteristics. The evolutionary sequence of mammals' molar morphology is from small to large, simple to complex crowns, and low to tall crown heights. Herbivores such as deer, sheep, rhinoceros and horse have crescent-shaped tooth crowns. Carnivores such as tigers and dogs have a pair of canine teeth, and their molars are conical (like a penholder). Omnivores such as pigs, giant pandas, apes and ape men have degenerated canine teeth and hill-shaped molars.

Mammoth Mammoth is a genera Elephantidae of Proboscidea. The prehistoric mammoth was gigantic with a height of approximately 4 m. They disappeared approximately 10,000 years ago. The existing Asian elephants and African elephants evolved from mammoths. China was the birthplace of the steppe mammoth (Mammuthus trogontherii). In 1973, China's first complete set of Songhua River Mammoth fossils was unearthed in Sanzhan Town,



Fig. 7 Mamenchisaurus hechuanensis

Zhaoyuan County. In 1992, woolly mammoth fossils were discovered in Dashahe in northern Gushan Town, Changqing District, Jinan City, Shandong Province, which is in the southernmost part of the northern hemisphere. One-million-year-old mammoth fossils were also found in Xiwangpo in Baodianin Town, Changzhi County, and in Lingshang Village in Tunliu County, Changzhi, Shanxi Province. China's largest mammoth skeleton was unearthed in the Zhalainoel Coal Mine in Lulunbuir City, Inner Mongolia, in 1980 (Fig. 8).

Mammoth Cave National Park, U.S.A. Mammoth Cave National Park is located in south-central Kentucky, U.S., and has a core protection area of 211 km^2. The park has the world's largest network of natural caves and underground passageways, which are characteristic examples of limestone formations. The park and its underground network of more than 560 km of surveyed passageways are home to a variety of flora and fauna, including numerous endangered species.

Mana Pools National Park, Sapi and Chewore Safari Areas, Zimbabwe This park is located in the borderland of Mashonaland, northwestern Zimbabwe, along the Zambezi River near Zambia. It has an area of 6,766 km^2. Large cliffs overhang the river and the floodplains. The area is home to a remarkable concentration of wild animals, including elephants, buffalo, leopards and cheetahs. An important concentration of Nile crocodiles can also be found in the area.

Management of Nature Reserves of Canada This book was written by Xuegong Xu et al. and was published by Peking University Press in 2000. The book introduces the functions of Canada's nature reserves. including ecological, educational, scientific research, economic, cultural and spiritual. It also explains the basic concepts of Canada's nature reserves management and ten general principles: ecological integrity and commemorative integrity, leadership and services, new protected areas, education and display, relationship between humans and the environment, research and science, appropriate excursions, public participation, collaboration and cooperation, and responsibilities and obligations.

Manas Wildlife Sanctuary, India This sanctuary is located in the borderland of Assam State in northeastern India near southern Bhutan. The sanctuary covers a core protection area of 500 km^2. On a gentle slope in the foothills of the Himalayas, where wooded hills give way to alluvial grasslands and tropical forests, the Manas Wildlife Sanctuary is home to a large variety of wildlife, including many endangered species, such as tigers, pygmy hogs, Indian rhinoceroses and Indian elephants.

Manchuria City Zhalainuoer National Mining Park, Inner Mongolia This park became a national mining park in 2005. It is located in Manzhouli City, Inner Mongolia Autonomous Region. The park is located on the Hailar

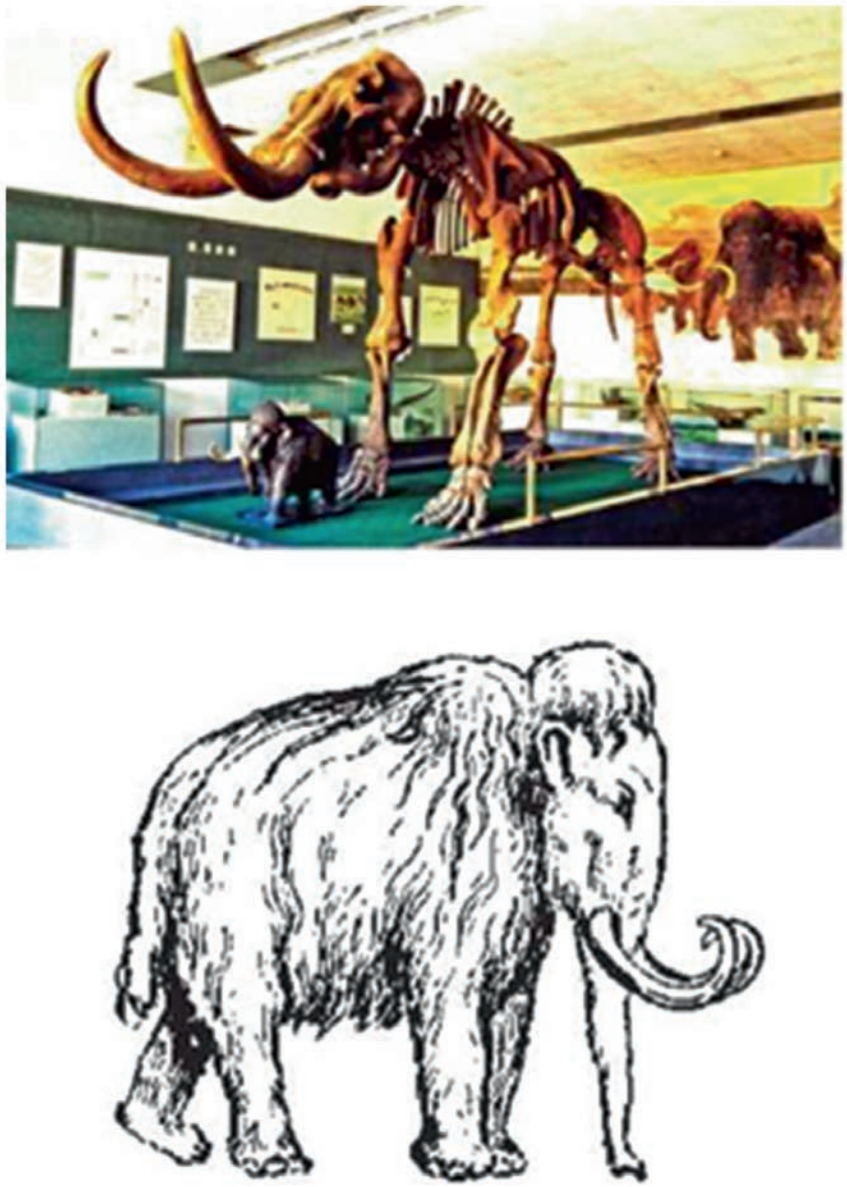


Fig. 8 Replica of a mammoth

Plateau on the western slope of the Daxinganling Mountains and is surrounded on three sides by low mountains. The main mining sites are the longest internal railway in China (119 km), more than 30 historical steam locomotives, mining huts and houses from the Russian and Japanese occupations, open pits, mining outcrops, faults, folds, fire zones, rockfalls and collapses. Numerous ancient human fossils have been discovered in the park.

Mangrove Coast Landscape This is a unique biological coastal landscape consisting of salt-tolerant mangrove communities. It is a special type of coastal wetland and biological breeding ground and habitat in tropical and subtropical areas. In China, mangrove coasts are mainly located in Guangdong, Hainan and Guangxi Provinces. Mangroves have lush canopies and special root systems that trap dead branches and fallen leaves, which decrease the

coastal erosion caused by storms and slow the tidal flow to promote sand and mud accumulation and coastal siltation. As such, mangrove transplanting has been adopted as a means of coastal protection in tropical coastal regions. There have been several successful cases on the coasts of Guangdong, Fujian and Zhejiang Provinces, and these coasts have become tourist attractions.

Mangrove Ecological Landscape This is a type of ecological landscape composed of a unique plant community with evergreen shrubs or trees in tropical or subtropical coastal mudflats. The main vegetation includes Rhizophora mangle, Rhizophora mucronata, Ceriops tagal, Kandelia obovata, Bruguiera gymnorthiza and Bruguiera sexangula, which are collectively called mangroves. Mangroves have various forms and growth extents. Their unique biological and ecological characteristics create spectacular landscapes along the coast. At high tide, the seawater submerges the tree trunks and branches of the mangrove, leaving only the green crown floating on the water and forming a spectacular 'forest on seawater' scenery (Fig. 9).

Man-Land Relationship This term refers to the interaction between humans and the geographical environment. The human-earth system is a complex and enormous system composed of different geographical environments and human social activities with interrelated subsystems. It includes certain structural and functional mechanisms and is constantly evolving. The 'people' and 'land' in the human-earth system reflect the unity of opposites. Different human and earth patterns formed during different stages of human civilization. Based on the overall geographical environment, development processes and adaptations to the carrying capacity of the geographical environment, this relationship has become the foundation of sustainable tourism development.

Manovo-Gounda St. Floris National Park, Central Africa Republic This park is located in the border area of Bamingui-Bangoran Prefecture in northern Central African Republic near Chad. It has a core protection area of 17,400 km^2. The outstanding value of the park is its diverse flora and fauna. The savannah within the park is home to many kinds of wild animals, including black rhinoceroses, wild elephants, cheetahs, wild dogs, red-fronted gazelles, buffalos, and various species of birds.

Mantle ► Earth's Mantle

Manú National Park, Peru This park is located on the border between Madre de Dios Province and Cusco Province in southeastern Peru. Manú National Park protects a core area of 15,328 km^2. It contains successive tiers of vegetation rising from 150 to 4,200 m above



Fig. 9 Mangrove ecological landscape

sea level. The lower tiers of vegetation are home to an unrivalled variety of animal and plant species. Approximately 850 species of birds have been identified, and rare species such as the giant otter and the giant armadillo are also present. Jaguars are often observed in the park.

Maoxun Chen Maoxun Chen (1936–) is a native of Chuxiong City, Yunnan Province. He graduated from the Department of Geology, Chongqing University and is a professor grade senior engineer. He is one of the founders of tourism earth science in China. He is a consultant for the Sichuan Science and Technology Advisory Group, an expert of the Sichuan Tourism Planning and Design Institute, and a visiting professor at Chengdu University of Technology and Southwest Normal University. In the 1980s, he founded the Sichuan Tourism Earth Science Research Institute and served as the first secretary-general. He edited a collection of research papers on 'Tourism Earth Science Research and Tourism Resources Development', and he published 'New Theory on Tourism Earth Science and Tourism Development' and more than ten papers on tourism earth science. He proposed that tourism earth science, tourism anthropology and tourism economics are the three major learning disciplines that support the development of modern tourism.

Maqên Amne Machin Geopark, Qinghai This geopark is located in Maqên County, Golog Tibetan Autonomous Prefecture, Qinghai Province. The geopark has an area of 1,783 km^2, and most of the geological features are concentrated in an area of 750 km^2. It became a national geopark in 2011. Glacial landforms are the main features of the geopark. The Amne Machin ice-capped peaks are majestic and splendid. There are 57 glaciers covering an area of 126 km^2. Among them, the Halong Glacier on the northeastern slope of Amne Machin is 7.7 km long and covers an area of 24 km^2. It is the longest and largest glacier along the Yellow River and has typical cirques, pyramidal peaks, arêtes, ice-scoured dams, glacial lakes and outwash fans. It illustrates the complete glacier development process, including ice and snow accumulation, glacier formation and movement at the source of the Yellow River. These features record the palaeo-climatic changes and geological evolution of western China and have high scientific value for research on the development of the Yellow River. The park is an ideal place for observing, studying and appreciating glaciers with its preservation of glacial relics such as ice mushrooms, ice waterfalls, eskers, ice arches and ice towers.

Marble Marble is a metamorphic rock with a carbonate mineral content over 50%. It is mainly composed of recrystallized calcite and dolomite and small amounts of metamorphosed marker minerals, such as tremolite, diopside, serpentine, phlogopite, scapolite, olivine, wollastonite and quartz. It generally has a granoblastic and flaky structure. It is formed by the regional metamorphism or thermal contact metamorphism of carbonate rocks (limestone and dolomite).

Marble Arch Caves and Cuilcagh Mountain Park, Northern Ireland and UK The Marble Arch Caves Geopark became a member of the Global Geoparks Network in 2004. It is located in County Fermanagh in Northern Ireland. The large cave system is located on the lower limestone slopes of the Cuilcagh Mountains and is one of the most significant cave systems in Britain and Ireland. Most of the caves formed within the upper Dartry Limestone Formation, a complex group of different types of limestone that vary greatly in thickness and character, reflecting increasing tectonic activity. These geological variations affect the overall cave development. In addition, the differences between the sandstones, shales and limestones account for the geodiversity and biodiversity of the area. The Marble Arch Caves provide high-quality geotourism by integrating the natural landscape and geoconservation for the long-term sustainable development of the area.

Marine Abrasion-Type Granite Landscape – Pingtan Type When subject to marine erosion, granite near the coast or in other areas



Fig. 10 Granite stack in Pingtan, Fujian Province

forms a landscape characterised by cliffs, platforms, stacks and caves. Sandy beaches and embankments along the coast formed by the deposition of fine granite sand from marine erosion are features of this landscape. Marine abrasion-type landscapes provide important evidence for determining sea level changes. The Pingtan Scenic Area in Fujian is a typical example of this landscape type (Fig. 10).

Marine Climate Marine climates occur in regions of the ocean, islands, and offshore regions affected by the ocean. Due to the effects of the large bodies of water, the summers are cool, the winters are mild, and the autumns are warmer than the springs. The annual and daily variations in temperature are small, and the extreme temperatures occur later than in continental climates. The seasonal distribution of the precipitation is relatively uniform. There are more rainy days than nonrainy days, with more clouds and fog and high humidity. The maritime climate is characterized by precipitation, warm temperatures, warm winters and cool summers.

Marine Cut Terrace Landscape *Synonym:* ► *Marine deposition terrace landscape*
This is a marine terrace landscape consisting of beaches that form with decreasing sea level or uplift of the land along the coast. The materials of these terraces always contain fauna fossils. The youngest terrace usually contains the remains of ancient coasts and lagoons (Fig. 11).

Marine Deposition Terrace Landscape ► Marine Cut Terrace Landscape

Marine Depositional Landform This is a landscape comprising landforms that is formed by the accumulation of loose materials transported to the coastal zone by wave action. The main features include underwater depositional terraces, beaches, lagoons and underwater bars (Fig. 12).

Marine Environmental Protection Law of the People's Republic of China This law was passed in 1999 during the 13th meeting of the Ninth National People's Congress (NPC) Standing Committee and implemented in April 2000. It contains: Chapter I, General Provisions; Chapter II, Marine Environmental Supervision and Administration; Chapter III, Marine Ecological Protection; Chapter IV, Prevention and Control of Pollution Damage to the Marine Environment by Land-based Pollutants; Chapter V, Prevention and Control of Marine Pollution Damage to the Coastal Environment by Construction Projects; Chapter VI, Prevention and Control of Marine Engineering Construction Project Pollution and Damage to the Marine Environment; Chapter VII, Prevention and Control of Dumping Pollution in the Marine Environment; Chapter VIII, Prevention and Control of Marine and Related



Fig. 11 Marine cut terrace landscape

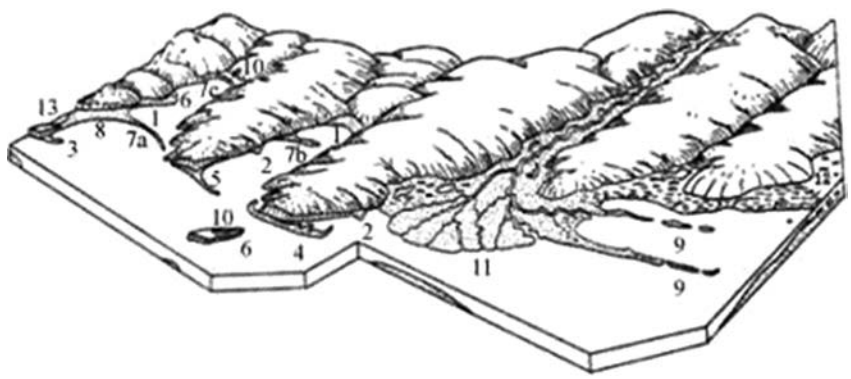


Fig. 12 Diagram of a marine depositional landform landscape. 1. beach; 2. facetted bank; 3 ~ 5. sand spits; 6. circular sand bar; 7. cross bay (7a. bay mouth bar; 7b. mid-bay bar; 7c. inner bay bar); 8. tombolo; 9. stacks; 10. lagoon; 11. delta; 12. muddy beach; 13. continent island

Activities Pollution Damage to the Marine Environment; Chapter IX, Law Responsibility; and Chapter X, Supplementary Provisions. The third chapter stipulates that marine nature reserves should be established in ocean areas, coasts, islands, coastal wetlands, estuaries and gulfs with special protection value and marine natural sites of great scientific and cultural values.

Marine Erosion in Landscape Formation Coastal erosion refers to mechanical, chemical and biological erosion caused by waves, tides, currents, storm surges, and gravel carried by seawater. Marine erosion can sculpt and modify the coast. Waves can impact coastal features by erosion, accumulation and deposition, while the sand, pebbles and gravels carried by waves and currents can affect the coast by abrasion and corrosion.

Marine Erosional Landform Landscape This is a landscape consisting of marine erosional features on coastal bedrock. The main features include sea caves, sea chasms, sea cliffs, sea stacks, mushroom-like rocks, sea arches, sea reefs and wave-cut platforms (Fig. 13).

Marine Facies Marine facies are sediments, rocks, or rock strata that form in a marine environment. Based on the seabed topography and the water depth, marine facies can be subdivided into littoral facies, continental shelf facies, semi-deepwater facies and deepwater facies. The main characteristics are that the lithic facies have minimal variations, always contain abundant fauna fossils, and are



Fig. 13 Marine erosion landscape in Bijiashan, Jinxian (Linghai City), Liaoning Province

mainly composed of clastics, clay, iron- and manganese-bearing rocks, siliceous rocks and carbonaceous rocks.

Marine Geography Marine geography is a cross-disciplinary field of oceanography and geography that focuses on the spatial structure, development, and interrelationships between human activities and the marine environment. It also includes the characteristics, distribution, development, utilization and protection of marine resources. This subject can be divided into marine natural geography, marine economic geography, marine political geography and regional marine geography.

Marine Glacier Marine glaciers are glaciers that form in the maritime climatic belt. This glacier classification was proposed by glaciologist Shi Yafeng to differentiate marine glaciers from continental glaciers based on the climatic characteristics of the glacier formation areas. Marine glaciers are affected by the maritime monsoon climate, which results in large amounts of rain. Both the accumulation and ablation are rapid. Due to the rapid glacier movement, natural disasters occur frequently in marine glaciers (Fig. 14).

Marine Regression A marine regression is a geologic process over a relatively short period of time during which the water retreats from the mainland back to the ocean, resulting in the expansion of deltaic sedimentary areas and the replacement of deep marine facies by shallow water facies. See "▶ Eustatic Movement".

Marine Transgression In Chinese, the term marine transgression is sometimes called marine advancement. It is a geologic event over a relatively short time during which sea level rises or the land sinks, resulting in flooding of the continent. A marine transgressive plane is a transgressive unconformity. On this plane, the marine sedimentary strata often exhibit the characteristics of an overcomplex unconformity.

Marl Marl is a loose, soft, brittle and relatively young sedimentary rock composed of silt, muddy carbonate and clay minerals. It is a transition rock type between clay rock and carbonate rock. It is usually grey, yellow and green and can also be darker. Marl is mainly composed of carbonate (30–70%), and the dominant minerals are calcite with small amounts of dolomite, aragonite and siderite. The main clay mineral is illite, and kaolinite and montmorillonite are uncommon. Marl is usually distributed in the transition zone between clay rock and limestone and appears in thin layers or lenticular formations between these two types of rocks.

Marsh Landscape *Synonym:* ▶ *Salt marsh landscape*

This is a type of swamp landscape composed of land with a very wet surface or seasonal water



Fig. 14 Hailougou modern marine glacier landscape, western Sichuan

ponding that has facilitated soil salinisation and the growth of saline plants. Salt marsh is a broad swamp category, but there are significant differences in water quality, soil, vegetation and fauna type compared to other types of swamps. The surface water of a salt marsh is alkaline, and the soil has a high salt content. The upper layer accumulates soluble salt, and saline plants grow on it, which is a basic characteristic of a salt marsh. Salt marshes are widely distributed along coasts, estuaries, arid or semi-arid grasslands and desert areas. In China, salt marshes are mainly found in the western arid and semi-arid plateaus in Inner Mongolia and Xinjiang Province, which have a continental climate, and the Qinghai-Tibet Plateau, which has an alpine climate. The marshes in these areas are small and scattered, whereas those in the Qaidam Basin are the largest. The coastal areas of the eastern Bohai Sea, the Yellow Sea and the East China Sea, which have muddy coasts, also have salt marshes of different sizes. The common plants include seepweed (Suaeda glauca), glasswort (Salicornia europaea) and Erigeron breviscapus.

Matrix *Synonym:* ▶ *Groundmass*

The sedimentary matrix is also called the groundmass and is the fine-grained portion that fills the gaps between the coarse and larger clastic fragments. Sericite, chlorite and other fine-grained clays are common matrix materials.

Meadow Meadows are areas of vegetation consisting of perennial herbaceous plants in moderate moisture conditions. Based on their ecological characteristics, meadows can be divided into typical, steppe, swamp, salt and alpine meadows. Meadows contain nonzonal vegetation that can occur in vegetation belts in different climate zones, but alpine meadows are clearly zonal. Typical meadows, also known as true meadows, are composed of typical mesophytes and are suitable for habitats with medium humidity. The dominant plants are mainly tall, wide-leaved, and moderate height grasses, and they are attractive. They are also known as 'five flowers meadows' in China and have high tourism value.

Meander Landscape A river meander is also known as a snake meander and is a landscape composed of meandering river channels. It is a common river morphology of the middle and lower river courses on plains, and it indicates that the river has developed into the mature stage. The flow in the meander often forms a vortex, causing the main current to skew towards the concave bank, which is subject to strong erosion. The flow along the convex bank is relatively slow, resulting in deposition of sand and mud. As the concave bank retreats and the convex bank continues to advance, the river channel will develop a series of curves like a snake. This

feature is called a river meander. Meanders are important objects for studying river development and evolution, and they are also important river landscape elements. They are significant tourism resources. For example, meanders are the main landscape features of Yanchuan Huanghe (Yellow River) National Geopark in Shaanxi Province. The so-called 'Nine Meanders' of the lower Jingjiang section of the Yangtze River are also famous meander landforms.

Medial Moraine Bar Landscape *Synonym:* ► *Interlobate moraine bar landscape*
When two or more glaciers meet, two lateral moraines join to form an embankment-like landscape. After the glaciers melt, a ridge-like landform forms along the glacial valley. This landform feature is called a medial moraine bar (Fig. 15).

Mediterranean Climate This climate type is mainly located on the western Mediterranean coasts, western coasts between 30° and 40° north and south latitudes, and the southern and southwestern coasts of Australia and the Cape of Good Hope in Africa. The summers are hot and dry, and the winters are mild and humid. Taking the northern hemisphere as an example, the subtropical high-pressure belt moves northwards in the summer, and the land is affected by the warm and dry continental air masses. In the winter, the high-pressure zone in the south moves to the south, and westerly winds (Mediterranean frontal belt) predominate and are accompanied by multiple cyclones that bring a warmer and more humid climate to the regions. The annual precipitation is moderate (300–600 mm). The landscape consists mainly of evergreen broadleaf forests and evergreen shrub forests.

Meijiang National Geopark, Hunan This geopark is located in Meijiang Town, Lianyuan City, Hunan Province, and it covers an area of 55 km^2. It was approved as one of the fifth group of national geoparks by the Ministry of Land and Resources in August 2009. Karst landforms in Palaeozoic carbonate rocks are the main features, and they are mainly located in the lower mountains and hills. Most of the scenic landscapes are composed of Permian and Carboniferous carbonate rocks. These landscapes are varied and densely distributed. There are also water landscapes, such as karst caves, gorges, peak clusters, peak forests, ravines, springs, lakes, and waterfalls.

Meishucun Micro-shelled Fauna The fossils of this fauna come from the earliest Cambrian rocks in Meishucun in the Jinning area, Yunnan Province. The Meishucun fauna is characterised by the absence of trilobite fossils, and all of the fossils are micro-shelled fauna. This fauna is currently known to include 12 classes, 57 genera and 98 species. From



Fig. 15 Medial moraine bar landscape (band of black gravel in the middle of the white glacier) (Credit: Bijaya2043)

the bottom to the top, the small shell fossils in the Meishucun Formation can be divided into three groups. (1) The first group is mainly composed of hyolithids, hyolithelminths, Monoplacophora, tubular fossils and globular fossils. (2) The second group contains many phyla with abundant fossil types, such as hyolithids, hyolithelminths, Monoplacophora, gastropods, exposed shell type fossils, brachiopods, tubular fossils, sclerite fossils, globular fossils, tooth-shaped type fossils and thoracic cavity fossils. This was the peak period for the development of small shell fossils. (3) The third group is composed of hyolithids, Monoplacophora, gastropods, hyolithelminths, sclerite fossils and globular fossils. The Qiongzhusi Formation overlies the third group and contains larger shell fossils, such as trilobites and Bradoria.

Meizhou Wuhuabaishizhang National Mining Park, Guangdong This mining park is located in the Baishiyan molybdenum-tungsten mine in northwestern Wuhua County, Meizhou City, Guangdong Province. It was approved by the Ministry of Land and Resources in 2010 and has an area of 2 km^2. The Baishi molybdenum deposit is one of several molybdenum and tungsten deposits discovered and mined in China. Unlike other open-cast mines in China and abroad, the medium-sized Baishi molybdenum and tungsten deposit is mined underground from quartz veins. After the closure of the mines, the underground roads and tracks were preserved. The previous mining activities exposed many interesting geological phenomena and mineralisation associations with the enrichment of molybdenum and tungsten in the external contact zone, which clearly shows the evolution and dynamic processes of molybdenum-tungsten deposits. Because of the long mining history, the park is used as cultural and historical heritage to show mineral processing equipment and tools and is of high geoscientific and tourism value.

Members of the Global Geoparks Network (GGN) The global geopark initiative began in 2001. In 2004, 17 European and 8 Chinese geoparks came together at UNESCO headquarters in Paris to form the Global Geoparks Network (GGN), in which national geological heritage groups from different countries agreed to contribute and benefit from their membership in a global network of exchange and cooperation. By 2017, the GGN had grown to include 125 sites in 35 countries. During the 38th session of UNESCO's General Conference in 2015, the 195 member states of UNESCO ratified the creation of a new label, the UNESCO Global Geoparks (UGGp). UNESCO supports member states' efforts to establish UGGps around the world, especially in developing areas without a geopark, in close collaboration with the GGN. The GGN, in which membership is obligatory for UGGps, is a legally constituted not-for-profit organisation with an annual membership fee. It is a dynamic global network in which the members are committed to work together, exchange best practises, and join in common projects to raise the quality standards of the products and practises of UNESCO global geoparks. Although the GGN comes together every 2 years in an international symposium, it functions through the operation of regional networks, such as the Asia Pacific and European Geoparks Networks, that meet twice a year to develop and promote joint activities. The global network continues to expand, drawing in new expertise and knowledge from around the world and different cultures. It develops best practises and sets high standards for territories that integrate the preservation of geological heritage into strategies for regional sustainable economic development. By the end of 2018, China had 37 global geoparks, the largest number of global geoparks in the world.

Memorial Stone Memorial stones are stones that commemorate historical or modern celebrities. They are ornamental stones with special commemorative significance or scientific value that have been collected by the nation, a group or a single person. Currently, there are four main types of memorial stones: (1) state memorial stones, which are stones collected by the nation or a department, such as the Changlin diamond, which was dedicated to the country by farmers; the Antarctic stone, which was given by China's

scientists to Beijing University; and memorial stones given by one nation to another as gifts, such as moon rocks, the Third Pole stone, gems, minerals and rare fossils; (2) celebrity memorial stones, such as the Lingbi stone and Taihu stone, which were collected in the past; the malachite collected by Guo Moruo; the Quaternary glacial stone collected by Li Siguang; and the Yuhua stones collected by Zhou Enlai and Deng Yingchao; (3) event memorial stones, such as the Three Gorges Dam core stone displayed on Tanzi Ridge to commemorate the Three Gorges Project; and (4) reminder memorial stones, such as the Baguoshi (Losing the Country Stone), which is a Yanyue remnant stone kept in Beihai with the carved words 'the Spring Sun on Qiongdao'; the Bajiashi (Losing the Family Stone), which was named 'Qingzhixiu' and is kept in the Summer Palace; and the Three Liaozhai Stones (Taihu stones), which comprise of the Lingbi Stone, Sanxing (Three Stars) Stone and Waming (Frog's Call) Stone, are kept in the former home of Pu Songling in Zibo, Shandong Province (Fig. 16).

Mesolithic Age The Mesolithic Age refers to the period between the Palaeolithic Age and the Neolithic Age. Archaeologically, these ages are relative. Geologically, the Mesolithic Age covers the Late Pleistocene and Early Holocene, and it extends from 10,000 to 20,000 years ago. The raw materials for the microliths from this period are mainly agate, chert, quartz (vein quartz) and chalcedony. Tools include pointed tools, scrapers, end cutters, stone knives, carving tools, stone cores, stone drills and stone clusters. Composite tools, arrows and bows were also used. The Mesolithic Age was a transitional period. Microliths have been found in the Late Palaeolithic Zhiyu and Xujiayao cultural relic sites.



Fig. 16 Core stone of the Three Gorges Dam

Meso-neoproterozoic Section in Jixian This is a Meso-Neoproterozoic section in Jixian County to the north of Tianjin City. This section was first published by Gao Zhenxi in 1934. Its profile is simple with clear strata sequences and top and bottom layers. It is a typical site indicating the stratigraphic division and correlation of the Meso-Neoproterozoic geological section, which has a total thickness of 9,200 m and is composed of 3 systems and 12 formations. The bottom portion contains the Changcheng (Great Wall) System (1.4 billion to 1.8 billion years ago), which contains thick layers of conglomerate, quartz sandstone and dolomite rich in iron and manganese that are interbedded with volcanic rocks and breccias. These rocks are rich in stromatolites and micro-plant fossils and can be divided into five formations with a total thickness of 4,255 m. The middle portion is the Jixian System (1 billion to 1.4 billion years ago), consisting of pale dolomite and chert-bearing dolomite strips interbedded with small amounts of sandstone and shale with abundant stromatolites. It can be divided into 4 formations with a total thickness of 4,577 m. The upper portion is the Qingbaikou System (0.8 billion to 1 billion years ago), which is composed of variegated shales, sandstone, conglomerate, limestone and marl. The sandstone has extensive two-way cross-bedding and is rich in macro-algae fossils. It can be divided into three formations with a total thickness of 311–855 m. Recently, an age of 1.3 billion years was obtained in the lower part, so the age of this layer may have to be adjusted.

Mesozoic Era Mesozoic Era is the geologic interval that extended from 251 million to 65.5 million years ago, which covers 185.5 million years. It includes the Triassic, Jurassic and Cretaceous Periods. The Mesozoic Erathem includes the rocks that formed during the Mesozoic Era.

Mesozoic Volcano Mesozoic volcanoes are volcanoes that formed during the Jurassic (145.5–199.6 million years ago) and the Cretaceous (65.5–145.5 years ago). There is an important area of Mesozoic volcanoes in eastern China that contains several types of volcanoes. Typical Mesozoic volcanoes can also be found in Zhejiang Province, Fujian Province, Jiangxi Province, Guangdong Province and Hong Kong. Most are eroded volcanoes, such as the Yandangshan caldera in Zhejiang Province, the Sai Kung eroded volcano in Hong Kong and the Niangniang Mountain eroded volcano in Nanjing.

Messel Pit Fossil Site, Germany This site is located in the town of Dieburg, Darmstadt City, Hesse State of Germany. It has a protection area of 0.7 km^2. The Messel Pit Fossil Site provides the richest scientific information about the palaeoecological environment during the Eocene Epoch (57 million to 36 million years ago). The site is a unique example of the evolution of early mammals, including unusually well-preserved mammal fossils – both integral bone fossils and visceral fossils of the mammals of the same period.

Metallic Mineral Metallic minerals are used for the extraction of metals, and they mainly include non-ferrous metal, ferrous metal, precious metal and rare metal minerals. Metallic minerals generally have metallic properties, such as a metallic or submetallic lustre, high opacity, good conductance and good thermal conductivity. Most are sulphides, some are oxides, and some are elemental metals. There are exceptions, such as sphalerite, cinnabar and cassiterite, which do not have typical metallic properties. Graphite has obvious metallic properties but is not a metallic mineral. With appropriate treatment, crystals or mineral aggregates can have high ornamental value.

Metamorphic Rock Metamorphic rock is a collective term for all types of rocks that are formed by metamorphism. It refers to rocks that have been transformed from existing rocks (including igneous, sedimentary and metamorphic rocks) into rocks with new mineral assemblages and metamorphosed structures at high temperatures and pressures. It is one of the three major rock types in the crust and is also the rock type with the most complex mineral assemblages and structures. Metamorphic rocks make up approximately 27% of the total volume of the crust. Metamorphic rocks inherit some features of the original lithology and have some new characteristics. They tend to be restricted by the composition and lithology of the original rock, but the metamorphism creates new mineral compositions and structures with new characteristics. Metamorphic rocks are widely distributed all around the world, and the bases of China's three ancient platforms (North China Platform, Yangtze Platform and Tarim Platform) are all composed of metamorphic rocks. There is a wide range of metamorphic rocks. Based on the original rock, metamorphic rocks can be divided into ortho-metamorphic rocks (metamorphosed from igneous rocks) and para-metamorphic rocks (metamorphosed from sedimentary rocks). According to the type of metamorphism, they can be divided into regional metamorphic rocks, thermal metamorphic rocks (including thermal contact metamorphic rocks and contact metasomatism metamorphic rocks), dynamic metamorphic rocks, and shock metamorphic rocks. Metamorphic rocks are often old and represent a long geological history. They are important for revealing the history of the Earth's formation and early evolution. The geological and geomorphic landscapes of metamorphic rocks are important tourism resources. For example, the Taishan, Wudangshan, Wutaishan and Songshan National Geoparks are all composed of metamorphic rocks (Fig. 17).

Metamorphic Rock Classification There are three systems of metamorphic rock classification: (1) based on the original type of rock; (2) based on the composition of the original rock; and (3) based on the degree of foliation (Table 1).

Metamorphism Metamorphism is a change in the minerals or geologic texture of a rock in the Earth's crust due to heat and pressure. There are many types of metamorphism. According to the nature of the metamorphism, it can be divided into regional metamorphism, thermal



Fig. 17 Metamorphic rocks

Table 1

Gneiss	Orthogneiss Paragneiss Migmatitic gneiss	Pelitic	Slate Phyllite Hornstone Schist Gneiss	Foliated metamorphic rock	Slate Phyllite Schist Gneiss Banded migmatite Mylonitic tectonite (primordium-mylonite-ultramylonite-phyllitic mylonite-blastomylonite)
Schist	Orthoschist Paraschist	Felsic	Felsic gneiss Felsic granulite Fine-grained gneiss	Non-foliated metamorphic rock	Marble Hornstone Skarns Quartzite – greisen Serpentinite Pseudo-tachylite Greenstone – greenschist Amphibole schist Cataclastic series tectonite (protocataclasite – cataclasite – ultracataclasite and fault gouge
Hornstone		Calcareous	Marble Skarns		
Phyllite		Siliceous	Quartzite Greisen		
Slate		Magnesian	Serpentinite		
Marble		Mafic	Greenstone-greenschist Amphibole schist Blueschist Mafic granulite Eclogite		
Quartzite					

metamorphism (including thermal contact metamorphism and contact metasomatic metamorphism), dynamic metamorphism and impact metamorphism. Based on the mode of rock transformation, metamorphism can be divided into recrystallization, metasomatism, injection, anatexis, migmatization and granitization. According to the change in temperature, it can be divided into prograde metamorphism (from low-temperature metamorphic minerals into high-temperature metamorphic minerals) and retrograde metamorphism (from high-

temperature metamorphic minerals into low-temperature metamorphic minerals). In addition, based on the temperature, metamorphism can be categorized as very low-level, low-level, intermediate metamorphism and high-level metamorphism. According to the pressure, it can also be divided into low pressure, medium pressure, high pressure and ultra-high pressure metamorphism. Research on metamorphism can reveal the process and mechanisms of the formation of metamorphic rocks as well as the early evolutionary history of the Earth.

Metasomatism Metasomatism is the replacement of a substance by another due to changes in the temperature, pressure and chemical composition of a solution. It is a mass transfer process involving the injection and escape of substances. The metasomatism process takes place in the presence of a solid and a solution, and the dissolution of the original mineral and the formation of new minerals occur simultaneously. The chemical composition of the original rock changes, and the newly formed rocks have various metasomatic structures. These are the two prominent characteristics of metasomatism.

Meteora, Greece This site is located in the Thessaly District in north-central Greece and has a core protected area of 3.75 km^2. It is a remote group of sandstone peaks with almost no way to pass through. Monks have lived in seclusion on these pinnacles since the eleventh century. During the restoration of the ideal of seclusion in the fifteenth century, the monks built 24 monasteries in the face of tremendous difficulties. The murals that were painted in the sixteenth century are representatives of the major stages of post-Byzantine painting.

Meteorite A meteorite is the remnant of a meteor that did not completely burn as it passed through the atmosphere and reached the ground. It is a celestial specimen from outer space, which can provide evidence of the physical state and chemical composition of other celestial bodies and help to determine the formation conditions and evolution of cosmic matter. Approximately 1,500 meteorites with masses greater than 100 kg are estimated to approach the Earth every year, but only approximately 10 kg of the meteorite remains reach the Earth's surface. Therefore, only four to five meteorite pieces can be found every year. Several types of meteorites associated with approximately 3,000 falling meteorites have been collected. More than 20,000 pieces of meteorites have been collected on Antarctica, and more than 2,000 pieces have been collected from deserts (through 1999) (Figs. 18 and 19).

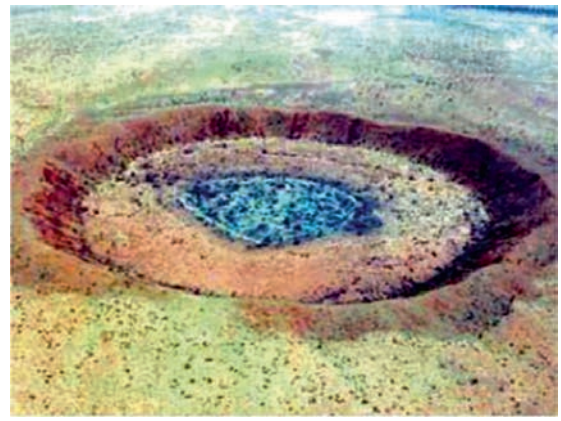


Fig. 18 Meteorite crater landscape

Meteorite Crater Landscape A meteorite crater is a circular depression formed by the impact of a meteorite on the surface of a planet, satellite, asteroid or other celestial body. A small mound is often located in the centre of the crater. The meteorite craters on Earth are often filled with water to form impact lakes, and there is always an island in the centre. Larger craters are also known as circular mountain rims. As a result of erosion and sedimentation, ancient meteorite craters can disappear and are not easy to identify. Typical examples are the craters on the Canadian Shield.

Meteorite Tourism Landscapes created by meteorite impacts are interesting tourism destinations. Meteorites are meteoroids that land on the ground. The rocks formed are called meteorolites or meteoric stones, and those with high iron contents are called aerosiderites or iron meteorites. Meteoric ice may also be present during a meteoroid landing. Each year, 1,500 meteorites with a mass greater than 100 kg pass through the atmosphere. Most are



Fig. 19 Meteorite. (Found in Qingshi County, Xinjiang)

reduced to approximately 10 kg by the time they reach the ground. The current global collection of major meteorites includes approximately 1,700 pieces. They can be classified into three major groups: meteorolites, aerosiderites, and lithosiderites or stony-iron meteorites. There are less than 100 meteorite museums in the world. They are important tourist attractions and venues for astronomical science popularisation and research. In China, the Jilin Meteorite Museum displays the world's largest meteorite, Jilin No. 1, which weighs 1,770 kg. The Xinjiang Meteorite Museum has the world's third largest aerosiderite (iron meteorite), which weighs 30 tons. These museums are important meteorite-related tourism resources.

Meteorological Tourism Resource The atmosphere can be cold, hot, dry and wet. Wind, cloud, rain, snow, frost, fog, lightning, scintillation, and other physical conditions and phenomena are meteorological tourism resources. The attractions will involve aurora (polar lights), flammules, mirages, fog, misty rain, snow and rosy clouds.

Meteorology Meteorology is the study of climate and weather. The phenomena of clouds, rain, snow, fog, thunder and lightning that are common in the atmosphere and their associated formation processes are called weather. Meteorological conditions that occur within a short periods of time, such as days or weeks, are called weather.

Mianzhu Qingping-Hanwang Geopark, Sichuan This geopark is located in northwestern Mianzhu, Sichuan Province. The park covers an area of 26.6 km^2, and the major geological features are concentrated in an area of 5.95 km^2. It became a national geopark in 2011. The geopark contains earthquake features and recovery projects. It has several landforms created by the magnitude 8 Wenchuan earthquake and the associated secondary disasters. The geopark is rich in features such as landslides, collapses, earthquake surface ruptures, mudflows, landslide dams, collapsed buildings, buildings damaged by rockfalls and mudflows, restoration projects, rescue and disaster relief projects, post-disaster reconstruction and disaster prevention measures.

Miarolitic Structure A miarolitic structure is typically a crystalline near-circular or irregular cavity in intrusive rocks. Euhedral quartz or other mineral crystals often grow on the walls of miarolitic cavities, and the cavities are generally believed to be the result of volume contraction and expulsion of the volatile portion of the melt during magmatic cooling. Miarolitic structures can be found in the granite in the Tailaoshan National Geopark in Fuding, Fujian Province.

Microcline The chemical composition of microcline is $K[AlSi_3O_8]$. It is a feldspar mineral with a triclinic system. Crystal twinning is common, and the crystals appear as blocky aggregates. Its colours are grey, white, light yellow, light red and pink. Green microcline is called amazonite. Its diaphaneity is from

transparent to translucent, and the cleavage has a vitreous or pearly lustre. Its specific gravity is 2.55–2.63, the Mohs hardness is 6–5.5, and the fractures are uneven. It mainly forms in igneous rocks, particularly granite, pegmatite and syenite. It is also found in some metamorphic rocks, especially schist, as well as in hydrothermal veins and contact metamorphic zones. Microcline in pegmatite is always accompanied by quartz and albite.

Micropalaeontology Micropalaeontology is a branch of palaeontology that specializes in the study of microfossils. Microfossils are tiny palaeobionts or small parts of large palaeobionts, including many phyla such as ancient invertebrates (e.g., foraminifera, radiolaria and ostracoda) and ancient plants (e.g., diatoms and charophyta), some chitinozoans and conodonts that have not yet been properly classified, and small quantities of teeth of ancient vertebrates. Micropalaeontology is based on the size but not the types of the objects. For this discipline, it is crucial to develop proper techniques to extract or separate the tiny objects from the rock and to make thin sections for microscopic study. Because microfossils are tiny and abundant, they are usually used for stratigraphic correlations during exploration drilling.

Middle Ordovician Darriwilian Section (GSSP 'Golden Spike') in Huangni-tang, Changshan, Zhejiang (Darriwilian) This point is a regional stratigraphic unit in the upper stage of the Upper Ordovician Series. It was defined by Hall in 1899 with reference to the graptolite-bearing rock bed in Victoria, Australia. The Ordovician Huangnitang System in Changshan, Zhejiang Province, has a complete stratigraphic sequence accompanied by continuous rock strata and abundant fossils. This section developed through the continuous strata of the Darriwilian Stage of the Middle Ordovician Series. The continuous evolution of graptolites and conodonts allows this section to be a marker for global correlations. The first occurrence of the graptolite zone with Undulograptus austrodentatus fossils led this section to become a Darriwilian GSSP based on the approval of the International Commission on Stratigraphy Ordovician Branch and the International Union of Geological Sciences. It was China's first 'Golden Spike'. This section is located in Huangnitang in Erduqiao Village, Changshan County (Zhoutangcun Village), in the Ordovician Ningguo Formation, and it mainly contains calcareous shale and argillaceous limestone (total thickness greater than 50 m) that contain graptolites, conodonts and brachiopod fossils.

Mid-ocean Ridge Mid-ocean ridges are also called oceanic central mountain ridges. These ridges are the longest and widest underwater mountain systems in the world; they cover approximately 33% of the ocean floor. The mid-ocean ridge known as the East Pacific Rise is located in the eastern Pacific Ocean, and it has fewer undulations than the Mid-Atlantic Ridge. The Mid-Atlantic Ridge is S-shaped and parallel to the coasts of both adjacent. The Central Indian Ocean has a '^' shape. The southern ends of the mid-ocean ridges of these three oceans connect in the southern hemisphere, whereas their northern ends enter the mainland via shallow seas or bays. The Mid-Atlantic Ridge is approximately 1–3 km higher than the adjacent oceanic basin floor, and the ridge top is approximately 2–3 km below sea level; however, parts of the ridge are above sea level, such as on Iceland. The mid-ocean ridges are dissected by a series of large faults that are perpendicular to or slightly oblique to the mountain ranges. Along these fault zones, there are narrow grooves, ridges and cliffs. On both sides of the fault zone, the seafloor is dissected into terraces of different depths. The Mid-Atlantic Ridge can be divided into the ridge crest area and the ridge margin areas. The ridge top is mainly composed of alternating nearly parallel ridges and valleys. The ridge top is composed of young oceanic crust that is overlain by a thin layer of sediment, but this layer is sometimes not present. Its topography is very rugged. As the age of the oceanic crust increases corresponding to the sedimentary layer thickens, the height difference between the ridge and valley decreases gradually, and some valleys can be filled up to

become terraces, resulting in gentle terrain along the margins.

Migmatite Migmatite is a unique type of rock that is formed by the blending of the materials in acidic rocks (granite) and intermediate basic metamorphic rocks. It has a dual nature akin to both igneous and metamorphic rocks. The mineral composition, rock texture and structure are typically very inconsistent. Based on the extent of migmatization and the rock texture and structure, migmatites can be divided into augen migmatite, striped migmatite and gneissose migmatite.

Migmatization Migmatization is the geological process in which acidic granite and intermediate-basic metamorphic rock mix and fuse together to form a migmatite. There are many theories for the formation of migmatite, and the main interpretations are 'anatexic migmatization' and 'metasomatic migmatization'. Migmatization is a common geologic process in old rocks.

Miguasha National Park, Canada This national park is situated on the southern coast of the Gaspé Peninsula, Province of Quebec, Canada, and has a core protected area of 0.87 km^2. The palaeontological fossil sites in the park are acknowledged as the most outstanding representative of the 'Age of Fishes' in the Devonian, and they contain fossil moulds traced back to 370 million years ago. Five of the six groups of fish fossils from this period have been excavated from the upper Devonian Escuminac Formation. The fossils of Cyclopterus lumpus, which are the most common and best-preserved species in the park, have the highest scientific value because this type of fish was the predecessor of quadrupeds, land vertebrates that walk on four legs and breath air.

Mine Site Protection Mining heritage sites include typical outcrops of mineral deposits, mining pits, remains of mines (such as mine shafts), mineral processing and metallurgical relics, and also mining-related cultural relics and cultural landscapes. They are not only important geological heritage sites but also important cultural or historical heritage. They are of great significance to the restoration of the environment and cultural history as well as to the transformation of post-mining sites to regional sustainable development after the cessation and closure of mines. Normally, rehabilitation and maintenance must be performed to restore the mining facilities and remediate the environmental and ecological damage. Proper planning and construction of facilities are necessary to meet the needs of recreation and tourism. The establishment of mining parks is one of the effective ways to protect and restore mining heritage sites.

Mineral A mineral is a natural, elementary substance or compound formed by geologic processes. Minerals are the components of rocks and mineral ores. Approximately 4,145 minerals are currently known; most are inorganic solid substances, whereas there are only a dozen liquid, gaseous or organic minerals. An elementary substance or chemical compound that comes from outside the Earth is called a cosmic mineral, and a simple substance or compound similar to a natural mineral obtained by artificial means is called a synthetic mineral. Minerals are important material resources that are widely used in the agricultural, industrial and science and technology sectors. Many minerals have special crystal forms or compositions and unique physical properties, such as colour, lustre and pattern, allowing them to become ornamental stones and natural landforms that are unique tourism resources.

Mineral Brittleness Mineral brittleness describes the extent that a mineral is crushed to a powder upon impact. Most transparent nonmetallic minerals are brittle, such as native sulphur, realgar and cinnabar. Brittleness can be used as a parameter for mineral identification.

Mineral Classification Mineral classification is the method of classifying minerals according to specific criteria, such as generic classification, usage classification, chemical classification and crystal chemistry classification. In general, minerals can be categorized as elemental minerals and compound minerals according to their chemical composition. An elemental substance is a mineral consisting of one element, such as diamond, which is

made up of C, and natural gold, which is composed of Au. Compounds are composed of anions and cations and can be divided into different types according to these ions.

Type	Minerals
Native elements	Diamond, native gold, native arsenic
Sulphide minerals	Galena, cinnabar, sphalerite
Oxide minerals	Magnetite, corundum, bornite, quartz
Hydroxide minerals	Bauxite, limonite, valentinite
Halide minerals	Rock salt, potassium salt, fluorite
Carbonate minerals	Calcite, malachite, magnesite
Sulphate minerals	Barite, gypsum, celestite
Nitrate minerals	Natratine
Chromate minerals	Chromite
Tungstomolybdate minerals	Wolframite, molybdenite
Phosphate, arsenate, vanadate	Tangeite, arsenicite, turquoise
Silicate minerals	Olivine, orthoclase, garnet
Borate minerals	Borax
Selenite, acetate minerals	Molybdomenite, lead schmitterite
Iodate minerals	Iolite
Oxyhydrogen halide minerals	Calcareite, hsianghualite
Sulphur halide mineral	Helvite

Eighteen types of elemental and compound minerals are shown above. The most common type is silicates, which account for approximately 24% of all minerals and 75% of their total mass. Sulphur halide is the rarest type, and there is only one of these minerals.

Mineral Cleavage Crystal parting occurs when minerals break along a plane of structural weakness due to an external stress; this plane is called a cleavage surface. The direction of a cleavage plane is parallel to that of the crystal structure surface (the planar surface formed by the arrangement of internal particles) and the direction of the plane of weakest bonding. Cleavage planes are distributed on the crystal in accordance with the symmetry of the crystal; that is, all crystal parting occurs simultaneously in the same direction as the crystal surface of the same crystal. The quality of cleavage is typically described by the terms eminent, perfect, distinct, difficult and imperfect.

Mineral Ductility Ductility refers to the capacity of an object, when subject to tension, to undergo significant plastic deformation before rupture. The ability to elongate to form a filament is the mineral's plasticity, whereas the ability to deform under compressive stress to form a thin sheet is its malleability. Natural metallic minerals and certain sulphide minerals, such as chalcocite, are ductile. Ductility is a characteristic of minerals.

Mineral Electrical Conductivity Mineral electrical conductivity is the conductance of a mineral. Different minerals have different conductivities. Usually, native and metallic minerals have better conductivity and are good conductors of electricity. Nonmetallic minerals are non-conductors, and most metallic minerals are semiconductors. The conductivities of minerals can be used for mineral identification or ore selection, and physical prospecting methods can be used in exploration for metallic ores. In the electronics industry, the nonmetallic mineral mica is used as an insulating material, and graphite is a popular material for making electrodes.

Mineral Flexibility Mineral flexibility refers to the capacity of a flaky mineral to bend without breaking when subject to an external force. For example, mica, vermiculite and chlorite can be bent but will return to their original shapes when the external force is removed. Mineral flexibility is also a means for mineral identification.

Mineral Fracture When subject to an external stress, a crystal does not necessarily break along the crystal surface, but a new surface can form, which is called a mineral fracture. There are several types of fractures, such as conchoidal (quartz), serrated (native copper), uneven (pyrite) and smooth (K-feldspar) fractures.

Mineral Hardness Mineral hardness is the ability of a mineral to resist some kinds of external mechanical action (e.g., carving, pressing and grinding). The mineral hardness generally

refers to the Mohs scale hardness, which is determined by comparisons between minerals and the standard hardness minerals. The standard hardness scale proposed by Mohs in 1822 is used in mineralogy. From soft to hard, the ten minerals are (1) talc, (2) gypsum, (3) calcite, (4) fluorite, (5) apatite, (6) orthoclase, (7) quartz, (8) topaz, (9) corundum and (10) diamond.

Mineral Lustre Mineral lustre is the capacity of a mineral surface to reflect visible light. The intensity of the mineral lustre depends on the refractive index, absorption coefficient and reflectivity of the mineral. In mineralogy, there are four levels of lustre from strong to weak: (1) metallic lustre, (2) submetallic lustre, (3) adamantine lustre, and (4) vitreous lustre. The adamantine and vitreous lustres are collectively known as nonmetallic lustre. Nonmetallic minerals are generally characterized by nonmetallic lustres, whereas metallic minerals are metallic or submetallic. The intensity of the mineral lustre is based on the reflection of the crystal surface and the cleavage surface. Several other reflective surfaces and aggregate forms can create unique lustres, such as pearly lustre, greasy lustre, resinous lustre, silky lustre, waxy lustre and dull lustre.

Mineral Nomenclature Minerals can be named in several ways: (1) Chemical composition, such as native gold and borax. (2) Physical properties, such as the Chinese names for tourmaline, which literally means 'electric stone' in Chinese due to its pyroelectric nature, and for realgar, which in Chinese means 'heroic yellow' because of the mineral's orange colour. (3) Form and shape, such as garnet, the name of which in Chinese means 'pomegranate stone' to describe its shape and colour, which are similar to pomegranate seeds. (4) Combination, such as sphalerite, which in Chinese means 'shinning zinc mineral' to describe its shiny characteristics and zinc content. (5) Location name, such as baotite, which is a silicate mineral that was first found in Baotou, Inner Mongolia, in 1960. (6) Name of people, such as hungchaoite, which is a magnesium borate mineral named after the Chinese geologist Zhang Hongzhao.

Mineral Phosphorescence Mineral phosphorescence is a phenomenon in which a fluorescent mineral crystal continues to glow for a period of time after external lighting is removed. For example, some fluorites can continue glowing at night after being illuminated during the day. These minerals have the nickname 'night illuminating pearl'.

Mineral Piezoelectricity Some mineral crystals can change their surface charge properties under pressure or tension. For example, when a-quartz is pressed along its long axis, equal and opposite charges are generated at the two ends, and when the compression is replaced by tension, the charges switch. When a piezoelectric crystal is placed in an alternating electric field, the crystal will expand or contract correspondingly and generate a mechanical vibration equal to the electric frequency. Mineral piezoelectricity has wide applicability in the electronics industry.

Mineral Properties The properties of minerals are the basis for mineral identification. The properties include the crystal system, composition, colour, lustre, aggregate shape, hardness, specific gravity (relative density), streak, fracture and cleavage. Mineral crystal systems include isometric, orthorhombic, monoclinic, triclinic, hexagonal and trigonal systems. Crystal twinning of minerals includes contact twinning and interpenetration twinning. Mineral aggregates include columnar, dendritic, bladed, acicular, blocky and reniform types.

Mineral Resources Law of the People's Republic of China On 29 August 1996, the 21st National People's Congress Standing Committee adopted the amendment to the 'Mineral Resources Law', and it was implemented on 1 January 1997. It contains seven chapters, including: Chapter I, General Provisions; Chapter II, Mineral resources exploration registration and exploitation of the approval; Chapter III, Mineral resources exploration; Chapter IV, Mineral resources exploitation; Chapter V Collective mining enterprises, individual mining; Chapter VI, Legal responsibilities; and Chapter VII

Supplementary Provisions. This law clearly states that mineral resources belong to the country and that the State Council exercises the State's ownership over these resources. Without the consent of the authorised government departments, mineral resources shall not be explored for and exploited within certain distances of major rivers and embankments as well as in areas designated by the State as nature reserves or important scenic areas of significant scientific, cultural and economic importance.

Mineral Spring Under specific geological and hydrogeological conditions, uncontaminated groundwater will naturally emerge from deep underground. Groundwater contains mineral salts, trace elements, carbon dioxide, gases and other elements. Natural mineral water is mainly used for drinking and medical treatment. Based on the chemical composition, mineral springs can be divided into carbonate springs, sulphur springs, sodium chloride springs, sodium bicarbonate springs, iodine springs and iron springs.

Mineral Use Applications of minerals in the industrial production, agriculture and tertiary industries include: (1) Use of mineral ingredients: (a) In the metallurgical industry for extracting useful elements from minerals and smelting them into metals for industrial uses. For example, the extraction of iron metal from magnetite and haematite is an important metallurgical process. Other examples are the extraction of lead from galena and the extraction of copper from chalcopyrite and bornite. In addition to the main elements, minerals also contain several trace elements, such as chromium, indium and germanium, in sphalerite ore. These trace elements are called dispersed elements, and they are also extracted during the extraction of the main metals. (b) As chemical raw materials. For example, fluorite can be processed into hydrofluoric acid, and pyrite can be used as a raw material for making sulphuric acid. (c) For agriculture, such as for the production of fertilizer for agricultural production. In addition to synthetic fertilizers, potassium salt is a source of potash fertilizer, and apatite is a source of phosphate fertilizer. (2) Physical properties of minerals. (a) Optical properties. Calcite, quartz and fluorite have long been used to make prisms for optical instruments, and many minerals have been used as gemstones due to their unique optical characteristics. (b) Mechanical properties. Suitable minerals are used for making grinding and cutting tools due to their hardness; minerals with hardnesses greater than 7 on the Mohs scale can be used for this purpose. The hardest mineral is diamond, followed by corundum, topaz and garnet. (c) Other properties. For example, asbestos can be used as asbestos board for insulation. Minerals with high melting points can be used as fire-resistant materials. Zeolite, attapulgite, montmorillonite, palygorskite and sepiolite, which have adsorption and cation exchange capacities, are suitable for use in removing toxic elements and heavy metals from wastewater, and they are an important raw material to mitigate water pollution. Several minerals are also used in traditional Chinese medicine, such as gypsum, which has an anti-fever effect; cinnabar, which has sedative effects; and borax, which has anti-inflammatory, detoxification and antiseptic effects.

Mineral Water Mineral water is groundwater that contains unique ingredients or gases. It can be divided into medical mineral water, portable mineral water and industrial mineral water. The standards of medical mineral water in China are as follows (Table 2):

Mineralogy Mineralogy is the study of the chemical composition, internal structure, form, physical and chemical properties, formation, occurrence, symbiotic combinations, changing conditions, and uses of minerals and their relationships. The main purpose of mineralogy is to maximize the development and utilization of mineral resources, assist in prospecting and provide scientific evidence about the evolution and changes of crustal

Table 2 China's medical mineral water quality standard (mg/L)

Composition	Concentration for medical use (mg/L)	Concentration of mineral water (mg/L)	Concentration of mineral water as named (mg/L)	Name of mineral water
Carbon dioxide	250	250	1,000	Carbonate water
Total hydrogen sulphide	1	1	2	Hydrogen sulphide water
Fluorine	1	2	2	Fluorine water
Bromine	5	5	25	Bromine water
Iodine	1	1	5	Iodine water
Strontium	10	10	10	Strontium water
Iron	10	10	10	Iron water
Lithium	1	1	5	Lithium water
Barium	5	5	5	Barium water
Manganese	1	1	–	–
Oxoboric acid	1.2	5	50	Silicic acid water
Meta-arsenic acid	1	1	1	Arsenic water
Metaphosphoric acid	5	5	–	–
Radium	1,011	1,011	>1,011	Radium water
Radon	37	47.14	129.5	Radon water
Temp/°C	≥34	–	–	Warm water
Degree of mineralisation (g/L)	<1,000	–	–	Fresh water

Source: *Standards of Geothermal Investigation* GB/T 11615-2002
Note: Bq (becquerel), a radiation unit, is equivalent to the activity per second in which one nucleus of radioactive material decays per second. Hot springs with radon are therapeutic to many diseases

materials. Specific minerals can be used as precious stones and ornamental stones and are important geotourism resources.

Mingyong Glacier Landscape The Mingyong Glacier, which is the longest glacier on the Meili Snow Mountain, is located in Diqing, Yunnan Province. It is 11.7 km long, has an elevation of 2,660 m, and is currently the second longest glacier in the Hengduan Range area and the lowest marine glacier in the monsoon belt. It is Yunnan's largest and longest valley glacier, and its ice front is at the lowest elevation. The height difference between the peak and the ice front is approximately 4,080 m. The mountain body above snowline is 1–3 km wide, there are three peaks higher than 6,000 m, and five additional peaks are more than 5,000 m high. The temperature is low on the peaks. The estimated annual average temperature of Peak Kagabo is −19.2 °C, and the annual average temperature of the snowline area between 4,800–5,200 m is approximately −3 to 5.6 °C. Abundant ice flows from the firn basin down along the steep slope, forming a glacial valley with large icefalls. Because the snowline is at a lower elevation and the temperature is higher, melting is rapid, and the glacier moves rapidly.

The upper part of the ice tongue can reach a velocity of 533 m per year. Maintenance of the ice tongue relies on the supply of precipitation. In the winter, the ice tongue can extend from an elevation of 5,500 m to 2,800 m, which is only 800 m from the Lancang River.

Mingzhong Tian Mingzhong Tian (1951–) graduated from China University of Geosciences (Wuhan) in 1980. He is currently a professor at the China University of Geosciences (Beijing) and a doctoral tutor and a geopark expert at the Ministry of Land and Resources. Over the years, he has devoted himself to studying Quaternary geology, geomorphology, geoparks and tourism earth science. He has published more than 70 academic papers and 15 monographs and textbooks. He won the second prize of the Beijing Science and Technology Progress Award, the second prize Teaching Award of the Ministry of Education and many other awards. He was awarded the title of 'Advanced Ethical Teacher' and 'Most Popular Teacher'. He also enjoys special government allowances from the State Council. He has contributed to the successful applications of seven global geoparks, 25 national geoparks, national mining parks, and provincial geoparks. He has conducted more than 50 related scientific research projects and has contributed to tourism earth science and geopark construction.

Mining Park A mining park is a site that makes use of an abandoned mine with geological and mining relics as well as facilities bearing scientific and cultural connotations. After restoration of the ecological environment, it is used for scientific research, science popularisation, tourism and leisure activities. Mine parks play an important role in protecting the relics of mining activities, exhibiting mining history and cultural artefacts, and disseminating mining knowledge. They also help mining cities achieve sustainable development. Since 2004, China has set up mine parks under the Ministry of Land and Resources. A mine park should meet the following four basic criteria. (1) It must be an abandoned mine or an abandoned part of a mine. After restoration, the ecological environment of the abandoned mine or the abandoned part of the mine is ideal for a mine park; however, the primary concern is that it must be safe. (2) It must have typical, rare and rich content of mining relics. (3) With mining heritage as the focus, it must fully integrate other natural and cultural landscapes to reflect the harmonious development of man and nature. (4) It must be coordinated with the needs of society and play an active role in guiding the transformation of the mining economy as well as promoting local social and economic development.

Minle Manganese Deposit, Xiangtan, Hunan This is a large manganese deposit that formed by multi-source chemical and biochemical precipitation in gulf-lagoon facies rocks. It is located in Huayuan County, Hunan Province. The Minle manganese deposit is shaped like a northeast-southwest-trending oval. The ores are in black shale of the Sininan Minle Formation and are mainly sedimentary manganese carbonate ores. The main mineral of the ores is rhodochrosite. The ores are typically middle- to low-grade manganese carbonate mixed with high contents of iron and phosphorus.

Mirage A mirage in Chinese is also known as the 'City on the Sea and Sea Dragon's Buildings'. This is a naturally occurring optical phenomenon in which light rays bend as a result of the differential density in layers of air and produces a displaced image of distant objects. Mirages often occur on the sea surface and in the desert. They often appear on the Penglai Sea near Shandong Province in China. In the past, people believed that it was a building formed by the breath exhaled from the Shen dragon, so it was called the Shen scenery (Fig. 20).

Mirage Landscape A mirage is a unique phenomenon of refraction in the atmosphere that takes place under special geographical and climate conditions. Mirages often occur during the winter and spring in the Arctic and during the summer in the desert. They can also occur along the coast or in the sky above rivers and lakes. The most famous mirages in China occur in Penglai in Shandong Province. They look like castles in the sky and have been called the 'celestial land of Penglai'.



Fig. 20 Mirage landscape

Misty Rain Landscape A landscape of smoke-like drizzle arouses emotions of tourists and adds value to their travel experience. An example of this landscape is the 'misty rain of South Lake' in Jiaxing, which is a fascinating landscape south of the Yangtze River that forms enchanting scenery for tourists.

Mixed Coniferous-Deciduous Forest This is a type of zonal forest vegetation in temperate and humid climate regions that consists of a mixture of evergreen coniferous and deciduous broadleaf species, such as Korean pine, Mongolian oak, tilia and ash. These forests are mainly located at Changbai Mountain, Zhangguangcailing and Xiaoxing'anling. They are extensively spread over the moderate to low mountains and hills between 40 and 60° N.

Miyun Yunmengshan National Geopark, Beijing Miyun Yunmengshan National Geopark covers several towns in Miyun County in Beijing Municipality such as Shicheng, Wengxizhuang and Xitiangezhuang. It became a national geopark in 2009. The structure of the Yunmengshan metamorphic core complex was discovered in the 1980s, and it is one of the three metamorphic core complexes that have been identified in China. The Archean metamorphic rocks in the northern and eastern parts of the geopark are amphibolite-granulite lithofacies of a moderately deep metamorphic rock series that developed during the formation of the crystalline basement of the North China Craton. The Palaeoarchean and Mesoarchean Miyun Group and the Neoarchean Sihetang Group in the park are the main representatives and are the locations where the strata were named.

Modern Glaciers In contrast to ancient glaciers, modern glaciers are glaciers that are still growing and developing. They are mainly located near the two poles and in alpine regions, and they cover approximately 10% of the Earth's land, which is an area of 16 million km^2. Modern glaciers store up approximately 85% of the global freshwater resources (Fig. 21).

Modern Tourism Geography This book was written by Yunting Lu and was published by Jiangsu People's Publishing House in 1988. In 1993, it was translated into traditional Chinese characters by Taiwan Landscape Enterprise Co., Ltd. The book was the earliest publication to provide extensive coverage of tourism geography in China. The Ministry of Education recognises it as teaching material that must be read by students in colleges and universities as well as postgraduates in tourism geography. It has played an important role in establishing the theoretical framework of tourism earth science as a new discipline.

Moho The full name of the Moho surface is the Mohorovicic Discontinuity, which is the boundary between the crust and the mantle. It was first discovered by the seismologist Andrija Mohorovicic in 1909, who realized that seismic waves accelerated in a zone located 50 km beneath the Earth's surface, which was interpreted as a geological discontinuity. Later, this zone was proven to be present not only below Europe but globally at various depths. It is shallow beneath the oceans (usually 5–15 km) and deep beneath the continents (generally 30–35 km). It is deepest (60–70 km) beneath the Qinghai-Tibet Plateau and Tianshan areas.

Mollusc Fossils Mollusc is a collective term for all fossils of the phylum Mollusca. There are ten classes in this phylum: Monoplacophora, Polyplacophora, Aplacophora, Scaphopoda,



Fig. 21 Tasman modern glacier, New Zealand

Rostroconchia, Gastropoda, Bivalvia, Cephalopoda, Tentaculita and Hyolitha. China has abundant and widespread mollusc fossils. In Chengjiang in Yunnan Province, there are four genera and four species of Chengjian mollusc fossils, represented by Hyolithoid. The Chiting Formation in the Xinhua hilly region of Taiwan contains abundant mollusc fossils, including Chlamys, Placenta, Oystrea, Cerithium, Turritella filiola and Limopsis species. The Ordovician Cephalopod fossils found in the Three Gorges Region in Hubei Province have straight or coiled, 2–6 m long, with knotted, tumorous and vertical lines on the surface.

Monarch Butterfly Biosphere Reserve, Mexico This reserve is located approximately 100 km northwest of Mexico City. The area has rugged mountainous terrain surrounded by dense forests. The core protection area covers 136 km^2, and including the buffer zone, the reserve covers an area of 563 km^2. In the autumn, millions to billions of butterflies return from across North America and gather on orange branches in the small woodlands in the forest reserve. In the spring, the butterflies began another 8-month migration to eastern Canada. During this period, four generations of butterflies complete their life-cycles.

Monazite Monazite is a phosphorus-cerium-lanthanum mineral ore that contains (Ce,La, Nd,Th)(PO_4,SiO_4). It crystallizes in the monoclinic system, and the crystals are blocky or prismatic. It can be brown, reddish brown, yellowish brown, pink, yellow, light green or white with white streaks. It has transparent to translucent diaphaneity, a resinous, waxy or vitreous lustre, a specific gravity of 5.1, and a Mohs hardness of 5–5.5. It mainly forms in pegmatite and coexists with zircon, apatite and niobium ore. However, monazite ore is mainly found in littoral and alluvial placer deposits. It is the main mineral ore for extracting cerium, lanthanum and thorium.

Monsoon Climate A monsoon climate is the climate of monsoon-dominated areas, which cover an extensive part of the Earth. Due to the differences in sea-land thermodynamics and pressure that vary with the season, the prevailing wind changes direction. In the summer, this climate is affected by the warm and moist air from the ocean, which brings hot and rainy weather. In the winter, it is affected by dry cold air from the continent, which makes the weather cold and dry.

Monte San Giorgio, Switzerland/Italy This site is located in the border area of Lombardy in southeastern Switzerland and northern Italy. It covers a core protection area of 10.8 km^2 and has a buffer zone of 32 km^2. In 2003, the main part on the Swiss side was added to the World Heritage List, and it was expanded to include the Italian side in 2010. The forest-covered Mount St. George looks like a pyramid and stands on the southern side of Lugano in Ticino, Switzerland. It is considered to be the most complete record of marine life from the Triassic (240 to 230 million years ago). The sequence of fossils documents forms of life that were protected in a tropical lagoon environment but were partially isolated by offshore reefs. The marine life in the lagoon was unusually rich. The fossils include marine reptiles, fish, bivalves, echinoderms and crustaceans.

Because the lagoon was close to the land, there are also many terrestrial biofossils, including terrestrial reptiles, insects and plants. As a result, the heritage site is a rich fossil site.

Moonmilk Stone Landscape This is a landscape consisting of milky white paste or powdered carbonate sediments with a high moisture content, high plasticity and non-fixiform. Moonmilk stone was first discovered in Switzerland in the early fifteenth century. Its mineral composition is complex; it is mainly calcite and aragonite and sometimes hydrous magnesite, calcium-magnesium carbonate, magnesite, trihydrate magnesite and dolomite. There are many causes for its formation, but microorganisms play an important role. There are numerous moonmilk stones in Shihua (Stone Flower) Cave in Beijing, Zhijin Cave in Guizhou Province and Jiutian (Nine Heavens) Cave in Shandong Province (Fig. 22).

Moonstone Moonstone is a feldspar gem composed of interspersed K and Na-rich feldspars that form a unique blurred moonshine effect of white or blue halos when the stone is rotated. It is usually colourless or white with blue, white or yellow halos. The main mining countries include India and Sri Lanka (Fig. 23).

Moraine Fan Landscape This is also known as a drift gravel fan landscape. It is a fan-shaped deposit that forms during the continuous and steady receding of a piedmont glacier. Due to plucking, the glacier carries gravel downstream and drops it along the flow. After the ice melts, the drift gravels connect with the source area, creating a fan-shaped landform, the diameter of which can range from more than a hundred metres to thousands of metres (Fig. 24).

Moraine Hills *Synonym:* ▶ *Hillock moraine landscape*

This is a landscape comprising low, wavy and undulating morainic hills. Wide shallow lakes are commonly located between the hills. The height variation of the hills is always consistent with the profile of the underlying bedrock.

Morne Trois Pitons National Park, Dominica This park is located in south-central Dominica Island and covers a core protection area of 68 km^2. The 1,342-m-high volcano, with the volcano Morne Trois Pitons (meaning 3-peaks mountain) as its peak, has dense tropical forests and volcanic features that have significant scientific research value. In the park approximately 70 km^2 away, there are steep cliffs, deep valleys, hanging waterfalls, 50 fumaroles, three freshwater lakes, one 'boiling lake' and five volcanos. The small mountainous area also contains many hot springs and rich biodiversity.

Morphology of Minerals *Synonym:* ▶ *Shape of minerals*



Fig. 22 Moonmilk stone landscape – Shihua Cave, Beijing



Fig. 23 Moonstone



Fig. 24 Moraine fan landscape at Baiyucuo in the northern Shaluli Mountains, western Sichuan

Minerals can be in monocrystal form, regular group form or aggregate form. The monocrystal mineral morphology includes the crystal shape, crystal habit, crystal size and striations. The regular group crystal form includes twin crystals, parallel crystals or the external characteristics between various crystals of the mineral. The aggregate morphology refers to the form of minerals of the same class aggregated together, and it hinges on the shape and arrangement of the monocrystals. In general, the morphology of a mineral depends on its internal structure and growth environment. Common mineral aggregates include radiating, stalactitic, reniform, botryoidal, oolitic and pisolitic aggregates (Figs. 25, 26, and 27).

Mosi-oa-Tuny/Victoria Falls, Zambia, Zimbabwe This park is located along the border between the Southern Province in Zambia and Matabeleland North Province in Zimbabwe, and it has an area of 87.8 km^2. The Zambezi River, which is more than 2 km wide at this point, plunges down a series of basalt gorges and raises an iridescent mist that can be seen more than 20 km away. It is one of the most spectacular waterfalls in the world.

Mould Stone ▶ Shape Stone

Moulin, Glacial Pothole Landscape A moulin is a pan-shaped glacial depression that develops on a fluvioglacial plain or along both sides of a kame. The fluvioglacial deposits and the permanent ice buried inside a kame melt when the climate becomes warmer. Moulins form due to the collapse of the cover materials or glacial erosion. Moulins are nearly round in map view, and the diameters can range from a few metres to dozens of metres. They are only a few metres high. When moulins are arranged in a row, they are called a moulin chain. Based on their shape and scale, they can be divided into disc-shaped potholes, pot-shaped potholes and tub-shaped potholes.



Fig. 25 Stalactitic aggregate

Mount Arxan Volcano-Warm Spring National Geopark, Inner Mongolia This geopark is located in northeastern Inner Mongolia in the city of Aershan, Xing'an League, Inner Mongolia, Daxinganling. It became a national geopark in 2004. It has five scenic sites: the Tianchi volcano and hot spring clusters, Rose Peak Granite Pillar Forest, Triangle Passage and Haosengou. The main attractions are craters, crater lakes, volcano lagoon lakes, hot springs, granite landforms, and Quaternary plateaus with meandering rivers. It is an area for scientific research, public education, protection and tourism. Arxan is not the name of the mountain but rather means 'holy water' in Mongolian.

Mount Athos, Greece Mount Athos is located on the Athos Peninsula in northeastern Greece. It covers an area of 330.42 km^2. The sacred mountain has been the spiritual centre of the Orthodox Church since 1054 and has enjoyed religious autonomy since the Byzantine Empire. Women and children are forbidden from the site, and it is also an important art region. The planning and design of its convent (which currently includes approximately 20 monasteries with 1,400 monks) has had an impact on religious communities as far away as Russia. The painting style has also affected the history of Orthodox art throughout the world.

Mount Changbaishan Volcano National Geopark, Jilin This geopark is located in the Changbaishan Mountain Scenic Area in Jilin Province and is dominated by volcanic landforms. It became a national geopark in 2009.



Fig. 26 Reniform aggregate



Fig. 27 Oolitic aggregate

Changbaishan Mountain Scenic Area is the largest area of volcanic rocks with the largest number of volcanos in eastern Asia. The Changbaishan stratovolcanoes, most of which are located on the lava platform or plateau, erupted from fractures on the northeastern and northwestern sides of the plateau. The colossal Lake Tianchi near Mount Changbaishan provides spectacular scenery. Other landscapes include waterfalls, hot springs and a well-protected pine forest.

Mount Changshan Liedao Islands National Geopark, Shandong This geopark is located in Changdao County in Shandong Province. The Changdao Islands consist of 32 islands that trend NNE. They form the natural boundary between the Bohai Sea and the Huanghai Sea, and they acquired national geopark status in 2005. The geological features include islands, marine erosional and depositional landforms, geological structures, volcanic landscapes, collapse landscapes, human fossils, and biodiversity.

Mount Chaya-shan National Geopark, Henan This geopark is located on the eastern edge of Funiushan in western Luanping County, Henan Province. It has an average elevation of 600 m, and the main geological attractions are the typical granite landscapes. It became a national geopark in 2004. The main body of the mountain is Yanshanian granite that is 140 million to 120 million years old. The geomorphic landscape that formed has been called the 'mountain granite rock landscape of the low peak'. It consists of dense mountains, including Nanshan Mountain, Beishan Mountain, and Liufeng Mountain, as well as Tianma Lake, Lugu Lake, Xiumi Lake and Baihua Lake.'

Mount Dabieshan (Liu'an) National Geopark, Anhui Mount Dabieshan (Liu'an) National Geopark is located at the junction between the three provinces of Hubei, Henan, and Anhui. Baimajian, which has an elevation of 1,774 m, is the highest peak of Mount Dabieshan. Tiantangzhai is the second highest peak and has an elevation of 1,729 m. It is the watershed of the Yangtze River and the Huai River. The geopark became a national geopark in 2005, and it includes scenic areas such as Tiantangzhai, Tongluozhai, Baimajian, Foziling, Dongshisun, Wanfohu, Wanfoshan and Songliaoyan. It is characterised by landscapes of granite and the rocks and minerals produced in the Dabieshan ultra-high-pressure and high-temperature structural-metamorphic tectonic belt. The geopark also has attractive water and cultural landscapes.

Mount Dazhang Basalt Column Landscape This is a landform composed of large columns of basalt located in Fuding, Fujian Province. The exposed columns cover an area of 0.21 km^2 and rise to elevations of 407–604 m. The height of the exposed columns reaches nearly 200 m, and all of the columns are either pentagonal or hexagonal. The columns are generally more than 60 cm in diameter, and they are regular and large. They are Neogene volcanic necks intruding into tuff of the Cretaceous Shimaoshan Formation. The rocks are mainly basalt that contains olivine mantle inclusions and brecciated lava with fine-grained allgovite and porphyritic allogovite. The columns in the central volcanic neck are composed of allgovite. This columnar joint landscape is comparable to that of Devils Tower in Wyoming, United States. It has important geological significance and aesthetic ornamental value. The Mount Dazhang basalt was originally mined from a large quarry. Chen Anze called for restrictions on quarrying activity to preserve the landscape of the allogovite volcanic neck. With an appropriate landscape



Fig. 28 Mount Dazhang basalt column landscape, Fujian Province

design, it is expected that China's 'Devils Tower', which is the world's highest and is higher than the American Devils Tower, will be established as a tourist site (Fig. 28).

Mount Feitianshan National Geopark, Hunan This geopark is located in the Suxian District and Beihu District of Chenzhou City, Hunan Province, and is characterised by its Danxia landform. It became a national geopark in 2002. The Danxia landform of flat-top towers are scattered and dissected by steep red cliffs. Many village walls are eroded into circular depressions and pits. The Wanhua karst cave formed in the Lower Carboniferous limestone and is approximately 9 km long, and it contains an underground river that is 2,245 m long. The cave contains 13 distinctive halls, the largest of which can accommodate thousands of people. The travertine deposits in the cave include stone fields, stalagmites, stalactites, pillars, stone pillars, and stone curtains. The 'underwater crystal cones', 'stone eggs' and 'bamboo shoots' are the main attractions.

Mount Fengshan Karst National Geopark, Guangxi Mount Fengshan Karst National Geopark is located in Fengshan County, northwest of Hechi City, in the Guangxi Zhuang Autonomous Region. It became a national geopark in 2005. The geopark is located along the southeastern border of the Yunnan-Guizhou Plateau. The highest elevation is 1,318 m, and the elevations generally range from 500 to 1,000 m. The elevation in the geopark varies from 300 to 500 m. A total of 40% of the geopark is covered by Palaeozoic carbonate rocks, which contain giant cave tunnels, cave halls, underground rivers and springs. The geopark has a beautiful and high-quality environment and has been called 'the hometown of longevity'.

Mount Huayingshan National Geopark, Sichuan Mount Huayingshan National Geopark is located in the eastern Sichuan Basin and stretches 300 km across 15 provinces and counties, including Sichuan and Chongqing, from north to south. It has been a national geopark since 2005. The peak of Mount Huangyingshan is Gaodeng Mountain, which has an elevation of 1,740 m and is the highest point in the lower part of the Sichuan Basin. The landscape includes moderate and low mountains, karst landscapes, geological structures, and complete stratigraphic sections. The geopark includes Gaodeng Mountain, Tianchi Lake and Xiaoshanba Scenic Area. The Gaodeng Mountain Scenic Area includes the Gaodeng Mountain Stone Forests, Shili Grand Canyon, Longwang Cave Anticline, and Gaodeng Mountain Syncline. Tianchi Lake has features such as Tianchi Lake, Bijia Cave, the Tianchi faults and folds, and the Xiangshui Cave Funnel Group. The Xiaoshanba Scenic

Area mainly features moderate and low mountain karst landscapes.

Mount Kenya National Park/Natural Forest, Kenya This park is located along the border between the Eastern and Central Provinces of Kenya, approximately 150 km northeast of the capital Nairobi. It has a core protection area of 1,420 km^2. Mount Kenya, which is 5,199 m above sea level, is the second highest mountain in Africa. As an ancient extinct volcano, it may have reached an elevation of 6,500 m when it was active (3.1–2.6 million years ago). The 12 glaciers on the mountain are melting rapidly, and another 4 secondary peaks are located at the top of the U-shaped glacial valley. Rugged glaciers and slopes covered by forests have made Mount Kenya the most attractive geomorphologic landscape in East Africa.

Mount Nimba Strict Nature Reserve, Ivory Coast and Guinea Mount Nimba Strict Nature Reserve is a cross-border natural heritage site that was first established by Ivory Coast and was then extended following Guinea's declaration. It is located in the Mount Nimba area, where the borders between Côte d'Ivoire, Guinea and Liberia meet. It has a core protection area of 180 km^2. Mount Nimba rises above the surrounding savannah along the borders of the three countries. Its slopes are covered by dense forest at the foot of grassy mountain pastures. They host especially rich flora and fauna with endemic species such as the viviparous toad and chimpanzees that use stones as tools.

Mount Phoenix Geopark, Heilongjiang This geopark is located within the Shanhetun Forestry Administration District in southeastern Heilongjiang Province. It has an area of 307 km^2, and most of the geological features are concentrated in an area of 50 km^2. It became a national geopark in 2011. The geopark contains interesting geological structures, geomorphology and water bodies. It is a famous tourist attraction in northern China and has long had the reputation of being the 'Oriental Shangri-La' and 'First Park in Guandong' (Guandong refers to the eastern part of the Shanhai Pass, including Liaoning Province, Jilin Province, Heilongjiang Province and the Inner Mongolia Autonomous Region). It has well-preserved heritage, such as the original alpine tundra wetlands and meadow wetlands at low, moderate and high elevations. It also features narrow, long and deep rift valleys and abruptly dropping waterfalls, which have high aesthetic value and are rare in the 14 provinces and regions north of the Yellow River. The extensive block field that formed due to ice and tectonic movements is magnificent. The area also has high ecological value that deserves conservation.

Mount Qiyun-shan National Geopark, Anhui This geopark is located in Huangshan City, Anhui Province, and became a national geopark in 2002. It features a typical Danxia landform in addition to dinosaur fossils, Taoist culture, and cliff carvings. The Danxia landform formed during the Late Cretaceous approximately 90 million years ago. The Cretaceous strata are rich in ancient fossils. Dinosaur fossils, including footprints, egg fossils and skeleton, have been discovered in recent years.

Mount Siguniangshan National Geopark, Sichuan This geopark is located in Xiaojin County, Tibetan Qiang Autonomous Prefecture of Ngawa in Sichuan Province. It lies along the eastern border of the Qingzang Plateau in the first level of the Chinese landform and is adjacent to the Wolong Nature Reserve in Wenchuan County. It became a national geopark in 2005. The geopark has very high mountain landforms and Quaternary glacial landforms with intense headwater dissection; thus, the valleys are steep, with relative heights of 2,000–2,500 m. The geopark is divided into three geomorphological zones, namely, the Very-high Mountainous Zone with Moderate Dissection, High Mountainous Zone with Deep Dissection and Moderately high Mountainous Zone with Deep Dissection, in which dozens of recent glaciers of various scales have developed.

Mount St. Helens Volcano Landscape Mount St. Helens is an active volcano in North America. It is located in the northern Cascade

Mountains in Washington State in the northwestern United States and has an elevation of 2,950 m. This volcano had been dormant for 123 years when it suddenly erupted on March 27, 1980. The eruption on May 18 was the most violent; the volcanic clouds reached an altitude of 20,000 m, and volcanic ash was dispersed over an area of 4,000 km^2. The ash was 1.8 cm thick over an area of 800 km^2 around the volcano. Rivers near the volcano were clogged and diverted, and many roads were buried. The lava flows caused forest fires that killed all living creatures within tens of kilometres of the volcano. Melting of large amounts of ice and snow caused turbulent rapids and flows and combined with the condensation of water vapour in the rising air to cause hazardous torrential rains, which carried the volcanic ash as mud flows that ran down from the peak and destroyed agricultural fields, forests and facilities. After the eruption, the surrounding terrain had changed drastically. The original volcanic cone collapsed, forming a new crater that was 3 km long, 1.5 km wide and 125 m deep. The eruption killed more than 60 people and turned 390 km^2 of land into a barren wasteland. The damage and losses were colossal. This eruption was the largest volcanic disaster in the history of the United States and the largest on Earth in the twentieth century.

Mount Tianshan Tianchi National Geopark, Xinjiang This geopark is located in Fukang City, Changji Hui Autonomous Prefecture, Xinjing Uygur Autonomous Region. It became a national geopark in 2009. This geopark contains a glacier-dammed lake, ancient glacial landforms, ancient volcanic landforms and a geological cross-section as well as fossils of extinct species. The modern glacial landforms in Bogda are well-developed, including an intact ice tongue, glacier crevasses, rivers on the ice, tunnels under the ice, glacier holes, glacial layering, and ice mushrooms. A mountainous landscape, peak cluster and canyon landforms are also present in the volcanic terrain. The Jurassic strata contain numerous 100-million-year-old plant fossils, such as cycads, ginkgos, ancient pines, and ferns.

Mount Tianzhushan National Geopark, Anhui See ▶ Tianzhushan Global Geopark, China.

Mount Wudangshan National Geopark, Hubei This geopark is located in the Mount Wudangshan Tourism Economic Zone, Shiyan City, Hubei Province. It covers an area of 312 km^2, and it was designated as one of the fifth group of national geoparks by the Ministry of Land and Resources in August 2009. Situated in the central part of the orogenic belt in the southern Qinling Mountains, Mount Wudangshan is part of a thrust system with global significance. Mount Wudangshan features various rock types, large lithological variations and a long period of formation (0.8–1.8 billion years ago). Basic dykes from the Jinningian Era are widely scattered, representing a rifting environment. The Laohekou-Baihe fracture zone is one of the most important secondary structural boundary faults in the orogenic belt. The unique rock associations at Mount Wudangshan and the sculptures that developed due to neotectonic movements constitute the unique metamorphic Fengcong landforms in the geopark.

Mount Wutaishan National Geopark, Shanxi Mount Wutaishan is a part of Taihangshan Mountain. It is located along the border between Wutai County and Fanzhi County, Xinzhou City, northeastern Shanxi Province, and it covers an area of 643 km^2. In August 2005, the Ministry of Land and Resources approved it as one of the 4th group of national geoparks. The northern foothills of Mount Wutai are steep, while the southern foothills are relatively gentle, with elevations of 624–3,058 m and a relative height difference of 2,434 m. The main peak, which has an elevation of 3,058 m, is the highest peak in northern China. The main peak is composed of five smaller flat-topped peaks, so it is called 'Wutaishan' (Five Flat-topped Mountain). The park is characterised by complete Early Precambrian stratigraphy, varied and typical lithologies, continuous outcrops, clear boundaries and unique structures, and it is a classical area of Precambrian geology in the country. Several

important Neo-Archean and Palaeoproterozoic geological units and tectonic events in China, such as the 'Wutai Group', 'Hutuo Group', 'Wutai Movement', 'Tiebao Movement' and Meso-Cenozoic Beitaiqi planation surface, are named after it.

Mount Xishan National Geopark in Taihu Lake, Suzhou, Jiangsu This geopark is located in the southeastern corner of Taihu, Jiangsu Province. The national park comprises more than 20 small islands, including Xishan Island, Taohua Island, San Shan Island and Hengshan Island. The main features are karst landforms, lake erosion landforms, and the natural ecology and human landscape. The stratigraphy of the geopark is from the Silurian to the Triassic and is very well-developed. Substantial evidence of human activity has been found in the karst cave of the East Berth Hill on San Shan Island, and more than 5,000 new and old stone artefacts have been unearthed, including scrapers, spikes, stone balls and stone axes. The Taihu Stone is very famous; it is a porous limestone and is native to the Taihu area.

Mount Yao Geopark, Henan This geopark is located in Lushan County, Pingdingshan, Henan Province. The geopark has an area of 156 km^2, and most of the geological features are concentrated in an area of 111 km^2. It became a national geopark in 2011. The geopark has attractive geology and geomorphology. It preserves the sedimentary strata of the Xionger, Luoyu, Ruyang and Jiunvdong groups and showcases the Zhengjiazhuang independent unit, Heyu superunit, Shenlin superunit, the Four Tree sequence and the Huangtugang independent intrusive body. The geopark also has five major groups of hot springs, including Shangtang, Zhongtang, Xiatang, Wentang and Jianchang. The natural landscapes of Mount Shiren and Mount Shengrenduo are also attractive, which brings added value to research and science popularisation tourism.

Mountain A mountain is a landform that protrudes above plains or terraces with a certain slope, a large elevation difference and lateral extent. Mountainous land is a general term for mountains, valleys, and intermountain basins. Its morphological elements include mountain tops, hillsides, and mountains. In geomorphology, mountainous regions are generally divided into four categories based on their elevations: elevations >5,000 m are called extremely high mountains, elevations between 3,500 and 5,000 m are called high mountains, elevations of 1,000–3,500 m are called medium-high mountains, and elevations of 500–1,000 m are called low mountains. In terms of the viewability of the landscape, mountainous terrain can be divided into four types based on the relative height of the terrain: (1) low mountains with relative heights of 200–500 m (<200 m is hilly), (2) medium-high mountains with relative heights of 500–1,000 m, (3) high mountains with relative heights of 1,000–2,500 m, and (4) extremely high mountains with relative heights of >2,500 m. Relative height is used as a classification of mountains in tourism earth science. (see ▶ Peak).

Mountain Building ▶ Orogeny

Mountain Glacier This is a type of glacier that forms in mountainous areas, where the form is controlled by the topography. Mountain glaciers are mainly located in alpine regions at middle and low latitudes. Their characteristics are small size, high snowline, small accumulation area, a distinct boundary between the charging and ablation zones, downward movement by gravity, high velocity and energy, and strong glacier erosion. Mountain glaciers can form in various parts of a mountain and include a variety of types, such as ice cirque glaciers, hanging valley glaciers, valley glaciers and piedmont glaciers (Fig. 29).

Mountain Tourism Mountain tourism is the tourism in mountainous environments, including activities such as mountain climbing, exploration, observation and outdoor experiences. It is a type of modern holiday tourism that combines mountain sightseeing, leisure and holiday, fitness, entertainment, education and sports.

Mud Ball Mud balls are spherical clay inclusions in conglomerate or sandstone. They are a



Fig. 29 Gornergrat glacier landscape in the Alps, Switzerland

product of flooding in rivers. They form when pieces of mud fall into water due to fluvial erosion along the bank and roll continuously into a ball in the water. Some have gravel stuck onto their surfaces.

Mud Crack A mud crack is also known as a drying crack or turtle shell crack. It is a layer structure in sedimentary rocks. Mud cracks are formed by the drying and dehydration of unconsolidated muddy sediments under the sun. The fissures are filled with sand and silty sand from the overlying layer. Mud cracks appear in plan view as irregular polygons, and they are V-shaped or U-shaped in cross-section. They are common on the top surface of clay rock and limestone, but imprints are often left on the bottom of the overlying strata. Mud cracks usually occur in coastal zones, tidal belts, and natural river embankments with intermittent exposure to sunlight. Hence, they can be used as markers for the identification of the depositional environment. V-shaped cracks are also an effective indicator of the top and bottom of rock strata (Fig. 30).

Mud Volcano and Mud Spring Tourism Landscape Under certain geological conditions, geothermal heat generated by tectonic forces or magmatic intrusions can cause groundwater, oil or gases in the subsurface to eject mud, rock fragments, gases and small amounts of groundwater, forming a natural landscape similar to a volcanic landscape. Mud volcanoes are generally less than 10 m high and dozens of metres in diameter. The largest mud volcano is near the Baku Oil Fields in the Caspian Sea area of Russia, where the cone is several hundred metres high. Along a 20-km-long zone in Kaohsiung in Taiwan, there are more than ten mud volcanoes. Mud volcanoes and mud springs have tourism value as well as medicinal value because the mud often contains a range of trace elements.

Mudflow Landscape *Synonym:* ▶ *Debris flow landscape*

In Chinese, this is also known as the 'mountain torrent, crawling dragon, bubbling water or escaping mosquito'. It is a geo-environmental landscape associated with a torrent of solid matter, such as sand, mud and gravel, that occurs suddenly in a small drainage area (several square kilometres) in a mountainous region. Mudflows are geologic hazards with strong destructive force that occur rapidly. They can destroy and bury houses, roads, farmlands and other facilities, causing casualties and property losses. They usually occur in mountainous areas. Mudflows generally contain more than 15%, and sometimes up to 80%, solid material. The scouring, transportation and deposition

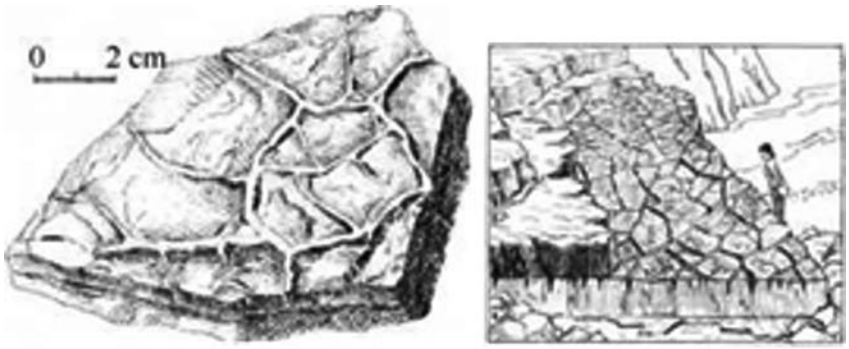


Fig. 30 Mud cracks

processes of a mudflow are very rapid. Within a short period of time, a mudflow can transport thousand or even tens of thousands of cubic metres of solid materials as well as hundreds of boulders weighing thousands of tons. Debris flows can be divided into three sections: (1) the upstream formation area, which is a catchment basin surrounded by steep mountain walls on three sides; (2) the middle course passage area, which is typically a narrow valley; and (3) the downstream deposition area, which comprises fan areas, known as debris fans, of various sizes. Debris fans are similar to pluvial fans, but the sediment sorting is worse because the sediment layers are always mixed with large and small materials, forming mixed gravel and mud layers. Stacked boulders sometimes form.

Mudstone; Argillite Mudstone is a sedimentary rock that solidifies from mud and clay. The texture is soft, the degree of consolidation is low, and recrystallization is not obvious. Its composition and structure are similar to those of shale, but the bedding is not well-developed, and it is not easy to break. Mudstone is mainly composed of illite, and it often contains other clay minerals, clastic minerals, autogenous minerals, iron-manganese materials and organic matter. The common types include: (1) calcareous mudstone, which is common in continental red rock strata and marine and lagoon facies sedimentary rock layers with some calcium carbonate (content <25%); (2) iron mudstone, which is often found in red rock strata and contains substantial amounts of iron minerals, such as haematite, limonite and goethite; the main colours are red, purple or greyish green; (3) siliceous mudstone, which contains more SiO_2 (up to 85% or more), no or little iron and carbonate materials, and always occurs with ferruginous, siliceous and manganic rocks; (4) carbonaceous mudstone, which contains a large amount of carbonized organic matter; and (5) black mudstone, which contains more organic matter and fine dispersed iron sulphide and is black. Mudstone is adhesive, absorbs water and is fire resistant, so it is widely used for brick and pottery production.

Muroto Geopark, Japan This geopark became a global geopark in 2011. It is located in the eastern part of Yuchi Prefecture in Japan and has an area of 248 km^2. It became the fifth Japanese global geopark after the Toya-Usu, Itoigawa, Uzen and San'in Kaigan geoparks. The coastline of this geopark has been uplifted due to plate movements and earthquakes. It preserves the very old cultural traditions, such as collecting and burning charcoal.

Muscovite The composition of muscovite is $KAl_2[AlSi_3O_{10}](OH,F)_2$. It has a monoclinic crystal structure and a pseudohexagonal form. Crystal twinning is common, and the crystals always have an aphanitic texture and are sometimes in the form of scale-like dense blocks or disseminated flakes. Its colour varies from colourless, grey, yellow, green, brown, red to bluish-purple with colourless streaks. The diaphaneity is from transparent to translucent, the lustre is vitreous or pearly, the specific gravity is 2.77–2.88, the Mohs hardness is 2.5–4, and the fractures are uneven. Muscovite mainly forms in igneous rocks, particularly granite. It can also

form in metamorphic rocks such as schist and gneiss. Mica schist is rich in muscovite.

Museum Tourism Museum tourism includes tourism activities conducted in museums. Museums are non-profit, permanent institutions that serve for social development and are open to the public. Museum tourism is a new form of tourism that has gradually emerged at home and abroad in recent decades. It has elevated tourism activities from general sightseeing to recreational activities with rich cultural content. China has more than 2,000 museums. As compilations of history and culture, they have become high-quality resources that attract tourists, especially those from other cultural backgrounds. In recent years, geological museums have developed extensively, creating conditions for the public to learn more about earth science.

Mylonite The term mylonite has two definitions: (1) Broadly, mylonite refers to a series of ductile tectonites that form at moderate and deep structural layers. Mylonites form in ductile shear zones and are a type of tectonite subject to fine granulation with a marked alignment that is created by plastic deformation, under which crystal dislocation and dynamic recrystallization of the same structure have taken place. The degree of 'fragmentation' of ductile tectonites is remarkably different from that of brittle tectonites. Ductile tectonites are characterized by an appearance like 'a broken lotus tissue'. Based on the degree of fine granulation, mylonites can be divided into mylonitic rocks of varying degrees of mylonitization, such as primordium, mylonite, ultra-mylonite, phyllite mylonite and blastomylonite. (2) In a narrow sense, mylonite refers to a type of ductile tectonites in the moderate to deep structural layers with medium mylonitization. The degree of mylonitization is between primordium and ultra-mylonite, and it is a very fine-grained dynamic metamorphic rock (grain size 0.1–0.5 mm). It contains a small amount of augen porphyroclasts. This rock is dense and hard and often has a banded structure. Under a microscope, undulatory extinction, fragmentation of particle edges and bending of various structural textures are common.

N

Nahanni National Park Reserve, Canada Nahanni National Park Reserve is located along the South Nahanni River near the Yukon in the southwestern corner of the Northwest Territories, Canada. It has a core protection area of 4,765 km^2 and was one of the first group of natural heritage sites inscribed on the World Heritage List. The reserve has a unique karst cave system and is one of the best destinations for rafting in North America. The reserve is home to animals of the boreal forest, and wolves, grizzly bears, caribou, wild sheep and mountain goats are found in the park's alpine forest environment.

Nam Lake Landscape Nam Lake is the largest saline lake in Tibet and is China's second largest saline lake. It is the world's largest high-elevation lake. In Mongolian and Manchurian, it is called Tenggelinuo'er. In Tibetan, Nam Lake means 'Heavenly Lake'. It is located in the area between Dangxung County and Baingion County 240 north of Lhasa and north of the main peak of the Nyainqentanglha Range. The lake surface is 4,718 m above sea level. It has a nearly rectangular shape, its east-west length is over 70 m, its north-south width is more than 30 km, and its area is 1,920 km^2. The maximum depth is 33 m, and it has a storage capacity of 76.8 billion m^3. The lake's formation and development were affected by the geological structure; it is a tectonic rift lake that formed due to Neogene Himalayan subsidence, and it has traces of glacial action. The lake water continues to retreat, and several ancient lake shores can be identified; the highest is approximately 80 m above the current lake surface. The snow-covered Nyainqentanglha Range is located south of Nam Lake, and plateaus and mounds are located to the north and west. The lake basin contains rich resources of wild animals, such as wild buffalos and goats. There are many wild birds, fine-scaled fish and scaleless fish in the lake. The lake water is clear, and it forms spectacular scenery that echoes the surrounding snowy mountains (Fig. 1).

Nanda Devi and Valley of Flowers National Parks, India This park is located in the borderland of northwestern India near Nepal and Tibet, and it now covers an area of 717.83 km^2 after being extended in 2005. Nestled high in the western Himalaya, India's Valley of Flowers National Park is renowned for its meadows of endemic alpine flowers and outstanding natural beauty. This diverse area is also home to rare and endangered animals, including the Asiatic black bear, snow leopard, brown bear and blue sheep.

Nanhuaan Period The Nanhuaan Period is the second period of the Neoproterozoic Era in China. It covered the interval from 800 million to 680 million years ago, a duration of 120 million years, and is equivalent to the international Neoproterozoic Cryogenian Period. The Nanhuaan System includes the rocks that formed during the Nanhuaan Period. The standard section of the system is located around Yangjiaping in Shimen, Yangtze area, Hunan Province.

Nanjing Liuhe National Geopark, Jiangsu This geopark is located on the northern border of the Liuhe District in Nanjing and is bounded to the north by Tianchang City, Anhui Province, and to the east by Yangzhou City, Jiangsu Province. Its major geological heritage covers an area of 60 km^2. Nanjing Liuhe National Geopark was designated as one of the fourth group of national geoparks by the Ministry of Land and Resources in August 2005. Its main geological attractions include Neogene volcanic clusters, groups of columnar joints and Yuhua strata. The landform is composed of hills, hillock farmlands and alluvial plains. Its terrain is high in the north and low in the south. The mountains are not high but are beautiful, and most are shield volcanos. Ye Mountain, the highest mountain in the geopark, is 231 m

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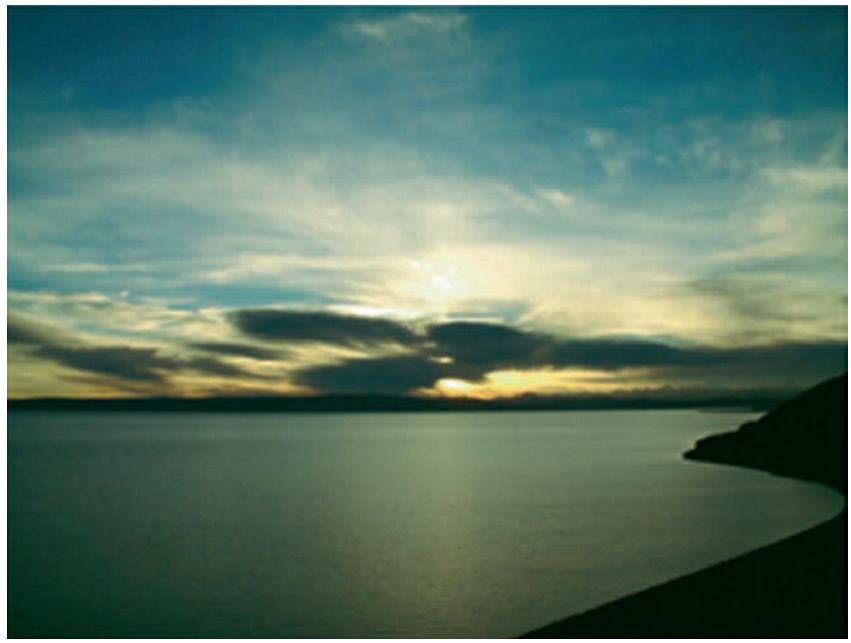


Fig. 1 Nam Lake landscape, Tibet

above sea level, and its peak is mainly composed of basalt.

Nanjing Volcanoes Landscape Nanjing Volcano is a broad concept. It actually represents the Cenozoic volcanic clusters in Jiangsu and Anhui Provinces, including the Jiangning Fangshan in southern Nanjing, the volcanoes around Liuhe, Xuyi and Yizheng in northern Nanjing, and Mingguang Volcano in Anhui Province. There are more than 20 volcanoes. The term Nanjing volcanoes was first proposed by Ferdinand von Richthofen, and Anderson conducted surveys in 1871 and 1876. These volcanoes mainly formed in the Miocene. In 1948, Cheng Yuqi conducted detailed volcanic mapping and petrologic research on the Jiangning Fangshan and published related monographs and survey reports. These publications have historical significance in China's research on volcanic geology. The Liuhe volcanoes have been designated a national geopark, and the Jiangning Fangshan has been included as part of the Nanjing Tangshan-Fangshan National Geopark. The Liuhe basalt has well-developed columnar joints. The columnar joints at Guizi Mountain, which is also known as the Guizi Stone Forest, have long been considered a famous scenic site in Nanjing. Guabu Mountain's columnar joints are wonderful scenery and are also a new scenic site known as the 'Columnar Lion' (Fig. 2).

Nanyang Dushan Jade National Mining Park, Henan This park is located in Nanyang City, Henan Province, covers a total area of 10.53 km^2 and became a national mining park in 2005. It has rich and complete mine remains, which have played an important role in the development of the jade culture in China. There are four scenic areas in the park: a mining relics area, forest ecological zone, agriculture ecological zone and the Binhe Wetland Park.

Narrow Gorge Landscape Narrow gorges develop from cliffy gorges. The valley slopes are very steep, but the valley floor has been widened slightly and accommodates small gravel shores or bedrock terraces. These gorges form in regions subject to significant neotectonic uplift. Narrow gorges are common in the Tongtianhe (Heavenly River) section in the upper Changjiang (Yangtze River).

National Academic Meeting of Tourism Earth Science The 1st National Academic Meeting of Tourism Earth Science was held in Beijing on 1–5 April, 1985. It was organised by the Science Popularisation Committee of the Geological Society of China, and it was attended by 130 participants, who submitted 86 papers.



Fig. 2 Nanjing volcanoes landscape

The China Tourism Earth Science Research Institute (Organising Committee) was established at the meeting. Daguang Sun, Jiqing Huang and Renzhi Hou were elected honorary presidents; Chunyu Li, Zhenxi Gao and Weihan Yin were elected as scientific advisers; Anze Chen was elected president; and Kaiming Tian, Chuankang Chen, Zhi Guo, Bingluo Wang, Xianmin Xia, Changren Sun and Guoxing Zhou were elected vice presidents. Weixin Li was the secretary-general, Erkuang Zhang was the deputy secretary-general, and there were 42 members. The conference adopted the recommendations of the Council and the State Council's 'Geosciences investigation and research work in developing tourism'. The meeting adopted the constitution and made recommendations for strengthening research in earth science for the development of the tourism industry to the State Council. Since 1985, the meeting has been held annually in different cities around China. The 33th annual meeting was scheduled to be held in Chongqing on 27–29 November 2018.

National Geopark in China, Self-Guided Geotour Book The Ministry of Land and Resources published the 'National Geopark Planning Compilation of Technical Requirements'. One of the provisions requires every geopark to publish a geopark science guidebook for the public. Therefore, each national geopark in China has a standardised book with an assigned serial number and similar format and design. As of March 2012, there were 221 serial numbers and 32 volumes (in provinces, municipalities and autonomous regions). Nine had been published, and the others were in the process of editing and printing. Because the books target the general public, they are written in simple, understandable language with many illustrations, pictures and diagrams. The geology and landscape of each park and their formation and evolution are introduced. These books provide tourists a convenient means of reference and are excellent self-guided tour books.

National Geopark of China National geoparks in China refer to nationally designated areas containing geological heritage with unique scientific, aesthetic, educational, and economic value. These areas usually possess outstanding geological, ecological and cultural landscapes and are properly managed under local governments or assigned organisations. They also have thorough environmental protection, geoconservation and sustainable development plans to support environmental protection and foster local sustainable development for the benefit of the local people.

National Geopark of China, Assessment Committee In August 2000, based on the National Geoheritage (Geoparks) Leading Group and Staff Notification (Department of Land and Resources No. [2000] 68), the Ministry of Land and Resources established

China's National Geoheritage (Geoparks) Assessment Committee. It comprises members from different professional backgrounds, such as geosciences, environment, planning, tourism, environmental conservation and management, and is responsible for assessing the qualifications of applicants.

National Geopark of China, Logo The idea of the Chinese National Geopark logo was initiated by Chen Anze, and the logo designed by Liang Xiangrong. The circle is surrounded by the Chinese characters for 'Chinese National Geopark' with the English translation at the bottom. The inner circle is a pictogram with the ancient Chinese character 'mountain', which stands for hills and caves. The centre is marked by the Chinese character 'water', representing water bodies such as rivers, lakes, the ocean, springs and waterfalls. It also resembles stratigraphy and geological structures of folds and faults. The lower part highlights the importance of palaeontology, which is represented by a Jurassic dinosaur, Mamenchisaurus, that was discovered in Sichuan. The design reflects the geodiversity and embodies the rich culture of China. It is a simple, impressive expression of the scientific and cultural connotations of Chinese geoparks. The logo can only be used with the authorisation of the Ministry of Lands and Resources.



National Geopark Planning and Technical Requirements The Ministry of Land and Resources released the Land & Resources Development (2010) No. 89 Document on 12 June 2010. It includes seven chapters that describe the basic principles of planning, references, focus and technical requirements, and scope of application. The technical requirements illustrate the three major tasks of geoparks: protection of geological relics and the natural environment, popularisation of scientific knowledge and promotion of sustainable economic and social development. It also stipulated the basic principles of the preparation of geoparks: conservation priority, scientific planning, utilisation, objectives, characteristics, and their roles in overall planning.

National Geopark, Comprehensive Study Report This report is one of the most important documents in an application for a national geopark. Based on the National Geopark Comprehensive Survey Report promulgated by the Ministry of Land and Resources in 2011, a detailed investigation on the geological heritage, natural environment, and historical, cultural and socio-economic conditions is needed to justify the application. The report comprises seven chapters: (1) qualifications; (2) scientific value; (3) geography; (4) regional geology; (5) landscape resource survey; (6) resource protection; and (7) geopark planning. The document should contain six geological maps and a planning outline.

National Geopark, Declaration and Approval The declaration and approval of national geoparks are performed every 2 years by the Ministry of Land and Resources. The preliminary assessment is done by the provincial Department of Land and Resources. If the result is satisfactory, the applying provincial geopark will be recommended to the Ministry of Land and Resources and then evaluated by the National Geopark Committee. If accepted, the nomination will be sent to the National Geoheritage Protection (Geopark) Committee for final assessment and approval before national geopark status is granted. In 2009, the assessment procedures changed, including (1) allowing an application only once every 2 years instead of once every year; (2) allowing only two applicants from

each province each time; and (3) the examination and approval will go through three stages, comprising review of applications by the assessment committee, establishment of the geopark within 3 years based on the geopark development standards and the requirements of the Ministry of Land and Resources, and, upon completion, MLR experts will perform a site inspection and verification of the details of the geopark prior to granting the title of National Geopark.

National Geopark, Establishment and Opening According to the 'National Geopark Establishment Standards' of the Ministry of Land and Resources, every potential geopark applicant should complete the establishment of the geopark within 3 years. To complete this process, the potential geopark must (1) prepare a geopark plan and geoheritage protection plan (30 points); (2) establish and complete an interpretation system (40 points); (3) conduct scientific research and activities (15 points); and (4) establish an efficient management structure and information system, including setting up an office, arranging human resources, constructing a geopark database, installing a security monitoring system and building a geopark website (15 points). After completion of this work and preparation, the geopark will be formally inspected and approved by the local government. It will then go through an inspection by experts representing the Ministry of Land and Resources. When the inspection is acceptable, formal approval will be given by the Ministry of Land Resources. The local government will then officially host the geopark opening ceremony, which marks the opening of the geopark to the public.

National Geopark, Supervision and Inspection System In 2008, the Ministry of Land and Resources set up a team of assessors to conduct routine inspections of the development of geoparks. The roles of this assessment team include (1) ensuring that the laws and regulations of geological heritage protection are properly enforced in the geopark; (2) monitoring the development and progress of the geopark; (3) monitoring the implementation of the geopark planning; (4) auditing the proper use of geological heritage protection funding; (5) investigating damage to geological heritage and illegal developments due to unlawful activities; (6) submitting an inspector's report to the Ministry of Land and Resources; and (7) investigating other matters associated with the healthy development of the geopark.

National Geopark, Technical Requirements The *National Geopark Planning and Technical Requirements* were promulgated by the Ministry of Land and Resources in 2010. In addition to the *Technical Requirements*, there are two annexes: (1) outline of *National Geopark Planning* and (2) outline of *National Geopark Planning Study.* The *Technical Requirements* provide planning principles, key points, results, planning submission, approval and release. They clearly stipulate that plans shall be formulated by the municipal and county governments in the region of the national park and shall be promulgated and implemented by the local municipal and county governments after being examined and approved by the Ministry of Land and Resources as the basis for the establishment and management of the national geopark.

National Geoparks Network of China The National Geoparks Network of China was established in 2000 by the Ministry of Land and Resources for the purpose of protecting geological heritage. The first group of 11 national geoparks, including Shilin Stone Forest, was reviewed in October 2000 and approved in March 2001. The second group of 33 national geoparks, including Huangshan, was reviewed in October 2001 and approved in 2002. Similar reviews and approval are generally carried out every year. The 3rd group included 41 national parks (including Wangwushan National Geopark in Henan Province), which were reviewed in 2003 and approved in 2004, and the 4th group included 53 national geoparks (including Taishan National Geopark), which were reviewed and approved in 2005. The 5th group included 44 national geoparks (including Jilin Changbaishan), which were reviewed and

approved in 2009. In September 2010, special approval was given to Hong Kong to establish a national geopark. The 6th group of 17 national geoparks (including the Luoping Paleontological Group Geoparks in Yunnan) was reviewed and approved in 2011. In 2012, 19 national geoparks (including Zhangye) were reviewed and approved. By December 2017, China had 207 national geoparks. To facilitate public understanding of the establishment of national geoparks, a numbering system has been used to identify the geoparks. For example, No. 001 is the code for Yunnan Shilin National Geopark. These numbers are the permanent codes of the national geoparks.

National Land and Resources Education Base (or Centre) This is a nationwide science popularisation initiative of the Ministry of Land and Resources. It is based on the 'Law of the People's Republic of China on Popularization of Science and Technology' and the 'Outline of Action for Science and Technology Popularization of the Ministry of Land and Resources (2004–2010)'. The focus of this initiative is to promote geoscience through comprehensive public education programmes and promotions. Geoparks and mining parks are used as training sites for these purposes.

National Main Functional Area Plan On December 21, 2010, the State Council announced the 'National Main Functional Area Plan' with Guo Fa (2010) No. 46 Document. It is a strategic, basic and guiding plan for the development of China's territories and space. It comprises of six parts: planning background, guiding ideology, planning objectives, national level thematic and functional areas, energy and resources, and protection and security measures. The plan incorporates national nature reserves, world cultural and natural heritage sites, national scenic attractions, forest parks and geoparks into the national list of prohibited development areas.

National Mining Park of China, Logo The outer circle contains the characters for National Mining Park of China in Chinese in the upper part and the words in English in the lower part. The inner pictogram contains an ancient Chinese character for 'mountain' representing mines, two crystals representing mineral resources, and a white curve representing mining shafts and opencast mining. The yellow and green colours are used to represent the restoration of mining sites. The logo expresses the importance of mining site restoration and their proper use for developing local sustainable tourism.



National Mining Parks of China The Ministry of Land and Resources began building national mining parks in 2005 in an effort to protect mining heritage and promote the sustainable development of the economy and society in mining areas. A total of 72 national mining parks had been built by 2017. The first group of 28 mining parks, including the Beijing Pinggu Huangsongyu National Mining Park, was approved on August 23, 2005. The second group of 33 mining parks, including the Heilongjiang Daqing Oilfield National Mining Park, was approved on May 17, 2010. China is the first country in the world to build national mining parks. To make it easier for people from all walks of life to become familiar with China's national mining parks and obtain relevant information, the parks were coded according to the date of being approved by the Ministry of Land and Resources. For example, '001' represents the code of the Beijing Pinggu Huangsongyu National Mining Park, and the other mining parks have followed this rule to obtain their respective permanent codes.

National Park A national park is a special natural park set up by a nation to protect natural landscapes and the ecological environment while providing the public recreation, research and earth science education. In addition to protecting the ecological environment, national parks provide enjoyment for visitors and are ideal sites for scientific research. Yellowstone National Park in the USA was established in 1872 and was the first national park in the world.

National Park Service, NPS On August 25, 1916, President Woodrow Wilson signed an act to set up the National Park Service (NPS), which is entrusted with the management of 35 national parks, national monuments and future national parks. The NPS is under the U.S. Department of the Interior and has stable administrative functions. With extensive experience in the planning and management of national parks and the long-standing and strong financial support of the federal government, the NPS has promoted the best practises of management and science-based creation of parks for its global counterparts. The NPS is designed to conserve the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of current and future generations. The NPS works with its partners to develop world-class working mechanisms for natural and cultural preservation.

National Park System, Argentina In 1903, Francisco Menenau donated 73 km^2 of land in a lake area at the foot of the Andes Mountains to the government to set up a national park, which began Argentina's establishment of nature reserves. In 1934, the Congress passed a law and began to devote efforts to the establishment of a national park system. The Nahuel Huapi and Iguassu National Parks were set up, and the National Park Police was established to stop logging and hunting in the park. The originally established national parks embody a strong sense of national sovereignty. A new law in 1970 incorporated the national park into a larger protection system, in which national parks should be protected as national monuments, educational reserves and nature reserves. Since the 1980s, the central government has delegated power to encourage local communities and governments to jointly manage park affairs. Ten national parks have been set up jointly by the central and local governments. The National Park System of Argentina currently includes 29 national parks, and the National Park Headquarters is in charge of the planning, guidance, and management of the national parks.

National Park System, Australia Australia established the second national park in the world. The Australian Federal Constitution later stipulated that it is the responsibility of state governments to set up and administer national parks and other types of natural reserves. Currently, the Australian Federal Government directly administers 15 parks and protected areas. State governments across the country have contributed to the establishment of a large national park system within Australia and Tasmania. In addition to national parks, local and state governments have established approximately 3,200 protected areas, such as conservation parks, reserves, and wildlife sanctuaries, which account for 5.3% of Australia's land area. The government has also built 228 marine parks or marine reserves in estuaries, of which Uluru-Kata Tjuta and Purnululu have been listed on the World Heritage List.

National Park System, Bolivia National parks play a core role in the protection of nature reserves in Bolivia. As of 2008, Bolivia had 13 national parks. In 1939, the government of Colombia launched Parque Nacional Sajama, the first national park in the country. In September 1995, the Kaa-Iya del Gran Chaco National Park was established; it has a total area of 33,996 km^2 and is the largest national park in Bolivia. In 2001, Noel Kempff Mercado National Park was added the World Heritage List. In Bolivia, Integrated Management Natural Areas are usually set up on the outskirts of national parks to serve as buffer zones to protect the core of the national park.

National Park System, Brazil The Brazilian government established the first national park, Itatiaia National Park, in 1937 based on the Rio de Janeiro Botanical Garden. There are currently 67 national parks, including two marine national parks. Tumucumaque National Park is located in the Amazon Basin and covers an area of 36,000 km^2. It is the largest national park in Brazil. Iguagu National Park (1986), Jau National Park (2000), Chapada dos Veadeiros and Emas National Parks (2001) have been listed as World Heritage Sites. Serra da Capivara National Park was listed as a cultural heritage site on the World Heritage List in 1991.

National Park System, Canada After establishing the third national park in the world in 1885, Canada established five new national parks in just 20 years. In 1911, Canada established the first national park service in the world. In the 1970s, Jean Chrétien emphasized the 'National Park System' regulations from a bio-geographical point of view, which promoted the development of the Canadian national park system. In a narrow sense, a national park refers to a park on land. Canada has tried to establish at least one symbolic national park in the natural preserves in 39 of its national parks. Under this system, 43 national parks were established, which fulfilled 60% of the original goal of establishing national parks. Broadly, national parks in Canada also include national marine conservation areas and national historical sites. The national park system is important for the development of eco-tourism, natural tourism, cultural tourism and heritage tourism in Canada. More than 10 national parks (including Banff National Park) have been listed on the World Heritage List by UNESCO.

National Park System, Chile Parque Nacional Vicente Perez Rosales, the first national park in Chile, was established in 1926. It is located in the southern Los Lagos region. The iconic image of this national park is the reflection of the volcano on the lake. Currently, Chile has 32 national parks in its national park system. Many are in high elevation areas in southern Chile and feature fjord shoreline landscapes, which have become a characteristic of Chile's national park system. In the Pacific, the Rapa Nui National Park on Easter Island was added to the World Heritage List by UNESCO as a cultural heritage site in 1995 because of its unique giant stone statues.

National Park System, Columbia National parks are part of the Colombian nature protection system and natural park system. The 55 national natural parks include 27 nature reserves. The Purace National Park, which is located in the central part of Columbia, namely, the Andean region, was established in 1968 and was the first national park in Colombia. Chiribiquete National Park in the Amazon Basin was established in 1989, covers an area of 12,800 km^2 and is the largest national park in Colombia. Situated in the tropics, many national parks protect typical tropical rainforests. However, the development and planting of tropical economic crops have posed serious challenges to the protection of natural resources and the ecological environment. In 1994, Los Katios National Park was added to the World Heritage List as a natural heritage site.

National Park System, Costa Rica The Costa Rican Ministry of Environment and Energy National Reserve Department is in charge of all affairs related to national parks. Currently, there are 26 national parks in Costa Rica. La Amistad International Peace Park (previously known as La Amistad International Park) and Cocos Island National Park were included in the World Heritage List by the United National Educational, Scientific and Cultural Organization (UNESCO). The national park system has introduced proactive and feasible policy measures for environmental protection and ecotourism development, which has been regarded as a model for other countries.

National Park System, Democratic Republic of Congo The Democratic Republic of Congo (DRC) straddles the equator. It established the first national park in Africa in 1925 while it was a colony of Belgium, which was the Albert National Park (renamed Virunga National Park

after the DRC gained independence). Two years after UNESCO launched the World Heritage List, the DRC government filed applications for its famous national parks to be added to the list. As of 1984, four national parks, namely, Virunga, Kahuzi-Biega, Garamba and Salonga, have been listed on the World Heritage List. The value of the national parks is that they can protect large herds of wildlife. The national parks on the World Heritage List are also on the List of World Heritage in Danger. Due to the outbreak of the civil war in 1998, the national parks are still in danger and thus are still on the list.

National Park System, Finland In 1956, seven national parks were established in Finland. An additional 12 national parks were opened in 1982. By the end of 2005, there were 35 national parks. Metsahallitus (a state-owned forest and park service company) is in charge of all affairs related to national parks. The national parks in Finland cover nearly 8,150 km^2, representing 2.5% of the country's land. In 2007, 1.7 million tourists visited Finland's national parks, half of which visited Pallas-Yllastunturi, Oulanka, Urho Kekkonen and Nuuksio.

National Park System, France In 1963, the French government established its first two national parks, Vanoise National Park in Savoie and Port-Cros National Park in Var. There are currently 10 national parks in France and French overseas territories. The government set up a French National Parks Bureau to manage this system. France is a highly developed country. The French national parks protect a total area of 3,710 km^2 in the core areas and 9,162 km^2 in buffer zones in France, covering more than 2% of the area of the country. The Parc National des Ecrins in the Alps covers 918 km^2 and is the largest national park in mainland France.

National Park System, Gabon In 2002, President Omar Bongo announced that more than 10% of the country's national heritage would be used for nature conservation with the designation of 13 national parks and the establishment of a national park system. This system was established to protect gorillas and forest elephants in the tropical rainforests of Africa. Only Costa Rica is comparable to Gabon in terms of the proportion of the country's total land area designated as national parks. In 2007, Lope-Iocanda National Park was added to the World Heritage List as a mixed cultural and natural heritage site due to its outstanding diversity of natural ecosystems and cultural landscape value.

National Park System, Germany Germany has 16 national parks, 14 biosphere reserves and 98 nature parks. The Nationalpark Bayerischer Wald was established in 1969 as the first national park in the country. The German nature conservation law stipulates that national parks and nature parks belong to the same large-scale system. Currently, the nature park system is large and is influential in Germany. The Lüneburg Heath Natural Park was established in 1921 and has longest history. The Black Forest Nature Park in north-central Germany covers an area of 3,750 km^2 and is the largest nature park in Germany. Most of the nature parks in the border areas are included in the European park network.

National Park System, India Hailey National Park, which is now called Jim Corbett National Park, was the first national park in India and was founded in 1935. Additional development was slow, and by 1970, only five national parks had been set up in the country. In 1972, the country issued the Wildlife Conservation Law and launched the 'Tiger Project' to protect natural habitats. In the 1980s, the federal government strengthened legislative actions in wildlife protection. As of April 2007, 96 national parks had been established. The national parks in India cover a total area of 38,029 km^2, accounting for 1.16% of the total land area of the country. The Indian government plans to set up a total of 166 national parks.

National Park System, Indonesia Indonesia began its first national park, Berbak National Park, on Sumatra Island in 1935, and subsequent large-scale system development began in 1980. The government has currently designated approximately 50 national parks. The parks range in size from Lorentz National

Park, which covers 25,050 km^2, to Kelimutu National Park, which covers only 50 km^2. The Karimun Java, Kepulauan Seribu, Kepulauan Wakatobi and Taka Bone Rate national parks play major roles as ocean parks because they contain large areas of water. The Komodo, Ujung Kulon, Lorentz, Bukit Barisan Selatan, Gunung Leuser and Kerinci Seblat national parks are listed on the World Heritage List, and Betung Kerihun is on the reserve list.

National Park System, Iran Iran's series of territorial reserve systems is composed of national parks, nature parks, wildlife sanctuaries and biosphere reserves. There are currently 7 national parks, 26 protected areas and 6 - wildlife refuges in the country, including Golestan, Sisangan, Kavir, Kharturan, Tandooreh, Khojir, Sorkhe Hesar, Bakhtegan, Lake Urmia and Bambo. In 1966, Golestan National Park was the first national park to be established in Iran, and it was recognised as Iran's first biodiversity reserve 10 years later.

National Park System, Israel The government of Israel promulgated Decree No. 5723 in 1963, which announced the establishment of the National Park Service and the National Nature Protection Agency. Because the designation of national parks has political implications, this process is under the jurisdiction of the Prime Minister's Office and guidance of the Minister of the Interior. National laws stipulate that the 'primary purpose of national parks and nature reserves is to satisfy tourists' enjoyment'. In 1998, the National Nature Protection Bureau were established by the National Assembly and the National Wildlife Conservation Bureau. As of July 2007, Israel had 41 national parks and 14 national nature reserves.

National Park System, Italy In 1922, to protect the Alpine Capra ibex (a wild antelope species), the Gran Paradiso National Park was established as the first national park in Italy. There are currently 24 national parks in Italy with a total area of 15,000 km^2, which accounts for approximately 5% of Italy's total land area. Pollino National Park (nearly 2,000 km^2) is the largest national park in Italy, and the smallest is Cinque Terre National Park (only 38.6 km^2). In 1998, Cilento and Vallo di Diano National Park, together with the nearby archaeological sites and cultural landscapes, was added to the World Heritage List. Italy's national parks, natural parks, and regional parks are inter-connected and linked with many towns, which promotes the conservation of natural resources and provides important places for outdoor recreation and natural tourism.

National Park System, Japan Japan has a unique national park system, which includes national parks (Kokuritsu Kōen) and quasi-national parks (Kokutei Kōen). Kokuritsu Kōen translates into "national park", and these parks are managed directly by the central government. There are currently 29 national parks, which form a common national park system. Kokutei Kōen is generally translated into 'quasi-national park', and these parks are recognised by the central government and managed by the prefectural and local governments. There are currently 56 quasi-national parks, which are important complements to the national park system. The *National Parks Law* was passed in 1931. In 1934, the first group of national parks was established, which included Setonaikai, Unzen and Kirishima. The total area of the national park system has reached 20,482 km^2 (5.4% of the total land area of Japan), and the total area of the quasi-national parks has reached 13,328 km^2 (3.6% of the total land area of Japan). In Japan's national parks, 61.9% of the land is owned by the country, 12.2% is publicly owned, and 25.9% is privately owned.

National Park System, Kenya Nature reserves and national parks make up the natural protection system in Kenya, and 20 nature reserves have been appointed as national parks. The first national park in the country, Nairobi National Park, was established in 1946. The current national park system includes savannahs, alpine snowy peaks, coral reefs, wildlife sanctuaries, and aboriginal reservations. Mount Kenya National Park and three other national parks in the Lake Turkana District

were added to the World Heritage List in 1997 and 2001, respectively. Ecological tourism centred on wildlife sightseeing forms the foundation for the sustainable development of national parks and the surrounding communities. The Kenya Wildlife Service (KWS) oversees the affairs concerning national parks in Kenya.

National Park System, Mexico Mexico recognises 67 federally protected natural areas, including national parks, which are administered by the National Commission of Protected Natural Areas (CONANP). In November 1917, Desierto de los Leones National Park was recognised as the first national park in Mexico. The Mexican government established new national parks from the 1930s through the twenty-first century. Mexican national parks cover a total area of 15,056 km^2. The national park system includes not only the rich historical cultural heritage of Indians but also the tropical forest ecosystem that is vital to the global environment. The parks are popular destinations for cultural heritage tourism and natural eco-tourism. In 1987, Palenque National Park was listed on the World Heritage List as a cultural heritage site.

National Park System, New Zealand In 1887, New Zealand established the fourth national park in the world, namely, the Tongariro National Park. New Zealand currently has 14 national parks, which are administered by the Department of Conservation under the 1980 National Park Act. The national park system has two important goals. First, it aims to preserve the unique landscapes, natural characteristics, and scientific value of ecosystems of national significance. It also provides the public with free access to parks on the basis of protecting the local flora and fauna and the overall interests of the park. Within the system, 550 km^2 is categorised as special protection areas, which only allow those with a special permit to enter. The wilderness areas established in the park only allow walking trails and simple houses to be built for wildlife monitoring and scientific research. Tongariro, Westland Tai Poutini, Aorak Mount Cook and the Fiordland National Park have been included on the *World Heritage List*.

National Park System, Norway Norway passed the 'Nature Protection Act' in 1954 to create an institutional environment for the establishment of protected areas within the country. The Nature Protection Government Advisory Committee proposed establishing a draft system plan for 16 national parks. The first two national parks were established in 1962 and 1963. By 1982, Norway had set up 16 national parks. In 1986, the Advisory Committee proposed a second park system. The government approved it in April 1993 and launched the second group of national parks. Currently, 36 national parks have been established, of which 29 are in Norway, and 7 are on Svalbard in the Arctic Ocean. Most national parks allow hiking, skiing and camping activities. Many have overnight accommodation facilities. In addition to national parks, Norway also has landscape reserves, nature reserves, natural monuments and other smaller protected areas.

National Park System, Peru Peru has nine national parks with a total area of 818 km^2, which represents 2.27% of its total land area. The National Park System of Peru serves as an example of safeguarding natural ecosystems by prohibiting the direct exploitation of natural resources and the immigration of outsiders by law. Visits to these national parks for scientific, cultural or educational purposes are encouraged by the government. Huascarán National Park and Manú National Park, respectively, were added to the World Heritage List in 1985 and 1987, respectively, due to their natural significance. In 1990 and 1992, Río Abiseo National Park was added to the World Heritage List for its cultural and natural values, respectively.

National Park System, Russia The first national park in Russia was established in 1983. Currently, there are 40 national parks in Russia with a total area of approximately 71,700 km^2. Russia's law on protected areas stipulates that national parks are lands or waters that are dedicated to nature conservation, ecological education, and scientific

research. These parks should have special ecological, historical, and aesthetic values. The government allows limited development of the tourism industry. Each park is zoned according to different functions, including 'Strictly Protected Areas', which are called Zavodnik in Russian. There are also recreational areas and buffer zones that allow economic activities such as tourism and traditional land uses (such as environmentally friendly agroforestry). To fulfil the strict protection function, formal strictly protected areas are often established in regions adjacent to the park. The Zabaysky State Park on the eastern bank of Lake Baikal has a strict Bar-guzin protected area. The Russian Ministry of Natural Resources is currently in charge of the national parks in the country.

National Park System, South Africa The national park system of South Africa has experienced a unique history of development. In 1884, Kruger began to promote the idea of national parks in South Africa. In 1926, Kruger National Park was established as the first national park in South Africa. Currently, South African National Parks (SANParks) manages most of the national parks in South Africa. However, the KwaZulu-Natal National Park is managed by the Ezemvelo KZN Wildlife (a new governmental organisation formed by the Natal Parks Board and the KwaZulu Department of Nature Conservation). Many national parks have joined the Peace Parks Foundation and were then renamed. National botanical gardens and provincial parks also play significant roles in South Africa. Private parks have become increasingly important in the preservation of natural resources. There are currently 19 protected areas named national parks, which are the best destinations for tourists to closely observe wildlife.

National Park System, South Korea In 1967, South Korea established the Chirisan National Park as the first national park in the country. It remains the largest national park in South Korea. The Tadohae National Park covers an area of 2,200 km^2, but the majority of the park is covered by water; thus, it is a marine national park. The Wolchulsan National Park is the smallest national park in South Korea and has an area of only 56 km^2. Except for Hallasan National Park and Gyeongju National Park, the national parks are under the direct management of the Korea National Park Service, which was established in 1987 and was initially part of the Ministry of Construction. It was transferred to the Ministry of Environment in 1998. South Korea currently has 20 national parks covering 6.6% of the country. Most are located in mountainous areas and coastal areas, and four of them contain sea areas.

National Park System, Spain In 1918, Spain established the National Park of Covadonga Mountain as the first national park in the country. It is home to golden eagles, bank beavers and wild wolves, and it was later renamed the National Park of the Picos de Europa. Under *Spanish Law 41/1997*, the Spanish government established a new model of shared management of the national parks between the national and the regional governments (or autonomous community governments). Spain now has 14 national parks, which are managed by the Ministry of Agriculture, Food and Environment. Dofiana National Park covers an area of 758 km^2 and is Spain's largest national park. Garajonay National Park was listed as a cultural heritage site in 1986, while Dofiana National Park (1994) and Teide National Park (2007) were included in the World Heritage List as natural heritage sites.

National Park System, Sri Lanka Sri Lanka established the Yala National Park and Wilpattu National Park in December 1938. Since then, the national park system has been expanded, and there are currently 20 national parks. Wilpattu National Park covers an area of 1,317 km^2 and is Sri Lanka's largest national park. Horagolla National Park, which was established in 2004, and Galwaysland National Park, which was established in 2006, are mainly protected by nature, and each covers less than 1 km^2. As a tropical island nation in the Indian Ocean, Sri Lanka's national park system covers a large area of tropical

rainforests and is a top choice for eco-tourism such as jungle adventures, wildlife tourism, and outdoor photography. The Forest Conservation Department is in charge of the national parks in the country.

National Park System, Sweden In 1909, Sweden took the lead in Europe in establishing the first group of nine national parks through legislation. The 29 national parks in Sweden are managed by the Swedish Environmental Protection Agency (EPA). More than 90% of the area of the parks is mountainous. The large parks are mostly in northern Sweden, such as the Sarek National Park and the Padjelanta National Park, each of which covers an area of 2,000 km^2. Many parks are now part of the northern region of Lapland, where the indigenous Sami people live. They have a harmonious culture based on the domestication of local reindeer. These regions are now listed on the World Heritage List. Because of the forest coverage, the total area of the three national parks in southern Sweden (Soderfisen, Dalby and Stenshuvud) is less than 20 km^2.

National Park System, Tanzania Preparations for building national parks in Tanzania began in the early twentieth century. In 1948, Tanzania announced the establishment of Serengeti National Park, and in 1951, it was included on the protection list as the first national park. There are now 16 national parks in Tanzania with a total area of more than 42,000 km^2. In 1959, the National Park Service was set up to manage the national parks. The national parks operate as state-owned enterprises. There are no financial subsidies from the government, but all revenues from park operations are used to develop the parks. Arusha and Serengeti National Parks have gained worldwide reputation as locations for filming wildlife documentaries. Serengeti National Park and Kilimanjaro National Park were added to the World Heritage List in 1981 and 1987, respectively.

National Park System, Thailand Khao Yai National Park, which was the first national park in Thailand, was planned to open as Thailand promulgated the *National Park Act* in 1961. The first national marine park was established in Khao Sam Roi Yot in 1966. In 1993, the government set up two separate agencies to manage the national land parks and marine parks. According to the *National Park Act of Thailand,* national parks should have ecological significance and aesthetic value, and the area for unique animals and plants must not be less than 10 km^2. Currently, Thailand has 102 national parks (of which 21 are national marine parks). Another 33 land-based national parks and three national marine parks are under construction. In 2002, the newly established Department of National Parks and Wildlife Conservation under the Ministry of Natural Resource and Environment of Thailand took control of the national parks from the Royal Forest Department of the Ministry of Agriculture and Cooperatives of Thailand.

National Park System, Turkey Karatepe Aslantas History National Park and Yozgat Famligi Pinewood National Park were established in 1958. As of 2008, the national park system in Turkey included 39 national parks with a total area of 8,778 km^2, seven of which are composed of dammed lakes that serve as tourist resorts. Turkey's national holiday resorts mainly consist of national parks, natural parks, and forest recreation sites, and they receive 15 million tourists annually for outdoor sightseeing. The national parks, together with the Wildlife Protection Service, take care of these recreational resources and are responsible for the development and maintenance of tourism infrastructure. In 1985, Göreme National Park and the Rock Sites of Cappadocia were added the World Heritage List as cultural and natural heritage sites.

National Park System, U.S.A. The national park system broadly refers to all natural and cultural heritage sites administered by the National Park Service (hereinafter abbreviated as NPS). Currently, the system includes a total of 394 parks, including 24 national battlefield parks, 18 national recreation areas, 76 national monuments, 120 national historical parks, 58 national parks, 10 national waterfront parks, and other national recreational sites,

which cover 319,713 km^2 and account for 3.6% of the US land area. In a narrow sense, the national park system refers to the 58 national parks administered by the NPS, of which 14, such as Mesa Verde National Park (1978) and Yellowstone National Park (1978), have been added to the World Heritage List by the UNESCO.

National Park System, United Kingdom Early in the nineteenth century, the English romantic poet William Woodsworth was deeply impressed by the rural scenery of the Lake District in England and hailed it as 'a state property that anyone has the right to appreciate with their eyes and by their heart'. This statement has become a foundation of the philosophy of building and developing national parks. In 1951, the Lake District, Peak District, Dartmoor, and Snowdonia were designated as the first national parks in Britain. The current national park system includes 10 national parks in England, covering 7% of its territory, three in Wales, which account for 20% of its land, and two in Scotland, accounting for 7% of its land. There are no national parks in Northern Ireland. Cairngorms is the largest national park in the United Kingdom, with a total area of 3,800 km^2. South Downs, the most-visited national park in the United Kingdom, receives nearly 40 million visitors annually. The national parks in the United Kingdom operate independently.

National Park System, Venezuela Venezuela established its first national park, Henri Pieter National Park, in 1937. The Canaima National Park, which covers an area of more than 30,000 km^2, is the country's largest and is the sixth largest national park in the world. In 1994, it was added to the World Heritage List. Due to Venezuela's location in the tropics and its rich resources, in addition to the government's emphasis on protection, there are currently 43 national parks, of which 13 are located in the western region, seven are in the Andean Mountains, three are in the plains, six are in the Central District, five are in the Eastern District, six are in the area of Guyana, and three are island and coastal national parks.

National Popular Science Education Base (or Centre) This has been an important initiative of the China Association for Science and Technology since 1999. The mission of this initiative is to increase public interest and enthusiasm in science. The National Popular Science Education Base (NPSEB) in a geopark has the important role of popularising earth science and nature by providing a venue for the public to understand the Earth's history and the different processes that shape the planet. It aligns with the national strategy of 'rejuvenating the country through science and education'. Regular education and learning activities, such as talks, fieldtrips, games, and events, are organised for the general public, schools, government or non-governmental organisations and local communities. Currently, many national geoparks in China are qualified and have been accredited as NPSEBs. The initiative is consistent with geoparks' primary objective of popularising the geosciences and provides them with a systematic and professional way of organising such learning activities. It also serves as national recognition of achievement in promoting science to the public. To become a NPSEB, a geopark must be supported and recommended by the provincial branch of the Association for Science and Technology.

National Scenic Area A national scenic area is a scenic area of a certain scale and scope or a region with appreciation, cultural or scientific value, a natural landscape, a concentrated cultural landscape, or a beautiful environment. These areas are visited by people and are used to conduct scientific and cultural activities. In China, scenic areas are categorised into national and provincial levels. By the end of 1995, China had 208 national scenic areas. China's national scenic areas are equivalent to national parks in other countries.

National Water Resource Scenic Area A national water resource scenic area is a specific water body, shore area or water resources project with aesthetic value, excellent environmental conditions and a certain scale. It is established to provide appreciation, entertainment, leisure,

vacation or scientific and cultural education activities. In China, national water resources scenic areas are approved and reviewed by the Ministry of Water Resources. By 2010, China had 314 national water scenic areas of different types, including reservoirs, wetlands, natural lakes, urban lakes, irrigation districts, soil and water conservation areas, and ancient water conservation projects. Water resource scenic areas are one of the research and service focuses of tourism earth science.

National-Level Scenic Area A national-level scenic area is an area whose natural, ecological or cultural landscapes reflect important natural processes or major historical and cultural developments, is representative of its natural state or has maintained its original appearance. Before a national-level scenic area is approved and announced by the State Council, the people's government of the province, autonomous region or municipality directly under the central government shall submit an application, which will be considered and reviewed by the Department of Construction of the State Council and other relevant departments, including the Department of Environmental Protection, the Department of Forestry and the Department of Cultural Relics. Alternative English names for a national-level scenic area include 'National Park of China', 'Scenic and Historic Interest Area' and 'National Key Scenic Area'.

Natural and Cultural Heritage of the Ohrid Region, Macedonia This region is located near the border with Albania on the shore of Lake Ohrid in southwestern Macedonia. Ohrid City is one of the oldest human settlements in Europe; most of the buildings in the city were built between the seventh and nineteenth centuries. The heritage includes the oldest Slav Monastery (St Pantelejmon) and iconic murals that were made in the eleventh to fourteenth centuries. The murals are said to be the most important iconographic artwork in the world after the collection in the Tretyakov Gallery in Moscow.

Natural Barrier Landscape ► Levee Landscape, ► Natural Barrier Landscape

Natural Complex The Earth's surface is composed of integrated and closely linked natural geographies, which are called natural geographical complexes. Natural complexes can be classified according to type-level sequences, or they can be merged hierarchically from lower-level units. Their horizontal extent and vertical thickness can also be expanded step by step. A tourist area is often a part of a natural complex.

Natural Landscape A natural landscape is a natural complex formed by the interaction of natural factors without the influence of humans. Natural landscapes include geologic geomorphologic landscapes, natural water body landscapes, bio-landscapes, atmospheric landscapes, and space landscapes. Natural landscapes that are affected by human factors such as artificial forests and reservoirs can be called semi-natural landscapes or artificial natural landscapes. Natural landscapes with ornamental value attract tourists and can become important tourism resources, making them the main research focus of tourism earth science.

Natural Levee Landscape *Synonym:* ► *Levee landscape, natural barrier landscape*

This is a landscape composed of natural levees deposited along river banks. During flood periods, the rate of overflow from the river decreases abruptly; therefore, its ability to carry sediments decreases. As a result, abundant sand and mud are deposited along the river banks. When the flood water retreats, various sections of these long levees remain behind, forming the highest part of the floodplain. The two slopes of the levee are asymmetrical; the back-valley slope is steep, but the valley-facing slope is gentle. The levee height increases in every flood. Whenever the levee remains intact, silt accumulates on the riverbed, and it may grow higher than the floodplain, forming an elevated river. Lakes or swamps are often located in the lowlands between two rivers. When a natural levee breaks, the river may change its course and flow out from the break to form a large flood fan. Natural levees are common along the banks of depositional rivers on plains. The

lower course of Huanghe (Yellow River) is the most extensive natural levee in China.

Natural Pollution Toxic substances in the natural environment may go through physical, chemical and biological processes and release toxic substances into the environment. Examples include volcanic ash and harmful gases from volcanic eruptions, smoke from forest fires caused by lightning, silt, dirt and viruses caused by floods, airborne salt particles from seawater evaporation, and liquid particles and sand mobilized by strong winds.

Natural Scenery Tourism Natural scenery tourism includes tourism activities in famous mountains and rivers, canyons and lakes, fountains and waterfalls, forests and grasslands, seashores and islands and other natural scenic areas. It is one of the earliest and most important forms of tourism products. Natural scenery tourism can serve as means of environmental education while providing tourists with the benefits of enjoying the beauty of nature, nurturing the soul, and exercising their will.

Natural System of Wrangel Island Reserve, Russia This reserve is located in the Arctic Ocean approximately 200 km north of the Chukchi Autonomous Region in the Far Eastern Federal District of Russia. Its core area covers 9,163 km^2. This heritage site in the Arctic Circle consists of the mountainous landscape of Wrangel Island (7,608 km^2), Geraard Island (11 km^2) and the surrounding waters. Wrangel Island was protected from the glacial effects of the Quaternary Ice Age and is characterised by exceptionally rich biodiversity. It has the largest population of Pacific walrus in the world and is home to the world's most concentrated polar bear nesting ground. It is the northernmost nesting area for 100 species of migratory birds, including many endangered birds. Currently, 417 species or subspecies of vascular plants have been identified on the island. Its species density is two times that of any other area of the Arctic tundra and higher than that of other Arctic islands.

Natural Tourism Earth Science Resources These are a kind of tourism earth science resource and play a dominant role. They are mainly composed of natural factors such as geology, geomorphology, meteorology, hydrology, and vegetation. Various types of landscapes are formed by lithospheric, hydrospheric, biospheric, atmospheric and cosmic factors. The factors affecting their formation include the geological and crustal structure, strata and rocks, geological dynamics, terrestrial hydrological characteristics and oceanic effects, climate latitude zoning and regional factors, biogeographic processes and their effects, and regional natural geographical environment factors. Due to the diversity of the formation conditions, the resulting landscapes and scenes are also complex. For example, Tianchi (or Heavenly Lake) at Changbai Mountain is a crater lake that was formed after a volcanic eruption. However, the causes of formation are related to the volcanic geology, atmospheric precipitation, thawing of ice and snow, and groundwater recharge. Therefore, the earth science landscape of Tianchi is a combined product of natural geological and geographical factors.

Nature and Geopark Styrian Eisenwurzen, Austria The Nature Park Eisenwurzen became a member of the Global Geoparks Network in 2004. It is located in southwestern Austria and covers an area of 586 km^2. Geologically, it is part of the Northern Calcareous Alps and is composed of limestones and dolomites from the Late Permian to the present, an interval of 250 million years. These rocks were faulted, folded and uplifted during the Alpine orogeny. The landscape was modified by glaciers during the Great Ice Age, and the rivers subsequently shaped the unique landscape. The geopark is geologically significant because it includes the type section of the Anisian stage of the Triassic, Cretaceous and Palaeogene rocks in the Gams area which is associated with the discovery of Austria's largest known marine reptile. The geopark is a magnificent window into the Earth's evolution and shows the harmonious interaction between nature and humans.

Nature Park Terra Vita, Germany Terra Vita Geopark is located in northwestern Germany and has an area of 1,220 km^2. It became a member of the Global Geoparks Network in 2004. Geologically, the park is subdivided into two regions. In the northern 'Aenkum-Bippener Berge', the hills formed during the ice age, and its elevation is higher than the surrounding northern German lowlands. The southern part of the park is classified as a typical mountain landscape. It consists of massive rock masses and separates the 'Muensterland Basin' in the south from the northwestern lowlands. The North Westfalian-Lippian ridge was folded and is characterised by several smaller substructures, such as overthrusts, faults, horsts, small anticlines and uplifts. Its northern edge is composed of Jurassic rocks, and the crest of the central mountain chain is made up of Upper Jurassic sandstones and limestones bearing the 'Dinosaur Footprints of Barkhausen', which is one of the most important geosites. Outcrops of Middle and Lower Jurassic soft shaly claystone with clay-iron concretions can be found in the southernmost part of the park.

Nature Reserve Nature reserves are specially protected areas, such as representative natural ecosystems, natural concentrated areas of rare and endangered wild animals and plants and unique natural relics. Nature reserves in China are divided into three categories: natural ecosystems, wildlife, and natural relics. Nature reserves play a role in protecting the environment and natural resources and also provide tourists with opportunities for ecotourism and environmental education activities.

Nature Reserve Management Regulations These regulations were promulgated by Order No. 167 of the State Council in October 1994 and went into force on 1 December 1994. They are outlined in five chapters: Chapter I, General Provisions; Chapter II, Nature Reserve Construction; Chapter III, Nature Reserve Management; Chapter IV, Legal Responsibility; and Chapter V, Supplementary Provisions. There are a total of 44 regulations. The regulations stipulate that geological structures of great scientific and cultural values deserve special protection. These features include marine areas, coasts, islands, wetlands, inland waters, forests, grasslands and deserts, natural caves, fossil regions, glaciers, volcanoes and hot springs. Nature reserves are to be established for protection, and each reserve area is divided into a core area, buffer zone, experimental area and peripheral protection zone. The public and organisations are prohibited from accessing the core area, and only scientific observations and research activities can be conducted in the buffer zone. The experimental area may be used for scientific activities, teaching and training, visits, tours, and domestication and breeding of rare and endangered wild animals and plants. No construction facilities are allowed in the core and buffer zone areas of nature reserves. No manufacturing facilities that pollute the environment and destroy resources or landscapes are allowed in the experimental area.

Naturtejo Geopark, Portugal This geopark is located in central Portugal and has an area of 4,617 km^2. It became a member of the Global Geoparks Network in 2006. The Bonham-Gacia Fossil Trail Park, the Gortes Valley Gorges, the Coron Hall-Douallo Romano Gold Mine, the granite landforms of Gadhaha Mountain, and the granite landscape of Monsanto Town are the main attractions. Geological heritage sites with national and international importance include outstanding landforms, geology, palaeontology, and mining relics. The Naturtejo Geopark opened a hiking network consisting of more than 260 km of trails that invite visitors to discover the geological diversity and culture of the geopark. Visitors can also start their geotourism on the Tajo River and Zezele by taking a trip by boat or kayak. Less adventurous tourists can choose to take a small bus tour of the geological features. Visitors can also learn about the archaeological sites through the museum network of the Naturtejo Geological Park and become acquainted with the local culture. The new restaurants and geological shops allow visitors to rest.

Needle-Leaf Forest *Synonym:* ▶ *Coniferous forest*
This term generally refers to cold temperate coniferous forests, also known as taiga, that are located in cold temperate regions between 45 and 70° N. They consist of pinus, picea, abies and larch. Larch forests are called 'bright coniferous forests', while evergreen spruce forests and fir forests are called 'dark coniferous forests'. In addition to the cold temperate zones, cold temperate coniferous forests are located in subtropical sub-alpine zones in warm temperate zones. Therefore, they can be considered to be cold-temperate zone vegetation in the vertical zones. In addition, pine forests and Chinese fir forests in low mountainous and hilly subtropical regions are considered warm coniferous forests.

Neixiang Baotianman National Geopark, Henan This geopark is located in the mountains of Neixiang County in the Qinling orogenic belt. It became a national geopark in 2002. The geopark contains a complex continental orogen that formed during several periods due to different processes, and the orogen played an important role in the formation and evolution of the Chinese mainland. The park records the evolutionary history of the orogenic belt over three billion years. The rich, systematic, continuous and complete information about continental dynamics makes it an ideal place for studying the evolution of the Qinling Orogenic Belt. The landscape formed by the Yanshanian granite is also very distinctive.

Nekton Nekton refers to free-swimming aquatic organisms (animals only), such as fish and whales. Palaeobionts such as the Palaeozoic amenoceras, the Mesozoic ammonites and syngnathus are all nektons. In addition to active swimming species, there are also semi-active or weak-swimming species, such as cockles and jellyfish. In addition, many animal larvae are good swimmers.

Neogene Period The Neogene Period is the second period of the Cenozoic Era, and it extended from 23.03 to 18.06 million years ago, a duration of 4.97 million years (old proposal). The latest proposal of the 2010 International Stratigraphic Chart states that it lasted from 23.03 to 2.588 million years ago. The Neogene System includes the rocks that formed during the Neogene Period, which is equivalent to the former Upper Tertiary System and includes the Miocene Series and Pliocene Series. It can be further subdivided into six stages. The Neogene Period was a time of tremendous development of herbaceous plants, and many modern genera and species started to develop. The Neogene Period was also the time of the development of Artiodactyla and the rapid evolution of elephants. Modern mammals developed, and their appearance was akin to the modern types. China's Neogene System mainly consists of terrestrial strata, so there are some difficulties in making stratigraphic correlations. Based on the mammalian fossils and the geomagnetic polarities, the Neogene System in China is divided into six stages, including the Mazegouan Stage and Gaozhuangian Stage of the Miocene Series and the Baodean Stage, Tonggurian Stage, Shanwangian Stage and Xiejian Stage of the Pliocene Series.

Neolith *Synonym:* ▶ *Chipped stone tool*
Ancient man used stones to strike hard rocks to form stone flakes or stone cores for use as tools. There are four methods of creating stone tools: (1) hammering method, (2) anvil method, (3) smashing method, and (4) indirect impact method. Chipped stone tools can be divided into pointed tools, scrapers, choppers, carving tools and spherical tools. The main materials used for making chipped stone tools are flint, onyx, quartzite, quartz sandstone, hornstone and various silicified rocks. Pointed tools have sharp tips, and two to three sides are polished. They generally have a suitable size for holding by ancient men. Pointed tools can be further divided into large and heavy pointed tools, triangular pointed tools and small pointed tools. Scrapers are a common type of chipped stone tool found in Palaeolithic and Mesolithic relic sites. They were made from the stone flakes that shattered from the impacted rocks. Based on the shape, they can

be divided into straight edge scrapers, concave edge scrapers, double edge scrapers, disc scrapers and multi-edge scrapers. Choppers are a kind of chipped stone made of flat pebbles, large stone flakes or stone cores. The stone edge or edges are usually modified to form single-edge or multi-edge tools, which can be used to cut up large animals or to make repairing tools. Choppers are also called chopping devices, cutting devices, axes or adzes. Carving tools are a kind of chipped stone found in the Mesolithic age. These tools were mainly used for wood engraving. Scrapers were found in the Zhiyu relic site in Shanxi Province, and similar scrapers were found in the 8th and 9th layers at Zhoukoudian site number 1. Spherical tools are a kind of chipped stone with a ball shape on which impact marks are visible. They have been found in the Xujia Kiln in Yanggao and at spot number 97 in Ding Village, Shanxi Province, and they are from the Middle Palaeolithic. The exact usage of spherical tools is still unclear. Some believe that were used for fighting animals at a distance (Fig. 3).

Neolithic Age The Neolithic Age is the final phase of the Stone Age, when primitive man had reached the highest standard of using stone tools. This age extended from the Early Holocene (more than 10,000 years ago) to the Middle Holocene (approximately 4,000 years ago). The emergence of neoliths and pottery marks the beginning of the Neolithic Age. The Nanzhuangtou Village Neolithic site in Xushui County, Hebei Province, contains stone tools, bone tools and pottery fragments that C-14 dating dates to 10,815 years before present. The neoliths may have been used through the Chalcolithic Age and the Bronze Age. The neoliths are tools, including axes, shovels, adzes, knives, chisels, choppers, grinding discs, spears, hammers, drills, burrs, arrowheads, hoes, net sinkers and scrapers. There are also bone tools, pottery, clam knives, and jade tools.



Fig. 3 Chipped stone tools

Neotectonic Movement A neotectonic movement is a recent crustal movement. The term 'neotectonic movement' was first proposed by Richarter in 1932 and Krans in 1933, and it was later systematized by Obruchev in 1948 to become a branch of geology. Scientists have several interpretations of the time of neotectonic movements. Nikolayev defined it as tectonic movements that occurred since the Neogene Period. Schulz emphasized that neotectonic movements are tectonic movements that formed modern landforms. Chinese scientists have adopted the 'post-Neogene' interpretation. Later, based on its important role in shaping China's modern landforms, several scientists proposed the 'late Upper Neogene Period' (3.4 million years ago) as the beginning of neotectonic movements. Neotectonic movements have various types and forms. In addition to horizontal and vertical movements, there are endogenic and exogenic force movements, orogenic and non-orogenic movements, acrogenic movements, tilting movements, taphrogenic movements, block faulting, fault creep and fault slip. Neotectonic movements control the landforms on Earth and are also directly related to the formation of earthquakes, volcanoes and hot springs; therefore, they directly affect the human living environment.

Neptunism Neptunism was a theory of geology popular from the end of the eighteenth century to the beginning of the nineteenth century that opposed the theory of plutonism. The major proponent was Professor Abraham Werner (1749–1817), who worked at the Mining Academy in Freiberg (Saxony), Germany. The theory stated that during the early stage of the formation of Earth, its surface was completely covered by an 'original ocean'. All rocks were created by crystallization of dissolved materials in seawater. A thick layer of granite, known as the 'original rock layer', formed first, followed by metamorphic rocks covering the original granite. Later, flooding occurred throughout the world, and mountains composed of early crystallized rocks were eroded to form sedimentary rocks, known as the 'transition layer'. The basalts within the sedimentary layers were interpreted as ash left by the burning of coal seams. Volcanoes were considered to be the result of the burning of underground coal and sulphur. Neptunism once played a dominant role in geology but failed in the face of increasing evidence in support of plutonism. However, in view of the historical development of geology, the debates between these two schools of thought made significant contributions to the advancement of geology.

New Zealand Sub-Antarctic Islands, New Zealand These islands are located in the ocean south of the South Island and are composed of five archipelagos, namely, Snares Islands/Tini Heke, Bounty Islands, Antipodes Islands, Auckland Islands and Campbell Island, that cover a core protection area of 764 km^2. The islands, which are between Antarctica and the subtropics, have high natural productivity, biodiversity and density of wild animals. In addition, the birds, vegetation and invertebrates have endemic characteristics and large populations. A large variety of oceanic seabirds and penguins build their nests here. The islands host a total of 126 bird species, including 40 seabirds, of which only five reproduce in the area.

Ngorongoro Conservation Area, Tanzania This conservation area is located in northern Tanzania and has an area of approximately 80,000 km^2. It covers plains, savannahs, tropical forests and bushes. The protected area was established in 1959. The land use is diversified. The area is a habitat for wild animals and a traditional pastoral area for the semi-nomadic Masai people. It also contains the largest caldera in the world, the Ngorongoro crater. The distribution of globally endangered species makes this area ecologically important. It provides an ideal habitat and migration route for wildlife, such as Africa's wild horses, zebras, gazelles and other animals, to the northern plains. In addition, archaeological research has uncovered evidence of human evolution and of the interactions between humans and the environment, including the oldest human footprints from 3.6 million years ago.

Ngorongoro Crater Landscape This is a crater landscape of volcanic eruptions and collapses in the East African Rift Valley in northern Tanzania. The crater is 18 km in diameter and 610 m deep. It is the world's second largest crater and is also a gathering spot for wildlife in Africa that accommodates 30,000 large animals. The crater is part of the Serengeti National Park, where farming is prohibited. This crater and a surrounding area of 8,300 km^2 were designated as protected areas in 1959, which restricted the number of grazing cattle and banned the construction of houses inside the crater. The upper part of the volcano is covered with snow for the entire year (Fig. 4).

Niangziguan Spring Landscape This is a spring landscape consisting of a group of springs on a sloping erosional structure. It is located in Niangziguan Town in Pingding County, Shanxi Province. The group comprises 32 springs at elevations of 372–392 m. The springs originate in Ordovician limestone and are sloping erosion structure springs. The average flow rate has been 12.04 m^3/s for many years. It is the largest spring in northern



Fig. 4 Landscape of Ngorongoro Volcano



Fig. 5 Niangziguan Spring landscape, Shanxi Province

China. It is a typical stable, large spring because it has a large area, good aquifer capacity, and stable discharge volume (Fig. 5).

Nidang-Type Stone Forest Landscape in Nidang, Guizhou This is a representative type of carbonaceous stone forest landscape. Nidang Stone Forest in Xingyi, Guizhou Province, is a typical example. This stone forest formed in the Middle Triassic limestone strata and contains irregular stone columns with prominent sharp pointed column tops and vertical dissolution marks, which are clearly indicative of surface water erosion. The column bases are surrounded by red earth with eroded holes, which are a sign of underground corrosion. The column heights range from 5 to 12 m, and the highest can reach 25 m. The Nidang-type stone forest has elegant forms and development potential for tourism. Nidang Park in Xingyi National Geopark, Guizhou Province, is a typical stone forest landform of this kind (Fig. 6).

Nihewan Biota This biota is located in the early Pleistocene Nihewan Formation in Yangyuan County, Hebei Province. The fossils are mainly mammals, including Proboscidipparion sinense,



Fig. 6 Nidang-type stone forest landscape in Nidang, Guizhou Province



Fig. 7 Nihewan biota

Equus sanmeniensis, Elasmotherium inexpectatum, Elasmotherium peii, Dicerorhi nusmerckii, Megantereon nihowanensis, late-stage Machairodus, Pachycrocuta brevirostris, Megaloceros, ancient Chinese bison, Sus lydekkeri, Cantschihliensis, foxes, Elephas namadicus and Archidiscodon. Other than individual Neogene fossil pieces, almost all of the fossils are from the Quaternary and are extinct. The ecological types of animals indicate that the environment was a temperate forest and grassland biota (Fig. 7).

Nihewan Quaternary Section in Zhangjiakou This geological section is located in the rock outcrops along both sides of the Sanggan River and Huliu River in northwestern Hebei Province. It was named the 'Nihowan Bed' by G.B. Barbour in 1924. The rock layers contain abundant mammal fossils called the Nihewan fauna. The Nihewan Bed (Formation) is composed of fluvio-lacustrine gravels and sandy clay layers. Its lower part is mostly grey or greyish green, while the upper part is mainly greyish yellow and is covered with loess. The layer below this bed contains the Pliocene 'Hipparion laterite'. Sixty fossils of mammal species were discovered in the Nihewan Formation, including large mammals, such as long-nosed three-toed horses (Proboscidipparion), sabre-toothed tigers (Smilodon), Sanmen horses (Equus sanmeniensis), Sambar deer (Cervus unicolor), ancient bison, woolly rhinoceros



Fig. 8 View of the Nihewan Basin

(Coelodonta antiquitatis) and Chinese raccoon dogs (Nyctereutes), and small mammals, such as entomophages (insectivores), rabbits (Lagomorpha) and rodents (Rodentia). These fossil mammals are similar to the Olivola fauna of Europe from the early stage of the late Villafranchian of the Pleistocene, approximately 1.2–1.8 million years ago (Fig. 8).

Ningaloo Coast, Australia The marine and land heritage site of the Ningaloo Coast is a remote area on the west coast of Western Australia. It has one of the longest offshore coral reefs in the world and is surrounded by a buffer zone. Its terrestrial environment is widely spread over karst landscapes with well-developed underground cave and river networks. The Ningaloo Coast is home to sharks and many other marine species, such as sea turtles. Unique cave systems, underground passages and river systems create a vast network that supports numerous rare species, resulting in marine and coastal areas with outstanding biodiversity.

Ningcheng National Geopark, Inner Mongolia Ningcheng National Geopark is located in Ningcheng County, Chifeng City, Inner Mongolia Autonomous Region. It became a national geopark in 2009. The main geological features include fossils, geological profiles and hot springs. Daohugou orycto-coenosis, which belongs to the Yanliao biota, was preserved in the Middle Jurassic Jiulongshan Formation. The other fossils were preserved in the Lower Cretaceous Yixian Formation and belong to the Jehol biota. The park represents the transition between the Yanliao biota and Jehol biota and is therefore a world class fossil location. The hot spring water is from the shallow subsurface, and it is abundant, having high quality, has a high content of trace elements, and reaches temperatures up to 96 °C. The hot spring water is sulphuric, acidic, nonuniform high-temperature fissure water. Qidan-Liao Cultural Heritage is the theme of humanistic tourism throughout the geopark, and there are many cultural remains, including the site of the Wall of the Middle Capital of Liao, Daming Tower, Jinxiao Tower, Banjie Tower, the Middle Capital of the Liao Museum, Black City Site and Falun Temple.

Ningde Global Geopark, China This geopark is located in Ningde City, Fujian Province, and covers an area of 2,660 km^2. It became a global geopark in 2010. The geopark has three major scenic districts: Baishuiyang, Baiyunshan and Taimushan. It is located in the southeastern part of the Eurasian continental plate, and it is an active belt along the continental margin of the Pacific Ocean and an important component of the volcanic belt in the Pacific. In contains granite, volcanic, riverbed erosion, and coastal erosion landforms. The Taijishan Jingdong Granite Peak Cluster – Stone Egg Landform is the most well-developed granite peak cluster-stone egg landform on the southeastern coast of China, and the Baishui Ocean flatbed bedrock, river erosion micro-geomorphic

landscape, and canyon stream landscape are rare shallow water sites. The park covers an area of 80,000 km^2. Baiyunshan is dominated by a pothole landscape that formed by the erosion of the Guxi and Longting Rivers. Ningde City is a well-known ethnic minority city inhabited by the Yi nationality. It has a strong ethnic culture. Fuan and Fuding are the 'hometowns of Chinese tea', and Pingnan is the 'hometown of China's covered bridges'.

Ninghai Wushan Seashore Grotto National Mining Park, Zhejiang This park is located in Wushan Village and Yuelan Village, Changjie Town, Ninghai County, Ningbo, Zhejiang Province, on the northern bank of Sanmen Bay in the East China Sea. The core area of the park covers approximately 2.30 km^2. The mining park was accredited in 2010 by the Ministry of Land and Resources. It is a hilly area with a group of 14 caves, including Taoist Rock, Yishan Mountain (also known as Santang Mountain), Yiming Mountain (also known as Xiachang Mountain) and Lantou Mountain. The two cave groups at Zhoushan and Smart Mountain are the main scenic sites of the Wushan Grottoes and are among the most abundant and complete quarry caves along the coast of China. One cavern has an excavation of more than 100 m. Due to the magnificent variations, the waterscape of the rattan trees in the cave and the marine scenery outside the cave is dramatic. Therefore, the landscape value of the area is high. The park contains breccia bearing grey-violet to brown crystal tuff. The scenic site has erosion landforms comprising exceptional waterscapes with seasonal waterfalls and colourful lichens in the quarries left behind by previous mining activities.

Ninghua Swan Karsts National Geopark, Fujian This geopark is located in western Ninghua County, Fujian Province, and became a national geopark in 2004. It has an area of 42 km^2. Its geological heritage includes hundreds of karst caves that are mainly located within an area of 16 km^2, with a cave density of 30,500 m/km^2. The park also contains Cretaceous mussel fossils, tortoise fossils, Pleistocene vertebrate fossils, ancient human remains and Danxia landforms.

Ningwu Ice Cave National Geopark, Shanxi This geopark is located on Luya Mountain in the northern part of the Lüliang Mountains in Ningwu County, Shanxi Province. It became a national geopark 2005. Its main geological landscapes include ice caves in the Ordovician Majiagou limestone, lakes in mountainous areas, the Ninghua Ancient Town, Ningwu Pass and other human landscapes. The elevation of the entrance to the ice cave is 2,220 m, and the cave is 85 m deep. The cave walls are covered by undulating stratified ice with natural ice pillars, ice curtains, ice falls, ice flowers, and ice stalactites and stalagmites, which are rare.

Niokolo-Koba National Park, Senegal Niokolo-Koba National Park is located in southeastern Senegal along the border between the provinces of East Senegal and Casamance, near Guinea. It covers a core protection area of 9,130 km^2. Gallery forests and savannahs are located along the banks of the Gambia River due to the availability of water. The geopark is rich in fauna, such as the Derby elands (the largest of the antelopes), chimpanzees, lions, leopards, a large population of elephants, and many birds, reptiles and amphibians.

Nitric Water Nitric water is a mineral water that contains nitrogen. The formation and distribution of nitric water is closely related to the regional geologic structure. Nitric water usually forms during groundwater circulation in a closed deep environment associated with large faults during intense neotectonic movements. It flows to the ground surface along regional faults. It is a basic and common type of medical hot mineral water and is effective for therapeutic use, particularly for treating diseases associated with the cardiovascular system, limbs, and gynaecological, skin and endocrine diseases (hyperthyroidism).

Noel Kempff Mercado National Park, Bolivia This park is located on the eastern border of Bolivia near Brazil. It is the largest natural park in the Amazon Basin and has

little human activity. The heritage site in the core area covers 15,234 km^2 and is at elevations of 200–1,000 m. The natural habitats include tropical savannah grasslands, rainforests and evergreen forests of the Amazon. The park illustrates the natural evolution that began in the Cambrian period one billion years ago. Approximately 4,000 species of wild plants, more than 600 species of birds, and endangered vertebrates with global conservation value live in the park.

Nonmetallic Mineral Nonmetallic minerals are useful due to their physical properties but are not used for the extraction of metals. Most nonmetallic minerals are rock-forming minerals, and some are nonmetallic ore minerals, but some are industrial raw materials by themselves, such as quartz, calcite, feldspar and kaolinite. Most gemstones and jades come from nonmetallic minerals, such as diamonds, rubies, emeralds, jadeites and nephrites. Some nonmetallic minerals are used to extract nonmetallic elements, such as the extraction of phosphorus from apatite. The physical properties of nonmetallic minerals are generally the opposite of those of metallic minerals. They have no lustre, poor conductance and low thermal conductivity, and they are transparent or translucent when cut into 0.03-mm-thick slices and observed under a microscope. Their crystal families and crystalline aggregates can be important ornamental stones.

Noosphere Noosphere is the sphere of human thought. The word derives from the Greek's words 'mind' and 'sphere', in lexical analogy to 'atmosphere' and 'biosphere', respectively. It was introduced by Pierre Teilhard de Chardin in 1922 in his Cosmo Genesis. Due to the development of human civilization, the part of the biosphere that has been continuously transformed is a unique geographical circle on the Earth's surface that is also known as the human circle or technological circle. As human civilization continues to evolve, it strongly influences the other layers, particularly the biosphere of the Earth's surface. Its ability to influence and control humans has become so strong that it is an important part of the Earth's circle.

Normal Fault A normal fault is a fault where the hanging wall block moves down along the fault plane relative to the footwall block. Some normal faults have planar surfaces, and some have curved surfaces. Listric fault systems with steep upper parts and shallowly dipping lower portions are common in Mesozoic and Cenozoic basins. Normal faults are typically extensional structures. When two normal faults dip towards each other, a graben can form through subsidence between the faults. In addition to crustal movement, gravity is sometimes responsible for the formation of small normal faults.

North American Plate This plate includes North America and the western part of the North Atlantic Ocean. Its eastern boundary is the Mid-Atlantic Ridges, and the East Pacific Rise lies to the west. This plate has migrated west due to the expansion of the Mid-Atlantic Ridges, which has caused it to collide with the Pacific Plate along the San Andreas transform fault. The North American Plate began to separate from the Eurasian Plate approximately 100 million years ago.

North China Platform The North China Platform is located between the Yinshan-Yanshan and Qinling-Dabie orogenic belts and covers northern China, the southern part of northeastern China and the Bohai Bay area. In 1945, Huang Jiqing called it the 'Sino Korean Platform'. Due to its small size and greater activity than other platforms, it is also called the 'Sino Korea paraplatform'. It is China's oldest platform. Rocks with isotopic ages older than 3.8 billion years have been found in eastern Hebei Province and Anshan, Liaoning Province. The base of the North China Platform aggregated 1.8 billion years ago during the Zhongtiao Orogeny. A non-metamorphosed layer formed above it in the Mesoproterozoic Era. Approximately 2.4 billion years ago, the original North China Platform disintegrated. Massive intrusions of magma and volcanic eruptions occurred in its eastern part, and the crust was strongly folded, accompanied by the formation of nappe structures. This area is part of the active continental margin of East Asia. The

Ordos in the west has remained stable, and the Mesozoic strata have generally remained horizontal. During the Late Mesozoic Era, the eastern part of this platform transitioned to an extensional environment, which resulted in the formation of the vast North China Plain. The North China Platform has rich tourism resources, and a series of geological parks of varying nature have been developed in recent years. Examples include: (a) the Taishan Global Geopark in Shangdong Province and the Qianxi-Qian'an Geological Park in Hebei, where the oldest Archaean rocks are found; (b) Jixian County National Geopark in Tianjin Province, which is dominated by Proterozoic strata; (c) Fangshan Global Geopark in Beijing; (d) Yuntaishan Global Geopark in Henan; (e) Songshan Global Geopark in Henan; (f) Shihua Cave in Beijing, which is characterised by karst erosion landforms; and (g) Yunmeng Mountain in Miyun, Beijing, which is characterised by Mesozoic intrusive rocks.

North Pennines AONB Geopark, UK This geopark is located in the hilly area of northern England and covers an area of approximately 2,000 km^2. It became a global geopark in 2004. The park includes Cumbria, Durham County and Northumberland. The geological features of the area are of global significance and include typical examples of base metal deposits. The North Pennines formed during the uplift of the Greater Alstomian area, which resulted in numerous major faults, the cliffs of western Eden and the fissures of Tyne to the north. In the hills, the drainage system of the valleys was cut, forming steep gorges in the lower reaches of the Allen River and the gradual opening of the river valley landscape to the Tis Valley.

North West Highlands, Scotland, UK This geopark is located in the far northwestern part of Scotland and covers an area of 2,000 km^2. It became a global geopark in 2005. The park has the most beautiful mountains and coastal landscapes in the UK and numerous important geological sites. The park contains two nature reserves, 54 geological survey and teaching sites, 26 special geosites for research, 17 special protected areas, and 11 special conservation areas. It also has ancient cultural sites, including an Iron Age fortress and defensive towers, the remains of Norwegians, and the castles and houses of Scottish nobles.

Northern Large Karst Spring Landscape This is an extensive spring outflow landscape in the arid and semi-arid regions in northern China. There are extensive areas of Cambrian, Ordovician and Sinian carbonate rocks in Shanxi, Shandong, Hebei, Henan, Shaanxi Provinces and the Beijing area in northern China. There are also scattered karst areas in Ningxia Province, Inner Mongolia, Gansu Province, Xinjiang Province and northeastern China. These karst areas have many karst spring outflows that are important sources of water for these arid and semi-arid regions. Informal statistics indicate that more than 150 springs have natural flows over 0.1 m^3/s, including approximately 60 springs with natural flows over 1 m^3/s (called large karst springs). The natural total flow of these huge springs is more than 200 m^3/s, and they often become important scenic sites. The Niangziguan spring group is the largest fissure karst spring in northern China, and the Jinan spring group is a typical large karst spring landscape in northern China.

Northern Mountain Hengshan Hengshan is one of the Wuyue (Five Peaks) of China and is located in southern Hunyuan County in Shanxi Province. The base of the mountain is made up of Precambrian metamorphic rock, and its upper part is composed of Cambrian and Ordovician limestone. It is a fault-block mountain, and the main peak, Xuanwu Peak, has an elevation of 2,016 m. The Datong Basin is located to the north, and the relative elevation difference is more than 1,000 m. The mountain looks majestic, and the rift valley and Jinlong (Golden Dragon) Gorge cuts through the mountain from north to south and carries a muddy flow. The narrowest part of this gorge is only 10 m wide. Hengshan has a long cultural history. It was honoured as the world's second mountain during the Qin Dynasty. It was named

Xuanyue in the book 'Shui Jing Zhu (A Note on Water)', which was written during the Northern Wei Dynasty. In the Ming Dynasty, it began to be called Beiyue Hengshan (Northern Mountain Hengshan). There are many cultural relics on the mountain, such as the Hengzhong Temple (also called the Beiyue Temple), Xuankong (Hanging) Temple, the Dazi (Big Characters) Ridge stone carving and the Hanzhun County ancient city relics. The Xuankong Temple was built during the Northern Wei Dynasty (approximately sixth century B.C.) and is an all-wood structure built on the cliff wall over the Jinlong Gorge. It is a masterpiece of ancient Chinese architecture.

Novohrad-Nograd Geopark, Hungary, Slovakia This geopark is located in central Europe in northern Hungary and southern Slovakia. It covers an area of 1,587 km^2. It became a global geopark in 2010. The park contains 63 settlements in Hungary and 28 settlements in Slovakia, and it is dominated by hills, gorges and basins. The iconic building in the park is the Somoska Castle, which was built on basalt and displays a unique combination of natural and cultural landscapes. The national border between Hungary and Slovakia passes under the castle. The rolling hills, volcanic plateau, and volcanic peaks in the park form beautiful scenery. The mountain peaks serve as a natural barrier that allows the area to maintain its unique local customs and traditions. It is a perfect blend of cultural landscape and geological history.

O

Oasis Landscape This is a desert area with abundant vegetation in a dry region (including deserts). Oases always have an elongated form and are located in the middle and lower parts of piedmont alluvial fans, where the groundwater is shallow, as well as along river banks. China's oases are mainly located along the piedmonts on the northern and southern slopes of Tianshan, the northern slope of Kunlunshan (Kunlun Mountains), the northern slope of Qilianshan (Qilian Mountains) and along the rivers and the alluvial fans downstream of the Yerqiang River, Hetian River, Tarim River and Urumqi River. These oases are all supplied by water that melts from ice and snow in the surrounding mountains. The oases in front of these piedmonts extend over great distances and are favourable sites for agricultural development with irrigation. They are paradises of flora and fauna in arid areas. Towns and villages in oases are located near each other, and they become areas of economic development in arid regions (Fig. 1).

Obsidian Obsidian is a rock composed of acidic volcanic glass. It occasionally contains small quantities of phenocrysts and crystallites. It is usually black and has a dense texture, a vitreous lustre and conchoidal fractures. Obsidian has a minimal water content; i.e. the H_2O+ content is less than 2%. Its appearance is just like a piece of shiny coal.

Ocean Park An ocean park is a theme park that uses marine life, marine geology and geomorphology to provide entertainment and leisure and to popularise marine knowledge. Most are built on beaches and islands. China's famous ocean parks include Ocean Park Hong Kong, Shanghai Ocean Park, and Dalian Old Beach Ocean Park. The coastal and island geology and landforms, particularly the coral reefs in tropical ocean parks, are research focuses of tourism earth science.

Oceanic Landscape An oceanic landscape is a geomorphic landscape that is formed by marine erosion and deposition, including erosional landforms such as sea cliffs, sea stacks, sea caves, abrasion terraces and sea chasms; depositional landforms such as marine beaches, headlands, sand spits, sand bars, gravel embankments, shingle beaches and shell dykes; and various island reef landscapes. Marine geomorphic landscapes are valuable for investigating coastal changes and are also important for tourism. Many tourist destinations, especially vacation resorts, are built on marine landforms.

Oceanic Trench An oceanic trench is a large linear oceanic depression with steep slopes on both sides. Most trenches are located in areas between a continental margin and island arcs or oceanic ridges. These trenches are parallel to the coastline of the mainland and are 2,000 m deeper than the surrounding seafloor. The depth usually exceeds 6,000 m, and the deepest can reach 11,000 m. They are several kilometres long and approximately 100 km wide. Most have an asymmetrical V-shaped cross-section, where the slope near the mainland is steeper than the slope near the ocean. The slopes always have terrace platforms. Deposits up to 1,500 m thick are located on the bottom. Together with island arcs, they form the modern active zone of the Earth's crust; the island arc and oceanic trench system are always connected to active seismic and volcanic zones. Oceanic trenches are well developed in the Pacific margin; the Mariana Trench near the western margin is the deepest oceanic trench in the world, with a depth of 11,521 m.

Oceanic Wave This is a phenomenon of water surface fluctuations and movement in a direction caused by the imbalance of water particles due to an external force. In general, waves refer to undulations caused by wind in the ocean, including swells and near-shore waves. The wavelengths are usually from dozens of

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centimetres to hundreds of metres, each cycle ranges from 0.5 to 25 s, and the wave heights can be from several cm to more than 20 m and in special cases can exceed 30 m. In a broad sense, waves also include tsunamis, storm surges and oceanic internal waves caused by the external and internal forces from celestial gravitational forces, seafloor earthquakes, volcanic eruptions, landslides, atmospheric pressure changes and uneven distributions of seawater densities. The vibration of water particles can create kinetic energy, and wave fluctuations can produce potential energy. The total amount of these two kinds of energy is substantial. Waves are the main mechanism for marine erosion and transportation and are a component of the ocean landscape for viewing (Fig. 2).

Ogasawara Islands, Japan This heritage site is located approximately 1,000 km south of Tokyo, Japan. It consists of three groups of more than 30 islands with a land area of 73.9 km^2. The island landscape is diverse and is home to endangered species such as



Fig. 1 Oasis landscape: Tarim Basin, Xinjiang



Fig. 2 Wave landscape

the Bonin flying fox, 195 species of endangered birds and a large number of wild animals. A total of 441 species of native plant groups have been discovered on the island group. The surrounding waters contain a wide variety of fish, otters and coral. The ecosystem of the Ogasawara Islands has experienced a series of biological evolution processes because they contain not only plant species from southeast and northwest Asia but also numerous indigenous endemic species.

Okapi Wildlife Reserve, Congo This reserve is located in Oriental Province in the northeastern Democratic Republic of the Congo, and it has a core protection area of 13,726.25 km^2. The Okapi Wildlife Reserve takes up 1/5 of the area of the Ituri Forest in northeastern Congo. The reserve and the Congo River are Africa's largest natural water system. The reserve is a sanctuary for endangered primates and birds and is home to 5,000 of the last 30,000 wild okapis in the world. The dazzling and picturesque scenery in the reserve includes the waterfalls along the Ituri River and Epulu River. The area is the traditional home to the Mobutis and Efes Pygmy nomads.

Old Marine Basin Topographically, an old marine basin is a basin-like ancient continental sea. An ancient continental sea (platform sea) located in a platform area will evolve into a marine basin. Examples include the Huanghai (Yellow Sea) Basin on the Sino Korean Platform in the Middle-Late Carboniferous Epoch and the Yangtze Basin on the Yangtze Platform in the early Palaeozoic Era.

Olivine The chemical composition of olivine is $(Mg,Fe)_2[SiO_4]$. Olivine is a magnesium iron silicate, and it gets its name from its olive-green colour. Its crystals are plank-like and are usually in granular aggregates. It has a vitreous lustre with a Mohs hardness of 6.6–7, a specific gravity of 3.2–3.5 and conchoidal fractures. This mineral mainly forms in ultramafic and mafic igneous rocks. It transforms to serpentine easily through alteration and is also a major component of meteorites. Gem-quality olivine is usually found in coarse peridot in the upper mantle. Predominant mining countries include Egypt, Myanmar, the United States and China (Fig. 3).

Olympic National Park, U.S.A. Olympic National Park is located in the northwestern corner of Washington State along the Pacific coast in the U.S. and has a core protection area of 3,696 km^2. The park is renowned for its diverse ecosystems. Glacier-covered peaks interspersed with extensive alpine meadows are surrounded by an extensive old growth forest, which contains the best example of



Fig. 3 Olivine crystals

intact and protected temperate rainforest in the Pacific Northwest. Eleven major river systems flow through the Olympic Mountains, offering some of the best habitat for anadromous fish species in the country. The park also includes 100 km of wilderness coastline, the longest undeveloped coast in the contiguous United States.

'One-Line Sky' of Granite *Synonym:* ► *'Line-like sky' of granite*
The flow of water cuts and erodes weak zones along vertical joints and faults and forms elongated depressions with vertical walls. Only a narrow portion of the sky can be seen from the bottoms of these depressions, so these features are called 'one-line sky'. The southern trail on Tiandoufeng (Heaven Blade Peak) in Huangshan and the Fairy Bridge at Xihai Gorge lie across the valley floor with a 'one-line sky' (Fig. 4).

Oolitic Limestone Oolitic limestone is also called oolite, and it is a limestone primarily composed of ooids. Based on the characteristics of the internal ooid structure, oolitic limestones can be divided into normal oolitic limestone, thin crust oolitic limestone, pseudo-oolitic limestone, allochemical oolitic limestone and negative oolitic limestone. According to the composition of the filling between the oolitic grains, oolitic limestones can be categorized as oosparite and oomicrite.



Fig. 4 'One-line sky' of granite at Tiandu Peak, Huangshan

Oolitic limestone forms in regions of oversaturated water, such as marine or lake wave zones or tidal channels. It is formed by both mechanical and chemical processes. Wave and tidal action agitate the water, which in turn causes biological debris, pellets, clastic and terrestrial debris to be suspended and simultaneously causes the carbon dioxide in the water to escape. Under such circumstances, the supersaturated calcium carbonate will precipitate around the grains to form a coating. This process repeats and eventually results in ooids with concentric coatings. When the oolitic grains reach a certain size, they are deposited on the seabed and consolidate into oolitic limestone. When the ooids are transported to a low energy zone, they form oomicrite. A typical oolitic limestone is located in the Yuntai National Geopark in Henan Province.

Opal Opal is a gem-grade mineraloid of hydrous silicon dioxide. Its name comes from the Latin 'oplus', meaning 'the beauty of gem in one body'. Its chemical composition is $SiO_2 \cdot nH_2O$, and it can be opaque, translucent or transparent with a waxy lustre. It has a Mohs hardness of 6–6.5 and can be white, yellow, red or black. Its main characteristic is an iridescent colour, which stems from the silicon spherical structure that flashes with a diffraction grating. In the ancient Roman Empire, Pliny the Elder once said 'On a piece of opal, you can see the beauty, colours and coherence of the ruby flame, amethyst stain and emerald sea'. A total of 95% of the world's opals are mined in Australia. Opals with strong iridescent colours, large iridescent surface area and high transparency are considered top-grade opals (Fig. 5).

Open Space Open space refers to areas that are completely or generally free of artificial structures. In a narrow sense, it refers to relatively open or well-vegetated areas in a city or on the outskirts that are used to improve the urban ecological environment and provide recreational sites for urban residents. Open space can be a playground, a square, or an area with good vegetation.

Ophiolite Ophiolite is also known as an ophiolite suite. It does not refer to a specific rock but

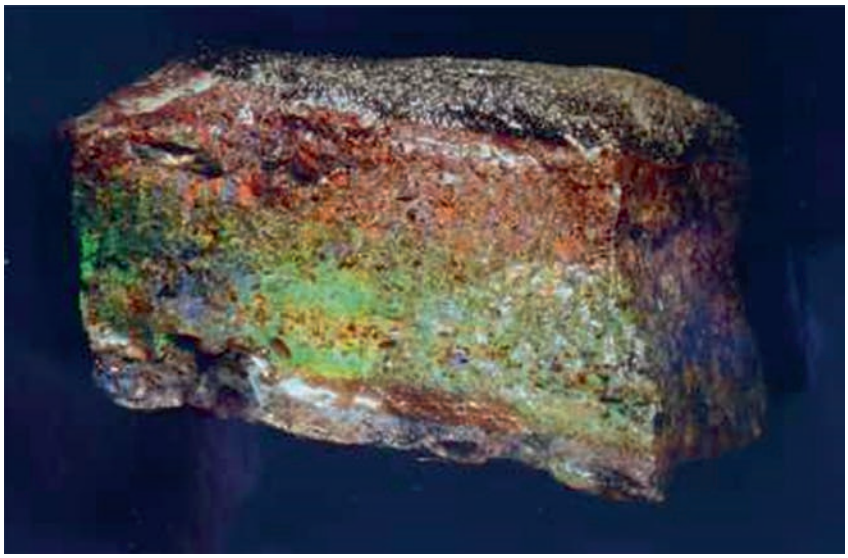


Fig. 5 Opal stone

rather to a unique combination of rocks. From bottom to top, ophiolite is composed of olivine, layered sedimentary rocks, a sheeted dyke swarm, pillow lava and a set of marine facies siliceous rocks containing radiolaria fossils. Ophiolite suites are considered to be the remnant oceanic crust from the collision of ancient plates. They are important for the determination of ancient plate boundaries. For example, the ophiolite zone along the Yarlung Zangbo River and the Xiangquan River in Tibet, which is 1,400 km long, is considered to be a suture zone that formed by the collision between the Indian Plate and the Eurasian Plate.

Ordos Geopark, Inner Mongolia This geopark is located in Ordos, Inner Mongolia Autonomous Region. The geopark has an area of 179 km^2, and 152 km^2 is covered by the major geological features. It became a national geopark in 2011. The park has abundant and varying landscape resources and geographical relics. It is a comprehensive geopark with interesting geological structures, archaeological relics, fossils and water body landscapes. The geopark comprises the Salawusu Site, Otog Dinosaur Footprints Site and Yellow River Desert Lake Site (including the Qixing Lake Resort, Engebei Resort and Whistling Dune Bay). Salawusu is the origin of the Salawusu standard cross-sections of the late Pleistocene era in northern China and the Salawusu animal fossils. The Otog dinosaur footprints site contains a mix of early Cretaceous Sauropoda dinosaur footprints and Theropoda footprints. Qixing Lake, Engebei and Whistling Dune Bay are geological landscapes resulting from changes that took place in the ancient course of the Yellow River. The park is also home to such geological landscapes and landforms as deserts, sand lakes, fluvial terraces, the Yellow River Valley and Whistling Dune Bay. These geological landscapes are highly representative and rare, and they have extremely high value for scientific research, knowledge dissemination and education.

Ordos Platform This platform is a part of the North China Platform. It is located between the Qinling Mountains and the Daqingshan Mountains in Inner Mongolia. The Helan Mountains-Liupan Mountains are located to the west, and the Huanghe (Yellow River) forms the eastern boundary. The North Shaanxi Loess Plateau is located to the south. Mesozoic and Palaeozoic strata with shallow dips are common in the river valley. The Mu Us Desert is located north of the platform and contains outcrops of ancient metamorphic rocks. Gradual uplift and subsidence were

common, and the deformation of the overlying strata is weak. These characteristics are typical of a platform. During the Mesozoic Era, the region was a large inland basin with nearly horizontal bedding. In the Cenozoic, the area was covered by large amounts of loess, forming the famous Loess Plateau, where the Luochuan Loess National Geopark was established. The Huanghe Hukou Waterfall is also located on nearly horizontal Mesozoic strata and has become the main feature of the Huanghe Hukou Waterfall National Geopark.

Ordovician Period The Ordovician Period is the second period of the Palaeozoic Era and extended from 488 to 444 million years ago, a duration of 44 million years. The Ordovician Era was first proposed in 1879 by C. Lapworth. The Ordovician System includes the rocks that formed during the Ordovician Period. The Ordovician System was first studied in Britain, and it was divided into six stages according to graptolite fossils. Currently, it is globally subdivided into three series and seven stages, and three stages have been established in China. The Middle Ordovician turtle crack limestone is the base material that forms the Xingwen 'Taianwu stone forest landscape'.

Ore Mineral The term ore mineral usually refers to a mineral from which one or more useful industrial metals can be extracted. For example, chalcopyrite and galena are ore minerals of copper and lead, respectively. Ore minerals are sometimes natural metals, such as gold and platinum, but most ores are compounds. Most industrial metals are refined from metal ores, and a single metal element can be extracted from several types of ores. For example, copper can be refined from chalcocite, bornite, chalcopyrite, cuprite, native copper and malachite. Some minerals can be used to extract two or more types of metal elements, such as carnotite, which is used for the extraction of uranium and vanadium.

Organic Reef Landscape ▶ Bioherm Landscape

Oriental Jasper ▶ Bloodstone

Origin of Life on Earth The origin of life on Earth is related to the time when the earliest organic cell was formed. In 1953, Miller first simulated the atmospheric conditions of the early Earth and mixed H_2, CH_4 or H_2O, CO_2, N_2 and CO in a solution to create amino acids, HCN and formaldehyde through sparking or ultraviolet radiation. However, it is still uncertain how these materials combined to form complex molecules such as RNA and evolve into living cells. RNA research is important for exploring the origin of life. RNA molecules can split and produce enzymes, which can promote reproduction. At temperatures of approximately 40 °C and pH 7.5–9 in the laboratory, a solution with Mg^{2+} can cause RNA division. These conditions may have existed near the vents at mid-ocean ridges of the Archean seafloor hydrothermal system. Some RNA can breed with other species and form cell membranes to wrap protocells. The CH_4 and NH_3 in the hot water vents can mix to form amino acids and then form deoxyribonucleic acid. The protocell membrane can supply energy and create the conditions for metabolism, contributing to the development of living cells. The first cells were primitive, and the metabolic systems were poorly developed. They survived by absorbing the surrounding nutrients and obtained energy and nutrients for growth and reproduction through fermentation of other organic substances. These cells are called heterotrophs. Cells that can produce their own food are called autotrophs. Both types of cells are anaerobes, which evolved from the DNA approximately four billion years ago. The most primitive cells are called archaebacteria, which then evolved into eubacteria. Heterotrophic organisms increased rapidly. Vying for food, they then evolved into autotrophs. The first autotrophs, such as cyanobacteria, first appeared on Earth approximately 3.5 billion years ago. They made their own food by photosynthesis. From inorganic substances to organic cells, the process of life evolution had begun. Some people believe in the extraterrestrial origin or earth-sowing hypothesis since amino acids have been found in interstellar dust. This hypothesis

proposes that these amino acids were the initial organic substances sowed on Earth.

Ornamental Stone ▶ Viewing Stone

Orogenesis Orogenesis has two implications: (1) The formation mechanism of 'orogenic belts' ('fold belts'). There are several theories about the formation mechanism of orogenic belts. The customary geosyncline theory postulates that orogenic belts form due to folding and inversion of geosynclines, accompanied by strong structural deformation, magmatic activity and dynamometamorphism. Plate tectonics holds that an orogenic belt is the result of convergence, subduction or collision of two adjacent plates, and the direction of compression (principal compressive stress direction) is perpendicular to the trend of the orogenic belt. Based on detailed studies, scientists have discovered that shear and even tensile stresses can also form orogenic belts. (2) The formation mechanism of 'mountain range'. The geosyncline theory states that mountain ranges form due to uplift caused by continuous compression of the orogenic belt subject to folding inversion. Plate tectonics focuses on several aspects, such as theories of delamination, crustal stretching and thinning, extrusion and buoyancy, of which delamination is the most important. The theory of isostasy is based on the fact that all of the major mountain ranges have 'roots' (indicative of mantle subsidence beneath the root), and this theory proposes that isostasy is the cause of mountain uplift.

Orogenic Belt This term is equivalent to 'fold belt' and indicates a fold-thrust tectonic belt formed by strong tectonic deformation, magmatic activity and dynamic metamorphism associated with the process of folding and inversion of a geosyncline. The traditional geosyncline-platform theory considers an orogenic belt to be the result of the transformation of a geosyncline into a fold belt, and it represents an active tectonic unit of the crust. The theory of plate tectonics considers orogenic belts to be the result of the subduction or collision of different plates; therefore, they are always located on plate boundaries. However, Chinese scientists have found that orogenic belts can be located in the centre of a plate, such as the Yanshan orogenic belt and the Tianshan orogenic belt, which are typical 'intraplate orogenic belts'. Their mechanism of formation still requires further detailed studies.

Orogenic Movement ▶ Orogeny

Orogeny *Synonym:* ▶ *Orogenic movement;* ▶ *Mountain building*

There are two different interpretations and two definitions for orogeny: (1) Mountain ranges are formed by crustal movements (Gilbert 1890). This definition focuses on the formation of mountains from the landform perspective. This concept is now rarely adopted, particularly by scientists that study terrain formation. (2) The orogenic belts are caused by strong deformation of the crust induced by crustal movement. This concept is currently more popular and widely accepted. This concept postulates that mountain building is an episodic process (Stille 1919) that alters the structure of rocks. This includes geologic processes such as folding, thrust deformation, magmatic activity and regional metamorphism but does not include the formation of landforms and mountains. The traditional geosyncline theory indicates that through folding and inversion uplift, an orogenic belt forms with the development of dense linear folds and reverse faults. Plate tectonics postulates that orogenic belts are the result of the collision or subduction of plate margins (such as the Pacific orogenic belt on the rim of the Pacific Plate), interplate sutures (such as the Alpine orogenic belt, which is a suture zone between two plates), and plates. However, there are also intraplate orogenic belts (such as the Yanshan orogenic belt and Tianshan orogenic belt). In the past, orogenic belts were thought to have been formed by horizontal compression. Over the past 30 years, it has been discovered that crustal extension (such as the extensional orogenic belt in the East African Rift) and strike-slip shear (such as the thick-skinned orogenic

belt of New Zealand's Southern Alps faults) can also form orogenic belts.

Orthoclase Orthoclase is a feldspar mineral containing $K[AlSi_3O_8]$. It is an important rock-forming mineral. It has a monoclinic crystal structure, and the crystals are columnar or blocky. Crystal twinning is common, and the aggregates are blocky, flaky or granular. The colour is white, colourless, light red, yellow, grey or green with white streaks. The diaphaneity ranges from transparent to translucent with a vitreous or pearly lustre. Its specific gravity is 2.55–2.63, and its Mohs hardness is 6–6.5. It has complete cleavage, uneven fractures and mainly forms in igneous and metamorphic rocks such as granite, pegmatite, rhyolite, trachyte, syenite, gneiss and schist.

Ortho-metamorphic Rocks See ► Metamorphic Rock.

Otog Dinosaur Fauna and Footprints This fossil site is located in the Cretaceous Zhidan Group and Dongsheng Formation around Chabusumu in Otog Banner, Ordos City, Inner Mongolia Autonomous Region. Abundant fossils of large dinosaurs, such as sauropods, theropods and ornithopods, have been excavated. The dinosaurs are mainly Psittacosaurus, Ikechosaurus, Wuerhosaurus, and possibly China's Ornithomimus. Dinosaur footprint fossils are well developed at this site, including footprints of Thetopod, which is the fastest known dinosaur (12 m/s). Turtle fossils have also been unearthed (Fig. 6).

Outline of the China Eco-environmental Protection This document was prepared by the State Environmental Protection Administration jointly with the relevant departments and was issued by the State Council on November 26, 2000, in the form of State Development and Reform Commission (2000) document No. 38. It has four major sections and 27 subsections, including the state of ecological environment protection, achievements and current problems, factors causing deterioration of the ecological environment, guiding ideology, principles and objectives of national ecological environment protection, the main content and requirements, measures and strategies.

Outwash Delta Landscape *Synonym:* ► *Fluvioglacial delta landscape*

This is a landscape composed of a depositional delta formed by fluvioglacial action. When the meltwater of glaciers flows into a lake, an outwash delta is formed by deposition. This type of delta is similar to a river delta, but the sediments contain glacial gravels.

Outwash Terrace Landscape, Fluvioglacial Terrace Landscape This is a landscape comprising terraces formed by glacial outwash deposition or erosion. Glacial erosion during the glaciation period and weathering of the bedrock due to low temperatures result in abundant debris, which greatly exceed the carrying capacity of the meltwater stream. Eventually, the debris piles up in the valley in front of the glacier. During the interglacial period, the amount of debris decreases, and the amount of meltwater increases. As the flow energy increases, the erosion becomes stronger,



Fig. 6 Otog dinosaurs

cutting the sediments that accumulated during the glacial period to form terraces, which are called outwash terraces.

Overhanging Cliff Granite Landscape – Huashan Type This type of landscape is composed of broken mountain blocks of granite with relative heights of over 1,000 m and elevations of 1,500 m above sea level. The surrounding slopes are steep and dangerous, and the rock properties are relatively uniform. Vertical joints are well-developed. Major faults are located at the edges of the rock mass, where neotectonic uplift was rapid. Intense collapse due to gravity is the main factor in the formation of this landscape. This is a typical example of a landform that results from tectonic erosion. 'Huashan Only Has One Road Since Ancient Times' is the best description of the steepness and ruggedness of this type of landform. The Huashan Scenic Area is an outstanding example of this type of granite landscape (Fig. 7).

Overthrust See ▶ Reverse Fault.

Oxbow Lake Landscape This is a landscape consisting of an oxbow-like lake, which is also called a mort lake. In flat plains, rivers tend to meander freely. When the river flow cuts through the neck of a meander to form a new river channel, the abandoned section is blocked by sand and mud as the flow rate and flow volume decrease. This section can become a lake shaped like an oxbow when it is filled with water. It is therefore called an oxbow lake. Typical examples are the lakes along the banks of the Jingjiang section of the lower Yangtze River. These lakes are locally called 'Moon Lakes'. Academics have proposed that all abandoned river courses that become lakes be called oxbow lakes (Fig. 8).

Oyster Reef Oyster reefs are composed of abundant fragments of oyster shells, other shellfish and coarse and fine sand cemented by seawater or groundwater with a high calcium carbonate content (Fig. 9).

Ozone Hole In recent years, due to the increasing number of aircraft operating in the stratosphere, several trace gases produced by human activities have entered the stratosphere, which has depleted the ozone concentration in the atmosphere and resulted in the 'ozone hole' in the Antarctic. Chlorofluorocarbons in



Fig. 7 Overhanging granite cliff of Huashan



Fig. 8 Oxbow lake landscape



Fig. 9 Oyster reef landscape

chemical agents such as refrigerants, sprays and foaming agents are the main causes of ozone depletion. The ozone layer absorbs most of the ultraviolet radiation from the sun and plays an important role in protecting life and regulating the Earth's climate. The ozone layer is the largest concentration of ozone in the stratosphere.

P

Pacific Plate The Pacific Plate is located in the Pacific Ocean and is mainly composed of oceanic crust. Its eastern boundary is the San Andreas transform fault, which separates it from the North American Plate. Its western boundary is the Mariana Trench, which separates it from the Philippine Sea Plate. Extension at the mid-ocean ridge in the Pacific Ocean is on-going and associated with extensive neutral-basic volcanic eruptions. Studies of the magnetic stripes on the oceanic crust and abundant seismic data indicate that the Pacific Plate is still expanding and subsiding towards the eastern and western margins, creating the most active volcanic and seismic belt in the world.

Pahoehoe *Synonym:* ▶ *Ropy lava landscape*
Pahoehoe is a type of volcanic landscape characterised by a wavy lava flow that looks like a rope. It has the following characteristics: (1) the lava surface is wavy, bulges up or is curvy, and it is called ropy lava when the extent of the curvature is small; (2) the lava flow is generally thin (1–5 m thick); (3) pores usually develop on both the top and bottom of the lava flow, debris materials are absent, and there is occasionally a thin 'clastic layer' at the bottom; (4) large pores or vents can form; and (5) lava blocks are transitional features along the edges or in the flow direction. The wavy pattern of the lava looks like a rolled-up rope and often appears as small rock flows. In particular, the rope shape is more pronounced in secondary lava flows. The protruded part of the rope-like feature often points in the flow direction. Based on the shape of the ropy lava, the direction of its protrusions and the intersection relationships, the lava flow direction and its sequence of movement can be determined. There are pahoehoes at Wudalianchi Volcano and Haikou Volcano (Fig. 1).

Painted Pottery Culture ▶ Yangshao Culture

Palaeo-anthropological Fossil This is a general term for the human fossils from 10,000 years ago. The evolution path from apes to humans is: Australopithecus, Peking Man (Homo erectus pekinensis), archaic Homo sapiens (ancient man) and late Homo sapiens (new man). The new man and the modern man belong to the same subspecies, and the others are extinct. Important ancient human fossils found in China include Dryopithecus wuduensis, Lufengpithecus lufengensis, Homo erectus yuanmouensis (1.7 million to 1.8 million years ago), Homo erectus lantianensis (750,000–980,000 years ago), Yunxian Man (830,000–890,000 years ago), Homo erectus pekinensis (290,000–600,000 years ago), Homo erectus nankinensis (approximately 400,000 years ago), Dali man (150,000–200,000 years), Changyang Man (195,000 years ago), Maba Man (129,000–130,000 years ago), Hetao Man (30,000–50,000 years ago), Liujiang Man (20,000 years ago) and the Upper Cave Man (13,000–20,000 years ago) (Fig. 2).

Palaeoanthropology Palaeoanthropology is also known as fossil anthropology, and it is a branch of physical anthropology. It is the study of the fossils of primates (including human fossils), the patterns of human origin and development, the relationships between fossil apes and modern apes and human beings, and the changes and patterns of the physical characteristics of humans during their development. Because fossils are the main focus of palaeoanthropology, this subject is an important branch of palaeontology. It is also closely related to subjects such as animal taxonomy, comparative anatomy, anthropotomy, anthropogenetics, Quaternary geology and taphonomy. Palaeoanthropology also studies the tools and artefacts made by ancient humans and other relics of their life and of the associated animals and plants. Based on these items and palaeogeographic, palaeoclimatic and geochronologic data, this subject also explores the pattern of social development of ancient humans. From this

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Fig. 1 Pahoehoe landscape at Huoshaoshan and Laoheishan in Wudalianchi

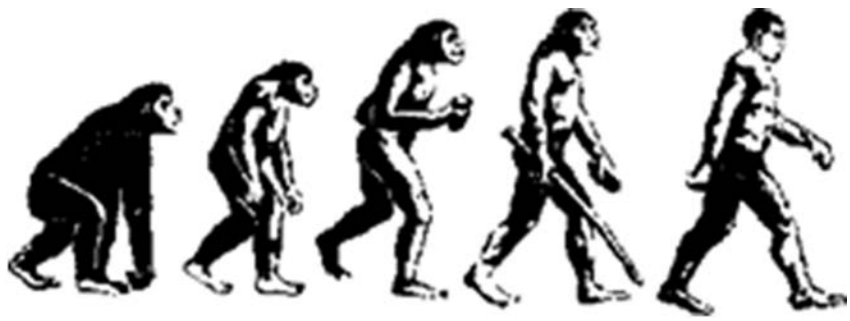


Fig. 2 Evolution of humans

perspective, palaeoanthropology is also closely related to other subjects, such as palaeolithic archaeology, palaeoecology, prehistoric studies and history. With the ongoing discovery of primate fossils (especially ancient humans), the discovery of new human fossil sites and palaeolithic sites, and the progress of investigation techniques, including new branches of science like molecular biology, palaeoanthropological research is becoming increasingly enriched.

Palaeobionts *Synonym:* ► *Ancient organisms*
Palaeobionts is a general term for the creatures that lived on Earth during the past. This term in Chinese is mostly found in the Chinese and Japanese scientific literature. Most palaeobionts, such as dinosaurs, have already become extinct, but a few palaeobionts have survived, such the giant pandas (which lived as early as the Pleistocene) and ginkgo (which existed as early as the Middle Triassic). They are called living fossils. The study of palaeobiont evolution is called palaeontology (see "► Palaeontology").

Palaeobotany Palaeobotany is the study of the patterns of survival, evolution, geographical distribution and species characteristics of plants. Plant fossils are important geological relics, and well-preserved fossils with ornamental value are a crucial geotourism resource.

Palaeoclimate Palaeoclimate is the climate of the past, including the climatic conditions during historical and geologic periods. For example, during the Quaternary Period, the entire planet became cold and experienced several phases of glaciation. From the perspectives of geography and climatology, the study of palaeoclimate plays an important role in understanding climate change, the formation of the modern climate and the evolution of the natural geographic environment. In geology, palaeoclimate studies facilitate research on stratigraphic divisions and comparisons, crustal evolution and the formation of and exploration for mineral resources.

Palaeoenvironment The palaeoenvironment is the natural environment of past geologic times.

Palaeogene Period The Palaeogene Period is the first period of the Cenozoic Era and is equivalent to the original late Tertiary Period. It lasted from 65.5 to 23.03 million years ago, a duration of 42.47 million years. The Palaeogene System, which was formerly called the Lower Tertiary System, includes the rocks that formed during the Palaeogene Period. It includes the Palaeocene Series, Eocene Series and Oligocene Series, which are further divided into nine stages. At the beginning of the Palaeogene Period, the Earth was subject to a major catastrophe induced by an asteroid collision that eventually led to the extinction of dinosaurs and marine organisms such as ammonites. Mammals and woody angiosperms flourished during the Palaeogene Period. In China, the Palaeogene System was mostly composed of terrestrial facies. Based on the rapid evolution and development of mammals, the terrestrial strata can be effectively compared; as a result, the Palaeogene System in China has been subdivided into eight stages, including the Shanghuan Stage and Chijiangian Stage of the Palaeocene Series, the Lingchan Stage, Lushian Stage, Yuanquan Stage and Caijiachongian Stage of the Eocene Series, and the Wulanbulagean Stage and Tabenbulukian Stage of the Oligocene Series. The marine facies of the Palaeogene System in the East China Sea, Tarim and Tibet are correlative to the international stages and fossil zones.

Palaeogene-Neogene Section in the Nanxiong Basin, Guangdong This Palaeogene section includes the lower part of the Shanghu Formation and the upper part of the Nongshan Formation, and it is dominated by purple-red siltstone that is rich in fossils of mammals, ogastropods, ostracods and charophytes. The Danxia Formation is located above this system and consists of purple-red sandstone. The Neogene is represented by the Dongxuanguan Formation and the Xiaolongtan Formation. The Dongxuanguan Formation is composed of lacustrine deposits of gravel, sand and clay. The Xiaolongtan Formation was deposited in a swamp environment in a hot and humid climate; hence, it contains lignite and peat. The Palaeogene-Neogene section in the western Nanxiong Basin is located north of Hongshizhai-Pingkeng Shitang-Shangxiuren Line 1 and is composed of purple, grey-green, green-grey fine clastic rocks of the Luofozhai Group and red, coarse clastic rocks of the Danxia Formation. The sequence is approximately 1,000 m thick. From the bottom to the top, the Luofozhai Group can be further divided into the Shanghu Formation, Nongshan Formation and Gucheng Formation. The Shanghu Formation contains Propocypris fauna, Cypris fauna, Obtusocharacurtata fossils, Gropesichara changzhouensis fossils, Lamellibranchia fossils, gastropods and aptychi fossils. The lower part of the Shanghu Formation is rich in mammal fauna that are represented by Bemalambda, which lived from the late Cretaceous to the early Middle Miocene. The Cretaceous-Palaeogene boundary is located between the Pingling Member and the lower Hui Member. The Nongshan Formation is composed of a clastic rock layer with multiple colours that is rich in Ostracoda, charophytes, Conchostraca and Gastropoda fossils. This late Palaeocene formation can be divided into the Zhuguikeng Member and Datang Member. The Guchencun Formation is composed of grey mudstone and marl with ostracods, charophytes, gastropods and Llamellibranchia fossils that lived in the early Eocene (Fig. 3).

Palaeogeography Palaeogeography includes research on the formation, development and evolution of the natural geography of the Earth's surface during geological periods, including changes in the land and sea, climate, biological successions, geographical regions, natural areas and natural zones. It is a cross-disciplinary field of geology and geography. The environmental evolution events that occurred in the Mesozoic and Cenozoic have had a profound impact on the modern natural geography, and they are a common research



Fig. 3 Sandy mudstone in the Late Cretaceous Upper Nanxiong Formation in the Nanxiong Basin in Guangdong

area of palaeogeography. Palaeogeography provides a scientific basis for explaining the formation and evolution of the natural geographical environment and is useful in enhancing the attraction of tourist destinations.

Palaeolithic Age The Palaeolithic Age was the first stage of the Stone Age. This age was an important stage of human development; it was the stage of Homo erectus and the early stage of archaic Homo sapiens and late Homo sapiens. The Palaeolithic Age is the equivalent of the entire Pleistocene. The early Palaeolithic is equivalent to the early to middle stages of the Pleistocene, approximately 200,000 to 3 million years ago. The Middle Palaeolithic is equivalent to the early and middle stages of the Late Pleistocene, approximately 30,000–200,000 years ago. The Late Palaeolithic is equivalent to the late stage of the Late Pleistocene, approximately 10,000–30,000 years ago. Because human evolution varied between different regions of the world, the dates of the Palaeolithic Age in different locations are not completely consistent.

Palaeontological and Fossil Man Tourism Landscape Resource This is a collective term for palaeontological fossils with fossils of ancient hominid species that can be used for tourism development. These fossils are important evidence for studies of the origin and evolution of life. Fossils with distinctive shapes or a beautiful appearance are tourist favourites, and many geological parks have been built on palaeontological sites. The following geoparks were established in connection with palaeontological fossils: Zigong in Sichuan Province (dinosaurs), Lufeng in Yunnan Province (dinosaurs), Liujiaxia in Gansu Province (dinosaur footprints), Jiayin in Heilongjiang Province (dinosaurs), Chaoyang in Liaoning Province (feathered dinosaurs), Xixia in Henan Province (dinosaur eggs), Yanqing in Beijing (petrified wood, dinosaur footprints), Chengjiang in Yunnan Province (Cambrian explosion) and Fangshan in Beijing (Peking Man, Homo erectus pekinensis). Palaeontological landscapes have become important tourism resources.

Palaeontological Tourism Landscape These landscapes include palaeontological remains and relics with aesthetic and scientific value. Over the more than four billion years of Earth's history, numerous fossils and palaeobiological relics have become an important earth science tourism resource. These resources include the petrified wood forest and dinosaur footprints in Yanqing, Beijing,



Fig. 4 Palaeosol layer (red band in middle) – Yanchuan, Shaanxi Province

the dinosaur groups in Zigong, Sichuan Province, Zucheng in Shandong Province, and Erlian in Inner Mongolia, as well as the Yuanmou Man in Yunnan Province and the Peking Man and Miocene fossil groups in Linqu, Shangdong Province.

Palaeontology Palaeontology is the study of biology and its evolution over various geological and historical periods. Fossils and relics of ancient biological activity preserved in rock strata of different ages allow the emergence and formation, classification and distribution, form and structure, evolution and extinction of biological species to be studied. This information is used to elucidate the development and evolution of the biological world and to determine the ages of geological events, the ancient geological environments, crustal evolution and metallogenic conditions. Palaeontology can be subdivided into palaeozoology, palaeontology, ancient vertebrates, ancient anthropology, micro- (ultra-micro-) palaeontology and palaeoecology. Geological heritage sites with palaeontological significance and interest are important geotourism resources.

Palaeosol or Palaeosoil A palaeosol is a historical soil layer preserved in rock strata. Palaeosols are mainly found in loess deposits. They formed under warm and humid climate conditions in which loess deposition was temporarily interrupted, followed by podsolisation of the loess that had accumulated earlier. Palaeosols mainly consist of brown and cinnamon soil. The former is a warm temperate forest soil, and the latter is a semi-arid steppe soil. Palaeosols are important for studying changes in palaeoclimate and palaeogeography (Fig. 4).

Palaeozoic Era The Palaeozoic Era refers to a geologic interval from 542 million to 251 million years ago, which covers almost 291 million years. The Palaeozoic Era includes the Cambrian, Ordovician, Silurian, Devonian, Carboniferous and Permian Periods. The Palaeozoic Erathem includes the rocks that formed during the Palaeozoic Era.

Palaeozoology Palaeozoology is the study of the patterns of survival, evolution and geographical distribution of animals in a geologic period. According to the focus of research, palaeozoology can be divided into vertebrate palaeontology and invertebrate palaeontology. Fossils of ancient fauna are major components of geoparks, important geological relics and crucial geotourism resources.

Palm-Shape Stalagmite Landscape This is a landscape composed of palm leaf-like stalagmites. It is a composite deposit resulting from dripping and splashing water. During the formation of a stalagmite from water droplets,



Fig. 5 Palm-shape stalagmite, Zhijin Cave, Guizhou Province

tiny water drops splash onto the stalagmite surface and create an ascending palm leaf pattern. Whenever the spatial distribution of the splash is uneven, the 'palm tree' is asymmetrical. Splashing water droplets require a larger dripping distance; therefore, palm-shaped stalagmites usually exist in tall caves. They are found in Dayan (Big Rock) Cave in Guilin and Doulu Cave in Chenzhou, Hunan Province. China's most famous palm-shaped stalagmite is the 'Yinyu (Silver Rain) Tree' in Zhijin Cave in Guizhou Province (Fig. 5).

Pangea Pangea is a supercontinent that existed in past geological times. A. Wegener, the originator of the theory of continental drift, first proposed the concept that the continents once formed a continuous land mass that was surrounded by a super ocean (i.e., Panthalassa). This supercontinent was called Pangea. Pangea was first divided into the supercontinents of Laurasia in the north and Gondwana in the south, which were separated by the Tethys Ocean, the sea in the middle of the land. The latest version of the hypothesis with respect to Pangea is in connection with the supercontinent Rodinia, which existed from 1,000 to 900 million years ago. It is postulated that all existing continents came from this supercontinent. This hypothesis has gained popular recognition.

Panzhihua Vanadic Titanomagnetite Deposit, Sichuan This deposit is located in the lower part of a gabbro mass that formed in a magma body in its late stage of development. The gabbro mass trends northeast and is divided into sections by faults and the Jinsha River. Located in Panzhihua City, southwestern Sichuan Province, the Panzhihua vanadic titanomagnetite deposit comprises six ore sections, namely, Zhujiabaobao, Lanjia Volcano, Jianbaobao, Daomakan, Gongshan and Nalaqing. In the winter of 1944, Cheng Yuqi sent Li Chunyu a letter stating that the Panzhihua titanium magnetite ores might contain vanadium and suggesting that the ores be examined for vanadium. Sampling and analysis showed that the ores contained vanadium. This made the deposit world famous. The discovery turned Panzhihua from a remote mountain ridge into a city of 850,000 residents and a shining pearl along the Jinsha River (Fig. 6).

Papahanaumokuakea, Hawaii, U.S.A. This site is located approximately 250 km northwest of the main island of Hawaii and covers more than 1,931 km. The heritage site has an area of 362,074 km^2 and is one of the largest marine protected areas in the world. The protection site comprises a group of linear low-elevation islands and atolls and the surrounding ocean areas. The site is the ancestral home of the existing Hawaiian aboriginal culture and has many religious and traditional cultural meanings. It represents the interaction between humans and nature. It is also believed to be the cradle of life as well as the place where the soul returns after death. Archaeological remains of human settlements and land use from before European colonisation have been unearthed at Nihoa and Makumanamana. Papahanaumokuakea's main natural heritage consists of pelagic creatures and habitats,



Fig. 6 Panzhihua vanadic titanomagnetite mine in Sichuan

including distinctive seamounts, sandy beaches, vast coral reefs and large lagoons.

Papuk Geopark, Croatia This geopark is located in the Slavonia region of eastern Croatia and covers an area of 336 km^2. In 2007, it was selected as a member of the Global Geopark Network. Fossils are common in the Mesozoic sedimentary rocks. The structural uplift and continued denudation of the Slavonian mountain range provided the materials for sedimentation. These sediments were eventually deposited in the valleys of the Sava and Drava rivers and reached a thickness greater than 1,000 m. The complex geologic effects of Papuk resulted in the formation of a hydrogeological system that includes several streams in canyons. The northern part of Rupnica has been protected as the first geological monument in Croatia because the columnar joints in the albite rhyolite form square and hexagonal rock pillars.

Parallel Unconformity A parallel unconformity is also known as a 'disconformity', which is a type of unconformable contact. The term refers to rocks where the upper and lower layers have similar attitudes, but an obvious interruption in sedimentation has occurred. A parallel unconformity indicates that after the deposition of the lower strata, the crust of this area was uplifted evenly, causing an interruption of sedimentation and denudation. Later, the crust subsided again, and sedimentation resumed. However, the uplift and subsidence did not alter the bed attitude, so the attitudes of the strata remained consistent.

Para-metamorphic Rocks See ▶ Metamorphic Rock.

Parasitic Volcano Landscape This is a type of volcanic landscape composed of small volcanoes around a main volcano. When the main volcanic eruption stops or during the later stage of its eruption, the main volcanic conduit can be blocked. A small amount of rising magma flows from the crater or from cracks on the sides of the volcanic cone and eventually forms small volcanoes. On Fenglu Ridge Volcano in Haikou, a pair of small volcanoes flank the main volcano. These small volcanoes, which are parasitic volcanoes, look like a pair of glasses; hence, they are also called Eye-Glasses Ridge. On Ji'an Ridge in Haikou, a small parasitic volcano formed inside the crater. This small volcano is also called an internal parasitic volcano (see the diagram of the Haikou Saddle Ridge crater and its lateral parasitic crater) (Fig. 7).

Parastratotype A parastratotype is a supplemental stratotype for a holostratotype used to illustrate the diversity and heterogeneity of a

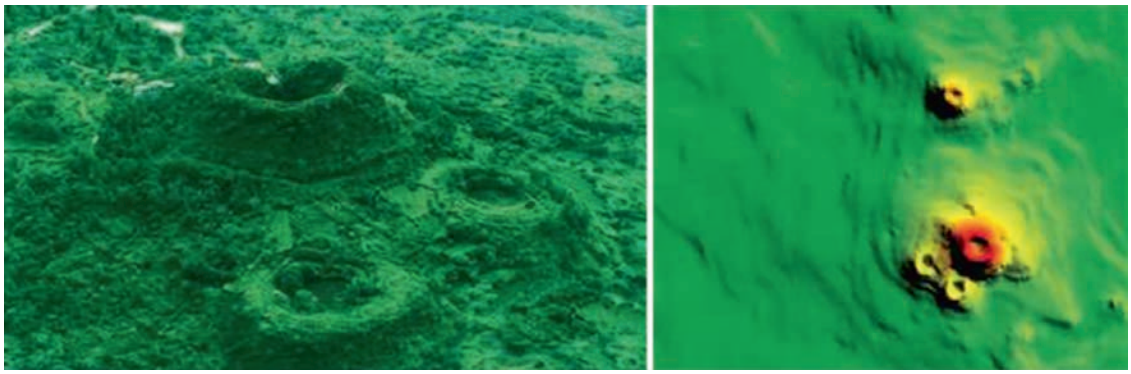


Fig. 7 Parasitic volcano landscape beside Ma'anling Ridge Volcano, Haikou

defined stratigraphic unit or to indicate other characteristics of a holostratotype.

Parco del Beigua, Italy This geopark is located in the Ligurian region of northwestern Italy and has an area of 390 km^2. It became a global geopark in 2005. The park comprises ten municipal districts, including all areas of the natural park in Beguaparco. In terms of science, aesthetics and education, the Geopark Beguaparco is the most striking area in Liguria. The region had an important role in the reconstruction of the geological history of Italy, especially the evolution of the Alps and its connection with the Apennines.

Parco Nazionaledel Cilento e Vallo di Diano Geopark, Italy This geopark is located in Campania, Province of Salerno, and covers an area of 392 km^2. It became a global geopark in 2010. The karst landform of the geopark comprises caves, funnels and basins. The geological relics in the area are distinctive due to the effects of tectonics, hydrogeology, and palaeo-biology. In addition to the natural beauty, the geopark also has a strong cultural and humanistic significance. Among them, the Carthus Monastery has been listed as a UNESCO World Heritage Site. In addition, the park has benefited from the National Park Service of the United States, which provided funding and technical support for the park to enhance its value.

Park Naturel Regional du Luberon, France This geopark is located in the Provence region in southern France and has an area of approximately 1,840 km^2. It became a member of the Global Geoparks Network in 2004. The geopark has interesting geological features. Brown hills with cliffs and ravines (dark red to golden yellow) are one of the most significant landscapes and have been protected since 2002. The grey mudstone hills surrounding the town of Apt are another extraordinary site. They were part of the Aptian stratotype described by Alcide d'Orbigny in 1840. Wonderful natural sites, such as the Oppedette and Véroncle Canyons, enrich the landscape diversity of the area. The exploitation of mineral resources (e.g., meteorites, lignite, clay and limestone) has made the area more distinctive, as evidenced by numerous quarries and factories.

Parks Canada Parks Canada was established in 1911 as a second-tier administrative agency specialising in national park management and became the world's first national park service. James B. Harkin, the Minister of Interior at the time, was the first commissioner of the agency. Over the last 100 years, many conventional government departments have disappeared, new ones were founded during cabinet reforms, and Parks Canada was relocated to other departments seven times. However, its core function has remained the same, and it has become an example of national parks management for other countries. The agency is regulated by the provisions of the *Canada National Parks Act*, which states that it is to act on behalf of the Canadian people to

preserve and demonstrate the natural and cultural heritage of Canada, to enhance the awareness and appreciation of the public towards the heritage, and to ensure the ecological and historical integrity of heritage for current and future generations. The official website of Parks Canada is http://www.pc.gc.ca.

Parkway A parkway is a road in a park or park-like area. Trees are usually planted on both sides of parkways.

Peak *Synonym:* ► *Mountain*

Peaks are also known as ridges or mountains. They stand out from the surrounding mountainous terrain and are mostly located on the tops of ridges. The side view of Hengcheng Peak provides the best illustration of the relationship between peaks and ridges. Peaks can be sharp, round, columnar, and flat topped. A mountainous area often has multiple peaks, and they are often eye-catching. Examples of peaks are Mount Everest in the Himalayas, the West Peak in Huashan, Zhu Rongfeng in Hengshan, Tiandu Peak in Huangshan and Tianzhu Peak in the Taishan Mountain, which are popular destinations for tourists.

Peak Cluster Depression Karst Landscape

This is a landform composed of interconnected upward-pointing rock peaks that surround depressions. These peaks are mainly conical, and the bottoms of the depressions are mostly covered with bare rocks or thin soils. Avens (or shafts) are usually developed here. The height difference from the peak to the bottom of the depression can range from tens of metres to more than 500 m. The groundwater is deep, and subterranean rivers are well developed. A typical location that represents the development of this landform is the Qibainong National Geopark in Dahua County, Guangxi Province. This park, which covers 486 km^2, contains more than 900 rock peaks with heights greater than 800 m, which is an average of 19 peaks per square kilometre. The karst depressions around these peaks have various sizes and depths, creating a spectacular landform. In the language of the minority Yao Group, this type of depression is called 'nong'. In the Qibainong area, there are approximately 2,566 nongs, an average of 5 per km^2 (Fig. 8).



Fig. 8 Karst peak and depression landscape – Fengshan, Guangxi Province

Peak Forest Plain Landscape This is a landform that is formed by the combination of karst plains and karst forests, where clusters of rock peaks stand on a slightly undulating or flat plain in an orderly pattern. The rock peaks have steep slopes and look like towers. When the peaks are very sparse, this landform is called a Gufeng Plain, which literally means a plain with isolated peaks. China's peak forest plain landform covers a total area of 12,600 km^2; 98% is in Guangxi Province, and the remainder is scattered around Lingling, Ningyuan and Jiangyong in Hunan Province and Duyun and Dusha in southern Guizhou Province. Its distribution is confined to 26–30°N latitude and elevations of 40–1,160 m. The relative heights are generally 100–200 m. The peak forest landform in the area from Guilin to Yangshuo is the world's largest distribution on land, and it has high aesthetic value in terms of its typical nature and rarity. It is a unique landform type (Fig. 9).

Peak-Valley Granite Landscape (Alpine) – Huangshan Type and Sanqingshan Type These landscapes include granite mountains with absolute elevations over 1,500 m and relative heights greater than 1,000 m. The landscapes are characterised by sharp, angular, and free-standing yet clustered spikes as well as deep and steep valleys. They mainly form due to congelifraction and erosion caused by water. Some researchers call this the 'Granite Stone Forest Landscape'. A small batholith or stock covering approximately 1,000 km^2 with well-developed vertical joints that experienced intense neotectonic uplift is a typical requirement for the formation of this landscape. The Huangshan Global Geopark and Sanqingshan National Geological Park are representatives of this type of landscape (Fig. 10).

Pearl In Chinese, pearl is also being called 'real bead'. They are organic gemstones found in shelled molluscs. Pearls are made up of calcium carbonate (aragonite) secreted inside a mollusc, which forms abundant tiny aragonite crystals. Its composition is 91.6% $CaCO_3$, 4% H_2O, 4% organic matter and 0.4% other materials. Pearls have various forms, including round, pear-shaped, egg-shaped, teardrop-shaped, button-shaped and irregular, and round pearls are most valuable. Pearls do not have a uniform content and have various colours, such as white, pink, light yellow, light



Fig. 9 Peak and plain landscape – Guilin, Guangxi Province



Fig. 10 Peak-valley landscape in Xihai, Huangshan



Fig. 11 Seawater pearls

green, light blue, brown, light purple and black. White pearls are most common. Pearls have white streaks, a typical soft pearly lustre with a rainbow halo and are transparent or translucent. China was the earliest country to practice pearl aquaculture and is the largest producer of pearls, including both cultured seawater pearls and freshwater pearls. The famous 'southern pearls' are represented by the pearls cultured in Hepu in Beihai, Guangxi Province. The 'eastern pearls' are represented by the pearls cultured in Japan, and 'western pearls' refers to the pearls cultured in the Mediterranean in Europe (Fig. 11).

Peat Soil Peat is an accumulation of partially decayed vegetation or organic matter that is unique to natural areas called peatlands, bogs, mires, moors, or muskegs. Constant, long-term or seasonal wet conditions provide ideal environments for the growth of aquatic vegetation. When plants die, large amounts of undecomposed or semi-decomposed plant residue accumulate and form a peat layer that is usually more than 50 cm thick. Peat is also a nonzonal soil that mainly forms in shallow lakes, swamps and waterlogged depressions, such as those in Sichuan, Heilongjiang and Jilin.

Peat Swamp Landscape This is a type of swamp landscape comprising peat accumulations, typical swamp vegetation and numerous plant communities, such as herbs, woody-herbal plants and mosses. Common species include bolting grass (Carex), bog sedge (Kobresia), dwarf bog birch (Betula), marsh tea (Ledum) and peat moss (Sphagnum). Due to the change in water, soil freezing and growth of bolting grass and bog sedge, peat swamps generally have undulating topography. In China, peat swamps are mainly located in the moist cold temperate and temperate regions in the northwest and in the alpine plateaus in Qinghai and Xinjiang Provinces (Fig. 12).

Peatland Landscape This is a natural landscape comprising accumulated peat. Peatlands, also called moors, the place where peat forms. Peat is composed of plant remains that have been buried for thousands of years in wetlands with a cold climate. Under conditions of low temperature, little rain and lack of air, the plant remains decompose slowly to form a unique organic matter that is mostly brownish yellow or light brown. In China, peatlands are generally located in the northern territories and in a few scattered sites in the low valley depressions in the south. The thickness of the peat layer is a key parameter to identify a peatland. The main plants that form peat are peat moss, ice moss, Carex and other aquatic vegetation. Based on the burial conditions, plant species and the extent of decomposition, peatlands can be divided into low moor peat, medium moor peat and high moor peat (Fig. 13).

Pebble A pebble is a well-polished rounded rock fragment with a diameter greater than 5 mm



Fig. 12 Peat swamp landscape



Fig. 13 Peatland landscape in Ireland

deposited in a river or lake. Pebbles form over long periods of time and are mainly composed of siliceous rock. The formation process is divided into the rock weathering stage, the rock disintegration and collapse stage, and the round grinding stage associated with river transportation.

Peculiar Plants Tourism Plants with certain peculiar and unique features can attract tourists, such as (1) extremely old pines, such as the Xuanyuan Cypress in Huangling, Shaanxi, the Zhou Pine in the Jin Temple of Taiyuan, and the Sui Plum Tree at the Qing Temple of Tiantaishan in Zhejiang; (2) trees with beautiful shapes, such as the Welcoming Pine and the Jiulong Pine at the Jeitai Temple in Beijing; (3) attractive colours, such as the red leaves of Xiangshan in Beijing; (4) alluring fragrances, such as the Osmanthus in Lushan, the 'Drunken Flower' of Tanzania (Chrysanthemum) and the 'Drunken Grass' of Ethiopia; (5) large trees, such as the Giant Tree of Tianmushan, the Giant Ginkgo of Qingchengshan and the General Cypress of Songshan; (6) trees with odd functions, such as those can grow bread, produce oil, and eat insects; (7) trees with strange

appearances, such as the 'sophora tree embracing a cypress' at the Yao Temple in Linfen, the three-layer fruit trees in Shanyin County, Shaanxi Province, the three-in-one tree in Hefeng County, Hubei Province, and the tree-holding tower and tower-holding tree in Puer County, Yunnan Province.

Pegmatite Pegmatites are dykes composed of large or coarse-grained minerals. They are usually made up of large crystals of K-feldspar, quartz and mica, such as in the common granite pegmatite. Some pegmatites may contain gem-quality minerals, such as aquamarine, tourmaline, topaz and rock crystal.

Peipiaosteus Peipiaosteus is a genus of Acipenseriformes under the subclass Chondrostei. Acipenseriformes primarily have cartilaginous endoskeletons with some degree of degradation of an external skeleton (scales), leaving arrays of longitudinal bone plates. Therefore, this fish almost had no scales. Peipiaosteus is small (approximately 20 cm long) and has a fusiform, slightly flat head, obtuse snout, some lines of small lateral scales and a crooked tail. They have been discovered and excavated in the Cretaceous rocks in the Beipiao area, Liaoning Province. Fossils with complete forms, exquisite shapes, and contrasting colours with the surrounding rocks are the most valuable (Fig. 14).

Pelean Type This type of volcanic eruption is named after the Mount Pelee on Martinique Island in the Lesser Antilles. A Pelean-type eruption is a violent eruption of viscous magma, usually rhyolitic, andesitic or trachytic. The erupted materials include hot volcaniclastic flows accompanied by the formation of volcanic dome. Lateral eruptions may occur along sides of the volcanic dome, forming pyroclastic flows.

Penghu Islands Landscape This is a general term for the landscape of 64 islands in the southeastern Taiwan Strait. The Penghu waterway is located approximately 48 km from the west coast of Taiwan. Its northernmost island is Mudouyu, the southernmost island is Qimeiyu, the westernmost island is Huayu, and the easternmost island is Chamouyu. The islands cover a total area of 127 km^2. They are all volcanic islands composed of basalt surrounded by coral reefs. The topography is generally flat with elevations of 30–40 m. The highest point (79 m) is on Maoyu (Cat Islet), and Penghu Island, Yuweng (Fisherman) Island and Baisha (White Sand) Island are the three largest islands. There is a causeway between Penghu and Baisha Islands that can be walked across at low tide (Fig. 15).

Penghu Volcanic Cluster Landscape Penghu is located in the Taiwan Strait and is composed of 64 basalt islands. Volcanic eruptions began in the Neogene, approximately 10.5–16.2 million years ago. The volcanoes are part of the formation of volcanoes in Nanjing and Zhangzhou in eastern mainland China. The basalt landscape in Penghu Bay is characterised by



Fig. 14 Peipiaosteus



Fig. 15 Penghu Islands landscape

columnar joints and marine erosion landforms. Columnar joints are arranged in a variety of patterns, such as the tower-shaped columnar joints of the Yuanbei basalt island, the radial columnar joints of the Qimei basalt islands and the arc-shaped columns of Xiyu. Basalt landscapes are common on all of the islands, including features such as sea caves, sea arches and marine stacks. The Penghu basalt has been well studied. Chen Paiyuan and Li Jima have published research papers on this topic. Penghu is a famous tourist area in Taiwan, and the Penghu Geological Park has been established.

Península Valdés, Argentina This site is located near the Atlantic Ocean on the northeastern edge of the Patagonia Plateau in southeastern Argentina. It is a marine mammal sanctuary of global significance. As the natural breeding site for a considerable number of northern right whale dolphins (Lissodelphis borealis), South Ocean walrus and South Ocean sea lions, the site can be considered the home of many marine mammals.

Peridotite Peridotite is the most common type of ultrabasic rock and is composed of olivine and pyroxene. Olivine can make up 40–90% of the rock, followed by hornblende, biotite, plagioclase and chromite. Peridotite is usually found in ultrabasic rocks or in inclusions in alkaline basalt. Peridotites of various sizes are located in the Nanjing Liuhe National Geopark; the large ones are 2 m in diameter.

Periglacial Rock Pillar Landscape A periglacial rock pillar is also known as a periglacial rock protrusion. It is a columnar or strip-like rock mass projecting from the ground that forms by frost splitting and frost heaving. The pillars generally range in height from dozens of centimetres to 2 m. There are two types. The first is rock pillars connected to the bedrock with vertical joints and cracks, composed of basalt, sandstone, schist and gneiss. This type of periglacial rock pillar is caused by frost splitting in a single cycle, where the pillar has not experienced vertical or horizontal movement. The second type is rock pillars that have separated from the bedrock. They are originally rock strips buried in the permafrost layer that have been uplifted by multiple cycles of frost heaving. This type is only few dozens of centimetres tall, and they are often slanted and unstable. Periglacial rock pillars often exist in permafrost with strong frost splitting effect. They are a significant indicator of climatic conditions.

Period and System Period is the basic chronostratigraphic unit of the international geologic timescale. It is equivalent to the time span of a system (basic lithostratigraphic unit) and is a subdivision of an era. For example, the Palaeozoic Era can be subdivided into six periods: the Cambrian Period, Ordovician Period, Silurian Period, Devonian Period, Carboniferous Period and Permian Period. Each period covers a different time span, and a period can be further subdivided into epochs. A system is all of the rocks that formed during a certain period; it is a higher level than a series but a lower level than an erathem in the International Chronostratigraphic Chart. Examples are the Cambrian System and the Triassic System. In general, a system can be subdivided into two to four series.

Perlite Perlite is made up of acidic volcanic glass with abundant pearl-shaped cracks. It often contains small amounts of quartz or feldspar phenocrysts. Perlite contains 2–6% H_2O+. Fluolite, which is very similar to perlite, contains more than 6% H_2O+.

Permian Period The Permian Period is the sixth period of the Palaeozoic Era; it lasted for 47 million years, from 290 to 252 million years ago. The Permian System is well developed in central Germany. Its lower part includes a set of red rocks that is known as the Rotliegendia Series, and its upper part is magnesium limestone called the Zechsteinian Series. Because this set of two characteristics are remarkable, Mergel coined it 'Dyas' (meaning dual division) in 1859, and it was later called the Permian System. However, as early as 1841, the British geologist Sir R.I. Murchison had discovered marine facies on top of the Carboniferous System at a site called Perm on the western slope of the Ural Mountains in Russia, and he called this unit Permian. The Dyas and Permian were later shown to be the same strata. Since the term Permian was first used, according to the nomenclature rule, the 1937 International Geological Conference formally adopted the name Permian, but the Chinese translation of the dual division remained unchanged. The Permian System is widely distributed in China and contains a variety of sedimentary types and rich organisms. In South China, the Permian marine strata are fully developed with a clear stratigraphic sequence and abundant biota fossils. With these unique geological features, these areas of the Permian System have become important study sites. Currently, the tripartite division of the Permian System prevails globally, and the Permian System is subdivided into three series and nine stages. The GSSPs for the Wuchiaping Stage and the Changxing Stage of the Leping Series are located in Laibin, Guangxi Province and Changxing, Zhejiang Province respectively. The Middle Permian limestone is the base material for the formation of the valuable 'stone forest landscape' in China.

Permian-Triassic Boundary Section (GSSP 'Golden Spike') in Changxing, Zhejiang This section is located in Meishan Town in Changxing County, Zhejiang Province. The Changxing Stage section overlies the Permian System and includes a thick layer of grey to dark grey limestone with a silicate zone and multiple layers of clay. The section is rich in conodont fossils and can be divided into four conodont zones, and the first appearance of the conodont Clarkia subcarinata marks the bottom boundary of the Changxing Stage. The section also contains Plaeofusulina fragments and fossils of Pseudotirolites and Tapashanitidaes. The Yinkengian Stage (equivalent to the Indian Stage on the International Stratigraphic Chart) at the bottom of the Triassic Series mainly consists of mudstone and limestone with five conodont zones, two ammonite zones and four bivalve zones. The bottom of this stage is also the global Permian-Triassic boundary and is marked by the first appearance of the conodont Hindeodus parvus. The GSSP in the Changxing section is located at the bottom of the Meishan D Section 27c in Changxing County, Zhejiang Province. This section was approved as a Permian-Triassic GSSP by the ICS and IUGS.

Permian-Triassic Boundary Section in Dalongkou, Xinjiang This section is one of

the most important boundary stratotype sections and points in northern China. It is located in Dalongkou in Santai Town, Jimusaer County, Xinjiang Province. The lower part of the Lower Triassic Series is the Dalongkou Stage. The rocks are characterised by purple silty mudstone and sandstone as well as a small amount of fine sandstone in the lower part (referred to as the upper part of the Guodikeng Formation). The upper and middle parts contain alternating layers of purplish red mudstone and silty sandstone with uneven thickness that are interbedded with greyish green lithic sandstone and silty sandstone (Jiucai Yuan Formation). The bottom of the Dalongkou Stage is the Permian-Triassic boundary and is largely signified by the first appearance of the fossil reptile Lystrosaurus and Lundbladispora pollen. This stage contains abundant fossils of ancient vertebrates, plants, pollen, Ostracoda and Estheria, which can be categorised into different combinations. The Dalongkou Stage and Yinhang Stage of China's Triassic marine facies are within approximately the same period and are equivalent to the Indian Stage on the International Stratigraphic Chart.

Petrified Forest of Lesvos, Greece This site is located in the northeastern Aegean Sea and covers an area of 1,630 km^2. Lesvos became a member of the Global Geoparks Network in 2004. The island on which the geopark is located is one of the largest islands in Greece and is shaped like a leaf. The island has fertile land and is rich in biodiversity. There are numerous silver-white olive trees, dark green pine trees, grey-green oak trees and unique wild flowers. On the western coast of the island, volcanic rock outcrops extend along the Aegean Sea, and the continual erosion has exposed ancient plant fossils. Visitors can learn about the legend of the disappearance of Atlantis and imagine the volcanic eruption 20 million years ago that destroyed the northern part of the Aegean Sea and turned it into a sea of fire.

Petrified Wood Petrified wood is silicified asbestos. When crocidolite (blue asbestos) in a rock is subject to metasomatism by a hot silicate-rich solution, it transforms into a cryptocrystalline quartz aggregate composed of silica but retains its asbestos fibrous structure. It is called petrified wood because it looks like a piece of wood (Fig. 16).

Petrology Petrology is one of the fundamental sciences of geology. It mainly includes studies of the chemical composition, mineral composition, structure, form, classification, formation conditions, distribution, occurrence, combinations, mineralization relationships, evolution and changes of rocks. Petrology is the foundation of regional geological surveys, mineral exploration, hydrogeology, engineering geology, environmental geology, geochemistry,



Fig. 16 Petrified wood

geophysics, agricultural geology, disaster geology and tourism geology. Based on the research focus, it can be divided into igneous petrology, sedimentary petrology, metamorphic petrology, rock chemistry, rock groups, experimental petrology, technical petrology, regional petrology, landscape petrology and ornamental petrology. Rocks and landscapes with aesthetic value are usually important for geological landscape tourism.

Phaeozem ▶ Black Soil

Phanerozoic Eon The time interval of the Phanerozoic Eon is from the lower boundary of the Cambrian Period (542 million years ago) to the present, and the Phanerozoic Eonothem includes all of the rocks that formed during this time. During this period, abundant higher living organisms appeared and evolved rapidly. The strata are well preserved, which has facilitated detailed studies of them. The Phanerozoic Eon (Eonothem) is further subdivided into the Palaeozoic Erathem (Era), Mesozoic Erathem (Era) and Cenozoic Erathem (Era).

Phases of Tourism Planning The phases of tourism planning refer to the spatial structure and temporal sequence of tourism development planning in a region. They are usually divided into short-term (5 years), medium-term (10 years) and long-term (15–20 years) planning, and the terms should be consistent with the national economic development plan. Short-term planning focuses on detailed planning of construction projects, medium-term planning focuses on strategic plans, and long-term planning envisions the future development of the tourism industry.

Phenology Flora and fauna grow in accordance with seasonal changes in the environment and temperature. Phenology is the discipline that studies the relationship between living phenomena and the growth rhythms of fauna and flora and the relationship between seasonal and environmental changes due to environmental factors, such as climate.

Phlogopite The composition of phlogopite is $KMg_3[AlSi_3O_{10}](F,OH)_2$. It crystallizes in the monoclinic crystal system. The crystal form is columnar or pseudohexagonal blocks, and it usually has a conical shape, sometimes with crystal twinning. It can also appear in a scale-like blocky aggregate form. It can be colourless, yellowish brown, light green or white with colourless streaks. The diaphaneity is transparent to opaque with a pearly lustre. The specific gravity is 2.76–2.90, the Mohs hardness is 2–2.5, and the fractures are uneven. It mainly forms in ultrabasic and contact-metamorphosed rocks.

Phoenix Islands Protected Area, Hawaii and Fiji These islands are located between Hawaii and Fiji and cover an area of 408,250 km^2. The area is a habitat for marine and terrestrial organisms in the South Pacific. The heritage site includes the Phoenix Islands, one of the three largest islands in Kiribati, and is the world's largest designated marine protected area. The protected area contains a well-preserved marine coralline ecosystem, 14 known seamount peaks (presumably extinct) and other deep-sea habitats. Approximately 800 animal species are known in the area, including approximately 200 coral species, 500 species of fish, 18 species of marine mammals and 44 species of birds. The structure and function of the protected area ecosystem demonstrate the original ecological natural characteristics as well as the importance of species migration routes and gene banks.

Phonolite Phonolite is an alkaline volcanic rock that gets its name because it generates a loud sound when tapped. It is composed of alkali feldspar, feldspathoids (such as nepheline, leucite, analcite, hauynite and noselite) and dark minerals. It is called nosean phonolite when it contains noselite and is called leucophonolite when it contains leucite. These two types of rocks exist in Jiangning Tongjing (Copper Well) in Nanjing, and nosean phonolite can also be found in Bamaoqiongzong in Tibet.

Photographic Tourism Photographic tourism is a type of tourism activity that focuses on photography. Photographers travel on holidays to take photos at nearby destinations or far-away places of interest to discover the natural and cultural landscapes through their cameras.

Phreatic Eruption *Synonym:* ▶ *Phreatic explosion;* ▶ *Gaseous explosion*
This is the phenomenon of gas ejection during a volcanic eruption. Gases released when magma moves slowly from a volcanic vent to the surface gather in shallow fissures, forming a pressurised chamber. When the pressure exceeds the load from the overlying strata, the chamber explodes. Concentrated gaseous explosions are usually discontinuous and cause gaseous ejections. Gaseous explosions are destructive and usually eject small amounts of magma.

Phreatic Explosion ▶ Phreatic Eruption

Phreatomagmatic Eruption This is a volcanic phenomenon that occurs when magma or magmatic heat comes into contact with water. When magma enters an aquifer or ice layer or when lava flows into a basin, water vapourises rapidly, and when the pressure increases and exceeds the load from the overlying strata, a phreatomagmatic eruption will occur.

Phyllite Phyllite is a shallow metamorphic rock with a phyllitic structure. It can be formed by the shallow metamorphism of various rocks, such as clay rock, siltstone, siliceous rock, intermediate acidic tuff, and calcareous rock. Its minerals are generally recrystallized, and the degree of metamorphism is slightly higher than that of slate. The new metamorphic minerals include sericite, chloritoid, quartz and plagioclase. Phyllite is characterized by a fine lepidoblastic texture and phyllitic foliations with a silky gloss. There are several types of phyllite, such as sericite, chloritoid, clay, silt phyllite, silicate phyllite, tuff phyllite and calcium phyllite (Fig. 17).

Phyllitic Foliation Phyllitic foliation is a type of planar structure comprising small-scale oriented minerals and small wrinkle marks that form during metamorphism. It is a typical structure of shallow metamorphic rocks that is composed of a parallel arrangement of micro-sericite. The small-scale minerals are generally not recognizable to the naked eye, and this is the main difference from the foliations that can be identified with the naked eye.



Fig. 17 Phyllite

Physical Geographic Process The physical geographic process includes studies of the occurrence, development, and evolution of physical geography and its associated elements. It includes climate change, landscape formation and evolution, hydrological processes, soil development and plant community development. The formation of landscapes and zones is an integrated natural geographic process. The purpose of studying the physical geographic process is to understand the formation and evolution of the Earth's surface system and its intrinsic dynamic mechanisms. The time scales of natural geographic processes are usually divided into daily, seasonal, annual, short-term, multi-year, and long-term changes. The study of natural geographic processes provides a scientific basis for the rational development and protection of tourism landscape resources.

Physical Geography Physical geography is one of the two main branches of geography and is the study of the natural environment of the Earth's surface. Its main focus is the natural environment that human beings rely on to survive and develop. The natural environment includes the lithosphere and soil, hydrosphere, biosphere and atmosphere. Physical geography is the study of the morphology, structure, function, spatial characteristics, formation and development of these zones as well as the interactions between them. The identification and analysis of natural geographical elements is the basis for conducting surveys of tourism resources and preparing tourism plans.



Fig. 18 Picture stone

Physical Regionalization The natural environment and its components have many similar properties and structures and can be grouped into different geographical systems with certain hierarchical relationships. Natural zoning includes comprehensive natural zoning and departmental natural zoning. Natural zoning includes the relative consistency within a zoning unit and the differences between the units as well as the hierarchical affiliations of different natural areas. Based on this concept, tourism zoning can be performed, and the locations of geoparks can be determined.

Physical Weathering Physical weathering is an important geological process that shapes landforms. Rocks exposed at the surface are affected by radiation, atmospheric circulation, hydrodynamics and gravity, which cause freezing and thawing, expansion and contraction, disintegration and crumbling, exfoliation and block separation. Over time, these continuous processes cause rocks to break down into small pieces from coarse to fine and eventually to loose sand and soil. Physical weathering helps to shape rocks into different types of landforms.

Picture Stone A picture stone is also known as a pattern stone or painting stone. The patterns on the stone are composed of various textures, lines and colours. The pattern composition is rich and varied, and this type of stone has become popular for collectors. Picture stones are mainly ornamental, and by appreciating them, viewers may increase their abilities in aesthetics appreciation. Collectors often seek picture stones with spiritual significance and internal connotations. Picture stones are widespread throughout China in the gravel layers of rivers, lakes and swamps and in the gobi, deserts, pluvial layers, talus accumulation layers, colluvial layers, pebble beaches and coastal areas. Collectors may find unexpected surprises in these sites (Fig. 18).

Piedmont A piedmont is the lower part of a mountain that is connected to a plain or valley. It has a distinct slope.

Pillow Lava Landscape This is a lava landscape with pillow-like features. In an underwater environment, lava flows gradually cool, and while they remain elastic, their external shells expand to form pillow-like features. Underwater environments include marine eruptions (shallow water at depths less than 500 m) and lava on land flowing into water bodies (coasts, inland lakes and rivers, and swamps). For example, the second lava flow of the Hawaiian volcanoes in 1801 was a normal ropy lava flow, but it became pillow lava when it reached the continental shelf. Pillow lava is characterised as follows: (1) It has pillow-like, spherical, raft-like or bread-like shapes, where the bottom is a concave-upward surface due to the underlying pillow-like body, and the

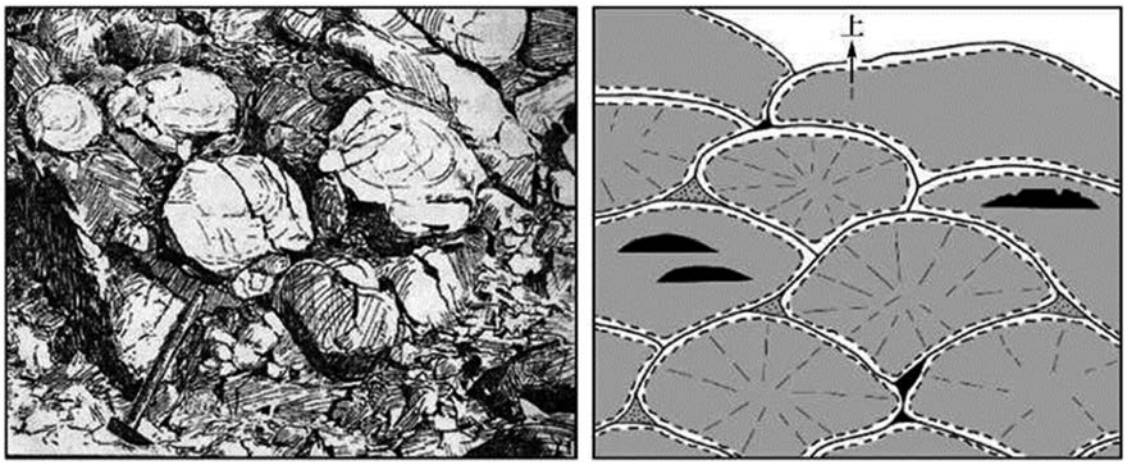


Fig. 19 Sketch of pillow lava (left: after Hatch 1949; right: after G.A. MacDonald 1972)

top is often an convex-upward surface. (2) Sizes range from a few metres to dozens of metres but can be as small as a few centimetres to a few millimetres. (3) A hard, glassy shell is formed by rapid surface cooling. (4) The pores at the surfaces are in a concentric pattern; (5) Spherical or radial fissures have formed during the cooling process. (6) Glassy volcanic clasts act as cement. (7) The long axis is generally parallel to the originally inclined lava flow (Fig. 19).

Pinggu Huangsongyu National Geopark, Beijing This geopark is located in Huangsongyu County, Pingdu District, Beijing, and it became a national geopark in 2009. The main geological features are quartzite landforms consisting of the Mesoproterozoic Great Wall Formation, the unconformity between the Proterozoic and Archean Eonothems, Mesoproterozoic breccia, the remains of palaeovolcanoes, karst caves and stratigraphic remains. The quartzite landforms are typical of the semi-arid area of northern China. The Changzhou trench strata of the Mesoproterozoic Great Wall Formation are not integrated into the Mesozoic gneiss. Jingdong Cave has an area of more than 20,000 m^2 and is more than 2,500 m long; The geopark contains a relatively complete set of the Mesoproterozoic Great Wall Formation.

Pinghe Lingtongshan Geopark, Fujian This geopark is located in Pinghe County in Fujian Province. The geopark has a total area of 36 km^2, and the main geological features are concentrated in an area of 16 km^2. It became a national geopark in 2011. It features volcanic peak clusters and other volcanic features. The geopark is representative of the active Cretaceous volcanic belts in eastern Fujian. Scientifically, the complete volcanic rock profiles, diverse rock types, and volcanic landforms are of great scientific value for research and science popularisation and protection.

Pingjiang Shiniuzhai Geopark, Hunan This geopark is located in Pingjiang County, Yueyang City, Hunan Province. It has an area of 78 km^2, and the main geological heritage area covers 21 km^2. It became a national geopark in 2011. The geopark is dominated by Danxia landforms with both granite landforms and water body landscapes. The geological remains are typical, rare, natural, graceful, and systematically integrated. The formation of the Danxia landforms in the park represents the evolution of the Earth since the Cretaceous in northeastern Hunan and even across southeastern China. Six geosites satisfy the requirements of national geoparks. The Danxia landform developed on granitic sandstone under special structural conditions. It is unique among the family of Danxia landforms. The 3.5-km-long cliff and the hundreds of miles of granitic sandstone and conglomerate provide

stunning scenery (it has been called white Danxia due to the leaching of the originally red Danxia) and extend over thousands of metres of the rocks. The Danxia landforms, such as groups of walls and various spherical (arc-shaped) weathering and erosion forms, are rare in China and abroad. The Danxia landforms of the park and the water and ecological landscapes combine to form an area with rare natural beauty.

Pingliang Mount Kongtongshan National Geopark, Gansu This geopark is located in Pingliang City in Gansu Province. With its elevation of 2,123 m above sea level, it is the 'first mountain of the west' along the ancient Silk Road. It became a national geopark in 2004. The geopark is characterised by landforms that developed in Cretaceous purple sandstone. Kongtong Mountain is in the Liupanshan Ranges and was shaped by weathering, water erosion and collapse, and it forms the unique northern Danxia landscape. The Emperor visited this area in ancient times, which was recorded in historical records. Taoist temples and monasteries have been built in this area since the Han Dynasty.

Pingnan Baishuiyang National Geopark, Fujian This geopark is located in Pingnan County, Fujian Province, at the borders between Pingnan, Zhenghe and Zhouning Counties. The geopark includes a combination of volcanic geology, landforms and waterscapes. The volcanic rocks record the volcanic evolution in the Baishuiyang area over more than 100 million years. It became a national geopark in 2005. The geopark lies in the middle of the Jiufeng mountain range and has an average elevation of 700–800 m. Its main geologic features comprise the Baishuiyang volcanic riverbed, Yuanyangxi Gorge, waterfalls, columnar joints, river erosion landforms, and the Yiyang large-scale volcanic caldera structures, which contain typical acidic and bimodal volcanic rocks.

Pingo Landscape ▶ Icicle

Pingshun Tianjishan Geopark, Shanxi This geopark is located in eastern Pingshun County, Changzhi City, Shanxi Province. It is situated in the central part of the main ridge of Mount Taihangshan. It covers an area of 174 km^2, and its main geological features cover an area of 59 km^2. It was designated as a national geopark by the Ministry of Land and Resources in December 2011. The main scenic districts from north to south comprise Tongtian Gorge, Tianji Mountain and Shenlong Bay. The main attractions of the geopark are the geomorphology, water landscapes, ecology and culture. It is a large, comprehensive geopark that integrates scientific research and tourism. The geopark has experienced a long and complicated geological history, and it records sedimentation dating back to 1.15 billion years ago that includes several major marine transgression-regression cycles. The geological heritage is from the Mesoproterozoic, Palaeozoic and Cenozoic periods. The stratigraphic characteristics, sedimentary structures and preserved fossils illustrate the evolution of the ancient marine environment and the palaeogeography of the epicontinental seas in northern China during the Palaeozoic Era, which have great scientific and research value. The aesthetically valuable grand and steep cliffs, deep valleys, tranquil caves, unique peaks and rocks with strange shapes in the geopark are nature's sculptures and represent valuable geological heritage for humans. There are also many springs, waterfalls and ponds in the geopark. Tianquan Waterfall, which is 216 m high and flows throughout the year, is a unique feature in China. The petrological features, sedimentary structures and preserved fossils of the complete Palaeozoic stratigraphic sections in the geopark are typical of North China and have great scientific research and conservation value.

Pingtang National Geopark, Guizhou This geopark lies on the southern edge of Guizhou Province in Pingtang County in the southern Miaoling Mountains. It is at the junction between the Jiuwan Mountains in Guangxi and the mountainous areas in southern Guizhou, and it covers an area of 25.8 km^2. It was designated as one of the fourth group of national geoparks by the Ministry of Land and Resources in August 2005. The geopark features a karst landform of Palaeozoic carbonate

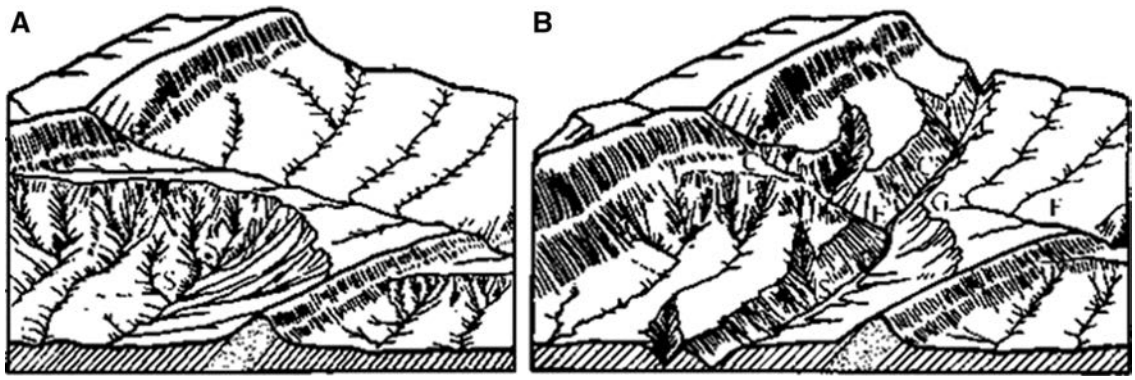


Fig. 20 Diagram of a capturing river. A. Before capturing; B. After capturing; C. Captured river; D. Capturing river; E. Capturing bend; F. Beheaded river; G. Wind mouth

rocks. Three rivers run through the geopark; two are surface rivers, and the other is an underground river. Its karst landscapes include peak forest basins and depressions, clustered mountain funnels, sinkhole funnel clusters, karst caves, arches, blind valleys and gorges.

Pingxiang Anyuan National Mining Park, Jiangxi This park is located in western Jiangxi Province and 5 km southeast of Pingxiang City. It is administered by the Anyuan District, Pingxiang City, and covers an area of 26.30 km^2. It became a national mining park in 2010. The main mining features includes typical geological profiles of the deposits, geological structures and palaeontological heritage, prospecting remains and indicators, mine stopes, smelting fields, ventilation and lighting facilities and equipment from daily life. Revolutionary human and natural landscapes can also be found in the park, forming a comprehensive mining park that integrates rich content, prominent features, industrial history, scientific research, science popularisation and sightseeing.

Pirate River *Synonym:* ►*Diverter, capturing river*

A pirate river is also known as a capturing river. During the process of watershed regression by rivers on both sides of a water divide, the stream with the stronger headward erosional power cuts back into the divide and captures the neighbouring river. The stronger river is called a capturing river. At the point where river-capture takes place, there is usually a marked bend, known as the elbow of capture. The riverbed of the capturing river is lower than that of the captured river, and the marked difference in water level helps to facilitate the formation of cascades. The capturing river will gradually grow and increase in water volume, resulting in strengthening of its erosional power. The cascade continues to recede towards the captured river and cuts down to the riverbed to form fluvial terraces or a valley-in-valley landscape (Fig. 20).

Pirin National Park, Bulgaria This park is located in the Pirin Mountains, Blagoevgrad Province, in southwestern Bulgaria near Macedonia, and it has a core protection area of 401 km^2. At elevations between 1,008 and 2,914 m, the site contains unique and diverse Balkan endemic landscapes with glacial lakes, waterfalls, caves and predominantly coniferous forests. More than 70 glacier lakes are dispersed among the towering and steep mountains, allowing the site to be the home to hundreds of rare local species, many of which are representative living plant fossils of the Balkans from the Pleistocene Period.

Pitons Management Area, Saint Lucia This site is located in the southwestern part of the Caribbean island of Saint Lucia. The core protection area covers 29 km^2. Pyton Mitta Ridge connects two volcanic plugs (770 and 743 m above sea level) The volcanic topography area includes geothermal fields, sulphur fumaroles, and springs. Coral reefs

account for nearly 60% of the water area, and the reefs are inhabited by 160 species of finfish, 60 species of cnidarians, several types of coral, 8 species of molluscs, 14 species of sponges, 11 species of echinoderms, 15 species of arthropods, and eight species of insects. The main vegetation type on the land is tropical rainforest, which gradually transitions to sub-tropical rainforests and small-scale dryland forests and then to dwarf forests at the tops of the mountains.

Plain A plain contains slightly undulating broad and flat ground with few valleys. Based on the elevation, plains can be divided into low (less than 200 m) and high plains. They can also be classified into tectonic-erosive plains and alluvial, marine and lacustrine plains. The three major plains in China are the Northeast Plain, North China Plain and the middle and lower reaches of the Yangtze River (Fig. 21).

Plain of Accumulation The long-term subsidence of the Earth's crust or the formation of basin-like depressions of various scales provides sites for compensatory deposition of a wide range of materials to form extensive plains of accumulation. For example, the bottom of the Bohai Sea and the coastal plains in Hebei Province are sinking at a rate of 1 cm per year, and the settlement since the Quaternary (two million years ago) has reached 800–1,000 m. However, the rate of fluvial deposition has exceeded the subsidence rate; hence, the plain has been expanding and advancing into the Bohai Sea, turning the marine area into extensive arable fields. Based on the cause of deposition, this type of plain can be categorised into floodplains, alluvial plains, lacustrine plains and marine depositional plains. The most extensive accumulation plains in the world are located in coastal areas, such as the North China Plain.

Plan of National Mining Park This plan is an important normative document for mining park construction and management. It mainly covers basic information, development and construction conditions, assessment of mining landscape resources, overall planning and layout, typical landscape planning, mining park museum planning, tourist attraction planning, tourist facility planning, foundation engineering planning, environmental treatment and ecological restoration planning, organisation and management, investment cost estimation and benefit evaluation.

Planation (Graded) Surface A planation surface, also called a graded surface, is a form of peneplain. When the Earth's crust experienced prolonged stable conditions, erosion and deposition caused by various external geologic dynamics tend to create a nearly level



Fig. 21 Plain

(inclination of 1–2‰) ground surface across different drainage basins. The cause of formation and the characteristics of a planation surface are complex as they involve erosion and depositional surfaces. A comparison of planation surfaces in different regions can facilitate the determination of the planation surface's age; hence, in the context of geomorphology, planation surfaces are significant as 'abstract strata'. The formation of a planation surfaces can take tens of millions to dozens of millions of years. The existing planation surfaces are mainly Neogene. After a planation surface is uplifted, its remnant parts can remain on the slope or hilltop, forming an ancient planation surface. When a planation surface is buried due to subsidence, it becomes a buried ancient planation surface. The north platform of Wutai Mountain formed in the Neogene and is the highest planation surface in northern China.

Planation in Landscape Formation Planation is an exogenous process that levels undulating ground by means of various forces, including wind, pitting, solution and waves. The uplift and subsidence of the surface caused by tectonic movements and the planation of landforms demonstrate the principle of the unity of opposites. An increase in the height difference between surfaces is counteracted by planation, which reduces the height difference and forms a relatively level land surface.

Plankton Plankton are a diverse collection of organisms that live in water and are unable to swim or have limited swimming ability. Most plankton are tiny, have a spherical, oblate or dendritic form or long protruding spines, and are generally radially symmetrical. A skeleton is not developed or is in the form of a thin shell. Motile organs are not well developed or missing. Their distribution is mainly controlled by the current flow. Examples are foraminifera, radiolaria and planktonic algae. Plankton are usually very abundant species and have a wide distribution. They can be divided into zooplankton and phytoplankton or be categorized into holoplankton, meroplankton and pseudoplankton. They can also be classified based on their size, but the classification criteria are inconsistent.

Planning Map of Geological Heritage Protection A geological heritage protection map is prepared according to the protection level of the geological heritage. According to the importance and distribution of the geological heritage sites, the protection zones can be divided into top, first, second and third grade protection zones (points and lines), which are marked with names and indicated with different colours on the base map with the corresponding scale. Important inflection points along the border of top class and primary protection areas must be measured and numbered on the map with a list of the coordinate data of the measuring points.

Planning Map of Land Utilisation of Geopark This is a map that depicts the different types of land use in a geopark. Land uses can be divided into (1) geological landscape sites, (2) park facilities, (3) residential and community land, (4) traffic and construction sites, (5) woodlands, (6) gardens, (7) arable land, (8) grasslands, (9) coastal areas, and (10) detention land. The map should use the latest topographic map as the base map with reference to the county, national or regional levels in accordance with the local government land use planning. The map should match the 'geopark land use classification table'.

Plant Community A plant community is an organic combination of different plant species living together in a relatively homogeneous environment. Each relatively stable plant community has a certain composition and structure. In general, in areas with superior habitat conditions, the species of the communities have a rich composition and complex structure, such as tropical rainforests. Under severe and harsh conditions, the communities are usually poorly composed and have simple structures, such as tundra deserts.

Plant Fossils Plants were the earliest life on Earth. Fossils of blue algae and fugus have been found in 3.5-billion-year-old Archaean rocks. Primitive bacteria and algae developed in the Archaean and early Proterozoic, and marine algae developed from the Middle Proterozoic to the Ordovician. Terrestrial spore-bearing plants developed from the Silurian

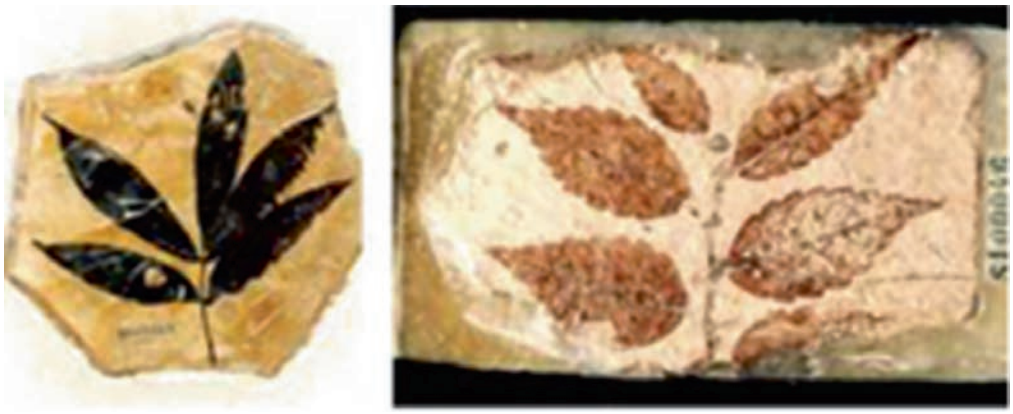


Fig. 22 Plant fossils

to the Carboniferous, and gymnosperms developed from the Permian to the Jurassic. Angiosperms prospered in the Cretaceous and Cenozoic. Plant fossils are key indicators used to identify and classify ancient continents, climatic regions and biogeographic regions. Ancient plants were also involved in mineral and rock formation. For example, the formation of Archaean sedimentary iron ore was related to ferro-bacteria activity. Various types of algae can form reef limestone, boghead coal and diatomite. Lower plants are associated with the formation of crude oil and oil shale, whereas higher plants are the basis for the formation of coal seams (Fig. 22).

Plate Suture *Synonym:* ► *Suture zone*

The term plate suture generally refers to a zone that is formed by the collision of two continental plates. Plate sutures represent palaeo-plate boundaries and therefore are an important basis for the reconstruction of palaeo-plates. The theory of plate tectonics postulates that the movement of oceanic plates causes them to collide and merge with continental plates and subsequently leads to deformation of the continental margins. The original remnants of the oceanic crust (usually in the form of an ophiolite complex) are retained in this deformed zone. It is generally accepted that this collision zone is the location of the original suture. When the Indian Plate drifted northwards, it collided with the ancient Eurasian continent, which led to the closure of the Neo-Tethys Ocean and the formation of the Indian Plate-Yarlung Tsangpo Plate suture zone. This zone contains an ophiolite complex that contains the remnants of the Neo-Tethys oceanic crust as well as materials of the subducting accretionary wedge, mélange and glaucophane schist. Plate tectonics theory currently categorises palaeo-plates in relation to the existence of suture zones. China and other countries have developed several geoparks associated with suture zones. For example, the Mula Mountain Geopark in Hubei Province and the Jingang Tai Geopark in Xingyang, Henan Province, are located in the suture zone between China's two main continental plates, the north and south. Many geological and tectonic features associated with the suture zone can be found along these zones. Another example is the rift valley in East Taiwan, which is the suture zone between the Eurasian Plate and the Philippine Plate. The geomorphologic and geological features of the suture can be seen in this valley.

Plate Tectonic Hypothesis Tectonic plates are 'rigid' massive lithospheric blocks bounded by mid-ocean ridges, transform faults, suture zones and orogenic belts. The Earth can be divided into the Eurasian Plate, Pacific Plate, Indian Ocean Plate, African Plate, Americas Plate and Antarctic Plate, some of which are oceanic plates, and some of which are continental plates. The plate tectonics hypothesis proposes that mass drifting, cracking (mid-ocean ridges), subduction (circum-Pacific Benioff zone), collisions (continental suture zones) and long-

distance movements of the six major plates and numerous secondary plates are the main mode of global lithospheric movements. The plate hypothesis holds that the rigid plates float on top of the upper mantle asthenosphere and that large-scale horizontal movements are caused by mantle convection. This hypothesis inherited the ideas of the 'theory of continental drift' and 'mantle convection' and has escalated them to a new theoretical level.

Plateau A plateau is a large mountainous area with an elevation of over 1,000 m that stands above the surrounding landforms. The Qinghai-Tibet Plateau, the Inner Mongolia Plateau, the Loess Plateau, and the Yunnan-Guizhou Plateau are the four major plateaus in China. The Qinghai-Tibet Plateau is the highest plateau in the world, with an average elevation of 4,000 m.

Platform A platform is a tectonic unit of the crust that is relatively stable and has not been deformed or metamorphosed. Typical examples are the North China Platform, Yangtze Platform, and Tarim Platform. Platforms usually have a 'double-layered structure', in which the upper part has not been deformed or metamorphosed (1 in the diagram) and is generally a horizontal sedimentary cover that lies on top of a strongly deformed and metamorphosed crystalline basement above an unconformity (2 in the diagram). The unconformity surface marks the period of stable platform formation (Fig. 23).

Plinian Type A Plinian-type eruption is a particularly strong type of volcanic eruption named after the Roman volcanologist and naturalist Pliny, who was killed during a catastrophic eruption of Vesuvius during his survey. This type of volcano has viscous magma and forms eruption columns composed of volcanic ash and pumice along with pyroclastic flows, ground surges and falling tuff. Caldera collapses are also common.

Plitvice Lakes National Park, Croatia Plitvice Lakes National Park is located in the border area approximately 10 km from Bihać in the Republic of Bosnia and Herzegovina in central Croatia. After an extension of the original heritage site, the site now covers a core protection area of 192 km^2. The flow of the upper reaches of the Korana River over the limestone and chalk for thousands of years has deposited travertine barriers, creating natural dams that in turn have created a series of beautiful lakes, caves and waterfalls. These geological processes continue today. The forests in the park are home to bears, wolves and many rare bird species.

Plum Rain This term refers to the continuous rainy weather that occurs in the middle and lower reaches of the Yangtze River and the Huaihe River in the early summer of each year and extends eastward through the southern tip of the Korean Peninsula to southern Japan. Since the early summer season is the blooming season of Jiangnan plums, it is called 'meiyu' (or plum rain) in Chinese. This term has been used for thousands of years.

Plutonism Plutonism was another school of geology popular from the end of the eighteenth century to the beginning of the nineteenth century that opposed the theory of neptunism. A proponent of plutonism was the Scottish geologist James Hutton (1726–1797). The

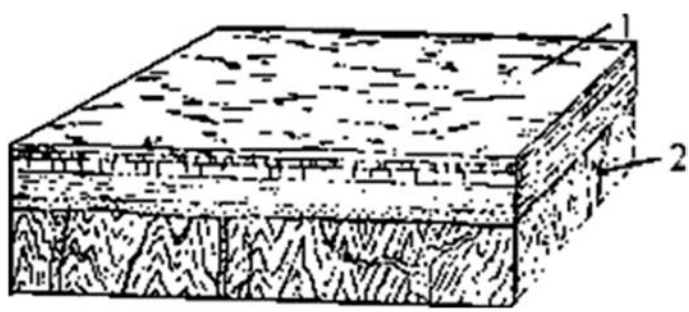


Fig. 23 Platform

theory stated that granite was the result of the melting of the interior of the earth. At the edges of large granite bodies, granite dykes penetrated into limestone layers, and the contact between the dykes and the limestone produced a burning phenomenon that demonstrated the effect of the high temperature due to lava intrusion. Careful field observations showed that most of the minerals contained in basalt had gone through several stages of melting, gradual cooling and crystallization. Plutonism challenged and superseded the erroneous Neptunism theory.

Polar and Sub-polar Continental Glacier Tourism Landscape Under continental climatic conditions in polar regions, most glaciers develop through the percolation and freezing process. The regions above and near the Antarctic and Arctic Circles, such as the glacier landscapes in Greenland, Iceland, Alaska and George Island in Antarctica, have important scientific and exploration tourism value.

Polar Glacier Polar glaciers are glaciers that form in the polar regions. They generally include the Antarctic continental glaciers and Arctic Greenland glaciers (Fig. 24).

Polar Light Landscape Auroras are caused by charged particles of the sun that are emitted into the magnetic field of the Earth. The particles enter the Earth's atmosphere at high latitudes, producing high levels of airborne plasma. Auroras have dazzling colours with beautiful patterns that are either moving or stationary. They are brightest at heights of 5–10 km above the ground. The 'aurora zone' lies within 22–27° from the poles, including northern Alaska, northern Canada, southern Iceland, northern Norway, southern Novaya Zemlya and southern Novosibirsk. Auroras can be seen approximately 2/3 of the year (245 days) and are the favourite tourist attraction in this region. In China, aurora can be seen once every year in Mohe in Heilongjiang Province and Altai in Xinjiang Province (Fig. 25).

Political Geography Political geography is a discipline that focuses on the relationship between social and political activities and the geographical environment. It involves studies of the current conditions and dynamic evolution of political and regional systems and the socio-political-economic conditions of countries around the world. It also studies the different geographical backgrounds of the formation of transnational corporations and their interactions, conflicts and interests. It also examines the geopolitics, development and changes in different countries and regions.

Polje Karst Landscape This is a landscape consisting of relatively flat valleys surrounded by peaks in areas of carbonate rocks. The term comes from the Serbian word 'poljie', which means field. This term is not related to the entire karst landform but rather only to the arable land in karst regions. It has been internationally recognised to generally refer to elongated or



Fig. 24 Polar glacial landscape in Antarctica. (Photo by Liu Xiaochun)



Fig. 25 Polar light landscape



Fig. 26 Polje karst landscape – Guangxi Province

elliptical karst valleys formed by structural forces. In China, the term karst basin is almost identical to polje. The karst basins in Anshun and Xingyi, Guizhou Province, and Wenshan in Yunnan Province are large poljes (Fig. 26).

Popcorn Landscape ▶ Cave Flower Landscape

Popular Science Action Plan This plan consists of various programmes that occur in different seasons to disseminate science and geological knowledge to the public, especially students and young people. Internships and work experiences are parts of the programme for training young people and college students to have better knowledge of environmental and geological conservation and to develop a strong sense of social responsibility. (See also geopark science popularisation action plan).

Porphyrite Porphyrite is an intermediate extrusive or hypabyssal rock with a porphyritic texture. Typical examples are dioritic porphyrite and andesitic porphyrite. A type of dioritic porphyrite associated with iron ore is present in the Wuhu area, and its discovery has promoted the formulation of the porphyrite iron ore model.

Porphyroclastic Lava A porphyroclastic lava is a fragmented but solid phenocryst in volcanic lava. A regenerated bead edge structure is developed at the periphery of the porphyroclast, and the matrix has the structure of glassy, fine or microscopic particles. These lavas are widely distributed in southeastern China, where they generally form rock domes.

Porphyry Porphyry is an extrusive acidic rock or hypabyssal rock with a porphyritic structure. The phenocrysts can be K-feldspar, feldspathoid and quartz. The nomenclature is based on the rock types and the difference in the phenocrysts, such as granite porphyry, syenite porphyry, rhyolite porphyry and rhodochrosite porphyry. For example, the bed of the Baishuiyang River in Fujian Province is composed of syenite porphyry.

Pothole Landscape This is a landscape with kettle-like holes in a river. A pothole is also known as a kettle hole or rock hole. Potholes are formed by erosion and abrasion of the bedrock, where pebbles are moved in circles by eddies in the riverbed. Potholes often form in the lower parts of waterfalls and cascades or on the shores of steep rapids.

Poyang Lake Landscape Poyang Lake is China's largest freshwater lake and is the second largest lake in China after Qinghai Lake. It is located in northern Jiangxi Province on the south bank of the Changjiang (Yangtze River) in the cities and townships of Nanchang, Xinjian, Jinxian, Yugan, Poyang, Douchang, Hukou, Jiujiang, Xingzi, De'an and Yongxiu. The lake basin formed due to crustal subsidence and continuous deposition. Due to the influence of the warm and wet southeastern monsoon climate, Poyang Lake has an annual precipitation of 1,636 mm, and the weather is colloquially described as 'green grass in the wetland and yellowish plums in misty rain'. It is a famous land of plenty in China. The environment and climatic conditions are suitable for the wintering of migratory birds. In the late autumn and early winter (October), thousands of birds arrive from Siberia, Mongolia, Japan, North Korea and northeastern and northwestern China, stay until the spring (April) and then fly away. The world's largest flock of white cranes is found here; in 2002, the population reached 4,000 or more, accounting for 95% of world's white cranes. Hence, it was given the name the 'World of White Cranes' and the 'Kingdom of Rare Birds' (Fig. 27).

Precambrian The Precambrian System is also called the 'Pre-Cambrian System' or 'Pre-Palaeozoic Erathem'. The Precambrian System is not a formal chronostratigraphic unit. It refers to the rocks that formed from the beginning of the Earth's history to the early Cambrian Period, and this period is called the Precambrian Period. Based on isotopic age dating, it is estimated that the Earth began to form approximately 4.6 billion years ago. The Precambrian Period covers at least four billion years, which accounts for nearly 90% of the Earth's history.

Pre-phanerozoic Eon *Synonym:* ► *Cryptozoic Eon*

The Pre-Phanerozoic Eon and Cryptozoic Eon are usually called the Precambrian Period or simply the Cryptozoic Eon. These terms generally refer to the prolonged interval of Earth's history from the oldest rocks to the Cambrian Period. The term Cryptozoic is no longer used; rather, the Archaean Eon and Proterozoic Eon are the two main subdivisions of the Precambrian Eon, and the term Phanerozoic Eon applies to the time interval from the Cambrian Period to the Quaternary Period.

Primeval Beech Forests of the Carpathians, Germany The German ancient beech forest is an outstanding example of the ongoing biological and ecological evolution of the post-glacial terrestrial ecosystem, and it illustrates the diversity of beech species in the Northern Hemisphere. The reproductive diffusion pathway is a crucial component of this



Fig. 27 Poyang Lake landscape

environment. Five new forests in the heritage site cover an area of 44 km^2. In 2007, the Slavonic and Ukrainian forests on the World Heritage List covered 293 km^2. This world heritage site is located in three countries (Slovakia, Ukraine, and Germany) and has since been renamed 'Ancient and Primeval Beech Forests in the Carpathians and Other Regions of Europe'.

Principle for Regional Tourism Planning This book was written by Bihu Wu and was published by China Tourism Publishing House in 2001. It discusses the basic theory and general paradigm of regional tourism planning and expounds the theories and methods of market analysis and professional evaluation as the basis of planning. It is a comprehensive and systematic tourism research monograph that summarises the principles of tourism planning in China.

Principles of Geotourism This book was written by Anze Chen, Yunting Lu and Young Ng and was published by Springer and Science Press Beijing in 2015. It was an English version of the book 'An Introduction to Tourism Earth Science', which was originally edited by Anze Chen and Yunting Lu and was published by Peking University Press in 1991. The book updated the contents of the original Chinese version and added several chapters covering geological heritage, geological conservation and geoparks. It is a useful book for non-Chinese readers to better understand the early and latest concepts of geotourism and tourism science being practised in China.

Principles of Tourism Earth Science This book was written by Jianrong Xin and was published by China University of Geosciences Press in 2006. It is divided into 15 chapters, which discuss the concepts, development and research missions of tourism earth science; the classification of tourism earth science resources; the spatiotemporal background and geological environment of nature-based tourism resources; the geological processes of natural landscape formation; the geological characteristics of cultural tourism resources; development and evaluation systems; classification of tourism destinations, spatial structure and tourism zoning; tourism environmental protection and ecotourism; and geoparks and their action plans.

Principles of Tourism Planning This book was written by Bihu Wu and Yu Xi and was

published by China Tourism Publishing House in 2010. The contents are divided into ten parts, including tourism research and planning, market analysis and forecasts, tourism resource investigation and evaluation, development of tourism products (attractions), tourism spatial structure planning, brand construction and marketing planning, reception and service planning, tourism area planning, tourism planning impact assessment and management, and tourism planning implementation and monitoring. It is a reference book describing practical techniques and methods of tourism planning.

Printed Popular Science Publications These publications are basic materials used by geoparks to promote geosciences. Printed, hard copy materials and publications can be in the form of books, pamphlets, brochures, and maps that introduce the geology, landscape, ecology, culture and history of the geopark and the surrounding areas. They are normally available at the geopark visitor or information centres or at the travel information kiosks of major airports and railway and bus stations. The language used to introduce these natural and human stories is simple and easily understandable, and the publications include colourful pictures, diagrams, pictures and maps for people from all walks of life. They also contain website addresses and QR codes for further details and information if needed by tourists, students and the public.

Proceedings of the First International Symposium on Granite Geology and Geomorphology This book was written and edited by Anze Chen et al. and was published in the 2007 'Geological Review' supplemental edition. More than 20 papers were collected. The contents include a new theory on the formation of granite, a summary of granite in China, the formation and classification of granite landforms, examples of granitic geology and geomorphology research, and research on geopark establishment. Using the study of the Sanqingshan granite as an example, the geological and geomorphic features, rock ages, formations, geochemical characteristics and evolutionary history are discussed. It was the first research collection on granite landforms and scenery in China, and it has important reference value for granite landscape research and scenic area construction.

Proceedings of the International Symposium on Geopark Development This book was edited by Xun Zhao et al. and was published by Geological Publishing House in 2010. The International Symposium on Geopark Development was held in global geoparks or national geoparks in China, such as in May 2006 in Jiaozuo City, Henan Province, in June 2007 in Lushan (Mount Lu), Jiangxi Province, and in August 2009 in Taishan (Mount Tai), Shandong Province. The theme of the papers centres on different aspects of geoparks, including their scientific value, public education, classification and comparison of geoheritage sites in China and overseas, geoheritage protection technologies, research and cooperation, geopark management and the development of the regional economy.

Prograde Metamorphism See ▶ Metamorphism.

Project Planning of Scenic Areas This book was written by Yanyong Wang and Ziqian Song, and it was published by China Tourism Publishing House in 2007. The book introduces the general principles and methods of project planning of scenic areas. It also analyses practical applications of principles and methods via selected cases and proposes numerous innovative ideas. It is highly theoretical, and the ideas are presented systematically in a practical way.

Proluvial Facies Proluvial facies are a type of terrestrial facies that commonly develop in arid or semi-arid regions. In mountainous areas, intermittent floods transport weathered materials of parent rocks to the valley mouth to form deposits. Abundant gravels, sand and silts transported by floods accumulate rapidly at the valley mouth to form a fan-shaped deposit, which is called a proluvial fan. The material is poorly sorted with unclear bedding. Particle gradation is remarkable in map view; a thick layer of coarse fragments mainly

composed of gravels is located close to the fan, but towards the outer margin, the particles gradually transition to smaller sizes in the form of sand, silt and mud, and the thickness decreases gradually with the development of cross-bedding.

Proluvial Fan Landscape When temporary floodwater flows out of a mountain pass in an arid or semi-arid region, the debris it carries is deposited to form a fan-shaped landscape that is called a proluvial fan landscape. Usually, there is no water in the river channels in the valleys in arid and semi-arid areas. The channel bed and valley sides accumulate debris that is eroded from the hills. During the onset of flash floods in the rainy season, the water in the valley rises and transports abundant debris downstreams. When the debris-laden flow reaches the mountain pass, where the gradient is gentle, its transportation capacity decreases drastically, so it deposits large amounts of gravel, sand and mud to form a depositional proluvial fan that extends from the hills to the plain (Fig. 28).

Promontory Landscape *Synonym:* ▶ *Headland landscape*

This is a landscape consisting of a pointed land mass protruding into the ocean or a lake. This landscape is often found in front of a peninsula, such as Cape Chengshan in Shandong Province, China, and the Cape of Good Hope at the southern tip of Africa. The formation of a headland is mainly caused by differential marine erosion of the coast, during which softer rock is eroded and recedes rapidly to form a bay or harbour. The more resistant rock recedes at a slower rate and eventually forms a projected headland separating two bays (Fig. 29).

Protection Laws and Regulations: Geological Landscape Tourism Resources Geological heritage protection and management regulations were announced by the Ministry of Geology and Mineral Resources on 4 May 1995. The contents include: Chapter I, General Provisions; Chapter II, Protection elements, including typical geological sections, important fossil sites, landforms such as karst, danxia, loess, yardang and other geological landscapes, special rocks of high ornamental value, waterfalls, lakes and spring landscapes of special value and significance, typical geohazard sites and other geosites of special geo-scientific value; Chapter III, Establishment of protection sites with different criteria and standards; Chapter IV, Management and protection of geological heritage, planning, requirements, organisations and responsibilities; Chapter V, Legal issues and responsibilities; and Chapter VI, Supplementary provisions.

Protection of Geoheritage This includes measures taken to protect rare geological relics and vulnerable geological environments from

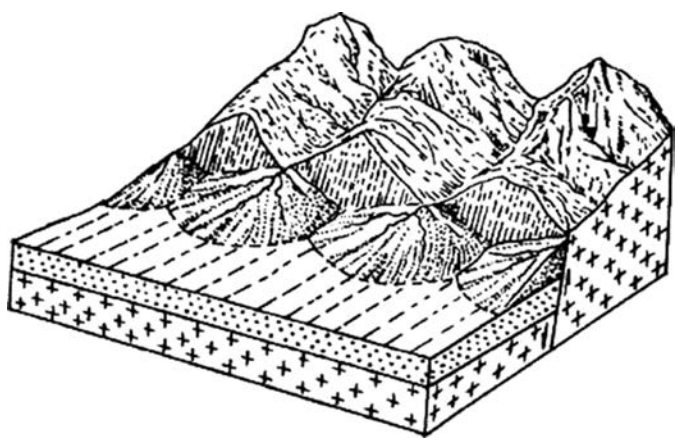


Fig. 28 Diagram of a proluvial fan



Fig. 29 Cape of Good Hope promontory landscape

damage. Geoheritage is the record and physical evidence of earth history. It is a unique natural resource and an invaluable asset of human beings; therefore, protection of geoheritage is of great significance. In 1995, the former Ministry of Geology and Mineral Resources promulgated the 'Geological Heritage Protection and Management Regulation', and in 2010, the State Council promulgated the 'Protection of Paleontological Fossils Protection Regulations'. In 1999, the Ministry of Land and Resources established the China Geopark System. These were major measures to protect geoheritage. The protection of geoheritage in China is mainly managed by the Ministry of Land and Resources.

Protection of Tourism Resources The protection of tourism resources refers to the protection of natural, cultural and social tourism resources, including the scenery, landscapes, geoheritage and environment, from destruction and pollution by means of increasing publicity and education, formulating laws and regulations and other means to maintain the original unique characteristics and attain sustainable use. Effective protective measures are formulated to counteract the factors causing the destruction of tourism resources, including the establishment of protection and management systems and agencies, delineating the scope and determining the objects of protection, and planning the carrying capacity, traffic and other measures.

Proterozoic Eon This term has a Greek origin meaning early primitive life. The Proterozoic Eon is the second unit in the history of crustal evolution; it spans from 2.5 billion years ago to 542 million years ago over a continuous interval of 1.958 billion years. The Proterozoic Eon is divided into the Palaeoproterozoic Era (Pt) (2.5 to 1.6 billion years ago), Proterozoic Era (Pt2) (1.6 to 1 billion years ago) and Neoproterozoic Era (Pt3) (1,000 to 542 million years ago).

Provincial (Autonomous Region) Geopark This is a geopark approved by the Department of Land and Resources of a provincial or autonomous region government. The provincial or autonomous geopark can then proceed to apply for national geopark status before applying for global geopark status.

Provincial Park System, Canada Canada has ten provinces and three regions, each of which has its own provincial park system. To preserve natural heritage and promote public appreciation and utilisation of the heritage, the National and Provincial Parks Association of Canada (NPPAC) was founded in 1963 and was later renamed the Canadian Parks and Wilderness Society (CPAWS). Currently, 830 provincial parks in British Columbia and 330 provincial parks in Ontario receive more than 10 million visitors every year. Provincial parks in Quebec are officially called 'national parks', and 23 such parks are now administered by the provincial government.

Provincial Tourism Earth Science Research Organisations After the establishment of the China Tourism Earth Science Research Institute in April 1985, local earth science academies in many provinces and cities across the country responded proactively. In 2–3 years, more than ten provincial tourism earth science research organisations were established, including Sichuan, Shandong, Guangdong and Guangxi, Fujian, Jiangxi, Zhejiang, Shanghai, Jiangsu, Anhui, Henan, Hebei, Liaoning, Jilin, Xinjiang, Shaanxi, and other provinces and cities. With the exception of Sichuan and Zhejiang, all were affiliated with the provincial geological society.

Provincial-Level Scenic Area A provincial-level scenic area is an area whose natural and cultural landscapes reflect important natural processes or major historical and cultural developments. It is a regional representative that is in its natural state or has maintained its original appearance. Before a provincial-level scenic area is approved and announced by the people's government of the province, autonomous region and municipality directly under the central government, the people's government at the county level shall submit an application, which will be discussed and reviewed by the Department of Construction under the people's government of the province or autonomous region or by the Department of Scenic Areas under the people's government of the municipality directly under the central government.

Psiloritis Natural Park, Greece This geopark is located on the beautiful Greek island of Crete in the southern Aegean Sea. It covers an area of 1,159 km^2 and became a member of the Global Geoparks Network in 2004. Mount Phoerotote and the northern coast of Crete are the two important attractions of the geopark. Mount Phoerotote is the most beautiful mountain on Crete, and the top of the mountain is 5,000 m above the bottom of the Mediterranean Sea. Rock columns and outcrops are clearly exposed on the island. Geological structures and landscapes of different scales can be seen. Large faults, fossil-bearing sites, caves, valleys and plateaus, folds and fascinating geomorphological structures provide a foundation for many thousand years of unique culture.

Psittacosaurus This small dinosaur was widely distributed across China in the early Cretaceous. It had a beak like a parrot, which is how it gets its name. It was a small ornithopod, 1–2 m long, and it walked on two legs. Its head is flat and wide but raised with a curved snout that ends in a horny beak. The forelimbs are slightly shorter than the hindlimbs. Psittacosaurs were active, and the young were raised in groups by their mothers. Swarms of young Psittacosaurus fossils have been found and well preserved in Chaoyang City, Liaoning Province (Figs. 30 and 31).

Pterosauria or Pterosaur Pterosaurs were not dinosaurs but rather a type of reptile that could fly. Their bones were light and hollow. They had small heads and slender beaks but large eyelets. Pterosaur fossils are rare. The Lower Cretaceous Series in Xinjiang Province contains Dsungaripterus and Noripterus fossils (Figs. 32 and 33).

Pubei Wuhuangshan Geopark, Guangxi This geopark is located in Pubei County, Qinzhou City, Guangxi Zhuang Autonomous Region. It

covers 40 km^2, and the 30 geosites cover 30.52 km^2. It became a national geopark in 2011. The geopark has fascinating granite geomorphic landscapes with spheroidal weathering and erosion forming picturesque rocks, platforms, peaks, cliffs, walls, valleys, rock pools and depressions. It is typical of spheroidal weathering in the southern coastal transition zone. Its beautiful landform is different from that of Mount Huangshan and Huashan and is also different from the eroded granites in Laoshan and Sanya. This is an ideal place for studying weathering and ecology.

Puerto Princesa Subterranean River National Park, The Philippines This park is located in the centre of Palawan Island in the western Philippines and has a core protection area of 57 km^2. Its main features are the karst landscapes in the underground river area. River water flowing directly into the ocean is a major wonder of the subterranean river, and the lower section of the river is affected by tidal activity. The park is also a valuable natural habitat for biodiversity conservation. With a complete ecosystem chain 'from mountain peaks to oceans', the site protects the most important forests in Asia.

Pulsating Spring Landscape ▶ Tidal Spring Landscape

Pumice Pumice is also known as 'pan stone', which means melted rock in Chinese. Pumice is made of volcanic glass with abundant pores filled with air, like a honeycomb. It has a low density (0.3–0.4/cm^3) and can float on water. Pumice generally refers to light-coloured porous acidic volcanic glass rock. Basaltic pumice usually has a higher density, so it does not float on water.

Purnululu National Park, Australia This park is located in the northeastern part of Western Australia, and it has an area of 2,397 km^2. The deep quartz sandstone canyons of the Bungar Bungere Range date back to the Devonian. Twenty million years of erosion have shaped the peaks into cones and honeycombs, and a dark grey cyanobacterial (a single-cell photosynthetic autotrophic organism) crust covers the sandstone on the steep cliffs. These features are caused by the interaction



Fig. 30 Psittacosaurus



Fig. 31 Nest of Psittacosaurus



Fig. 32 Pterosauria fossil



Fig. 33 Diagram of a pterosaur

between many natural factors, such as geology, ecology, wind erosion and climate. Over the past 30 years, the park has transformed itself from an obscure wilderness into a popular area sought after by photographers from all over the world. It has also been regarded as Australia's 'Grand Canyon' and is becoming as popular as Ayers Rock.

Purog Kangri Ice Field Landscape The Purog Kangri Icefield, the largest in the northern Tibetan Plateau, is composed of several ice-cap-type glaciers. It covers an area of 422 km^2 and is a rare icefield at low latitudes. Its ice reserve is approximately 52.15 km^3, and the snowline is at elevations of 5,620–5,860 m. The icefield radiates into the surrounding wide shallow valleys and forms more than 50 glacial tongues of varying lengths, which extend to the middle of the valleys or to the foothills. The largest forms a tongue with a wide tail when it reaches the foothills. Ice tower forests also form in the lower tongue section (Fig. 34).

Putaoxiang Peak Forest Plain Landscape, Yangshuo County Inside an area of 36 km^2 in Putaoxiang (9 km long north-south, 4 km wide east-west) in Yangshuo, Guilin, there are 130 stone peaks, in an average density of 3.6 peaks/km^2. The highest density is 8 peaks/km^2. The peak slopes are generally steeper than 60°. The average relative height is almost 100 m, and ponds are common below the peaks. This peak forest plain is one of the world's most developed and has a large area and elegant landforms. It is also a precious natural heritage.

Putorana Plateau, Russia This heritage site is located in the northwestern Krasnoyarsk Krai region of the Russian Federation. It is under the jurisdiction of the Putorana State Nature Reserve. It is located in the heart of the Putorana plateau in the northern part of Central Siberia approximately 100 km from the North Pole. The plateau is protected to preserve the sub-Arctic to Arctic ecosystems, including the original coniferous forest, frozen forest, Arctic tundra and Arctic desert system, in the remote mountainous environments. The region also contains cold-water lakes and river systems that are inaccessible. Important reindeer migration routes cross the heritage area, illustrating interesting natural phenomena.



Fig. 34 Landscape of Puruo Gangri glacier. (After Yao Tandong et al.)

Pyramidal Dune Landscape This is a desert landscape consisting of star-shaped or conical sand dunes. A pyramidal dune is a tall sand dune with clear edges and a pyramid shape. This kind of sand dune is a product of sand accumulation by wind from various directions and can be more than 100–200 m high. Pyramidal dunes are common in the northern foothills of Kunlun Mountain and in the centre of the Badain Jaran Desert in China. When the northerly and northwesterly winds blow, the mountains form a barrier, and the airflow forms a large whirlpool that is also subject to the localised influence of the south-westerly wind in front of the mountain. These winds interfere with each other; thus, the wind directions are complex. They blow the sand and eventually deposit it to form pyramidal dunes (Fig. 35).

Pyrenees – Mont Perdu, France and Spain These mountains are located on the border between southwestern France and northeastern Spain. The cross-border heritage site was expanded in 1999, and the core protection area now covers 306 km^2. The remarkable mountain scenery extends around Mount Perdu, a limestone block that reaches 3,352 m above sea level. On the Spanish side, there are two of Europe's largest and deepest canyons, and the area near the French border has three steep walls that form a circular depression ('tiankeng', or large sinkhole), which is a classic example of similar geological landscapes. The prairie landscape of the heritage site hosted the once widely popular agricultural lifestyle of the mountain areas of Europe, which is only preserved today in this small part of the Pyrenees. The heritage site provides unique insights into the past European society with unique villages, farms, fields, highland pastures, and scenic mountain roads.

Pyrite The chemical composition of pyrite is FeS_2. It is an important sulphur mineral ore with a sulphur content 53.4%. It belongs to the isometric crystal system, and the crystal form is cubic, pentagonal dodecahedral or octahedral. Crystal twinning is common, and the crystal faces are usually striped. It also appears as clumpy, granular, reniform, stalactitic, botryoidal or nodular aggregates. It is light yellow with greenish black streaks. It has opaque diaphaneity, a metallic lustre, a specific gravity of 5.0, a Mohs hardness of 6–6.5 and conchoidal fractures. It is a common secondary mineral in magmatic, sedimentary and metamorphic rocks. Pyrite is a raw material for refining sulphuric acid. Pyrite crystals are very good ornamental stones (Fig. 36).

Pyroclastic Flow Unit A pyroclastic flow unit is a tongue-like pyroclastic flow deposit that forms in a volcanic eruption. It is generally composed



Fig. 35 Pyramidal dune landscape – Tengger Desert



Fig. 36 Pyrite

of various types of ignimbrites and other volcaniclastic rocks. The unit can be related to a single eruption or to several consecutive eruptions that form a composite volcanic pyroclastic flow unit made up of multiple accumulated pyroclastic flow units. The rock structure and formation of a pyroclastic flow unit can be divided into longitudinal or transverse banding and can have different degrees of melting. Therefore, the landform of pyroclastic flows (which are generally known as ignimbrite strata) is controlled by the lithological variations inside the unit, which cause many varieties of landscapes.

Pyroclastic Rocks A pyroclastic rock is a rock that is formed by the consolidation of different types of transported and deposited clastic debris after a volcanic eruption. Pyroclastic materials include clastic rock debris, mineral crystal fragments and volcanic glass fragments. Another type of fragment comes from unconsolidated magmatic debris that are still in a molten slurry state before tearing and deposition induced by the explosion; these are called magma fragments (or plastic fragments). Tuff and ignimbrite are typical pyroclastic rocks in acidic volcanic areas.

Pyroclastics; Tephra Pyroclastic is the collective term for all clastic materials that are produced during volcanic eruptions. Pyroclastics are the main component of volcaniclastic rocks. Different types of pyroclastics include agglomerates, breccia, detritus, pumice, scoria, fiamme, plastic vitric fragments, glass fragments, crystal fragments, volcanic balls, hot volcanic balls and volcanic dust. Their characteristics are described below (Table 1).

Pyrolusite Pyrolusite, which has the composition MnO_2, is the main mineral used for manganese smelting. It contains 63.2% manganese. It belongs to the tetragonal crystal system, and the crystals have small granular or acicular shapes. It is often in a blocky aggregate form. Its colour and streaks are black, and it has a submetallic lustre, a specific gravity of 4.84, a low Mohs hardness and easily stains hands. It mainly forms in deep sediment or by the oxidation of primary manganese ore. It is an important raw material for smelting manganese.

Pyrophyllite Deposit, Qingtian, Zhejiang Located in southeastern Qingtian County, Zhejiang Province, the Qingtian Shankou pyrophyllite deposit is the largest pyrophyllite deposit in China. The ore bed of the deposit is located in acidic lava and volcaniclastic rocks in the middle and upper parts of the second section of the Upper Jurassic Xishantou Group, which formed on the southeastern side of a barren caldera in the Late Jurassic. It is a type of volcanic late gas-hydrothermal alteration replacement (filling) deposit. The major ore components of the deposit are pyrophyllite and quartz followed by corundum, dumortierite (first discovery), albic vermiculite, alnico and other new montmorillonite minerals. The compact and fine stone blocks are called 'Icy Stone', and they are good for carving. The deposit has a long history of pyrophyllite mining. The stone ores of the deposit, known as 'Qingtian Stones', are famous for carving seals. The 'Qingtian

Table 1 Types of volcaniclastic rocks

Type	Fragment form	Name of deposit	Appearance	Internal structure	Size	Rock
Fragments of consolidated rock	Hard rock	Hard	No definite shape	Indefinite structure	>50 mm	Agglomerate
					50–2 mm	Breccia
					<2 mm	Lithic fragment
				Porous structure	Indefinite	Pumice, scoria
Fragments in molten state	Unconsolidated to semi- consolidated magma	Plastic	Definite shape	Definite structure	>2 mm	Magma fragment
					<2 mm	Plastic vitric fragment
		Semi-plastic to hard	Definite shape	Definite structure	Generally small	Vitric fragment
Crystalline mineral fragment	Hard mineral	Hard	Indefinite shape	Indefinite structure	Indefinite	Crystal fragment
Aggregate of pyroclastics	Hard pyroclastic aggregate	Solidified to semi-solidified	Indefinite shape	Indefinite structure	Indefinite	Volcanic ash ball
	Plastic pyroclastics	Solidified to semi-consolidated	Definite shape	Definite structure	Indefinite	Hot volcanic ash ball
						Volcanic dust



Fig. 37 Stone seals of Qingtian

County Chronicle' reports that Qingtian stone carving first appeared during the Six Dynasties (A.D. 221–589) (Fig. 37).

Pyroxene Pyroxene is the general name for the pyroxene family of minerals, which can be categorized into two sub-families: orthopyroxene and monoclinic pyroxene (clinopyroxene). These sub-families can be further subdivided into numerous species, such as enstatite, bronzite, hypersthenite, diopside, calcisite, augite, acmite augite and spodumenite. The crystals are usually equant, dark (ranging from green, brown, and tan to black), and have a vitreous lustre, a Mohs hardness of 5–7 and a specific gravity of 3.1–3.5. Pyroxene is an important rock-forming mineral that is mainly found in igneous rocks.

Q

Qaidam Block This block is a rhombic massif covering 120,000 km^2 that lies between the Qilian Mountains and the Kunlun Orogenic Belt. The block is mainly overlain by Cenozoic rocks. The outcrops in the north are early Proterozoic metamorphic rocks. The Nanhuan-Sinian System in this block is overlain by an unmetamorphosed moraine layer. In the early Palaeozoic, its northern margin was composed of stable carbonate deposits, and its southern border was composed of geo-synclinal clastic rocks mixed with neutral-basic volcanic rocks. Molasse formed and was widely distributed in the early Late Palaeozoic. The Carboniferous-Permian system is dominated by alternating marine-terrestrial facies. Inland basins developed during the Meso-Cenozoic Era. Intense folding took place in the late Cenozoic Era; and at this time, the northern and southern borders of this basin were deformed by basin-vergent thrust faults. These are typical characteristics of foreland basins. The Qaidam Block contains a wealth of resources. The Cenozoic geological processes also created many distinctive landforms, including rare inland geological landscapes.

Qeshm Geopark, Iran This geopark is located in the western part of the Iranian island of Qeshm and covers an area of 320 km^2. In 2006, it was selected as a member of the Global Geoparks Network. Qashm Geopark is one of the largest salt caves in the world, with a total length of 6,000 m and a unique landscape. The geopark is ideal for research in geology, zoology, botany and archaeology. The island is long and narrow, stretching parallel to the coast of the mainland and dividing the Khuran Strait. The curving coastline is generally rocky except for sandy beaches and mudflats on the northern and western coasts. The highest elevation is 406 m above sea level. The climate is dry, the land is barren, and cereals, vegetables, melons and dates are grown. Ancient Portuguese castles, mosques, Seyyed Mozaffar's shrines, Bibi Maryam Tomb, ponds and mangroves are additional tourist attractions on the island.

Qian Zhang Qian Zhang (164–114 BC) was born in Chenggu County in Hanzhong (now Shaanxi Province). He was a traveller and explorer during the Han Dynasty. In 139 BC, he was sent on a diplomatic mission to the Western Regions, during which he travelled through the desert, climbed over the Onion Ridge (Pamirs), and visited Central Asian countries, including Dayuan, Kangju, Darouzhi and Daxia (Tochari). He returned via the northern foot of Mount Kunlun in 126 BC. These 13 years were full of hardships. In 119 BC, he was sent to Wusun with his deputies to countries such as Dayuan, Kangju, Daxia (Tochari) and Anxi (Parthian). He returned to Changan in 115 BC and passed away the following year. Qian Zhang led the first Chinese delegation sent to the Western Regions by the imperial court. He opened up the export of products such as silk and brought back political, economic and geographical information about the countries in the Western Regions. He promoted economic and cultural exchanges between the East and West. The route he travelled was later known as the 'Silk Road'.

Qian'an-Type Mud Forest Landscape This is a large-scale sandstone landscape in China formed by erosion. The calcareous alkali soil layer in Qian'an, Jilin Province, has a consolidated top that protects the underlying rock layers. Vertical joints are well developed, and through rainstorm scouring, groundwater erosion and subsurface erosion, the ground surface was dissected to form numerous channels, ditches and steep walls, leaving many isolated soil pillars, soil mounds or soil walls on the ground. Because these features resemble wolf teeth and stand along the lakeside terraces, the locals call them 'Wolf teeth embankment'. Liu Dongshen called them 'mud forest' (Fig. 1).

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Fig. 1 Qian'an-type silty mud forest landscape – Qian'an, Jilin Province

Qianan Mud Forest National Geopark, Jilin This geopark is located in Qianan County, Jilin Province, and has an area of 112 km^2. It became a national geopark in 2009. Its main geological features include mud forest landscapes and fossils in Quaternary argillaceous siltstones. Mud forests, which formed east of Dabusu Lake, have varied shapes, including intersecting ravines, undulating mountains, forests of mud columns, linked peaks and ridges and steep soil walls. Nineteen species, 18 genera, 12 families and 6 orders of vertebrate remains have been found, including 12 existing species and 7 extinct species, all of which are members of the late Pleistocene Mammoth-Coelodonta fauna of northeastern China.

Qianan-Qianxi Geopark, Hebei This geopark is located in Qianan County, Qianan City, Hebei Province, and it became a national geopark in 2009. It is a comprehensive geopark that integrates the stratigraphy of the Archaean Qianxi Group with geological structures and landforms. The Qianxi Group contains the oldest strata in China and is also one of the six oldest existing continental nuclei in the world. The Qianxi Group is exposed and distributed widely across the geopark and provides important evidence of the early formation and evolution of the Earth. In addition, the Dongqianan region of Hebei is the oldest known metamorphic area, and it contains Palaeo-archaean to Neo-archaean rocks. The geopark contains a complete Ordovician stratigraphic section and is also the place where the Quaternary stratigraphic section of the Qianan Group was named. Xiqishan Gorge is 5,000 m long. The underground karst relics, including a golden karst cave with seven layers that is approximately 10 km long, is one of the largest karst caves in northern China.

Qiandongnan Miaoling National Geopark, Guizhou This geopark is located in Qiandongnan Miao and Dong Autonomous Prefecture, Guizhou Province, and covers an area of 225 km^2. It became a national geopark in 2009. Its main geological features include a karst landscape and palaeontological fossils. Abundant fossils can be found in the Wuliu-Zengjiaya section behind Balang Village in Gedong, which serves as a potential global stratotype section and point for the boundary between the second and third series of the Cambrian. The precious Kaili biota and Taijiang biota are two world-class palaeontological features. Other attractive features of the geopark include arches, karst caves, peak clusters, peak forests, peak pillars, blade-shaped hills and mesas.

Qianjiang Xiaonanhai National Geopark, Chongqing Qianjiang Xiaonanhai National Geopark is located in Qianjiang, a district in

southeastern Chongqing, approximately 400 km from the city. In March 2004, it was approved by the Ministry of Land and Resources as one of the third group of national geoparks. It is dominated by earthquake-induced barrier lakes and also contains other geological landscapes. Its main features include the Xiaonanhai earthquake site, Bamianshan karst landforms, Yangtoushan karst geological landscape, ancient fossils, sedimentary structures, remnants of ancient glaciers, erosional landforms generated by flowing water, the historic base of the 9th Division of the Red Army and an ancient monument commemorating free ferry service.

Qiantang River Spring Tide The Qiantang River spring tide is a famous tidal phenomenon in China, and only the surge tide of the Brazilian Amazon is comparable to it. The estuary of the Qiantang River, Hangzhou Bay, has a wide inlet and a narrow inner channel like a trumpet. The ocean water enters through the 100-km-wide mouth, but the river channel becomes narrower, and the riverbed becomes shallower. The seawater is bound by the river banks on both sides and is pushed by the flow of the Qiantang River from upstream, so the tidal water accumulates to form surging tides with a wave wall that is 3–10 m high. The surge tide occurs from the 1st to the 5th days and from the 15th to the 20th days of each lunar month, and the best time to see the tide is from the 15th day to the 18th day of the 8th month of the lunar calendar (Fig. 2).

Qianxi Jinchangyu National Mining Park, Hebei This park is located in Qianxi County in eastern Hebei Province, and it covers an area of 4.50 km^2. It became a national mining park in 2010. The Jinchangyu ultra-large gold deposit is the largest such deposit on the eastern margin of the North China Platform and is known as the 'Gold Field' because of its long gold mining history. Its mining heritage mainly includes representative rock minerals, prospecting features, metallogenic models, mining remains, mineral processing and metallurgical technology and equipment, mine waste dumps, tailings impoundment areas and environmental engineering structures. The mining geological heritage mainly includes typical gold deposit rocks, minerals, geologic profiles and representative mining belts. The mining activity heritage mainly includes mining roads, smelting and refining heritage. Its production line, which boasts the lowest ore grade and the highest ore recovery ratio, is representative of the high technological levels of the Jingchangyu Gold Mine.



Fig. 2 Qiantang River spring tide landscape

Qijiang Wood Fossil-Dinosaur National Geopark, Chongqing This geopark is located in Qijiang County, Chongqing Municipality, and has an area of 108 km^2. It became a national geopark in 2009. Its main geological features include fossils, red beds, sedimentary structures and waterscapes. Numerous well-preserved petrified wood from conifers are concentrated in several places. Dinosaur footprints as well as impressions of skins and hair are well preserved. The red beds in the park are mainly composed of Jurassic and Cretaceous red gravels.

Qilian Orogenic Belt This belt is located between the North China Platform and the Qaidam Block. Its main body lies in the Qilian Mountains at the border between Qinghai and Gansus Provinces. The orogenesis included the Hexi Corridor and the steep eastern margin and northern margin of the Qaidam Basin. From north to south, this belt can roughly be divided into three zones: (a) central Qilian is an uplifted block with exposed metamorphic crystalline basement; (b) northern Qilian was an early Palaeozoic deep sea trench and active continental margin, which includes several ophiolite belts and numerous island-arc volcanic rocks; and (c) southern Qilian was an early Palaeozoic passive continental margin with a large amount of Silurian clastic flysch. After the Caledonian orogeny, the entire belt was uplifted. Devonian molasse sediments were deposited widely across the piedmont depression. A unified North China Craton formed when North China, Qilian and Qaidam merged. In the late stage of the Middle Cenozoic, Qilian was compressed again, causing additional mountain uplift and the formation of a thrust nappe structural belt that pushed along both sides.

Qimen Guniujiang National Geopark, Anhui This park is located in Qimen County, Anhui Province, and became a national park in 2004. Granite peaks and landforms are the dominant features. They were formed by multiple granite rock bodies that intruded during the Yanshanian period. The park also contains granite rock caves formed by water erosion, hydrogeological landscapes such as springs, rivers, and waterfalls, and the Qingbaikou Formation profile. There are two lithologies in the Yinniujiang granite: the early lithology is composed of medium-grained granite, which weathers easily, and the main lithology is porphyritic granite, which is harder and forms many granite peaks.

Qingbaikouan Period The Qingbaikouan Period is the first period of the Neoproterozoic Era in China. It extended from 1 billion to 800 million years ago, which is a duration of 200 million years. The Qingbaikouan System includes the rocks that formed during the Qingbaikouan Period. The standard section of the system is located at Qingbaikou in Yanchi Town, Mentougou District, Beijing. However, the latest dating data show that the Qingbaikou System strata are actually from the Mesoproterozoic Era. Further verification of the Qingbaikou Period is pending.

Qingchuan Earthquake Remains Geopark, Sichuan This geopark is located in Qingchuan County, Guangyuan City, Sichuan Province. It has an area of 209 km^2 with geological features concentrated into an area of 65 km^2. It became a national geopark in 2011. The geopark is categorised as a geopark of geohazards and was the first in China with earthquake geology as its main theme. The earthquake relics are mainly located in towns such as Hongguang, Shiba and Magong. They can be classified into different types, such as collapses of mountains (represented by Magong), combined collapses and debris flows (represented by Wangjiashan in Donghekou), combined collapses and landslides (represented by the Zhaojiashan collapse and landslides in Shiba), rock landslides (represented by the Shibangou landslide in Hongguang), soil landslides (the Libaisi landslide in Hongguang) and landslide dams. These earthquake relics have become valuable sites for studying earthquake-induced geological disasters and provide numerous research opportunities for detailed studies.

Qinghai Lake Geopark, Qinghai Qinghai Lake is located in the northeastern Tibetan Plateau

200 km northwest of Xining, the capital city of Qinghai Province. Qinghai Lake has an area of 4,583 km^2, all of which is important geological heritage. Qinghai Lake became a national geopark after being approved by the Ministry of Land and Resources in December 2011. The park is home to a variety of distinctive geological features and landscapes, including plateau lakes represented by Qinghai Lake, rivers with splendid scenery, such as the Buha River and Shaliu River, swamp wetlands represented by Xiannvwan, and islands represented by Bird Island. With a combination of lakes, rivers, wetlands and deserts, the park has remarkable scientific and aesthetic value and is the leading tourist attraction in Qinghai's tourism industry. Qinghai Lake is China's largest, and the world's second largest, inland saltwater lake. It is one of China's first group of internationally important wetlands and is a typical tectonic rift lake in China. The Qinghai Lake area has undergone a complete development over the course of its formation and contains varied sediments, meandering rivers, active deltas, vast sand dunes and grasslands, diverse lakes and rich lake sediments. All of these features are important for studying the formation and evolution of Qinghai Lake and the environmental and climatic changes of the Tibetan Plateau since the late Cenozoic.

Qinghai Lake Landscape In Mongolian, Qinghai is also known as Kukunaoer, which literally means 'blue sea'. Qinghai Lake is located in the Qinghai Lake Basin in northeastern Qinghai Province. It is China's largest inland lake and salt lake. It formed due to fault subsidence between the Datong Mountain and Riyue Mountain areas of the Qilian Mountains and Nanshan Mountain in Qinghai Province. It is 105 km long, 63 km wide, has a circumference of 360 km and covers an area of 4,583 km^2. Its deepest part is 38 m deep, and it has a catchment area of approximately 29,661 km^2. The lake surface elevation is 3,196 m. The Buha River flows in from the northwest, and the bird's island is a famous tourist attraction (Fig. 3).

Qinglian Wang Qinglian Wang (1939–) graduated from the Department of Geology and Geography of Peking University. He is a professor at Hebei Normal University and has engaged in teaching and research of tourism geography. He is the editor of 'Tourism Geography of China', 'Tourism Geography', 'Shijiazhuang Famous Scenery Resources' and 'Coastal Resources in Hebei'. He also participated in the compilation of 'An Introduction to Tourism Earth Science'. He has published more than 20 academic papers related to tourism earth science.

Qingtian Stone This is a collective name for the seal stones produced in the Lishui area in Zhejiang Province. The name comes from the main production sites at Tushu Mountain, Fang Mountain and Fengmun Mountain in Shankou Town, Qingtian County. This stone is a Late Jurassic intermediate acidic volcanic rock (rhyolite and rhyolitic crystal tuff) subject to hydrothermal alteration. Its main component is pyrophyllite with small amounts of quartz, sericite, kaolinite, montmorillonite, sillimanite, epidote and diaspore. It is waxy with a vitreous lustre and is slightly transparent or translucent. It has a fine and dense texture, relatively soft and with a density of approximately 2.7 g/cm^3. This stone is resistant to water, moisture and fire and is rarely discoloured or deformed. The natural Qingtian stone can be divided into single colour, multiple colour, hard jade and red columnar types, which can be further subdivided into more than 100 varieties. The famous varieties are light-shade steatitic, fish steatitic and Fengmen green types. Most are characterised by fine, pure, dense, moist, steatitic, glamourous and peculiar characteristics (Fig. 4).

Qingzhou National Geopark, Shandong Qingzhou National Geopark is located in Qingzhou City, Shandong Province, and covers an area of 70 km^2. It became a national geopark in 2009. Its main geological features include karst landscapes, stratigraphy and structures. Numerous karst landforms are present, including collapse basins and dissolution basins, daigu, stone forests, mountains, collapse cliffs, dry valleys, arches, sinkholes



Fig. 3 Qinghai Lake landscape



Fig. 4 Qingtian stone

and dolines. The park contains more than 100 karst caves; the most representative are Heilong Cave, Simen Cave and Gaoming Cave. It also contains a typical Cambrian-Ordovician section that includes the Yeli Formation and Liangjiashan Formation, a section of the Quaternary Heituhu Formation section, a parallel unconformity between the Sanshanzi Formation and Majiagou Formation, the Neoarchean Mengshan petrographic suite of the Fuping cycle, rock masses of the Dongjingtai thrust and the Cambrian fault contact.

Qin-Huangdao Liujiang National Geopark, Hebei This geopark is located in Qinhuangdao City, Hebei Province, with the Bohai Sea to the south and Yanshan to the north. It became a national geopark in 2002. It features palaeontological fossils, stratigraphic profiles, and karst and granite landforms. The stratigraphic section has clear boundaries, rich fossils and well-developed sedimentary structures. Additional geological relics are abundant, including three major rock types, various geological structures, folds and faults

of various sizes and forms as well as river terraces, sea erosion and marine deposits. The geopark is a good place for geotechnical geology fieldtrips and studies and for the popularisation of geoscience knowledge to the public.

Qinling Axis The Qingling Axis is a secondary tectonic structural unit along the southern margin of the North China Platform. The name was coined by Huang Jiqing in 1945. It is oriented EW and extends east along the main ridge of the Qinling Mountains via the Nanyang Basin to the Huaiyang Shield. This area is mainly composed of ancient metamorphic rocks. Recent studies reveal that the main body of these metamorphic rocks, including the Qinling Group, Kuanping Group, Taowan Group and Liuling Group, belong to the Mesoproterozoic, Neoproterozoic or Palaeozoic Erathems. The so-called 'Qingling Axis' is the base of the Qingling orogenic belt, which is characterised as an overthrust system. Due to the recent extensive uplift of the Qinling Mountains and the presence of hard rocks, abundant distinctive landforms have formed, which are a good foundation for geopark development.

Qinling Global Geopark, China This geopark is located in the middle of the Qinling Mountains in China and covers an area of 1,074 km^2. It became a global geopark in 2009. The geopark has been divided into five scenic areas: the Lishan Rift Depression Structure Area, Yushan Island Arc-type Granite Peak Ridge Geomorphological Area, Cuihuashan Landslide Geomorphology Area, Ice Crystal Top Ductile Shear Zone and Tectonic Mixed Rock Formation Area, South Pacific Whiteboard Block Collision Zone and Quaternary Glacier Area. The geopark is a representation of a complex continental orogen of the Qinling Mountains and includes prominent geological remains of the orogenic belt and Quaternary geological features, such as landslides and glacial landforms. Because Zhongnan Mountain is situated in the central part of the Qinling orogenic belt, it forms a natural boundary between northern and southern China's natural geology, geography, ecology, climate, and cultures. The entire area is of scientific importance due to its typical representations of regional geological processes. The landslide geology is exceptional with all kinds of landslide features, such as landslide cliffs, seascapes, piled caves, and collapsed lake landscapes. The two dammed lakes on the northern slope of the Qinling Mountains, Shuichi Lake and Ganzi Lake, were formed by landslides. The Cuihuashan landslide is composed of many smaller landslides. It is of great scientific value for studying the formation of historical landslides in the Qinling and Guanzhong Plains.

Qitai Silicified Wood-Dinosaur National Geopark, Xinjiang This geopark is located 150 km north of Qitai County in the Xinjiang Uygur Autonomous Region. It became a national geopark in 2004. The main geological features are the fossils and geomorphology. In a long narrow gully zone that is 5 km long and 2.33 km wide, nearly 1,000 petrified trees have been exposed. The main species are cypress, primitive spruce and South American fir. The ages of the trees range from hundreds to thousands of years, and most are approximately 1 m in diameter. The largest is more than 2 m in diameter and 26 m long. Dinosaur fossils are also present. The area has the peculiar Yadang landscape and colourful rocks.

Qomolangma Ammonite This fossil comes from the Mount Everest region. There are abundant Qomolangma ammonite fossils in the Mount Qomolangma region in Tibet. This mountain area was once part of the ancient Himalayan Sea, and the mountains formed during mountain-building associated with crustal uplift. Therefore, the ammonites that lived in the ocean were preserved in rocks and exposed at the Earth's surface. These fossils are evidence for crustal movements in the Himalayan region and serve as indicators to reconstruct the ancient ecological and environmental conditions (Fig. 5).

Qualitative Evaluation of Landscape Tourism Resource This is one of the evaluation methods for tourism resources. Through



Fig. 5 Qomolangma ammonite

detailed investigations and comparisons, the quality of landscape resources is reviewed in terms of their development values, and the overall assessment is presented using a descriptive method. The evaluation is usually summarised under the three major values of science, art and education, which can be further sub-divided into three major benefits and six conditions. The benefits are the economic, social and environmental benefits, and the six conditions are location and traffic, scenic and associated factors, tourist capacity, tourist source and market, investment and difficulties of facility construction. These factors determine the relative value of a landscape tourism resource of an area.

Quanzhou Leigongling National Mining Park, Guangxi This park is located in the southeastern corner of Quanzhou County, Guilin City, Guangxi Zhuang Autonomous Region, and covers an area of 3.6 km^2. It consists of two manganese mining areas (Leigong Tower Park and Baotaling Park) and a water park. It became a national mining park in 2010. The park features Quaternary weathering and accumulation manganese ore with manganese deposits distributed in the superficial layer, which is convenient for mining and separation. The tailings and silts have contributed to river channel sedimentation, and the sediment is now higher than the water surface. As a result, interconnected and isolated islands have formed, which are rarer and more attractive than the mining features in other national mining parks. The park is in the Xiangjiang section of the upper reach of the Yangtze River system and demonstrates the oversight of abandoned mine environments, protecting water resources and restoring the ecological environment along the upper reach of the Yangtze River.

Quartz Quartz is a common rock-forming mineral with the composition SiO_2. It crystallizes in a hexagonal crystal system, where the crystals are in the form of hexagonal columns. The column surfaces have transverse growth striations, and crystal twinning is common. It always appears in druse, in granular clusters or in blocky aggregates. The colours range from white, grey, red, purple, pink, yellow, green, and brown to black. It is often colourless and transparent with white streaks. It has transparent to translucent diaphaneity, and the fresh cleavage surfaces are vitreous, but the fractures have a greasy lustre. Its specific gravity is 2.65, its Mohs hardness is 7, and the fractures are conchoidal to uneven. Quartz usually forms in magmatic rocks, metamorphic rocks and sedimentary rocks, and it is sometimes found in ore veins containing metallic minerals.

Quartz Sandstone Quartz sandstone is a sedimentary clastic rock that contains more than 95% quartz and siliceous clastic matter. It also contains small amounts of or even no feldspar, lithic fragments and heavy minerals. Quartz sandstones are mainly Upper Triassic, Lower Jurassic and middle Lower Jurassic in age. The clastic grains are mainly monocrystalline quartz, and the sorting and roundness are good. The compositional and structural maturities are also very high. Quartz sandstone mainly forms in stable tectonic environments in which the parent rocks have experienced long periods of weathering, and deposition gradually occurs subsequent to transport by

water. The Devonian quartz sandstone in Zhangjiajie is a typical example of the unique landscape of Zhangjiajie.

Quartzite Quartzite is a metamorphic rock that contains at least 85% quartz. Quartzite can form in association with small amounts of feldspar, mica, hornblende, pyroxene and chlorite. It usually has a granoblastic texture and a flaky structure. Quartzite is light-coloured, dense and hard. It forms from siliceous rocks by regional, dynamic and contact metamorphism.

Quaternary Geology Quaternary geology is the geology of the Quaternary Period, which is the most recent period of the Earth's development, and its associated geological events. It involves studies of the geological background, temporal and spatial distribution of the associated geological events, evolution and driving mechanisms. This topic covers extensive areas such as geological dating, sediments, strata, palaeontology, ancient humans, palaeoclimate, palaeosols, palaeogeographic changes, neotectonic movements, volcanic activities and volcanic deposits, palaeokarst development and cave deposits, ancient earthquakes, palaeogeological disasters, the evolution of ancient hydrological conditions and Quaternary mineral reserves. Since most landscape tourism takes place in landscapes that formed during the Quaternary Period, Quaternary geology is closely related to tourism earth science.

Quaternary Period The Quaternary Period is the most recent period in Earth's history and is related to the older Tertiary Period (now the Palaeogene-Neogene Period) (1854). There have been longstanding arguments about two aspects of the Quaternary Period: (1) the original concept of the Neogene System included the time interval of the Quaternary Period, and there is an argument as to whether this nomenclature should be deleted; and (2) the lower age limit of the Quaternary Period was once considered to be 1.8 million years or 1.64 million years ago. However, Chinese geologists (An Zhiseng and Wang Naiwen et al. in 1979 and later Liu Dongsheng et al.) proposed that the onset of the glacial climate in the northern hemisphere should represent the boundary of the Quaternary Period. This postulation has gradually gained recognition and support from many geologists around the world. The 2010 International Union of Geological Sciences (IUGS) and the International Commission of Stratigraphy (ICS) conducted an extensive review, and the experts eventually voted to retain the term Quaternary and revise the lower age limit of the Quaternary Period to 2.588 million years ago. On the palaeomagnetic timescale, the Gauss magnetic chron/Matuyama magnetic chron boundary coincides with the onset of the glacial climate in the northern hemisphere. The Quaternary System includes the rocks that formed during the 2.6 million years of the Quaternary Period. The Quaternary Period (System) is divided into the Pleistocene Period (System) and the Holocene Period (System), which are roughly equivalent to the Palaeolithic age and the Neolithic age, respectively. The Quaternary System in China is divided into the Nihewanian Stage of the Lower Pleistocene Series, the Zhoukoudianian Stage of the Middle Pleistocene Series and the Salawusuan Stage of the Upper Pleistocene Series. Based on the distribution of ancient human and mammal fossils, the terrestrial facies of the Pleistocene Series in China are divided into nine chronozones. In northern China, loess, which is an aeolian deposit, developed under periglacial climatic conditions. Based on the time of formation, the loess is divided into the Wucheng loess of the Early Pleistocene Epoch, the Lishi loess from the end of the Early Pleistocene to the Middle Pleistocene Epoch, and the Late Pleistocene Malan loess. The Lishi loess deposit is the thickest, and the Malan loess is most widely distributed. The loess contains multiple palaeosol layers, indicating warm periods between the cold periods. The loess/palaeosol cycles correspond to the deep-sea isotope stages, which are the manifestations of the Quaternary glacial and periglacial periods in the land areas and the marine environment.

The isotopic staging of the deep sea (or ocean) is derived from the determination of the oxygen isotope ratios of calcareous foraminifera shells at different times. High ratios indicate cold climates, while low ratios indicate warm conditions. Using MIS or D as codes, from top to bottom, the Holocene is MIS1 (warm period), the Pleistocene is MIS2 (Ice Age), and so on. The last 1.2 million years include MIS1 to MIS36, which coincide with radioactive dating ages. Accurate ages have been obtained for every MIS, which are far more accurate than the traditional division of the four glacial-periglacial periods in Europe. The Quaternary Period is also known as the Human Period, although real humans (Homo habilis in Africa) emerged approximately two million years ago. The famous Peking Man (Homo erectus) of Zhoukoudia in China is approximately 400,000–500,000 years old. The Quaternary lacustrine siltstone is the base material for the formation of the 'Yardan landform landscape'.

R

Radium Water This is a kind of medical hot mineral water. In accordance with the National Medical Hot Mineral Water Quality Standard, water with a radium salt content over 10.11 g/L can be called radium water.

Radon Spring A radon spring is a mineral spring that contains radon. The radon springs in China are mainly low-level mineralised springs. Famous radon springs include the Conghua Liuxihe Hot Spring in Guangdong Province, Xiaotangshan Hot Spring in Beijing, Tanggangzi Hot Spring and Xingcheng Mineral Spring in Liaoning Province.

Radon Water Radon water, also called radium water or radioactive radon water, is hot mineral water containing radon. It is the most unique type of therapeutic water. It is potable and can be used for bathing, and it has anti-inflammatory effects and can be used to treat endocrine disorders, the peripheral nerve system, gynaecological diseases and urinary disease. It is particularly effective for curing skin diseases. The water of the Tengchong Hot Spring in Yunnan Province contains 209 becquerel/L of radon, which has curative effect on more than 40 kinds of diseases.

Raft-Crystal Cone Landscape A raft-crystal cone is a karst cave depositional crystal cone that grows on a calcite membrane and gets its name from its appearance. It is a composite deposit of water dripping and pool sedimentation. Its formation process is as follows: Upon the impact of dripping water, the cave raft (calcite film or membrane) on the surface of the pool water breaks into fragments and precipitates to the pool bottom to form a fixed-point heap underneath the water. After precipitation, the calcite film in the water attaches to crystals, which further build up the calcite pile, and this heap further facilitates crystallisation in the water. This interactive process forms more symmetrical cone-shaped stalagmites underwater. These cones are found in Chushui (Pouring Water) Cave in Gongcheng and in Bama Crystal Palace and Wanhua Cave in Chenzhou, Hunan Province (Figs. 1 and 2).

Rafting Tourism These are rafting activities in streams, rivers or other water areas with suitable rapids using rafting equipment. Rafting tourism aims to explore the mysteries of nature. It is the best way for people to embrace, experience, and return to nature. It is also dynamic, experiential, and challenging, and has the quality of motivating people to return. It is a unique tourism activity that is a combination of adventure tourism and ecotourism.

Raindrop Imprints These features are small shallow pits formed by rain that falls onto the surface of unconsolidated sand, mud or clay deposits. They are circular or elliptical recesses that remain on the surface of sedimentary rocks. They generally are 2–3 mm in diameter, 1–2 mm deep, commonly form on the top of argillaceous or sandy rock strata, and can also be casted on the bottom face of the overlying strata. They can be used to determine the top and bottom surfaces of a rock (Fig. 3).

Rain-Flower Pebble ► Yuhua Stone

Rainforests of the Atsinanana, Madagascar These rainforests are located on the border between the provinces of Antsiranana and Mahazanga in northeastern Madagascar. The core protection area covers 4,796 km^2. The heritage site is composed of six national parks in the eastern part of the island. The rainforests that have survived to this day are critical to sustaining ecological evolution processes and are necessary for supporting the unique biodiversity of Madagascar Island. Madagascar separated from the mainland 60 million years ago, and the animals and plants have evolved in isolation.

Rare Animals and Plants Rare animals and plants refer to endangered and endemic species. The former refers to species of wild animals and plants that are endangered due to the species' own actions or because they have been affected by human activities or natural

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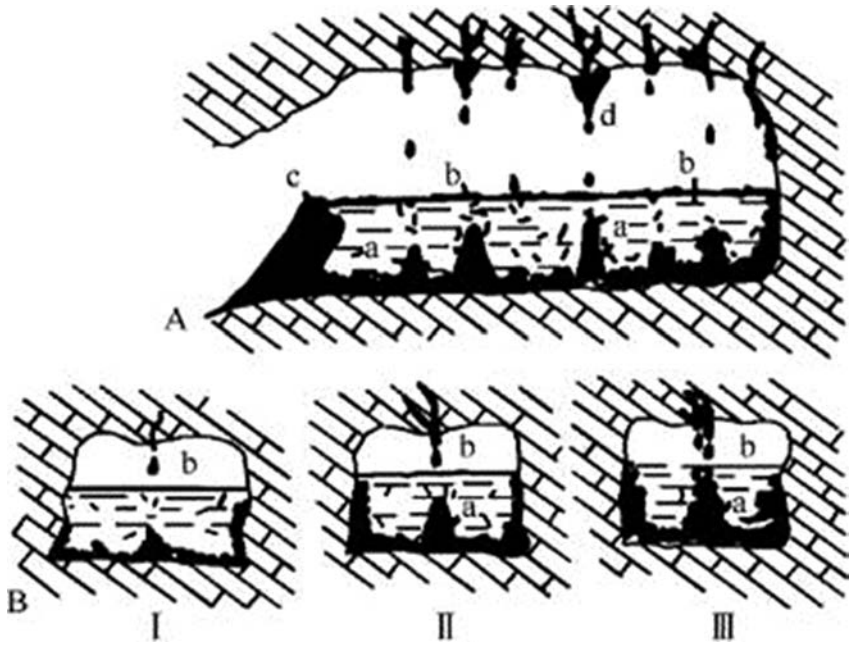


Fig. 1 (**a**) Raft crystal pool (**b**) I, II & III deposition of raft crystal cone; a. underwater crystal cone; b. raft formation on water surface; c. water on cave ceiling



Fig. 2 Raft-crystal cone landscape – Bama Crystal Palace, Guangxi Province

disasters. From the perspective of species management, the term 'endangered' refers to the species listed in the Appendix to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The latter refers to animals and plants that are found only in limited areas and are not naturally found in other areas. Rare animals and plants, such as the giant pandas, are important tourist resources and are attractive to tourists. However, special care and attention must be taken with tourism activities that may have negative impacts on the well-being of rare animals and plants. Therefore, these rare animals and plants should be closely monitored.

Realgar Realgar is also known as 'cockscomb stone'. Its composition is AsS, and it is an important arsenic mineral. It contains 70.1% arsenic and belongs to the monoclinic crystal system. The crystals are short columns, and the



Fig. 3 Rain pits or raindrop imprints

crystal surfaces are striped with longitudinal striations. The aggregates are granular, dense or blocky but sometimes appear as soil-like blocks or crust-like aggregates. It is bright red to orange with orange to red streaks and has transparent to translucent diaphaneity, a resinous to greasy lustre, a specific gravity of 3.56, a Mohs hardness of 1.5–2 and conchoidal fractures. Its melting point is very low (310 °C), and it emits a garlic odour when burned. It is a low-temperature hydrothermal mineral and often coexists with orpiment and stibnite. It is an important raw material for the extraction of arsenic. It is a common pigment, and realgar crystals are also important ornamental stones.

Recreation Recreation includes sightseeing and resting either in individual or group activities during free time. Recreation includes three aspects. In terms of industry, recreation is tourism in a broad sense. Geographically, recreation is one of the basic functions of cities (including urban areas, suburbs and outskirts) and can be differentiated from leisure activities, as it is more organized. From the view of behavioural psychology, recreation is a combination of material and cultural pursuits. Recreation processes produce, consume and accumulate energy; thus, a recreational system is a system for storing and producing urban social energy. Because it is also a process used to gain energy, it enables people to become more energized, knowledgeable and healthy in conducting their productive and creative activities to facilitate the material and cultural progress of society.

Recrystallization Recrystallization is a metamorphic process in which atoms of a mineral are reorganized by altering the original mineral. It includes recrystallization of the original mineral, which causes the original crystal grains to become coarser (such as the transformation of fine calcite to coarse calcite with the mineral composition remaining unchanged) and changes the original chemical composition under the new temperature and pressure conditions to form new minerals (such as the transformation of kaolinite to andalusite and quartz). Recrystallization is different from the crystallization of rock during cooling. It takes place in the solid state.

Red Earth *Synonym:* ► *Red soil*

High temperature and humidity in mid-subtropical regions allow rapid desilication and bio-enrichment, which facilitate the formation of red soil. Red soils are acidic to very acidic and rich in iron-aluminium oxides. They can be found in the vast lowlands and hilly areas south of the Yangtze River and at approximately 24–32° N. The soil is characterized by its viscosity, infertile nature, acidity and dryness.

Red Soil ► Red Earth

Red Tourism Red tourism is a common tourism activity in China in which tourists visit historical memorial sites of revolutions and relics and experience the revolutionary spirit they carry as attractions. People can learn about the history and traditions of past revolutions, invigorate their spirit, relax and increase their knowledge through tourism. Since the reform and the continuous increase of tourism in China, red tourism has gradually become a new area with significant social influence and growing market demand. In December 2004, the General Office of the Central Committee of the Communist Party of China and the General Office of the State Council issued The Outline of National Red Tourism Development from 2004 to 2010, which clearly defined the overall idea, layout, and major measures for the development of red tourism.

Red-Silk Inkstone This stone gets its name from its red and purple silk pattern. It is a silty marl or mud dolomitic limestone from the Ordovician Majiagou Formation, and it is produced in Linqu County, Shandong Province. It is composed of 90% or more calcite with small amounts of dolomite, iron, manganese and mud. Its red silk pattern is a thin layer of mud, limonite and carbonate marl that was deformed during sedimentation. The inkstone can be divided into yellow base red silk, red base yellow silk and purple base yellow silk types based on the texture. Red is the most common colour, and colour banding is also common. The yellow base red silk type is considered the best. It has moderate hardness with a fine texture. The silk pattern is delicate and tends to be in parallel arrays of ripples or concentric circles. The red silk inkstone feels like cream when touched, is able to disperse ink like oil, keeps the ink as black as lacquer, is capable of holding water without wasting it, and can keep the ink moist when covered. It is the best type of Shandong inkstones (Fig. 4).

Redwood National and State Park, U.S.A. Redwood National and State Park is located in northwestern California along the Pacific coast in the U.S.A. It is a region of coastal mountains north of San Francisco and has a core protection area of 568 km^2. It is covered with a magnificent forest of coastal redwood trees, which are the tallest and most impressive trees in the world. The marine life and terrestrial life are equally remarkable, particularly the sea lions, bald eagles and the endangered California brown pelican.



Fig. 4 Raw red-silk ink stone

Reed Flute Cave Landscape, Guilin This is a famous karst cave in China. Located in Guangming Mountain in the northwestern suburbs of Guilin City, this cave is a hall-type cave with an east-west length of 240 m, a north-south width of 50–90 m and a height of 10–18 m. The cave bottom covers an area of 14,900 m^2 and is 15–25 m above the ground surface in the foothills. Northeast of the hall, a canyon-like corridor runs EW along the cave fissure. A very deep aven is located at its end. Chemical deposition is ongoing inside the cave; hence, stalagmites and karst columns are as dense as the wood in a forest. On the cave wall, 77 historical ink writings have been found. The earliest can be dated to the Southern Dynasties and were signed by Qi Yongming (483–493 AD). Five writings have been dated to the Tang Dynasty, ten to the Song Dynasty, one to the Yuan Dynasty, four to the Ming Dynasty, another four to the Republic of China period, and 52 lack identification. The important wall writings are on the walls of the large hall, and understandably, tourists visited this cave as early as the 5th century. The Reed Flute Cave was opened to tourists in 1962, and it has since been visited by numerous leaders from many nations, and as such, it has got to its nickname of 'National Guest's Cave'. The cave hosts up to a million visitors annually, most of which are locals. It is one of the most famous caves for tourists in China (Fig. 5).

Reference Section A reference section is ancillary to a stratotype section. Whenever a stratotype section is defined, a reference section can be established to clarify the concept or extend it to other regions. It can be specified as a secondary stratotype.

Regional Chronostratigraphic Scale This scale is a set of stratigraphic units suitable for use in a specific biogeographical region. It generally includes the regional stages and chronozones. Several marine facies regional stages (such as the Qixia Stage and Maokou Stage of the Middle Permian Series) and terrestrial facies



Fig. 5 Landscape inside Ludi (Reed Flute) Cave in Guilin, Guangxi Province

regional stages (such as the Shanwang Stage of the Miocene Series and the Nihewan Stage of the Quaternary System) have been identified in China. However, there are also several higher-level regional chronostratigraphic units, such as the Changchengian Period and Jixianian Period of the Mesoproterozoic Era and the Nanhuan Period and Sinian Period of the Neoproterozoic Era. Further verification of the corresponding relationships between the regional chronostratigraphic scale and the international chronostratigraphic units hinges on continuous in-depth research on these topics.

Regional Development Regional development is the economic growth, social development, and other regional structural changes in a country or a region. Tourism development and operations are often important driving forces for regional development. The impacts of tourism on a region can be studied in the context of regional development.

Regional Diversity of Tourism Resources Regional differentiation is the most fundamental earth science characteristic of tourism resources, and it refers to the basic factors that form different types of tourism resources, each with its own characteristics. Regional differentiation is affected by multiple factors, including latitudinal climatic factors (ranging from tropical, subtropical, and temperate to polar), altitudinal topographic and geomorphological factors (ranging from plains, low mountains, undulating hills, and high mountains to plateaus), the geographical distribution of oceans, land and lakes, the geological structures and varied lithological and petrological characteristics of different rock strata, and historical, cultural and national folklore.

Regional Economic Geography Regional economic geography focuses on the conditions and patterns of regional economic development at different scales. It includes the regional distributions of economic structures, economic specialization and development, the formation of economic centres and the geography of economic zones. Studying the status and role of the tourism industry is an important part of regional economic geography.

Regional Environment The regional environment includes the natural and social environments within a specific geographical area. The regional environment is a relative concept between the settlement environment and the global environment. It can be based on the scale and intrinsic connections to be determined by human needs.

Regional Geography Regional geography is the study of the combinations of various geographical elements within a region and their mutual relationships and interactions to comprehensively determine regional characteristics and clarify the geography of regional human-land relations.

Regional Geology Regional geology is a comprehensive and fundamental science of a specific area's stratigraphy, geological structures, magmatic activities and igneous rocks, metallogenic conditions, Quaternary geology and geomorphology, hydrological engineering and environmental geology, geophysics and geochemistry. Research on regional geology focuses on the geological structures, the overall characteristics of the area's evolution and its intrinsic links with geological processes. Regional geological surveys are the foundation of geological heritage protection and the establishment of geoparks.

Regional Geomorphological Factors of Landscape Formation The regional variations in the Earth's surface control the formation of the regional landscapes, including highlands, mountains, hills, basins and plains. Mountains can be classified based on their heights as high, medium and low mountains and hills. Mountains with relative heights over 1,000 m are classified as deeply eroded mountains, those with relative heights of 500–1,000 m are moderately eroded mountains, and those with relative heights of 200–500 m are slightly eroded mountains. China's regional landscape is composed of three geomorphological plateaus that are separated by mountain ranges, which have essentially controlled the types and distribution of natural landscapes in China.

Regional Metamorphism Regional metamorphism is the metamorphism that occurs over a large area under both high-temperature and high-pressure conditions. Regional metamorphism is often the result of regional crustal movement, so it is always associated with tectonic events and magmatic activity.

Regional Physical Geography Regional physical geography is a branch of physical geography that includes the overall structure, composition, and dynamics of the physical environment in a given region. It focuses on analyses of the interrelationships, interactions, formation and evolution of the physical components of the natural environment as well as studies of regional development and the associated human-earth relationship. Regional physical geography provides the scientific basis for studying the environment and the sustainable development of tourism and scenic areas.

Regional Structure of China China is one of the most complex continents and formed from the combination of many palaeocontinents of different sizes. The North China Platform and its northern part are part of the Eurasian Plate; the Yangtze Platform, Qaidam Basin and Tarim Basin originated from the Australian Plate; the main body of the majestic Qinghai-Tibet Plateau originated from the Indian Plate; and the narrow coastal mountains of Taiwan are part of the Philippine Sea Plate. China contains three Pre-Nanhuan cratons (stable ancient platforms) and is surrounded by five orogenic belts. These three cratons are the North China Platform, Yangtze Platform and Tarim Platform, and the five orogenic belts are (1) the Tianshan-Daxing'anling Variscan orogenic belt; (2) the Qilian Mountain-Dabie Mountains and Qinling-Kunlun Caledonian-Indosinian superimposed orogenic belts; (3) the Qinghai and Tibet-Yunnan West-Himalayan composite orogenic belt; (4) the South China Caledonian orogenic belt; and (5) the Western Pacific Yanshan-Himalayan orogenic belt (including Taiwan's rift valley suture belt, the Jiamusi tectonic belt and the Nadanhada Ridge tectonic belt). The Helan Mountains-Longmen Mountains-Hengduan Mountains in Central China form a large jagged gravity gradient zone and a zone of abrupt crustal changes. Its northern margin is crossed by a linear NNE-trending seismic belt. Using it as the boundary, China can be divided into an eastern region, where the crust is thin, the geological structure mainly trends northeast, the crust is generally a stable depression (equivalent to a platform)

composed of an extensive syncline, and the crust is relatively balanced, and a western region, where the crust is thick, the structure mainly trends E-W, the degree of crustal equilibrium is low, and the crust is generally an active anticlinorium-type compressional uplifted area (equivalent to a geosyncline). Previous studies indicate that the mainland of China has undergone several tectonic cycles, including the Qianxi orogeny (2.8 billion years ago), Wutai orogeny (i.e., Fuping movement, 2.5 billion years ago), Luliang orogeny (1.8 billion years ago), Jinning orogeny (800 million years ago), Caledonian orogeny (410 million years ago), Variscan orogeny (295 million years ago), Indosinian orogeny (250–200 million years ago), Yanshan orogeny (approximately 200–65 million years ago) and Himalayan orogeny (65 million years ago). Five structural systems, including a latitudinal tectonic system, longitudinal tectonic system, the Cathaysian-Neocathaysian tectonic system, the Xiyu-Hexi tectonic system, and the Qinghai-Tibet tectonic system, have formed. Crustal blocks from several ancient plates, which have drifted (transform and rotational movements) since the Permian, combined during the Indosinian movement and continued to drift northwards to their present position. Recent data indicate that the Indian Plate is still moving northwards into the Qinghai-Tibet Plateau, causing it to move ENE along a clockwise track.

Regional Tectonic Structures In China, regional tectonic structures usually refer to the tectonic structures in a province (district) or in a structural zone. Examples are the Tanlu fault zone across the eastern part of the North China craton and the Daxing'anling Range-Taihangshan Mountain fault zone. The scale of the maps used to study these structures is typically 1:500,000 to 1:4,000,000.

Regional Tourism Planning Regional tourism planning is the overall planning for the development of tourism at different administrative levels (e.g., country, provinces, cities, counties). Its main tasks include researching and determining the status and role of tourism in the regional and national economies, proposing the goals and determining the scale, structure, and arrangement and rate of tourism development, and providing an effective support system for the healthy and sustainable development of tourism. Based on the level of detail, the planning can be further categorized as strategic planning of regional tourism development, master planning of regional tourism development and general management planning of regional tourism activities.

Regionalisation of Natural Tourism Resources It is essential to design an overall zoning plan for the development of nature-based tourism in an area. Several tasks are involved. The first is to investigate and study the types, scale, quality, and conditions of geological and geographical formations and the distribution of the resources. Based on the results, a scientific evaluation of the economic and social values of these resources should be conducted. Then, an integrated plan for developing nature-based tourism as a core business of the area is developed. This research provides an understanding of the formation, development, changes and inherent characteristics of the nature-based tourism area. In addition, by using a more scientific approach, objectives and guidelines for the tourist destination can be developed. Currently, there are no standardised zoning methods in China. Zonings are based on administrative levels and tourist cities, the distribution of tourism resources, different geological and geographical conditions and the specific conditions of the tourism industry development.

Regulatory Plan of a Tourism Area A regulatory plan of a tourism area is a detailed plan for a tourism area that lays out specific controls for construction and other management requirements in the region. It adds detail to the overall plan and specifies guidance for all development and construction activities within the region to ensure that tourism facilities and projects are built as planned.

Regulus Stone This stone is called 'Xuanyuan stone' and 'Beichen stone' in Chinese, and it is a kind of iron-containing dolomite or siliceous

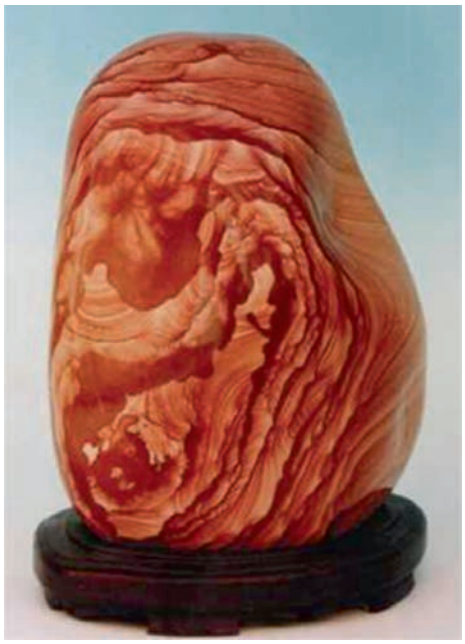


Fig. 6 Regulus stone

limestone that is mainly mined at Miao (Temple) Mountain northeast of Pinggu in Beijing. The stone was given this name because there is a Xuanyuan (Regulus) Temple on this mountain. Regulus stone is light greyish green or greyish ochre and has a Mohs hardness of 4. It formed in the Sinian red earth, which had stained the stone surface a red colour. The stone is full of small cracks and undulating patterns like crocodile skin or a walnut shell; hence, it has the qualities of slimness, wrinkliness, leakage and penetrability. When struck, it generates an interesting clear sound. Large stones are ideal for landscape gardening, and the small ones are suitable for imitating natural scenery (Fig. 6).

Relative Age Relative ages represent the chronological order of younger and older strata relative to each other. For example, the relative age of a stratigraphic unit can be identified as Ordovician according to its fossils, and it can then be determined to be younger than rocks of the Cambrian Period and older than rocks of the Silurian Period. However, these ages are relative. The chronostratigraphic units eonothem, erathem, system, series and stage are relative or chronological ages, and they can then be translated into numerical ages to form the geologic time scale.

Relative Height The relative height is the difference between the absolute heights of two arbitrary points or surfaces. The heights of mountains can be categorized by determining the elevations of other points relative to the elevation of any hypothetical point. Travel geoscientists usually use the difference in elevation between a mountain surface and the peak as the relative height of the mountain to classify a mountain as a low mountain, medium-high mountain, high mountain, or extremely high mountain. For example, the relative height of Huangshan is greater than 1,000 m, so it should be called a high mountain.

Religious Geography Religious geography is a science that studies the regional development of religious landscapes (e.g., architecture, etiquette, festivals, ceremonies, taboos, and customs) and their spatial variations in religious systems. It is an important field of human geography.

Religious Tourism Religious tourism is a type of tourism that hinges on religious culture and the related natural and cultural resources to attract religious followers and general tourists to activities such as worshiping, studying, sightseeing, and cultural exchanges. The religious tourism resources in China mainly include Buddhist tourism resources, such as famous mountains, temples, caves, and pagodas. Taoist tourism resources include famous mountains, palaces and temples, cave carvings and remains. Islamic tourism resources include mosques and famous monuments, and Christian tourism resources include famous churches and relics.

Remains Fossil Remains fossils are the fossilized bodies or the original hard bodies of ancient animal dung, working tools or decorations of ancient man.

Remnant Snow on the Broken Bridge (Hangzhou) This is one of the Ten Spectacular Sceneries of West Lake. The Broken Bridge is located on the eastern side of the



Fig. 7 Remnant snow on the Broken Bridge landscape

Baidi (White Embankment) in West Lake. It faces Hangzhou City and is backed by Baoshi (Gemstone) Mountain, and it is the dyke that divides the outer lake and the northern inner lake. The bridge is at a higher level, so it has a clear view and is the best place to watch the snow on West Lake in the winter. Whenever early snow falls on the top of Baoshi Mountain, it can be seen from West Lake from the south, and the snow or ice on the arch of the Broken Bridges melts under the sun, revealing some of the bridge railings, while both ends of the bridge are still covered with snow. Under such conditions, the entire bridge is barely discernible and looks broken. Hence, this scenery was given the name 'remnant snow on the Broken Bridge' (Fig. 7).

Remnants of a Glacial Abrasion Landscape This is a landscape composed of features remaining after glacial erosion. When a glacier flows, gravel and sand inside the firn grind, slide and abrade the rock below the ice, forming polished surfaces, striation marks, glacial pavements and streaked stones (Fig. 8).

Remote Sensing Image Remote sensing images include photographs and other digital products that record electromagnetic waves of various objects using film, photo paper, and tape as carriers. Aerial photographs and satellite photographs are the most commonly used remote sensing images. In tourism research, tourist resources and environmental information at different spatial and temporal resolutions can be obtained through the interpretation of remote sensing images of tourist areas.

Remote Sensing Satellite Images of Geopark Images are derived from satellite images and prepared according to remote sensing data with a similar scale as the planning map. The map should bear the name of the geopark and its associated location names and features. This will greatly help in the compilation of the geoscience guide map and act as a base map for preparing other planning maps.

Renqiu Huabei Oilfield National Mining Park, Hebei This park is located in the triangular area between Beijing, Tianjin and Baoding. The park is 151 km from Beijing and covers an area of 78 km^2. It became a national mining park in 2005. The park comprises three theme attractions, namely, Yanling Mine Theme Park, which is a petroleum technology exhibition area, the Ren-4 well petroleum exploitation area, which provides an introduction to petroleum exploitation, and the Baiyangdian tourist attraction, which is an ecological sightseeing area. All of the landscape designs in the



Fig. 8 Landscape of glacial movement traces in the northern Shaluli Mountains, western Sichuan (glacial pavement, abrasion marks and glacial gravel)

park are centred on petroleum exploration, exploitation, refining and transportation as well as other elements related to mechanical equipment. The park attempts to reproduce the conditions of the subsurface reservoir and show the balance between the petroleum industry and nature.

Representative Type of Karst Stone Forest Landscapes in China This is a classification of stone forest landscapes in China. The representative types of karst stone forests in China can be classified into eight categories: (1) Laiyuan Baishi Mountain-type (towers) stone forest landscape, Heibei Province; (2) Wufeng Chaibu Stream-type stone forest landscape, Hubei Province; (3) Xingwen Tai'an-type stone forest landscape, Sichuan Province; (4) Baoting Xian An-type stone forest landscape, Hainan Province; (5) Hezhou Gupo Mountain-type marble forest landscape, Guangxi Province; (6) Shilin-type stone forest landscape, Yunnan Province; (7) Nidang-type stone forest landscape, Guizhou Province; and (8) Anxian-type calcareous conglomerate stone forest landscape, Sichuan Province. These landscapes are categorised according to the karst stone forest landscape classification principles.

Reptiles Reptiles have always been a large group of fauna and were the true terrestrial quadrupeds. They laid eggs and hatched them on land. Reptiles first appeared in the late Palaeozoic and Mesozoic and flourished throughout the land, air, seas, rivers, lakes and swamps, but they declined sharply at the end of the Mesozoic. Only a few have survived to the present. Reptiles are mysterious due to their strange forms. Other than turtles, complete fossils of other reptiles are difficult to obtain, so complete sets have high ornamental value. Fossils of turtles, lizards, alligators, pterosaurs and dinosaurs are important fossil types.

Research on Basic Theory and Development of Karst Tourism Resources This book was written by Anze Chen et al. and was published by Seismological Press in 2004. This book includes a selection of papers from the 'China's First Karst Tourism Earth Science Symposium'. It contains the basic theory of karst tourism resources, the development of karst cave tourism, examples of karst tourism resources and development in Chongqing and other regions of Sichuan, the current status and prospects of tourism development in China and overseas, and the five major aspects of the establishment of national geoparks. It is a representative work of karst tourism resources research in China.

Research on Karst Landform in Fangshan, China This book was written by Xun Zhao et al. and was published by Geological Publishing House in 2010. Focusing on the karst geomorphology of the Fangshan District, it analyses the history of the neotectonic movements in North China and information about palaeo-climate and palaeo-environmental changes. It also performs a comparative analysis between the karst geomorphology in China and overseas. It has important reference value for tourism resource development, geopark construction, geoheritage protection and tourism earth science in the Fangshan District, Beijing.

Research on Regional Tourism Development This book was edited by Chuankang Chen, Kang Guo, and Guilong Pang and was published by Meteorological Press in 1992. It consists of three main parts: theory and methodology, topical research and comprehensive research. It covers geography, geology, tourism, economy, environmental protection, publicity, education, and management. The book reflects the trends and level of research on regional tourism development in China in the early 1990s.

Research on the Tourism Development Strategy in Western China This book was written by Feng Liu and was published by China Travel Press in 2001. It is a comprehensive, systematic, holistic and forward-looking study on the development and development strategy of tourism resources in western China. It also proposed several new ideas, methods and models for tourism development in the west.

Reserve Géologique de Haute Provence, France Reserve Geologique de Haute Provence is located in the upper Provence Alps and Val Province in southeastern France. Its elevation ranges from 400 m to 2,960 m in the highland, and it covers an area of 2,300 km^2. It became a member of the Global Geoparks Network in 2004. The area is dominated by agricultural activities (especially sheep, which play an important role in the protection of landscape) and tourism. The focus of the tourism is on leisure, natural scenery and cultural landscapes. Three quiet paths connect different scenic areas. Visitors can focus on fossils, outcrops, history, landscape and vegetation. The geological relics are not isolated, and tourists can increase their knowledge. The museums associated with these three trails are Musee-Promenade (Digne-les-Bains), the Museum of Fossils (Castellane) and the Museum of Geology (Baule).

Resources of Tourism Earth Science These are resources associated with earth science that can be used for tourism development. They can be divided into natural and cultural resources.

Resurgent Caldera Landscape This is a type of volcanic landscape. There are two stages in the formation of a common caldera; the first is the volcanic eruption, and the second is the formation of a large crater with subsidence. If a caldera becomes active again after its formation, the erupted material is usually in the form of spraying lava or, when intruding, in the form of a rock dome. Eventually, the intruded magma forms intrusive rock bodies in the central part of the caldera. This type of caldera, which has experienced subsidence and then another eruption, is called a resurgent caldera. The Valles Caldera in New Mexico, the USA, is a typical example. Yandangshan in Zhejiang Province is a resurgent caldera that formed approximately 100 million years ago.

Retrograde Metamorphism See ► Metamorphism.

Reunion Island's Peaks, Cirques and Cliffs, France This heritage site is located in the southwestern Indian Ocean east of Madagascar, and it covers the core of the Reunion National Park. It has an area of more than 1,000 km^2, which is approximately 40% of the total area of the island. Reunion Island is composed of two volcanic mountains. The heritage area contains two towering volcanic peaks, tall cliffs, and three cliff-edge cirques that overlook the island. The lower cliffs and forests cover gorges and basins that altogether form magnificent scenery. The area is a natural habitat for plants, which are diverse but include endemic local species. The subtropical rainforest, cloud forest, and woods intertwine to form a colourful and attractive outdoor mosaic of ecological systems and characteristic landscapes.

Reverse Fault *Synonym:* ► *Thrust fault*

A reverse fault is a fault where the hanging wall block moves upward along the fault plane relative to the footwall block. Reverse faults can be categorized as high-angle and low-angle reverse faults, and a dip of 45° has long been considered the dividing line between the two types. However, some Chinese scientists regard 30° as more practical and appropriate since this angle is more consistent with the

theory of fracture mechanics. In the past, low-angle reverse faults were usually called overthrusts, and the large low-angle long-range detachment reverse faults were called detachment or decollement.

Reversed River A reversed river refers to the section of a river that flows towards the elbow of capture after the river-capture process. Its flow direction is opposite to that of the beheaded river. If an existing terrace is present, its dip is opposite to the flow direction of the reversed river. Typical examples are the Yigong Cangbu River and Palong Cangbu River in Yigong National Geopark in Tibet. These two rivers developed along a Palaeozoic rift belt. The Yigong Cangbu River flows southeast, and the Palong River flows northwest. They form a nearly linear channel, and they are sometimes mistaken as a single river system, but geographically they are separate rivers flowing in opposite directions.

Rhodonite This is a gem-quality mineral with the chemical composition $(Mn, Fe, Ca)_5[Si_5O_{15}]$. It is in the triclinic system with tabular crystals of a massive and granular habit. Its colour is similar to that of peach flowers, and in Chinese, it is also known as peach blossom jade or Peking pastel green. It usually contains black spots and veinlets. The main mining areas include Massachusetts in the United States, the Ural Mountains in Russia and New South Wales in Australia. In China, high-quality rhodonite is mined in Beijing as well as in Shang County in Shaanxi Province, Suzhou in Jiangsu Province and in Qinghai and Sichuan Provinces.

Rhyolite Rhyolite is an extrusive acidic rock with a porphyritic structure. The phenocrysts are mainly quartz and alkali feldspar and occasionally plagioclase. The matrix is dense cryptocrystalline glassy materials. Rhyolite is widely distributed in many provinces in eastern China and forms unique landforms. Typical examples are the Yandangshan and Linhai landscapes in Zhejiang Province, Baishuiyang in Fujian Province, Mirs Bay in Shenzhen, Guangdong Province and the Hong Kong Geopark in Sai Kung.

Rhyolite Landform Landscape of the Yandangshan This landform is located in the area between Wenzhou and Taizhou in southeastern Zhejiang Province. Yandangshan is a reactivated eroded volcano composed of Cretaceous rhyolite. Four stages of volcanic activity occurred. The first was the eruption of ignimbrite, which was followed by emissions of thick lava, explosions of tuff, and a second eruption of ignimbrite. Finally, central intrusive bodies formed due to magma intrusions. The rocks that formed during these four stages have a ring-like distribution pattern. Crustal uplift, fracture formation, disintegration, collapse, weathering and erosion created features such as superimposed peaks, stone bridges, natural bridges, sharp peaks, single pillars, unique stones, collapse deposit caves, U-shaped and V-shaped valleys and waterfalls. The caldera of Yandangshan is a representative Mesozoic eroded volcano and is a typical type of rhyolite landform landscape.

Rhyolitic Rock Rhyolitic rocks are volcanic rocks that have the same bulk-rock composition as rhyolite. They include lava and volcaniclastic rocks, such as rhyolite, rhyolitic tuff and rhyolitic ignimbrite.

Rhyolitic Structure A rhyolitic structure is a flow structure in volcanic rock that is represented by oriented or elongated pores of different colours or different bands, stripes, or minerals. A typical example is the rhyolitic structure in the Dalongshu scenic area in the Yandangshan Geopark, Zhejiang Province (Fig. 9).

Ridge A ridge usually runs in a consistent direction with steep cliffs on both sides and defines the boundary of the watershed of a long mountain range.

Riegel Landscape ► Cross Wall Landscape

Rift Lake A rift lake is a type of tectonic lake that forms when a basin caused by fault subsidence is filled with water. It is characterised by a simple elongated shape and straight shorelines, steep slopes, great depth and a regular distribution pattern. Examples in China include Dianchi Lake and Erhai Lake in Yunnan Province, Qionghai Lake in Sichuan Province, Hulun Lake in Inner Mongolia and Qinghai Lake in Qinghai Province. The lake system in

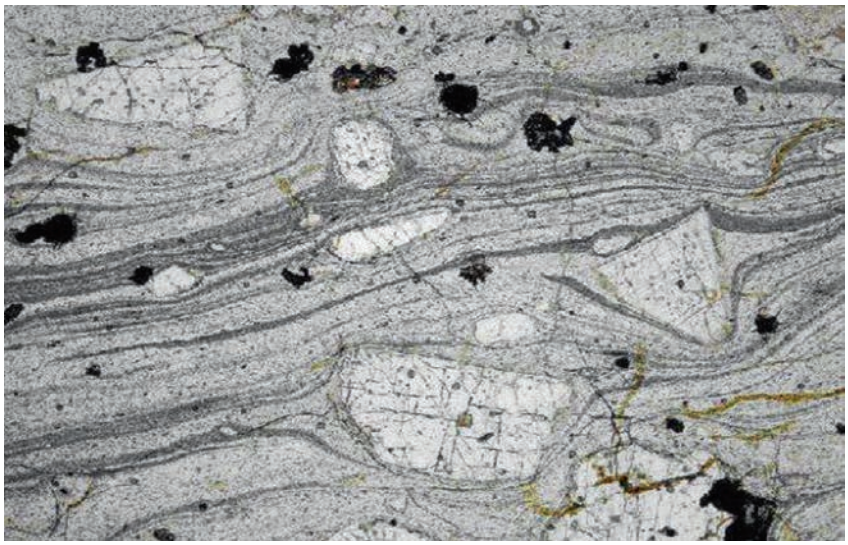


Fig. 9 Rhyolitic structure

the Great Rift Valley (including Lake Tanganyika) in East Africa is a world-renowned rift lake system (Fig. 10).

Rift Valley A rift valley is related to plate tectonics, and the term refers to an extensive belt-like structure in the lithosphere with high-angle normal faults forming boundaries on both sides. Rift valleys are formed by extensional tectonics, which causes the lithosphere to rupture and become thinner. Rift valleys are the initial stage of continental disintegration and oceanic basin formation. Based on their activity, rift valleys can be classified into active rift valleys (such as the East African Rift Valley) and passive rift valleys (such as the Rhine Rift). Based on the type of crust, rift valleys can also be divided into continental rift valleys (rift valleys with continents on both sides, such as the East African Rift, the Rhine Rift and the Baikal Rift) and oceanic rift valleys (such as the Mid-Atlantic Ridge, the Indian Ocean Ridge and the Mid-Pacific Oceanic Ridge).

Rime Landscape This landscape, also known as a 'tree hanger', is a white or milky opaque ice layer attached to the windward side of an object on the ground (such as tree branches or electric wires). It is a product of the constant accumulation of unfrozen foggy water droplets that have a temperature below zero and are blown onto tree branches and other objects. Rime is a common natural phenomenon in northern China, and it is also a splendid scenery of ice and snow. The Songhua River is a famous site with this landscape (Fig. 11).

Rimstone Dam Landscape Rimstone dams form when a rimstone reaches a height of 1 m or more. They get their name because they look like dams. These features form a rimstone dam landscape, which is a landform created by the flow of water on the cave bottom. When over-saturated calcium carbonate solution flows over the undulating cave bottom and reaches a high spot on the ground, carbon dioxide is released, and calcium carbonate precipitates to form a rimstone. Over time, a series of curved terracing pools forms. These pools are called travertine pools, and they look like terrace fields when viewed from a distance. These pools were once called 'Fairy Fields', 'Dragon Fields' or 'Stone Fields'. They are currently called stone terraces. The Huanglong Cave in Zhangjiajie has an area of stone terraces covering approximately 10,000 m^2, which has become a key sightseeing attraction (Fig. 12).

Rimstone Landscape A rimstone is a deposit that builds up at the edge of a small karst pool. It forms from the deposition of calcium carbonate along the pool edge when the water at the cave bottom flows through a small pool. Its existence indicates the location where pool water gathers.



Fig. 10 Legendary horse anchor post of Genghis Khan in Hulun Lake



Fig. 11 Rime landscape

Ring Reef Landscape ▶ Atoll Landscape

Rio Abiseo National Park, Peru This park is located along the border between La Libertad Province and San Martin Province in central Peru. The core protection area covers 2,745 km^2. The government established the Abisio River National Park in 1983 to protect the unique rainforest plant and animal resources in the Andean mountain region. The park's flora and fauna include numerous native species. The yellow-tailed monkey, which was once considered extinct, can only be found in this park.

Río Plátano Biosphere Reserve, Honduras Río Plátano Biosphere Reserve is located along the Caribbean coast along the border of Gracias a Dios and Cologne in northeastern Honduras, and it covers an area of 5,000 km^2. The Plátano River flows past the reserve, which has allowed it to become one of the few remaining tropical rainforests in Central America. It has abundant and varied plants and wildlife. In the



Fig. 12 Rimstone dam landscape – Zhanjiajie Huanglong Cave, Hunan Province

mountainous landscape that slopes down to the Caribbean coast, more than 2,000 indigenous people have preserved their traditional way of life.

Ripple Mark A ripple mark is a regular wave-like trace that forms on the surface of sediments or sedimentary rock. It is a typical sedimentary structure and an important marker to assess the sedimentary environment. Ripple marks usually form on the top of a rock layer and can also appear on the bottom of the overlying strata. Therefore, they can be used to determine the rock sequence. They are wave-like undulating marks caused by the action of waves, currents and wind on the surface of non-viscous sediments. Ripple marks are common in sandstone, siltstone and granular limestone. In plan view, ripple marks consist of a series of parallel or forked wave peaks or troughs, and in cross-section, the peaks and troughs are alternately undulating, and they are oriented perpendicular to the direction of the fluid movement. Based on the dynamics of their formation, ripple marks can be divided into wave marks, water flow marks, interference wave marks and wind wave marks. Further subdivisions can be made according to the form, symmetry, and size.

River Island *Synonym:* ▶ *Sand bar landscape;* ▶ *Heart-shaped sand bar landscape*

A heart-shaped sand bar is a shoal in a riverbed or an underwater shoal that is exposed during the dry season. Its upstream portion is subject to flow erosion, while its lower part or tail is subject to deposition. As a result, the bar gradually moves downstream. When it grows to a large size, it is called a river island.

River Island Landscape When a heart-shaped sand bar in a river becomes tall, lateral erosion on both sides of it can become more intense, causing the bar to permanently stand above the water surface, even during the flood period. Juzi (Tangerine) Island in the Xiangjiang River in Changsha and Chongming Island in the Yangtze estuary are typical examples of river islands. The Shanghai Chongming Island National Geopark was established on the basis of a river island (Fig. 13).

River or Stream Terrace Landscape This is a landscape comprising terraces higher than the flood level along the river banks. These terraces are formed by the deposition and erosion of the river. Based on the mode of formation and the composition and structure of the terrace, these landforms can be divided into eroded terraces, depositional terraces, base terraces, buried terraces, upper stacked terraces and internal stacked terraces. River terraces are an indicator of the river's development history. The longitudinal variation in height of terraces



Fig. 13 Landscape of Juzizhou, Changsha

of similar ages can also be used to analyse the pattern of tectonic activity.

River Trail Lake Tourism Landscape This is a landscape of a lake that is formed by the modification of a river course, such as an oxbow lake which is formed by cutting off a meander. Xuanwu Lake and Mochou Lake in Nanjing, East Lake in Wuhan, and Honghu Lake and Hongze Lake on the Jianghan Plain are all oxbow lakes.

Riverbed A riverbed is a channel with a river at the bottom of a valley. During the normal flow period, river water is contained in and flows along the riverbed. However, during a flood, the river overflows the riverbed and flows onto the floodplain. The riverbed can bend subject to lateral erosion; hence, it continually changes its course. Common landscape features in a riverbed are potholes (deep pools), deep rock grooves, thresholds, cascades (waterfalls), shoals, channel sand bars and river islands.

Rocca Di Cerere Geopark, Italy This geopark is located in central Sicily, Italy, and covers an area of 1,298 km^2. It became a European geopark in 2001. It is a rich environment, and the largest part is the 'gypsum-sulphur' plateau. The plateau was formed by the Messinian crisis, when the Mediterranean Sea began to recede approximately seven million years ago. Chemical sedimentation formed a large deposit consisting of several types of salts, of which gypsum is the most important. The Erei Hills are composed of a flyschioid formation, and the morphology was sculpted by erosion into steps with large amounts of 'Marne' (clay) and chalk found in the Trubi Formation that are sometimes covered by calcarenitic plateaus with cuestas that are commonly collapsed on their sides. Since ancient times, miners have searched the area for sulphur minerals. Farmers, shepherds, miners, warriors, paupers, kings, women and men all lived here.

Roche Moutonnee Landscape, Saracen Stone Landscape This is also known as a goat's forehead landscape. A roche moutonnee is a



Fig. 14 Roche moutonnee landscape. (After Siguang Li)

product of glacial abrasion and plucking, which causes the moulding of hard homogeneous rocks that project above the general level and appear as a goat's back or forehead. A roche moutonnee is oval in map view, and the long axis is parallel to the direction of glacial movement. The slopes on the two sides are not symmetrical; the upstream side is gentle with a polished surface, but the downstream side is steeper and rougher with fractured rocks. The shape of a roche moutonnee is indicative of the glacier's movement direction (Fig. 14).

Rock A rock is a solid aggregate composed of one or more minerals, including volcanic glass, biological remains, and colloids. The materials that make up rock mainly come from the Earth's crust and mantle. Rocks can be divided into igneous rocks, sedimentary rocks and metamorphic rocks. These three types of rocks form landscapes with different characteristics, and many scenic spots in China contain representative rock types.

Rock Avalanche Landscape ▶ Rockfall Landscape

Rock Block Field Landscape ▶ Block Sea Landscape

Rock Cave-Type Granite Landscape – Fu'an Type On a granite surface, especially when it lies on a valley floor, many rock caves can form in the direction of the stream flow. On a horizontal plane, most of these caves or holes are circular. On a vertical plane, they generally have a round barrel or irregular shape. The diameter ranges from a dozen centimetres to more than 10 m, and they are approximately 2 m deep but can reach a depth of 10 m or more below waterfalls or along the lower part of rapids. This type of cave is a unique type of depression that is carved by pebbles and sand caught in flowing water, which then wash and grind the surface at weak points (geodes or dark mineral clusters) in the rock. This process can be observed in valleys of granite or other rock types. The rock cave-type granite landscape has become the landscape theme of Fu'an National Geological Park in Fujian Province (Fig. 15).

Rock Crystal Rock crystals are transparent quartz crystals with the composition SiO_2. Based on the characteristics and industrial usage, they can be categorized as piezoelectric rock crystals, optical rock crystals, smelting rock crystals and craft rock crystals. Craft crystals include all types of coloured quartz that can be used as handicraft materials. Rock crystals generally form in hydrothermal geodes (Fig. 16). As a gem, a rock crystal is a quartz



Fig. 15 Granite rock cave, Bai Yun (White Cloud) Mountain, Fu'an, Fujian Province

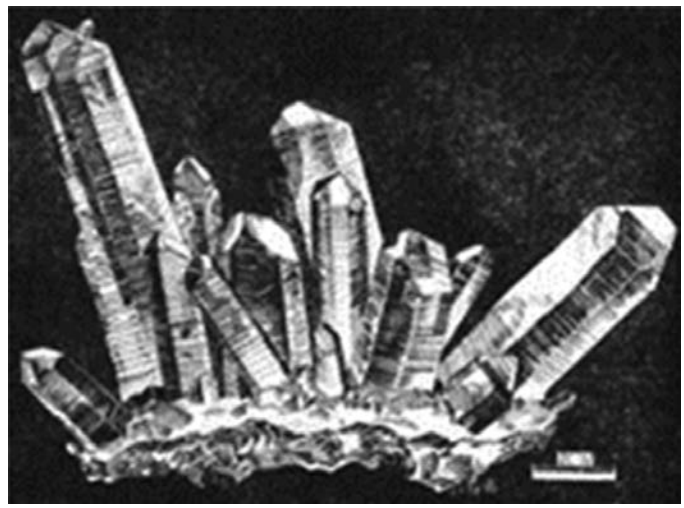


Fig. 16 Rock crystal

crystal with high transparency and a perfect crystal shape. Rock crystals belong to the large quartz family and have a phanerocrystalline texture. Its main component is silica, and it may contain trace impurities of iron, manganese, magnesium, aluminium and titanium. Based on its colour, inclusions and nature, rock crystals can be categorised as amethyst, yellow quartz, smoky quartz, rose quartz, black crystals, hair quartz, agate, starlight crystals, cat's eye quartz and sand crystals. Rock crystals are mainly found in quartz veins and cavities in granite pegmatite. They can be found in alluvial placer deposits after weathering. Famous rock crystal mining areas in China are the East China Sea in Shandong Province and on Hainan Island (Fig. 17).

Rock Cycle The rock cycle refers to the relationships between igneous, sedimentary and metamorphic rocks and their processes of transformation. Hot magma cools to form



Fig. 17 Rock crystal

igneous rocks, and igneous rocks at the surface are subject to weathering and erosion to form rock fragments. Water and wind carry the debris into rivers, lakes and oceans, where they are deposited to form sedimentary rocks. Igneous and sedimentary rocks are transformed into metamorphic rocks by pressure, heat and fluid effects in the Earth's crust. Metamorphic rocks exposed at the surface are worn into debris and transported to form new sedimentary rocks. Sedimentary and metamorphic rocks are melted due to heat, stress and fluid effects to form magma, and the magma cools into igneous rocks. This rock cycle is a continuous process, and the concept of the rock cycle is important for understanding the formation of landforms and landscapes.

Rock Fragment ► Lithic Fragment

Rock Glacier Landscape This is a landscape composed of extensive glacial moraines. Rock glaciers are dozens to hundreds of metres long and wide, and the cross-sectional profile shows a raised form. They are formed by moraine transportation or by sliding of rocks on a slope due to freezing and thawing. The steeper the front slope is, the more active the rock glacier is (Fig. 18).

Rock Islands Southern Lagoon, Palau This site is located in Palau, a western Pacific island nation, and has a protected area of 1,002 km^2, including 445 uninhabited limestone islands formed due to volcanic activity. The blue lagoon is surrounded by coral reefs, and many islands have a unique mushroom-like landscape. More than 385 species of coral and different types of biological habitats form the complex coral reef systems, which add to the aesthetic value of the heritage site. It also has a rich variety of vegetation, birds and marine life, including dugongs and at least 13 kinds of sharks. The listed heritage site protects the most concentrated seawater lakes in the world. They are independent seawater bodies that had been formed when they were cut off from the ocean by the land. This unique island group is conducive to maintaining the intrinsic mix of native species, and new species will likely be discovered in the future.

Rock Landform Tourism Landscape This is a geomorphological landscape with aesthetic and tourism value that is made up of different rock types. Distinctive geomorphological tourism landscapes can form in certain rock formations due to tectonic processes and erosion. These landscapes include (1) geomorphological landscapes composed of mesas, pillars, tower-shaped peaks, and canyons with approximately horizontal sedimentary rock layers subjected to prolonged erosion, such as the Danxia landscape, which is made up of



Fig. 18 Rock glacier landscape in the northern Shaluli Mountains, western Sichuan

Cretaceous red sandstone layers, the Gu-like (butte) landscape, which is made up of thick limestone and marl, the peak forest, peak bundle, and stone forest landscapes, and the Baishishan tower-shaped peak and deep depression landscapes, which are composed of dolomite with flint; (2) cuesta landscapes made up of eroded dipping sedimentary rock layers; (3) granite landscapes, such as Huangshan, Huashan, Sanqingshan and Laoshan Mountains, which are made up of eroded granite; and (4) volcanic rock landscapes, such as Changbaishan in Jilin Province, Wudalianchi in Heilongjiang Province, Devil's Tower (columnar basalt) in the USA, and Yandangshan in Zhejiang Province, which are made up of eroded extrusive volcanic rocks.

Rock Painting The term rock painting refers to coloured paintings, line engravings and embossed art created inside rock caves and on cliff walls and isolated rock bodies. It is regarded as a distinctive type of stone carving with unsophisticated and natural methods and stone tools used by ancient humans to record their modes of production, living, desires and imagination during the early development of human society. Rock paintings are widespread on all continents and more than 150 countries around the world, but the most abundant paintings have been discovered in Europe, Africa, and India and China in Asia. The rock paintings in China can be divided into northern and southern paintings. The northern paintings are mostly engravings, while the southern paintings were generally painted with red paints made of haematite powder mixed with ox blood. Rock painting is a cultural phenomenon of early human society, and the images in rock paintings constitute an early literature record of ancient humans prior to the invention of words. A typical example is the Youjiang rock painting in Guangxi Province (Fig. 19).

Rock Spine Landscape This is a unique type of biokarst landscape. Rock spines form on cave walls under the dim light near the cave mouth. They are needle-like erosional residual substances in parallel clusters. Their tops are sharp, but their bases are relatively thick, and the sharp tops point towards the light. Rock spines are generally a few centimetres long, whereas the longest can reach 15 cm, and their diameter ranges between 0.3 and 1.5 cm. Their forms are related to the biological dissolution of calcium carbonate by blue-green algae and red algae; hence, rock spines are a unique form resulting from biological



Fig. 19 Rock painting in Mandela Mountain, Alxa

karst effects. They point in the same direction because of the phototactic property of the algae's growth. The individual algae that form the rock spine is tiny and can only be observed for detailed study via electron microscopy (Fig. 20).

Rockfall Landscape *Synonym:* ►*Rock avalanche landscape*
This is a geomorphic landscape that forms by the collapse of a rock mass in a piedmont (or valley) due to gravity. Rockfalls occur extensively in hard rock masses, especially carbonate rocks, clastic rocks and metamorphic rocks with structural fragmentation or weak layers. In addition to natural rockfalls, some rock avalanches are caused by human activities along railways, roads and open cast mines. The fallen rock that accumulates at the slope edge is called a talus cone. Rock avalanches are very damaging; they can destroy buildings, block traffic and cause serious casualties and property losses.

Rock-Forming Mineral The main rock-forming minerals are silicates and carbonates. Based on the content, minerals in igneous rocks can be categorized as primary, secondary and accessory minerals. In sedimentary rocks, the common minerals are quartz, feldspar and calcite. Metamorphic rocks are mainly composed of metamorphic minerals.

Rocky Coast A rocky coast is a coast composed of hard rocks. It is a natural extension of mountainous hills to the sea. Rocky coasts can have steep shores and rocky cliffs, which are usually related to faulting and are often accompanied by capes, headlands and bays. Many of China's coastal resorts are located at the bases of rocky coasts, such as Dalian, Qinhuangdao, Qingdao, Lianyungang, Xiamen and Sanya.

Rocky Desert Landscape There are two kinds of rocky deserts: (1) mountain deserts, which are mountainous desert areas with bare rocks, sparse vegetation, desolate scenery, and depressions without water that are covered by clastic rocks; and (2) stone deserts, which are landforms with bare exposed rocks left behind after the sand is blown away due to wind erosion and physical weathering. Deserts cover large areas of the world, and many are found in North America and northwestern China (Fig. 21).

Rokua Geopark, Finland This geopark is located near the Arctic Circle and contains a wide variety of glacial landforms. It covers an area of 1,326 km^2 and became a global geopark in 2010. The park consists of the Oulujoki Canyon Park, the Loko Serpentine Hill Park and the Lake Oulujärvi Park. Glacial landforms are widely distributed in Loko

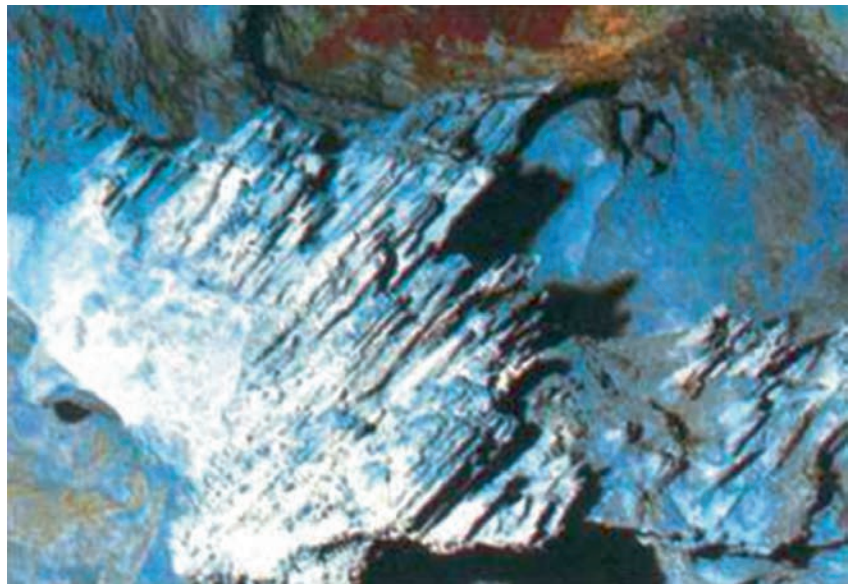


Fig. 20 Rock spine landscape – Luotian Dayan east cave, Guilin



Fig. 21 Rocky desert landscape – Inner Mongolia. (After Dong Zhibao)

Serpentine Hill Park. Lakes and potholes are also abundant, and the country's deepest potholes are located here. The Loqaul National Park has large pine forests. Oulujoki Canyon is a national-level landscape area that is located in the north-south plant transition zone and contains rich vegetation types. Lake Oulujärvi is one of Finland's largest open lakes. The lake and blue sky form stunning scenery.

Ropy Lava Landscape ▶ Pahoehoe

Rose Quartz Rose quartz is a pale pink to deep rose-pink massive quartz crystal. It is transparent to translucent and commonly has milk drop-like gaseous inclusions, giving the crystal a milky transparency. There are sometimes parallel needle-like inclusions, and polishing the crystal surface along the parallel inclusions results in a starlight or cat's eye effect (Fig. 22).

Rosy Cloud Landscape This is a luminous phenomenon created by changes in sunlight

passing through clouds at sunrise and sunset. The natural beauty of rosy clouds with the surrounding landscape creates perfect tourist scenery.

Round Peak and Long Ridge-Type Granite Landscape – Hengshan Type This is a granite landscape characterised by slender ridges with bald peaks. The orientation of the regional tectonics controls the orientation of the ridges, whereas vertical fissures perpendicular to the ridge control the existence of the round bald peaks. Extensive structural fissures, a warm, hot and rainy climate, and intense chemical weathering and erosion by water are important factors in forming this landscape. Through these geological processes, the Hengshan granite has been transformed into elongated mountain ridges with bird head-shaped bald peaks along them. This landscape is unique in the Five Mountains. 'Flying Hengshan' is an appropriate description of this landscape, which is also called 'granite landscape – Hengshan type' (Fig. 23).



Fig. 22 Rose quartz

Ruby Ruby is red corundum. Its chemical composition is aluminium sesquioxide (Al_2O_3). Its red or pink colour stems from the trace element chromium (Cr^{3+}). Rubies with a high degree of transparency and a blood red colour, especially the so-called 'pigeon blood red' type, are considered the most valuable and are sometimes more expensive than a diamond of similar size. Rubies form in some magmatic rocks and metamorphic rocks and are also found in the gravel layers of rivers. The main production areas include Myanmar, Sri Lanka, Thailand and Australia. Rubies are also mined in Fujian, Hainan and Taiwan Provinces in China (Fig. 24).

Ruins of Ancient Quarries of Volcanic Rocks Some volcanic rocks are good building materials. Volcanic rocks were mined in ancient China, and several relics have remained. These quarry ruins can be exposed or underground. There is an ancient quarry cave group in the Changyu Stone Cave in Wenling, Zhejiang Province. This ruin is large and is now included as a part of the Yangdangshan Global Geopark. It is also a national mining park (Fig. 25).

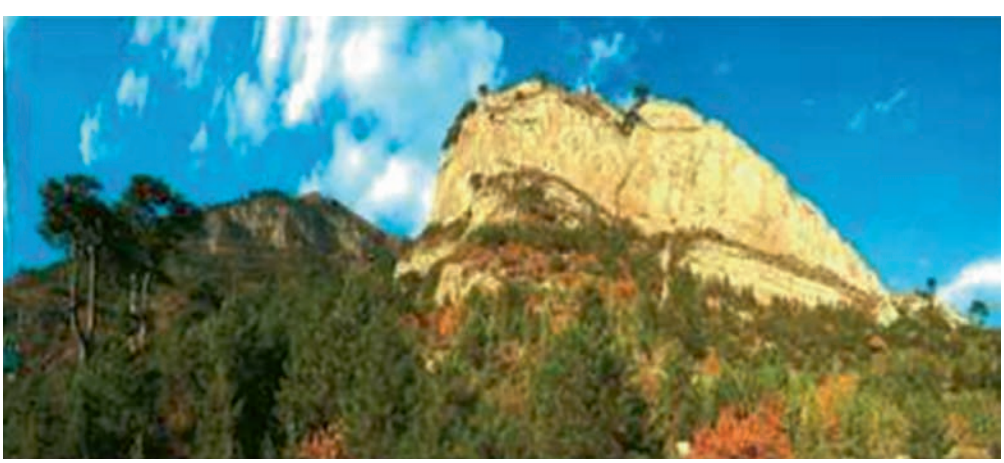


Fig. 23 Granite landscape –Hengshan type

Ruins of Pompeii City The eruption of Vesuvius in 79 A.D. created six pyroclastic flows. It was the largest eruption in its history. The scorching volcanic debris and falling volcanic ash quickly buried the city of Pompeii, which was populated by 20,000 inhabitants. The buried relics of this city were not discovered until 1680, and the volcanic ash preserved scenes of the people killed and their lives. The ash and debris also caused serious damage to the nearby coastal cities of Herculaneum and Stambia (Figs. 26 and 27).

Rule of Territorial Differentiation Geographical differentiation is a universal rule of geography that forms the foundation for explaining the diversity and order of natural landscapes. It includes latitudinal zonality and non-latitudinal zonality. Zonal differences are induced because solar radiation is unevenly distributed on the surface, which leads to natural variations from south to north. Non-latitudinal differences refer to the land-sea distribution, topography, and tectonic factors caused by the internal energy of the Earth. The disparities caused by these influences include the differences in dryness and humidity caused by the distance from the ocean and the vertical differentiation due to topography. The differences in landscapes within a tourist area are also a reflection of this concept.

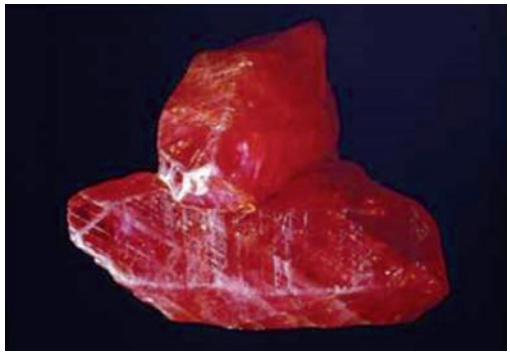


Fig. 24 Twin crystals of ruby

Rural Geography Rural geography is the study of the formation, structure, function, development and evolution of rural areas and their spatial distribution. It explores the patterns of development of different economic, social, demographic, settlement, cultural resources and their usage in rural areas. It involves the spatial changes in environmental issues and is a branch of human geography. Rural geography is an important foundation for rural tourism research.

Rural Landscape Rural landscape is the most basic unit of the rural territorial complex. It refers to a unified and coordinated complex in rural areas with a consistent natural geographical basis, in which the utilization and human impacts are similar, the structures and functions are similar or interrelated, and the



Fig. 25 Quarry landscape in Zhangyu Dongtian



Fig. 26 Figures of humans that died during the volcanic eruption (plaster moulds)



Fig. 27 Mt. Vesuvius behind the remains of Pompeii

elements are interconnected and mutually restricted. It is a comprehensive representation of several parameters, such as the economy, culture, society and nature, in rural areas. Since rural areas are mainly occupied by people engaged in agricultural production, which is characterized by the interweaving of economic and natural reproduction, rural landscapes experience an ongoing transition from natural landscapes to cultural landscapes. Based on this, a rural landscape can be considered a human landscape (or cultural landscape) with some of the characteristics of a natural landscape.

Rural Tourism Rural tourism is a form of tourism that uses rural nature, pastoral scenery, rural folk culture, agriculture, group culture, and residential culture as tourist attractions. China's modern rural tourism began with the Shenzhen Lichee Festival in the late 1980s. In the early 1990s, rural tourism was rapidly promoted throughout China as a form of poverty alleviation and structural adjustment of the agricultural industry, led by the successful demonstration of the Peach Blossom Festival in Chengdu's suburban Longquanyishufang Village.

Rutile The composition of rutile is TiO_2. It contains 60% titanium and often also

contains iron, niobium and tantalum. Rutile, brookite, and anatase are the three mineral forms of titanium dioxide. The crystals are prismatic and striated, and they sometimes appear as fine acicular crystals inside quartz. Twinning is common, and it sometimes appears as blocky aggregates. It can be reddish brown, red, yellow or black with light brown to light yellow streaks. It has transparent to opaque diaphaneity, a sub-metallic to adamantine lustre, a specific gravity of 4.23, a Mohs scale hardness of 6.0–6.5 and conchoidal to uneven fractures. It exists as a secondary mineral in many magmatic rocks, schist and gneiss. It sometimes appears as acicular inclusions in quartz, corundum and other transparent minerals.

Ruyang Dinosaur Geopark, Henan This geopark is located in western Ruyang County, Henan Province. It covers an area of 122 km^2, and most of the geological features are concentrated in an area of 50 km^2. It became a national geopark in 2011. They key attractions of the geopark are its dinosaur fossils, granite landforms and stratigraphy. The geopark has a complete stratigraphy and a complex structure. The dinosaur fossils are characterised by their age, large size and new genus. They include important dinosaur bone fossils with scientific significance for studying the distribution, classification, migration, evolution and extinction of the Cretaceous Sauropoda in China and Asia as well as for studying the geographic extents of ancient animals. The discovery of the Ruyang Ankylosaurus fossils was important for studying the classification of Ankylosaurus and added a new specimen of China's Ankylosaurus fossils, and it extended its geographical distribution southward. In addition, the Ruyang cross-sections of the mid-Neoproterozoic strata in the park represent the stratigraphic sections of the North China Platform. The granite landforms of West Tai Mountain have high aesthetic and tourism values.

Rwenzori Mountains National Park, Uganda This park is located in the Rwenzori Mountains in southwestern Uganda near the border with the Democratic Republic of the Congo. It has a core protection area of 996 km^2. The park occupies the main part of the Rwenzori Mountains, including the third highest peak in Africa (Margarita Peak, 5,109 m above sea level). Glaciers, waterfalls and lakes have made the site one of the most beautiful high-mountain scenic areas. The park provides a diverse home for endangered species and contains rich and unusual plant landscapes. In particular, it is famous for the giant Photinia serratifolia.

S

Sagarmatha National Park, Nepal Sagarmatha National Park is located in eastern Nepal near the Tibet region of China. It has a core protection area of 1,148 km^2. It is an unusual natural area with dramatic mountains, glaciers and deep valleys. Mount Everest is the icon of the park and is the highest mountain in the world.

Sai Kung Rhyolitic Rock Columns Landscape, Hong Kong A reactivated Mesozoic caldera is located in Sai Kung, Hong Kong, the central part of which contains a large area of exposed rhyolitic columnar joints, which form a landscape of stone columns. It is characterised by an extensive distribution of regular and large columns. Many small islands are composed of this type of column, with features such as sea caves, sea arches and a columnar one-line sky over the sea. Many columns on these islands have sunk into the sea to become submerged columns. The features are so amazing that Hong Kong has preserved this spectacular landform. In 2009, it was designated as a national geopark, and it became a global geopark in 2011 (Fig. 1).

Saline Lake A saline lake is also known as a mineral lake or mineralised lake. The water has a salinity over 35 g/l or over 24.7 g/L. The lake water has a high chloride content and is highly mineralised, so its hardness is greater than that of a freshwater lake. Saline lakes are sometimes called salt lakes. Saline lakes in China are generally the moderately trophic or low trophic types. In most lakes, the salinity continues to increase over time. These lakes have two main causes of formation: (1) they are relics of an ancient ocean; or (2) they are at the ends of inland rivers. China's saline lakes are mainly located in the western region. This region contains more saline lakes than freshwater lakes, and they account for approximately 55% of the total lake surface area. The Jilantai Saline Pool in Inner Mongolia and the Chake Saline Lake in Qinghai Province are typical examples (Fig. 2).

Saline Lake Landscape This is a type of lake landscape. In a broad sense, a salt lake is equivalent to a saline lake. In a narrower sense, a salt lake refers only to a chloride lake. In general, the term salt lake refers to a saline lake (i.e., a lake with a salinity over 35 g/L). Salt lakes are mature lakes that are rich in various minerals, so they are important mineral resources. Based on the chemical composition of the lake water, salt lakes can be classified as carbonate lakes, sulphate lakes and chloride lakes. Based on the salt sediments, salt lakes can be divided into rock salt lakes, mirabilite lakes, alkali lakes, borate salt lakes and potassium-magnesium salt lakes. According to the state of the brine, salt lakes can be categorised into brine lakes, dry salt lakes and undersand lakes. Based on their origin, salt lakes can be divided into marine source salt lakes, terrestrial source salt lakes and mixed source salt lakes. China has the most abundant salt lakes in the world, and nearly all are located in the vast inland areas. Thousands of salt lakes extend from Jilin Province in the northeast, west through Inner Mongolia, Ningxia, Gansu, Qinghai and Xinjiang Provinces to Tibet. The Qinghai-Tibet Plateau is known as the 'Home of Salt Lakes' and contains several hundred salt lakes, such as Lake Duogecuoren (Doke Tsoring) in Tibet, which has an elevation of 4,814 m and is the highest salt lake in the world, and Lake Aiding in Xinjiang Province, which has an elevation of 154 m below sea level and is the lowest salt lake in China (Fig. 3).

Salonga National Park, Congo Salonga National Park is located in the borderland of four provinces, namely, Kasai-Oriental, Kasai-Occidental, Bandundu and Equateur, in the west-central part of the Republic of the Congo. It consists of a north park and south park and covers an area of 36,000 km^2. The park is Africa's largest tropical rainforest reserve. Situated at the heart of the central

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Fig. 1 Rhyolitic stone column landscape in Sai Kung, Hong Kong



Fig. 2 Salt lake landscape in Jilantai

basin of the Congo River, the park is isolated and accessible only by water. It is the natural habitat of many endemic endangered species, such as the dwarf chimpanzee, the Congo peacock, the forest elephant and the African slender-snouted or 'false' crocodile.

Salt Desert Landscape A salt desert is also known as a salt marsh mud desert. It is a landscape where the surface is covered with salt and saline soil. In arid areas covered by large amounts of salt, saline groundwater rises to the surface along capillary pores. The water evaporates rapidly, and the salts accumulate on the surface, forming a salt desert. Salt deserts also form when salt lakes dry to expose the bottom. Only a few salt-tolerant plants can grow in salt deserts, which are barren areas with poor soil. There are large areas of salt



Fig. 3 Geermu salt lake landscape, Qinghai Province

deserts in the central Qaidam Basin, Qinghai Province (Fig. 4).

Salt Marsh Landscape ▶ Marsh Landscape

San'in Kaigan Geopark, Japan This geopark is located in the San'in area of Japan and has an area of 87 km^2. It became a global geopark in 2010. The geopark is centred on the San'in Coast National Park. The ancient Japanese archipelago is part of the Asian continent, and visitors can observe ancient and modern coastal history. The magnificent natural scenery and beautiful coastline are also great attractions. Other attractions include Tango Shaqiu, the Bintuo Coast, Xuanwudong Park, the Danmao Coast, and the Tottori Sand Dunes and Hot Springs.

Sand Sand is a medium-grained clastic material that has been eroded by mechanical weathering of exposed surface rocks. Sand has an average particle size of 0.0625–2 mm. Sand is widely distributed in Quaternary sediments and modern rivers, lakes and deserts, and its main components are quartz, feldspar and mica. Sand has good water permeability and serves as good groundwater storage layers.

Sand Bar Landscape ▶ River Island

Sand Bar Landscape, Shoal Landscape This is a landscape composed of shoals exposed above the water surface in rivers, lakes and shores. It is a general term that includes heart-shaped bars and river islands in rivers and the sandy bars that form along the shores of lakes or the ocean. It is a typical fluvial and lacustrine depositional landform.

Sand Desert A sand desert is covered with large amounts of quicksand and different types of sand dunes. Sand deserts are the most extensive landforms and landscapes in desert areas. China contains approximately 637,000 km^2 of desert, which mainly includes the Taklamakan Desert, Gurbantonggut Desert, Badan Jaran Desert, Tengger Desert, and Mu Us Sandy Land (Fig. 5).

Sand Desert Landscape This is a kind of desert landscape that is mainly composed of sand dunes and dune ridges. China's deserts are located in Xinjiang, Gansu, Shaanxi, Inner Mongolia and Qinghai Provinces, and they cover a total area of 1,282,000 km^2, which accounts for 13.4% of the total area of the



Fig. 4 Salt desert landscape – Lop Nur, Xinjiang Province. (After Dong Zhibao)



Fig. 5 Desert landscape

country. The main deserts are the Taklimakan Desert and Kumtag Desert in the Tarim Basin and the Gurbantunggut Desert in the Junggar Basin in Xinjiang Province; the Badain Jaran Desert in western Inner Mongolia; the Mu Us Desert on the Ordos Plateau between Inner Mongolia and Shaanxi Province; and the Tengger Desert in the Helan Mountains (Fig. 6).

Sand Landscape This is a collective term for geomorphic landscapes formed by the accumulation of sand grains, rock fragments and wind-eroded gravels. In arid areas, wind erosion can form large landforms, such as deserts, hamadas, rocky deserts, gobi and salt deserts, and various small and medium-sized features, such as sand dunes, dune ridges, and sand chains. In coastal regions, sand beaches can



Fig. 6 Desert landscape – Kumtag Desert, Xinjiang Province. (After Dong Zhibao)

form, and small sand dunes can sometimes be found on the beach. Sand landscapes contain many interesting natural phenomena, such as sounding sand. Compounded by the extreme inland conditions in desert areas, sand landforms are an important resource for scientific expedition, exploration, tourism and sand therapy (Fig. 7).

Sand Spit Landscape A sand spit landscape consists of narrow sandy embankment-like landforms, the base of which are linked to the coast. The ends project into the ocean or lake through marine deposition. These features commonly form in bays, straits, estuaries and protruded coasts through the lateral transportation of sand and mud. The front bends slightly inland, and the seaward slope is steeper than the landward slope. During its formation, if the direction of the waves or the longshore drift changes, a sand spit often forms on the inner side. Sand spits in river estuaries tend to move constantly due to the occurrence of dry and flood periods. Sand spits have various forms due to the effects of different sources of materials, different wave dimensions and changes in wave directions. Common sand spit forms include arrowhead spits, wing-like spits and sickle-shaped spits (Fig. 8).

Sand-Blowing *Synonym:* ► *Dust-floating weather* The wind blows sand and dust to heights above the horizontal line of sight, which significantly reduces the horizontal visibility. Smaller dust particles are suspended in the air and cause horizontal visibilities of less than 10 km. Droughts, deforestation, overgrazing, land desertification, construction, overdevelopment and other human activities are the causes of sand-blowing and dust-floating weather, which cause poor air quality and are hazardous to health.

Sandstone Sandstone is a clastic rock in which grains ranging in size from 0.0625 to 2 mm and accounts for more than 50% of the clastic material. Sandstone has a stable structure, and it is usually pale brown or red. It is mainly composed of clastic matters and filling materials. The clastic matter is from land-based sources, and it mainly consists of quartz and feldspar, which account for more than 50%, followed by lithic fragments, muscovite, chlorite and heavy minerals. The filling material



Fig. 7 Landscape of wind-accumulated landforms – Taklimakan Desert, Xinjiang Province. (After Dong Zhibao)

Fig. 8 Sand spit landscape



includes cement and clastic matrix, the composition and structure of which reflect the physical and chemical conditions and the geologic environment during the rock-forming process. Sandstone provides important information about the geologic and historical period of its formation. The clastic matter is useful for determining the provenance, the directional structures indicate the flow direction, and the geometry of the sand body reflects the sedimentary environment. Based on the depositional environment, sandstones can be divided into quartz sandstone, feldspar sandstone and lithic sandstone. Sand layers and sandstone strata serve as the main storage layers for oil, gas and groundwater. Most sands and sandstones can be used as grinding agents, raw materials for glass-making and construction materials. Sandstone is also an important landscape forming rock. For

example, the Danxia landscape is composed of sandstone.

Sandstone Honeycomb Cave Group Landscape This type of landscape forms in sandstone landforms. Groups of caves of varying sizes, forms and depths often form on parallel sandstone strata, and this landform is called a sandstone honeycomb cave group landscape. These caves form as a result of differential weathering, fluvial erosion and wind action. They always form in arrays and are interconnected. Small caves are sometimes enclosed inside larger caves, and all of these features constitute spectacular sandstone cave groups. They are common on the red cliffs of the Danxia landform, and they can also be found in the wind-eroded sandstone cliffs in China's northwestern regions, such as the honeycomb cave group on the sandstone cliff along the rivers in Mawu Gorge in Guide County, Qinghai Province.

Sandstone Multi-coloured Dome Landscape This type of landform develops in arid and semi-arid areas. Due to erosion caused by torrential rain and strong wind, Mesozoic multi-coloured sandy conglomerate, mudstone and siltstone knolls form a dome landscape with many colours, such as red, yellow, purple, green and brown. From above, these knolls look like colourful eggs. Their colours are related to the environmental conditions during the sedimentation process. In general, red comes from abundant iron oxide in the rock under hot and arid oxidising conditions, while black comes from sediments under reducing conditions. The multiple colours indicate the complex and changing environment during the sedimentation process. This type of landform can be found in Zhangye in Gansu Province and in Xingjiang Province (Fig. 9).

Sandstorm *Synonym:* ▶ *Dust storm*

Sandstorms are also known as dust storms. Strong winds blow large amounts of dust and dirt into the air, making the air particularly hazy and causing horizontal visibilities of less than 1 km. Sandstorms can be classified according to the horizontal visibility. Strong sandstorms have a horizontal visibility of <500 m, and weak sandstorms have horizontal visibilities of 500–1,000 m. Dust storms mainly occur in the late spring and early summer, causing traffic delays and problems with farming and other human activities. Sandstorms are the main supplier of loess materials in China.

Sangay National Park, Ecuador This park is located on the border between Morona-Santiago Province, Chimborazo Province and Tungurahua Province in southeastern Ecuador, and it has an area of 2,719 km^2. With its outstanding natural beauty and two active volcanoes, the park illustrates a spectrum of ecosystems, ranging from tropical rainforests to glaciers, with striking contrasts between snow-capped peaks and forests in the plains. Its isolation from human settlements has encouraged the survival of indigenous species, such as the mountain tapir and the Andean condor.

Sangha Trinational Site This site is located at the junction of Cameroon, the Republic of the Congo and the Central African Republic in the northwestern Congo Basin. It consists of three adjacent national parks with a total area of 7,500 km^2. Most of the site has not yet been affected by human activities. It is characterised by a rich and diverse wet tropical rainforest ecosystem. There is a wide range of animals and plants, including the Nile crocodile and the giant carnivorous tiger fish. The forests provide a habitat for herbaceous plants. The Sanga River Basin also hosts a large population of forest elephants, extremely endangered western lowland gorillas, and endangered chimpanzees. The environment has largely allowed the continuation of the ecosystems and species evolution processes and has preserved rich biodiversity features, including numerous endangered animal populations.

Sanidine The main composition of sanidine is K $[AlSi_3O_8]$, and it always contains some Na $[AlSi_3O_8]$. Because it forms under high-temperature conditions, it is also called high-temperature sanidine. It crystallizes in the monoclinic crystal system, and crystal twinning is common. It is light white or colourless with white streaks. Its diaphaneity is



Fig. 9 Sandstone multi-coloured dome landscape – Zhangye, Gansu Province

translucent with a vitreous lustre. Its specific gravity is 2.56–2.62, and its Mohs hardness is 6. It usually forms in extrusive rocks such as trachyte and rhyolite and sometimes in contact-metamorphosed rocks.

Sanjiang Source Stone The source of the Yellow River, Changjiang (Yangtze River) and Lancang River (called Sanjiang or Three Rivers) is rich in ornamental stones, which are known as the Sanjiang source stones or stones of the sources of the Three Rivers. Most are metamorphosed sedimentary rocks or volcanic rocks that have been polished by river erosion and abrasion. These rocks are mainly composed of silica and often contain iron, aluminium, manganese and other impurities. The main characteristics are (1) many varieties, such as Heyuan (River Source) stone, Huangshui picture stone, Sondo stone and Danma colour stone (Kunlun stone); (2) rich colours, mostly including black but also red, yellow, ochre and green; (3) peculiar shapes and spirit, with either the appearance of a winding mountain range or the landscape of a town along the water; and (4) a spiritual mood empowered by natural mystery. New types are often discovered (Fig. 10).

Sanqingshan Global Geopark, China *Synonyms:* ▶ *Sanqingshan National Geopark, Jiangxi*

This geopark is located in Shangrao City in Jiangxi Province. It has a total area of 229 km^2 and became a global geopark in 2012. The geopark is a masterpiece of earth science and records the evolution and development of the Earth over one billion years. It contains many geological features which are connected to sedimentology, stratigraphy, palaeontology, petrology, geotectonics, geodynamics and geomorphology. It contains valuable geological heritage relics and biological components from more than 200 million years of evolution. In addition to being an ecological paradise, it contains a typical Yanshanian granite body with Yu Jingfeng (1,816 m above sea level) as the main peak. It was named the 'Sanqingshan-style granite peak landscape'. The 'Shuchun Goddess' (spheroidal weathering body) and 'Gigantic Python' (granite pillars) are landmarks of Sanqingshan. It is a natural museum of granite geomorphology and illustrates the harmonious coexistence of man and nature over more than a thousand years. The geopark is a valuable cultural heritage site of the Chinese Taoist 'Heaven and Man Oneness' ideology. It contains exhibits of ancient Chinese architecture. Early poets once praised it as 'Yunxiang (homeland of clouds), Songlang (gallery of pine) and Qishi (wonders of rocks)'. Sanqingshan has inspired



Fig. 10 Sanjiang source stone (abraded conglomerate)

many artists, photographers, and sculptors and is the birthplace of the 'Gan Opera' and 'Light Dance' of Juangxi Province.

Sanqingshan National Geopark, Jiangxi See ▶ Sanqingshan Global Geopark, China.

Sapphire Sapphire is a blue and transparent corundum. Currently, the gemstone trade collectively applies this term to corundum of all colours except ruby. Its chemical composition is aluminium sesquioxide (Al_2O_3), and its blue colour comes from the trace elements titanium (Ti^{4+}) and iron (Fe^{2+}). Its crystal structure is hexagonal scalenohedral or cylindrical, and its Mohs hardness is 9, which is second only to that of diamond. Transparent or translucent sapphires with a bright blue colour rank the best, and hibiscus blue or cornflower blue sapphires are considered top-grade sapphires. The largest cut sapphire, called the Logan Sapphire, weighs 423 carats and is now displayed in the Smithsonian Museum of Natural History in Washington D.C., United States. Sapphires are mainly found in alkaline basalt in the form of xenoliths. They are also found in contact metamorphism zones and become placer deposits after weathering. The main mining areas include India, Myanmar, Sri Lanka, Thailand and Australia. Sapphires are also mined in Shandong, Heilongjiang, Jiangsu and Hainan Provinces in China (Fig. 11).

Saryarka-Steppe and Lakes, Northern Kazakhstan This heritage site is located in northern Kazakhstan, approximately 120 km southwest of the capital of Astana, and covers a core protection area of 4,503 km^2. It consists of two state nature reserves, Naurzum and Korgalzhyn. Saliakar is a wetland of great importance to migratory waterbirds, including globally endangered birds, the extremely rare Siberian White Crane, Dalmatian Pelican, and Athena Osprey. The wetland is an important stopover point and meeting point for birds migrating from Africa, Europe and South Asia to the breeding grounds in western and eastern Siberia. The 2,000 km^2 central Asian savannah in the heritage area contains more than half of the area's grassland plant species, numerous endangered birds and extremely endangered saiga antelope.

Satellite Remote Sensing Based on the differences in the electromagnetic characteristics of different objects, satellites and spacecraft can be used as platforms for sensors to detect the nature and characteristics of ground objects. Remote sensing technology for identifying various types of ground objects is called satellite remote sensing. Satellite remote sensing is characterized by wide sightlines and high repeatability. It can effectively investigate and evaluate the surface conditions and natural resources in tourist areas. It is an important means for tourism planning and tourism resource development and management.

Sauropterygia or Sauropterygians Sauropterygians were aquatic amphibians. They adapted to living in the water and had long necks and strong short limbs. They flourished during the Triassic. Typical examples are the Guizhousaurus, Plesiosaurus and typical marine-type Himalayasaurus and Chaohusaurus.



Fig. 11 Sapphire crystal

Savanna Ecological Landscape A savanna is a tropical or subtropical grassland ecological landscape composed of perennial drought-tolerant grasses mixed with drought-tolerant shrubs and scattered isolated trees. Gramineae dominate the plant community; they are 1–3 m tall and have narrow and erect leaves. The grass dries up but stays in situ for the entire year; hence, the savanna landscape always appears yellowish brown.

Scale of a Geopark Planning Map The scale of a geopark map is dependent on the size of the geopark. Geoparks can be divided into: 1. small geoparks: area up to 20 km^2 and a map scale of 1:5,000 or 1:10,000; 2. medium geoparks: area of 20–100 km^2, map scale of 1:10,000 or 1:25,000; 3. large geoparks: area of 100–500 km^2, map scale of 1:25,000 or 1:50,000; and 4. extra-large geoparks: area >500 km^2, map scale of 1:50,000 or 1:100,000. The map should have a column at the bottom right corner indicating the name of the project, the map, the name of the contractor, the date and, if necessary, the names of the mapping project manager (with signature) and his team.

Scapolite The composition of scapolite is similar to that of plagioclase, but it contains additional anions of Cl^-, $(CO^3)^{2-}$ and $(SO_4)^{2-}$. Scapolite includes calcium-rich meionite and sodium-rich marialite. It has a tetragonal crystal system, the crystals are columnar, and the aggregates are granular and platy. It is colourless, white, grey, light blue, light green, light yellow, light brown, pink or violet in colour. It has transparent to translucent diaphaneity, a vitreous to pearly or resinous lustre, a specific gravity of 2.50–2.78, and a Mohs hardness of 5.5–6. It is common in skarn deposits and forms with garnet and diopside. It also forms in gneiss and amphibolite.

Scenic Area A scenic area is an area that has a sufficient scale, reputation and features for sightseeing or scientific and cultural activities. Currently, China's scenic areas are classified into national and provincial scenic areas and are administered by the relevant departments at various levels.

Scenic Area Regulations These regulations were promulgated in the September 2006 Decree No. 474 of the State Council and enacted in December of the same year. A total of 52 regulations are outlined in several chapters: Chapter I, General Provisions; Chapter II, Establishment; Chapter III, Planning; Chapter IV, Protection; Chapter V, Utilisation and Management; Chapter VI, Legal Liabilities; and Chapter VII, Supplementary Provisions. Scenic areas refer to areas with a beautiful environment and outstanding cultural or scientific values for tourists and scientific research and studies. Newly established scenic areas cannot overlap with nature reserves and shall be properly coordinated to ensure no overlap. These scenic areas must be established in coordination with

nature reserves, scenic planning and nature reserve planning. Natural and cultural landscapes with national representation shall apply for the establishment of a national scenic area, and those with regional representation shall apply for the establishment of provincial-level scenic attractions.

Scenic Byway A scenic byway is a road that has aesthetic scenic, natural, cultural, historical and recreational values and is worth saving and renovating from the perspective of archaeology. It is difficult to provide a clear definition of a scenic byway. In a broad sense, a scenic byway refers to a route with dual functions of transportation and landscape appreciation. In a narrow sense, it refers to various specific forms of scenic routes, including scenic highways (paths), greenways and park roads, scenic roads, heritage corridors, and cultural routes.

Schist Schist is a metamorphic rock with a typical flaky structure. The mineral composition of schist is complex and diverse. It is composed of flaky or columnar minerals (>50%) and granular minerals (30–40%). It is characterized by the alignment of flaky or columnar minerals such as mica, chlorite, hornblende and talc on the same plane. The granular minerals are usually quartz and feldspar, and the feldspar content is generally lower than the quartz content. Common metamorphic minerals include andalusite, garnet, hauynite, staurolite, epidote, cordierite and glaucophane. Schist is a moderately metamorphosed rock that has a higher degree of metamorphism than slate and phyllite, and its granularity is coarser than that of phyllite. It is also characterized by a lepidoblastic or fibroblastic texture (sometimes with a porphyroblastic texture). Based on the main metamorphic minerals, it can be called mica schist, green schist, angular flash schist, or talc schist (Fig. 12).

Schistosity Schistosity is a platy structure that forms during metamorphism as a result of the parallel, even and continuous alignment of platy and columnar mineral constituents on the same plane. Common platy and columnar minerals are mica, hornblende, talc and chlorite. Schistosity is common in moderately metamorphosed rocks. The mineral grains of schistosity are coarser than those of phyllitic foliation, and they are identifiable to the naked eye.

Schlieren During the crystallization of magma, some early crystallized minerals cluster to form sheets or bands in the rock mass. Schlieren are different from xenoliths, and they tend to have unclear margins and a definite directional alignment. The mineral composition (e.g., biotite or hornblende) is often different from that of the country rock.

Science of Tourism Resources This book was written by Wencai Su and Wenchang Sun and was published by Higher Education Press in 1998. The book discusses the meanings, characteristics, objects, contents, and methods of research on tourism resources. It also describes in detail various tourism resources, including geology, geomorphology, water bodies, biology, meteorological climates, celestial phenomena, historical heritage, ancient architecture, ancient mausoleums, cities and towns, religious culture and social customs. The distribution, protection and development planning of tourism resources are also discussed. It is used as a textbook for tourism majors in colleges and universities.

Scientific Explanation Plan This plan provides visitors with information about the geological, ecological and cultural elements and their interactions within the geopark.

Scientific Exploration Tourism Scientific exploration tourism is a type of high-end tourism that focuses on scientific research. It usually refers to themed tourism activities designed and organized for certain people. It is characterized by rich scientific content and the goals of exploring and understanding the natural phenomena in an area and collecting scientific data. In addition to special tours organized for experts in certain fields, there are also themed scientific tours arranged for the public under the guidance of experts. The content includes geology, biology, ecology, meteorology, hydrology, glaciers, volcanoes, and caves.

Scratch ▶ Stria

Fig. 12 Schist

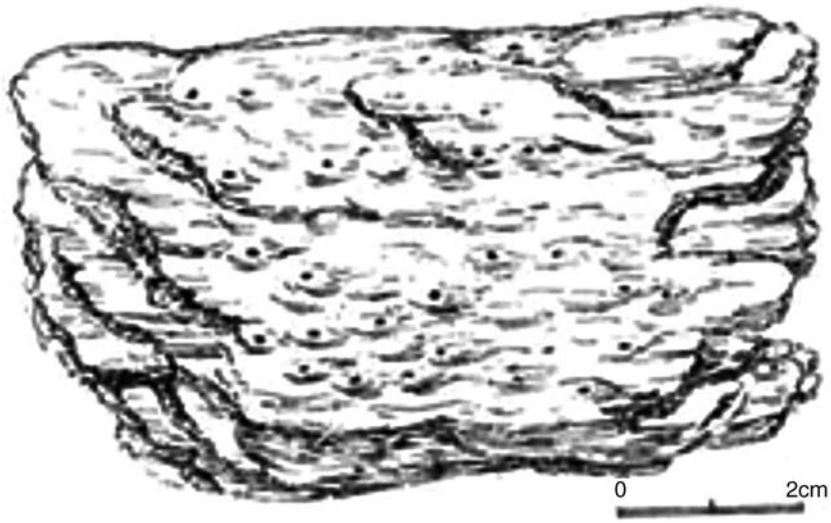




Fig. 13 Screen-like granite peak, Hexigten Banner, Inner Mongolia

Screen-Like Granite Peak These peaks are planar with cross-sections that look like a screen and sides that looks like a pillar. They usually form as a result of rockfalls after weathering along a set of vertical joints (Fig. 13).

Sea Arch Landscape This is a kind of marine erosional landscape in a rocky harbour. It looks like an arched bridge, so it is called a sea arch. Sea arches often form on coastal headlands, where both sides of the headland are subject to intense marine erosion. Sea caves form first and are later eroded to form a sea arch. They are also known as 'sea domes' in Chinese. In northern China, there are many typical sea arches near Jinshajui (Gold Mountain Mouth) in Beidaihe (Fig. 14).

Sea Cave Landscape This is a cave landscape consisting of marine caves that form near sea level and are deeper (towards land) than their width (parallel to the shoreline). Cave formation is controlled by the direction of seawater erosion, the homogeneity of the rock and the joint patterns. Caves are usually located at the base of the sea cliff or wave-cut platform. Sea



Fig. 14 Sea arch landscape in Manjia beach in the Jinzhou area, Dalian City, Liaoning

caves of various heights can be found in the bedrock along the northern coasts of China. They are an important indicator of coastal uplift (Fig. 15).

Sea Chasm Landscape This is a landscape consisting of linear grooves that develop on the inland side near sea level on a wave-cut platform (terrace). The horizontal extent is parallel with the coastline. In a vertical section, it looks like a 'V' lying horizontally and pointing towards land. If sea level changes, it can look like a horizontal rectangle or 'U'. The innermost part of a sea chasm indicates the average sea level, and the ceiling and floor indicate the high and low tides. Sea chasms are not the same as sea caves; their length along the shoreline is much greater than their inland depth, whereas the depth of a sea cave is much greater than its width (Fig. 16).

Sea Level Rise The melting of glaciers and the thermal expansion of the upper seawater are reasons for the rise in sea level. Sea level rise can also be caused by other natural factors, such as vertical crustal movements. The sum of global sea level rise and the vertical movement of the earth's crust accounts for the total change in sea level in an area. The changes are relative. Rising sea level can inundate low-lying coastal areas and erode the coast. It can also increase the intensity and frequency of storm surges, which endanger the life and property of people living in coastal areas and will cause salination of the land.

Sea of Clouds A sea of clouds is an important mountain landscape composed of a unique cloud layer formed under suitable humidity and wind speed conditions. The cloud layer is lower than the peak height, so it looks like a wavy sea with a rolling surface when viewed from the peak. It gets the name sea of clouds from this scenery. Famous locations in China include Huangshan Mountain and Emei Mountain.

Sea Stack Landscape This landscape is composed of isolated columnar or tower-like landforms along a rocky coast. Sea stacks form when a coastal headland or marine terrace is eroded by wave action, and a rock pillar, which is separated from the shore, remains behind in the water and stands on the wave-cut platform. Sea stacks can also form from the collapse of a sea arch due to long-term marine erosion.



Fig. 15 Sea cave landscape in Bijiashan, Jinxian (Linghai City), Liaoning Province



Fig. 16 Sea chasm landscape in Shidao, Xisha, Hainan Province

Some stacks are in the form of an eroded mushroom. Sea stacks are common along China's coastline. Typical examples include the Heishi (Black Rock) Reef in Dalian, Jiangnu (Lady Jiang) Grave in Suizhong, Yingjiao (Eagle Point) Rock in Beidaihe, Yandun (Smoke Pier) in Shandong Province, Shilaoren (Stone Old Man) in Qingdao, and 'Nantian Yizhu (Southern Pillar)' at Tianya Haijiao (Sky and Sea End) in Hainan Province.



Fig. 17 Sea stack landscape in Zhangdao, Shandong Province

The Jiangnu Grave is composed of four individual stacks, the tallest of which is 16 m tall. The Yingjiao Rock in Beidaihe is 17 m tall (Fig. 17).

Seafloor Spreading Hypothesis Mantle material is extruded along mid-ocean ridges and large rifts and fills the rift valleys to form new oceanic crust, and the mantle flows away from the ridge, so the seafloor continues to expand. After a long period of drifting and expansion, the oceanic crust then sinks into the mantle in the Benioff zone. This cycle repeats, causing the oceanic lithosphere to continue to grow and be consumed, and this process keep refreshing continually. The discovery of the striped magnetic symmetry at mid-ocean ridges and the younger age of oceanic lithosphere than the continental lithosphere substantiated the seafloor spreading hypothesis and the wire magnetic recording transfer model. The seafloor spreading hypothesis greatly facilitated the development of the continental drift theory and paved the way for establishing and laying a theoretical foundation for plate tectonics theory because it provided the dynamic mechanism for continental drift.

Seal Stone Also called seal engraving stone. This is a stone used for engraving seals. Seals are a unique form of Chinese art, and as early as 3,000 years ago during the Shang Dynasty, seals were commonly used as symbols of power and means of communication. Later, due to the active involvement of the literati and the discovery of many varieties of stones suitable for seal engraving, seal stones became materials with high ornamental value. As a material for artwork, seal stones can be appreciated in two ways: (1) their design and sophisticated craftsmanship; and (2) the escalating standard of craftmanship and the associated calligraphy. Before the Yuan Dynasty, seal stones were mainly made of hard materials (gold, silver, copper, iron and ivory), but in the Yuan Dynasty, softer material became more popular, and China's four major seal stones (Shoushan stone, chicken blood stone, Qingtian stone and Balin stone) came into existence (Fig. 18).

Sea-Land Breeze The sea-land breeze is a wind system with a 1-day cycle caused by the difference between the day and night heat distributions over the sea and land. During the day,



Fig. 18 Seal stone (a type of pyrophyllite)

the wind blows from the sea to the land; at night, the wind blows from the land to the sea. The former is called the sea breeze, and the latter is called the land breeze; collectively, they are called the land and sea breezes.

Seashore *Synonym:* ▶ *Seaside*
A seashore refers to the area between the low tide mark and the highest level that the largest waves can reach. It includes the foreshore and the backshore. It generally indicates the portion of the coast near the sea. The seashore is home to many marine organisms; for example, crabs are common in this area. Waves scour the coastline into various shapes.

Seaside ▶ Seashore

Second Group of National-Level Scenic Areas On August 1, 1988, the State Council announced an additional 40 national-level scenic areas. Three scenic areas, namely, Sanqingshan, Wulingyuan and the Three Parallel Rivers of Yunnan Protected Areas, were added the World Heritage List by UNESCO. Such scenic areas as Longhushan in Jiangxi and Danxiashan in Guangdong have been designated as global geoparks by UNESCO.

Sectoral Economic Geography Sectoral economic geography studies the characteristics and processes of the layout of the social and economic sectors and the spatial organization and spatial structure of economic geography, such as industrial geography, agricultural geography, traffic geography and business geography. Tourism geography is a component of tourism economics that focuses on the characteristics and processes of tourism patterns and their spatial organization. Sectoral economic geography is a subsidiary or component of economic geography.

Sedimentary Facies A sedimentary facies refers to the physical manifestation of the depositional environment. A sedimentary facies is a distinctive overall account of the conditions and characteristics of sedimentation, including the characteristics of the rock, palaeobionts and geochemistry. The term sedimentary facies were first introduced by the Swiss geologist A. Gressly in 1838. Currently, most scientists accept the definition of sedimentary facies as 'a combination of sediments (rocks) and palaeobionts that form in a given sedimentary environment', which emphasizes the dual significance of the environmental conditions during sedimentation and of the depositional environment. Sedimentary facies can be categorized as continental facies, marine facies and transitional facies based on the geographical environment.

Sedimentary Rocks Sedimentary rocks were once called 'aquatic rocks' in Chinese. They form on or near the Earth's surface from the consolidation of loose sediments. They often appear in layered formations and are one of the three major rock types (igneous, sedimentary and metamorphic rocks) that constitute the Earth's crust. Sedimentary rocks are widely distributed, and they cover 75% of the surface of the Earth. Based on their formation, composition and structure, they can be divided into clastic rocks, clay rocks and biochemical

rocks. The most common sedimentary rocks are shale, sandstone, conglomerate and limestone, which account for approximately 95% of all sedimentary rocks. Based on the source of the rock materials, they can be divided into volcaniclastic rocks, terrestrial sedimentary rocks and endogenous sedimentary rocks. Sedimentary rock is an important landscape rock type. Many famous scenic areas in China are composed of sedimentary rocks, such as Zhangjiajie, Danxia Mountain and Wuyi Mountain, which consist of sandstone or glutenite. The peak forest in Guilin, the stone forest in Yunnan, the Three Gorges and numerous karst caves around China are composed of limestone (Table 1).

Sedimentary Structure Sedimentary structure is the spatial distribution and arrangement of the components of sedimentary rocks. It is the structure that forms through physical, chemical and biological effects during or after deposition. Primary sedimentary structures, such as bedding and ripple marks, are controlled by the sedimentation conditions and form during or prior to sedimentation. Structures such as sutures that are formed by compaction or lithification during or after sedimentation are called secondary sedimentary structures. Primary sedimentary structures are good indicators of the force and flow of the sedimentary medium and can be used to assess the depositional environment and the proper sequence of rock strata.

Sedimentary Texture Sedimentary texture is a general synthesis of the grain size, morphology, extent of crystallization, rock properties and relationships of sedimentary rocks. Sedimentary texture is closely related to the genesis of sedimentary rocks. Based on the formation process and grain size, sedimentary rocks can generally be divided into clastic textures, chemical textures and biological textures. According to the size of the clastic grains, clastic textures can be further subdivided into gravel textures, sandy textures, silty textures and muddy textures. Chemical textures are formed by chemical precipitation and can be either cryptocrystalline or phanerocrystalline. Biological textures are textures composed of biological remains.

Seismite A seismite is a rock formed by the deformation of in situ or parautochthonous soft sediments caused by earthquakes. Seismites can be divided into soft sediments with liquefaction-induced deformation, soft sediments with plastic deformation and hard layers with brittle deformation, such as faults and ground fissures. Deformed sedimentary material is located inside and between the strata and is distinct from the normal sequence of sedimentary rocks. Seismites often form unique deformed shapes in normal sedimentary rocks and make up ornamental and attractive rock landscapes. The Laiyuan National Geopark in Hebei Province has a range of typical seismites.

Selenium Spring A selenium spring is a mineral spring rich in selenium, where the spring water is suitable for drinking and bathing.

Selous Game Reserve, Tanzania Selous Game Reserve is located along the borders between the southeastern coast of Tanzania, Morogoro, Lindi, Mtwara and Ruvuma. Large numbers of elephants, black rhinoceroses, cheetahs, giraffes, hippopotami and crocodiles live in this immense sanctuary, which has a core protection area of 44,800 km^2 and is relatively undisturbed by human impacts.

Semi-fixed Dune Landscape This is a transitional type of dune landscape between fixed dunes and fluid dunes. Semi-fixed dunes have low mobility, but under certain conditions, they can transform into a fluid dune or a fixed dune. The ecological environment associated with a semi-fixed dune zone is very fragile. Protective measures should be implemented to turn them into fixed dunes (Fig. 19).

Sequence Stratigraphic Unit Sequence stratigraphy is a branch of lithostratigraphy. The basic unit of lithostratigraphy is the bed, but the basic unit of sequence stratigraphy is the sequence. A sequence comprises a set of relatively continuous and formation-related rock strata, the top and bottom of which are

Table 1 Types of common sedimentary rocks

Source type	Volcanic origin	Terrigenous		Endogenous		
		Terrigenous sedimentary rock		Endogenous sedimentary rock		
Major type	Volcaniclastic rock	Clastic rock	Argillaceous rock	Evaporite	Non-evaporite	Combustible organic rock
Classification based on grain diameter	Agglomerate (>64 mm) Volcanic breccia (64–2 mm) Tuff (<2 mm)	Conglomerate (>2 mm) Sandstone (2–0.0625 mm) Siltstone (0.0625–0.0039 mm)	Kaolinitic clay rock, illitic clay rock, montmorillonitic clay rock, mudstone, shale (<0.0039 mm)	Gypsum, anhydrite, rock salt, magnesium-potassium salt	Aluminium rock, iron rock, manganese rock, phosphorus rock, carbonate rock, siliceous rock	Coal, oil shale



Fig. 19 Semi-fixed dune landscape – Alxa, Inner Mongolia

unconformities or correlative conformities. Sequence stratigraphic units can be subdivided into megasequences, supersequences, sequences, systems tracts and parasequences. Sequence boundaries are the results of geologic events or sea level changes.

Serengeti National Park, Tanzania Serengeti National Park is located in northern Tanzania along the border between Arusha and Shinyanga. It is near the border with Kenya and has a core protection area of 14,763 km^2. The vast plains of the Serengeti comprise endless savannah.

Serpentine Serpentine is the collective term for the serpentine family of minerals, and it has the chemical formula $Mg_6[Si_4O_{10}](OH)_8$. It contains aluminium, iron, nickel and cobalt and is a silicate mineral with a foliated structure. The crystals are small, bladed or platy, and the aggregates are blocky or fibrous. Its colour is white, yellow, green or brown. It has translucent to opaque diaphaneity, a specific gravity of 2.52, a Mohs hardness of 2.5–3.5, and conchoidal to splintery fractures. Serpentine is the product of the hydrothermal metasomatism of olivine and pyroxene in ultramafic rocks, and it can also form when dolomite is affected by hydrothermal processes. Serpentine is the raw material for manufacturing calcium-magnesium-phosphate fertilizers and refractory tools. Serpentine with a dense texture and an apple-green colour is a good material for carving and is called Xiuyan jade in Chinese (Fig. 20).

Serpentinite Serpentinite is a deep metamorphic rock consisting mainly of serpentine minerals. The main minerals are serpentine, chrysotile, and antigorite, and the secondary minerals are magnetite, chromite, ilmenite and magnesium-iron carbonate minerals. It is usually light or dark green. Serpentinite is dense and always has a flaky texture with a snakeskin-like pattern. It mainly forms by the hydrothermal metasomatism of ultramafic rocks, which causes serpentinization of the olivine and pyroxene. The serpentinized rocks always form with metallic minerals, including chromium, iron and nickel, and other non-metallic minerals, such as magnesite, talc and asbestos. Serpentine jade transformed from serpentinite is a popular ornamental stone.

Settlement Geography Settlement geography is the study of the formation, development, morphological changes, distribution, and evolutionary trends of settlements (residential sites) and their relationships to the geographical environment. It refers to the study of small towns and rural settlements and is a branch of



Fig. 20 Serpentine

human geography. In recent years, settlement geography has played a significant role in studies of tourism in villages and towns. For example, the historical and cultural values of the famous Fujian Tulou have been unveiled and publicized with the help of settlement geographers.

Seventh Group of National-Level Scenic Areas On December 28, 2009, the State Council announced another 21 national-level scenic areas, including five in Guizhou Province, five in Hunan Province, three in Fujian Province, two in Henan Province, two in the Tibet Autonomous Region and one each in Zhejiang Province, Jiangxi Province, Heilongjiang Province and Guangdong Province.

Seventy-Two Happy Places Happy place means the land of blessing, which implies that anyone living in such a place is blessed and can become immortal. The happy places listed in the Taoist books mainly imply fairylands controlled by immortals, and these places are second behind the big caves. The seventy-two happy places listed below come from the book 'Map of Heaven and Earth Palaces' by the Taoist Sima Chengzhen of the Tang Dynasty:

Serial	Name	Location
1	Defei Mountain	Jurong County, Jiangning Fu (today's Jiangsu Province)
2	Gaizhu Mountain	Xiandu County, Quzhou (Xiandu
		County had not yet been established in Quzhou in the Tang Dynasty) (Zhejiang today)
3	Xianwei Mountain	15 miles from Liangcheng County near Baixicao City, Wenzhou (today's Yueqing, Zhejiang)
4	Dongxian Yuan	Huangyan County, Taizhou (in Zhejiang today)
5	Xixian Yuan	Jiaoling in Huangyan County, Taizhou (Zhejiang)
6	Nantian Mountain	East Donghai in Nantian, Qingtian County, Zhejiang
7	Yuliu Mountain	On Penglai Island, Donghai (Shandong)
8	Qingyu Mountain	Neighbouring the Fusang fairyland, west of Donghai (Jiangsu)
9	Yumu Cave	Southern Yusi Mountain (today's Yongxing area in Jiangxi)
10	Danxia Cave	Western Magu Mountain (today's Nancheng area, Jiangxi)
11	Junshan Mountain Qinhcao Lake	Dongting (today's Lake Dongting, Hunan)

(*continued*)

(*continued*)

Serial	Name	Location
12	Daruo Rock	Yongjia County, Wenzhou (in today's Zhejiang)
13	Jiao Yuan	Northern Jianyang County, Jianzhou (in today's Fujian)
14	Lingxu	Northern Tangxing County, Taizhou (today's Tiantai, Zhejiang)
15	Wozhou	Southern Shan County, Yuezhou (today's Shengzhou, Zhejiang)
16	Tianlao Cen	Shan County (today's Shengzhou, Zhejiang)
17	Ruoye Creek	Southern Kuaiji County, Yuezhou (today's Shaoxing, Zhejiang)
18	Jinting Mountain	Eastern Shengzhou, Zhejiang with a Jinting Cave
19	Qingyuan Mountain	Qingyuan County, Guangzhou (in today's Guangdong)
20	An Mountain	Northern Jiaozhou (today's Guangdong and Guangxi)
21	Maling Mountain	Shuidong, Guonei, Chenzhou (today's Chenzhou City, Hunan)
22	Eyang Mountain	Changsha County, Tanzhou (today's Hunan)
23	Dongzhen Xu	Changsha County, Tanzhou. All known as 'Dongzhen Tan' (Hunan)
24	Qingyu Tan	Western Zhurong Peak, Nanyue (Hengyang, Hunan)
25	Guangtian Tan	Xiyuantou, Hengshan (Hunan)
26	Dongling Yuan	Western Zhaoxian Guan, Nanyue Hengshan (Hunan)
27	Donggong Mountain	Wuling in Guanli County, Jianzhou (today's Donggong Mountain in Zhenghe, Zhouning and Pingnan Counties)

(*continued*)

Serial	Name	Location
28	Tao Mountain	Anguo County, Wenzhou (Angu County in Ruian, Zhejiang)
29	Sanhuang Well	Hengyang County, Wenzhou (today's Pingyang, Zhejiang)
30	Lanke Mountain	Xi'an County, Quzhou (today's Quzhou City, Zhejiang)
31	Le Creek	Eastern Jianyang, Jianzhou (today's Fujian)
32	Longhu Mountain	Guixi County, Xinzhou (today's Guixi City, Jiangxi)
33	Ling Mountain	Shangrao County, Xinzhou (today's Jiangxi)
34	Quan Yuan	Luofu Mountain (today's Boluo areas, Guangdong)
35	Jinjing Mountain	Qianhua County, Qianzhou (today's Ningdou, Jiangxi)
36	Gezao Mountain	Xingan County, Jizhou (today's Qingjiang, Jiangxi)
37	Shifeng Mountain	Fengcheng County, Hongzhou (today's Jiangxi)
38	Xiaoyao Mountain	Nanchang County, Hongzhou (today's Nanchang, Jiangxi)
39	Dongbai Yuan	Eastern Xinwu County, Hongzhou (today's Fengxin, Jiangxi)
40	Bochi Mountain	Chuzhou (today's Huai'an, Jiangsu)
41	Lun Mountain	Dantu County, Runzhou (today's Jiangsu)
42	Maogong Tan	Zhangzhou County, Suzhou (today's Wu County, Jiangsu)
43	Jilong Mountain	Liyang County, Hezhou (today's He County, Anhui)
44	Tongbai Mountain	Tongbai County, Tangzhou (today's Henan)
45	Pingdou Mountain	

(*continued*)

Serial	Name	Location
		Fengdu County, Zhongzhou (today's Fengdu, Chongqing)
46	Luluo Mountain	Northern Wuling County, Langzhou (today's Taoyuan, Hunan)
47	Huxi Mountain	Pengze County, southern Jiangzhou (today's Jiangxi)
48	Zhanglong Mountain	Northern Liling County, Tanzhou (today's Hunan)
49	Baofu Mountain	Lianshan County, Lianzhou (today's Guangdong)
50	Damian Mountain	Chengdu County, Yizhou (today's Dujiangyan City, Sichuan)
51	Yuanchen Mountain	Duchang County, Jiangzhou (today's Jiangxi)
52	Mati Mountain	Poyang County, Raozhou (today's Poyang County, Jiangxi)
53	De Mountain	Wuling County, Langzhou (today's Taoyuan, Hunan)
54	Gaoxilanshui Mountain	Lantian County, Yongzhou (today's Shaanxi)
55	Lanshui	Lantian County, Xidu (today's Shaanxi)
56	Yu Peak	Jingzhao County, Xidu (today's Xi'an, Shaanxi)
57	Tianzhu Mountain	Yuqian County, Hangzhou (today's Lin'an areas, Zhejiang)
58	Shanggu Mountain	Shangzhou (today's Shang County, Shaanxi)
59	Zhanggong Cave	Yixing County, Changzhou (today's Yixing City, Jiangsu)
60	Simahui Mountain Tiantai, Taizhou (today's Zhejiang)	Tiantai, Taizhou (today's Zhejiang)
61	Changzai Mountain	Changshan County, Qizhou (today's Zouping, Shangdong)
62	Zhongtiao Mountain	Yuxiang County, Hezhong Fu (today's Yongji, Shanxi)
63	Jiaohu Yucheng Cave	Yaozhou, Xigu (today's Yaoan, Yunnan)
64	Mianzhu Mountain	Mianzhu County, Hanzhou (today's Sichuan)
65	Lushui	Xiliangzhou (Laingzhou stated in 'Yu's Book' that this area was the location where the Yalong River merged with the Jinsha River)
66	Gan Mountain	Qiannan (today's Guizhou)
67	Wanghuang Mountain	Hanzhou (today's Guanghan, Sichuan)
68	Jicheng Mountain	Ancient Xianshu or called Shishu. It was in Yunzhong County (today's Datong, Shanxi)
69	Yun Mountain	Wugang County, Shaozhou (today's Wugang, Hunan)
70	Beimang Mountain	Luoyang County in Dongdu (today's Luoyang, Henan)
71	Lushan Mountain	Lianjiang County, Fuzhou (today's Fujian)
72	Donghai Mountain	25 km east of Haizhou, such as Yuntaishan (today's Haizhou Town, Lianyun Port, Jiangsu)

(*continued*)

Shale Shale is an argillaceous rock with specific textures and fissures that is formed by compaction, dehydration, and recrystallization of clayey materials. Shale is mainly composed of illite as well as other clay minerals, clastic minerals and authigenic minerals. Common types are black shale, carbonaceous shale, oil shale, siliceous shale, ferruginous shale and calcareous shale. Shale is impervious, so it often serves as an aquifuge.

Shan Hai Jing (Classic of Mountains and Seas) This book is considered the oldest

geographical writing in China. The author is unknown. It is thought to have been written during the late Warring States Period (approximately 200 BC) and was then supplemented in the Qin and Han Dynasties. It is the earliest geographical work to have survived to the present in China. The book is divided into three categories: Classic of the Mountains, Classic of the Seas and Classic of the Great Wilderness. Classic of the Mountains is the most valuable section and divides the country into five parts: the central mountains, southern mountains, western mountains, northern mountains and eastern mountains. It also describes rivers, roads, nationalities, animals, vegetation, minerals, medicines, sacrifices and witch doctors. The book recorded 89 types of minerals and rocks and 170 metal ore deposit areas, and it is the oldest geological document in China. The Classic of the Seas and Classic of the Great Wilderness mainly contain myths, which decrease their reference value.

Shanghang Zijinshan National Mining Park, Fujian This park is located in southwestern Fujian, faces Taiwan across the ocean and has a total area of 30 km^2. It became a national mining park in 2005 as one of the first mining parks in China. The park has a reception area, areas to view the Zijinshan gold production process and the Zijinshan biological copper extraction process, the Zijin Geological Mining Museum and the Zijinshan National Mine Park Recreation Area. It has a good interpretation system, modern infrastructure and a beautiful landscape.

Shangnan Jinsixia National Geopark, Shaanxi Shangnan Jinsixia National Geopark is located in the Qinling Mountains in Shangnan County, Shaanxi Province. It covers an area of 28 km^2. It became a national geopark in 2009. Its main geological attractions include tectonic karst gorges and multi-level waterfall landscapes. The geological features of the Qinling orogenic belt are completely preserved in the geopark. Geological features such as a limestone ravine-narrow gorge-canyon landform system, a 13 storey waterfall and a cliff-like waterfall have been completely preserved.

Shanshui City The concept of the shanshui (mountain and water) city is first proposed by Qian Xuesen, who proposed to 'combine Chinese landscape poetry, Chinese classical garden architecture, and Chinese landscape painting to create a shanshui city'. Many interpretations of landscape cities have been presented, and they include five main ideas: (1) an emphasis on the use of natural forms of landscape in cities; (2) an emphasis on the integration of the artificial environment and the natural environment; (3) an emphasis on the integration of the cultural environment and the ecological environment; (4) the shanshui city is a Chinese version of the sustainable cities that are used internationally; and (5) the shanshui city is believed to be an ideal city that is consistent with the philosophy of ancient China, which advocates harmony between nature and man.

Shantungosaurus giganteus Shantungosaurus giganteus was found in August 1964 in Longgu Jian (Keel Stream) in Lubiao Village, Zhucheng, Shangdong Province. This is by far the largest Hadrosaurus that has been discovered. From head to tail, it is 15 m long, has a standing height of 8 m and has nearly a thousand teeth. It lived during the late Cretaceous. This Hadrosaur is similar to the Edmontosaurus, which has been found in the United States and Canada, which further proves that when the Shantungosaurus was alive, the Asian continent was connected to the North American continent (Fig. 21).

Shape of Minerals ► Morphology of Minerals

Shanwang Biota The Shanwang biota is found in diatomite of the Early Miocene Shanwang Formation in the Jiejia River Basin, eastern Linqu County, Shandong Province. These strata contain many kinds of elegant animal and plant fossils; hence, this site has long been known as a 'Museum of Ancient Fossils'. The main fossils include diatoms, pollens, large plant fossils, ostracods, insects, fish, amphibians, reptiles, birds and mammals. The signature fossils are Rana basaltica, Bufo linquensis, Procynops miocenicus, Mionatrix, Alligator luicus, Shandongornis shawanensis,



Fig. 21 Shantungosaurus giganteus

Shanwang bats (Chiroptera), Diatomys shantungensis, Hemicyon hareni, Palaeomeryx tricornis, Lagomeryx and Rhinocerotidae. The Shanwang biota provides evidence for studying the evolution of biota and environmental changes in eastern China since the Cenozoic (Fig. 22).

Shanwang National Geopark, Shandong This park is located approximately 22 km east of Linxi County in Shandong Province and became a national geopark in 2002. The park is located in the Linqu Depression in the Luzhong uplift area. Its highest peak is Lushan Mountain, which has an elevation of 405 m. It is composed of the Jiejiahe Basin and the Baojiahe Basin, and its periphery is composed of basalt hills. The park is characterised by ancient mountains and volcanic landscapes that reflect its formation. The park contains the richest and most complete bird fossils found in China to date. The fossils were mainly preserved in the diatomite layer of the Miocene Shanwang Formation (approximately 14 million years old). More than a dozen types of fossils of more than 600 species have been found, including insects, fish, spiders, amphibians, crawlers, birds and mammals. The fossilised veins of worms are clear and well preserved, and some still retain brilliant colours. A total of 11 orders, 46 families, 100 genera, and 182 species have been studied and identified. These fossils are called the Shanwang fauna.

Shaoguan Furongshan National Mining Park, Guangdong This park is located in Shaoguan, Guangdong Province, next to downtown Shaoguan. It covers a total area of 21.70 km^2 and became a national mining park in 2005. The park preserves coal and limestone mining remains as well as numerous geological relics and cultural landscapes. It has three main scenic areas, including a theme sculpture square, landscape sketch scenic area and mine park museum, as well as several scenic sites, such as Furong Mountain and Ancient Temple, weather station, Lotus Park, Magnolia Park, Lotus Cave and Lotus Lake. It is a comprehensive national mine park that integrates geological hazard management, ecological environment protection, mining culture and leisure and sightseeing.

Shape Stone *Synonym:* ▶ *Mould stone*

Shape stone generally refers to a stone, mineral or fossil with its original peculiar shape. It should have the qualities of 'slimness, wrinkliness, leaking, penetrability and



Fig. 22 Shanwang biota

weirdness'. 'Slimness (Shou)' implies majesty and masculinity with exposed bones and muscles in a balanced manner. 'Wrinkliness (Zhou)' implies an undulating stone surface with many patterns. 'Leaking (Lou)' means holes or pores in the rock, which enable people to see through the stone, both up to the sky and down to the ground. 'Penetrability (Tou)' refers to the overall porosity and abundance of holes in a stone that can allow water and mist to pass through the rock. 'Weirdness (Chou)', the opposite to beauty, simply implies majesty and is an outstanding feature. There are three main ways to appreciate a shape stone: (1) One should pay attention to the appearance, observe the natural characteristics of the stone and further explore the aesthetics of its inner side and the opportunity to extend this aspect. (2) One should emphasise the spiritual aspect of the stone with reference to its stability, balance, strength, posture, ingenuity, subtleness, abstractness and composition. (3) One should grasp the characteristics of the shape stone in a balanced and comprehensive manner based on the entire object and its individual parts (Fig. 23).

Shark Bay, Western Australia, Australia This site is located in the northwestern part of the state of Western Australia on the Indian Ocean. The islands and surrounding waters combine with the mainland coast to create three unique natural landscapes, including an area of 4,800 km^2 that is the world's largest and most abundant seagrass habitat, unique sea cow (dugong) communities and stromatolites. Stromatolites are layered mounds, columns, and sheet-like sedimentary rocks that form by the growth of layers of cyanobacteria, single-celled photosynthesising microbes that live in a wide range of environments, ranging from shallow shelfs to lakes, rivers, and even soils. The area supports 26 threatened Australian mammal species, more than 230 species of birds, and nearly 150 species of reptiles. The area is an important breeding ground and nursery for fish, crustaceans, and coelenterates. There are more than 323 fish species, with many of them sharks and rays.

Shehong Silicified Wood National Geopark, Sichuan Shehong Silicified Wood National Geopark is located in Mingxing, Shehong, Suining, Sichuan, and it became a national geopark in 2005. Its main features include petrified fossil wood, dinosaur fossils, gorges, ripple marks, lacustrine sediments, water



Fig. 23 Shape stone

landscapes, ebony wood and ancient human fossils. The Longfeng Gorge in the park is a deep gorge. Darendong Cave, an ancient site of primitive tribes, and large-scale Han Dynasty tombs are located along the gorge.

Shell Beach Ridge Landscape This is a landscape consisting of embankment-like landforms that are formed by the accumulation of shells. A shell ridge is also known as clam dyke and is an embankment composed of shell fragments, fine sand and silt on a muddy plain in the coastal zone. They form near the high tide mark and are a reliable marker of an ancient coast. There are three famous shell beach ridges in the world, namely, China's Tianjin Shell Ridge, the Louisiana Shell Ridge in the U.S.A. and the Suriname Shell Ridge in South America. The Tianjin Shell Ridge is 0.5–5 m high, dozens to hundreds of metres wide and hundreds of kilometres long. It has a convex top with tails on both sides that gradually thin down. From the land to the sea, there are four arrays of shell ridges, including Ridge I, Ridge II, Ridge III and Ridge IV, which run from north to south in a consistent direction along the coast of Bohai Bay. It is a relic of the ancient Bohai Bay coastline that formed when the ancient Yellow River entered the ocean from Tianjin. The ridge is also an important marker of coastline retreat (Fig. 24).

Shengming Wu Shengming Wu (1941–) graduated from the Institute of Geography of the Chinese Academy of Sciences in 1967. He was the first committee member of the China Tourism Earth Science Research Institute. His works include 'China's Book – Full Record of China's 21 National Geoparks', 'Ornamental Stones and Tourism', 'The Magnificent Underground Art Palace – Cave Tours in China' and 'The Beauty of National Parks'.

Shennongjia National Geopark, Hubei Shennongjia National Geopark is located in the southern Shennongjia forest region in Hubei Province, and it covers an area of 954.9 km^2. It became a national geopark in 2005. The area is part of the Tapa Mountains and has an average elevation of over 1,800 m, and Shennong Peak reaches 3,105 m. The geological features comprise glacial landforms, glaciers, flowing water and karst. In addition, there are albino animals and Palaeolithic sites where ancient people lived. The Dajiuhu Scenic Area is characterised by glacial landforms and alpine meadows. Tectonic landforms with erosional features are the main geomorphologic landscapes in the



Fig. 24 Shell beach ridge landscape

Banqiao Scenic Area. The Shennong Peak Scenic Area contains magnificent mountain landscapes, and the Tianyan Scenic Area illustrates the development of gorges and karst landforms. The Xiangxiyuan Scenic Area features gorges and river sources. Interesting fault structures and waterscapes can be observed in the Laojunshan Scenic Area.

Shenzhen Dapeng Peninsula National Geopark, Guangdong Shenzhen Dapeng Peninsula National Geopark, Guangdong, is located in eastern Shenzhen. It is approximately 50 km from downtown Shenzhen, adjacent to Hong Kong across the sea to the west. It became a national geopark in 2005. The geopark is characterised by Mesozoic volcanoes and coastal depositional landforms. It has several scenic areas, such as Dajiaojia Island, Shuangfengzhou Islet, Qiniangshan Peak, Yangmeikeng Village, Wangmuwei, Dongchong Beach and Xichong Beach. Dapeng Mountain is surrounded on three sides by the ocean and has seven peaks of various shapes. The highest is Qiniangshan Peak, which has an elevation of 869 m. The main features of the geopark are ancient volcanoes and coastal landforms. It also has typical volcanic facies, palaeontological sites (including ancient cultural sites), faults, folds, waterfalls, landslide and rockfall landscapes, and coral reefs.

Shenzhen Fenghuangshan National Mining Park, Guangdong This park is located in Shenzhen, Guangdong Province, and has three scenic areas: Furong, Fenghuang Mountain and Yanhu Lake. It covers an area of 2.67 km^2 and became a national mining park in 2005. The park uses the distinctive mining remains as the main landscape features. It combines beautiful green landscapes, the unique design of the museum, the subtle sculptures, and the splendid natural and cultural landscape resources to embody the historical connotations of mining development.

Shenzhen Pengqian National Mining Park, Guangdong This park is located in the Longgang District, Shenzhen City, with Daya Bay and Dapeng Bay to the east. It became a national mining park in 2005. The park focuses on the mining ruins landscape of the Pengxi marble mining area and integrates other experimental programmes. It is a functional park that combines knowledge and art with personal experience and is composed of a large underground goaf and four mine lakes.

Shetland Geopark This geopark acquired its global status in 2009 and has an area of

1,468 km^2. It has richer geological diversity than any geopark of similar size in Europe. It is full of breathtaking geological landscapes that span approximately three billion years. Shetland is an archipelago of more than 100 islands and contains rocks from the Precambrian to the Carboniferous. The many notable features include the North Rock igneous complex, which contains the best section through a volcano in the British Isles, St. Michael's Island, which is the largest active sand bar in the UK and the best in Europe, and the Shetland Ophiolite, which has been described as the world's most compact, exposed, complete, and easily accessible ophiolite.

Shexian Inkstone This stone, which is also known as the Dragon Tail inkstone, is mined in She Creek on Longwei Mountain in Wuyang, Jiangxi Province. This stone was given this name because the site was called Shezhou in the past. Shexian inkstone is composed of shallow metamorphosed shale from the Sinian era that contains small amounts of impurities, such as copper and charcoal. It is a relatively soft stone but is slightly harder than the Duanxi stone. It has a dense structure and rich patterns. The grains are tiny and are difficult to distinguish with the naked eye. The main minerals are sericite, chlorite and small amounts of silty sand and metal sulphide. The 'Ming Dynasty United Monograph' states: 'There are five grades of Shexian inkstone, namely, Meizi (eyebrow), Waishan Luowen (outer radish veins), Lishan Luowen (inner radish veins), Jinxing (gold star), and Lukeng (donkey pit).' Today, this stone is mainly categorised into the Luowen (radish pattern), Meizi Zhimeiwen (eyebrow pattern), Jinxing (gold star) and Jinyun (gold halo) types. During metamorphism, the sericite and chlorite tend to form a particular pattern, such as rib or brow patterns. In literati circles, Shexian inkstone has gained the reputation of having the capacity of 'throwing away excessive ink and achieving a moist ink lustre with one wash' (Fig. 25).

Shidu National Geopark, Beijing This geopark is located in the southwestern Fangshan District, Beijing, along the middle and upper reaches of the Juma River. It spans Shidu and Zhangfang and borders Yishui County in Hebei Province to the west and south. The total area is 301 km^2. It became a national geopark in 2004. In the Juma River Valley from Zhangfang to Pingshuo, the tributaries of the Daqing River run through distinctive landscapes that have been named Shidu. The main geological features in the geopark include surface karst and valley landforms, underground karst caves and sedimentary and



Fig. 25 Shexian ink stone

structural features. The geopark has a northern karst landscape with a variety of geological geoheritage sites and good natural and cultural environments.

Shield A shield is generally an area of exposed Precambrian (or Pre-Nanhuan) crystalline basement, such as the Canadian Shield, Superior Shield and Baltic Shield. Because the rock exposed in a shield is very old, it has particular significance for revealing the early history of the Earth.

Shield Volcano Landscape This is a type of volcanic landscape associated with broad dome-shaped and conical shield-like features with gentle slopes that form when low-viscosity magma flows along slopes from the central or lateral vents. Basaltic magma generally forms shield volcanoes. There are two types of shield volcanoes: (1) Hawaiian type: these volcanoes are large and have multiple causes of formation. Some large shield volcanoes have collapsed craters, fallen lava cones, cinder cones and smaller rock shields. The world's largest shield volcano is the active Mauna Loa volcano. (2) Icelandic type: these volcanoes are small and have a single cause of formation. In general, they are less than 15 km wide, and the crater is less than 1 km in diameter. This type of shield volcano is almost completely symmetrical. It is formed by a central eruption that develops numerous thin pahoehoes. The crater is surrounded by fallen lavas forming the rim. The Skjald Breiduer Volcano in Iceland is a typical example of this type (Fig. 26).

Shihua Cave National Geopark, Beijing This geopark is located in the low valley along the middle reaches of the Dashi River in Xishan, Beijing. It became a national geopark in 2002. It is composed of Shihuadong and Yinhu Caves, which formed in Cambrian Ordovician and limestone. Shihua Cave has seven floors; the first to fifth floors have a total length of 5,000 m and are dry, and the 6th and 7th floors contain underground rivers and water-filled caves. Silver Fox Cave is a single layer of caves containing an underground river. The two caves are rich in secondary chemical sinks, with the former producing milkstone and large numbers of stone flowers and the latter producing silver-white acicular calcium burrs resembling 'upside-down silver foxes'.

Shilin Global Geopark, China *Synonyms:*
► *Shilin National Geopark, Yunnan*
Stone Forest Geopark became a global geopark in 2004. It is located in Yunnan Province and covers an area of 400 km^2 with likely the most diverse karst landforms in the world. The area was a littoral offshore environment in the Late Palaeozoic, in which extremely thick



Fig. 26 Shield volcano landscape

limestone and dolomite were deposited. Subsequent crustal uplift and water erosion through joints created a multiple, superimposed, well-stratified karst landscape. It is a 'karst museum' with varied shapes and forms that are globally unique, such as knife-edge-like, mushroom and tower-shaped pinnacles with heights ranging from 20 to 50 m. Other geomorphic features include clusters of karst peaks, ridges, valleys, caves, sinkholes, funnels, depressions, arches, lakes, and underground streams, which are ideal for sightseeing and studying karstification and the regional geological evolution of the Earth's surface. The rich and varied culture of minority groups such as the Yi and the many additional cultural values make the geopark a world-renowned scenic attraction.

Shilin National Geopark, Yunnan See ▶ Shilin Global Geopark, China.

Shilin-Type Stone Forest Landscape in Shilin County, Yunnan This is a representative type of carbonate stone forest landscape. It is composed of the Permian Qixia Stage and Maokou Stage limestone and is represented by the Shilin Stone Forest in Yunnan Province. This stone forest is composed of bioclastic limestone with stone columns of various forms (sharp cones, swords, mushrooms, cylinders, forts and irregular shapes). The columns are generally more than 10 m high, and the highest are 50 m tall or more. Most are joined in clusters, but some are isolated. The column bases have the characteristics of subsurface karst corrosion. The upper columns, especially those at the top, have significant signs of rainwater erosion, such as vertical grooves and irregular rough surfaces. The edges of some vertical grooves are thin and sharp, like blades. This stone forest experienced two stages of subsurface karst dissolution and surface rainwash. This landform mainly formed in the Middle Pleistocene and was later exposed to erosion of the red earth, followed by surface erosion to form the present landscape. Among all stone forest types, the Shilin-type stone forest landscape is most valuable for tourism development. China's Shilin Global Geopark is composed of this landscape (Fig. 27).



Fig. 27 Sketch of the Shilin Stone Forest in Shilin County, Yunnan Province

Shilongite Shilongite is a unique variety of basalt that is rich in potassium. Shilongite is rare, and it is only found at Laoheishan and Huoshaoshan in Wudalianchi, Heilongjiang Province. It gets its name because the lava flow looks like a shilong, which is translated literally as a stone dragon. Its main minerals include olivine, pyroxene, leucite, sanidine and volcanic glass. The leucite and sanidine form the main matrix, which has a cryptocrystalline pattern. The shilongite in Laoheishan contains approximately 1–5% leucite, but the shilongite in Huoshaoshan does not contain any leucite.

Shingle Beach Ridge Landscape This is a landscape consisting of coastal embankment landforms composed of coarse shingles on the outer margin of a coastal beach. Its development reflects a bay environment with a source of abundant shingles and persistent directional waves. In China, on the outer margin of the shingle beach near the coastal zone west of the Dashi (Big Rock) River estuary near Shanhaiguan, several long shingle beaches run east to west parallel to the coastline. The materials making up these shingle beaches came from rivers in mountain areas. These materials were transported to the coast during flood periods and moved by waves to form these shingle beaches (Fig. 28).

Shirakami-Sanchi, Japan This site is located on the boundary between Aomori ken and Akita ken in northern Honshu, Japan, and it covers a core protected area of 101 km^2. This trackless site includes the last virgin remains of the cool temperate forest of Siebold's beech trees, which once covered the hills and mountain slopes of Japan. Black bears, mountain goats and 87 species of birds can be found in this forest.

Shiretoko, Japan This site is located in the northeastern corner of Hokkaido. The protected area includes the area from the centre of the peninsula to Haishu and the surrounding waters. The region is an outstanding example of the interaction between marine and terrestrial ecology. It has been greatly affected by seasonal low-latitude sea ice, and it has extraordinary ecosystem productivity.

Shishan Volcanic Cluster Landscape, Haikou This cluster is located in Shishan Town and Yongxing Town, south of Haikou City. There are more than 40 volcanoes,

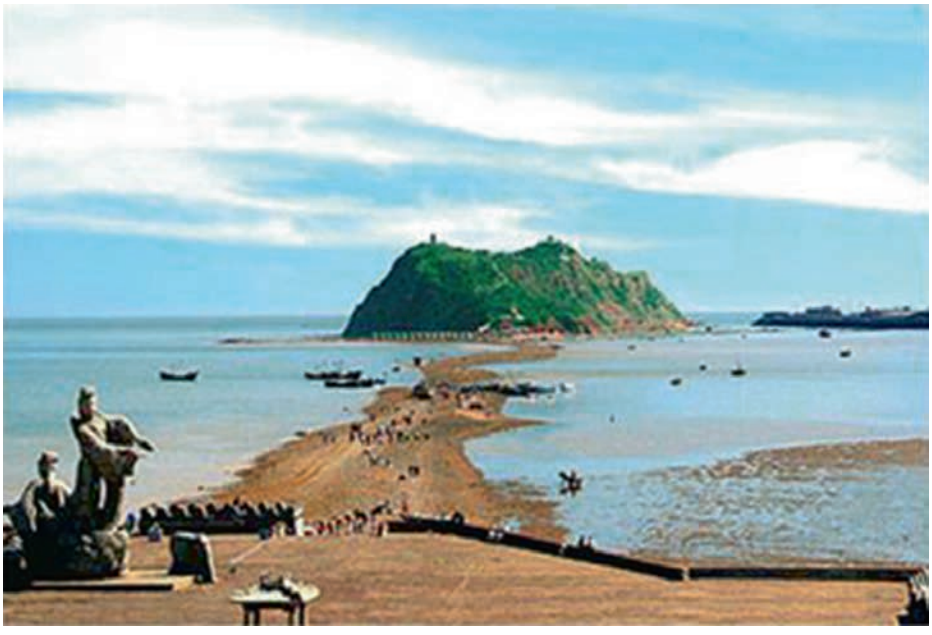


Fig. 28 Shingle beach ridge landscape

including lava cones and shield volcanoes, that formed from magmatic eruptions. Typical examples are Fenglu Ridge, Changdao Ridge, Leihu Ridge and Yongmao Ridge. There are also low flat craters associated with phreatomagmatic eruptions, such as Shuangchi Ridge and Lojingpan. Lava tunnels also formed associated with the volcano development. Their number and scale rank first in China. Typical examples are the Seventy-Two Caves and the Fairy Cave. This volcanic landscape enriches the tropical ecological landscape. The combination of the volcanoes and the local inhabitants creates a volcanic folklore culture. This volcanic cluster is China's only volcanic showcase of Quaternary basalt associated with a tropical island city. The main area of Ma'an Ridge has become Hainan's most famous volcanic tourism site. This volcanic cluster and Huguangyan in Zhanjiang have been approved as the Leiqiong Global Geopark.

Shizhuyuan Tungsten (Tin, Bismuth and Molybdenum) Deposit, Chenzhou, Hunan This is a world-class high-temperature hydrothermal polymetallic deposit. Located in Chenzhou County, Hunan Province, the Shizhuyuan tungsten (tin, bismuth and molybdenum) deposit is located along the contact zone between the Yanshanian Qilianshan bimicaceous granite and the muddy limestone of the Upper Devonian Shetianqiao Formation. The deposit includes four ore bodies; from the bottom to the top, it comprises a marble-type tin ore body, a skarn-type tungsten-bismuth ore body, a quartz/mica skarn-type tungsten-molybdenum-bismuth ore body, and a quartz/mica-type-tungsten-molybdenum-bismuth-tin ore body in a vein network. The main minerals are tungsten, molybdenum and bismuth. Its enormous tungsten, bismuth and fluorite reserves are the largest in the world. Mining began no later than the Qianlong years of the Qing Dynasty. According to the 'Hunan Annals', which were published during the Guangxu Period in Qing Dynasty, Shizhuyuan and Getengping in Chenzhou became government-approved tin mines in Qianlong's eleventh year (1746). The site is now a national mining park.

Shizuishan National Mining Park, Ningxia This park is located on the southern side of the Shizuishan Industrial Park and the northern side of the Huinong District, Ningxia Province. It is administered by the Huinong District, Shizuishan City, and its built-up area covers 17.7 km^2. It was designated as a national mining park in 2010. Dominated by subsidence landforms, the Huinong Scenic Area has typical geological disaster features and preserves stratigraphic sections, ground fissures, hypergolic gangue, abandoned coalers and remnants of mining life. Consisting of Qishishan Mountain, Gangue Mountain and Xinghai Lake, the Dawukou Scenic Area has been transformed from areas of gangue and fly ash accumulation in a former coal washery and power plant in Shizuishan City. It contains typical mining production heritage.

Shock Metamorphism Shock metamorphism is induced by the impact of high-speed meteorites onto the Earth's surface. It is characterized by a short duration, high pressure and high temperature. Shock metamorphic rocks are located in meteorite craters. The impact mainly causes: (1) the mineral crystals to deform and break; (2) the formation of new high-pressure metamorphic minerals at the surface, such as coesite, stishovite, diamond and 'impact glass' (tektite, which was initially believed to be composed of a 'glass meteorite' but has been shown to be a type of impact glass); and (3) melting of minerals (such as magnetite) that are difficult to melt at normal temperatures. These three characteristics are the main markers for distinguishing shock metamorphism.

Shopping Tourism Shopping tourism is a type of tourism that focuses on purchasing goods in locations away from people's hometowns. In contrast to general tourists, shopping tourists usually have specific goods or shops in mind and pay close attention to the quality of the goods. Shopping is the main goal and activity, while sightseeing and touring are subsidiary activities.

Shoushan National Mining Park, Fujian This park is located in the northern part of Fuzhou City, Fujian Province. It covers an area of 202 km^2 and became a mining geopark in 2005. The park can be divided into five areas, namely, Shoushan, Rixi, Hung Hom, Lingtou and Guihu. The main feature is the Shoushan Stone Mine Relics, which showcase the original site of the 'Shoushan Stone' and 'Hot Spring' in Fuzhou. The mining park has a historical mine shaft that is more than 300 m wide. It also contains the China Shoushan Stone Pavilion, Shoushan Stone Ancient Street, Shoushan Stone Cultural Square, Tianhuang Treasure Creek, a man-made lake and other tourist attractions.

Shoushan Stone ► Agalmatolite

Shoushan Stone Deposit, Fujian The Shoushan stone deposit is a large volcanic hydrothermal metasomatic deposit with a small amount of aluminium ore located in Shoushan Village, Hongliao Township, northern Fuzhou City, Fujian Province. The deposit is located in the upper segment of the acidic pyroclastic rocks in the lower section of the Upper Jurassic Bantou Formation. It was formed by the mineralisation of fused rhyolite tuff and brecciated rhyolite tuff under intense volcanic hydrothermal action that resulted in pyrophyllite-siliconate-aluminium ores. The ore mass of the deposit is layered or has lens and convex shapes. The boundary between the ore mass and the surrounding rocks is transitional. Pyrophyllite is the major mineral component of the deposit, followed by quartz, diaspore, dickite and kaolinite. Shoushan stones, which are used for carving, are composed mainly of dickite and kaolinite minerals and are commonly known as 'Tian Huang'. Records reveal that the Shoushan stones were discovered during the Five Dynasties (A.D. 907–960). The deposit is now a national mining park.

Shouyun National Mining Park, Beijing This park is located in the town of Jugezhuang, Miyun County, Beijing, and has a total area of 16.30 km^2. The Ministry of Land and Resources approved it as a national mining park in May 2010. The area around the park has a long mining history extending over 2,000 years. There are records of iron ore mining from as early as the Western Han Dynasty (202–8 BC), and the area was once the largest iron ore mine in Beijing. The ore deposits were associated with metamorphosed volcanic-sedimentary rocks and Precambrian banded ferrosilicon. The mining site in the park is relatively complete and preserves the unique processes and activities from prospecting to mining and refining. The geotourism resources include mineral and mining production sites, relics of mining activities, and historical records of mining development and mining products, which have great value for tourism development and utilisation.

Shui Jing Zhu (Commentary on the Water Classic) This book is a famous ancient Chinese geography book written by Daoyuan Li (472–527 AD) during the Northern Wei Dynasty. It includes 40 volumes. Based on the outline of 'Shui Jing Zhu' (Commentary on the Water Classic), Li greatly elaborated and supplemented the content into a book with 20 times more material than the original. 'Shui Jing' (Water Classics) is a work from the Three Kingdoms Period (approximately 220–280 AD). The original author is unknown, and the full text is very simple; it includes only approximately 10,000 words about the origins, flows and destinations of approximately 130 rivers. 'Shui Jing Zhu' (Commentary on the Water Classic) documented 1,252 rivers of various sizes, fully recording the landforms, hydrology, vegetation, water conservancy, economic development, cities, historic sites, rocks and minerals, legends, and customs and citing 437 references. Much of the information was based on the personal investigations and detailed interviews by the author. The book is of great scientific value as it represents the most systematic and comprehensive geographical work of China in the early sixth century and provides important references for studies of historical geography, farmland, water conservancy, history, archaeology, ethnology, and literature.

Sial This term refers to the composition of the upper layer of the Earth's crust, which consists mainly of sedimentary rocks, granite and metamorphic rocks. The Conrad discontinuity divides the crust into the upper crust and lower crust. The upper crust is a silica-aluminium-rich layer, while the lower crust is mainly a silica-magnesium-rich (sima) layer. The silica-aluminium-rich layer is the lower crustal lithospheric layer and is composed of basic rocks and metamorphic rocks. Because the Conrad discontinuity has an intermittent pattern globally, the upper and lower crusts are not always discretely divided. Silica-magnesium-rich layers are widespread globally and exist in both the continents and oceans, while silica-aluminium-rich layers mainly exist in the continental crust but tend to be very thin, or even missing, in the oceanic crusts. The continental crust is an average of 35 km thick and can reach 60–70 km thick, but the oceanic crust is only 5–15 km thick.

Sian Ka'an, Mexico Sian Ka'an is located in Quintana Roo State in eastern Mexico on the east coast of the Yucatán Peninsula and covers a core protection area of 5,280 km^2. In the language of the Mayan people who once inhabited this region, Sian Ka'an means 'origin of the sky'. This biosphere reserve contains tropical forests, mangroves and marshes as well as a large marine section intersected by a barrier reef. It provides a habitat for remarkably rich flora and fauna comprising more than 300 species of birds as well as a large number of the region's characteristic terrestrial vertebrates, which live together in the diverse environment formed by its complex hydrological system.

Sichuan Geological Survey Route Series The chief editor of this book was Maoxun Chen. The series was published by the Chengdu University of Science and Technology Press from 1991 to 1996. It is published in two languages, and the English translators are Tao Zhang and Lisheng Zhang. It comprises nine volumes, including 'Investigation Guide of the Natural Landscape of the High Altitude Karst Geology in Huanglong- Jiuzhaigou, Sichuan Province', 'Investigation Guide of the Zigong Dinosaurs and Karst Geology in Southern Sichuan', 'Investigation Guide of the Geology, Geomorphology and Landslides in the Three Gorges of Yangtze River', 'Investigation Guide of the Quaternary Glacial Geology and Landscapes of Mount Luoji', 'Investigation Guide of the Glaciers of Mount Gongga and Hailuo (Sea Snail) Valley and Quaternary Geology', 'Investigation Guide of the Nappe Tectonic Zones and Landscapes in Mount Longmen', 'Investigation Guide of the Songpan – Ganze Indosinian Fold Belt in the Eastern Qinghai-Tibet Plateau', 'Investigation Guide of the Geology and Landscapes of Mount Emei' and 'Investigation Guide of the Geology of the Panxi Rift Valley'.

Sichuan Wolong Giant Panda Sanctuaries, Sichuan These sanctuaries are located in the western Sichuan Plain in Sichuan Province, and the core protection area covers 9,245 km^2. The Sichuan Giant Panda Habitat is home to more than 30% of the endangered giant pandas in the world. It includes seven natural reserves and nine scenic sites in the Songshan and Jiajinshan districts. Giant pandas are living fossils left over from the ancient tropical forest environments in the Palaeogene and the Neogene. These protected areas constitute the largest and most complete remnant of giant panda habitats.

Side Groove Landscape This is a landscape composed of horizontal grooves along the edges of cave walls. They form near the water surface, and the height and width generally do not exceed 1 m. These grooves mainly form inside karst caves, and they can sometimes be found on steep cliffs surrounded by water outside the cave. Side grooves are often layered, indicating that the water level has changed. Each layer corresponds to a period of stable water. Side grooves that develop on cliffs outside a cave may have been formed by biological activity as well as water dissolution.

Sierozem *Synonym:* ▶ *Calcareous soil*

A sierozem is a weak leaching soil that forms in the warm temperate zone in arid steppe vegetation. It develops on the parent material

of loess and is formed by weak humus accumulation and strong gypsum and soluble salt deposition. The soil is greyish brown, yellowish brown and brown. The profile contains a small amount of gypsum, and the entire section has a strong lime reaction. It is a zonal soil type in desert grassland areas and is between black loess and grey desert soil.

Sierra Norte di Sevilla, Andalusia, Spain This geopark is located in the Morena Mountains between Ossa-Molina and the geological region of southern Portugal, and it covers an area of 1,774 km^2. It became a global geopark in 2011. The geopark is one of the largest natural parks in Andalusia and has a rich geological heritage that has promoted sustainable economic development through geotourism. Most of the rocks in the geopark can be dated back to the Precambrian, Palaeozoic (540 million years), Permian (290 million years) and Early Triassic (258 million years), but some of the sedimentary rocks exposed in the southeastern part of the park were formed 20 million years ago during the Miocene.

Sightseeing Sightseeing is one of the most common tourism activities. The goal of sightseeing is to appreciate nature, urban views, scenic areas and historic sites. Through sightseeing, people can enjoy the beauty of scenery, relax their mind and body and re-energize themselves. It is one of the world's oldest, most common and basic ways of travelling.

Siguang Li Siguang Li (1889–1971), nicknamed Zhongkui, was a native of Huanggang City, Hubei Province. He was a geologist and a founder of geomechanics as well as one of the founders of China's geology. He was a professor and director of the Department of Geology at Peking University. After the founding of the People's Republic of China, he served as minister of geology and vice president of the Chinese Academy of Sciences, chairman of the China Association for Science and Technology, and vice president of the World Association of Scientists. He devoted his life to research on palaeontology, glaciology, geomechanics and energy minerals. He made significant contributions to the development of China's energy industry. His major works include 'The Geology of China', 'Shovel Branch of Northern China', 'Mount Lu in the Ice Age', 'Introduction to Geomechanics', and 'Seismology and Geology'.

Siliceous Sinter *Synonym:* ▶ *Geyserite landscape*
This is a type of sinter landscape containing deposits on the ground or hot rock layers derived from the dissolved silica in geysers, boiling springs and hot mineral springs. Siliceous sinter is mainly composed of amorphous opal or chalcedony. The water that brings the dissolved silica to the surface is generally at a temperature over 180 °C. In this respect, siliceous sinter is a good indicator of high subsurface temperatures. Some siliceous sinters contain a small amount of iron or magnesium, which gives them a variety of colours. Dissolved silica is generally in solution in the hot spring water, but if the concentration is very high, some silica will be transformed into the colloidal form when cooled. The process of silica precipitation is complex, and high pH, high saturation, high temperature, and the existence of colloidal silica and other substances promote the formation of opal siliceous sinter. Algae activity can also play a role in this process (Fig. 29).

Silicified Wood or Petrified Wood Silicified wood is also known as petrified wood or wood jade. These fossils are the result of the silicification of ancient buried trees, such as cycads, ginkgo trees, conifers and cyatheas. These fossils preserve the external form and internal structure of the original plants. Based on the degree of crystallisation and petrification, silicified wood can be made up of aphanocrystalline quartz, chalcedony, opal, calcite, dolomite, limonite and pyrite, and it can be light yellow to yellow, red, yellowish brown, reddish brown, brown, black, grey and white. In China, silicified wood fossils have been found in Xinjiang Province, Inner Mongolia, Yunnan Province, Hebei Province, Beijing, Hubei Province, Shandong Province, Gansu Province, Fujian Province, Liaoning Province,

Shanxi Province, Jiangxi Province and Sichuan Province. These fossils are preserved in Mesozoic terrestrial facies, and the plant species are mainly conifers. The Cenozoic fossils are dominantly angiosperms (Fig. 30).

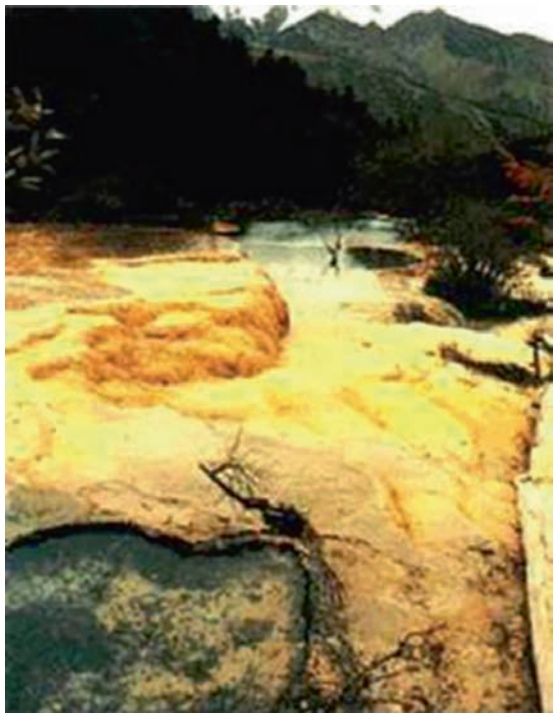


Fig. 29 Siliceous sinter landscape

Silk Road The Silk Road refers to the land route explored by Zhangqian in his expedition to the western regions during the Western Han Dynasty (202 B.C. to 8 A.D.) from Chang'an (now Xi'an), through Gansu, Xinjiang, to Central Asia, Western Asia, and ultimately the Mediterranean countries. This route was given the name Silk Road (also known as the 'Northwestern Silk Road') because silk products were the main commodities transported to the west. There were three basic routes during the Western Han and Eastern Han periods: Southern Route, Middle Route and Northern Route. There was also a maritime Silk Road, which facilitated communication with southeast Asia, southern Asia, western Asia, Europe and Africa from the sea. This sea route started in Yuanding Year 4 of Emperor Wudi of the Han Dynasty (113 B.C.). The earliest port of departure was today's Hepu Port in Beihai, Guangxi Province, and other departure ports were developed later, such as Guangzhou (during the Jin Dynasty) and Quanzhou (during the Southern Song Dynasty).

Sill A sill is also called a sheet and is a tabular magma intrusion that has intruded between layers of rocks (rock strata) and is concordant (uniformly distributed) with the rock strata. Sills are generally thin but have large areal

Fig. 30 Silicified wood



extents. Basic and ultrabasic rocks are commonly associated with sills.

Sillimanite The composition of sillimanite is Al [$AlSiO_5$], and it crystallizes in an orthorhombic crystal system. The crystals are acicular, usually in the form of radiating fibrous aggregates. The colour is grey, brown or greyish green. It has a vitreous or silky lustre and uneven fractures. Its specific gravity is 3.23–3.25, and its Mohs hardness is 7. Sillimanite is a standard mineral of metamorphic rocks and is common in intrusive rocks, contact metamorphic zones with aluminium-rich rocks, and crystalline schist and gneiss.

Silt Silt is a fine-grained clastic material that has been eroded by weathering of exposed surface rocks. Silt has a particle size of 0.0036–0.0625 mm, which is between sand and clay. It is mainly distributed in ocean, river and lake sediments. Its composition is similar to that of sand, but it contains fewer rock clastics.

Siltstone Siltstone is a clastic sedimentary rock consisting of grains with sizes of 0.0039–0.0625 mm. It contains at least 50% silt, and its clastic composition is relatively simple: mainly quartz and small amounts of feldspar, mica, chlorite and clay minerals but little detritus. Based on the particle size, siltstone can be divided into coarse siltstone (0.0312–0.0625 mm) and fine siltstone (0.0039–0.0312 mm). According to the clastic content, it can be divided into feldspar siltstone, quartz siltstone, detritus siltstone (very rare) and other transitional types. Based on the cementing material, sandstone can be divided into clayey, ferrous, calcareous and dolomitic siltstones. Based on the composition, it can be categorized as argillaceous siltstone, ferrous siltstone and calcareous siltstone. The grains in siltstone are usually angular. Siltstone forms under weak hydrodynamic conditions, and it often contains thin horizontal bedding with thin sand beds and convoluted bedding.

Silurian Boundary Section in Ziyang, Ankang, Shaanxi This section is along the boundary between the Silurian Llandovery Series (First Series) and the Wenlockian Series (Second Series). The section is well developed in East Qinling, especially in the Ziyang area in Ankang, Shaanxi Province, where the outcrop is adequately exposed with a continuous graptolite bed that has attracted the attention of academics in China and abroad. The section is also located at Xianzhong Goukou in Bajiaokou Village, Ziyang County, Shaanxi Province. Its lower bed (top of the Llandovery Series) is called the 'Wujiahe Formation' and is made up of a thin to moderately thick layer of silty slate and a thick layer of sandstone that are rich in graptolite fossils with a Cyrtogaptus sakmaricus fossil layer at the top. The upper bed (Wenlockian Series) is called the 'Xianzhong Gou Formation' and consists of a thin to moderately thick layer of sandstone that is also rich in graptolite fossils. The lowest Cyrtogaptus centrfugus fossil layer represents the boundary between the Wenlockian Series and the Llandovery Series.

Silurian Period The Silurian Period is the third period of the Palaeozoic Era; it lasted for 28 million years, from 444 to 416 million years ago. It was named by the geologist R.I. Murchison in 1839. The Silurian System includes the rocks that formed during the Silurian Period. Internationally, the Silurian System is subdivided into four series and seven stages, which are classified basing on graptolite fossils.

Silurian System in the Three Gorges Areas of Hubei This is the Silurian System in the Three Gorges areas of Hubei. This system is located in the Dazhongba area of Yichang City, Hubei Province, and it includes two stage stratotype sections, namely, the 'Longmaxi Stage' and the 'Dazhong Stage' at the base of the Silurian. The 'Longmaxi Stage' section is mainly composed of black graptolitic shale that is rich in graptolite fossils, and the first appearance of Akidograpus ascensus is considered the standard indicator. There are four graptolite zones, which are equivalent to the 'Rhuddanian Stage' on the International Stratigraphic Chart. The lower part of the 'Dazhong Stage' section is composed of black graptolitic shale that gradually transitions into a thin layer of

yellowish green shale in the upper part, which is signified by the first appearance of the graptolite Demirastrites tragulatus as a standard indicator and is equivalent to the 'Aeroian Stage' on the International Stratigraphic Chart.

Sima See ▶ Sial.

Simangaliso Wetland Park, South Africa This park is also known as 'St. Lucia Wetland Park' and is located in the Indian Ocean coastal area of KwaZulu-Natal in the northeastern corner of South Africa. It has a core protection area of 2,395 km^2. The numerous landform types include coral reefs, narrow sandy beaches, coastal sand dunes, lakes, swamps, and endless reeds and grassy wetlands. The interactions of different types of environments, combined with factors such as floods, coastal storms, and the transitional geography between the tropical and subtropical regions of Africa, have made the heritage sites rich in species diversity and have also allowed the emergence and development of new species.

Simien National Park, Ethiopia Simien National Park is located in the Gondar Zone in northwestern Ethiopia and protects a core area of 220 km^2. Massive erosion on the Ethiopian plateau has created one of the most spectacular landscapes in the world, with jagged mountain peaks, deep valleys and sharp precipices dropping 1,500 m. The park is home to several extremely rare animals, such as the Gelada baboon, the Simien fox and the Walia ibex, a goat found nowhere else in the world.

Sinan Wujiang Karst National Geopark, Guizhou This geopark is located in Sinan County, Guizhou Province, and covers an area of 97 km^2. It became a national geopark in 2009. It is characterised by karst landscapes that formed in Ordovician and Permian limestones. The well-developed karst landscapes on the surface and below ground created a complete karst system. There are gorges and fluvial landforms. Collapses, landslides, soil creep and soil flow occur in the geopark. Numerous Permian palaeontological fossils can be found in Centougai in Qinggangpo Town, and the main fossils are armenoceras and ammonitida.

Sinharaja Forest Reserve, Sri Lanka This reserve is located along the border between Sabaragamuwa Province and Southern Province in southwestern Sri Lanka and has a core protection area of 85.6 km^2. The reserve is the country's last major area of primary tropical rainforest. More than 60% of the trees are endemic, and many are considered rare. There is also abundant endemic wildlife, especially birds. The reserve is also home to more than 50% of Sri Lanka's endemic species of mammals and butterflies as well as many kinds of insects, reptiles and rare amphibians.

Sinian Period The Sinian Period is the third period of the Neoproterozoic Era in China. It extended from 680 million to 542 million years ago, a duration of 138 million years, and is equivalent to the international Ediacaran Period. The Sinian System includes the rocks that formed during the Sinian Period. The standard section of the system is located in the Three Gorges area. The term 'Sinian' originates from the nomenclature in ancient China (Latin Sina). It was first used as a stratigraphic term by Richthofen in 1871. Its initial meaning refers to the large body of carbonate rocks that were deposited on top of an ancient metamorphic rock system.

Sinian System in the Three Gorges Area of Shaanxi East This section, which is located in Xiling Gorge in Yichang, Hubei Province, is China's best developed and well-studied section in the early stage. By 1924, Li Siguang had established a standard strata bed sequence at this location. Initially, the Sinian System was divided into four formations: the Liantuo Formation (Nantuo sandstones), Nantuo Formation (Nantuo moraine), Doushantuo Formation and Dengying Formation. At the second working meeting on stratigraphic dating convened by China's National Commission of Stratigraphy in 1999, the meaning of the Sinian System was redefined. The newly defined Sinian System is limited to the Upper Doushantuo Formation and Dengying Formation of the original Sinian System. On this basis, the Doushantuo

Stage and Dengying Stage were established in accordance with the fossil assemblage characteristics. These stages signify remarkable changes in global tectonics, environments and biological evolution. The most prominent feature is the evolution of multicellular organisms (including metazoans and advanced red algae, green algae and kelp). This period is equivalent to the era of the Ediacaran biota, including China's Miaohe biota, Gaojiashan biota and Weng'an biota. The section is dominated by carbonatite, which is approximately 300–1,200 m thick and is located above the Nantou moraines and beneath the Cambrian 'Meishucun Stage', which is rich in small shell-bearing fauna fossils. This section can be compared to the chronozone of 542–680 million years ago.

Sinian-Cambrian Boundary Section at Meishucun, Jinning, Yunnan This is a geological boundary section located on the Tuan Shan hilltop, Xiao Wai Tou Shan and Baodaowan areas at the Kunyang phosphorus mine site northwest of Meishucun Hill Village. It is an important geological section for studies of the Sinian-Cambrian boundary, and it was selected by the International Working Group on the Precambrian-Cambrian Boundary as China's international boundary stratotype. The section includes sedimentary layers of phosphate, carbonate and clastic rocks called the Yuhucun Formation and Qiongzhusi Formation. Algae fossils, trace fossils, small shell-bearing fauna fossils and trilobite fossils are present from the bottom to the top. Three boundary points were proposed for the base of the Cambrian: (1) The bottom of the first trilobite fossil bed, which corresponds to the bottom of the oldest Parabadiella trilobite fossil layer in the black shale bed in the Yu'an Member of the Qiongzhusi Formation; this early proposal was not adopted. (2) The bottom of the small shell-bearing fauna fossil bed, where the earliest small shell-bearing fauna fossil Anabarites-Circothea combination (boundary line reference 'A') first appears; however, this proposal is not internationally accepted. (3) The boundary between the Anabarites-Circotheca combination and Paragloborilus-Siphogonuchites small shell-bearing fossil beds (boundary line reference 'B'); this was adopted as China's boundary point for demarcating the Precambrian (Sinian)-Cambrian.

Sinkhole, Ponor, Shakehole, Doline Karst Landscape A sinkhole is a near-vertical cavern that discharges surface water in a karst area. It is formed by dissolution, mechanical erosion and collapse caused by running water along fissures. These caverns are distributed in karst depressions, polje bottoms and sometimes on slopes. Sinkholes have various forms such as circular, oval and slot-shaped. Their depths range from several metres to more than a hundred metres. When they have steep walls and a great depth, they are called vertical shafts. Some sinkholes are not only drain holes but also serve as vertical seepage holes to discharge excessive groundwater overflow during periods of flooding. They are called estavelles and are commonly called 'leigong hole' in China, which means 'Thunder God Hole'. The Qingjiang River enters the ground through the Tenglong Hole in Lichuan City, Hubei Province, to form unique scenery called 'Crouching Dragon Swallows the Qingjiang River'. This hole is 35 m high and 25 m wide and is at an elevation of 1,061 m. From this hole, the Qingjiang River drops to an elevation of 30 m, which forms the scenery of one of the world's very rare large sinkholes.

Sinoceras Sinoceras is a genus of cephalopods and is one of China's unique fossils, which is where it gets its name. It is shaped like a pagoda or bamboo shoot, so it also has the nicknames Pagoda Stone, Bamboo Shoot Stone or Exorcism Stone. Sinoceras fossils are considered higher quality if their internal structures have been exposed along the central longitudinal section of the shell by weathering. They are mined from the Middle Ordovician (480 million years ago) purple or light greenish grey limestone strata with mud cracks in western Hubei and Hunan Provinces. In 1994, a 162-cm-long piece of Sinoceras fossil was



Fig. 31 Sinoceras

unearthed in a limestone layer in Hubei Province. This fossil is by far the largest invertebrate fossil ever found in China (Fig. 31).

Sino-Korean Block This block was named by Huang Jiqing in 1945 and 1980 as the 'Sino-Korea Platform' and 'Sino-Korean Paraplatform', respectively. It is equivalent to the North China Platform. Some researchers believe that it should be called the 'Sino-Korean Block' because older rock systems have been exposed from eastern Hebei Province to North Anshan in northern China.

Sinosauropteryx Sinosauropteryx is a genus of the theropod Compsognathus. It was found in the tuffaceous siltstone layer of the Lower Cretaceous Yixian Formation in Sihetun, Beipiao, Chaoyang City. Chinese and international palaeontologists consider Sinosauropteryx to be the first feathered theropod dinosaur found and it was a transitional species between dinosaurs and birds. This important discovery provided crucial evidence for the hypothesis that birds originated from small theropod dinosaurs (Fig. 32).

Sinter Landscape Groundwater, geothermal water and underground steam may contain dissolved calcium bicarbonate and other minerals. The chemical deposits along the spring pool edge or in cracks are called sinters. Sinters have strange shapes with many colours, so they have high ornamental value. Sinters and the associated spring pools form a sinter landscape. Based on the composition, sinter can be classified into calcareous sinter, sulphurous sinter, siliceous sinter, salt sinter and metallic mineral sinter. Calcareous sinter (travertine) is most common.

Sinter Tourism Landscape Groundwater brings dissolved minerals to the surface, which settle to form a 'sinter' landscape. Common sinters include sulphur sinters, siliceous sinters, calcareous sinters, salt sinters and metal sinters, and calcareous sinters or travertine are most common. Sinters have unique and distinct forms and many colours, and their tourism value is high. Examples are the travertine stream in Huanglong and the travertine pool in Jiuzhaigou, Sichuan Province, and the Baishuitai (White Water Platform) composed of sediments in a carbonic spring in Zhongdian, Yunnan Province. They are rare natural features in China.

Sir Charles Lyell, Baronet Sir Charles Lyell, Baronet (1797–1875), was a male and the founder of modern geology. He was the president of the Geological Society of London. He was elected a fellow of the Royal Society in 1826 and was awarded a Royal Medal in 1834, the Copley Medal in 1858 and the Wollaston Medal in 1866. His major works are 'Principles of Geology' (4 volumes), 'Elements of Geology' and 'A Manual of Elementary Geology'.

Fig. 32 Sinosauropteryx



Sister Geopark Sister parks relationships are established between geoparks for mutual benefits through better exchange of knowledge and experiences. These geoparks normally have similarities in their natural or geological resources and management, but this is not most essential. They work together for mutual promotion, marketing, joint activities, research, experience and knowledge sharing, and staff exchanges.

Site Plan of a Tourism Area A site plan of a tourism area is a plan that lists the requirements for all construction and engineering projects based on the regulatory plan. According to the Methods of Urban Plan Formulation issued by the Ministry of Housing and Urban-Rural Development, a site plan should include the following content: (1) analysis of construction conditions and an overall technological and economical evaluation; (2) the spatial layout of structures, roads and green areas, landscape design and the master plan; (3) a road traffic design; (4) a green area design; (5) an engineering pipeline design; (6) a vertical design (7) an estimate of the construction, demolition and total costs and an analysis of the investment benefit.

Sixth Group of National-Level Scenic Areas On December 31, 2005, the State Council announced an additional ten national-level scenic areas. Among them, Wugongshan Scenic

Area in Jiangxi Province and Ziquejie Terrace and Meishan Caves in Hunan Province were included in the first group of the 'Tentative List of China's Natural Heritage Sites' and the first group of the 'Tentative List of China's Natural and Cultural Heritage Sites' by the State Council in January 2006.

Skiing Tourism Skiing tourism includes skiing activities on alpine or artificial snow fields with special equipment. The Alps in Europe is the most famous destination for skiing. In recent years, Heilongjiang, Jilin and Liaoning Provinces have built skiing tourism bases with natural snow fields, while areas such as Beijing have constructed artificial snow fields. Skiing has become an important part of winter tourism.

Škocjan Caves, Croatia Škocjan Caves are located in the borderland of southwestern Slovenia near Istria, Croatia, and have a core protection area of 4.1 km^2. The exceptional system of limestone caves comprises collapsed dolines, approximately 6 km of underground passages with a total depth of more than 200 m, numerous waterfalls and one of the largest known underground chambers. The site, which is located in the Kras region (literally meaning karst), is one of the most famous in the world for studies of karst phenomena.

Slate Slate is a shallow metamorphic rock with a lamellar structure that can be formed by shallow metamorphism of various rocks, such as the clay rock, siltstone, siliceous rock, intermediate acidic tuff, carbonaceous rock and calcareous rock. The degree of metamorphism is very low, and the minerals are generally not recrystallized. The rocks are mainly clay slate, silty slate, siliceous slate, tuff slate, carbonaceous slate, and calcareous slate. Slate can be named by putting the name of the new metamorphic minerals in front, such as sericite clay slate and chlorite clay slate. Slate has a dense texture and fine grains with smooth cleavage surfaces.

Slaty Cleavage Slaty cleavage is a structure that looks like piled wood planks and forms during the deformation and metamorphism of rocks. It occurs in shallow metamorphic rocks and it has different definitions: (1) it is a group of cleavage that often forms due to subsurface stress, and it can be parallel or oblique to the bedding of the existing rock. The cleavage faces are straight and smooth and are often accompanied by small amounts of dynamic metamorphic minerals (e.g., sericite and chlorite); (2) it is a planar structure that forms along the bedding planes of an existing rock due to contact metamorphism.

Smoky Quartz Smoky quartz is also known as 'Chinese Ink Quartz' and is a good material for gems. It can be brown, brownish black or black. The cause of the varying colours is unknown. Some think that they are caused by organic material or carbon, but others believe they are due to rock radiation. Smoky quartz is an excellent material for crafts and for making lenses. Famous mining areas include the Alps in Switzerland, Brazil and Madagascar.

Snow Disasters Snow disasters are natural phenomena caused by large amounts of snowfall over a long period of time that cause widespread snow cover. Snow disasters mainly occur in stable snow-covered areas and unstable snow-covered mountainous regions and occasionally in transient snow areas. Snowstorms can cause traffic jams and damage to communication lines, affecting normal tourism activities.

Snowline This is also known as the balance line, and it is the line where the snowfall equals the melting rate. Because the snowfall above the snowline is greater than the melting rate, the area above the snowline is permanently covered with snow. In contrast, the area below the snowline has annual snowfall less than the melting rate, so the snow cover is only seasonal. Due to the effects of temperature, the amount of precipitation and topography, the elevation of the snowline varies in different regions. The aspect and elevation are the determining factors for the formation of glaciers in any location (Fig. 33).

Snowstorm Storms accompanied by heavy snowfall are called snow storms. During snowstorms, the horizontal visibility is less than 1 km, the wind speed reaches 56 km/h, and the temperature drops below −5 °C.



Fig. 33 Glacial snowline in the Tibetan Plateau (4,200 m)

Snowy Landscape Snowy landscapes are important meteorological tourism resources during the winter in high latitude and cold regions, especially mountainous areas. The extensive snow coverage and ice scenery in northeastern China are important attractions for tourists and provide excellent venues for winter sports activities.

Sobrarbe Geopark, Spain This geopark was set up in 2006. It is located in the heart of the southern Pyrenees Mountains in Aragon, Spain, and it covers an area of 2,202 km^2. The main geosites in the geopark include the ancient metal mining relics in the Palaeozoic mountain range in the northern part of the area, whereas the southern area contains younger Mesozoic to Palaeogene rocks that were affected by glacial processes during the Quaternary. The mountains that make up the Ordesa and Monte Perdido National Parks were shaped by groundwater. The karst and sedimentary landforms are both favourable tourist destinations. The clear outcrops of Eocene to Oligocene sedimentary rocks are ideal locations for studying the relationship between tectonic activity and sedimentation in the Eocene foreland basin. Fossils have also been discovered, including money bugs and saltwater crocodiles. In addition, the geopark has opened a route through which visitors can learn about the basic geological features of the area. Five bicycle routes have also been constructed, with stops to view interesting geological features.

Socotra Archipelago, Somalia These islands are located approximately 200 km east of Cape Somalia and southeast of Yemen, near the Gulf of Aden and adjacent to the Arabian Sea in the Indian Ocean. The total protection area covers 4,104 km^2. The archipelago is 250 km long and consists of four large islands and two smaller islands. The diverse and unique flora and fauna of the islands add value to its biodiversity; 37% of the 825 plant species, 90% of the reptiles, and 95% of the snail species have not been found in other parts of the world. The heritage site supports the most important land birds and seabirds in the world, including many endangered birds. The Socotra Archipelago also has abundant marine resources, including 253 species of reef-building corals, 730 species of coastal fish, and 300 types of crabs, lobsters and shrimps.

Soda Straw Landscape A soda straw is a slender, hollow tube-like depositional feature that

hangs on the roof of a karst cave and it gets its name because it looks like a straw. When calcium carbonate solution seeps from a crack in the cave roof, the solution droplets regularly (from seconds to hours) hang on the roof. Carbon dioxide in the droplets escape, causing the water droplets to become saturated. Calcium carbonate released from the droplets crystallises to form a very thin calcium membrane. When the water drops, the calcium membrane bursts, and a small amount of calcium carbonate is deposited on the cave roof, forming a ring. The ring's diameter is similar to that of the water droplet. Dripping water droplets continue to supply calcium carbonate, and the ring will accumulate downwards to form a slender and hollow soda straw-like stalactite. The inner diameter of the straw is generally 3–4 mm, the wall thickness is 0.5–2 mm, and the lengths range from dozens of centimetres to several metres. Soda straws are the basis of stalactite formation. When the straw's internal passage is blocked, water seeps along the outside walls and is deposited to form inverted cone-shaped, icicle-shaped or breast-shaped stalactites, and the stalactite cross-section shows the concentric circular patterns of the soda straw (Fig. 34).

Soil and Water Loss Due to the effects of external forces such as water, gravity and wind, land and water resources can be damaged, causing losses of these resources and reductions in productivity. This is called surface or soil erosion as well as water and soil losses.



Fig. 34 Soda straw landscape – Guangxi Province

Soil Classification Based on their composition, occurrence and formation, soils can be classified into different categories. Currently, there are two main classifications: the genetic classification based on the soil-forming processes and the classification based on the characteristics of soil profiles. The Unified Soil Classification System (USCS) of North America classifies soils into three groups: (1) coarse-grained soils (e.g., sands and gravels) (2) fine-grained soils (e.g., silts and clays) and (3) highly organic soils (referred to as 'peat').

Soil Fall Landscape *Synonym:* ▶ *Landslide landscape*
This is a geological phenomenon in which the soil on a steep slope suddenly detaches from the mountain and slides due to gravity. They are common in regions with loess or loess-like soil. The scale and damage are generally lower than that of the rockslides.

Soil Geography Soil geography is a discipline that studies the relationship between soil and the geographical environment. It is an interdisciplinary field between soil science and physical geography that focuses on the occurrence, development, classification, and distribution of soil, soil surveys and the mapping and zoning of soil. It provides a scientific basis for planning, rational use, soil improvement and the evaluation and protection of soil resources.

Soil Lime This is a type of soil with a very high calcium content. It develops on parent material such as limestone. Erosion and weathering form saturated salts. Soil lime has obvious lithological characteristics and is a type of intrazonal soil that is generally localized.

Soil Pollution The harmful and toxic substances generated by human activities can enter the soil and accumulate to concentrations that exceed the self-purification capacity of the soil itself, resulting in deteriorations of soil properties, changes in the physiological function of plants, and negative effects on humans. The main sources of soil pollution are industrial and municipal wastewater and solid waste. In addition, atmospheric pollutants, including

pesticides, fertilizers, livestock excreta and wastes, can be deposited on the ground through sedimentation and precipitation. The pollutants that crops absorb and take in from the soil can cause direct harm to human health through the food chain.

Soil Science Soil science is the science of the composition, physics, chemistry, biological properties, fertility characteristics, formation, evolution, classification, distribution, mapping, utilization, improvement, and management of soils.

Solonchak Solonchak is a type of soil with a very high salt content. In arid and semi-arid areas and areas where the groundwater table is high, evaporation causes salty groundwater to rise through the capillary pores to the surface, leading to salt accumulation.

Solution Cap Landscape This is a cap-like mountain landform that is formed by dissolution. In areas with carbonate rocks, isolated cap-like mountains with flat tops, steep cliffs and gentle slopes can form due to dissolution and gravitational collapse in strata with different lithologies. This type of landform is called 'gu' in Shandong Province, and it resembles the karst isolated peak landscape in southern China. Baodugu on Xionger Mountain has been rated as the best of the 72 gu (solution caps) in central Shangdong Province. There is also a Sinian limestone solution cap in the Huangling anticline around the Three Gorges (Fig. 35).

Solution Marks Surface water can cause dissolution of soluble rocks, creating small grooves and pits that are known as solution marks. These marks are generally wide and deep; they are a few centimetres to more than 10 cm wide and deep and can be a few centimetres to several metres long. Solution marks are common, particularly in areas with annual precipitation greater than 700 mm. They can be divided into angular, patched, honeycomb, fish-scale and window shade shapes (Fig. 36).

Songliao Block This block is located on the eastern side of the Daxing'anling Range and covers an area of approximately 260,000 km^2, which is roughly equivalent of the Songliao Plain. In general, its shape resembles an irregular



Fig. 35 Solution cap landscape – Shandong Province



Fig. 36 Solution marks landscape – Shilin, Yunnan

rectangle with a NNE trend. There is currently no agreement about the basement of this block. Some believe that this block has Precambrian crystalline basement, but others believe that the base is a massif that formed due to Hercynian folding. During the Cenozoic, this area was a large basin with thick continental sediments; hence, it has become an important oil-producing area in China.

Songshan Global Geopark, China Songshan Geopark is located in Dengfeng City, Henan Province, and covers an area of 464 km^2. It became a global geopark in 2004. It includes ten scenic districts stretching from west to east, including Anposhan Mountain, Wufo Mountain, Danyang Mountain, Shaolin Mountain, Taishi Mountain and Wuzhi Ridge. These mountains have steep slopes and cliffs and rise above each other, providing magnificent views. Located at the southern margin of the North China craton, it is geologically significant because of its clear representative structure that covers five geological periods over 3.6 billion years of Earth's history. It has been named 'five generations living together' by geologists. Songshan is the 'Central Mountain' and is one of the China's famous 'Five Mountains'. It has numerous cultural features, including ten temples and monasteries, five shrines, five palaces, three Taoist temples, four Buddhist convents, four caves, three forums and more than 270 pagodas. It is one of the hubs of Buddhism, Confucianism and Taoism.

Songshan National Geopark, Henan See ▶ Songshan Global Geopark, China.

South American Plate The South American Plate includes the western part of South America and the South Atlantic. Its eastern boundary is the Mid-Atlantic Ridges, and the deep Chilean Trench, which is near to the coast of South America, is located to the west. This plate moves west, and the deep Chile-Peru Trench and the towering Andean Mountain ranges formed due to the subduction of the Nazca Plate to the west.

South China Block Some scientists limit the Cathaysian Block to the area between China's southern and eastern coasts and the vast Caledonian Trench to the north. Hence, this block is also called the 'South China Block'. Its area is similar to that of the 'Cathaysian Block'.

South China Karst, China This heritage site is located in southern China, including the provinces of Yunnan, Guizhou and Chongqing City. It has a core protection area of 476 km^2. The total karst area of southern China covers more than 500,000 km^2 and is an outstanding representative of humid tropical and subtropical karst landscapes around the world. Yunnan Shilin is a world-class karst landform with a wide variety of shapes

and colours and forms first-class natural scenery. The Guizhou Bolangjiang River is a world-class example of pyramidal and towering karst topography. Chongqing Wulong's karsts contain large-scale tiankengs, natural arches and caves.

South China Orogenic Belt This belt is located in Hunan Province, southern Jiangxi Province, Fujian Province, Guangdong Province, and parts of Guangxi and Zhejiang Provinces in southern China. It lies in the vast areas between southern Ghiangnania and northern Cathaysia. In the past, some scientists called it the South China and East Caledonian Fold Belt or the South China and East Caledonian Orogenic Belt. In the late Palaeozoic, this region became a stable block. In the Mesozoic, the area was greatly affected by the subduction of the Pacific Plate accompanied by strong volcanic activity and magmatic intrusions, followed by the deposition of red strata of terrestrial facies in fault basins. This eventually resulted in the formation of a typical Danxia landform in eastern China, which has provided significant geological resources for tourism development.

Southern Mountain Hengshan The Southern Mountain Hengshan is one of the Wuyue (Five Peaks) of China. It is located in western Hengshan County on the western side of the Xiang River, Hunan Province. It is a fault-block mountain composed of Yanshanian granite. The main peak, Zhurong (Fire God) Peak, has an elevation of 1,300.2 m in. The mountain is towering and spectacular. Hengshan has a long cultural history. Local people believe that in ancient times, King Shun had visited the area during his travel to the southern part of the country. They also believe that King Yu had also visited during his flood control operation. This mountain was also a place of worship by emperors of various dynasties and has been a holy site of Buddhism. More than 200 temples were built here, including the important relics of the Nanyue (South Peak) Temple, Zhusheng Monastery, Buddhist Scriptures Hall, Fangguang Temple, Nantian (Southern Heaven) Gate and the Banshan Pavilion. The Nanyue Temple was built during the Tang Dynasty and covers approximately 100,000 m^2, which makes it the largest ancient architectural complex in Jiangnan. Other cultural monuments include the Anti-Japanese War Heroes Shrine, which was built in 1942 and has an architectural style akin to that of the Nanjing Zhongshan Mausoleum and a similar solemn atmosphere.

Space Tourism Space is an attractive tourism resource. In the early 1960s, the Soviet astronaut Yuri Gagarin travelled outside the Earth by spacecraft and was impressed by the beauty of the Earth and Moon. In the early 1980s, the royal prince of Saudi Arabia travelled to space at his own expense. Scientists from various countries have visited space using spacecraft and space shuttles to conduct scientific experiments. The United States Seattle Space Exploration Company began organising space tours in 1993. A typical trip will consist of flying 5–8 orbits around the Earth and will last for 8–12 h. Approximately 250 people have made reservations by paying $52,220 each. The US space travel company Virgin Galactic's spacecraft was tested successfully in October 2010 and began their private space tourism business at end of 2011. In 2003, China launched the Divine 5 and 6 manned spacecraft. Since then, many countries have started to compete in the potentially large space tourism market.

Space Tourism System Space tourism can be performed by travelling on spacecraft to observe the Earth and universe from space. In the future, spacecraft also may also take tourists to the moon, Venus and other planets for sightseeing.

Special Animal Community Tourism Special animal communities in some geographically unique regions attract tourists. The animals may appear as a single community or as comprehensive and integrated animal communities. Animals living in single communities include the Tibetan antelope in Kekemianli, the golden monkey in Shangnan, Shaanxi Province, the snakes on Snake Island near Dalian, the birds of Qinghai Lake in Qinghai and the butterflies in the Butterfly Valley in Taiwan. Examples of comprehensive

communities include the well-preserved Late Mesozoic fauna in New Zealand. This is the oldest comprehensive animal community on Earth. After Madagascar detached from the African continent approximately 100 million years ago, the island developed a unique and independent ecosystem, and it has retained animal communities that are supposedly extinct in other regions. They attract large numbers of scientific researchers and tourists.

Special Tourism Planning Special tourism planning focuses on specific areas of tourism development, such as marketing planning, tour guide system planning, campsite planning and self-driving route planning. Special planning helps to sort out difficult and unsolved problems in tourism planning and make it more operational.

Specialisation of Cultural Landscape Cultural landscapes are also called human landscapes and include the tangible and intangible cultural landscapes that are a major part of tourism resources. Cultural landscapes are closely related to the geosciences, and the existence of human beings is also a result of the geological evolution process. All cultural landscapes were built up from the geosciences. For example, geological, geomorphological, hydrological and climatic elements affect site selection, the selection of materials, location, and the arrangement and preservation of cultural landscape elements. These elements also affect the intangible cultural landscape in the context of its form, characteristics, distribution, interaction and extent. Certain geological hazards can also damage the cultural landscape. In this context, the assessment of the causes of formation, distribution, usage and preservation of cultural landscapes should be based on the geosciences. Cultural landscape tourism resources are an important area of study in connection with tourism earth science.

Species Species is the basic unit of biological classification. The study of species is a historical process, but there is currently no universally agreed definition of living species. The traditional definition of species is the concept of morphological species; a species is a group of individuals with similar forms, and the basic structure is the individual. The prevailing definition is that species are groups of natural populations that can communicate with each other for reproduction and are segregated from other groups reproductively. As such, the basic structure of species is the population rather than the individual, and the concept of a social group is emphasized. In biology, the standard of reproductive segregation of species is only applicable to sexual species but is not applicable to asexual species or fossil species. The classification of asexual and fossil species emphasizes the morphological concept, in which species are judged based on the continuity of their morphological characteristics. The scientific naming of species adopts a binominal nomenclature.

Specific Science Activities for Youngsters Special activities will be organised by the geopark management for young students. The activities include interactive games and activities, such as geological knowledge Q & A sessions, Earth, park, and local knowledge competitions, 'love my hometown – love my country' essay contests, 'learn to use topographic maps' programmes, 'using a compass to find direction' programmes, and treasure hunts in the park. In addition, regular fieldtrips are organised in the spring and autumn, and camps are organised during the summer and winter. These activities utilise the available geopark resources and make the park a learning centre for all young people.

Specifications for Surveys of Tourism Resources in China The regulations and criteria for surveys are set by the China National Tourism Administration (CNTA). They include the types of tourism resources, designation of survey areas, operational requirements (e.g., basic data collection, completion of forms, picture collection, and report compilation), report inspection and acceptance. In 1992, CNTA presented the 'Specifications of survey on tourism resources in China' (trial version). The specifications are listed in five chapters and categorise tourism

resources into two major groups, six subgroups and 74 fundamental types.

Speleothem A speleothem is sediment deposited in a cave due to chemical precipitation or crystallisation from solution. Based on the mode of sedimentation, Zhu Xiewen categorised speleothems into five types: gravitational water deposits, non-gravitational water deposits, synergetic deposits, superimposed deposits and isohomogenous deposits. These 5 types include more than 60 individual forms. Inside over 400 karst caves that have been opened to tourists in China, common and important speleothems include gravitational water depositional features such as soda straws, stalactites, heliotropic stalactites, stalagmites, pillars, stone curtains, cave flags, stone waterfalls, stone shields, rimstones, rimstone dams, stone terraces and calcite rafts; non-gravitational water depositional features such as helictites, colour band flowerstones, and calcite flowerstones; synergetic deposits such as lotus pots, calcium membrane crystal cones, palm-like stalagmites, breast-shaped stalactites and calcite beads; superimposed depositional features such as spindle stones and candlestick stones; and isohomogenous depositional features such as coral stones, milk stones and hull deposits. These features fill and decorate the space inside the caves and have become important tourism resources (Fig. 37).

Sphalerite Sphalerite is mainly composed of ZnS and contains 67.1% zinc. Its crystal form is tetrahedral or dodecahedral, and it exhibits curved crystal surfaces. It generally forms in massive, granular, nodule-like and botryoidal aggregates. It has a significant range of colours from black, brown, yellow, red, green, and grey to white with light brown to colourless streaks. It has translucent to transparent diaphaneity, a resinous to adamantine lustre, a specific gravity of 3.9–4.1, a Mohs hardness of 3.5–4 and conchoidal fractures. It is usually found in hydrothermal veins and forms with dolomite, quartz, pyrite, galena, fluorite, barite and calcite. Sphalerite ores and crystal clusters can be crafted to become ornamental stones.

Spinel The composition of spinel is $MgAl_2O_4$, and it is an oxidized mineral. It often contains iron, chromium, manganese and zinc. The crystals are isometric and often appear as octahedrons or aggregates of octahedrons and rhombic dodecahedrons. It sometimes appears as platy, granular and dense aggregates. It can be red, green, brown or black with white streaks. It has transparent to opaque



Fig. 37 Calcite crystal pool and raft stalagmite in Wulong Furong Cave, Chongqing

diaphaneity, a vitreous lustre, a specific gravity of 3.5–4.1, a Mohs scale hardness of 8 and conchoidal to uneven fractures. Spinel mainly forms in several types of metamorphic rocks, such as serpentine, gneiss and marble. It can also form in mafic rocks. Transparent spinel with bright colours can be used as gemstones. Gem-grade spinel is mainly magnesium aluminium spinel, which has various colours ranging from colourless, pink, red, purple, light purple, violet, blue, and yellow to brown. Spinel is mainly categorized according to its colour, such as red spinel, orange spinel, violet spinel, and blue spinel. It is a common gem material.

Spinel Gem A spinel gem is spinel with gem-grade quality. It mainly refers to magnesia-alumina spinel, which is a magnesium-aluminium oxide ($MgAl_2O_4$). It has a Mohs hardness of 8 and a high refractive index. It is easily confused with ruby and red garnet. It has many colours and can be colourless, pink, red, purple, light purple, bluish purple, blue, yellow and brown. Some spinel can have asterism (star effect), and a rare and precious variety appears blue in daylight but violet under an incandescent lamp (Fig. 38).

Spring Landscape Tourism Resources A spring is a natural feature where groundwater flows from an aquifer to the Earth's surface. It is called the spring landscape tourism resource when it has ornamental, drinking and therapeutic value and can be used as a tourism resource. Based on the type of flow, springs can be classified into rising springs (also known as pressure springs) and dropping springs. Based on the consistency of the flow, springs can be categorised as intermittent springs and pulsating springs. According to the water temperature, springs can be divided into cold springs, warm springs, hot springs and super-heated gas springs. Based on drinking standards, springs can be categorised as mineral springs (mineral water for potable use) and medical springs (for drinking and bathing). Springs and their associated depositional features can form important landscapes with ornamental value. They are also sources of mineral water for tourism. Hot springs are excellent resources for recreational and therapeutic resorts; hence, springs are an important tourism resource.

Spring Tourism Landscape A spring is a natural outflow of water from the ground. Springs can form natural landscapes with important tourism value. Examples are the Seventy-Two Springs in Jinan, which have led the city to be called 'Spring City', and the Yuquan (Jade Spring) at Yuquan Hill, which was appraised by Qianlong Emperor as the 'World's Premier Spring'. Based on the hydrodynamic



Fig. 38 Spinel crystals

conditions, springs can be divided into rising springs and falling springs. According to the geological conditions of the outflows, springs can be classified into contact springs, overflow springs, hanging springs, fault springs and karst springs. Based on their unique characteristics and functions, springs can be divided into intermittent springs (geysers), pulsating springs, crying springs, laughing springs, shy springs, fish springs, fire springs, ice springs, milk springs, sweet springs, bitter springs, medicinal springs and mineral springs. Springs are one of the most important types of tourism landscape resources.

Srebarna Nature Reserve, Bulgaria The Srebarna Nature Reserve is located in the borderland of northeastern Bulgaria near Romania and adjacent to the Danube, and it has a core protection area of 6.3 km^2. The word 'Srebarna' means 'silver lake'. It is a freshwater reserve along the Danube and is the breeding ground of nearly 100 species of birds, many of which are rare or endangered. Approximately 80 other bird species migrate and seek refuge there every winter. Among the most interesting bird species are the Dalmatian pelican, great egret, night heron, purple heron, glossy ibis and white spoonbill.

St Kilda, United Kingdom This site is located in the Atlantic west of the British Isles of Hebrides. The core protection area covers 242.01 km^2. St. Kilda is a group of spectacular volcanic islands, including the islands of Hirta, Dun, Soay and Boreray. The island group is known for the most rugged cliffs in Europe and therefore provides an ideal habitat for a large group of rare and endangered birds, especially puffins and gannets. The island group has had no human settlements since 1930, and there is evidence of human survival in the extremely harsh environments of the Hebrides region for more than 2,000 years. Traces of human activities include architectural structures, arable land and traditional Scottish Highland stone houses. These remains demonstrate the fragile character of the surviving economy that developed based on bird hunting, agriculture, and shepherding.

Stalactite-Stalagmite *Synonym:* ► *Column landscape*

In karst caves, stalagmites and stalactites grow towards each other and eventually join to form a feature called a karst column, which 'stands on the ground and points towards the sky'. A dense column cluster looks like a 'virgin forest'. In China, some columns reach heights of 30–40 m. Karst cave columns and columns on the ground have different origins. Karst columns form from travertine accumulation, while the latter form by the weathering and erosion of carbonate rocks.

Stalagmite Landscape Stalagmites are deposits that grow upwards from a cave floor. They get the name 'stone bamboo shoot' in Chinese because they look like bamboo shoots, and they always occur in pairs with a corresponding stalactite. Their location is determined by falling water droplets. Water droplets from a stalactite contain surplus carbon dioxide, and when they reach the ground, the water splashes into numerous tiny droplets or forms thin, wide and flowing water membranes. The water surface area expands and facilitates the release of carbon dioxide. Consequently, calcium carbonate is deposited, followed by aggregation and growth of the stalagmite. The cross-section shows characteristics of sequential stacked cap-type growth away from the dripping water in the centre. This is important for studies of the sedimentation rate, changes in the sedimentary environment and age determination. The shape of stalagmites is controlled by the chemical properties of the water droplets, dissolved substances, drip distance, drip frequency and air flow conditions. As a result, stalagmites of various forms, such as conical and pagoda-shaped, can form. In general, their diameter is much greater than that of the corresponding stalactite. Stalagmites are the main component of the beautiful scenery in karst caves, especially when the stalagmite surface looks like a palm leaf, pine cone or mushroom due to the deposition from splashing water. They look unique when they climb up along a 'bamboo shoot'. Stalagmites are abundant and cluster in



Fig. 39 Stalagmite landscape – Bama Crystal Palace, Guangxi Province

many caves. For example, Yuanyang Cave in Fengshan, Guangxi Province, contains two tall stalagmites with heights of 29 m and 36.4 m, and more than 32 stalagmites are more than 10 m high (Fig. 39).

Standard Global Chronostratigraphic (Geochronologic) Scale This scale is a hierarchical system of stratigraphic units around the world and is composed of eonothems, erathems, systems and series (and the corresponding chronostratigraphic units, such as eons, eras, periods and epochs, respectively). It serves to provide a standard for identifying all rock ages and linking all rocks around the world with the global geologic history. The units listed in the Standard Global Chronostratigraphic Scale are equivalent to the corresponding time spans, and it is theoretically globally applicable. This scale is also called the geologic time scale.

State Park Systems, U.S.A. The 50 states in the United States have established their own state park systems. State parks were established and developed occurred earlier than national parks. The first state park was the Indian Hot Spring State Park in Georgia, which dates to 1825. Since then, it has been a public park administered by the state government. It was not officially recognised as a 'State Park' until 1931. The state park systems of most US states were founded during Roosevelt's New Deal in the 1930s, during which the Civilian Conservation Corps (abbreviated as CCC) played an important role in the early phases of park development. Currently, there are as many as 6,624 state parks, which make important contributions to natural conservation, outdoor recreation, tourism, learning and education.

Statues Carved on Cliffs Statues carved on cliffs mainly comprise statues associated with Buddhism. They are usually located in the open air or in a shallow niche. They often exist in groups or are in a cave. The rock masses used for carving are generally thick, easy to carve and resistant to weathering, such as quartz sandstone, limestone and dolomite. Typical examples include the Maitreya Buddha statue (Cretaceous sandstone) in the Leshan Lingyun Temple, Sichuan Province, and the cliff statues at Kongwang Mountain in Lianyungang, Jiangsu Province (Fig. 40).

Staurolite The composition of staurolite is $FeAl_4[Si_4]_2O(OH)_2$, and it is a product of



Fig. 40 Leshan Buddha, Sichuan Province

regional metamorphism. It may contain manganese or cobalt. It crystallizes in the pseudo-orthorhombic crystal system, and the crystals are prismatic. Staurolite is often twinned with a cross-shape or 'X-shape', from which it was given the name 'cruciform stone'. It can be brown or brownish black, and it has a specific gravity of 3.65–3.77 and a Mohs hardness of 7–7.5. It often occurs in crystalline schist and in placer deposits.

Stegodon huanghoensis Stegodon huanghoensis is a species of Proboscida. Its name was chosen because this set of fossils was found in the Huanghe (Yellow River) district. It was 4 m tall and 8 m long with 3-m-long tusks, which are like a pair of swords. Therefore, it is also called the 'sword-tusk elephant'. This set of Stegodon fossils is currently the most complete set in the world. This fossil is an important palaeontological finding for studies of the palaeo-geography and ancient climate in the Gansu area (Fig. 41).

Steppe ► Grassland

Stibnite Stibnite is an important antimony mineral ore that is composed of Sb_2S_3. It contains 71.4% antimony and has long columnar or acicular crystals. Its crystals belong to the orthorhombic system, and the crystal surfaces have longitudinal stripes and are usually tarnished. The aggregates are often radiating or granular. Its colour and streaks are lead-grey. It has opaque diaphaneity, a metallic lustre, a specific gravity of 4.63–4.66, a Mohs hardness of 2 and a low melting point (550 °C). It is a low-temperature hydrothermal mineral and often forms with realgar, orpiment and cinnabar. It is an important raw material for antimony smelting. It can also be crafted into excellent ornamental stones.

Stock A stock is a common type of small intrusive body with an exposed outcrop area less than 100 km^2. Stocks are often circular or irregular in map view. The contact surfaces are steep and extend downwards like tree roots. For example, the granite mass of Huangshan Mountain is a stock.



Fig. 41 Fossil of Stegodon huanghoensis

Stone Age This is an archaeological term for the early stage of human history. Early human beings relied on stone tools for protection and living. The Stone Age was the initial stage in the development of human culture and was also the longest period of human development. It covered almost the entire Quaternary, Pleistocene and Early Holocene, which was from approximately 3 million years ago to approximately 4,000 years. A few human tribes still use stone tools. In archaeology, the Stone Age is divided into three stages, namely, the Palaeolithic, Mesolithic and Neolithic ages.

Stone Egg Granite Landscape – Gulangyu Type This is a landscape with in situ or displaced granite blocks that look like round eggs and is called a 'stone egg landscape'. It is a distinctive structure on the weathering crust of granite. Zeng Zhaoxuan first proposed the term 'Stone Egg Landform' in the mid-1950s. Under hot and humid climatic conditions, intense chemical weathering along three sets of joints in granite causes the rock to appear like circles or concentric circles. Hilltops or curves on slopes are favourable locations for stone eggs to form. The Wanshishan Scenic Area in Xiamen, Fujian Province, and the Yishan Scenic Area in Zhoucheng, Shandong Province, are typical examples of this type of granite landscape.

Stone Forest Landscape, Shilin Landscape This is a type of carbonate landform landscape. Under humid climate conditions, carbonate rocks tend to dissolve and be modified by other dynamic geological effects to form columns more than 5 m tall with various forms. They can develop in clusters or in isolation to form a unique karst landscape that looks like a woodland when viewed from a distance. The dissolution process includes subterranean dissolution and surface rainwater erosion. The resulting columnar forms include sword-like, sharp cone-like, mushroom-like, pagoda-like, cylindrical, castle-like and irregular forms (Fig. 42).

Stone Gate Landscape of Volcanic Rocks A volcanic stone gate is also called a stone entrance. It is a natural gate-like feature composed of a pair of cliffs. This term was also proposed by Xu Xiake during his tour of



Fig. 42 Shilin (stone forest) landscape – Shilin, Yunnan

Yandangshan. This feature forms when overlapping screen-like peaks collapse and disintegrate along joints. The Xiansheng Gate of Yandangshan is a typical example; it is 200 m high, and the margins are 6–16 m apart. A 'one line sky' landform is located in front of it, and when looking up from inside the gate, the sky is nearly obscured by the cliffs (Fig. 43).

Stone Ring Landscape This is a landscape of permafrost. In flat periglacial ground mixed with coarse and fine materials, freezing and thawing will cause the soil and fine gravel to gather in the middle, while the larger stones are pushed outwards to form a ring or polygon, and such feature looks artificial. This feature is called a stone ring (Fig. 44).

Stone River Landscape ▶ Block Stream

Stone Waterfall Landscape A stone waterfall is a depositional feature of calcium carbonate. It gets its name from its appearance which looks like a waterfall. It is a type of wall flowstone. When wall cracks extend and become larger, water seepage increases, forming magnificent stone waterfalls on the steep wall. An entire cave wall covered with white calcium carbonate looks like a hanging waterfall. The stone waterfall in Luotian in Yangshou, Guilin, is 130 m wide and 32 m high. It and the stone waterfall in the Biyun Cave in Fuyang, Zhejiang Province, constitute magnificent landscapes.

Stonehammer Geopark, Canada This geopark is located on the eastern coast of Canada and has an area of 2,500 km^2. It became a global geopark in 2010. The geopark is the birthplace of Canadian geology. The landscape is the result of plate collisions, oceanic opening, volcanic and seismic activity, ice ages and climate change. The folded Cambrian rocks record the evolution of life from the Cambrian explosion to the evolution of vertebrates and the emergence of terrestrial organisms. The park records almost all of the geological events from the early Cambrian period to the most recent glacial period. As the location of the beginning of Canadian geology, the park also has great historical significance.

Stonehenge Granite Landscape – Hexigten Banner Type This is a granite landscape composed of stone columns more than 5 m tall with straight edges that are in isolation or in clusters. Some researchers call it a 'granite stone forest landscape'. Uniform rock properties, close and parallel horizontal joint sets and relatively widely spaced vertical joint sets are favourable conditions for the development

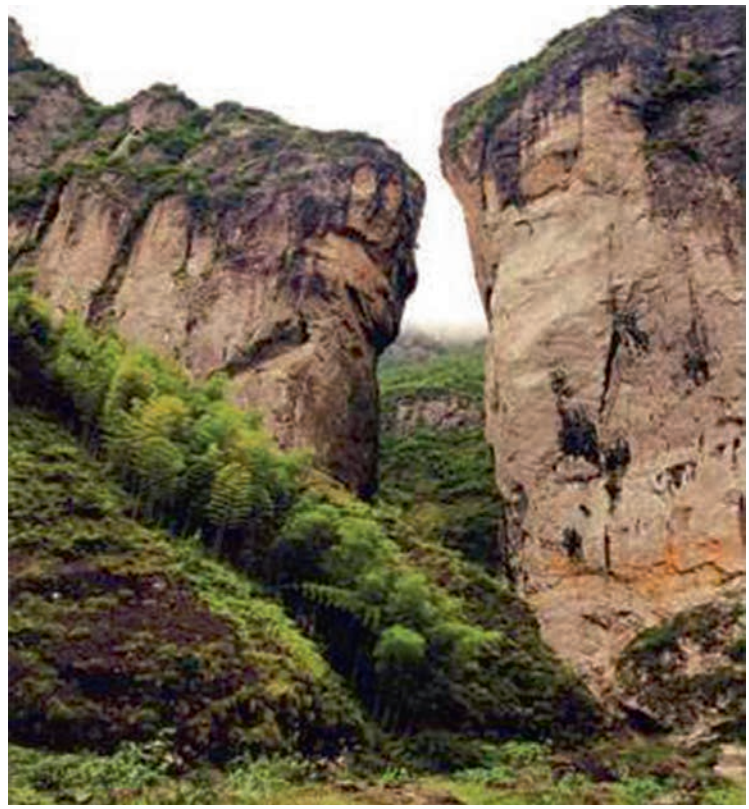


Fig. 43 Stone gate landscape of volcanic rocks – Yangdang Mountain Xiansheng Gate, Zhejiang Province

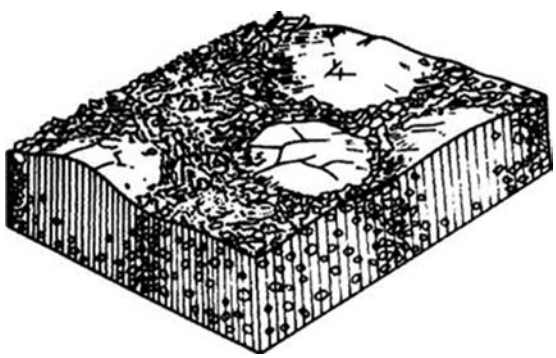


Fig. 44 Stone ring

of this type of landscape. The intense congelifraction that occurs at the low temperatures at high elevations and the resulting ice cracking are the main external forces that have caused its formation. Many stone columns appear in comb-like arrays at elevation, some stand separately, most have angular edges, and a few are arc-shaped as a result of wind abrasion. The Hexigten Banner Global Geopark in Inner Mongolia is an example of this landscape (Fig. 45).

Strait Landscape A strait landscape consists of narrow elongated waterways that separate two continents, a continent from an island or an island from another island. There are thousands of straits around the world; approximately 130 are navigable, and more than 40 are major international navigation waterways. They are important channels that link oceans and seas. Typical examples are the Taiwan Strait, Strait of Malacca, Strait of Gibraltar, Strait of Bosporus and Dardanelles Strait. Straits form through the prolonged erosion of land by seawater along fissures on an isthmus or by the submergence of lowlands or depressions on subsiding land. In general, straits have deep water with torrents and eddies. They also have important military and shipping significance. There are three main straits in China: (1) the Taiwan Strait, which links the East China Sea and the South China Sea and has a total length of 380 km; (2) the Bohai Strait,



Fig. 45 Stonehenge granite landscape of Hexigten, Inner Mongolia

which links the Bohai Sea and Huanghai Sea and is 115 km long; and (3) the Qiongzhou Strait, which connects the South China Sea and Beibu Bay and is 70 km long.

Stratification ► Bedding

Stratigraphic Classification Rocks have many different characteristics and properties that can be used for stratigraphic classification. There are several types of stratigraphic classifications, such as lithostratigraphic, biostratigraphic, magnetostratigraphic, chemostratigraphic, chronostratigraphic, event stratigraphic, and quantitative stratigraphic classifications.

Stratigraphic Correlation Stratigraphic correlation is the process of determining whether the stratigraphic units in different regions have consistent or inconsistent characteristics and properties or whether the strata are correlative or not correlative. Stratigraphic correlation is the extension of stratigraphic units or stratigraphic boundaries away from a stratigraphic zone. Please see "► Stratigraphic Classification".

Stratigraphic Gap ► Lacuna

Stratigraphic Tourism Landscape This is a landscape in strata with tourism and scientific research value. The Earth's strata generally refer to rock layers and deposited materials, including sedimentary, volcanic and metamorphic rocks, that formed between the Archaean and the Cenozoic, and they are the basis for studying the Earth's history. These strata have recorded the geological events associated with the evolution of the Earth in various regions, such as the palaeoclimate, palaeoenvironment, palaeo-geomorphology, palaeontology, palaeo-seismic activities, palaeo-hydrology, tectonic movements, palaeomagnetism, and ore-forming processes. The main stratigraphic tourism landscapes are the stratotype GSSPs (Golden Spikes) with globally significant international boundaries, stratigraphic sections with standard national significance, stratigraphic sections with standard regional significance and magmatic and metamorphic stratigraphic sections.

Stratigraphic Unit To make stratigraphic comparisons and compile geological maps, it is necessary to categorize rock layers or rock bodies with similar characteristics into units, which are called stratigraphic units. Because of the diverse characteristics of rock strata, the classification of stratigraphic units is also diverse, including chronostratigraphic units, lithostratigraphic units, biostratigraphic units,

sequence stratigraphic units and magnetostratigraphic units. Stratigraphic units, especially lithostratigraphic units, are key controlling factors of rock landforms and landscape types and thus are important to geotourism.

Stratigraphy Stratigraphy is the study of the characteristics and properties of all stratified or layered rock formations in the Earth's crust. Classifying these rocks into different types and units allows the spatial relationship with the relevant time sequence to be established. Stratigraphy covers the shape, distribution, lithology, fossil content, geological age, geophysical and geochemical rock properties, associated geological relics, formation environment and evolutionary history of these rocks. The stratified rocks within the Earth's crust, including sedimentary rocks (consolidated or unconsolidated sediments), volcanic rocks and metamorphic rocks, are included in stratigraphy.

Stratigraphy and Rocks as Landscape Over Earth's evolution, different types of sedimentary, metamorphic, volcanic, and magmatic intrusive rocks have formed. Under certain conditions, the different types of rocks will form different types of landscapes for tourism.

Stratotype A stratotype is the original or a subsequently designated standard correlative type section or boundary of a named stratigraphic unit or stratigraphic boundary. In a particular stratigraphic sequence, a stratotype represents a particular interval or a particular reference exposure of strata. It constitutes a criterion for defining and identifying the stratigraphic unit's location or the stratigraphic boundaries. This interval is the unit stratotype of the stratigraphic unit, and the specific reference point is the boundary stratotype. A chronostratigraphic stratotype relies on the boundary stratotype to be defined, whereas a lithostratigraphic stratotype mainly depends on the unit stratotype.

Stratum A stratum is a rock layer with a common composition or characteristics. Generally, the term is associated with sedimentary rocks and volcanic rocks that can be distinguished from adjacent strata and rocks by clear interfaces or interpreted interfaces upon study. Strata with the same characteristics tend to form specific landforms; therefore, stratigraphy is an important basis for studying the landscape in connection with rock landforms.

Stria *Synonym:* ▶ *Striation;* ▶ *Scratch*

When two rock blocks slide past each other, scratches are left on the fracture walls due to the abrasion of breccia or clastic rock. These scratches can be used to determine the direction of relative movement of the blocks. In general, the scratches are deep and wide at one end but narrow and shallow at the other. When the rock particle sizes are the same on both walls, the movement direction of the opposite wall is from the wide and deep end towards the shallow and narrow end. When the scratch along the movement direction is touched, there is a feeling of exceptional smoothness. Sometimes, the scratches indicate more than one slip direction on the same surface. Upon detailed inspection, they are in different directions, indicating that there have been several sliding movements. Scratches can be formed by glacial action, flooding or landslides; hence, not all scratches are fault-related scratches. Careful identification is necessary. A comprehensive quantification of these scratches can help determine the major stress directions.

Striated Pebble Landscape *Synonym:* ▶ *Abraded gravel landscape*

This landscape is composed of pebbles and gravels etched with glacial scratches on the polished surfaces. When moraine gravels move in a certain direction for a long time under pressure, the gravel surface will be abraded to create polished surfaces and linear streaks (Fig. 46).

Striation ▶ Stria

Strike The strike represents the orientation of the intersection of a planar feature with a horizontal plane, and it also represents the direction of a line projected onto a horizontal plane. A structural plane may be an actual fracture plane (such as a fault plane), or it can be an identifiable geometric plane (such as the axial surface of a fold). The strike can be presented

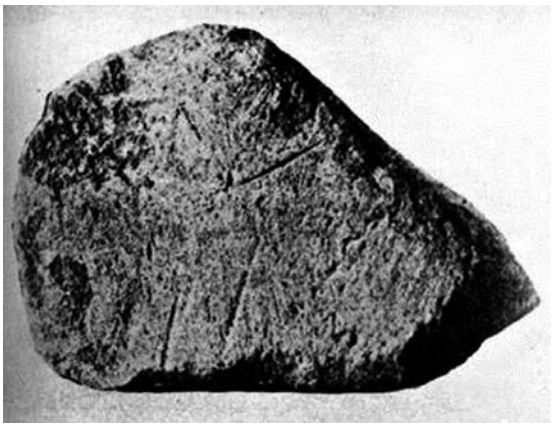


Fig. 46 Glacial striated pebble. (After Li Siguang)

as an azimuth (such as 300°), or it can be expressed as a quadrant compass bearing (e.g., 64.1265° N, 21.8174° W of Reykjavik, Iceland).

Stromatolite Algae absorb sea water containing calcium and magnesium carbonate and other particles, which eventually coagulate and precipitate to form a type of fossil called a stromatolite. Alternating laminated layers of different colours form as result of seasonal changes and varying rates of deposition. Stromatolite layers can have different shapes, including laminar, spherical, hemispherical, columnar, cylindrical, conical and dendritic. Stromatolites are abundant in China. They are mined in the Proterozoic dolomite and dolomitic limestone strata in the north and the Sinian dolomitic limestone and siliceous dolomite strata in the south.

Strombolian Type This is a type of volcanic eruption named after the Stromboli Volcano on the west coast of Italy. It is characterised by an overflow of moderately viscous magma with low energy bursts. The magma composition is mainly basaltic-andesitic, and it is moderately to extremely thick. The erupted materials include spherical spindle-like volcanic bombs and volcanic slags. The volcano's form is generally a volcanic cone (Fig. 47).

Strontium Water This is hot mineral water that contains strontium. According to the National Medical Hot Mineral Water and Natural Drinking Mineral Water Quality Standard, water with strontium contents over 10 mg/L or over 0.2 mg/L can be classified as medical strontium water and potable strontium water, respectively. Strontium water is widespread in many provinces, autonomous regions and municipalities in China.

Structural Basin A structural basin is a large to medium-sized syncline with two equal horizontal axes that forms due to crustal subsidence. It is different from the definition of 'geomorphic basin' in geography. Some but not all geomorphic basins are structural basins. Structural basins can be divided into depressions (such as the Jiangsu Plain) and faulted basins (such as the Fen-Wei Basin).

Structural Geology Structural geology is a branch of geology that focuses on the tectonic phenomena, patterns, formation and development processes of the geological bodies that make up the lithosphere. It includes studies of the geometric shapes, occurrence, patterns, combinations, spatial relations and development of geological structures to explore the formation, orientation, intensity and dynamics of these structures. The main objective is to identify and describe different types of tectonic deformation and displacements of medium- to small-scale geological bodies, such as folds, fractures, facets, joints, cleavage and bedding, in specific areas. It involves conducting surveys of the form and occurrence of these structures, drawing and using cameras to analyse and determine their formation processes.

Structural Grain A structure has a pattern that is called the structural grain, which includes lines and planes. A rock's structural grain refers to all textural lines and planes (structural planes) and includes both primary and secondary structures, divisional structures (such as fault planes) and indicative structures (such as fold axes) as well as all types of structures that are formed by internal dynamics (crustal movements) and external dynamics (non-crustal movements).

Structural Kinematics Structural kinematics is a branch of structural geology that focuses on the dynamics of geological tectonics, dynamic characteristics, dynamic processes and



Fig. 47 Strombolian-type volcano landscape

sources. Structural geometry, structural kinematics, and structural dynamics are the three main components of structural geology. The structural geometry (the spatial geometric relationships between structural elements of various levels and scales and the established structural geometric forms) and structural dynamics (the dynamic state, processes and patterns) can reveal the dynamic processes of geological bodies. Because the methods use observations of existing structures to infer past states and processes, structural kinematics tends to be nonunique and speculative. Therefore, during the structural kinematics analysis process, factors such as the rock mechanical properties, boundary conditions, stress modes and duration need to be considered carefully and validated by experiments (including physical modelling, physical simulations and numerical simulations).

Study on Stone Forest Karst Landscapes in China This book was written by Anze Chen et al. and was published by Science Press in 2011. The monograph discusses the definition, types, formation, scientific value, aesthetic value, science popularisation value and tourism development value of the karst stone forest landscapes in China. It also conducts systematic in-depth research on the distribution, formation, types, geological characteristics, evolution conditions, protection and development of the karst stone forest landscapes in 11 provinces (regions) of China, including Yunnan, Guizhou, Sichuan, Chongqing, Hunan, Hubei, Guangxi, Fujian, Hainan, Hebei, and Henan. As of 2011, it was the most complete monograph of karst stone forest landscape research in China.

Study on Tourism Resources Landscape This book was edited by Xingzhong Wang and was published by Shaanxi Science and Technology Press in 1990. It includes approximately 190,000 words. Based on tourism behavioural science and behavioural geography, the book systematically discusses the perceptions, interactions and cognition of tourists towards tourism resources and different types of tourist areas. It further discusses the formation of various landscapes, the extrinsic and intrinsic meanings of tourism resources and the

characteristics of tourism functions. It fills the gap in tourism geography research. The book is divided into two major parts; the first is about perception and cognition of tourism landscapes, and the second introduces numerous kinds of nature-based tourism resources and cultural tourism resources.

Stylolite A stylolite is a jagged surface that forms in sedimentary rocks by pressure solution. Stylolites are common in limestone and quartzite. In cross-section, they look like zigzag curves, and in plan view, they form undulating surfaces. Three-dimensionally, they are composed of concave and convex columns of varying sizes, which are called suture columns. Stylolites can vary in size significantly; the dimensions from the concave to convex columns can be up to dozens of centimetres or larger but can be less than 1 mm. Stylolites can serve as pathways for oil and gas migration, and they play an active role in their transportation and accumulation.

Subage and Substage A subage is lower than an age in the hierarchy of regional geochronologic units. It is equivalent to the time span of a substage (regional stratigraphic unit). A substage is the rock that formed during a subage; it is a regional stratigraphic unit that is lower than a stage and is a subdivision of a stage. The nomenclature is similar to that of stages; they are named after a location. A substage can also be labelled as a lower substage, middle substage or upper substage.

Subbeticas Geopark, Spain The park became a global geopark in 2006. It covers an area of 320 km^2. Its landscape is closely related to the geology. The ridges are composed of hard limestone, while the gorges formed on soft clay, carbonates and other rocks. Sedimentation occurred from 200 million to 25 million years ago from the Jurassic to the Palaeogene and into the Neogene. The rocks in Subbeticas Geopark contain abundant fossils, especially Mesozoic ammonites (a type of extinct marine mollusc). As a result, the park has become one of the most important research sites for ammonite fossils in the world. It is also an important area for studying the formation of the Betica Mountains. From the peak of 'Picacho de Cabra', the three major geological regions that make up Andalusia are visible: the Morena Mountains, the Guadalquivir Basin and the Betica Mountains. In addition, the geopark has a karst landscape with high educational and scientific value and is rich in biodiversity.

Submarine Landscape This is a general term for landscapes on the Earth's surface that are covered with seawater. The sea floor can be divided into three main topographic components: the continental margins, oceanic basins and mid-ocean ridges. These components can be further subdivided into secondary terrain units, such as shoals, coral reefs, abrasive platforms, seafloor canyons, ocean ridges (seamounts), guyots, sea basins and oceanic trenches. The continental margins are vast transition zones between the mainland and the ocean floor, accounting for approximately 22% of the total ocean area. The margins consist of the continental shelf, continental slope, continental rise and oceanic trenches-island arcs. The oceanic basins are located between the oceanic ridges and the continental margins, and they account for approximately 45% of the total ocean area. The oceanic basins are dissected by oceanic ridges of positive topography, forming several symmetrical oceanic depressions with depths of approximately 4,000–5,000 m. These depressions are called oceanic basins, whereas the elongated depressions with greater widths and gentler slopes are called oceanic troughs. Oceanic basins can be further divided into abyssal plains and abyssal hills. Mid-ocean ridges are the widest and longest mountain systems in the ocean, accounting for approximately 33% of the total ocean area.

Subterranean Stream Cave Landscape *Synonym:* ▶ *Underground river cave landscape*

This is a landform composed of dry karst caves connected to caves containing underground rivers, in which cave development is ongoing and is creating caves that are fully or partially filled with water. Underground river caves (or cave systems) always have different layers.

In general, the upper layers are dry caves, and developing underground river caves are in the lower layer. China's underground river caves are mainly located in the southern Qinling Mountains, eastern Yunnan Province and west of the Guilin-Yichang areas. These vast areas include Guangxi, Guizhou, Yunnan, Sichuan and Hunan Provinces and Chongqing City. This area contains at least 2,836 underground rivers with a total length of approximately 13,919 km. Underground rivers are best developed in Guangxi, Guizhou and Yunnan Provinces, which account for 59.8% of China's underground rivers. Caves favourable for water sports are more valuable for tourism, such as the Shui (Water) Cave in Benxi, Yinhu (Silver Fox) Cave in Beijing and Longgong (Dragon Palace) Cave in Guizhou Province (Fig. 48).

Subtropical Desert Climate This climate type can be found in the inland and coastal regions in the western parts of the continents near the Tropic of Cancer to 25° north and south latitudes, covering northern Africa, the Arabian Peninsula in Asia and the inland areas of the Australian desert. Due to the subtropical high-pressure belt and the trade winds, continental tropical air masses prevail throughout the year with little rainfall (approximately 100 mm per annum). The sunshine is strong, and the temperatures are high with an average annual temperature of 30 °C. Subtropical desert vegetation dominates this climate. The distribution and formation of the great deserts in the world are closely related to this type of climate.

Subtropical Evergreen Broadleaf Forest Ecological Landscape This is a type of ecological landscape in the subtropical monsoon climate region that is dominated by broadleaf forests. The broadleaf forest is evergreen and is mainly composed of evergreen dicotyledons. The plant structure is much simpler than that of a tropical rainforest. The trees are generally divided into two layers with a height of approximately 16–20 m, and they rarely exceed 25 m. Climbers and epiphytic plants are common and mainly include herbaceous and woody vines.

Subtropical High The centre of the subtropical high is located in the high-pressure system in



Fig. 48 Subterranean stream cave in Benxi, Liaoning Province

the subtropical zone. The warm air in the vicinity of the equator rises to the upper atmosphere and flows towards the two poles. As the air cools near 30° north and south latitude, the surface pressure increases to form a subtropical high.

Subtropical Monsoon Climate This climate type can be found on the eastern coasts of subtropical continents that extend from 25° to 35° north and south latitudes in the northern and southern hemispheres. It is mainly located in the southern Qinling Mountains – Huaihe line in eastern China, southeastern North America, eastern South America, southeast Australia and the southeast corner of Africa. The subtropical monsoon climate is controlled by tropical marine air masses during the summer and polar continental air masses in the winter, when the temperature and precipitation are low. The seasonal distribution of rainfall is uneven, and the natural vegetation landscape is subtropical evergreen broadleaf forest.

Subvolcanic Rocks Subvolcanic rocks are a type of ultra-hypabyssal rock that has the same magma source as volcanic rocks. Subvolcanic rocks look similar to rocks that form from volcanic eruptions. The characteristics of subvolcanic rocks include: (1) they form at the same time as or later than volcanic rocks; (2) subvolcanic rocks and volcanic rocks form in the same areas; (3) subvolcanic rocks and volcanic rocks have similar compositions; (4) subvolcanic rocks have the characteristics of both lava and hypabyssal rocks; and (5) subvolcanic rocks often occur as small dykes and veins. The flat riverbed of the Baishuiyang National Geopark in Fujian Province is composed of typical subvolcanic rocks.

Suichang Gold Mine National Mining Park, Zhejiang This park is located in Suichang County, Lishui City, Zhejiang Province. It covers a total area of 33 km^2 and became a national mining park in 2005. The park can be divided into several parts, including the service centre, mining exhibition area and leisure and sightseeing area. Visitors can experience various underground mining activities and understand the mystery and hardships of mining through sensory experiences.

Suiyang Shuanghedong Cave National Geopark, Guizhou Suiyang Shuanghedong Cave National Geopark is located in Suiyang, Zunyi, Guizhou. It was approved by the Ministry of Land and Resources as one of the third group of national geoparks in 2004. Its unique features include karst caves and associated landforms. Except for the area from Mount Taiyangshan and Mount Jinlinshan to Qianhegou Village, which have experienced tectonic erosion, most of the areas are karst peak clusters, depressions and valleys with caves, blind valleys, skylights, underground rivers, vertical shafts and other landforms. There are many karst caves, including gypsum caves, water curtain caves and caves called Osmanthus (or Dafeng), Mountain King, Luojiao, Lianwang, Fir Forest and Arahant. Each cave has distinctive features. There are also springs rich in sulphur, iron, zinc, and radon.

Sulphate Spring This is a hot spring that contains sulphur dioxide. Sulphur springs usually contain more than 1,000 mg/L of sulphate, so the water has a bitter taste.

Sulphur Flower Landscape This is a type of sinter landscape. On the inner wall and rim of the vapour holes in an active volcanic area and a high-temperature hydrothermal activity area, needle-like or granular sulphur crystals can accumulate to form layers of sulphur flowers that are bright yellow. The sulphur may originate from volcanic and magmatic activity. The sulphur at the source has a negative bivalence and thus is stable. When it rises with the magma and reaches the sulphide-oxide interface, magma sulphur (S^{2-}) will separate due to the pressure drop, and some H_2S will form sulphur through incomplete oxidation. The sulphur brought to the surface has a temperature of approximately 130 °C. In this respect, sulphur flowers are a key indicator of the geothermal resource. In the hydrothermal zone, sulphur flowers and metal sulphides can be used to assess the thermal properties of the hydrothermal zone through isotope analysis.



Fig. 49 Sulphur flower landscape

In China, sulphur flowers can be found in the volcanic areas at Wudalianchi and Changbai Mountain and the active hydrothermal regions in southern Tibet, western Sichuan Province, Yunnan Province and northern Taiwan (Fig. 49).

Summer (Winter) Geology Camps for Youngsters Summer and winter camps are organised by the geopark authority during school holidays. The camping activities include classroom lectures, workshops, experiments, visits, surveys, fieldtrips and discussions, and they make use of the available facilities and resources of the geopark. The concepts of geoconservation, geopark, nature conservation, basic geology and geomorphology, and the ecological and cultural elements of the environment are covered. The geopark provides a safe, resource-rich, and friendly environment for such activities.

Sundarbans National Park, India This park is located in the Ganges Delta to the southeast of western Bengal in eastern India. The park is adjacent to another world heritage site, the Sundarbans Reserve Forest in Bangladesh, and covers an area of 1,330 km^2. It contains the world's largest area of mangrove forests. Numerous rare and endangered species live in the park, including tigers, aquatic mammals, birds and reptiles.

Sunstone Sunstone is also known as 'sunlight stone' and is an important gemstone of the plagioclase subgroup. It is commonly golden red or reddish brown and is usually translucent. Because sunstone contains metal flakes such as haematite and goethite, which are roughly uniformly arrayed, gold red rays reflect when the stone is rotated, resembling glittering gold sand; therefore, it is also called gold sand stone. It is mainly mined in India and the United States (Fig. 50).

Surge Tuff A surge tuff is a tuff that is formed by a vapour magmatic eruption caused by the interaction of magma or magmatic heat with cold water (including groundwater and surface water). A base surge tuff is also known as a

swell deposit tuff. Typical examples can be found on Yanghua Ridge in Haikou, Hainan Province, and Weizhou Island in Beihai, Guangxi Province, where extensive bedding or sinking fallen rock structures are present (Fig. 51).

Surtsey Island, Iceland This island is located approximately 32 km off the southern coast of Iceland and has a core protection area of 33.7 km^2. A volcanic eruption from 1963 to 1967 created this new island, which has been protected since. This remarkable event provided the world with a pristine nature laboratory. It is protected from all human activities and will continue to provide unique and long-term information about how plants and animals grow and evolve on a new island. Scientists began studying the island in 1964. They have observed the entire process of seeds being carried by ocean currents to the arrival of moulds, bacteria, and fungi. The first vascular plant sprouted in 1965, and ten species were established within 10 years. In 2004, there were 60 species of vascular plants, 75 species of moss, 71 species of lichen, and 24 species of fungi. Of the 89 bird species recorded, 57 also live in other parts of Iceland. In the 1.41 km^2 island area, 335 species of invertebrates have been discovered.



Fig. 50 Sunstone

Surtsey Type This is a type of volcanic eruption named after the Surtsey Volcano near Iceland. It is a phreatomagmatic eruption caused by the contact of magma or the heat of magma with cold water. The eruption can include a basal surge and the accumulation of fallen ash to form features such as tuff rings, tuff cones or low flat craters.

Sustainable Development The concept of sustainable development was first proposed by the United Nations Conference on the Human Environment in Stockholm in 1972. It was defined as development that meets the needs of the present generation without compromising the ability of future generations to meet their needs. It is necessary for achieving economic development as well as protecting the natural resources, environment, fresh water, oceans, land, and forests on which humankind



Fig. 51 Fallen rock collapse structure in a base surge tuff on Weizhou Island, Beihai, Guangxi Province

depends. The core of sustainable development is development, but it requires economic and social development under the premise of strictly controlling the population, improving the quality of the population, protecting the environment and sustainably using resources.

Suture Zone ▶ Plate Suture

Swamp A swamp is an area with a wet surface or thin layers of water associated with the growth of water and marsh plants. Marsh wetlands are some of the most important ecosystems on earth and account for approximately 0.8% of the land area. Swamps also indicate the presence of peat. China's swamps are mainly located in the Sanjiang Plain, Daxing'anling and Xiaoxing'anling Ranges in Northeast China, the Zoige Plateau in Sichuan and along the ocean, lakes and rivers.

Swamp Ecological Landscape This is a type of ecological landscape where hygrophilous plants have adapted to the hydric soil on land that is permanently or seasonally saturated with water. In a narrow sense, a swamp should contain abundant peat. Swamp ecological landscapes include swamp vegetation (e.g., reeds, mosses, alders, cedars, peat mosses, sundews and nepenthes) and swamp fauna (e.g., mammals, birds, reptiles, amphibians, fish, invertebrates and insects; representative mammals are otters, rodents and water shrews; the birds include various snipes, wading birds such as cranes and herons, natatorial birds such as ducks and geese and raptors such as swamp swans; the amphibians include toads and frogs; the reptiles include snakes; and many types of fish and diptera larva live under the water). Many types of swamps are widely distributed in China. In eastern China, the swamps are larger and have many varieties due to the warm and moist conditions, but western China mainly contains eutrophic swamps (Fig. 52).

Swamp Facies Swamp facies are sediments that form in swamp environments. They are a type of terrestrial facies. Swamp facies developed extensively during the Carboniferous, Jurassic, Palaeogene and Neogene Periods, when the



Fig. 52 Swamp ecological landscape

climate was warm and humid, the plants in the swamps were lush, and there were extensive accumulations of peat. The buried peat was then transformed into coal. In addition to coal seams, swamp facies include Carbonaceous shale, siltstone and mudstone with structures such as massive bedding, horizontal bedding and occasional fine-grained sand. Swamp facies develop in reducing environments, so they always contain abundant plant fossils as well as siderite and pyrite.

Swamp Landscape A swamp is a depression with stagnant water that is populated by hygrophilous and hydrophilous plants and peat accumulations. Swamp landscapes are composed of swamps. Based on the geographical environment and the cause of formation, swamp landscapes can be classified into low swamp landscapes, transitional swamp landscapes, high swamp landscapes, peatland landscapes and salt marsh landscapes.

Swiss Alps Jungfrau-Aletsch, Switzerland This heritage site is located in the northeastern part of the Valais region in southwestern Switzerland. The Jungfrau, Aletsch Glacier, and Bietschhorn Peaks were added to the list in 2001, and the expansion in 2007 increased the core protection area from the original 539 km^2 to 824 km^2. The heritage site is a good example of the topography of the Alps, and it includes the most heavily eroded areas of the mountains and the largest glaciers in Eurasia. The conservation area covers a variety of ecosystems, and the continuous ladder-like sequence of habitats was caused by climate change associated with the retreat of the glaciers. Because of its outstanding natural beauty and because it contains a wealth of information about the development of mountains, glaciers and climate change, the heritage sites are prominent and have universal value.

Swiss Tectonic Arena Sardona, Switzerland The Sardona Geological Zone is located along the border between Glarus and Graubünden in eastern Switzerland, and it has a core protection area of 328 km^2. The elevations of the peaks exceed 3,000 m. There are seven mountains in the area, which highlight the orogeny caused by continental collision and the characteristic geological features formed by the collision, and such activity had eventually compressed the sequence of rocks. The heritage site clearly shows the geological structure and processes in three dimensions. Since the eighteenth century, this area has been an important scientific research site for the geological science community. Glarus, in the Alps, is home to a series of mountains separated by narrow valleys that have been eroded by glaciers. It is the largest post-glacial landslide site in the central Alps.

Syenite Syenite is an intermediate plutonic rock. The bulk rock $K_2O + N_2O$ content generally reaches 9%, and the chemical composition is consistent with that of alkali rocks. Syenite contains no quartz or only a small amount (<5%), and the remainder is mainly alkali feldspar. Its nonmenclature, such as hornblende syenite, biotite syenite and pyroxene syenite, is based on the amount of dark minerals contained in the rock. For example, the rock at Nankou in Beijing is hornblende syenite, and the rock at Linxian in Shanxi Province is tveitasite.

Symposium on the Construction of Geoparks and the Protection of Geoheritage in Western China The symposium on the construction of geoparks and the protection of geoheritage in western China was held in Chengdu, Sichuan Province, on 31 July – 1 August 2001. It was jointly organised by the China Tourism Earth Science Research Institute and the Sichuan Tourism Earth Science Research Institute. The symposium had 133 attendees, and 65 papers were presented. The main theme of the symposium was the 'Development and Prospects of China Geoparks'. The Sichuan Tourism Earth Science Research Institute edited and published the proceedings.

Syncline A syncline is a fold in which the rock layers dip towards each other, and the younger layers are in the centre. It is called a synform if the strata dip towards each other, but the older layers are in the centre. When a series of minor folds is superimposed on a large syncline, it is called a synclinorium. In cross-section, the

secondary folds have the shape of inverted fans. Both synclines and anticlines are major components of fold belts or fold systems. There are different types of synclines and different causes of formation. Large synclines tend to become structural basins, which are ideal locations for oil- and gas-bearing strata and coal deposition.

Synclinorium See ▶ Syncline.

Synform See ▶ Syncline.

Synthetic Mineral Synthetic minerals are artificial minerals, such as synthetic diamond, synthetic piezoelectric quartz and synthetic ruby, that are made in factories or laboratories and have similar properties of the natural minerals. Because natural minerals are rare and the demand for them cannot be met, people have begun to simulate the physical and chemical formation conditions of these minerals and synthesize these minerals by artificial means. For example, quartz has a piezoelectric effect, and thin directionally cut quartz plates have been used extensively in the industrial electronics sector. Since 1947, when artificial piezoelectric quartz was first created in the laboratory, abundant transparent and useful quartz crystals have been produced for industrial use. Currently, all optical and industrial quartz crystals are synthetic. Synthetic diamonds are also widely used in drilling and cutting tools and in the electronics and gem industries due to their hardness, semiconducting properties and dazzling lustre. Research into synthetic minerals is developing rapidly. It is now possible to synthesize artificial minerals similar to natural minerals as well as minerals that do not exist naturally.

T

Taï National Park, Ivory Coast Taï National Park, which is located along the border near Liberia in southwestern Ivory Coast, is surrounded by the Guiglo Reservoir and crisscrossing rivers, and it has an area of 3,300 km^2. This park is one of the last major remnants of the primary tropical forest in West Africa. Its rich natural flora and threatened mammal species, including the pygmy hippopotamus and 11 species of monkeys, are of great conservation value and scientific interest.

Tai'an-Type Stone Forest, Xingwen, Sichuan This is a representative type of carbonate rock stone forest landscape. It is composed of Ordovician limestone, and the Tai'an type in Xingwen, Sichuan Province, is a typical example. The stone forest developed in the Upper Ordovician Baota Formation limestone, which is a thin layer of argillaceous limestone containing mud layers and bioclasts, and it is characterised by tumour-like and turtle crack-like structures. The column bodies are rounded and elegant, and they have several forms, such as pagodas, torches, mushrooms and cones. Parallel concave-convex strips also appear on the column surface as a result of differential weathering, making this a unique landform compared with other types of stone forests. In southwestern China, this type of stone forest developed in the Baota Formation limestone. Other examples are Hongshilin (Red Stone Forest) in Guzhang, Hunan Province, and Wangsheng Stone Forest in Chongqing City, which are second only to the Yunnan Stone Forest as the most valuable stone forest sites with development potential for tourism. The Tai'an Park of the Xingwen Global Geopark in China is composed of this kind of landform (Fig. 1).

Taihang Mountains Carbonate Gorge-Group Landscape This is a large gorge group landscape in Cambrian and Ordovician carbonate rocks. It is composed of the network of the Juma River, Hutuo River, Zhang River, Qin River and Taihang Eight Passes. It has a north-south length of 600 km and an east-west width of 250 km, and this area contains the magnificent Taihang Mountains gorge system. This type of landscape is rare both in China and abroad. It has unique aesthetic characteristics for a regional gorge group. For example, Hutian Gorge has a total length of approximately 42 km, but the narrowest spot is just more than 10 m wide. Its highest elevation is 1,822 m, and the greatest depth is 1,336 m. Both sides of this gorge contain numerous branch gorges, forming a distinctive landscape of gorges in the gorge and gorges enclosing gorges (Fig. 2).

Taihu Lake Landscape This is the largest lake in the eastern coastal region of China and the third largest freshwater lake. It is located on the boundary between Jiangsu and Zhejiang Provinces to the south of the Yangtze Delta. The lake surface looks like a crescent with its convex side pointing to the west. The lake shore is irregular with many bays and is dotted with alternating promontories and indentations. There are more than 40 islands in the lake, and Dongting West Hill is the largest. The lake has a surface area of 2,428 km^2. The entire Taihu Lake system includes more than 180 large and small lakes, and with the associated large and small rivers, they form a dense water network like a cobweb. The eastern and northern shores have several low mounds, such as Dongting East Hill, Lingyanshan, Huishan and Majishan. The hills and lakes form spectacular scenery for tourists. The mounds and islands are famous for their tea plantations, sericulture, and subtropical fruit trees, such as bayberry, loquat, chestnuts and citrus fruits (Fig. 3).

Taihu Stone This stone gets its name because it is found in Taihu Lake in Jiangsu Province. In the past, the term mainly referred to the carbonate rocks found in the area from Dongting Xishan to Yixing, and the most famous type

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Fig. 1 Xian'an-type stone forest landscape, Baoting, Hainan Province



Fig. 2 Taihang Mountains carbonate rock gorge-group landscape, Shanxi Province

was the rocks at Yuan Mountain and Yuqi Mountain. Currently, Taihu stone is a collective name for all karst carbonate rocks of various shapes. 'Dry Taihu stone' is produced in the hilly areas around Taihu Lake and is a limestone that has been eroded by acidic red soil. This rock looks dry, coarse and angular. 'Watery Taihu stone' is produced in the lake, where the limestone has been subjected to water corrosion and wave erosion, so holes of various shapes (locally called marble holes) have formed. Taihu stones are generally large and are suitable for display or stacking. Taihu stone can be judged by 15 standards: slimness,



Fig. 3 Lake Taihu landscape

wrinkliness, leakiness, penetrability, elegance, clarity, naughtiness, ugliness, robustness, strangeness, quality, colour, shape, oddness and majesty (Fig. 4).

Tailuge Gorge Landscape, Taiwan This is a 20-km-long karst gorge of marble that extends from Tailuge to Tianxiang. This gorge has a maximum depth of approximately 1,660 m, and the narrowest spot is only 10–20 m wide. The cliffs on both sides of the gorge are nearly vertical with relative heights of 200–300 m. The stream in this gorge runs down rapidly from Hehuan (Acacia) Mountain at an elevation of over 3,000 m and drops 20–30 m per kilometre. The continuous erosion by water has continually deepened the gorge, forming the magnificent Tailuge Gorge scenery (Fig. 5).

Taining Global Geopark, China This geopark is located in northwestern Fujian Province. It has an area of 492 km^2 and became a global geopark in 2005. It has four scenic districts, namely, Shiwang, Dajinhu, Baixianya and Jinyushan, as well as the Taining Ancient City. It is composed of a red sedimentary Danxia landform but also has granite and volcanic landforms as well as interesting geologic structures and geomorphology. The geopark is rich in biodiversity and culture. It contains more than 80 narrow rock ravines, more than 150 corridor-type valleys, and a group of canyons composed of 240 gorges. The geopark is characterised by deep canyons, cliffs, caves and ecology.

Taishan Global Geopark, China *Synonyms:*
► *Taishan National Park, Shangdong, China;*
► *Taishan, China*

This geopark is located in Tai'an City in central Shandong Province, and it covers an area of 158 km^2. It became a global geopark in 2006. The geopark is divided into the Taishan core area and outer area. The core area has five geosites, namely, Hongmen, Zhongtianmen, Nantianmen, Houshiwu, and Taohuayu. The outer area has three geosites: Lianhua Mountain, Laoshan Mountain, and Taoshan Mountain. The geopark is located in the western part of the continental margin tectonic belt of eastern China. Taishan is located in the Luzhonglong fault zone in the Ruxi block of the North China Platform and is a secondary structural unit of this platform. Taishan's rich geological heritage resources have important research value for geosciences such as petrology, stratigraphy and palaeontology, sedimentology, tectonics, geomorphology, and earth history. The heritage is particularly significant for the study of early Precambrian Earth evolution. The Taishan Group is the oldest strata in northern China and records the long and



Fig. 4 Taihu stone



Fig. 5 Tailuge Gorge landscape of Taiwan

complicated evolution over nearly 3 billion years since the Archean. Taishan also has a long history and is a symbol of the spirit of seeking truthfulness and the enterprising spirit of the Chinese nation. Taishan history and culture is the epitome of the history and culture of China.

Taishan Stone This is a type of metamorphic rock in the Taishan area composed of plagioclase gneiss and biotite plagioclase amphibole gneiss. It gets its name because it is mined in the area around Mount Taishan in Shandong Province. It is mainly greyish black, cyan and greyish green with irregular white, brown or red patterns. This stone has numerous patterns, shapes, colours, qualities and sounds. Approximately 20 varieties have been found, such as Taishan egg stone, Taishan jade and turtle pattern stone. Taishan stone has a fine and hard texture with angular edges. It is so solid that it creates an impression of sturdiness and stability, so it is often used to carve Shigandang (evil prevention stone). Its patterns are mainly composed of light-coloured minerals (plagioclase, K-feldspar and quartz) that formed in a later stage in reticular, dendritic, banded and clump shapes, which then filled rock fissures and were exposed by long-term water erosion. As an ornamental rock with cultural significance, Taishan stone has gradually become popular as gifts or collectibles (Fig. 6).

Taishan National Park, Shangdong, China ▶ Taishan Global Geopark, China

Taishan, China See ▶ Taishan Global Geopark, China

Taiwan Orogenic Belt This belt refers to the Cenozoic arc-continent collisional orogenic belt comprising Taiwan Island and the nearby islands. The belt generally trends NNE, consistent with the long axis of Taiwan Island. The strata gradually become younger from the



Fig. 6 Taishan stone (gneiss with boudinage structure)

main watershed of the Central Range to the west. This structure is similar to that of the accretionary wedge and foreland basin on the front edge of the Eurasian Plate. The oldest strata belong to the Tananao Group, which is located along the eastern slope of the Central Range. This group contains a sequence of green schist, volcanic rocks and amphibolites. Its upper part contains marble containing Carboniferous-Permian shovel type fossils, which are the oldest basement rocks in this orogenic belt. Palaeogene and Neogene marine and marine-terrigenous sediments are distributed to the west of the Central Range. The coastal range east of the Central Range is part of the Philippine Sea Plate. The Taitung Longitudinal Valley between these ranges has been confirmed as a plate suture zone. Therefore, the Taiwan orogenic belt is essentially a continental margin orogenic belt on the eastern margin of Eurasia.

Taiwan Special Landscape (North Taiwan) This book was written by Xin Wang and was published by Hiking Culture Publishing House in 2004. It introduces the development background, unique landforms, geomorphic features and geological evolution of northern Taiwan, including the north coast, Taipei basin, Mount Taitun volcano area, Huoyanshan (Flame Mountain), the eastern section of the Central Cross-Island Highway (river landscape) and Kinmen. It is a useful reference for environmental and tourism planning, and it can also be used as a guide book for popularising tourism earth science in northern Taiwan.

Taiwan Special Landscape (South Taiwan) This book was written by Xin Wang and was published by Hiking Culture Publishing House in 2004. The book introduces the geographic conditions, types of landforms, and distribution, formation and characteristics of the landscapes of southern Taiwan. It covers areas such as the east coast, mud volcanos, Hengchun Peninsula and Penghu. It also discusses the international trends and mechanisms of landscape conservation. It is useful as a reference for environmental and tourism planning, and it can also be used as a guide book for popularising tourism earth science in southern Taiwan.

Taiyuan Loess Landscape This is also known as Taiyuan loess landscape formed by loess accumulation. It specifically refers to the long strip of tableland covered with loess along the banks of the Yellow River, Wei River and Fen River in the Fenwei Basin. An example is the Taiyuan loess landscape in the Guanzhong Basin in Shaanxi Province (Fig. 7).

Taiyuan Xishan National Mining Park, Shanxi This park is located in the Wanbolin District, Taiyuan City, and covers an area of 3.10 km^2. It was designated as one of the second group of national mining parks by the Ministry of Land and Resources in May 2010. The main part of the park includes modern mine sites, the Nanshan Changwang Forest, a Japanese gun turret, stone kilns and other mining features. The park will be turned into a national-level forest park by restoring abandoned coal mines, waste disposal sites and the surrounding ecological environment. The park will be developed into a coal industrial development tourist base that integrates underground visits with modern mining development.

Taklimakan Desert Landscape The Taklamakan Desert dominates the hinterland of the Tarim Basin in the Xinjiang Uygur Autonomous Region. It is also known as the Tarim Desert. This desert is 1,000 km long from east to west and 500 km wide from north to south with an area of approximately 330,000 km^2. It is China's largest desert. The forms of the sand dunes are diverse. Generally, the sand dunes are



Fig. 7 Loess Taiyuan landscape in Guanzhong Basin, Shaanxi Province

70–80 m high, and the highest reaches 250 m. Mobile sand dunes make up 85% of the dunes. The longest desert highway in the world, with a total length of 552 km, runs from the Lunnan Oilfield to Minfeng and was built on mobile sand dunes (Fig. 8).

Takyr Landscape A takyr is a desert composed of clay, and they are usually located in low-lying areas of a desert. Takyrs originate as seasonal lakes, whereas during the summer, rivers bring water laden with silt and mud into the low-lying land, where the sediments are deposited. In the winters, the lake dries up. This repeated process eventually forms a takyr, also called a mud desert (Fig. 9).

Talamanca Range-La Amistad Reserves/La Amistad National Park, Costa Rica, Panama These two reserves, which are located along the border between Costa Rica and Panama, are commonly referred to as 'friendship national parks', and they cover a core protection area of 5,678 km^2. The location of this unique site, which was affected by Quaternary glaciers, has allowed the fauna and flora of North and South America to interbreed. Tropical rainforests cover most of the area.

Tancheng-Lujiang Fault *Synonym:* ► *Tanlu fault*

The Tancheng-Lujiang fault zone is called the Yishu Fault Zone in Shandong Province. The fault zone trends NNE and mainly consists of grabens and horsts formed by four faults. It may cross the Bohai Sea northwards to connect with the Yilan-Yitong Fault and Mishan-Dunhua Fault and then extend away from China. It was a large sinistral fault zone in the Mesozoic, but it was reactivated as a dextral shear zone in the Cenozoic. The time of formation and the extent of the translational movement of this fault zone are still debated; however, there is consensus about its significance in the tectonics of China since the Mesozoic.

Tangible Cultural Landscape Tourism Resource System Mankind has created and preserved many ancient ruins, buildings, castles, gardens, tombs, temples and dwellings as well as modern cities, villages, roads, bridges, water conservancy facilities and factories, which have aesthetic and tourism value. These features form a tangible cultural tourism resource system with rich and brilliant content.



Fig. 8 Taklimakan Desert Highway, Xinjiang



Fig. 9 Takyr landscape – Lop Nor, Xinjiang Province (after Dong Zhibao)

Tangshan Kailuan Coal National Mining Park, Hebei This park is located in the centre of Tangshan City and is mainly composed of Tangshan Mine and Dananhu Park (a former coal mining and processing area). It covers an area of 1.15 million m^2. It was approved by the Ministry of Land and Resources in August 2005 as one of the first group of national mining parks. The main scenic site is divided into three parts: an exploration of the mining area, an earthquake experience area, and the coal mine town. It is composed of mining and cultural exposition areas, a mining heritage display area, the underground production

experience area (underground exploration tour), a cultural and creative leisure area (Kailuan magic land) and other scenic sites.

Tanlu Fault ▶ Tancheng-Lujiang Fault

Tanzanite Tanzanite is a gem-quality blue zoisite discovered in 1967 in Arusha, northern Tanzania, Africa, near the famous tourism attraction of Mount Kilimanjaro. This is the only place in the world where tanzanite is mined. In 1969, Tiffany & Co. named it tanzanite after the country and brought it to the market. Since then, tanzanite has been popular with American women. Currently, more than 80% of tanzanite is consumed in the United States. Tanzanite is mainly blue, but some is violet. Some appears blue, purple or golden yellow when viewed from different angles. It is easy to craft because it is softer than ruby and sapphire. Some people only consider it a semi-precious gemstone, so it is less expensive. However, when people became aware that the gemstone called the 'Heart of the Ocean' worn by the actress Kate Winslet in the movie 'Titanic' was actually tanzanite, the cost of this gemstone has significantly increased (Fig. 10).



Fig. 10 Tanzanite crystal

Taohe Ink Slab Taohe stone is produced from the deep water of the Taohe River in Lintan County, Gansu Province, so it was given the name Taohe ink slab. This stone is green and thus is also known as 'Taohe green stone'. It is a shallow metamorphosed argillaceous rock that is mainly composed of layered silicate minerals such as sericite and chlorite. It has a scale-like structure with a directional arrangement. It has the characteristics of the aluminium-rich series and illite clay, and it has low trace element and radioactive element contents. It has a density of 2.75–2.77 g/cm^3, a saturated water absorption coefficient of 0.45–0.47, a porosity of 1.2–1.3% and a particle size of 0.011–0.053 mm. There are four main varieties: (1) duck head green, or 'green ripple stone', which is bluish green, has a ripple pattern, hard fine texture, jade-like lustre, and is a top-grade Taohe inkstone; (2) parrot green, which is dark green with a fine moist texture; those with dark 'ink dots' are most valuable; (3) willow green, which is light green like willow leaves in the spring and dotted with cinnabar spots; and (4) rose red Taohe stone, which is exceptionally eye-catching (Fig. 11).



Fig. 11 Very old Taohe ink slab

Tarbosaurus or Tarbosaurs This dinosaur belongs to the Tyrannosaurus family and was first discovered in Outer Mongolia. In 2010, similar fossils were unearthed in Kazuo County, Chaoyang City, Liaoning Province; hence, it is known as the 'Chinese Tyrannosaur'. It was probably the largest terrestrial



Fig. 12 Tarbosaurus

carnivorous dinosaur on Earth. It lived during the Late Cretaceous. The fossil is 12 m long and approximately 4 m tall, and it has a heavy skull that is 1.58 m long. The head is high on the side with two large eye holes in the front, and the teeth are well developed. The forelimbs are thin and degenerated, with two fingers on each limb. However, the hind legs are strong enough to facilitate running at a speed of approximately 40 km per hour. They gathered together to hunt and eat, and their teeth and hind legs were effective tools. They preyed on large plant-eating dinosaurs such as the Triceratops (Fig. 12).

Tarim Block This block is located between the Tianshan Orogenic Belt and the Kunlun Orogenic Belt. Its surface area reaches 560,000 km^2; therefore, it is also called the 'Tarim Platform'. Data have confirmed that the Tarim block has Precambrian crystalline basement with an age of 3.3 billion years. Platform-cover type deposition began in the Mesoproterozoic Era and lasted until the Late Palaeozoic. In the Cenozoic, the region became a large inland basin with land-vergent structures on both sides. These structures indicate that this basin has been subject to compression since the Cenozoic. The Tarim Basin is now one of the most important oil and gas regions in China. This basin is covered by the Taklamakan Desert, and unique desert landforms have formed many distinctive landscapes for geological tourism that are characteristics of China's western regions.

Tasmanian Wilderness, Australia This site is located at the southwestern corner of Tasmania in Australia. The expansion in 1989 increased the core protection area to 13,836 km^2. The heritage area was significantly affected by glaciers and has many deep gorges. It is one of the few remaining temperate rainforest regions in the world. The remains of limestone caves provide evidence of the human occupation of the area for more than 20,000 years.

Tassili n'Ajjer, Algeria This site is located along the border between the provinces of Illizi and Tamanrasset in southeastern Algeria. The total area is 72,000 km^2. The heritage site, which resembles the landscape of the moon, has important geological research value. It contains the world's most important prehistoric cave artwork. More than 15,000 pieces of paintings and sculptures record climate change, animal migration, and the evolution of human life in the sub-Saharan region since 6,000 BC. Due to the weathering of sandstone, a 'stone forest' formed, which has high aesthetic value.

Te Wahipounamu South West, New Zealand This park is located in the southern part of the South Island and covers an area of 26,000 km^2. The site is composed of three national parks on the World Heritage List, namely, Westland National Park, Mount Cook National Park and Fiordland National Park; thus it was renamed 'Te Wahipounamu-South West New Zealand'. The landscape in the park has been shaped into fjords, rocky coasts, towering cliffs, lakes and waterfalls by successive glaciations. Two-thirds of the park is covered by southern beech and podocarps, some of which are more than 800 years old.

Tectonic Landform Tourism Landscape This is a geomorphic landscape with tourism value formed by changes of the geological structures. For example, mountain ranges, mountain systems and mountain ridges form due to violent neotectonic movements. Most of China's mountains were formed by these processes. For example, the Himalayas are some of the youngest mountains in the world; they have been formed by neotectonic movements and are still being uplifted by several millimetres per year. Block mountains located in regions of significant differential neotectonic movements are the most spectacular and are the best mountain landform tourism travel resources. Examples are Taishan and Mount Qomolangma.

Tectonic Rift Lake Landscape This is a water-filled lowland depression landscape formed by tectonic movements, displacements on faults or geological depressions. Examples are Lake Baikal in Russia, Lake Tanganyika in Africa, the Dead Sea in Jordan and China's Qinghai Lake, Dianchi Lake and Erhai Lake. These lakes are associated with uplifted fault-block mountains. Famous lakes and famous mountains often occur in pairs, such as Dianchi Lake and West Mountain, Erhai Lake and Cangshan Mountain, and Qinghai Lake and Riyue Mountain.

Tectonic Unit A tectonic unit is an area of land that is different from the surrounding areas and has the same or similar geologic characteristics (geological structure, sedimentary structure, magmatic activity, and metamorphism) and evolutionary history. The traditional geosyncline-platform theory, which is based on crustal activity, includes two basic tectonic units: geosynclines (active zones) and platforms (stable areas). Plate tectonics divides the globe into primary structural units, including six major plates, and each primary structural unit can be further subdivided into secondary tectonic units.

Tectonic Valley Landscape This is a type of valley landscape comprising features formed by river erosion along tectonic depressions (e.g., synclines, grabens) or weak zones (e.g., zones with dense joints, faults and anticline axes). The form is controlled by the tectonic structure. Typical examples are narrow and deep valleys along faults. Many natural valleys are related to faults (Fig. 13).

Tectonics *Synonym:* ▶ *Geotectonics*
Geotectonics includes massive regional (or even intercontinental, oceanic, or global) structures that can serve as a structural framework. These megastructures affect the regional tectonics, land subsidence, magmatic activity, metamorphism and basic regional geologic

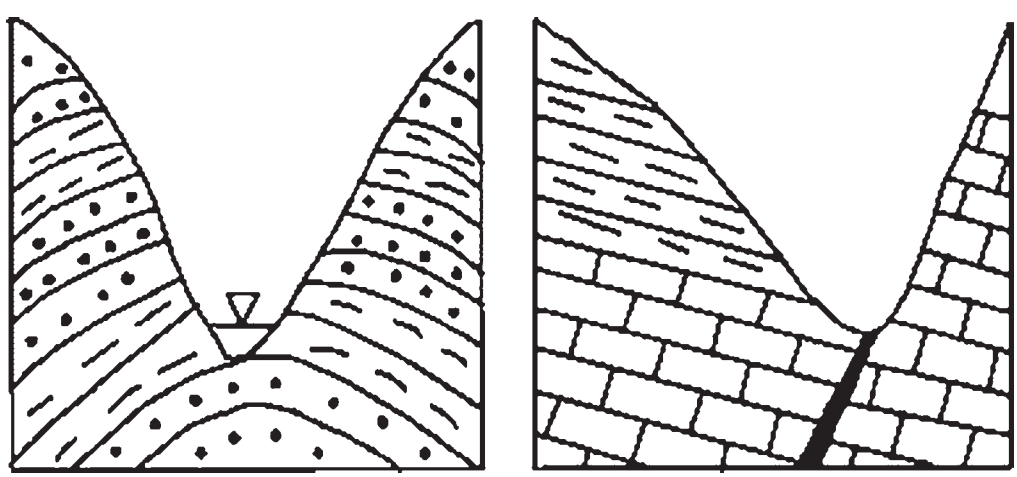


Fig. 13 Diagram of tectonic valley formation (left: anticlinal valley; right: fault valley)

characteristics, and they also control the geologic evolution of a region. Geotectonics is an area of integrated comprehensive research based on regional strata, tectonic and magmatic activity, and metamorphism. Its objective is to understand the basic characteristics of the continental crust and oceanic crust, to categorize different geotectonic units, to determine the formation mechanisms and development processes of different tectonic units, such as orogenic belts and tectonic basins, and to determine the composition, structure and evolution of the crust and lithosphere.

Teide National Park, Canary Islands, Spain This national park is located on Tenerife in the Canary Islands in the Atlantic Ocean. The core protection area covers 190 km^2. Teide-Pico Viejo, with an elevation of 3,718 m, is a major feature of the park and the highest point in Spanish territory. If measured from the bottom of the ocean, it has a height of 7,500 m. It is the third highest volcanic structure in the world. Atmospheric conditions create impressive and fascinating images of the mountain and sea landscapes.

Temperate Desert Climate Temperate desert climates are located in the temperate continental hinterlands and are characterized by arid, extremely arid desert climates. The seasonal and daily temperatures vary with hot summers and cold winters as well as warm days and cold nights. Clouds are few and small, and sunshine is extensive with strong solar radiation. These regions are extremely dry with very little rainfall (less than 200 mm per annum). Some areas, such as Central Asia and the Tarim Basin in China, have no rain for many years. The natural landscape includes desert vegetation with sparsely distributed desert plants.

Temperate Marine Climate The temperate climates in the temperate regions of islands and coastal areas are significantly affected by the oceans. They are located mainly on the western coasts at latitudes of 40–60° north and south, such as Western Europe and the long, narrow west coasts of North and South America. The Netherlands, Belgium, and Denmark are typically influenced by ocean air masses with westerly winds that prevail throughout the year, and they are characterized by more rain and smaller temperature variations. The annual rainfall is approximately 700–1,000 mm, which is evenly distributed across the seasons. Temperate deciduous broadleaf forest is the main vegetation.

Temperate Monsoon This climate type is located on the east coast of Asia at latitudes of 35–55° north and south. These areas include north and northeast China and Russia's Far East. The prevailing wind direction varies significantly between the winter and summer. During the summer monsoon, when the polar sea air is prevailing, it is warm and rainy with small temperature differences between the north and south. The winter monsoon is controlled by the polar continental air masses. The winter is cold and dry, and there are large temperature differences between the north and south. The annual rainfall is between 500 and 700 mm and is concentrated in the summer. Coniferous and broadleaf mixed forest landscapes are common. The landscapes in temperate semi-humid climates are characterized by deciduous broadleaf forests and coniferous and deciduous broadleaf mixed forests.

Temperate Steppe This climate type is mainly distributed in the inland regions of Asia and Europe, North America and South America. These regions are located far from the ocean or are blocked by mountains, so little water circulation occurs. This climate is controlled by the continental air masses for the entire year. The scarce precipitation results in a semi-arid climate. The summers are hot, and the winters are cold with large variations between the day and night temperatures. This climate type is a transition between the dry temperate desert climate and the humid marine climate.

Ten Big Caves Big caves, which in Chinese means 'cave and sky', have long been regarded as a part of the Taoist fairyland, with mountains and a pleasant landscape of hills and water. 'Cave and sky' in Taoism implies a cave that can provide a passage through all mountains and leads to heaven, and this type

Table 1 Ten big caves in China

Serial	Name	Other names	Location
1	Wangwu Cave	Small heaven	Wangwu Mountain between Yuanqu County in Shanxi Province and Jiyuan City in Henan Province
2	Weiyu Cave	Large heaven	Weiyu Mountain in Huangyan County, Zhejiang Province
3	Xicheng Cave	Heaven of truth of Yaiyuan	Xiqing Mountain in Qinghai Province
4	Xixuan Cave	Heaven of truth of Sanyuan	Huashan Mountain in Shaanxi Province
5	Qinghcheng Cave	Heaven of Baoxian Wanshi	Qingcheng Mountain in Qingchengshan City, Sichuan Province
6	Chicheng Cave	Heaven of Ziyu Qingping	Chicheng Mountain in Tiantai County, Zhejiang Province
7	Luofu Cave	Heaven of Zhuming Yaozhen	Luofu Mountain between Zengcheng County and Boluo County, Guangdong Province
8	Juqu Cave	Heaven of Jintan Huayang	Mao Mountain in Jiangsu Province
9	Kuocang Cave	Heaven of Chengde Yinxuan	Kuocang Mountain between Xianju County and Linhai County in Zhejiang Province
10	Linwu Cave	Heaven of Zuojiao Youxu	Tingshan Mountain in West Lake, Wu County, Jiangsu Province

of 'cave and sky' is a good landscape for fairies to live. It is also a tranquil place to advocate for nature and for Taoist monks to retreat to. The rich herbal and mineral resources in these environments allow monks or taoists to practice alchemy of medicinal pills. For thousands of years, many Taoist monks have practised monasticism in these areas, and their practices have played important roles in naming these mountains and in promoting their preservation. China's top ten big caves are listed in Table 1.

Tengchong Hot Spring landscape This is a famous hot spring landscape in China located 11 km south of Tengchong County, Yunnan Province. This spring group has a north-south alignment and geothermal activity at the surface. The spring types vary widely. The main features include hot springs, thermal springs, boiling springs, boiling fountains, fumaroles, steaming ground, sinter, hydrothermal explosions, hydrothermal alteration, and hydrothermal mineralisation. Siliceous sinter, calcareous sinter, sulphurous sinter and efflorescence of various shapes are common. Boiling water flows everywhere, and the mist and hot air move around. These features form the famous hot spring landscape in Tengchong. As early as 1639, Xu Xiake performed a field study of the intense hydrothermal activity in the Liuhuangtang (Sulphur Pond) area. Liuhuangtang (Dagunguo, i.e. Boiling Pot) is a boiling spring with a diameter of 3 m and a depth of 1 m. Its temperature can reach as high as 96.6°C (which is the local boiling point). There is also an intermittent flow of boiling water with a flow rate of 0.9 L/s. The salinity is 28.11 g/L, and the chloride is sodium bicarbonate. Abundant boiling springs are located on the left bank and bed of the Zaotang River. There are also boiling fountains and fumaroles. A shallow borehole was drilled in 1976 to a depth of 26 m, and the temperature at the bottom was 145°C. The average gold and silver contents of the hot spring are approximately 2.73 times higher than the Clarke values. Mineralisation of precious metals is significant (Fig. 14).

Tengchong Volcanic Cluster Landscape, Yunnan This volcanic cluster is located in the basin west of Gaoligong Mountain in the southern Hengduan Ranges, western Yunnan Province. It is 90 km long and 30 km wide.



Fig. 14 Tengchong Dagunguo volcanic hot spring landscape



Fig. 15 Tengchong volcanic cluster landscape

There are more than 70 volcanic cones and more than 20 well-preserved craters. Daying Mountain has an elevation of 2,595 m. Ma'an Mountain, Heikong Mountain and Laifeng Mountain have intact forms with basalt as the main rock, as well as andesite and trachyte. The volcanic eruptions mainly took place 92,000 to 3,700,000 years ago (Fig. 15).

Tengchong Volcano National Geopark, Yunnan This geopark is located in Tengchong County and Lianghe County in southwestern Yunnan Province. It became a national geopark in 2002. It is characterised by volcanic relics and geothermal springs. The geopark contains 97 volcanoes and many types of volcanic cones. There are also lava platforms, ring craters, lava caves, lava flows and primary joint structures. The pyroclastic materials include volcanic bombs, breccia, volcanic ash, pumice and volcanic scoria. The 124 geothermal sites and hot springs are additional interesting attractions.

Tenglong Cave Landscape in Lichuan, Hubei This is the longest karst cave composed of water holes and dry holes. It is located in the Qingjiang underground river section in Lichuan, Hubei Province. This cave developed at the contact between the Triassic Jialing River Formation and the Daye Formation, and it is located at the transition between a syncline and an anticline. The Tenglong cave system generally trends NE-ENE. Its total length is 52.8 km; the water hole is 16.8 km long, and the dry hole is 36 km long. This is by far the longest karst cave known in China. The dry hole's entrance is 64 m high and 61.5 m wide. The exit is Bai (White) Cave in the east, which hangs high above the Qianxi (Thousand Creek) River valley. The main cave is 869 m long, and the chamber is grand and spacious. This cave is generally 40 m wide, but the widest part can reach 70–80 m. It is 50–70 m high, but the height of the Yaowu (Demon Fog) Mountain section reaches 237 m. There are numerous branch caves, 29 of which have been surveyed. Four are large with lengths of 898–3,000 m. The water hole of Tenglong Cave is relatively straight and flat. Its entrance is an inclined aven with a height of 35 m and a width of 25 m. The Qingjiang River drops by 30 m and flows into the ground in the form of a waterfall to become an underground flow. The maximum flow reaches 25.3 m^3/s, forming the magnificent scenery of 'Wolong (Crouching Dragon) Swallows the Qingjiang River' (Fig. 16).



Fig. 16 Gigantic cave entrance of Tenglong Cave in Lichuan, Hubei Province

Tentative List of National Natural and Cultural (Mixed) Heritage in China On January 12, 2006, the Ministry of Construction issued the first tentative list of national natural and cultural heritage (mixed) in China, including 13 national-level scenic areas and their nearby areas of expansion. In 2009, the Ministry of Construction issued the second tentative list of national natural and cultural heritage in China, which consisted of eight heritage units with five national-level scenic areas.

Tentative List of National Natural Heritages in China The Department of Construction plans and administers the applications for all natural heritage as well as natural and cultural heritage in China on behalf of the State Council. On January 12, 2006, the Ministry of Construction issued the first tentative list of national natural heritage in China, which consisted of 17 heritage units that include 14 national scenic areas. In 2009, the Ministry of Construction issued the second tentative list of national natural heritage in China, consisting of 18 heritage units with 12 national-level scenic areas.

Tentative List of World Heritages The tentative list of world heritage, also known as the 'preparatory list', is an inventory of properties situated in the territory of each province that is intended to be considered for nomination for addition to the World Heritage List. To ensure the establishment of a representative, balanced and credible World Heritage List and attempt to reduce the costs that are incurred in the application for and review of heritage, the World Heritage Committee encourages each province to update the tentative list in a timely fashion. In addition, nominations to the World

Table 2 Types of Fluvial Facies

Micro-landform	Sedimentation type	Formation cause – sectional type
Riverbed Convex bank (shore) Channel bar (river island)	Delayed deposition Convex bank (river bank deposition) Depositional channel bar	Bottom deposition (river channel deposition)
Natural embankment, Flood fan on channel bar, Floodplain	Natural embankment deposit Chute deposit Flood fan deposit Floodplain deposit	Top deposition (flood deposition)
Oxbow lake	Abandoned channel deposit (oxbow lake deposit)	Transitional deposition

Heritage List will not be considered unless the nominated property has already been included on the province's tentative list.

Terrestrial Facies *Synonym:* ► *Continental facies*
Terrestrial facies, also called continental facies, are deposits, rocks or strata that form in terrestrial environments. Based on the depositional environment and sediment characteristics, terrestrial facies can be further divided into fluvial facies, remnant facies, diluvial facies, proluvial facies, lacustrine facies, swamp facies, desert facies and glacial facies. Terrestrial facies are characterized by numerous rock types and significant lateral changes. Common rock types are clastic rocks and clay rocks, but some terrestrial lakes and swamps mainly contain chemical and biochemical rocks (Table 2).

Terrestrial Hydrological and Marine Factors of Landscape Formation The factors that form distinctive terrestrial hydrological landscapes include glaciers, rivers, lakes, marshes and wetlands, groundwater and springs. Other factors, such as waves, ocean currents and marine life, control the formation of coastal landscapes and the creation of marine tourism resources.

Terrestrial Hydrology Terrestrial hydrology is the study of the distribution and hydrological processes of water bodies on land, including both surface and subsurface water bodies such as rivers, lakes, swamps, glaciers and groundwater.

Tethys Tethys is the name of an ancient Greek goodness of the sea, and the term refers to the Mediterranean Sea. Geologically, Tethys is equivalent to the ancient Mediterranean Sea. It formed between the supercontinents of Laurasia and Gondwana, roughly along the Alps-Himalaya orogenic belt in southern Europe, and it extended from the Pyrenees, Apennines, Alps, Karpaty and Caucasus ranges to Asia Minor, the Hindu Kush Mountains, the Pamirs and the Himalayas. It then turned south through Myanmar, the Indo-China Peninsula and Malaysia, extended to Sumatra and Timor, and linked to the circum-Pacific Ocean area. Tethys might have existed as early as the Neoproterozoic and lasted through the Palaeozoic and Mesozoic to the early Neogene. The rocks of Tethys experienced large-scale uplift during the Alps-Himalaya orogeny and became the highest mountain system in the world. The existing Mediterranean Sea between Europe and Africa is the remnant of Tethys.

Text Stone A text stone is an ornamental stone that can arouse the appreciative feeling of viewers through its intrinsic meaning, which is represented by the changing tones of its pattern and texture. Stones with the Chinese characters 'Zhong', 'Hua', 'Qi' and 'Shi' are typical examples of text stones. There are many text stones with several Chinese calligraphy styles, including zhuan (seal), li (scribe), kai (norm) and xing (running). The characters on text stones are natural and are comparable to writing except that they are written on another base. There is a 'Cangzishi' (Character Stone) in Guizhou Pingtang National Geopark with five Chinese characters resembling 'Chinese Communist Party'. This is a typical text stone (Fig. 17).

Texture Stone Due to geological processes driven by internal and external forces, minerals can become mobile and recrystallise to form a



Fig. 17 Text stones

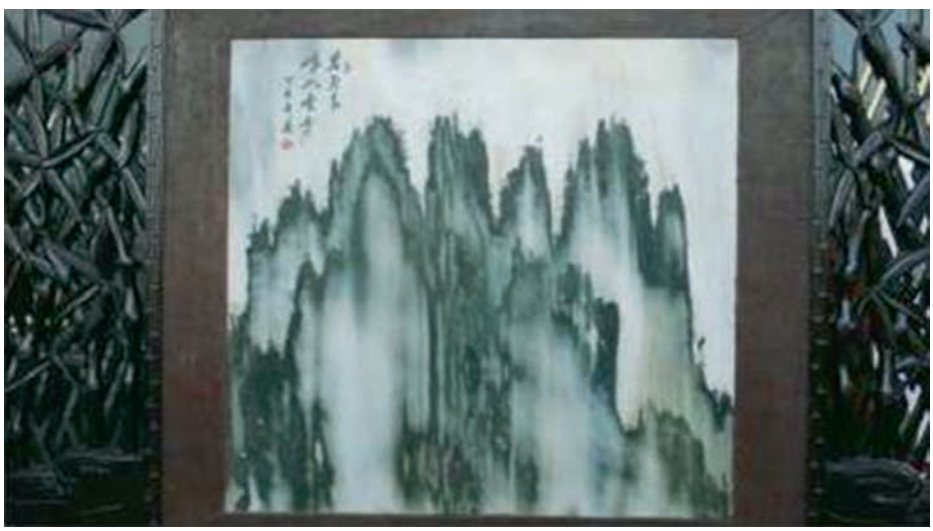


Fig. 18 Texture stone (landscape painting pattern in marble)

new type of rock through physical and chemical processes. These rocks are usually called texture stone and are common in sedimentary, metamorphic, and igneous rocks. Texture stones have clear and beautiful textures, bedding, cleavage and patterns. The beauty depends on its attractiveness, shape and spiritual implications. The textures on the stone mainly form during the formation of the rock. In particular, sedimentary rock layers explicitly reflect such rhythms. Some natural rocks have good textural patterns that can be further revealed through crafting and polishing. Chinese painting stones, colourful cloud stones, Danma stones, peony stones and marble all belong to this type of stone (Fig. 18).

The 30th International Geological Congress Field Trip Guide This book was edited by Hongfei Hou and Anze Chen et al. and was published by Geological Publishing House in 1996. The English edition has a total of six volumes. Volume 1 covers stratigraphy,

palaeontology, sedimentology, petroleum and coal geology and investigations. Volume 2 focuses on Precambrian geology, mineral resources, seismology and investigations. Volume 3 covers volcanoes, Quaternary geology, geomorphology, hydrogeology, engineering geology, environmental geology and geothermal energy and investigations, and Volume 4 covers rock mineralogy and investigations. Volume 5 focuses on regional geology, structural geology, structural metamorphic belts and investigations, and Volume 6 covers regional geology and investigations in Beijing and the neighbouring areas. This guide includes field trip guides for more than 100 geological tours for the 30th International Geological Congress that cover the essentials of Chinese geology. It remains an important guide for overseas geologists coming to China for professional geological travel.

The Carnic Alps Global Geopark, Austria and Italy This geopark is located along the southern part of the border between Austria and Italy. It consists of two east-west-trending, approximately 140-km-long mountain ranges, the Carnic Alps and the Geeta Alps. The mountains are separated by Lethach Canyon and Galata Gorge to the east. The total area is approximately 830 km^2. It became a global geopark in 2012. The geopark has approximately 19,600 residents, and it contains a handful of geological features, particularly a preserved Ordovician-Upper Permian sedimentary sequence. The largest plant fossil in Austria was discovered in the Geeta Alps.

The Chinese Academy of Tourism Earth Science and Geopark Research, Geological Society of China In 2004, the Standing Committee of the Geological Society of China decided to rename the 'Committee of Tourism Earth Science, Geological Society of China' to the 'Chinese Academy of Tourism Earth Science and Geopark Research, Geological Society of China'. At the 20th National Academic Meeting of Tourism Earth Science in June 2005, the Chinese Academy of Tourism Earth Science and Geopark Research, Geological Society of China, was formally established. The incorporation of geopark research created a solid platform for the development of tourism earth science and marked a new era of tourism earth science.

The English Riviera Geopark, UK This geopark became a global geopark in 2007. It is located in the Torbay district of Devon, England, and covers 104 km^2. The area surrounding the park has rich geodiversity and well-exposed geological features from the Devonian to the Pleistocene. The geological landscape has a close relationship with the people of Torbay. It is one of the most concentrated areas of the British Geological Protection Area. There are 11 special scientific sites of interest and national protected areas (SSSI) and 15 regionally important areas (RIGS). The Torbay District has a dedicated agency that is directly responsible for the management of most of the protected areas. It also undertakes education and community activities related to the sustainable use of natural heritage in Torbay.

The Pantanal Conservation Area, Brazil This conservation area is located in southwestern Mato Grosso in Brazil and in northwestern Mato Grosso do Sul in southern Brazil, adjacent to the Bolivian border. It consists of four independent conservation areas that cover a core conservation area of 1,878 km^2. Although it only accounts for 1.3% of Brazil's land area, Pantanal is one of the largest freshwater wetland ecosystems in the world. The reserve contains the sources of the Cuyaba River and the Paraguay River, and it has excellent vegetation and wildlife species diversity.

The Sundarbans, Bangladesh This site is located in the southwestern corner of Bangladesh and is adjacent to West Bengal, India. It is a river delta that was formed by the confluence and alluvial processes of the Ganges River, the Brahmaputra River and the Meghna River. Near the Bay of Bengal, the Sundarbans is one of the world's largest mangrove reserves with a core protection area of 1,395 km^2. The neighbouring Sundarbans National Park in India was added to the World Heritage List in 1987. The reserve is surrounded by tidal waterways, coastal mud

and islands formed by salt-resistant mangroves. It has a variety of wild animals, including 260 bird species, Bengal tigers and endangered species such as estuarine crocodiles and Indian pythons.

The Travelogue of Xiake Xu This is a renowned geography book from the Ming Dynasty. It was written by Hongzu Xu (nickname Xiake Xu). The originals have been scattered and lost, and the existing editions were compiled over time. Ten volumes with more than 600,000 words remain today (however, circulations of 12 volumes, 20 volumes and more have been described). The book describes the author's travel observations from 1607 to 1640 AD and records the geography, geology, geomorphology, karst landforms, hydrology, vegetation and phenology in detail. It also established a new direction in geography that includes systematic observations, descriptions and understanding of nature. Furthermore, it contributed greatly to research on karst landforms in limestone areas by providing vivid, detailed and accurate explanations of the features, structures and formations of caves, underground rivers, peak forests, sinkholes, stalactites, and stalagmites. Its research on limestone landforms preceded that of Europe by more than 200 years. In addition, Xu's vivid and meticulous descriptions make the travelogue an excellent literary work.

Theme Park A theme park is a new type of park planned and built around a specific theme embodying unique environmental and amusement projects. It is a stage for recreation and entertainment activities as well as a leisure and entertainment industry. In 1955, Walt Disney built the world's first Disneyland in Los Angeles, pioneering the development of theme park. On 21 September 1989, the opening of 'Splendid China' in the Overseas Chinese Town of Shenzhen marked the birth of China's theme parks. Currently, China's theme parks are categorised according to different themes, namely, folk customs, natural ecology, future science and technology, history and culture, miniature landscapes, leisure and recreation.

Theory and Practice of Protection and Development of Natural Heritage Site: A Case Study of Mount Yuntai Global Geopark, China This book was written by Ting Zhao and Xun Zhao et al. and was published by Geological Publishing House in 2005. It provides a systematic summary of world natural heritage sites, including national parks, wetlands, biosphere reserves, natural and cultural heritage and global geoparks. Taking Mount Yuntai Global Geopark as an example, it analyses the relationship between the protection and development of geoheritage.

Theory and Practice of Tourism Earth Science: Earth Science Proceedings and Papers This book was edited by Anze Chen and Yunting Lu, and it is a collection of papers from the annual National Academic Meeting of Tourism Earth Science. Eighteen volumes were published from 1985 to 2013 by Geological Publishing House and China Forestry Publishing House. After the establishment of the national geoparks in 2000, it was renamed 'Tourism Earth Science and Geopark Establishment – Earth Science Proceedings and Papers'. They are the most important documents and a literary treasure vault of tourism earth science, providing both theoretical and practical foundations for the establishment and development of this new interdisciplinary field.

Thermal Contact Metamorphism Thermal contact metamorphism is metamorphism under high-temperature conditions. There are two main types: (1) thermal contact metamorphism, which is caused by a magmatic intrusion, the heat energy of which changes the minerals and geologic texture of the surrounding rock in the contact zone but with no change in chemical composition; and (2) contact metasomatic metamorphism, during which magmatic hydrothermal metasomatism in the late stage changes the chemical composition, mineral composition and structure of the surrounding rock at the contact zone. In the former, no chemical or metasomatic changes occur, and thermal contact metamorphic rocks, such as chert and spotted slate, can form. The latter is

characterized by changes in chemical composition and lithology, and contact metasomatic metamorphic rocks, such as skarn rocks, can form.

Thermal Pollution Thermal pollution is pollution caused by the heat energy discharged from modern industrial production and other human activities. Hot water discharged from the cooling systems of thermal power plants, nuclear power plants, coal-fired power plants, and iron and steel plants as well as the production waste discharged from factories, such as petroleum, chemical and papermaking facilities, contains large amounts of waste heat. Additional energy is released from households and vehicle exhaust heat. Heat pollution can pollute the atmosphere and water bodies. The waste heat energy increases the air and water temperatures, leading to changes in the ecological environment.

Thermal Spring ▶ Hot Spring

Third Group of National-Level Scenic Areas On January 10, 1994, the State Council announced another 35 national-level scenic areas. Three scenic areas, namely, Mount Siguniang and Xiling Snow Mountain in Sichuan Province and the Libo Zhangjiang Scenic Spot, have been added to the World Heritage List by UNESCO as natural heritage sites. Dajinhu in Fujian Province and Wangwushan and Yuntaishan National Park in Henan Province have been designated as global geoparks by UNESCO.

Three Gorges of Yangtze River National Geopark (Hubei, Chongqing) This geopark is located in the Three Gorges area (Huo Tang Xia, Wu Gorge and Xiling Gorge), western Fengjie County, Chongqing City, and Yichang, Hubei, is located to the east. It became a national geopark in 2004. The geopark is characterised by a gorge that was formed by the main stream of the Yangtze River and the geological and geomorphological features on both sides. The Three Gorges are most famous canyons in the world. They have the oldest metamorphic basement in southern China, which formed 2.9 billion years ago. The geopark has a complete geological profile that records 800 million years of crustal evolution, and more than 30 palaeontological fossils and thousands of species have been discovered. It is one of the birthplaces of human civilisation and preserves numerous ancient cultural relics, such as the 'Wushan people' from two million years ago, the 'Dashi' culture, the Bachu culture and the Three Kingdoms sites.

Three Parallel Rivers of Yunnan Protected Areas, China This famous scenic area is located in northwestern Yunnan Province. It covers three autonomous prefecture cities, Diqing Tibetan, Nujiang Lisu and Lijiang, as well as eight counties with a total area of 8,609 km^2. It contains iconic gorges that are deeply dissected along predominately N-S-trending faults. The three rivers, Nujiang, Lancang and Jinshajiang, flow parallel for more than 170 km without intersecting. The area contains eight scenic sites, namely, Gaoligong Mountain, Meili Snow Mountain, Haba Snow Mountain, Qianhu Mountain, Hongshan, Yunling, Laojunshan and Laowwoshan. The region is likely the world's richest outdoor geological and geomorphological museum. The area is also an important conduit and refuge for the movement of species and has the richest wildlife community in Eurasia.

Thrust Fault ▶ Reverse Fault

Thungyai-Huai Kha Khaeng Wildlife Sanctuaries, Thailand These sanctuaries are located in northern Thailand on the border with Myanmar, between Kanda Buriram, Dae and Uthai Thani. The core protection area covers 5,774.64 km^2 and includes almost all types of terrestrial forest habitats. Due to the little human activity, it has become a home for many types of wild animals. It provides shelter for 77% of the large mammals in the region (especially wild elephants and Indian tigers), 50% of the large birds and 33% of the terrestrial vertebrates.

Tianchi (Heavenly Lake) Landscape, Changbai Mountains This is a landscape composed of the crater lake of a dormant volcano. The famous Tianchi in Changbai Mountain is a well-preserved composite volcano that formed



Fig. 19 Tianchi landscape at Changbai Mountain

due to several causes. It is located in southeastern Jilin Province near the North Korean border. Its main peak, Jiangjun Peak, has an elevation of 2,749 m and lies inside North Korea. The Tianchi Volcano experienced stages of shield formation (1.20–2.77 million years ago) and cone formation (40,000 to 58,000 years ago) during the late Pleistocene and Holocene. The Holocene eruptions were mainly associated with the accumulation of fallen pumice. The 1668 and 1702 eruptions are described in detail in historical records. Their volcanic ash fell onto the townships along the east coast of Korea at distances up to 150 km. The Tianchi volcanic eruptions experienced three stages, during which the flows transitioned from basaltic to trachytic to alkaline. Tianchi is spectacular and magnificent. It was approved as a national geopark in 2009 (Fig. 19).

Tiankeng Landscape or Ceiling Pit Landscape This is a unique large-scale collapse landform in karst areas in which the depressions can be wider and deeper than 100 m. The width-depth ratio is approximately 1, and most of the rock walls are vertical. Tiangkengs, or ceiling pits, usually develop in the thick vadose zone in the deep depressed areas of a peak cluster. Based on the mode of formation, they can be classified into collapse tiankeng and erosional (scouring) tiankeng, and the former is more common. The nomenclature of this landform is different in different regions of China. It is called a 'rock bay' in Xingwen, 'stone courtyard' in Wulong, 'dragon pot' in Yunyang, 'stone circle' in Leye, 'tiankeng (heavenly ditch)' in Fengjie and 'tuo (heap)'in Pingtang. The term 'tiankeng' (heavenly ditch)' is taken from the Xiaozhai tiankeng in Fengjie County, Chongqing City. It was first proposed as a karst tiankeng by the karstologist Zhu Xuewen in October 2001 to describe a negative landform in a calcium carbonate area with steep walls and a depth and diameter greater than 100 m. As a new scientific terminology, the term 'tiankeng' has begun to be used globally (Fig. 20).

Tianmen Mountain and Tianmen Cave Landscape in Zhangjiajie, Hunan This is a landscape that was formed by dissolution through holes in the middle of Tianmen Mountain. Located approximately 8 km south of Zhangjiajie, the cave developed in thick Cambrian limestone, dolomite and dolomitic limestone. This highest peak of Tianmen Mountain is 1,518 m high, and it is a karst mountain with steep cliffs on all sides. Tianmen Cave is a dissolution cave in the middle of Tianmen Mountain. It is 98 m long, 37 m wide and 131.5 m high. The cave bottom is 1,260 m above sea level. Some people have suggested that Tianmen Cave formed as the result of the dissolution of a doline, but confirmation of its evolution is subject to further detailed study (Fig. 21).

Tianshan Orogenic Belt This belt is oriented east-west in Central Xinjiang between the



Fig. 20 Tiankeng (sinkhole) landscape – Xiaozhai, Fengjie, Chongqing



Fig. 21 Tianmen Cave landscape in Zhangjiajie, Hunan Province

Junggar Block and the Tarim Block. Its area is similar to that of the Tianshan Mountains and stretches east to the Beishan area in Gansu Province. From north to south, the Tianshan Mountains can be divided into the northern, central and southern tectonic belts. Because the Central Tianshan Mountains contain abundant Precambrian rocks, they are considered to be an individual ancient uplift. Overlying this belt, the Lower Palaeozoic Erathem has the sedimentary characteristics and biota of South China. Recent studies suggest that the Northern Tianshan Mountains are an accretionary wedge between the Junggar Block and the Palaeozoic North Tianshan Ocean with extensive late Palaeozoic intermediate to basic volcanic activity. The South Tianshan Ocean is considered to have been a part of the northern margin of the Tarim Basin. The Palaeozoic amalgamation caused the uplift of the Tianshan Mountain and the retreat of the ocean. The Tianshan Mountains became active again from the late Mesozoic to the Cenozoic. Compression from both sides caused substantial uplift, which resulted in the current Tianshan Ranges separating the two basins to the north and south. Due to the Cenozoic uplift of the Tianshan Mountains, many unique landforms formed, which have become important tourism resources for the development of geological parks. The Tianchi (Heavenly Pool) in the Tianshan Mountains is a classical moraine-dammed lake, and the Kuqa Grand Canyon on the southern slope of

the Tianshan Mountains is a Meso-Cenozoic Danxia eolation landform. The formation of these landforms was closely related to the compression and uplift of the Tianshan Mountains.

Tianshui Mount Maijishan National Geopark, Gansu This geopark is located in Tianshui, Gansu Province. It became one of the 5th group of national geoparks in August 2009. It contains Danxia and granite landforms, typical stratigraphic sections, the deep Hequ and the art of the grottoes. The 40-km-long, 5–9-km-wide Danfeng Group ophiolite belt is located in the region. Other important features include the northeast Songpan tectonic site in the West Qinling Mountains, Danxia landforms with vertical cliffs, table mountains, peak forests, conical Danxia hills, and the deep Qu Xi gorge. The Maijishan grottoes were built in the late Qin Dynasty, more than 1,600 years ago. They contain 204 cave niches and 7,866 clay sculptures, and they are protected as national cultural relic protection units.

Tianzhushan Global Geopark, China This geopark is located in Qianshan County, Anqing City, Anhui Province. It has an area of 414 km^2 and became a global geopark in 2001. It includes granite geology and geological heritage with ultra-high-pressure metamorphic rocks. The geopark consists of two areas: north and south. The northern area is the Tianzhushan granite geological area, and the southern area is an area of scientific research on ultra-high-pressure metamorphic rocks. The main peak of the Tianzhushan is 1,488 m above sea level, and it is 400 m higher than the surrounding mountains. Its stability is a major concern because severe rockfalls can be life-threatening. The landform has been named the Tianzhushan style.

Tibetan Dzi Beads This is a special magnetic agate found in the Himalayas (e.g., eastern Tibet in China and Bhutan). It is locally called 'Nine Eye Shale' and is characterised by red, black, yellow and white stripes. It has a Mohs hardness of 7–8.5 and is one of the seven treasures of Tibetan Buddhism. It is called the 'Nine Eye Heavenly Beads' today. Its magnetic properties are three times that of quartz and is probably the strongest magnetic agate in the world. For this reason, Tibetan agate is called Dzi beads or heavenly beads, whereas the agate found in Brazil, Iran, Russia, Indonesia and Taiwan is not given this name (Fig. 22).



Fig. 22 Tibetan Dzi beads (agate beads)

Tidal Bank Landscape This is a landscape in an intertidal beach. It is also known as a tidal flat and is part of the marine coast between the high and low tide marks. It is a wide intertidal beach area that slopes gently towards the sea and is submerged at high tide and exposed at low tide. Every year, China's coastal areas receive more than 2 billion tons of sand and mud transported from the Yellow River, Changjiang (Yangtze River) and Zhujiang (Pearl River); as a result, tidal banks are widely developed. There are two main types of tidal banks: (1) tidal banks in estuaries and deltas, such as the coasts north of Jiangsu Province and west of Bohai; and (2) tidal banks that form from sand and mud transported by currents along the coast and deposited in concealed bays, such as those along the coasts from Hangzhou Bay to north of the mouth of the Minjiang River (Fig. 23).

Tidal Bore of the Qiantang River This is a typical dramatic tidal scenery. Hangzhou Bay outside the Qiantang River has a wide and deep outer portion but a narrow and shallow inner part. It is a typical horn-shaped bay with an inlet approximately 100 km wide but a narrow channel approximately 20 km wide in Ganpu to the west. The river is only 3 km wide when it



Fig. 23 Tidal bank landscape

reaches Yanguan Town in Haining. When the tide comes in, the deep bay accommodates a large amount of seawater, but due to the rapid narrowing of the river channel, the tidal water moving upstream cannot rise in time and is pushed by the following waves. The waves rise progressively, eventually creating a scenery of rolling and roaring tidal flows. This scenery has been described as the most incredible tidal scenery, and the Qiantang River is considered the best place to watch this tidal bore landscape.

Tidal Spring Landscape *Synonym:* ► *Pulsating spring landscape*
A tidal spring is also known as a periodic spring because its flow volume is characterised by non-seasonal periodic changes. These periodic changes can be regular or irregular and are a result of the siphoning action in the karst hydrological system. Therefore, these springs are sometimes called karst siphon springs. These tidal springs are found in both southern and northern China, mainly in Guizhou, Yunnan, Guangxi and Sichuan Provinces. An example is the 'Sanchaoshui (Three Tides)' in northwestern Xiuwen County along the lower section of the Maotiao River. These spring groups are located in middle Upper Cambrian laminated dolomite strata, and the elevation of the spring outlet is at 1,260 m. In year 11 of Daoguang in the Qing Dynasty (1831 AD), a crescent pool was built at this location, and the spring water began to flow from the carved stone dragon's mouth. The flow splashed strongly during high tides but trickled weakly during low tides.

Tide A tide is the periodic movement of seawater caused by the combined effects of the gravitational forces exerted by the moon and the sun. Tides include the periodic rise and fall of sea level and the periodic lateral flow of seawater. The former is called a tidal wave, and the latter is known as a tidal current. In Chinese, the day tide is called 'Chao', and the night tide is called 'Xi', which are similar. The seawater rises to its highest level at high tide. The high tide mark is the boundary between the land and the ocean at high tide. The seawater falls to its lowest level at low tide, and the low tide mark is the boundary between the land and the ocean at low tide. In most locations, a complete cycle of tidal rising and falling takes 12 hours and 25 min. When there are two equal high and low tides each day, it is called a semi-diurnal tide. When there is only one high and one low tide each day, it is called a diurnal tide.

Tide Tourism Landscape A tidal landscape can have tourism value. The Earth is subject to solar and lunar gravitational forces during its rotation and revolution. The tides change

daily; there is a morning tide and an evening tide, which are collectively called ocean tides. In ancient China, watching the tidal changes along the coast was regarded as a tourism resource. The tide-viewing in Qiantangjiang, Zhejiang, is most famous. Due to its trumpet-shaped estuary, seawater flows from the 100 km long inlet into the 3 km wide channel near Ninghai from the 100-kilometre-long inlet. Constrained by the narrow channel, the waves push against each other, forming a huge wall of water that makes a thundering noise as the water rushes like a thousand running horses. The maximum tidal range can reach 8–9 m, and during the large tide season, thousands of tourists come to watch the tides.

Tikal National Park, Guatemala This national park is located in Petén Province in northern Guatemala. It has an area of 576 km^2 and is covered by lush jungles. The park has important remains left behind by the Mayans that lived here from the sixth century to the tenth century AD. Religious ceremonial centres include dungeon temples and palaces as well as public squares connected by slopes. The ruins of residential areas are scattered throughout the surrounding countryside.

Time Difference *Synonym:* ► *Time lag*
The Earth's rotation causes day and night to occur at different times at different locations on Earth. Therefore, sunrise and sunset occur at different times in different countries, and this phenomenon is called a time difference. During international travel, the time difference, or time lag, can affect the biological clock of the human body. Travellers need to know the time difference between their departure and destination cities to better adjust and adapt to the time changes and differences.

Time Lag ► Time Difference

Time Zone The 1884 International Meridian Conference divided the globe into 24 time zones, each of which covers 15° of longitude. The time zone with the central meridian is the zero time zone. The east and west are each divided into twelve different time zones, and the 12th east and west time zones are half time zones that share 180° longitude. When travelling, it is convenient to adjust clocks to the local time by determining the time zone in which the destination is located.

Tombolo; Attached Island/Land-Tied Island This landscape usually forms between an island and the nearby mainland. Waves weaken in the sheltered areas near the mainland, and such energy weakening allows sediments to be deposited in the quiet water. The sediments can be eroded by waves on the side facing the open sea. The removed sediments are further deposited in the nearby protected areas of water, forming sand bars and spits. When the sand spits grow, they eventually link the mainland and the island to form a tombolo. A typical example in China is Zhifu Island in Yantai, Shandong Province.

Tongariro National Park, New Zealand This national park is located in the southwestern part of the North Island of New Zealand. It has an area of 795 km^2. It contains mixed cultural and natural heritage and is on the World Heritage List. The mountains at the centre of the park have important religious and cultural significance for the Maori people, symbolising the spiritual link between the residents' community and the natural environment.

Tongchang Copper Mine, Dexing City This is one of the largest copper mines in China. It is located on Kongque (Peacock) Hill in the Huaiyu mountain range in Dexing City, Jiangxi Province. The Tongchang copper mine is Asia's largest, China's first and the world's second opencast copper mine. The copper mineral reserves are the largest in the country; the total amount is 9,618,000 tons, of which 8,378,000 tons are usable. This mineral deposit is characterised by its abundant and centralised reserves, shallow burial, low stripping ratio, good separability of ore and comprehensive utilisation. The copper ore body is deposited in granite porphyry and along the outer contact zone. Dexing gets its name 'China's Copper Capital' because it has a long copper mining history enriched with an extensive copper culture. According to historic records, copper mining was active

in the Tang and Song Dynasties, and the slag hills can still be seen. This field has been mined on and off for approximately 500 years, and it has now become a national mining park.

Tongling Tongguanshan National Mining Park, Anhui This mining park is located in the southern part of Tongling City in southern Anhui Province. The total area is 4.95 km^2, and it was accredited as a national mining park in 2010. Its copper mining history covers more than 3,000 years; it can be traced back to Shang and Zhou, flourished during the Han and Tang Dynasties, and continues to the present. Inside the mining park, visitors can observe copper mining and metallurgic relics from before the Tang Dynasty. Old mining facilities as well as modern copper mining processes, excavations, and ventilation and transportation equipment are also displayed. In addition, previous mining programmes and production techniques as well as the results of geological prospecting research at this site have been included in the teaching materials at colleges and universities for the study of mineralogy and metallurgy. Tongguanshan is the epitome of the history of copper mining in China over the past 3,000 years and is also an important part of Chinese bronze culture.

Tonglushan Copper-Iron Mine, Daye County This is the remains of an old copper mine located in one of the China's main mining fields that is rich in copper and iron ore. It is located in Daye County, Huangshi City, Hubei Province. The ore body lies in the uplifted portion of a Yanshanian pluton of quartz-syenite-diorite-porphyrite and along the internal and external contact zones with the marble cognate xenoliths and exotic xenoliths of the Lower Triassic Daya Group. There are 12 ore bodies (groups) of varying sizes in 3 ore belts. The mining activity in this area has a long history. Historic mining sites were discovered during recent mining. Archaeological excavations have shown that hundreds of vertical shafts, inclined shafts and staple shafts (blind shafts) with different structures were constructed using different support methods over a period of a thousand years from the Western Zhou Dynasty to Han Dynasty, and a 100-metre mine gallery with copper melting furnaces from the Early Spring and Autumn Periods was found and restored. This site is by far the most extensive, longest operating and best-preserved old copper mine in China. The Tonglushan copper-iron mine is one of the top five major copper centres in the country (Fig. 24).

Topaz In Chinese, topaz is also known as 'yellow gemstone' or 'yellow crystal'. It is an aluminium silicate containing fluorine, and its composition is $Al_2[SiO_4]$ $(F.OH)_2$. The crystal structure is prismatic with striations on the faces parallel to the long dimension. It has a Mohs hardness of 8 and a specific density of 3.53–3.57 g/cm^3. It is commonly yellow but can be red, pink, blue and colourless, and blue, wine yellow and pink topaz is most valuable. Its colour can be altered artificially to become azure or golden yellow. Special attention should be paid when purchasing topaz. Gem-grade topaz forms under high-temperature conditions with volatile components. It mainly exists in granite pegmatite and in placer deposits. Famous mining countries include Brazil, the United States and Russia. Topaz is also produced in Inner Mongolia, Xinjiang Province, and the Dabie Mountains in China (Fig. 25).

Topographic Rain Topographic rain occurs when a warm and humid air stream meets a topographical barrier of higher terrain and is forced to climb along the windward slope. The warm and humid air cools while ascending, which causes condensation and rainfall.

Toponomy Toponomy is the study of the names of places, including their origins, composition, meaning, evolution, distribution patterns, standardization and functions of reading and writing as well as their relationship with the natural and social environments. In tourism research, the knowledge of toponymy is often used to explore the natural, historical and cultural resources for designating tourist destinations.

Tornado A tornado is a tunnel-shaped cloud extending from a cumulonimbus cloud to the



Fig. 24 Tonglushan copper-iron mine relics



Fig. 25 Topaz crystal

ground. A tornado is generated under the most unstable weather with powerful atmospheric convection. The wind speed can reach grade 12 or higher on the Beaufort Wind Scale. Tornados are usually accompanied by thunderstorms, torrential rain and hailstorms and have great destructive power.

Torrential Ravine Tourism Landscape These are unique landscapes in the upper courses of rivers in highland regions with steep slopes and torrential water flows. This type of landscape provides ideal places for adventures and rafting. Examples are Taiwan's Hsiukuluan River, Dajiexi in Hehuanshan and the Maling River in Guizhou Province.

Tour System Planning of National Mining Parks This planning considers the distributions and characteristics of the landscape resources of parks, such as mining relics, geological relics, human cultural landscapes and natural landscapes, and it allocates the landscape resources of the park to form a complete

landscape system. Specifically, the planning consists of five aspects, including landscape structure planning, landscape layout planning, tourist attraction construction planning, tourist route planning and tourist capacity planning.

Tourism Tourism is also called travelling and usually refers to activity out of one's usual place of residence for more than one night, mainly for relaxation instead of employment. Tourism is a people-oriented social, economic and cultural phenomenon. Tourism is a comprehensive industry that consists of numerous business entities that serve the needs of tourists. It is mainly made up of travel agents, the transport industry and accommodation providers represented by hotels. They are the three major pillars of the modern tourism industry.

Tourism Aesthetics Xiu Qiao was the editor-in-chief of this book, which was published by Nankai University Press in 1987. It was the first tourism aesthetics textbook in China. The book is divided into three chapters. The first chapter focuses on aesthetics and tourism, and it mainly describes the morphologies, characteristics and appreciation of the beauty of scenery. It also elaborates on the appreciation of gardens, paintings, calligraphy, ancient architecture, sculpture and tourism souvenirs in China. The second chapter describes the relationship between the psychology of aesthetic judgement and aesthetic judgement. The third chapter describes the environmental art, locations, exterior design and interior decoration of hotels.

Tourism and Climate This book was edited by Qirun Yao et al. and was published by China Tourism Publishing House in 1986. It was the only book about tourism climate in China from the 1980s until 2012. It is divided into 15 parts, including the tourism climate in the northeast, the capital of Beijing, North China, northwestern and eastern China, the Hubei Basin and Hunan Basin, the Sichuan Basin, the Yungui Plateau (Yunnan-Guizhou Plateau), the scenery of South China, the Qinghai-Tibet Plateau (Tibetan Plateau) and famous coastal scenery and major mountains.

Tourism Anthropology Tourism anthropology is the study of the relationships among residents in tourist destinations, social organizations, tourism developers and tourists from cultural and aesthetic perspectives. During the 1970s and 1980s, the main goal of tourism anthropology was to study the influence of tourism on the society and culture of a destination. In the 1990s, researchers began studying the sustainable development of tourism, and they started to think about how to achieve social and cultural sustainability. Anthropologists who focus on the society of tourism destinations believe that tourism triggers social and cultural changes; thus, they view tourism as a form of internalization and development and as a superstructure that depends on other more fundamental social elements.

Tourism Channel Tourism channels are the routes and links between tourist source areas and destinations. A channel refers to spatially defined tourist traffic routes, such as roads that connect transportation hubs, hotels and tourist destinations. Some of the roads in tourist regions are the main entrances to tourist destinations. Tourism markets will expand unequally along tourism channels in different directions.

Tourism City A tourism city is a city with a unique natural or cultural landscape and unique resources that can attract tourists and has a certain level of tourist capability. In 1995, the China National Tourism Administration issued the 'Circular on Launching and Selection of China's Outstanding Tourism Cities'. The establishment of an excellent tourism city in China must be based on the 'Interim Measures for the Administration of the Construction of China's Outstanding Tourism Cities and the Inspection Standards for China's Outstanding Tourism Cities (2003)'. The inspection team of the National Tourism Administration is responsible for inspecting and approving cities that have met the standards of excellence.

Tourism Commodities Tourism commodities are goods made to meet the needs of tourists.

There are three main categories of tourism commodities: souvenirs, food and travel supplies.

Tourism Community A tourism community is a community with a shared interest as a tourist destination that usually consists of local residents, tourists, businessmen and administrators. Members of such communities include not only people working in the tourism industry but also those in other occupations. Together, they bear the positive and negative effects of tourism on the economy, society, culture, and environment. A tourism community is a regional social unit that forms in a certain area over a long period of time around a tourist attraction.

Tourism Decision-Making Tourism decision-making includes decisions about the routes and destinations of tourism before departure. The process of gathering information and making decisions based on one's preferences is called tourism decision-making. This process usually includes three steps: understanding the needs, collecting information and making decisions through evaluations and comparisons.

Tourism Demand Tourism demand refers to the amounts of tourism products and the number of tourist destinations that tourists are willing and able to buy at a certain price during a period of time. Two aspects influence tourist demand: the level of economic development in the tourist source area, including personal income, occupation, paid vacations, educational level, and personal preferences, and the conditions and supply of tourist destinations, including the attractiveness of tourism resources, prices, exchange rates, traffic conditions, reception facilities, and tourism organizations.

Tourism Demand Forecasting Model Before any tourism planning can be performed, a forecast based on a mathematical model of the number of guests expected over the short, medium and long terms is needed. This includes estimates of the numbers of people and days of vacation and the per capita consumption. The forecasts are divided into short-term (2–3 years), medium-term (3–5 years) and long-term (over 5 years) forecasts. Many mathematical formulas and models are available for tourism demand forecasting. Four types of models are often used: trend extrapolation models, structural models, simulation models and qualitative models.

Tourism Design Through the creation, integration and connection of tourism-related elements and research on each target market segment, a product portfolio can be proposed, and the feasibility of releasing it to the market can be systematically evaluated. The understanding and evaluation of tourism resources is the basis of tourism design. Planning for the system of tourism products can be difficult, and research on the tourism market is the key to its success.

Tourism Destination Marketing Tourism destination marketing is the mode of marketing at the regional level. The core idea is to comprehensively promote the tourist destination and increase its overall competitiveness, after which marketing can then be carried out for the tourism products. It has two levels: the first level focuses on the destination and its tourism products, and the second includes the marketing activities of commercial enterprises that promote individual products. These two levels complement each other.

Tourism Development Strategy A tourism development strategy is a long-term plan and guiding principles developed by countries or regions for tourism development. From the trade perspective, a tourism development strategy is a general plan of the goals, means and methods for tourism development that is made according to the internal and external environments and its accessible resources to achieve long-term, stable and sustained development. It is a reflection of the industrial economy and is also the basis for formulating an industrial plan. It can be divided into macro and micro levels. From a microscale perspective, a tourism development strategy is a combination of plans, measures and programmes formulated by a regional tourism industry based on the strength of its tourism enterprises. In regional

tourism, a development strategy is composed of marketing, human resource management, pricing and promotional plans; thus, the microscale concept is the development strategy made by tourism enterprises from the view of marketing. From a macroscale perspective, a tourism development strategy focuses on the establishment of middle and long-term directions, goals and tasks of development.

Tourism Earth Science This is a new interdisciplinary field combining earth science and tourism. The meaning of tourism earth science has become better defined with the continuous development of the discipline. In 1985, when the Chinese Academy of Tourism Earth Science was established, its definition was included in the second article of the constitution, which stated 'Tourism earth science is a new interdiscipline utilising the theory and methodology of earth science for the survey, research, planning, development and protection of tourism resources'. In 1991, Anze Chen and Yunting Lu edited 'Introduction to Tourism Earth Science'. They proposed a more in-depth meaning, stating that 'tourism earth science is a new branch of earth science. It studies the relationships between travelling, sightseeing, recuperative and recreational activities of human beings and the material composition and structure of the earth's surface as well as the transfer and changes of energy. It covers the domains of both geological and geographical tourism. Therefore, tourism earth science is a generic term for the study of tourism geology and tourism geography.' In the 'Grand Tourism Earth Science Dictionary', its definition was expanded and refined. Tourism earth science is a new interdisciplinary subject integrating earth science and tourism, primarily including tourism geology and tourism geography. Tourism earth science is based on the theories and methods of earth science and adopts the theories and methods of other disciplines (e.g., aesthetics, environmental science, landscape science and tourism) to study various issues related to earth science and tourism. These include: (1) Studying the main element of the tourism industry – tourism resources. These studies focus on the natural resources of tourism, including their types, formation, distribution, aesthetic value, scientific value, science popularisation value, tourism development value, protection methods, tourism planning and the development of regional and scenic areas. They also investigate the elements of the geosciences related to human landscape resources, such as the geological background and environmental factors of ancient architecture, ancient cultural sites, grottoes and gardens. Recently, ornamental stones, gemstones, jade and other tourism resource products have also been included. (2) Studying the subjective element of the tourism industry – the tourist market. This includes the patterns of tourists and the impacts of various factors on the supply of tourists, including the geographical environment, transportation conditions, and economic development of a region. (3) Studying the media element of the tourism industry – tourism reception facilities and policies. This covers earth science issues related to the construction of tourism service facilities, such as the selection of roads and construction sites, route selection, foundation stability, conditions and feasibility of site rehabilitation (e.g., temperature, humidity, sunlight, radioactivity, magnetism, electricity, trace elements, negative oxygen ion field values, and water quality of bath treatments). It also studies factors affecting tourism, such as geological hazards (e.g., earthquakes, volcanic eruptions, landslides, mudslides, floods, and falling rocks) that may threaten tourist safety as well as the associated regulations for preventing and alleviating these potential problems. (4) Studying the theories and practices related to geopark establishment and management, such as their classification, assessment criteria, geological heritage protection, planning, geotourism product design, interpretation and appreciation systems, scientific research, earth science popularisation and information systems. In addition to geoparks, world heritage sites, scenic attractions, forest parks, mining parks, and water conservancy scenic areas are also within the scope of

study. Tourism earth science is a fundamental discipline integrating tourism and earth science that enriches both disciplines in a healthy and orderly manner. Tourism earth science is often called 'geotourism' outside China. However, tourism earth science is more academic in nature and focuses more on adopting the concepts, theories and methodologies of earth science in studying tourism activities. It has become a new, rapidly growing branch of the broader academic discipline of earth science with well-proven practical needs and is able to create new research and job opportunities for earth scientists around the world.

Tourism Earth Science and a New Dimension on Tourism Development This book was written by Maoxun Chen and was published by Sichuan Science and Technology Press in 2006. It is divided into two parts: tourism earth science research and a new dimension in tourism development. The content includes the theory and practice of tourism earth science, an outline of a new dimension in tourism development, regional tourism development strategies, hot springs and tourism, artificial reservoirs and tourism, wonders of geology and landscapes and tourism, tourism resort models, tourism area planning and construction, and overseas tourism development.

Tourism Earth Science Commodities Tourism earth science commodities are commercial tourism products with geological connotations that meet the needs of visitors. Examples are precious stones, jades, ink-stones and handicrafts polished and processed from minerals and rocks as well as unprocessed natural stones with aesthetic and commemorative value. In a broader sense, they should also include mineral water, hot springs, geotourism routes, and audio-visual products that popularise earth science. Unlike other commercial tourist products, tourism earth science commodities contain rich earth science characteristics. They can be used as specimens and research materials for learning earth science in addition to their normal usage or appreciation. Tourism earth science commodities should be designed according to their local characteristics.

Tourism Earth Science Industry The tourism earth science industry is part of a well-developed industry. It is a new type of industry that uses earth science knowledge to facilitate tourism development. It mainly includes: (1) earth science resources investigation, evaluation and planning; (2) tourism earth science projects (districts, sites, routes) design, consultation, organisation and implementation; (3) undertaking tourism earth science projects such as roads, airports, ports, construction site selection, foundation stability, geological heritage protection, water source exploration, and geological hazard assessment and prevention; (4) developing and operating geological tourism commodities such as mineral water, hot springs, ornamental stones, precious stones, and jade; (5) establishing and operating specialised fully equipped travel agency network systems with earth science characteristics and developing geotourism; (6) establishing systems for geopark management and services such as geopark planning and design institutes, research institutes, training centres, exhibition production centres (including the design and construction of geopark museums, production of earth science films and interpretation facilities, and production of information network facilities), tourism earth science books and electronic publishing centres; and (7) managing and operating geotourism bases, mainly including various types of geoparks and natural protected areas characterised by geological heritage. The purpose of establishing the tourism earth science industry is to enlarge the earth science services field, protect geological heritage, disseminate earth science knowledge, and promote sustainable economic and social development.

Tourism Earth Science of Huangshan This book was written by Jiyuan Hu and was published by Huangshan Publishing House in 1996. It explains the research history, physical geography and geology of Huangshan in easy-to-understand language. It also describes Huangshan's tourism earth science resources and the characteristics of tourist attractions,

and it proposes suggestions for development and protection.

Tourism Earth Science of Mount Emei This book was written by Huairen Liu and was published by Chongqing Publishing House in 1998. The book briefly discusses the geological history, strata, rocks, structures, and palaeo-biological characteristics of Mount Emei. It systematically introduces the geological tourism resources of Mount Emei and presents a scientific analysis of the intrinsic link between the formation of Mount Emei's beautiful scenery and its geological evolution. The meteorology, vegetation, animals and other geographical landscapes are also briefly introduced. This was the first geotourism picture book to introduce Mount Emei.

Tourism Earth Science Organisation A tourism earth science organisation is an academic organisation or association that studies and promotes the development of tourism earth science. The tourism earth science organisations in China mainly include the Academy of Tourism Earth Science and Geopark Research of the Geological Society of China, the Professional Tourism Geographical Committee of the Geographical Society of China, the Cave Research Society of the Geological Society of China, the Regional Tourism Development Research Institute, all local tourism earth science research institutes (such as the Tourism Earth Science Research Institute of Sichuan Province) as well as the Tourism Earth Science Research Association, Tourism Geology Committee and Geopark Committee established by the provincial Geological Society of China. Tourism earth science organisations play an important role in uniting tourism earth science experts, exchanging research results, and promoting China's tourism development, especially bringing knowledge of earth science into tourism products.

Tourism Earth Science Research and Tourism Resources Development This book was edited by the Sichuan Tourism Earth Science Research Institute and was published by Sichuan University Press. It is a collection of academic papers of the Sichuan Tourism Earth Science Research Institute from 1990 to 2003 in five volumes. The contents include earth science resources, environmental protection and sustainable development; research on ecotourism; tourism development and strategies; theory and methodologies of tourism earth science; and the evaluation and exposition of development planning of scenic site resources.

Tourism Earth Science Resource System This is a system of interrelated tourism earth science resources that is integrated within the areas accessible to human beings. Based on the concentric structure of the Earth, earth resources can be categorised into six major systems, 47 landscape types and 159 landscape subtypes. Based on each landscape's composition, geographical distribution, formation factors, grouping forms and scenic characteristics, each landscape sub-type can be further subdivided into more specific landscape character units. For example, the clastic tourism earth science landscape sub-type can be further sub-divided into the Zhangshiyan-type landscape, Zhangjiajie-type landscape, Wu'urhe-type wind-eroded castle landscape, Danxia-type landscape, Zhangye sandstone colourful hill-type landscape, Taiwan Yeliu-type landscape, Luliang-type multi-coloured sand forest landscape, Yuanmou-type soil forest landscape, Qian'an mud forest landscape and Yardang landscape (Table 3). The tourism earth science resource system can be categorised in Table 3.

Tourism Ecological Planning Tourism ecological planning is a type of special tourism planning based on ecological protection. It includes natural ecological planning and human ecology planning. It incorporates the elements of tourism activities as well as the social and economic factors related to tourism into the tourism area ecosystem, and it rationally allocates them according to the principles of ecology to maintain the sustainable development of tourism ecosystems.

Tourism Ecology Tourism ecology is the study of the interaction and mutual influence

Table 3 Categories of the tourism earth science system

Macrosystem of tourism earth science resource	Tourism earth science resource system	Tourism earth science landscape type	Tourism earth science landscape sub-type
1. Macrosystem of lithospheric tourism resources	1. Tourism resource system of geological landscapes	1. Stratigraphic tourism landscapes	1. Global boundary stratotype section (Jindingzi) landscape 2. Standard national section landscape 3. Standard regional section landscape 4. Standard local section landscape 5. Basic rock (body) section landscape 6. Intermediate rock (body) section landscape 7. Acidic rock (body) section landscape 8. Alkaline rock (body) section landscape 9. Contact metamorphic zone section landscape 10. Thermal contact metamorphic section landscape 11. Migmatite section landscape 12. Ultra-high-pressure metamorphic zone section landscape 13. Sedimentary facies section landscape
		2. Palaeontological and fossil man tourism landscapes	14. Palaeo-anthropological fossil landscape 15. Palaeo-anthropological human activity relic landscape 16. Palaeontological invertebrate landscape 17. Palaeontological fauna landscape 18. Palaeontological flora landscape 19. Palaeo-biological activity relic landscape
		3. Tourism landscape of endogenic geological processes	20. Global structure landscape 21. Regional structure landscape 22. Intermediate and micro-structure landscape
		4. Tourism landscape of exogenic geological processes	23. Fluvial erosion landscape 24. Fluvial deposition landscape 25. Wind erosion landscape 26. Wind deposition landscape
		5. Geological tourism landscape of mineral resources	27. Typical (aesthetical) mineral mining site landscape 28. Typical metal mining site landscape 29. Typical non-metal mining site landscape 30. Typical energy mine landscape
		6. Environmental geological heritage tourism landscapes	31. Palaeo-seismic relic (heritage) landscape 32. Recent seismic relic landscape 33. Meteorite impact relic landscape 34. Mountain collapse relic landscape 35. Landslip relic landscape 36. Debris flow relic landscape 37. Ground crack relic landscape 38. Ground collapse relic landscape 39. Mining relic landscape
	2. Tourism resource system of geomorphology	7. Tectonic landform tourism landscapes	40. Block mountain landscape 41. Fault scarp landscape 42. Fault valley landscape 43. Fold mountain landscape
		8. Rock landform tourism landscapes	44. Granite landscape 45. Clastic rock landscape 46. Karst landscape 47. Loess landscape 48. Sand landscape 49. Metamorphic rock landscape
		9. Volcanic landform tourism landscapes	50. Volcanic edifice landscape 51. Volcanic lava landscape
		10. Glacial landform tourism landscapes	52. Glacial erosion landscape 53. Glacial deposition landscape 54. Periglacial fringe landscape
	3. Tourism resource system of caves	11. Limestone cave tourism landscapes	55. Limestone dry cave landscape 56. Limestone active cave landscape 57. Gypsum cave landscape
		12. Lava tunnel (cave) tourism landscapes	58. Basalt tunnel (cave) landscape 59. Rhyolite tunnel (cave) landscape
		13. Other cave tourism landscapes	60. Collapse stack cave landscape 61. Differential weathering cave landscape 62. Ice cavern landscape 63. Artificial cave landscape

(*continued*)

Table 3 (continued)

Macrosystem of tourism earth science resource	Tourism earth science resource system	Tourism earth science landscape type	Tourism earth science landscape sub-type
2. Macrosystem of hydrosphere tourism resources	4. Tourism resource system of the ocean	14. Ocean tourism resource landscapes	64. Marine erosion landscape 65. Marine deposition landscape
		15. Island tourism landscapes	66. Oceanic island landscape 67. Tombolo landscape
		16. Coral reef tourism landscapes	68. Coastal reef landscape 69. Fort reef landscape 70. Atoll landscape
		17. Tide and wave tourism landscapes	71. Tidal landscape 72. Wave landscape 73. Tsunami landscape
	5. Tourism resource system of rivers	18. River tourism landscapes	74. Rafting river section landscape 75. Scenic river section landscape 76. Scenic stream landscape 77. Artificial channel landscape
		19. Waterfall tourism landscapes	78. Dry river tributary waterfall landscape 79. Mountain waterfall landscape 80. Underground waterfall landscape
		20. Canyon tourism landscapes	81. Large canyon landscape 82. Medium canyon landscape 83. Small canyon landscape
		21. River delta tourism landscape	84. River delta landscape
	6. Tourism resource system of lakes	22. Natural lake tourism landscapes	85. Tectonic rift lake landscape 86. River trail lake landscape 87. Marine trail lake landscape 88. Glacial trail lake landscape 89. Volcanic lake landscape 90. Wind erosion lake landscape 91. Cave lake landscape 92. Salt lake landscape
		23. Artificial lake tourism landscape	93. Man-made reservoir landscape
	7. Tourism resource system of glaciers	24. Polar glacier tourism landscape	94. Polar glacier landscape
		25. Mountain glacier tourism landscape	95. Mountain glacier landscape
	8. Tourism resource system of groundwater	26. Spring tourism landscapes	96. Hot spring landscape 97. Hot gas flow landscape 98. Cool spring landscape 99. Mud volcano landscape 100. Mud spring landscape 101. 'Dragon eye' landscape
		27. Sinter tourism landscapes	102. Travertine platform landscape 103. Travertine pool landscape 104. Travertine flow landscape
		28. Subterranean river tourism landscape	105. Subterranean river landscape
3. Macrosystem of cultural sphere tourism resources	9. Tourism resource system of material cultural landscapes	29. Ancient cultural relic (heritage)tourism landscapes	106. Ancient cultural heritage landscape 107. Ancient building landscape 108. Ancient tomb landscape 109. Grotto landscape 110. Stone carving landscape
		30. Modern cultural relic and heritage site tourism landscapes	111. Modern cultural relic landscape 112. Modern cultural heritage site landscape
	10. Tourism resource system of non-material cultural landscapes	31. Oral literature tourism landscapes 32. Performance art tourism landscapes	113. Folk literature landscape 114. Music landscape 115. Art landscape 116. Opera landscape 117. Acrobatics landscape
		33. Folk customs tourism landscape	118. Folk customs landscape
		34. Traditional handcraft tourism landscape	119. Traditional handcraft landscape

(*continued*)

Table 3 (continued)

Macrosystem of tourism earth science resource	Tourism earth science resource system	Tourism earth science landscape type	Tourism earth science landscape sub-type
4. Macrosystem of biosphere tourism resources	11. Tourism resource system of flora	35. Natural forest tourism landscapes	120. Virgin forest landscape 121. Secondary forest landscape 122. Rainforest landscape 123. Mangrove landscape
		36. Plantation forest and vegetation tourism landscapes	124. Botanical garden landscape 125. Flower show landscape 126. Old and valuable tree landscape
		37. Wetland vegetation tourism landscapes	127. Freshwater wetland vegetation landscape 128. Coastal wetland vegetation landscape 129 Swamp vegetation landscape
		38. Grassland tourism landscapes	130. Alpine grassland landscape 131. Mountain grassland vegetation 132. Meadow vegetation
	12. Tourism resource system of fauna	39. Wild animal tourism landscapes	133. Wildlife nature reserve landscape 134. Special wildlife community landscape
		40. Zoo tourism landscapes	135. Integrated zoo landscape 136. Aquarium landscape 137. Entertainment-style animal landscape
5. Macrosystem of atmospheric tourism resources	13. Tourism resource system of meteorology	41. Special astronomical phenomenon tourism landscapes	138. Polar light landscape 139. Buddha's halo landscape 140. Mirage landscape
		42. Special meteorological phenomenon tourism landscapes	141. Cloud and mist landscape 142. Rosy cloud landscape 143. Misty rain landscape 144. Sugar snow landscape
	14. Tourism resource system of climate	43. Special climate tourism landscapes	145. Summer heat-avoiding climate landscape 146. Cold-avoiding climate landscape 147. Sunshine climate landscape
	15. Tourism resource system of clean air	44. Clean air tourism landscapes	148. Highland clean air landscape 149. Polar clean air landscape 150. Forest clean air landscape 151. Marine clean air landscape
6. Macrosystem of cosmic space tourism resources	16. Tourism resource system of outer space	45. Cosmic space tourism landscapes	152. Cosmic space landscape 153. Celestial body landscape
	17. Tourism resource system of astronomical observations	46. Astronomical observation tourism landscapes	154. Night sky landscape 155. Solar eclipse landscape 156. Lunar eclipse landscape 157. Meteor landscape 158. Sunspot landscape
		47. Meteorite tourism landscapes	159. Meteorite landscape 160. Cosmic dust landscape

between tourism elements (including the six tourism elements, tourism activities, tourism exploitation, and management of tourist destinations) and the natural environment. Tourism ecology studies the composition, structure, management and optimization methods of tourism in relation to ecology and provides theoretical support for the sustainability of tourism.

Tourism Economics Tourism economics is an interdisciplinary field of tourism science and economics. It is the study of the economics of tourism activities and the related economic phenomena, relations and laws.

Tourism Environmental Protection Planning Tourism environmental protection planning is tourism planning that focuses on the interactions between tourism development, tourism activities, and the natural, socio-economic and cultural environments. It is based on environmental assessments. It proposes countermeasures or suggestions for

problems such as the division of functional areas, tourist capacity, forms of tourism, construction, ecological protection, and environmental governance. Its purpose is to protect and manage the resources of tourism destinations, the natural ecological environment and cultural landscapes.

Tourism Experience A tourism experience is the process of an individual changing and adjusting his/her own state of mind while travelling. This process occurs after appreciating, associating with, imitating, and spending time during travelling. The process of having a tourism experience is continuous and consists of multiple special and meaningful moments added together as something different from one's typical life. Tourism expectation is the criteria by which people measure their experience. Tourism experience includes entertainment, education, escape, appreciation and empathy. Principles of diversity, participation, authenticity and challenge should be followed to provide enjoyable and unique tourism experiences.

Tourism Facilities Tourism facilities are facilities built to meet the needs of tourists. Tourism facilities provide all kinds of services for tourists from departure to arrival, including providing food, transportation, consulting, accommodations, shopping, entertainment, communications, medical care, safety, and scientific guides.

Tourism Geographical Environment The tourism geographical environment refers to the geographical environment of the earth's surface on which living things, especially human beings, depend for survival and development. According to the meaning and classification of the geographical environment, the tourism geographical environment can be divided into the tourism natural environment, tourism economic environment and tourism social and cultural environment. These environmental concepts are often referred to as tourism environments in the tourism industry. To a large extent, tourism development depends on the geographical environment of tourism. In turn, the development of tourism can adversely affect the tourism environment. Therefore, the protection of tourism environments has become an important issue for the sustainable development of tourism.

Tourism Geography This book was edited by Mingde Lei and was published by Northwest University Press in 1988. It includes an introduction to tourism, a brief history of tourism geography, tourism geography resources, direction and volume of tourist flows, tourism transport geography, tourism ecology and environmental protection, tourism appreciation, tourism planning and maps, and the geographical divisions of tourism in China and around the world.

This is an interdisciplinary subject of geography and tourism and is a new subject of earth science. Theories and methods of geography are used to study the relationship between human travelling habits, patterns and preferences with their geographical and socio-economic environments. The interactions between different mechanisms and processes are studied to highlight the spatial pattern and organisation for better tourism planning and management. The main research areas cover the laws associated with the utilisation of tourism resources, resource evaluation, tourist markets, development strategies and forecasts, socio-economic impacts, design, zoning, planning and protection of tourist attractions. Both human and physical geographers play important roles in making the subject useful and applicable in actual situations. Other academics involved in social, economic, cultural, historical, archaeological, architectural, landscape, and aesthetics studies also make great contributions to this subject. Research methodologies of natural science and social science are adopted. Qualitative and quantitative analyses and deductive and inductive methods are used to address the research objectives. This is a rapidly growing academic subject in China as a result of the extensive tourism development in China.

Tourism Geography (Book) This book was written by Jigang Bao, Yifang Chu and Hua Peng et al. and was published by Higher Education Press in 1993. The contents include a

general introduction, development of tourism geography, tourist behaviour, a forecast of tourism demand, evaluations of tourism resources and destinations, carrying capacity, transportation, tourism zoning, tourism development strategy and planning, regional impact of tourism development and tourism maps. It contains novel teaching material for college tourism geography.

Tourism Geography in China This book was written by Jinbu Zhou and was published by Zhejiang People's Publishing House in 1985. The book was China's first tourism geography textbook. The book comprehensively introduces the geographical conditions of tourism and landscape resources in China and analyses, evaluates and describes the geographical characteristics of tourist sites. It is divided into three parts: introduction, overall national discussion and regional discussions.

Tourism Geological Environment The tourism geological environment refers to the geological and geomorphological background and conditions of tourist sites. It specifically refers to the combination of strata, rocks, geological structures, geomorphology and landforms of a scenic site or location. The attractions of the natural landscapes, such as peaks, valleys, caves, rocks, rivers, lakes, waterfalls, and springs, are the products of geological processes and are controlled by geological factors. Tectonic processes generating the structural features and their characteristics, occurrence and scale play controlling roles in the formation and development of natural landscapes. From a macro-scale perspective, they control the geomorphic pattern, shape, orientation and elevation of mountain ranges and the formation of water systems, rivers, lakes and groundwater. From the micro-scale point of view, they also control the forms of peaks, valleys, caves, and springs in an area. The tourism geological environment is an important criterion of tourism resource evaluation.

Tourism Geology Tourism geology is an interdisciplinary subject of geology and tourism that studies geology-related issues in tourism, including the classification, formation, evolution and implications of geological features and processes, their regional distribution, and the processes and aesthetic features of geology and landforms in nature tourism resources. These studies provide a scientific basis for the establishment of nature tourism attractions (e.g., geoparks, scenic areas, and world natural heritage sites) and methods for disseminating geological and scientific knowledge to tourists. Tourism geology also involves route design, guide materials, geological surveys and evaluations of geological sites for both the general public and professionals. These studies are helpful for formulating sustainable tourism plans and developments. In recent years, geological products such as ornamental stones and gems, geopark establishment, geoheritage protection, and world natural heritage evaluation have also been listed as research areas of tourism geology.

Tourism Geology (Book) This book was written by Shiyu Yang and Zhiliang Wu and was published by Nankai University Press in 2006. It is a teaching material for tourism colleges and universities. The book discusses the geological perspectives related to tourism and is an important resource for tourism earth science.

Tourism Landscape of Endogenic Geological Processes This is a geological landscape with tourism and scientific research value that was formed by the internal forces of the Earth, including the dynamics related to tectonic movements, magmatic intrusions, volcanic eruptions, metamorphism and seismic activity. Hence, these landscapes are also called 'tourism landscapes of endogenic geological processes'. Examples are typical structural geologic features, seismic relics, crustal deformation, magmatic intrusions, volcanic landforms, metamorphism and metamorphic rock sections.

Tourism Landscape of Exogenic Geological Processes This is a landscape with tourism and scientific research value that was formed by the external forces of the Earth. The dynamics of the air, water and living organisms are affected by solar energy and the gravity of the Earth, sun and moon, and they affect the processes that

occur on the surface of the Earth. These processes include weathering, erosion, transportation, deposition and diagenesis, and they reduce the degree of undulation, decrease the height differences and shape the morphology of the Earth's surface. Important tourism landscapes due to exogenic geological processes include landscapes associated with water erosion, fluvial deposition, wind erosion, marine erosion and glacial erosion, and the resulting features include canyons, ancient river relics, wave-cut platforms, sea caves, and shell depositional banks.

Tourism Market A tourism market is also called a tourism demand market or a tourist source market. It can be divided into three categories based on the consumers: international, domestic and local tourist markets.

Tourism Market Positioning Tourism market positioning includes the judgements about the prospects of the sales of tourism products. Based on research and tourism market segmentation, we can understand each tourist destination's main target market segments and analyse the changes in their market share and the trends of development in each segment over different time periods. This can be achieved through evaluations of the scale, marketing potential and demand of the market segments and the strengths, weaknesses, opportunities and challenges of local tourist attractions. The tourism market is generally divided into primary markets, secondary markets and tertiary markets, which are also known as core markets, medium-distance markets and long-distance markets, respectively. Markets can also be divided into main markets, marginal markets and opportunity markets.

Tourism Market Survey A tourism market survey is a survey for tourists about their backgrounds, needs, and levels of spending and satisfaction. It purposefully and systemically gathers, analyses and summarizes the consumers' demands for changes in the tourism market as well as information and materials of tourism marketing to understand the existing and potential tourist market and provide a basis for tourism development and business decision making. The main contents of surveys include the market environment, existing and potential demands, product combinations and tourists' feedback.

Tourism Marketing Tourism marketing is the study of marketing processes and the corresponding strategies to operate and promote tourism. It also studies marketing concepts, market segmentation principles, target market principles, and marketing strategies. The contents of marketing vary in different tourism companies based on their products and market divisions. It is the method of promoting tourism products using marketing theories and methods.

Tourism Marketing Planning Tourism marketing planning is a type of special tourism planning. Guided by tourism consumption and demand, it aims at coordinating various tourism economic activities through analysis, planning, implementation, gathering feedback and operations to achieve results that satisfy tourists and benefit business people.

Tourism Mediator Tourism mediators include all facilities, policies and measures that originally connect a tourism subject and object, thus enabling the smooth and continuous development of tourism activities. They include travel agents, the transportation industry, the hotel industry, entertainment venues, and tourist shops that provide food, accommodations, transportation, tours, shopping and entertainment services for tourists as well as policies and measures that ensure the smooth operation of tourism activities.

Tourism Motivation Tourism motivation includes the internal reasons or impulses that directly cause individuals to perform tourism activities. Tourism activities reflect spiritual and cultural needs when people already have a satisfactory material life. Mo-tse (468–376 BC), a Chinese scholar in the pre-Qin period, was the first to discuss tourism motivation. He said, 'One will only ask for delicacy when he is no longer starving, beauty when he is no longer cold, enjoyment when he is no longer in danger'. This quote explains that when people's needs of having enough food, warm clothes and good living conditions are satisfied, they

start to pursue 'delicacy', 'beauty' and 'enjoyment', which are also the main content and motivation of tourism activities. Mo-tse can thus be called the pioneer of tourism studies. Kiichi Tanaka, a Japanese scholar in the twentieth century, classified tourism motivations into four categories: emotional, physical, spiritual and economical motivations. The American scholar Robert McIntosh also divided tourism motivations into four types: for the health of the body, cultural pursuits, socializing and status and reputation. These comments do not contradict what Mo-tse said 2,400 years ago.

Tourism Object Tourism objects are also called tourism resources and include all objects and phenomena in nature or social life that attract tourists. Tourism resources are tourism objects but are not the same thing. Only tourism objects that can be visited by tourism subjects are tourism resources.

Tourism of Natural Scenery This book was written by Shicai Chen and was published by Seismological Press in 1993. It consists of 24 articles, including exploration, evaluation, planning, development, protection, appreciation, and tour guides of natural scenery.

Tourism Planning Tourism planning is the optimization of the allocation of tourism resources in a region and making plans for the future development of the tourism industry based on the tourism resources and the internal and external conditions of the area. The essence of tourism planning is to make scientific and well-defined plans for the optimal allocation of production factors related to the development of regional tourism based on the changes in the market environment and the requirements for sustainable development.

Tourism Planning Studies Tourism planning studies is a discipline that focuses on the optimal allocation, scientific planning and sustainability of tourism based on in-depth studies of its subjects, objects and media. Based on the market requirements and the characteristics of tourism resources, this discipline helps to achieve anticipated benefits in certain regional tourism systems over a certain period of time through the planning of the tourism spaces, functions, facilities and brand images of tourist destinations. Tourism planning enables us to estimate and adjust to changes, thus facilitating orderly development and enhancing socio-economic and environmental benefits.

Tourism Products Tourism products are products designed, processed and assembled using natural, historical, cultural and social resources. Tourism products are created according to the needs of tourist source markets with certain functions and themes for tourists to choose, purchase and consume. They provide tourists with supporting services, such as transportation, tourism, accommodations, food, shopping, and entertainment along certain routes or areas.

Tourism Project Tourism projects are projects invested in and built within a certain period of time and budget for tourism activities or to help achieve the goals of the tourism industry. They include scenic attraction projects, hotel construction projects, amusement facility projects, tourism commodity development projects, transportation projects, tourism training and education projects involving food, housing, transportation, touring, shopping, and entertainment, and other aspects. These projects cover the entire process of tourism development.

Tourism Project Planning This book was written by Zhenzhi Yang and was published by Tsinghua University Press in 2007. It includes ten chapters on the basic concepts of tourism project planning; basic principles of tourism project planning; conditions and environmental analysis of tourism project development; market surveys of tourism project planning; tourism project positioning reports; tourism project planning and design; project investment estimation; project cost-benefit analysis; tourism project marketing planning; and project management. It is an important reference book for tourism planning.

Tourism Region Tourism regions are designated regions that are mainly or partly used for tourism or related activities. They are usually based on administrative areas and are made

up of several tourist attractions with similar natures, transportation networks, tourism service facilities and regions with tourism functions.

Tourism Resource for Escaping Heat A location with a cool and pleasant climate to escape the summer heat is an ideal tourism resource. Three types of summer resorts serve this purpose. 1. Alpine plateau type: higher elevations have lower temperatures and provide pleasant environments for vacationers. These places include Baguio in the Philippines, which has an elevation of 1,600 m and a temperature 6.7 degrees lower than in Manila. Lushan is China's famous summer resort and is located 1,500 m higher than the nearby Jiujiang City; its average temperature is 5.6 degrees lower than in Jiujiang. 2. Coastal type: due to the influence of the ocean, the temperature along the coast during the summer is lower than inland, and these regions often have mild and humid climates. Coastal cities such as Dalian, Qingdao and Beidaihe are good examples of these locations. 3. High-latitude type: the temperature changes with the latitude. For example, Hammerfest, Norway, which is located at 70°40′ near the Barents Sea, is a summer resort in Europe.

Tourism Resource for Visitors Escaping the Cold The world's tourist destinations for escaping the cold are located in tropical, subtropical, and maritime climate areas. China's Sanya in Hainan, Guangxi's North Sea in Guangxi, Bali in Indonesia, and Phuket in Thailand are examples. Tourists also make use of the different climates in the southern and northern hemispheres to travel; for example, Australia is a favourite destination for people to escape from the cold winters in the northern hemisphere.

Tourism Resource for Visitors Looking for Clean Air Industries and economic activities discharge harmful substances, which poison the air and pollute water and soils. In particular, people that work and live in mining and urban areas experience lower quality environments, and they have a pressing need for clean air and an unpolluted and pleasant environment after work or when they have holidays. Tourist destinations with clean air have therefore become important nature-based tourism resources.

Tourism Resource for Visitors Looking for Forest Clean Air Environments Forests with clean air are a type of tourism resource associated with the climate. Forests can purify air, remove dust, regulate the climate, reduce noise, and absorb carbon dioxide, sulphur dioxide and harmful gases. They alleviate the negative impacts of pollution. Forests far from cities with clean air are considered high-quality tourist destinations.

Tourism Resource for Visitors Looking for Sunshine Resources Sunshine can be an important tourism resource. Coastal countries in the Mediterranean have subtropical climates with long periods of sun. Large numbers of beach resorts have been built for tourists and have turned the region into a world-renowned tourist destination. The daylight at the poles is also another type of tourist attraction in high-latitude regions. Due to the rotation and revolution of the Earth, the Arctic region experiences daylight for the entire day around the peak of summer. This phenomenon has been called 'white night' or 'polar night'. Countries in far northern Europe enjoy warm and humid maritime climates with more than seventy days of 'white night'. They have become excellent destinations for tourists who want to avoid the hot summer and experience the polar night.

Tourism Resource Studies Tourism resource studies is a discipline specializing in research on tourism resources. It mainly includes comprehensive research on the formation, categories, distribution, evaluation and rational exploitation of tourism resources.

Tourism Resource System of Geological Landscapes This is a resource system with tourism value that was formed by geological processes. During the 4-billion-year evolution of the Earth, abundant geological relics with tourism value have been left behind in every layer of the Earth and in all types of rocks. These are geological landscape tourism resources. They include stratigraphic section

tourism landscapes, palaeo-biotic and palaeo-anthropological tourism landscapes, endogenic geological process tourism landscapes, exogenic geological process tourism landscapes, mineral resource tourism landscapes and environmental geological relic tourism landscapes.

Tourism Resource System of Geomorphological Landscape This is a geomorphic landscape with aesthetic value that formed as a result of geological processes on the Earth's surface. These landscapes can be divided into tectonic landform landscapes, rock landform landscapes, volcanic landscapes and glacial landscapes. They can be further divided into several landscape sub-types, such as block mountain landscapes, granite landscapes, clastic rock landscapes, karst landscapes, loess landscapes, sand landscapes, metamorphic rock landscapes, lava landscapes, glacial erosion landscapes, marine erosion landscapes, aeolian landscapes and gravity flow landscapes. Geomorphological landscapes are one of the most important types of tourism resources.

Tourism Resource System of Marine Landscape This is a resource system with tourism value associated with oceans (including islands and coasts). The oceans are the main bodies of water, while seas are located along the margins of oceans. Oceanic geomorphic units, such as beaches (intertidal zones), continental shelves, continental slopes, continental rises, oceanic trenches, deep-sea basins and mid-ocean ridges, are located continuously from the shore to the deep ocean. Based on their locations, oceans can be categorised into inland seas, marginal seas, intercontinental seas, closed seas, residual seas and open seas. Oceans in different climates have different coastal geomorphological landscapes, beach landscapes and physical-chemical conditions; hence, different types of ocean tourism resource systems with varying functions and landscapes have formed.

Tourism Resource System of Plant Landscapes This is a landscape tourism resource made up of various types of vegetation, including trees, shrubs, grasses, moss, algae and other plants with scientific value. Examples are the relict plants that have survived from past geological periods, such as ginkgo, cycads, the dove tree and several historical trees, such as Zhou Bai (cypress in the Zhou Dynasty) and Tang Huai (sophora in the Tang Dynasty) as well as a variety of famous flowering and rare plants, which together form a splendid tourism resource system of plant landscapes.

Tourism Resource System of River Landscape Fluvial processes have high tourism value. These landscapes include scenic sections of rivers, flowing river sections, canyons formed by fluvial erosion, waterfalls, rapids, meanders and river islands. Many rivers are highly attractive tourism corridors, such as China's Changjiang, Huanghe, the Nile River in Africa and Europe's Danube and Rhine rivers.

Tourism Resources Guihua Yang was the chief editor of this book, which was published by Yunnan University Press in 1994. The book has 264,000 words and is divided into two chapters: 'Study of Tourism Resources' and 'Practice of Tourism Resources'. The first chapter focuses on the introduction, formation, characteristics and classification of tourism resources, natural tourism resources and cultural tourism resources. The second chapter covers the investigation and evaluation of tourism resources, tourism resource development planning, tourism resources and environmental protection and construction.

Tourism Resources Development Planning According to surveys and the evaluation of tourism resources, the general layout of tourism resources development will be designed based on the nature and characteristics of the resources, the development prospects of tourism destinations, the social, economic and cultural development trends and the requirements for sustainable development. Development planning and design are connected but different. First, tourism

development planning is generally a macro-scale development strategy research and policy formulation process, whereas design is relatively specific and is a comprehensive arrangement for the development of tourism resources in specific tourist areas, including development plans, project planning, overall layout, land planning and landscape design. Second, in theory, development planning and design should be integrated; they should be guided by development strategies while reflecting strategic intentions. Therefore, to facilitate research into the disciplines and development of tourism, we generally use the expression 'tourism resources development planning'.

Tourism Resources in Qinghai Province This book was written by Zhongxiao Zhang and was published by Qinghai People's Publishing House in 1992. It contains 210,000 words and systematically summarises the tourism resources (categorisation, characteristics, and evaluation) in Qinghai Province. It was the first book on tourism resources and development in Qinghai Province.

Tourism Resources Study Based on the theories and methods of tourism earth science, a tourism resources study investigates the resources of tourist industry development and provides a scientific basis for regional tourism development and planning. The main research areas cover the classification of nature tourism resources, geological feature and phenomenon development and formation, landscape features and evolution, resource evaluation and utilisation, and tourism planning and development.

Tourism Route Planning Tourism route planning is an aspect of tourism product planning that involves the planning of routes in a park. The six elements of tourism along the tourist route are organized based on the characteristics of the resources and the theme of a tour. It is a linear tourism product based on the layout of attractions in a scenic area or site. Spatially, it can be divided into long-distance route planning between scenic sites and tourist areas and internal route planning at scenic sites.

Tourism Science Tourism science is a basic theory that supports tourism earth science. It is a discipline that studies tourist behaviour, the composition and distribution of the tourist market, the composition and valuation of tourism destinations and tourism facilities, and measures that support tourism activities to ensure the healthy and sustainable development of tourism. (See ▶ Tourism Earth Science).

Tourism Service Facilities Planning Tourism service facilities planning mainly focuses on accommodation facilities and other related products, including booking and information services before arrival and catering, entertainment, conferences, and financial and communications service after arrival. It also includes planning of the scale, layout and style of reception facilities.

Tourism Service Science Tourism service science is the study of the principles, mentalities and skills of tourism service as well as the psychology and competition of service based on the theories and methods of service science. The goal is to provide tourism services, apply quality management and encourage culture building and innovation in tourism services.

Tourism Sociology Tourism sociology is a branch of sociology that studies people's motivations, roles, and institutional and interpersonal relationships in tourism and how these elements influence tourists and tourism destinations. It has four different aspects: 1. the motivations, attitudes, reactions and roles of a tourist; 2. the relationship between tourists and the local residents; 3. the development and structure of tourism systems; and 4. the influence of tourism. Tourism sociology is multi-angled rather than unified, and many schools of tourism sociology coexist. It includes schools such as development and evolution theory, neo-Durkheimian, conflict and critical theory, functionalism, Weberism, cultural anthropology, phenomenology, feminism, symbolic interactionism, and postmodernism.

Tourism Subject A tourism subject involves customer markets and tourists. The type of

products supplied in tourist destinations is determined by the geographical location, economic development, type and number of tourists and their structure and level of consumption in the tourism market.

Tourist Destination A tourist destination refers to an area used for tourism. To be regarded by the public as a worthwhile tourist destination, a tourist destination must have: (1) a relatively stable group of tourists with a certain size; (2) important and systematic tourist attractions (unique tourism resources of a certain scale); (3) a certain geographical location and an independent administrative region (e.g., a scenic area, city, region, country); and (4) a self-contained system providing complete tourism services and facilities (e.g., food, accommodations, transportation, touring, shopping and entertainment). In addition to the necessary objective conditions, purposeful planning and building are also important for tourism destinations.

Tourist Guide A tourist guide is someone who has obtained a Tour Guide Certificate according to the applicable regulations and has been appointed by a travel agency to provide tourists with guidance, introductions and other related tourism services. Tour guides in China are divided into four categories: tour managers (international tour guides), full itinerary guides, local guides and scenic area guides. Electronic guides, as opposed to human tour guides, are electronic tour systems and devices that can be used to improve upon the original human interpretations.

Tourist Hotel Tourist hotels are hotels that can accommodate tourists, business travellers, holiday guests and conferences. They include star hotels (which are divided into five levels: one star, two stars, three stars, four stars, and five stars; the greater the number of stars, the better the hotel is), theme hotels (hotels designed and constructed with a specific theme) and farmhouse inns.

Tourist Map A tourist map is a map showing tourist areas, routes, attractions, transportation, accommodations and facilities. They are important tools for tourists to obtain information during their travels and visits.

Tourist Safety Research Tourist safety research includes research undertaken to ensure tourist safety. It could cover safety issues related to geological and weather hazards and potentially dangerous scenic sites and facilities. Based on the results of these studies, suggestions can be made to prevent and minimise such risks.

Tourist Source Area Tourist source areas are regions from which tourists travel to destinations. The level of economic development is usually related to the importance of tourist source areas. With the development of the economy, China has become a significant source of tourists. Economically developed areas, such as the Yangtze River Delta, Pearl River Delta region and Bohai rim region, have become important tourist source areas in China.

Tourmaline Tourmaline is the collective name for the tourmaline family of minerals. It is a crystalline boron silicate mineral with additional elements, such as aluminium, sodium, iron and magnesium. It crystallizes in the trigonal system, and the crystals are prismatic with transverse streaks. It has a rounded triangular cross-section, and it sometimes appears in the form of blocky and dense aggregates. Tourmaline has seven species: elbaite (with many colours), aphrizite (black), buergerite, dravite (brown), rubellite (pink), chromium dravite (green) and calcium dravite (black, brown, yellowish-green). The crystals are usually pink at one end and green at the other, and they can grow to very large sizes. The streak is colourless. It has transparent to translucent diaphaneity, a vitreous lustre, a specific gravity of 3.0–3.2, a Mohs hardness of 7–7.5, and uneven to conchoidal fractures. It mainly forms in granite, pegmatite and some metamorphic rocks. It coexists with many minerals, such as beryl, zircon, quartz and feldspar. Crystals with beautiful colours can be used as gems (Fig. 26). The Chinese trade name ‘Bixi’ (bluish green seal) refers to the gem-grade tourmaline. Its main composition is calcium, magnesium, and aluminium silicate. In China’s historical literature, it has been called Chuza

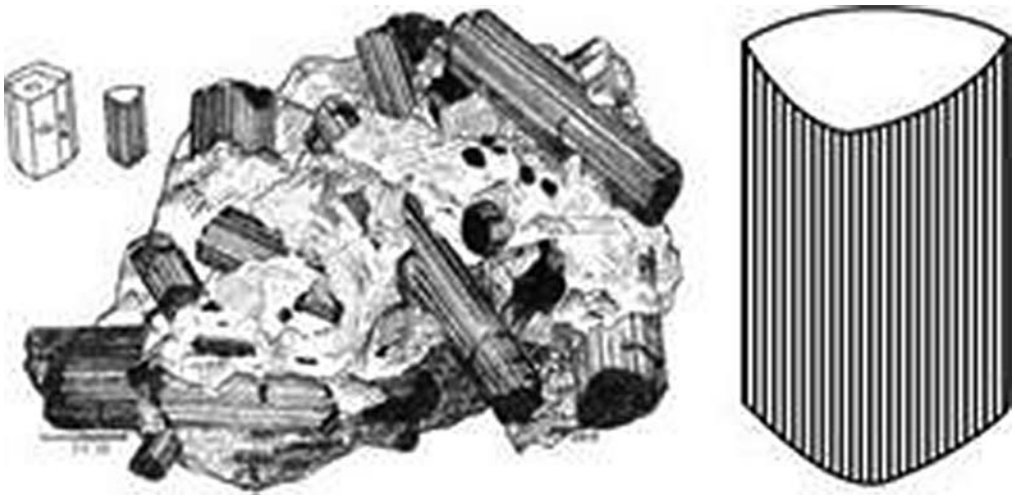


Fig. 26 Tourmaline

(broken base), Bixi (bluish green seal), Bixiaxi (bluish green cloud) and Suixiejin (broken evil gold). Azure and bright rose-red tourmaline are top-grade gems. A single tourmaline crystal may have two or three colours. Red tourmaline, which is called rubellite, is most valuable. This mineral is often found in granite pegmatite. The main production areas include Brazil, the United States and Tanzania. China produces tourmaline in Xinjiang Province (Fig. 27).

Tower Peak Granite Landscape (Low Mountain): Chayashan Type This is a landscape consisting of tower peaks with heights from approximately a dozen metres to 100 m. They form in isolation or in groups in granite masses at elevations below 1,000 m. The overall appearance is similar to an alpine peak landscape, but the peaks are smaller and at higher elevations. The tops of the peaks are rounded, and the landscape is also called a 'pure tower peak granite landscape'. It is smaller than an alpine peak landscape, and it has numerous features with curving surfaces and collapsed stacked stone caves. Small canyons also form. This landscape evolves from an alpine peak granite landscape. In the early stage, the spikes and prismatic pillars collapse due to structural movement. Due to weathering, the height of the mountain gradually decreases to 500–1,000 m, and as a result



Fig. 27 Tourmaline crystal

of the more intense chemical weathering in a hot and humid climate, the spikes, prismatic pillars and fallen rocks become rounded. This landscape is a transitional type between the alpine peak granite landscape and the stone



Fig. 28 Tower peak granite landscape in Chayashan, Henan Province

egg granite landscape. Chayashan National Geopark in Suiping, Henan Province, is a good example (Fig. 28).

Tower-Shaped Granite Peak These peaks are smaller than fort-like peaks. They have broad lower parts and slender upper parts, resembling a pagoda. The surrounding slopes are steep and mainly form as a result of weathering along two sets of vertical joints. These peaks are usually isolated.

Toya Caldera and Usu Volcano Geopark, Japan This geopark is located in southwestern Hokkaido, Japan, and become a global geopark in 2009. The geopark has a volcanic history that extends from the 110,000-year-old Toya Caldera to the 10,000- to 20,000-year-old Mount Usu as well as the recent eruptions, including nine since 1663. These sites are currently dormant, and visitors can learn about the volcanic activity and about the interaction and adaptation of humans to natural changes. Abundant fauna and flora live in the thick forest and abundant water resources. These fauna and flora have experienced and been changed by the volcanic activity in the region.

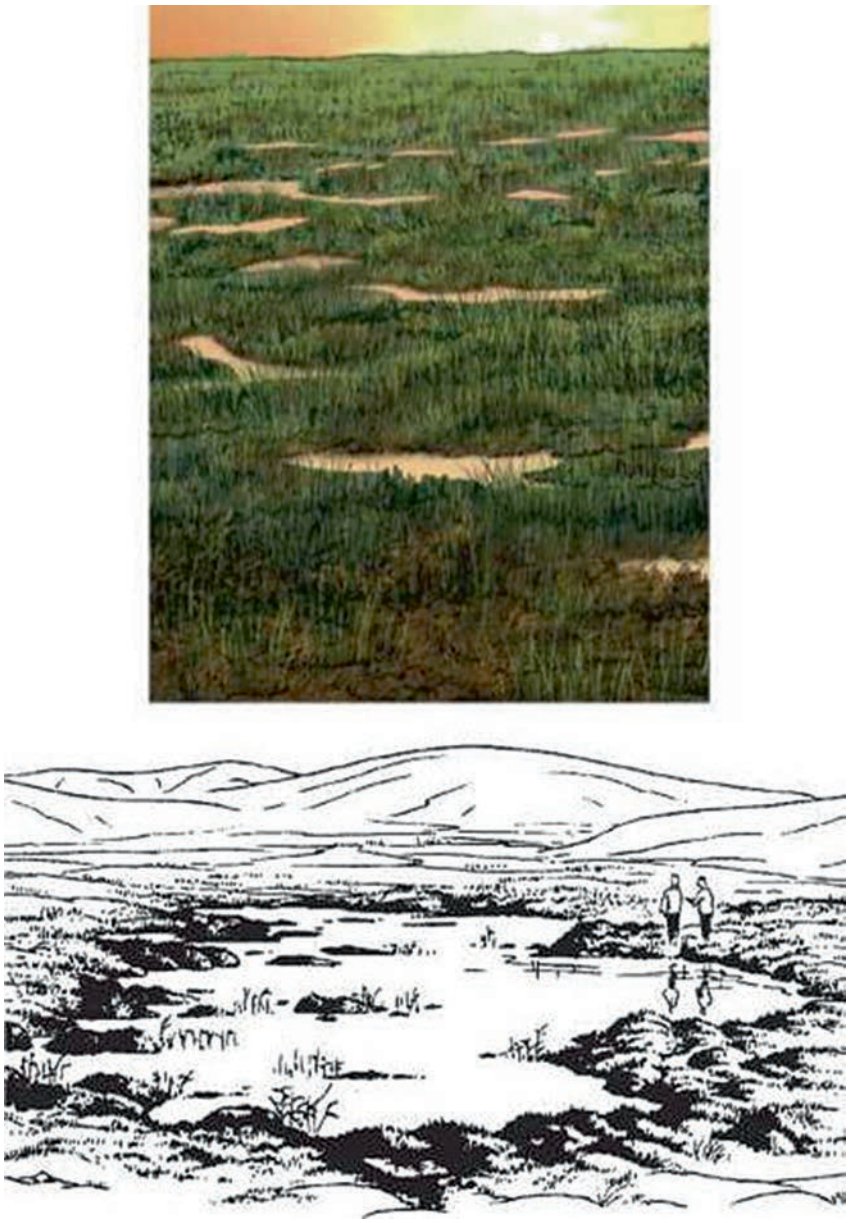
Trace Fossil ▶ Ichnofossil

Trace Fossil or Ichnofossil Trace fossils refer to the body parts and traces of activity left behind by various fauna. Common trace fossils include footprints, tracks, burrows and bored holes. These traces often have radiating and tubular structures, which are common traces of worms, arthropods, sea urchins, molluscs and terrestrial tetrapods. Arthropods commonly leave regular 'footprints' on land or along the shores of lakes. Eggs and dung of ovipara are also ichnofossils, and dinosaur footprints, bird footprints, trilobite relics, dinosaur and fish dung and stone artefacts of the Ape Man (Homo erectus) are trace fossils with high ornamental value.

Trachyte Trachyte is a slightly alkali intermediate volcanic rock. The bulk rock contains approximately 9% alkaline material (K_2O+Na_2O). The composition is equivalent to that of intrusive syenite. Some alkali feldspar, plagioclase and small amounts of biotite and hornblende appear as phenocrysts. The volcanic relics in the Fushan Mountain National Geopark in Zonhyang, Anhui Province, and in the Xiqiao Mountain National Geopark in Guangdong Province mainly consist of trachyte.

Transition Swamp Landscape This type of swamp landscape is also called an intermediate swamp, and it is a swamp type between low swamps and high swamps. They mainly form in valleys or high floodplains along the upper courses of rivers. The water is supplied by groundwater, the river or precipitation. The

Fig. 29 Swamp landscape



main vegetation includes shrub bushes, Carex, dwarf bog birch (Betula fruticosa), oil bog birch (Betula ovalifolia), marsh tea (Ledum palustre), leatherleaf (Chamaedaphne calyculata), silver moss (Bryum argenteum) and Sphagnum moss (Sphagnum palustre). The peat layer is relatively thick, and the swamps can be used for farming when drained. These swamps are mainly located in the Changbai Mountain, Daxing'anling and Xiaoxing'anling regions (Fig. 29).

Transport Hub *Synonym:* ▶ *Transport interchange*

A transport hub is the intersection of one or more modes of transportation and includes a variety of transport facilities that are commonly used to handle the transfer, delivery, and arrival operations of passengers and cargo. In a scenic area or park, the transport hub is usually a tourist support centre and an important distribution and transfer centre for tourists travelling to different destinations.

Transport Interchange ► Transport Hub

Transverse Dune Landscape This is a desert landscape consisting of chains of large barchan dunes. Transverse dunes can generally reach lengths of 10–20 km and heights up to 100 m. Adjacent dune chains can be up to 1,500–3,500 m apart. The dunes are perpendicular to the wind direction, so they are called transverse dunes. The two slopes are asymmetrical; the windward slope is long and gentle, but the leeward slope is short and steep. The windward slope is often superimposed with several small barchan dunes. Transverse dunes form due to wind from two opposite directions. When two air currents meet and block each other or when the airflow is deflected by a mountain, a transverse dune perpendicular to the prevailing wind direction will form. Transverse sand dunes are located in the Tengger Desert and Kumtag Desert in China (Fig. 30).

Travel Agency Travel agencies are companies with the approval of the State Tourism Department to solicit, organize, receive, and provide services for tourists and to carry out domestic, inbound or outbound tourism businesses.

Travel Collection of Chuankang Chen This book was edited by Wenchang Sun and was published in 2003 by Qingdao Publishing House. The book is a collection of excerpts compiled from Chuankang Chen (1931–1997). The collection covers four parts, namely, geography, tourism geography, regional development and the philosophy of geology.

Travel Guide of Beijing Landscapes This book was written by Zongzheng Xiao and Guangzhen Cui et al. and was published by Geological Press in 1990. The content includes 44 scenes and geological landscapes in Beijing, such as Fangshan, Fengtai, Mentougou, Shijingshan, Haidian, Yanqing, Changping, Miyun, Huairou, and Pinggu. It describes the geological formations and evolution patterns of these landscapes in detail. It is extracurricular reading for young students that tour Beijing landscapes and reflects the contributions of geologists in serving tourism earth science. Renzhi Hou (1911–2013), a famous historical geographer and academician of the Chinese Academy of Sciences, wrote the preface.

Travertine Travertine, which is also called calcareous sinter, is a dense, porous, banded calcareous deposit. It is creamy or reddish in colour and is composed of precipitated calcite. It generally occurs on the surfaces of limestone caves. It forms when spring water saturated with calcium carbonate reaches the ground



Fig. 30 Transverse dune landscape – Kumutage Desert, Xinjiang Province (after Dong Zhibao)

surface and releases the carbon dioxide due to the low pressure. The calcium carbonate then accumulates at the mouth of the spring to form travertine. Travertine is usually in the form of irregular stalactite and stalagmite blocks with crust-like layers. Its inner part always contains voids left by the plant's decay. The engineering characteristics and genetic analysis of travertine are important to construction projects. (See ▶ Calcareous Sinter).

Tremolite The chemical composition of tremolite is $Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$. The crystals are long and bladed, and crystal twinning is common. It is sometimes in the form of columnar, fibrous, feathery (radiating), blocky or granular aggregates. It can be colourless, white, grey, green, pink or brown. It has transparent to translucent diaphaneity, a vitreous or silky lustre, a specific gravity of 2.90–3.20 and a Mohs hardness of 5–6. It belongs to the same subfamily as actinolite. It is mainly found in contact-metamorphosed limestone and dolomite and sometimes in serpentinite. Tremolite is a heat and electric insulator and is resistant to acids, alkalinity, and corrosion, so it has a wide range of usages.

Triangular Fault Facets Scarps cut by running water in gullies or valleys that form cliffs with triangular facets constitute landforms with triangular fault facets. Examples include the fault along the northern slope of the Qinling Mountains and the fault with triangular facets along the foothills in the Weihe Plain. They form unique scenic areas.

Triassic Period The Triassic Period is the first period of the Mesozoic Era; it extended from 252 to 199 million years ago with a duration of 52.4 million years. The Triassic System includes the rocks that formed during the Triassic Period. It was named after a site in southern Germany, where the lithological characteristics are distinctively tripartite. During the Triassic Period, the land area continued to expand, and the sea surface decreased. Terrestrial facies strata are well developed with lush terrestrial plants, and this period was another important interval of coal formation. Invertebrates such as ammonites and belemnites developed rapidly. Vertebrates began to flourish, whereas primitive dinosaur species and mammal-like species developed rapidly in the Late Triassic Epoch. The Triassic System is widely distributed in China with rich biota. Due to the folding and crustal uplift in the late Palaeozoic Era, China's Triassic Period was roughly bounded by the Kunlun-Qinling-Dabieshan line, forming a palaeogeographical pattern of marine facies in the south and continental facies in the north. A range of inland lakes and basins of various sizes formed in the north. Except for some areas in Hainan, Yunnan and Guizhou Provinces that were subject to alternating terrestrial and marine sedimentation in the Lower and Middle Triassic Series, most areas in southern China experienced marine sedimentation. Currently, the Triassic System is divided into three series and seven stages globally. In China, the subdivision is mainly based on the two sedimentation types of terrestrial and marine facies.

Trilobite Fossil Trilobites, of the class Trilobita, are a fossil group of extinct marine invertebrate arthropods. They have varying sizes ranging from a few millimetres to tens of centimetres. Trilobites flourished during the Cambrian and Ordovician and went extinct at the end of the Permian, with an evolutionary history of 300 million years. Trilobites had a flat body and a solid carapace with a soft peritoneal and appendages on the ventral side. The exoskeleton had two depressions on the back, which was divided longitudinally into three distinct lobes of head, chest and tail, from which the group gets its name. Trilobite fossils are mainly found in limestone, marl and shale. The famous trilobite fossils in Shangdong Province are known as Swallow Stone because the fossils appear like a flock of flying swallows. The ornamental types of trilobite fossils are called Bat Bug (Swallow Stone), Sichuan Bug, West Hunan Bug and Crown Bug.

Trinomial Nomenclature Trinomial nomenclature refers to the names of taxa below the rank of species, which are composed of three parts. The first part indicates the genus, the second part indicates the species, and the third part is the

subspecies. This is an expanded version of the binominal nomenclature, where a subspecies name is added after the species name. An example is *Lithostrotion planocystatum* minor, where Lithostrotion (columnar coral) is the genus, planocystatum (plank-like) is the adjective, and minor (small) is the second adjective. The label 'subsp.' (abbreviation subspecies) is sometimes used before the second adjective. Directly translated, the nomenclature in Chinese is 'small plank-like columnar coral' or 'plank-like columnar coral, small subspecies'. The adjectives for species and subspecies are written in lowercase letters, and the name is italicized. The surname of the person that discovered it can be added after the subspecies name, with the first letter capitalized and written in Roman letters.

Tropical Monsoon Climate This type of climate is mainly found in the eastern parts of the regions between the 10°N and S latitudes and the Tropics of Cancer and Capricorn. It is the typical climate of the Indochina Peninsula and the subcontinent of India, which are affected by southwest monsoons. The southern part of Yunnan in China and the southeastern slopes of the Himalayas have similar climates. The annual temperature is higher than 20°C. During the year, the direction of the prevailing wind changes significantly. Because it is controlled by equatorial air masses in the summer, precipitation is abundant and makes the summer the rainy season. In the winter, the precipitation is greatly reduced by continental air masses, which creates the dry season. The annual precipitation is between 1,500 and 2,000 mm, and 80–90% falls during the rainy season. The climate supports the growth of tropical monsoon forests in the region.

Tropical Monsoon Forest Ecological Landscape This is a type of ecological landscape distributed in the tropics with periodic dry and wet seasons. It is composed of drought-tolerant tropical evergreen and deciduous broadleaf trees. Seasonality is significant, and most of the trees shed their leaves in the dry season. Compared with tropical rainforests, trees in tropical monsoon forests are shorter with fewer species and a simpler community structure. The dominant species are more obvious, and buttress roots and the cauliflory phenomenon are uncommon. Climbers, epiphytes and parasitic plants are also rare.

Tropical Rainforest A tropical rainforest is a zone of forest vegetation distributed within 20° latitude of the equator. Tropical rainforests consist of lush, humid, and heat-tolerant evergreen trees with roots, epiphytes, 'old stem flowers', and 'strand plants', drip tips and other unique ecological characteristics. They are mainly located in the Amazon River Basin in South America, tropical regions in Southeast Asia, and the Congo Basin in Africa. They are also located in parts of China, such as Hainan, southern Taiwan, Yunnan, and southern Guangxi. Rainforests can effectively regulate the climate over large areas, and they are also the most important species gene banks on Earth. Tropical rainforest landscapes usually have high tourism value.

Tropical Rainforest Ecological Landscape This is a type of ecological landscape in hot wet regions with abundant rainfall, comprising lush woodland communities. The species composition is extremely rich, and most plants are woody species of the more than 45,000 higher plant species. The vegetation is mostly tall and dense with a general height over 30 m. From the canopy to the ground, there are 5–8 overlapping layers. The dominant trees can be up to 30–40 m high. Most have smooth bark, and some have buttress roots and are cauliflory. There are also large numbers of climbers and epiphytic plants. This landscape system is evergreen, and with adequate food and a favourable environment, it supports a wide range of fauna, especially reptiles, amphibians and insects.

Tropical Rainforest Heritage of Sumatra, Indonesia This site is located on the coast of the Strait of Malacca on the eastern and western sides of Indonesia's Sumatra Island and has a core protection area of 25,951 km^2. The rainforest area consists of three national parks: Gunung Leuser, Kerinci Seblat and Bukit Barisan Selatan. The heritage sites have great potential benefits for the long-term

protection of the unique and diverse habitats of Sumatra Island. The reserve hosts approximately 10,000 types of plants, including 17 native species, more than 200 species of mammals, and 580 species of birds, including 465 species of resident birds and 21 species of native birds. The reserve contains 22 species of mammals that are unique to Asia, 15 of which are endemic to Indonesia, including Sumatra.

Tropical Savanna Climate This climate is also known as the savannah climate. It is generally located between 10° N and S latitude and the Tropic of Cancer. It covers areas in south-central Africa, southeastern Brazil, northern Venezuela, the inland region of the Indian subcontinent, the interior of the Indochina Peninsula and northern and eastern Australian. The annual temperature is high (average of 25°C), and the annual precipitation is between 750 and 1,000 mm. The climate is controlled by the equatorial low-pressure belt and the trade winds. The wet and dry seasonal variation is obvious, creating a natural savanna vegetation landscape.

Tropical Storm A tropical storm is a type of tropical cyclone with the maximum wind strength of grades 8–9 (17.2–24.4 m/s) near the centre. It must cover a large area of the tropical ocean surface and be affected by the earth's geostrophic deflection force.

Tsingy de Bemaraha Strict Nature Reserve, Madagascar This park is located in the borderland in southern Mahajanga Province, western Madagascar, near Toliara Province, and it has an area of 1,520 km^2. Tsingy de Bemaraha Strict Nature Reserve comprises karst landscapes and limestone uplands cut into impressive 'needle-like' peaks and a 'forest' of limestone. The banks of the Manambolo River form a spectacular canyon with rolling hills and high peaks. The undisturbed forests, lakes and mangrove swamps are habitats for rare and endangered lemurs and birds.

Tubbataha Reef Marine Park, The Philippines This park is located in the central part of the Sulu Sea in the southwestern marine area of the Philippines. It covers an area of 130,028 km^2 after the extension of the site in 2009. It includes the North and South Reefs. It is a unique example of an atoll reef with a high density of marine species. The North Islet serves as a nesting site for birds and marine turtles.

Tuff Tuff is mainly composed of pyroclastic materials less than 2 mm in diameter (i.e., volcanic ash) that are cemented by finer volcanic dust. Tuffs form from the deposition of fine pyroclastic materials from the volcanic plumes of eruptions that are transported by the eruption's airflow, the atmospheric air streams and wind. Hence, tuffs are a product of the deposition of materials out of the air after an eruption. The landscape of the ancient quarry caves in the Zhangyu Cave Tianjing area in the Yandangshan Global Geopark are almost entirely composed of tuff. The materials of the third phase of eruptions in the main park of the Yandangshan Geopark are all tuffs.

Tuff Cone A tuff cone is a landform that forms from a phreatic eruption or phreatomagmatic eruption. It is characterised by a conical shape with a thick deposit at the crater edge. It is generally more than 100 m tall, steep and has a maximum dip of 25°.

Tuff Ring Landscape This is a type of landscape with a circular distribution of tuff around a crater. The tuff layer is generally less than 50 m thick with a dip less than 12°. A tuff ring is a volcano formed by a phreatic eruption or phreatomagmatic eruption (Fig. 31).

Tundra Tundra is a low, dense vegetation type consisting of small shrubs, perennial herbs, lichens, and bryophytes that can be found in cold, humid climates in polar or alpine zones. The tundra region has long and cold winters, short and cool summers, little precipitation and strong winds. Permafrost is common under the soil. The surface only melts in the summer, and the surface is poorly drained and often saturated. Tundra can be divided into polar tundra and high mountain tundra. The former is located in the border regions of Eurasia and North America, and the latter is located in temperate cold and humid alpine areas.

Tundra Ecosystem Landscape A tundra, also called a 'moss plain', is a typical cold climate

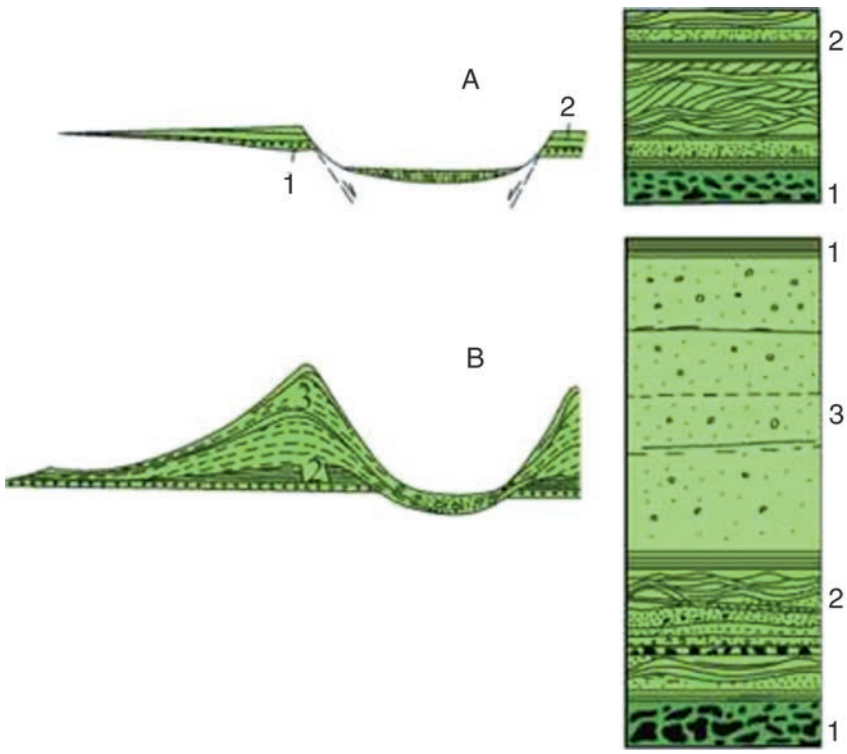


Fig. 31 Section of a tuff ring and tuff cone (after R.V. Fisher, H.U. Schminke) (**a**) tuff ring. (**b**) tuff cone 1. basal eruption breccia; 2. thin basal surge deposit; 3. thick blocky deposit

ecosystem. Tundras are mainly located in the northern fringes of Eurasia and North America, forming a roughly contiguous tundra belt. In tundras, the winters are cold and long, and the summers are cool and short. The annual precipitation is 200–300 mm, and the wind is strong. Permafrost is always present beneath the surface soil. The cold wet environment often results in physiological drought for plants. The community structure is simple, usually comprising only 1–2 layers. The plant species composition is very poor, with approximately 100–200 species, which are mainly mosses and lichens, perennial cyperaceous, gramineous, Ranunculaceae and cruciferous herbs and Salicaceae, heather and Betulaceae dwarf shrubs. They are usually evergreen perennial plants with large and striking flowers. Tundra is not as monotonous or dull as the desert, but the fauna species are limited, mainly comprising reindeer, muskox, arctic fox, polar bear, wolf and lemming. In the summer, many migratory birds come to the tundra to breed.

Turpan Huoyanshan Geopark, Xinjiang This geopark is located in Turpan City, Turpan area, Xinjiang Uygur Autonomous Region, and it covers an area of 290 km^2. A provincial geopark was set up in 2009, and it was upgraded to a national geopark in 2011. It is a comprehensive geopark with the clastic rocks of the Flaming Mountain as the main attractions. It is also characterised by geological, ecological and cultural landscapes. The integration of geology, fluvial landscapes, geological sections and waterscapes with the ancient civilisation of the western regions gives the geopark rich scientific value and aesthetic significance.

Turquoise Turquoise is regarded as a variety of jade by gemstone craftsman in China. It is a phosphate of copper and aluminium in the form of cryptocrystalline blocks or nodules with different shades of blue or green. It has a Mohs hardness of 5–6, a waxy lustre and a fine texture. It was used for decorative purposes with green jade and agate during the Neolithic age. Yun County in Hubei Province is famous

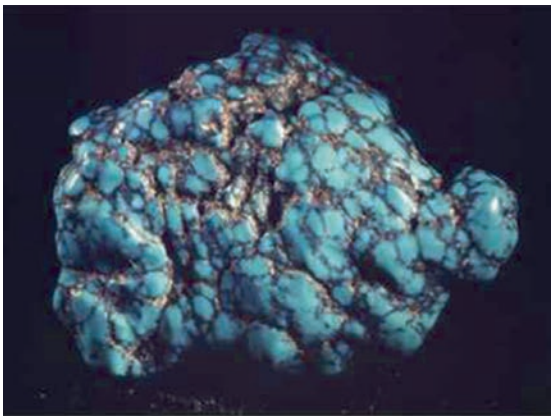


Fig. 32 Raw stone of turquoise

for its high-quality turquoise. Recently, turquoise has also been found in Shaanxi, Xinjiang, Anhui and Henan Provinces. The world's most famous turquoise is produced in Persia (Iran). Because Persian turquoise has long been exported to European countries via Turkey, this gemstone is called 'Turkey Jade' or 'Turkish Jade' (Fig. 32).

Tuscan Mining Park, Italy This geopark is located in a metalliferous mountain area and covers an area of 1,087 km^2. It became a global geopark in 2010. The park is located in one of the most important mining areas in Italy. It comprises attractive coastal and mountain landscapes, and it is the home of an important cultural and art area that includes the city of Tuská and nearby cities.

Type Geological Section A type geological section is also known as a standard geological section. It refers to an actual (or inferred) section in a certain direction that shows the geological characteristics (e.g., strata, structures, lithology) of the ground surface or the area at a certain depth.

Type Section A type section is a typical section on which a new stratigraphic unit is established. The profile should have a considerable thickness, a complete outcrop, abundant fossils, clear top and bottom boundaries and well-defined relationships with the overlying and lower stratigraphic units. Its scientific significance is equivalent to that of a stratotype.

Types of Tourism Planning The types of tourism planning include tourism planning performed in different areas and times under various specific conditions by institutions with different natures and expertise. The General Specification for Tourism Planning, which was issued by the National Tourism Bureau, stipulates several main categories of tourism plans: tourism development plans, overall plans, regulatory plans and site plans of tourism areas.

Types of Volcanoes Volcanoes can be classified according to the mode of eruption, form of the deposits and internal structures, such as lava flows, pyroclastic cones, lava domes, lava spikes, parasitic volcanoes, maar volcanoes, lava platforms, shield volcanoes, stratovolcanoes, calderas, volcanic slag cones, layered volcanoes and broken volcanoes.

Typhoon Typhoons form in all tropical oceans except the South Atlantic Ocean. They have very low atmospheric pressures, warm centres and strongly developed tropical cyclones. Typhoons have different names in different locations. In the northwest Pacific and the South China Sea, they are called typhoons. In the North Atlantic and the Caribbean, they are called hurricanes, while in the Indian Ocean and the Bay of Bengal, they are called tropical storms. Since 1989, China has used the international names for tropical storms if a tropical cyclone reaches maximum winds speeds of grades 8–9. When the wind speed of the centre reaches grades 10–11, it is called a severe tropical storm. When the wind speed reaches grade 12, it is called a typhoon. Typhoons occur with strong convection, very strong and destructive winds and torrential rains. They are considered a natural hazard and pose a threat to human life and property.

U

Ujung Kulon National Park, Indonesia This national park is located in Indonesia's Banten Province in the westernmost part of the island of Java, south of the Sunda Strait. It covers an area of 1,230 km^2. The park consists of the Ujung Kulon Peninsula and several offshore islands, including the Krakatoa Nature Reserve. In addition to its natural beauty and outstanding geological scientific value (especially for inland volcanic research), the park also has the largest remaining lowland rainforest in the Javanese plains.

Ukhahlamba Drakensberg Park, South Africa This park is located in southwestern KwaZulu-Natal Province in South Africa, adjacent to the border area of Lesotho. It has a core protection area of 2,428 km^2. The basaltic peaks, steep cliffs, golden sandstone gravels and the natural beauty of the Drakensberg Park are the main attractions. The winding meadows around high mountains, the rugged valleys and the rocky fjords add further highlights to the park. The diverse nature of this heritage site provides safe habitats for local endemic and endangered species of global significance, especially birds and plants. Over the past 4,000 years, indigenous people created many caves and rock-shelters with the largest and most concentrated group of paintings in Africa south of the Sahara south. The rock paintings depict the animal world and human life. Their excellent quality and the diversity of themes are remarkable and reflect the spiritual life of the extinct indigenous San people.

Ultrabasic Rocks Ultrabasic rocks are a large group of igneous rocks that are usually formed by the intrusion of mantle magma into the Earth's crust or by the eruption of magma onto the ground surface. Ultrabasic rocks contain less than 45% SiO_2 and higher contents of MgO and FeO but no quartz. The main minerals are olivine, pyroxene, and mafic plagioclase. Ultrabasic rocks have dark colours and high densities. Common types are peridotite and pyroxenite.

Ultra-High-Pressure Metamorphism Ultra-high-pressure metamorphism is the metamorphism that takes place under super-high-pressure conditions. It is characterized by the formation of eclogite, jadeite quartzite and aragonitic marble with ultra-high-pressure metamorphic minerals such as coesite and diamond. These ultra-high-pressure minerals are generally believed to form at pressures of 2.5–3.5 GPa and at depths of approximately 80–120 km. Their exposure at the surface is a result of delamination and uplift.

Uluru-Kata Tjuta National Park, Australia This famous national park is located near the centre of Australia in the southwestern corner of Australia's Northern Territory. The total area is 1,325 km^2. The heritage site was formerly known as Uluru (Ayers Rock) National Park. The unique and spectacular geological structure overlooks the endless red sand plains of central Australia. Uluru's rock monoliths and the Kata Tjuta to the west have been regarded as religious mountains for the world's oldest human society. The Anangu aborigines are the traditional owners of the Uluru – Kata Tjuta area.

Umbrella Effect Human and natural factors, including manufacturing plants, cars, wars, bush and grassland fires and volcanic eruptions, can release large amounts of smoke and dust into the atmosphere and weaken the effects of solar radiation on the ground, causing ground cooling. This effect is like a parasol over the earth and is also known as the 'parasol effect'. The parasol effect causes a decrease in the solar radiation received by the ground and increases in cloudy and foggy weather, which affects air, sea and ground traffic.

Unconformity An unconformity is an 'unconformable contact'. It forms when there is a substantial interruption in sedimentation or

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the formation of a lacuna, and the sequence of palaeontological evolution is discontinuous. This evidence indicates that the ages of the rocks are different. The types of unconformities include angular unconformities, parallel unconformities and disconformities.

Underground River Cave Landscape ▶ Subterranean Stream Cave Landscape

Underground River Tourism Landscape This landscape is composed of flowing water in an underground karst cave, which is typically located in a carbonaceous rock region. The underground channel is called a 'dry underground river system' when it is composed of dry underground river channels and their tributaries. These features can form an underground river tourism landscape for people to tour and appreciate. Examples are the Dragon Palace underground river and the Benxi water cave in Guizhou Province.

Underwater 'Dragon Eye' Tourism Landscape This is a spring that flows from the rock at the bottom of the ocean, a lake or a river. A freshwater spring that flows from beneath the sea bed near the coast is called a 'sea dragon eye'. An example is on the east coast of Zhijin County at Dalian, where a series of freshwater springs rises from the sea bed to form a spectacular 'sea dragon eye' scenery. Other examples are the 'Dung Spring', which flows from the riverbed of the Huanghe section between Hancheng, Shaanxi Province, and Wanrong, Shanxi Province, and the 50°C hot spring that flows from the bed of the Qinglong River at Lulong, Hebei Province. These springs have important tourism value and are water resources that can be developed further.

Underwater Eruption This is a volcanic eruption in an underwater environment, such as the bottoms of shallow seas, deep seas, lakes and other water bodies. When hot magma meets cold water, a vapor explosion occurs, accompanied by a non-explosive type of clastic effect. Therefore, underwater eruptions tends to produce glassy clastic rock, which is called hyaloclastite. This is a different form of volcanic eruption from eruptions on land.

Unified Mountain and Basin-Building Mechanism Orogenesis and basin formation can be reconciled in a unified dynamic model. Based on studies of typical regions, such as the Qinling-Weihe Basin and the Qinghai-Tibet Plateau, Chinese scientists have proposed a unified mechanism of post-compression tension, fault blocks, and balanced mountain- and basin-building, which can be summarized as follows: (1) Intense Mesozoic compression caused the occurrence of large-scale 'mantle uplift' and 'mantle depression'. (2) Compression began to weaken, and through the effect of gravitational equilibrium, the areas of mantle depression became mountains, while the adjacent regions of mantle uplift became basins. (3) Cenozoic orogenesis and basin building occurred due to tensile effects and were expressed in the form of fault blocks. This model can adequately explain the geological features of the Qinling-Weihe Basin and the Qinghai-Tibet Plateau. This unified mechanism has three main characteristics: (1) It groups multiple elements (compressional effects, tensile effects and gravitational equilibrium effects) into a unified mechanism. (2) It translates the leading factors into the proper order to describe the evolutionary history and mechanism of the mountain-basin building process. (3) It puts the mountain-building process (banded orogenic belt), plateau-building process ('surface orogenic belt' or 'mountain-building region') and basin-building process into a unified and gradual mechanism. Therefore, it has universal significance.

Uniformitarianism Uniformitarianism is an important theory of geology that is the opposite of catastrophism. This theory holds that the evolution of the Earth and its living things are extremely slow and systematically interrelated. Their initial differences are small, and significant differences can only be identified after the long-term accumulation of gradual changes. Modern geological processes are similar to those that occurred the past. Therefore, there are no drastic and abrupt changes. The dynamics of geological processes originate from the Earth itself, and catastrophic changes due to supernatural powers do not occur. This theory

was founded by James Hutton (1726–1791) and was later developed and popularised by Charles Lyell (1797–1875).

United Nations Convention to Combat Desertification (UNCCD) This was one of the major international environmental conventions within the framework of Agenda 21 of the 1992 United Nations Conference on Environment and Development in the United Nations. Its full name is 'United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa'. The convention was adopted at the Diplomatic Conference in Paris, France, on 17 June 1994 and went into force on 26 December 1996. The objective of the convention is to combat desertification and mitigate the effects of drought in countries experiencing serious drought and/or desertification, particularly in Africa.

Unzen Volcanic Area Geopark, Japan This park became a global geopark in 2009. The geopark is located in the southern part of Nagasaki Prefecture in Kyushu, western Japan. Before the Unzen volcano formed, the region of the Shimabara Peninsula was a shallow sea. The strata deposited in this shallow sea are called the 'Kuchinotsu Group'. Visitors can observe these rocks to the south of the peninsula. Volcanic activity, such as the eruption of low-viscosity basaltic lava flows, formed the gentle slope in the south. The Unzen volcano is located in the central part of the peninsula, where many lava domes were created by viscous dacite magma. The narrow region extending from Beppu City to the Shimabara Peninsula is characterised by abundant normal and strike-slip faults trending approximately EW to NE-SW and is described as the Beppu-Shimabara Graben. The Unzen volcano developed within one of these active basins (Unzen Graben).

Upper Cave Man Site The Upper Cave Man site is a site of ancient human fossils that was found in 1933 in a limestone cave at spot number 1 in Zhoukoudian, Fangshan, Beijing. Ten individual human fossils have been excavated, including 3 complete skulls. The skull morphology indicates that the Upper Cave Man's appearance was similar to that of modern man and that it was a late Homo sapiens. In addition to the stone and bone artefacts, many decorations dyed in red have been found in the cave. They include fish bones with holes, clam shells, animal teeth and stone beads, and they are proof of artistic activities carried out by the Upper Cave Man. The site belongs to the Late Palaeolithic culture. This cave also contains 47 species of mammal fossils, including extinct species of Crocuta ultima, Ursus spelaeus and ostriches. Unfortunately, the Upper Cave Man fossils were lost with the Peking Man skull (Fig. 1).



Fig. 1 Upper Cave Man site

Upper Ordovician Hirnantian Global Stratotype Section and Point (GSSP) 'Golden Spike' at Wangjiawan, Yichang, Hubei The term 'Hirnantian' originates from Hirnat in the Bala area of Wales, UK. The 'Hirnantian Stage' represents the uppermost Ordovician strata. Continuous sedimentation occurred in the Ordovician-Silurian strata in the Wangjiawan area in Yichang, Hubei Province. These rocks are rich in graptolite and brachiopod fossils that can be used for global

comparisons. In May 2006, the International Union of Geological Sciences (IUGS) formally approved the proposal for the adoption of the section in northern Wangjiawan in Yichang, Hubei Province, as the global stratotype section and point for the bottom boundary of the 'Hirnantian Stage'. Wangjiawan is located 42 km north of Yichang City. The Ordovician-Silurian outcrop at this location extends 150 m along the highway between the northern and southern Wangjiawan sections. The Ordovician Wufeng Formation in the northern Wangjiawan section is mainly composed of siliceous shale and other siliceous rocks. The bottom boundary of the 'Hirnantian Stage' (the 'Golden Spike') is demarcated at the bottom of bed AFA97a and is defined by the first occurrence of the graptolite *Normalograptus extraordinarius*.

Urban Ecosystems Urban ecosystems include cities, towns and urban areas built by humans. They include the population, infrastructure and the surrounding semi-urban or 'peri-urban' environments that surround cities as well as agricultural and natural landscapes.

By considering urban areas as part of a broader social-ecological system, tourism earth scientists can investigate how urban landscapes function and how they affect other landscapes with which they interact. In this context, urban environments are affected by their surrounding environment, but they also change and affect that environment. By understanding these interactions and influences, more sustainable development options can be formulated to improve the development of these urban ecosystems.

Urban Geography Urban geography studies the formation, development, combinations, and spatial patterns of urban changes under different geographical conditions. It is an important branch of human geography and an important part of urban planning and studies. Urban geography is also a foundation of urban tourism planning.

Urban Tourism Urban tourism involves activities with cities as destinations. Urban tourism mainly includes visiting urban sites, streets and cultural attractions as well as participating in urban cultural activities. It can also refer to activities such as sightseeing, leisure, shopping, entertainment, dinning and meeting friends away from their usual places of residence and workplaces.

Urho-Type Wind-Eroded 'Castle' Landscape This landscape is a representative sandstone landform found in the arid and windy climate zone of Tarim. It mainly consists of geomorphological features such as castle-shaped flat-topped mesas, stone walls, stone corridors and stone pillars (stone mushrooms), which formed in the parent rocks of the Lower Cretaceous riverine and lacustrine facies auburn-greyish green banded sandstone and mudstone due to wind erosion and intermittent water erosion. This landform was given its name because it was first discovered in Urho on the northwestern margin of the Junggar Basin, Xinjiang Province. It is also called the 'Wind City Landform' because the main features look like castles formed by wind erosion. This landscape is a potential tourism resource for further development.

Uvala, Karst Depression Landscape This is a common karst landform with enclosed negative topography. It is sometimes difficult to distinguish it clearly from a karst funnel or doline. In general, karst depressions have larger areas with bottom diameters greater than one hundred metres. The surfaces are relatively flat and covered with loose sediments. Dolines and avens are common. These depressions are generally appropriate for agricultural use, whereas karst dolines are generally smaller and hence are not suitable for agricultural use. Karst depressions have obvious zonal characteristics. They have star shapes or polygonal shapes in humid regions, such as the cone karst area of southern China. There are at least 2,851 enclosed depressions in an area of 1,000 km^2 in the subterranean river district in Du'an, Guangxi Province. However, in the semi-arid north, the depressions are small, sparse and nearly circular. In tectonic areas, they can develop into bead-like depressions. Some countries use a broad



Fig. 2 Karst depression landscape – Fengshan, Guangxi Province

definition of karst depressions that includes all kinds of enclosed negative topography formed by karst in carbonate areas, including funnels, round depressions, synthetic depressions, trough valleys, karst basins and many other types (Fig. 2).

Uvs Nuur Basin, Mongolia/Russia This site is located along the border between Ubsu Province in northwestern Mongolia and the Republic of Tuva in the Russian Federation. The core protection area of the cross-border heritage site covers 8,980 km^2, and the buffer area covers 10,688 km^2. The basin is named after Lake Ubudsu, which is a large salt lake. The area is a stopover site for migratory birds, water birds and seabirds. The habitat consists of 12 protected areas, representing the main biomes in eastern Eurasia. The savannah ecosystem supports many species of birds, and the desert is home to large groups of rare animals, such as gerbils, jumping rodents, and cats. The mountainous region is also an important habitat for globally endangered species such as snow leopards, sheep and Asian wild goats.

V

Vacation Climate Resources A vacation climate resource refers to a tourism resource in the form of comfortable and favourable climate conditions able to attract tourists for vacation or leisure. It is mainly in the form of summer resorts or winter retreats. Typical examples are Harbin in the summer, Hainan Island in the winter, Kunming, which has mild weather throughout the year, and the Chengde summer resort.

Vacation Tour *Synonym:* ▶ *Holiday tour*
A vacation tour involves high-quality and high-level leisure, recreation and entertainment activities when people go to certain destinations for a period of time away from their usual places of residence.

Vallée de Mai Nature Reserve, Seychelles This reserve is located at the heart of the small island of Praslin northeast of Mahé, Seychelles, and it has a core protection area of 0.2 km^2. The reserve includes the vestiges of a natural palm forest that are preserved in nearly their original state. The famous *coco de mer*, from a palm tree that was once believed to grow in the ocean, has the largest seed in the plant kingdom.

Valley Landscape ▶ Canyon Landscape

Valley of Ten Thousand Smokes Landscape This landscape forms splendid scenery in North America and is named after a valley that contains numerous fumaroles that emit plumes. The valley is located near the Katmai Volcano in the southwestern Alaskan Peninsula in the United States. It covers an area of 145 km^2 and is within the circum-Pacific volcanic belt. The volcanoes are active and generate frequent earthquakes. On June 6, 1912, Katmai Volcano erupted violently. Its top was blown off and collapsed, forming a crater that is 4.8 km long and 3.2 km wide and causing the formation of a new volcano, the Novarupta Volcano, 10 km away. During the eruption, large amounts of materials soared into the sky, and the surrounding valleys were covered with up to 200 m of volcanic ash. All of the fauna and flora were incinerated by the heat. Tens of thousands of fumaroles and smoke plumes emitted large amounts of hot gas. Some of the plumes reached a height of 350 m, forming a thick layer of smoke that, when illuminated by sunlight, reflected numerous rainbow colours. Four years after the eruption, the smoke plume was still 45 m high with a temperature up to 649 °C. An area of 24 km^2 around the volcano was still shrouded in water vapor and volcanic smoke, and the Valley of Ten Thousand Smokes gets the name from these features. Since then, the volcanic activity has decreased gradually, leaving behind only 12 fumaroles. Plants began to flourish, and grey bears and moose returned. In 1918, this site became Katmai National Park (Fig. 1).

Valley-in-Valley Landscape This is a landscape where a new valley has formed in an existing valley. Due to lowering of the erosional surface, neotectonic uplift and climatic changes, river downcutting can become more pronounced, which creates new valleys inside an old valley. This is called a valley-in-valley landform. The original valley floor is transformed into a valley shoulder above the standing valley. This is a landform of rejuvenation. This landform is common in the broad valleys in northern China. In the alpine regions in western China, many glacial U-shaped valleys often contain river-cut valleys that formed during inter-glacial periods (Fig. 2).

Variscan Movement See ▶ Hereynian Movement.

Vegetation Vegetation refers to the total population of plant communities in an area. Vegetation is closely related to natural environmental factors such as climate, landforms, soil, animals and hydrology. From a global perspective, vegetation can be divided into two categories, namely, marine vegetation and terrestrial vegetation. Algae dominate the green vegetation in marine vegetation, and

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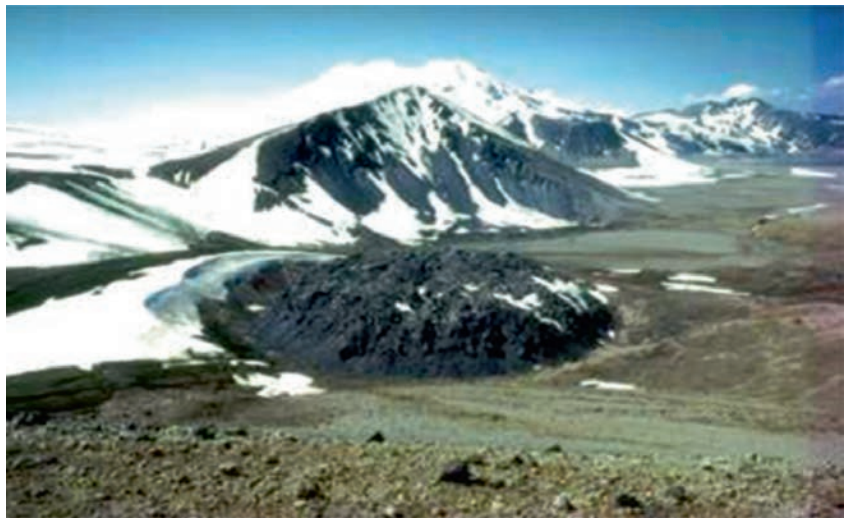


Fig. 1 Valley of Ten Thousand Smokes, Alaska, U.S.A

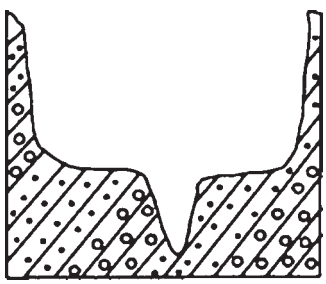


Fig. 2 Valley-in-valley (glacial and river valleys)

the productivity is low. The dominant terrestrial vegetation is seed plants, and different vegetation types form due to the differences in the terrestrial environment. Vegetation can also be divided into natural and artificial vegetation. Natural vegetation is a product of the long-term development of plants in an area. Artificial vegetation includes farmland, orchards, pastures, plantations, and urban green spaces.

Vertical Cave Karst Landscape This is a karst cave with water flowing along vertical cave channels or steep cave walls. It is generally called a vertical shaft, natural well or dissolved well. They can be tens to hundreds of metres deep. These caves form as a result of a decrease in the water table, which causes thickening of the seepage zone and the downward development of sinkholes or the collapse of cave roofs. The bottom of the cave reaches the groundwater surface or the underground river body. Sinkholes and tiankengs are examples of this landform. In China, vertical karst caves are mainly located on the Yunnan-Guizhou plateau, especially in the mountainous areas of karst peak clusters. The Tianxing (Heavenly Star) cave system in Wulong, Chongqing City, is by far the deepest cavern system identified in China, with a maximum depth of 1,020 m. The deepest single descending shaft cave in China is the Miao Pit, which is 681 m deep and has a single drop of 491 m (Fig. 3).

Vertical Crustal Movement Vertical crustal movement includes the vertical uplift or subsidence of the Earth's crust. Crustal uplift ends sedimentation on the Earth's surface and causes the denudation of previous areas of deposition, resulting in formation of unconformity in the strata (such as the unconformity in the Ordovician to Early Carboniferous strata in the North China Platform). When subsidence occurs later, sedimentation begins again and forms a sedimentary discontinuity in the newly deposited strata, resulting in a disconformity. If the period of the sedimentary discontinuity is long and the denudation is significant, an extensive planation surface or a peneplain can develop with widely distributed siliceous conglomerates (such as the Middle Devonian conglomerate in the Yangtze Platform).

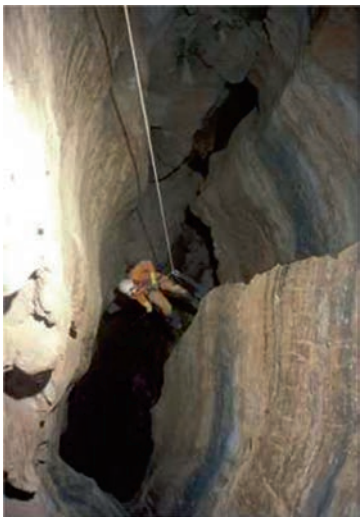


Fig. 3 Karst vertical shaft landscape – Wulong, Chongqing

Vertical Zonality Vertical zonality is the variation in natural geography based on differences in elevation in mountainous areas. The rapid decrease in temperature and the increases in precipitation and humidity with increasing elevation cause a vertical zoning of mountain climates. Because of this zoning, the physical and geographical elements, such as soil and biology, also vary. Almost every mountainous region has vertical zoning. The vertical zonality is closely associated with the height of the mountains, the orientations of the slopes, and the geographic location. The vertical variations in different locations may have different patterns, ranging from the low latitudes to the high latitudes and from coastal to mountainous areas. These vertical variations are less complicated in most arid regions.

Vesicular Structure The gas in a volcanic lava flow will diffuse upwards while flowing and leave holes in the lava after cooling; this is called a vesicular structure. Its shape can be round, elliptical, cloud-shaped, or tube-shaped. The shape of the hole and the array orientation usually indicates the lava flow direction. Vesicular structures are common in China's geoparks that are composed of basalt (Fig. 4).

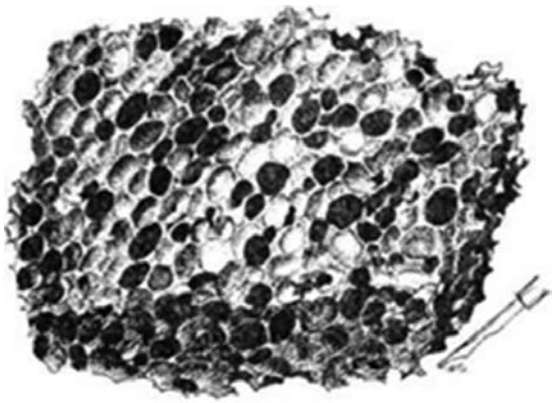


Fig. 4 Vesicular structure

Vesuvius Volcano Landscape Vesuvius is an active volcano in Europe and is located 11 km east of Naples in Italy. The world's largest volcanic observatory was established here. In 63 A.D., Vesuvius experienced a major earthquake. On August 24, 79 A.D., the volcano erupted. Two cities, Herculaneum and Pompeii, were completely buried under volcanic ash and pumice stone. In 1713, a well was drilled in Herculaneum, which encountered an amphitheatre. Since then, many statues and plaques with inscriptions of the 63 A.D. earthquake have been unearthed. Pompeii is buried relatively shallowly, and nearly the entire city has been excavated. The city wall is 4.8 km long. Since the beginning of the twentieth century, Vesuvius has erupted several times; the 1994 eruption buried the ruins of this ancient city under 0.3 m of volcanic ash (Fig. 5).

Viewing Stone *Synonym:* ► *Ornamental Stone*, ► *Enjoyable Stone*

In Chinese, ornamental stones are also called weird stones, elegant stones or beautiful stones. They are natural stones with ornamental, associative and commemorative value that give a sense of beauty for enjoyment. They also have economic, cultural, scientific research and collection value. They are generally characterised by peculiar shapes, gorgeous colours, tough and stable qualities and natural forms. Rocks, minerals and fossils can become ornamental stones when they have a certain



Fig. 5 Vesuvius Volcano landscape

mysterious quality or cultural significance and are characterised by natural beauty and peculiar form. There are a wide variety of ornamental stones with particular labels, such as place name stones, image stones, colour stones, culture stones, generic stones (rocks, minerals and fossils), landscape stones and craft stones. However, this term does not usually include stones in natural landscapes and craft stones that have been artificially processed. Ornamental stones are an important commodity in tourism.

Vikos-Aoos Geopark, Greece This geopark is located in the city of Ioannina in northwestern Greece, and it covers an area of 12,500 km^2. It became a global geopark in 2010. It has a well-preserved generally mountain landscape, including the most impressive feature in western Greece, the Vikos-Aoos Gorge. The geopark has exceptionally rich geological diversity as well as an enormous natural habitat extending from lowland landscapes to alpine landscapes. The management responsible for running the geopark pays attention to the development of a sustainable tourism industry by incorporating local villagers.

Villuercas Ibores Jara Geopark, Spain This geopark is located in the Extremadura region of Spain and covers an area of 2,544 km^2. It became a global geopark in 2011. The unique geomorphological features of the park are influenced by the structural geology. The folds and faults formed due to strong tectonic processes. The rocks, which include the oldest

rocks in Europe, are from a wide range of geological periods, including the Sinian, Cambrian, Ordovician, and Silurian (650 million to 400 million years ago). The geopark also has rich biodiversity with bird protection and biodiversity corridors and monumental trees. There is also early evidence of a mining culture and ornamental stones and boulders that can be dated back to the Bronze Age and Iron Age.

Virgin Komi Forests, Russian Federation This site is situated in the Komi Republic in the northern Ural Mountains in Russia, and it has a core protection area of 32,800 km^2. The Virgin Komi Forests protect the Ural Mountain tundra as well as the largest remaining old-growth coniferous forest in Europe. For more than 60 years, scholars have monitored and studied the vast area of pine woods, poplar forests, beech forests, peat bogs, rivers and natural lakes.

Virunga National Park, Congo Virunga National Park is located in North Kivu Province in the eastern Democratic Republic of the Congo adjacent to the borders with Uganda and Rwanda. It has a core protection area of 7,900 km^2. The park hosts an outstanding diversity of habitats, ranging from swamps and steppes to the snowfields of Rwenzori at elevations of over 5,000 m and from lava plains to the savannahs on the slopes of volcanoes. Mountain gorillas are found in the park, approximately 20,000 hippopotami live in the rivers, and birds from Siberia spend their winters in the park.

Visibility Visibility is an index that reflects atmospheric transparency and is defined as the maximum distance that a person with normal vision can recognize a black target of a certain size from the background sky near the horizon. Visibility is divided into 10 levels; for example, 0 represents visibility of 0–50 m, 2 represents visibility of 200–500 m, 3 represents visibility of 500–1000 m, and 4 represents visibility of 1–2 km. Visibility is closely related to the weather conditions at the time of assessment. Poor visibility often occurs during rain or in foggy and hazy weather, storms or sandstorms.

Vitric Fragment *Synonym:* ► *Glass fragment*
A vitric fragment is a type of volcanic ash. Due to rapid cooling, the erupted magma is in a glassy state, and the bubble in the fluid diffuses outwards due to the decreasing pressure. The volcanic glass that contains the gas bubbles will eventually burst to form glass fragments with the shapes of bows or chicken bones. Vitric fragments are generally smaller than 0.5 mm.

Volcanic Agglomerate A volcanic agglomerate is a type of volcanic rock. During a volcanic eruption, the magma pierces through the overlying strata or older rocks, which breaks them into fragments of varying sizes. When the diameters of the rock fragments are is greater than 50 mm, the rock is called an agglomerate. A volcanic rock composed mainly of these aggregates is called a volcanic agglomerate, and these rocks are generally distributed around the crater. This is an important marker for determining the crater location.

Volcanic Ash; Ash Volcanic ash is composed of volcaniclastic fragments less than 2 mm in diameter that form during volcanic eruptions. It includes crystal fragments, rock detritus (clasts) and glass fragments (vitric fragments, shards) that are formed by rapid cooling of magma.

Volcanic Belt A volcanic belt is a landform that contains a series of volcanoes in a specific tectonic location, such as the edge of a plate or along a large regional fault.

Volcanic Bomb When a volcano erupts, the molten magma is thrown into the air at high velocity. The magma rotates due to resistance and tension, and when it lands on the ground, cooled or semi-cooled volcanic bombs are formed. Volcanic bombs have diverse forms and are typically spindle-like, pear-shaped, twist-like, snake-like or clump-shaped. They can be hollow or have a core. For example, some volcanic bombs in Wudalianchi have granitic cores. The key to distinguishing volcanic bombs is the internal colour, pores and the extent of crystallisation with concentric patterns. Volcanic bombs are valuable geological specimens and have high scientific research, ornamental and collection value (Fig. 6).



Fig. 6 Twisted volcanic bomb, Wudalianchi

Volcanic Breccia During a volcanic eruption, the magma pierces through the overlying strata or older rocks, which breaks them into fragments of varying sizes. These rock fragments are solidified by lava or volcanic ash into volcanic breccia. When the diameters of the rock fragments are 2–50 mm (circumference of 64 mm), the rock is called a breccia. A volcanic rock is called a volcanic breccia when it is mainly composed of breccia.

Volcanic Cluster A volcanic cluster refers to a regional distribution of volcanoes in a particular region, such as China's Datong volcanic cluster and the Haikou (in Hainan North) volcanic cluster in Hainan Province.

Volcanic Collapse Cave Landscape This cave landscape consists of caves of different sizes and shapes that form due to fracturing of volcanic rocks, the formation of joints and gravity collapse. The landscape includes flat caves, upright caves and inclined caves (Fig. 7).

Volcanic Debris Flow Landscape A volcanic debris flow is a density current composed of the hot gases and debris produced during volcanic eruptions. The cooled rocks are collectively known as molten pyroclastic rocks. Volcanic debris flows form due to vertical air eruption and columnar collapse, low-pressure super boiling, directional explosions and dome collapses. The Mesozoic volcanic rocks in eastern China are widely distributed volcanic debris flows that are also called ignimbrites. Extensive outcrops can be found in Yandangshan in Zhejiang Province, Baishuiyang in Ningde, Fujian Province, and Hong Kong Global Geopark in Sai Kung.

Volcanic Dome Landscape A volcanic dome landscape is a type of landscape associated with uplifted domes that form when magma moves or flows to the Earth's surface. There are 4 types of volcanic domes: (1) dome-shaped geological bodies composed of materials from a central eruption; (2) dome-shaped geological bodies consisting mainly of pyroclastic flows, which are called ignimbrite shields in accordance with P. W. Francis; (3) dome-shaped structures caused by upward folding of the overlying rock strata by magma movement; and (4) dome-shaped structures that form by the upward intrusion of magma inside a caldera, which are also called resurgent domes.

Volcanic Dust Volcanic dust is very small volcanic debris that forms when volcanoes erupt.

Volcanic Earthquake This is an earthquake caused by volcanic activity. During the volcanic process, magma can shake the surrounding rocks and cause vibrations. The resulting earthquakes can occur prior to or concurrent with volcanic eruptions. Volcanic earthquakes are not common and only represent approximately 7% of all earthquakes. Their main characteristics are that the source is limited to the region of volcanic activity, and the earthquakes are shallow and do not exceed a depth of 10 km. The earthquakes are usually large and are not associated with a major fault. Their impact is usually confined and small.

Volcanic Edifice This is a general term for various geologic elements associated with volcanoes. It generally refers to the volcanic conduit and the associated deposits and structures, such as the craters, vents, deposits and intrusive domes. Craters and vents are the basic elements of a volcanic edifice.

Volcanic Effusion This is a phenomenon in which magma spills over the surface in a relatively calm manner. This magma movement can form lava rivers, lava falls or lava lakes. An example is the Hawaiian volcanoes.

Volcanic Eruptions Volcanic eruptions are divided into two broad categories according



Fig. 7 Collapse volcanic cave landscape at the Lingfeng Three Caves in Yandangshan, Zhejiang Province

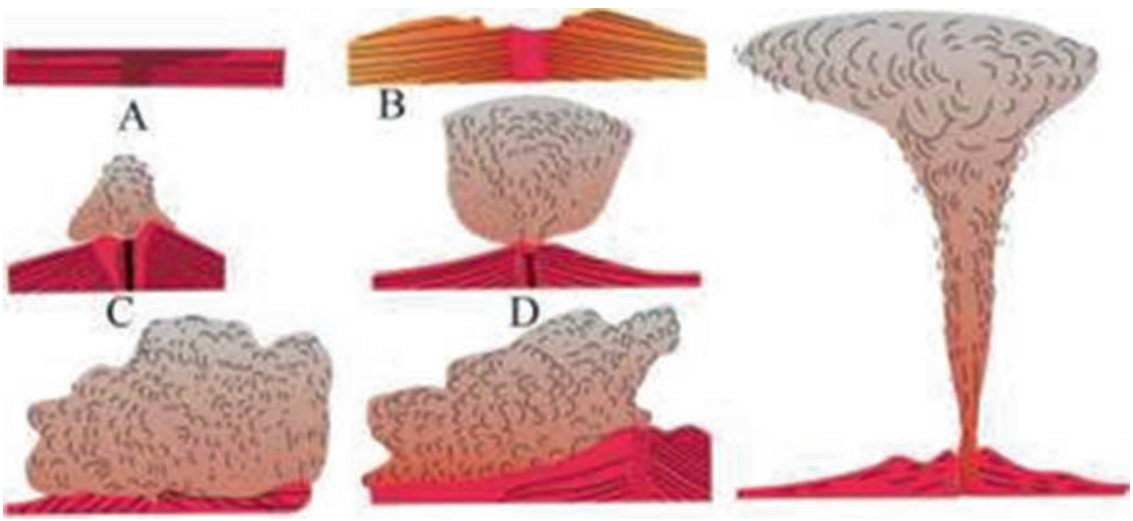


Fig. 8 Diagrams of volcanic eruption types. (**a**). flood basalt type; (**b**). Hawaiian type; (**c**). Strombolian type; (**d**). Vulcanian type; (**e**). mixed type; (**f**). Pelee type; (**g**). Plinian type

to the type of magma channel. One is rift eruptions, which are also known as Icelandic volcanic eruptions, during which magma flows to the ground surface along cracks in the Earth's crust. The other type is central eruptions, during which the magma is ejected from a conduit. The differences in the physical and chemical properties of the magma, such as its viscosity and gas content, determine the mode of the eruption. To signify the characteristics of volcanic eruptions, volcanoes are usually named after specific types, such as Hawaiian, flood basaltic, Strombolian, Vulcanian and Plinian type eruptions (Fig. 8).

Volcanic Explosion A volcanic explosion is a phenomenon in which volcanoes erupt in a violent manner under certain conditions. It is a process of rapid energy release. This energy can be either from highly compressed gas in the magma or from vapour generated when magma or magmatic heat comes into contact with water.

Volcanic Facies Volcanic facies is a general term for the collective products of volcanic activity



Fig. 9 Volcanic geothermal station, New Zealand

in a certain environment. Different environmental conditions result in different volcanic facies. The environment refers to the conditions of the volcanic eruption region on land or in the sea, the area of accumulation, the position on the ground surface or near the surface, and the specific locations of the volcanic structure, such as the near-source crater or the volcanic slope away from the crater (See ► Magmatic Rocks).

Volcanic Geothermal Energy Volcanic geothermal energy is the underground heat energy associated with volcanic activity. The Earth contains an enormous heat energy resource, and volcanic eruptions are a display of the Earth's internal thermal energy at the surface. In addition, hot springs, boiling springs, intermittent springs, hydrothermal explosions and hydrothermal alteration are all geothermal features on the Earth's surface. Volcanic eruptions are related to the presence of high-temperature magma chambers underground, which can heat circulating groundwater. This heated groundwater is either stored underground or emitted from the ground surface as volcanic hot springs. Countries with numerous volcanoes, such as Japan and New Zealand, have rich geothermal energy resources, and several geothermal power plants have been constructed. There are many hot springs in the Tengchong volcanic area in China, some of which have temperatures up to 82 °C (Fig. 9).

Volcanic Hazard Volcanic hazards are natural disasters caused by volcanic eruptions. Volcanic eruptions can cause direct disasters as well as indirect disasters due to the abrupt change in climate. Volcanic hazards generally include the following: (1) damage caused by volcanic debris flows; (2) damage caused by lava flows; (3) damage caused by volcanic landslides and mud and rock flows; (4) damage caused by falling volcanic ash and volcanic debris; (5) damage induced by volcanic gases and the associated aerosols; (6) volcanic earthquake disasters; (7) damage induced by volcanic shock waves; (8) tsunamis caused by earthquakes; and (9) flight safety threatened by high-altitude volcanic ash. Ruins from volcanic hazards can remain, such as Pompeii, which has become a popular tourist's attraction for science education (Fig. 10).

Volcanic Hot Spring Landscape in the Changbai Mountains This is a hot spring that is supplied by water from a crater lake. Changbai Mountain Hot Spring is located on



Fig. 10 Imagery of the path of a volcanic ash flow and pyroclastic flow into settlements, Unzen Volcano, Japan

the northeastern side (Tianchi) of Changbai Mountain in Antu County, Jilin Province, and it is on the right bank of the Erdaobai River, approximately 800 m from the waterfall. The numerous hot springs in the group trend NNE along a Middle Pleistocene alkaline trachyte clastic zone. There are 103 springs in this district, including 32 major springs and six springs with flow rates over 1 L/s. The largest spring has a flow rate as high as 6,827 L/s, and the others are below 1 L/s. The total flow volume is 52 L/s. The spring water temperature ranges from 40 °C to 82 °C and is mostly 60–70 °C. The salinity is 129–147 g/L and is sodium bicarbonate. The soluble silica content is 84–104 mg/L, and it contains various trace elements, such as boron, arsenic, copper, titanium, manganese, cobalt and nickel. The springs have a strong hydrogen sulphide odour, and the total hydrogen sulphide content is 103 mg/L. Yellow sulphur flowers and reddish brown iron oxide are located near the spring mouth. Some of the water from the Changbai Mountain Hot Spring flows out at the bottom of Tiachi Lake, which heats the water to 20–40 °C within an area 300 m long and 40–50 m wide in the northeastern part of the lake. The phenomenon of hot spring water flowing out at the bottom of a crater lake is rare. The hot spring water is effective for the treatment of arthritis, stomach diseases and skin diseases (Fig. 11).

Volcanic Lake Landscape Volcanic lakes form when a crater is flooded with water. The Tianchi at Changbai Mountain is an eroded crater filled with water, and the crater of Nangelaqiu in Wudalianchi is also filled with water and forms a small volcanic lake (Fig. 12).

Volcanic Landscape A volcanic landscape is a geomorphic relic left by volcanic activity and associated processes. Volcanoes are an important manifestation of crustal movements, and they have played extremely important roles in all stages of the Earth's history. Currently active volcanoes and volcanoes that have become extinct have left behind a variety of relics, such as craters, lava lakes, lava rivers,



Fig. 11 Volcanic hot spring landscape at Changbai Mountain

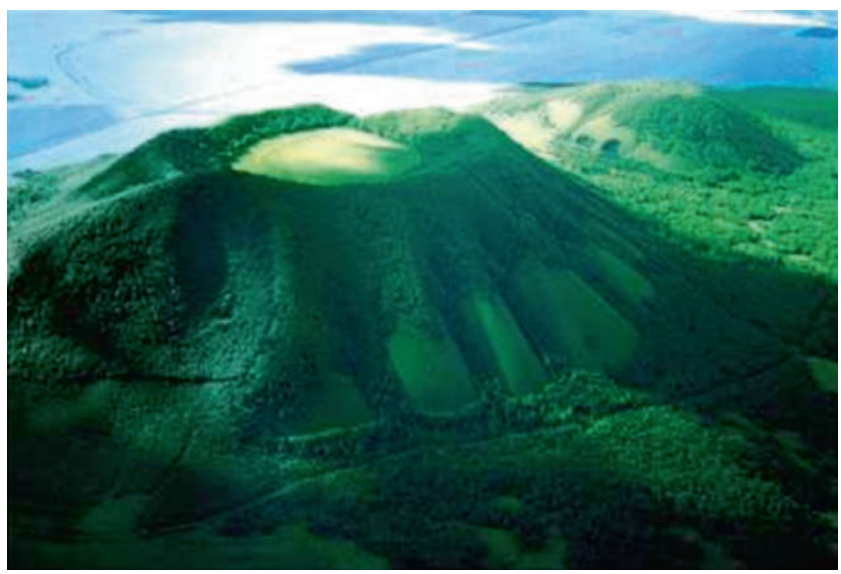


Fig. 12 Nangelaqiu Crater landscape, Wudalianchi

volcanic cones, volcanic necks, lava tunnels, pillow-like lavas, rope-like lavas, driblet cones and laccoliths. Additional features are composed of volcanic rocks affected by erosion and weathering, such as overlapping screen-like peaks of volcanic rocks, sharp volcanic peaks, stone gates of volcanic rocks, volcanic rock gorges, natural bridges of volcanic rocks, and volcanic collapse caves. Volcanic activity forms these volcanic landscape resources, which have important scientific research and tourism value.

Volcanic Lava Cave Tourism Landscape A cave that formed in lava can have high tourism value. After lava from a volcano cools and hardens, a series of complex lava caves and tunnels can form due to the escape of gas and shrinkage of the lava. These caves can be large and can become important cave tourism landscapes. An example is the Shishan Volcanic

National Geological Park in Haikou, Hainan Province, which includes several large lava tunnels. The Wolong Cave is approximately 10 m wide, 7 m tall and approximately 3,000 m long, and its walls are composed of polished shiny basalt. The walls of the Fairy Cave are covered with thorn-like lava, in which the traces of magma flows can be observed; the largest chamber is approximately 14.7 m high and has an area of 5,800 m^2.

Volcanic Mineral Spring This is a spring in a volcanic area that is rich in minerals. Based on the mineral composition, these springs can be divided into bicarbonate springs, silicon springs, strontium springs, barium springs, iron springs and radon springs. Volcanic mineral spring water is potable. Some springs are effective for curing rheumatism, neurasthenia and high blood pressure. The Nanyao (South Medicine) Spring in Wudalianchi is a cold spring of iron, bicarbonate, strontium and silicon. Its spring water can be used for medicinal use and for consumption (Fig. 13).

Volcanic Mud This is a dark grey to black non-sticky soil which main ingredient is volcanic glass. Volcanic mud contains certain medicinal elements that can be used for health-care purposes. The Leiqiong Global Geopark (Haikou Scenic District) has developed a type of 'volcanic mud' mineral soap that has become popular in the market. Wudalianchi volcanic mud has also been developed into a series of products, including mineral essence nutritional masks, cleansing milk, shampoo, volcanic mud skin cream, foot cream and whitening moisturising cream (Fig. 14).

Volcanic Mud Treatment Volcanic mud treatment refers to the process of smearing mud that contains beneficial minerals on the body or immersing the entire body in the mud to achieve therapeutic effects or to alleviate symptoms. This treatment is also called a mud bath. There are specialised mud treatment facilities in the Wudalianchi Global Geopark.

Volcanic Mudflow Landscape A volcanic mudflow is a volcanic debris landscape composed of a mixture of volcanic debris and a transporting medium (e.g., water). When water is the transporting medium, all of the clastic materials are close to each other and collide frequently, and they move due to gravity and fluid dynamics. When the flow velocity decreases, these materials settle to form a volcanic mudflow deposit. There are three types of volcanic mud flows: (1) hot volcanic debris that flow into rivers and lakes; (2) hot volcanic mudflows composed of a mixture of the volcanic debris in the crater and water during an eruption; and (3) volcanic mudflows that form when volcanic debris on the slopes of a volcano flows down the slope during torrential rainstorms.

Volcanic Neck Landscape This is a type of volcanic landscape that forms when a volcanic conduit is filled with lava or pyroclastic rocks to create a volcanic neck or rock neck.



Fig. 13 Hot spring landscape, Changbai Mountain



Fig. 14 Volcanic mud therapy – Wudalianchi

Geological features that characterise volcanic necks are: (1) Volcanic necks are usually circular in map view. Most tabular conduits are filled with tuff, but some are filled with lava or lava breccia. Vertical or steeply inclined conical conduits are often filled with lava and seldom with both lava and pyroclastic rocks. Linear conduits are often filled with lava, breccia or tuff. (2) Volcanic necks can form positive or negative topography depending on the degree of rock resistance. Volcanic necks composed of acidic lava always form positive topography and form steep high peaks.

Volcanic Rock Gorge Landscape This is a gorge-type landscape formed by regional faulting and erosion of volcanic rocks caused by water. The gorge walls are composed of overlapping peaks and hanging waterfalls, which commonly expose stratigraphic sections. The Mesozoic volcanoes in Zhejiang Province contain many famous volcanic rock gorge landscapes. A typical example is Jingmig Gorge in Yangdangshan. The Yuanyang Stream in Pingnan, Fujian Province, is also a Mesozoic volcanic rock gorge.

Volcanic Rocks Volcanic rocks are also known as extrusive rocks, and they form when magma erupts onto the ground surface (or into water) and cools. The rock forms when lava erupts in a relatively calm eruption and it is often composed of fine-grained or crystalline minerals or amorphous glass. If the magma bursts out in the form of a violent eruption, the resulting rock contains clastic rock or minerals in addition to the fine-grained or cryptocrystalline minerals or glass, and the rock is known as pyroclastic rock. In China, more than 20 national geoparks have volcanic rocks as the theme, which cover the entire range of volcanic rocks.

Volcanic Scoria Volcanic scoria is residual fragments of volcanic rocks with dense pores. It is usually black or brown, porous and denser than acidic pumice rock. It often forms around a crater (Fig. 15).

Volcanic Scoria Cone Landscape A volcanic scoria cone is also called a clastic cone. It is a type of volcanic landscape composed of small volcanoes formed by Strombolian eruptions. Its main body is composed of volcaniclastic rocks with some lava, and its main rock content is basaltic-andesitic, though sometimes with dacite and rhyolite. The cone width ranges from 0.25 to 2.5 km with an average



Fig. 15 Scoria at Haikou, Hainan Province



Fig. 16 Datong Jinshan Volcano volcanic scoria cone landscape

of 0.9 km. The common rock facies are: (1) extremely small rock mass-volcanic slag flows; (2) volcanic bombs formed by splashed magma with a shape like cow dung, spindles or sometimes layers; (3) a combination of lava flows and rapidly splashed lavas; (4) welded volcanic tuffs and breccia inside the scoria cone; and (5) large pieces of volcanic clasts and bombs around the crater with smaller debris on the downwind side (Fig. 16).

Volcanic Sharp Peak Landscape This is a landscape of sharp peaks composed of volcanic rocks. In his book 'A Note on Travel in Yangdang Mountain', Xu Xiake adopted the term 'sharp peak'. Guanyin Peak in Yandangshan is an example of this landform. Sharp volcanic peaks are formed by several volcanic eruptions, after which the weathering and collapse of the rocks results in a sharp volcanic peak landform (Fig. 17).

Volcano Volcanoes are mountains with particular structures and shapes that form as a result of the movement of magma through the Earth's crust to the surface, sometimes accompanied by water vapour and ash. The name volcano originates from the Italian 'vul-cano', which was the name of a volcano in the Lipari Islands in the Mediterranean Sea. It was named after the Roman god of fire Vulcan and has become a name for this volcanic landform. Volcanoes can be divided into extinct volcanoes and active volcanoes. Based on the erupted materials and forms, they can be categorised into shield volcanoes, cone volcanoes and layered volcanoes. Volcanoes are important for geological research and are also an important tourism resource. Many tourist attractions around the world are modern or ancient volcanoes, such as the Wudalianchi Global Geopark in Heilongjiang Province, Haikou Shishan



Fig. 17 Sharp volcanic peak landscape – Yandangshan Guanyin Peak, Zhejiang Province

Volcanic Cluster National Geopark in Hainan Province, Mount Vesuvius in Italy, Yellowstone in the USA and Mount Fuji in Japan.

Volcano Holy Landscape, Mount Ngauruhoe This is one of the most famous volcanic landscapes in New Zealand. Mount Ngauruhoe is cone-shaped with a 400-m-diameter crater at the peak. Volcanic activity began more than two million years ago, and it has been active since the 1830s. Every two years, there is vigorous activity, resulting in the formation of secondary volcanic cones in the crater. Local Maoris regard it as a deity and hold ritual ceremonies every year. When the British botanist John C. Bidwill first ascended its summit, the Maoris became very angry, and coincidentally, the volcano erupted for half an hour. In 1887, the Maori donated three volcanoes, including Ngauruhoe, to the government to prevent Europeans from selling them in pieces. In 1894, the New Zealand government officially established the Togariro National Park. The Maoris' faith saved this treasure, and in return, this volcano has silently dedicated itself to demonstrating its capacity of nature and culture (Fig. 18).

Volcanoes and Plate Tectonics The Earth's crust is made up of several plates that collide, and volcanic eruptions are common at the plate edges. For example, molten magma rises due to the movement of the Eurasian Plate, the Philippine Plate and the Pacific Plate, which has led to volcanic eruptions and the formation of volcanic island chains. In addition, in connection with seafloor spreading, magma erupts along mid-ocean ridges.

Volcanoes of Kamchatka, Russia This site is located in Kamchatka Krai on the Kamchatka Peninsula in the Far Eastern Federal District of Russia. After an extension in 2001, the site now covers a core protection area of 38,302 km^2. Due to the numerous active volcanos, diverse types of volcanoes and volcanic phenomena, the site is the most outstanding volcanic area in the world. The site consists of six sequentially designated protected areas and includes the majority of the volcanic features on the Kamchatka Peninsula. The interactions between active volcanoes and glaciers have shaped the spectacular dynamic natural beauty.

Volcano-Tectonic Depression Landscape Based on regional faults and sedimentation, volcano-tectonic depressions are composed of groups of several volcanoes. They are a kind of basin-like volcano cluster that forms due to regional tectonic and volcanic activities. This type of volcano-tectonic depression is present in Tonglu and Xinchang in Zhejiang Province. They have been called volcanic basins in previous studies.

Vredefort Dome, South Africa This site is located in the northwestern part of the Central Free State, South Africa, approximately 120 km southwest of Johannesburg, and it covers a core protection area of 300 km^2. The



Fig. 18 Landscape of Ngauruhoe Volcano

heritage site includes a large part of a meteorite impact structure that dates to 2.023 billion years ago. It is the oldest impact crater to be discovered on the Earth's surface. With a radius of 190 km, it is the largest and most heavily eroded impact crater. The Vredefort Crater witnessed the largest single energy release event on Earth and provides a complete subsurface geological profile of an impact crater.

V-Shaped Valley Landscape A V-shaped valley is a river landscape feature in the early stage of development. In this stage (equivalent to the upper course of a river or a region subject to strong neotectonic uplift), the downward erosion of the river is stronger than its lateral erosion, causing rapid vertical corrasion. As a result, the valley deepens rapidly to form a deep narrow V-shaped valley with steep slopes, accompanied by a riverbed with a steep gradient, rapid flow and the development of thresholds and waterfalls. A typical example in China is the Jinsha River valley along the upper Yangtze River (Changjiang), where the narrowest section in Hutiao (Leaping Tiger) Gorge is only 40–60 m wide, up to 3,000 m, and the slope gradient is up to 70°. V-shaped valleys have different characteristics in different stages of development, so they can be categorised as cliffy gorges, narrow gorges and canyons. V-shaped valleys are important tourism resources.



Fig. 19 Vulcanian-type volcano landscape

Vulcanian Type This is a type of volcanic eruption named after the Vulcano Volcano, which is located near the island of Sicily in the Mediterranean. This type of volcano has viscous magma, and the eruptions are mainly in the form of volcanic explosions. The magma composition is mainly andesitic and rhyolitic. There are seldom lava flows, and when they exist, they are thick and short. The explosions tend to create semi-cooled rock blocks or bread-like volcanic bombs. The

erupted materials range from glasses to clasts, mainly in the form of volcanic ash, and eventually form pyroclastic cones (Fig. 19).

Vulkaneifel Geopark, Germany This geopark is located in northwestern Germany at the transition between the lower land in the north and the hilly terrain in the northwest. It has an area of 1,220 km^2 and has been a member of the Global Geoparks Network since 2004. The Vulkaneifel Highland has gently sloping hills, numerous V-shaped valleys cutting through Devonian sedimentary rocks and nearly 350 eruption centres, indicating that the area has an exciting volcanic past. Several of the volcanoes are known for features from the Earth's upper mantle and stacked masses. The geopark is a typical crater lake district. Seventy-four crater lakes have been discovered; nine are still full of water, whereas the others contain swamps and have dried out or have been eroded, leaving only remains. The most impressive are the three crater lakes that lie along an ancient eruption crevice, which have different water levels. The Pulver crater lake near Gillenfeld Village is round and is a complete crater. It is 1 km in diameter, and the maximum depth is 72 m.

W

W National Park, Niger This park is located in southwestern Niger near the borders with Burkina Faso and Benin, and it has a core protection area of 2,200 km^2. W National Park is located in the transition zone between savannah and tropical forests and demonstrates the important ecological features in the region between the West African woodlands and savannah. The site reflects the interactions between human activity and natural resources since the Neolithic Period and illustrates the evolution of the regional biodiversity structure.

Wadden Sea, Netherlands and Germany This sea is located northeast of the Netherlands and northwest of Germany, and it has a core protection area of 9,683 km^2. The heritage site consists of the Wadden Sea Reserve in the Netherlands and the Wadden Sea National Park in Schleswig-Holstein, Germany. The heritage area accounts for more than 66% of the entire Wadden Sea. It is a relatively flat and temperate coastal wetland. The interaction of several complex geographical and biological factors has led to numerous transitional habitats and tidal channels as well as sandy tidal flats, sea meadows, mussel beds, sandbars, mudflats, salt marshes, and estuaries. The coasts and sand dunes host innumerable animal and plant species, including marine mammals such as harbour seals, grey seals and harbour porpoises. Every year, more than 12 million waterbirds migrate to this area for breeding and wintering. More than 10% of the 29 species of birds call this area home.

Wadi Al-Hitan (Whale Valley), Egypt This site is located in Egypt's Fayoum Province, 80 km west of the capital, Cairo, in the western desert. The unique and dry desert environment preserves the traces of the early evolution of life. The fossils represent an important stage in biological evolution: the evolution of whales from terrestrial animals into mammals that live in the ocean. These palaeontological relics explain this evolutionary process. The fossils vividly display the life forms and lifestyles of the transitional whales. The number of whale fossils, their burial concentration, and their preservation quality are all excellent.

Wadi Rum Protected Area, Jordan This protected area is located in southern Jordan, near the border with Saudi Arabia, and it covers an area of 740 km^2. It was added to the World Heritage List as a natural and cultural heritage site. Its varied landscape of desert features includes a series of gorges, natural arches, cliffs, slopes, large areas of sandstone remnants and caves. Rock paintings, stone carvings, and archaeological remains illustrate the history of human-environment interaction over the past 12,000 years. Approximately 25,000 petroglyphs and 20,000 pieces of stone art trace the development of human thought and the early development of the alphabet. The heritage site shows the historical evolution of pastoralism, agriculture and urban activities in the region.

Wafangdian Diamond Deposit, Liaoning This is China's largest prime diamond deposit. The ore field is located in the southern Liaoning Peninsula. The ore field formed on the concave Fuzhou-Dalian platform on the Sino-Korean para-platform and is composed of 18 kimberlite tubes and 58 kimberlite veins. Three kimberlite tubes in the lower/root part of a volcanic passage are of industrial value. The isotopic ages of the tubes are from 341 million to 463 million years old, and the tubes are from the Caledonian tectonic period. The kimberlite is composed mainly of olivine, phlogopite, almandine, ilmenite and diamond (Fig. 1).

Walter Penck Walter Penck (1888–1923) was a German geomorphologist, geographer and geologist. He was the son of Albrecht Penck, a physical geographer and geomorphologist (1858–1945 AD). He studied at the University of Berlin, University of Heidelberg and Yale University. He was mainly engaged in geomorphology teaching and research, and he

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Fig. 1 Wafangdian diamond mine in Liaoning

considered geomorphology to be an interdisciplinary subject between geography and geology. He published more than 27 works, including 'Morphological Analysis of Landforms'. His ideas about geomorphic evolution were different from the erosion cycle (youth, mature and old stages) theory of W.M. Davis. He considered landforms to be the result of the interaction between tectonic uplift and denudation and a reflection of the nature and processes of crustal movement, where geomorphology provides evidence for understanding the nature and processes of endogenic geological forces. He developed the parallel retreat theory of slopes and proposed the concepts of piedmont ladders and large folds in the formation of landforms and associated deposition. Penck's geomorphology theories and methods are highly regarded by geomorphologists today.

Wanchuan River Landscape, Hainan The Wanchuan River is a famous river in the eastern part of Hainan Island. This river has two sources: (1) the southern source, where the Lehui Stream starts on the southern ridge at Linbei Village on Wuzhi Mountain and flows for 109 km; and (2) the northern source, which is the Dingan Stream that starts to the south of Limu Ridge, converges at Hekouzui in Qionghai City (now called the Wanquan River) and enters the South China Sea at Boao Harbour via Jiaji with a total length of approximately 163 km. This river is a tropical river in a beautiful ecological environment that is unaffected by pollution, and it has been called China's 'Amazon River'. Its estuary is known for the spectacular scenery of three rivers (Waquan River, Longgun River and Jiuqu River), three islands (Dongyu Island, Shapo Island and Yuanyang Island), two harbours (Boao Harbour and Tanmen Harbour) and one rock (Sheng Gong Rock in the middle of the river), and it is characterised by ocean water, sand beaches, red reefs and woodlands with bright sunshine, fresh air and clear streams. It is one of the best protected natural estuaries in the world (Fig. 2).

Wangwushan National Geopark, Henan See ► Wangwushan-Daimeishan Global Geopark, China.

Wangwushan-Daimeishan Global Geopark, China This geopark is located west of Jiyuan City and north of Xin'an County. The geopark has an area of 986 km^2, and it became a global geopark in 2006. The park has five scenic areas, namely, Wangwushan and Xiaolangdi, including Tiantan Mountain, Xiaolangdi, Wulongkou, the Three Gorges of the Yellow River, and Xiaogoubei. It is a landscape with typical geological sections and landscapes as well as ecological and cultural landscapes. The geological features include (1) Wangwu Mountain, the Yellow River Valley and Emei



Fig. 2 Wanchuan River Landscape, Hainan

Mountain, which has a magnificent landscape of mountains and rivers; (2) Taiguyu and Yuanguyu, which contain Palaeozoic, Mesozoic and Cenozoic strata and several named stratigraphic profiles; (3) evidence of the Precambrian Zhongti movement, Wangwushan movement and other geological events that illustrate the geological evolution of northern China and other parts of the world; (4) the Jiyuan Basin, which formed an integral part of the Ordos Basin in the Mesozoic and contains diverse types of lacustrine deposits with abundant fossils; and (5) the Cenozoic Yellow River in Baligye and Sanmenxia, which illustrate the formation of the Yellow River and human development.

Wanshan Mercury Mine, Tongren, Guizhou This is a world-class mercury mine located in eastern Guizhou Province near the Hunan-Guizhou border. The ore bodies lie in the Middle and Lower Cambrian limestone strata and are composed of numerous layers with high continuity. The Wanshan mercury mine is composed of five large-scale ore deposits, including the Shanmudong mega-scale mercury mine, the Zhangjiawan mercury mine, and 15 small- to medium-scale ore fields. Due to its large reserves, the mine has become the world-famous 'Mercury Capital'. From the Ming and Qing Dynasties until the establishment of the Republic of China, this mine was the major mercury mining area in Guizhou Province. According to legends, mining occurred here during the Warring States period. It is now a national mining park (Fig. 3).

Wanshan Mercury National Mining Park, Guizhou This park is located in eastern Guizhou Province. Wanshan Mercury National Mining Park was the largest natural cinnabar producing area in the world. Today, it is the largest mineral production base in China and contains the remains of a world-renowned mercury mine. It became a national mining



Fig. 3 Wanshan mercury mine

park in 2005. Wanshan is known as 'China's mercury capital' because it has a profound history of exploitation and because its abundant mining cultural landscapes have been preserved. The mine parks are rich in mining relics and have different landscape types. The main features include the 970-km-long underground tunnel, the goaf that covers 3.75 km^2 and groups of ancient caves on steep cliffs.

Wansheng National Geopark, Chongqing Wansheng National Geopark is located in Wansheng District, Municipality of Chongqing. It became a national geopark in 2009. It contains a stone forest composed of Middle Ordovician jointed limestone, gorges and water landscapes. Karst landforms are the main geological features of the geopark. It contains stone forests, clints, dissolution basins, dolines, sinkholes, karst valleys, underground rivers, and karst caves. The canyon landforms are mainly located in the Black Valley Scenic Area. The water landscapes consist of rivers, such as the Liyuhe River and Liujiahe River, well-developed springs and waterfalls. Sinoceras are the main fossils. The tectonic features include the regional geological structure, local joint structures, or combinations of the two.

Warm Current Warm currents usually originate from tropical and subtropical seas and have temperatures higher than that of the nearby seawater. The seawater is clearer with a slight blue colour. The salinity is also higher than that of the surrounding water; however, the oxygen, silicate and phosphate levels are lower. Warm currents have substantial impacts on the climate of the coastal regions they flow past.

Warm Swamp Landscape This is a type of swamp landscape comprising swamps formed by the saturation of geothermal water on the ground surface or by poor drainage in low-lying hot spring areas. Warm swamps are common in relatively open areas with geothermal activity. The swamps can cover areas from several hundreds to tens of thousands of square metres. The water temperature is mainly 15–20 °C with higher temperatures around the spring mouths. The swamp margins are 10–30 cm deep and have lush algae (Fig. 4).

Water Drop Quartz Water drop quartz is actually an agate that contains water. The bigger the cavity with trapped water is, the higher the quality is. It is a common craft material, and some are precious ornamental stones.

Water Law of the People's Republic of China This law was revised and passed in August 2002 during the 29th meeting of the Standing Committee of the Ninth National People's Congress (NPC) and went into force on 1 October 2002. The details of the law are outlined in eight chapters: Chapter I, General Provisions; Chapter II, Water Resources Planning; Chapter III, Water Resources Development and Utilisation; Chapter IV, Protection of Water Resources, Waters and Water Projects; Chapter V, Water Resources Allocation and



Fig. 4 Warm Swamp Landscape

Conservation; Chapter 6, Water Dispute Handling and Law Enforcement Supervision and Inspection; Chapter VII, Legal Responsibility; and Chapter VIII, Supplementary Provisions. The law stipulates the development, utilisation, conservation, protection, prevention and control of water hazards, and functions of water resources. There are guidelines for urban and rural residents to properly utilise water and prevent wastage.

Water Pollution The pollutants in water include suspended solids, dissolved substances, sediments, and aquatic organisms. Water pollution occurs when a certain amount of sewage, wastewater, and various pollutants enter a water body and exceeds its natural self-purification capacity, resulting in degradations of the physical and chemical properties of the water. The water body may have a high sediment content or a poor bio-community composition. These changes destroy the functions of the natural ecosystem and decrease the value of the water.

Water Quality Water quality is determined by its physical (e.g., colour, turbidity, and odour), chemical (e.g., inorganic and organic contents) and biological (e.g., bacteria, microorganisms, plankton, and benthos) properties. Studies include the background values of natural water and suspended matter in river belts as well as the content and composition of pollutants and their temporal and spatial variations. A series of water quality parameters and water quality standards for drinking, industrial and fishery waters have been defined to evaluate water quality.

Water Source Protection Water source protection includes various engineering and non-engineering measures adopted to prevent the pollution of water sources, mainly including the implementation of legislation, designation of water source protection areas, the formulation of ecosystem protection plans for areas surrounding upstream areas and water sources, and the execution of ecological engineering and other protective measures, such as water purification through wetlands.

Water Stone This is also called water-absorbing stone and is an ornamental stone with a strong water absorption capacity. It is travertine that is mainly composed of calcium carbonate with an age of a few decades to thousands of years; the larger the size is, the longer the period of formation. It forms from limestone that is dissolved in water, forming an over-saturated carbonate solution that then precipitates through physical and chemical action, and the water then rises due to capillary action. Water

stones can be divided into sand-deposited stones and calc-sinter. Sand-deposited stones are a mixture of algae, weeds and trees with sand and mud that form by geologic action. Travertine stones are calc-sinter accumulations that sometimes contain moss and worm fossils. They are usually yellow, brown or white with beautiful shapes and hard textures. They also have tubular, hollow or striped patterns and can be used as bonsai rocks to hold moisture. Water stones can be found everywhere in China, but those from Beijing, Shandong, Hunan, Shanxi and Hebei Provinces have the highest quality (Fig. 5).



Fig. 5 Water stone (a type of travertine)

Water System *Synonym:* ▶ *Drainage*

The term water system refers to all surface water flows in a system, including all of the main rivers, tributaries of all levels and lakes connected to these rivers in a river basin. In map view, the geometric form of a water system can be dendritic, parallel, lattice, annular, radial or convergent. A water system is closely related to the regional geological structure and geomorphic conditions. Rivers that develop in areas of subsidence tend to have a convergent form. Rivers in dome-shaped uplifted areas tend to have radial patterns. A water system in an active fault zone tends to have a lattice pattern with right-angle bends. Parallel water systems usually develop in steeply dipping areas, whereas rivers that develop in karst regions tend to have a dotted stars pattern (Fig. 6).

Waterfall A waterfall is a rapid stream that flows down from a cliff or a steep ridge due to an abrupt change in the slope of the riverbed. The water falls to form a waterfall, usually along the fissure of a riverbed. Waterfalls generally consist of water curtains and the deep pools below them. Waterfalls in China are mainly distributed in the vast areas south of the Qinling-Huaihe line, especially in the Zhegan Mountains, the Yungui Plateau and the Himalayas. Based on their hydrological

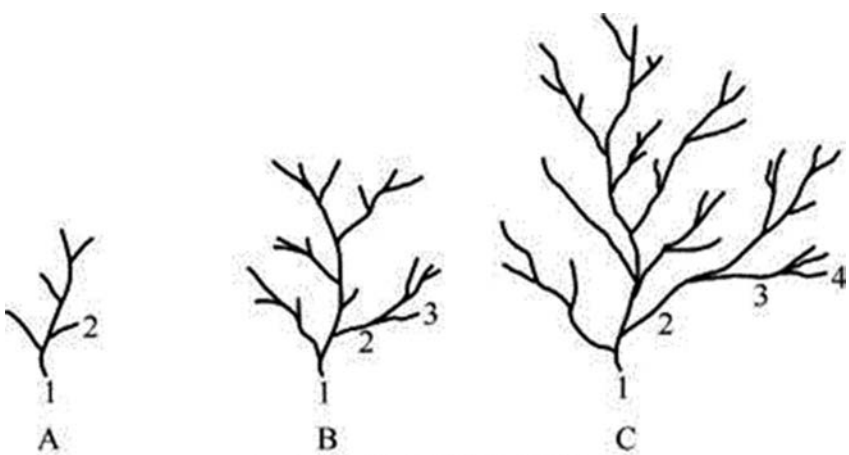


Fig. 6 River system development. (**a**, **b** and **c**) indicate stages of development. Main course; 2. tertiary tributary; 3. secondary tributary; 4. primary tributary

characteristics, waterfalls can be divided into perennial waterfalls, seasonal waterfalls and sporadic waterfalls. According to the formation mode, they can be divided into structural waterfalls, plug-type waterfalls, captured waterfalls, differential erosion waterfalls, karst waterfalls and glacial waterfalls.

Waterfall Tourism Landscape This is a landscape of waterfalls with tourism value. Based on their location, waterfalls can be classified as (1) main river tributary waterfalls, (2) mountain waterfalls and (3) underground waterfalls. Waterfalls can also be classified based on their formation process as (1) karst waterfall landscapes, such as Huangguoshu Waterfall in Guizhou Province and Detian Waterfall in Guangxi Province; (2) structural waterfall landscapes, which form when water erodes into rock layers of different hardnesses as a result of tectonic movements, and a hard rock layer forms the waterfall layer; for example, the Hukou Waterfall on the Huanghe is located on a hard and thick layer of Triassic sandstone, which reduced the river's width from 250 m to 50 m and formed a drop of 34 m, creating a grand waterfall; (3) volcanic lava waterfalls, which form due to blockage of a river channel by a volcanic eruption or lava flow, such as the Tianchi Waterfall on Changbai Mountain, Jilin Province, and the Jingpohu Waterfall in Heilongjiang Province; and (4) landslide, debris flow and glacial waterfalls, which are formed by blockage of a river channel by materials deposited due to exogenic geological processes; an example is the Diexi Waterfall in Sichuan, which formed by damming of the river after an earthquake.

Watershed It is an area that feeds all the water running under it and draining off of it into a body of water. It may integrate other watersheds to form a network of rivers and streams and progressively drain into larger water areas. Topography determines where and how water flows. Ridge tops surrounding a body of water determine the boundary of a watershed. Watershed can be categorised into symmetrical and asymmetric forms. The dividing line of a symmetrical watershed is located at the centre of the watershed, and the slope gradients and lengths on both sides are identical. The dividing line of an asymmetrical watershed is skewed towards one side, and the two slopes are not symmetrical. Symmetrical watersheds are very rare, and most watersheds are asymmetrical.

Waterton Glacier International Peace Park, Canada and the U.S.A. This park is located along the border between the Province of Alberta, Canada, and Montana in the U.S., and it has a core protection area of 4,576 km^2. The park, which was formed by the union of Waterton Lakes National Park in Canada and Glacier National Park in the United States in 1932, is a predecessor of successful modern international cooperation in nature conservation and a classic example of the concept that 'interests transcend borders'. The natural scenery also provides a sanctuary for rich flora and a variety of mammals. Its grasslands, forests, high mountains and glaciers are especially attractive.

Water-Well Tourism Landscape Wells are engineering structures developed by humans to use groundwater. Many famous tourism areas have wells as sightseeing features. An example is the 'Bitter and Sweet Wells next to Baiyun Hall', one of the 18 scenes of the North Peak of Hengshan. These two wells are near each other, but the water from one is sweet, while the water from the other is bitter. In addition, the 'Imperial Concubine Zhen Well' in Beijing's Imperial Palace is associated with a tragic historical event. Other tourism sites are the 'Jiu Jing (Nine Wells)' at the scenic site 'Jiu Tan-Jiu Chi-Jiu Jing-Er Si Wu Wan (Nine Ponds Nine Pools Nine Wells and Twenty-five Bends)' in the South Peak Hengshan tourism zone.

Wave-Built Platform Landscape This is a landscape comprising platform-like landforms formed by marine erosion and deposition. During their formation, marine erosion first creates rock fragments in the bedrock of the coast, which are transported by waves and deposited at the slope edge to form a wave-built platform.

This can be considered a type of underwater depositional terrace.

Wave-Cut Cliff Landscape This is a landscape consisting of steep cliffs on a rocky coast carved by marine erosion and gravitational collapse along joints or bedding. The formation process is as follows. The slope near the shore is steep and is subject to wave action. Waves carrying debris and gravels wash against the slope, scouring and eroding the cliff surface and forming wave-cut notches at the cliff base. Through repeated wave action, the notches expand inwards, and the upper rock eventually collapses, forming a steep cliff. This process continues and results in further retreat of the coast. Before the collapsed debris at the wave-cut cliff base is washed away by waves, it can protect the coast from waves for a certain period of time. However, when the debris is moved away by waves, coastal erosional resumes. However, following the widening of the wave-cut platform and building up of accumulated debris in the water, the wave action is restricted, and, the cliff recession rate decreases or even stops. Many bedrock coasts in northern China have a wave-cut cliff landscape (Fig. 7).

Wavy Flow Mark Landscape This is a landscape composed of wave-like concave depressions on karst cave walls (mainly near the cave mouth) that are formed by dissolution and erosion by turbulent water. These flow marks are often in clusters. Their longitudinal profile is asymmetrical with a long and gentle profile against the waterflow but a short and steep profile in the waterflow direction. The current flow direction can be determined based on the principle that the arc-shaped ridge line always points upstream. Therefore, a wavy flow mark is also called a directional flow mark. Wavy flow marks can be characterised by their wavy pattern, such as the wavelength, wave height and wave width. The wavelength is the crucial element and can range from 1–2 cm to more than 1 m. The wavelength is inversely proportional to the water flow rate. The flow velocity can be calculated from the wavelength, viscosity coefficient and water temperature. For example, in the cave of the Guilin karst peak forest plain, the flow marks range from 30 to 50 cm long; hence, the flow rate during formation is estimated to have been 4–10 cm/s (Fig. 8).

Wavy Lava Landscape See ▶ Pahoehoe.

Weathering in Landscape Formation Weathering is a fundamental geological process that shapes landforms. It can be classified into chemical weathering, physical weathering and biological weathering, and all are related to the in situ breakdown of minerals



Fig. 7 Wave-cut cliff landscape in Changdao, Shandong Province



Fig. 8 Ripple marks – Seventy-Two Forks Cave, Wulong, Chongqing

and rock masses. Weathering is an important factor in sculpting natural landforms, such as the egg-shape granitic landforms formed by spheroidal weathering.

Weihai Jinzhou National Mining Park, Shandong This park is located in Xiachu Town, Rushan City, Weihai City, Shandong Province, and it covers an area of 2.7 km^2. It was designated as one of the second group of national mining parks by the Ministry of Land and Resources in May 2010. The park is situated in the central part of the Muping-Rushan metallogenic belt and is an ore field with moderate- and low-temperature hydrothermal quartz vein filling gold ore. The Jinzhou Gold Ore Area is the main part of the park, and it features remnants of mining geology, mining activity, mining disasters and geological landforms. It integrates information about gold, sightseeing and tourism, scientific research, science popularisation education, and leisure and recreation.

Weihan Yin Weihan Yin (1911–2000) was a native of Nanjing City, Jiangsu Province. In 1933, he graduated from the Department of Geology, Nanjing National Central University. He had served in the Economics Department of the Nanjing National Government, the Department of Geology at Nanjing Central University, and the Mineral Resources Survey Office of the Resources Committee. After the founding of the People's Republic of China, he worked at Nanjing Geological Exploration Technical College, Anhui Mount Tongguan Copper Exploration Team (Head), Nanjing Geological College, Beijing Geological College, and Geological Press (Deputy Chief Editor). In the early days of the PRC, he compiled 'Mineral Petrology' and 'Crystal Mineralogy and Petrology', which became important textbooks for geological universities at that time. He was one of the geologists who pioneered earth science popularisation. He edited 'Popularising Geology in Simple Language', 'Popularising Ore Deposit Studies in Simple Language', and 'Earthquake Q&A'. He was the scientific adviser to the China Tourism Earth Science Research Institute. Starting in 1980, he edited the 'China Famous Landscape Series'. He was one of the pioneers in the study of tourism earth science and played an important role in the development of the discipline in China.

Weishan Lake Landscape Weishan Lake is also known as Nansi (South Four) Lake and is composed of four interconnected lakes: Weishan Lake, Zhaoyang Lake, Nanyang Lake and Dushan Lake. It is located on the

boundary between Shandong and Jiangsu Provinces. This lake system is 120 km long and has a maximum east-west width of 25 km. The lake surface covers 1,266 km^2, which makes it the largest freshwater lake in northern China. The lake contains scenic locations, such as Weishan Island and the old Nanyang town. Weishan Island is the largest island in Weishan Lake and has an area of approximately 9 km^2. The island has the tombs for three sages, Weizi, Muyi and Zhangliang, which are important cultural relics. During the anti-Japanese war, Weishan Lake was a base for the revolutionary armed forces Weishan troop, the canal brigade and the railway guerrillas' troop, who had many heroic achievements and left behind many stories, including the popular song 'Playing My Beloved Crude Pipa' (Fig. 9).

Weizhou Island Volcano Landscape This is a volcanic landscape on Weizhou Island in the Beibu Gulf south of Beihai City, Guangxi Province. This island is composed of volcanic rocks, including volcanoes composed of erupted magma and low flat volcanoes that was formed by phreatomagmatic eruptions. One of the low flat phreatomagmatic craters has been submerged by seawater, but the tuff ring wall is still clearly exposed. The profile of the basal surge tuff at the volcano's base shows typical cross-bedding, wavy bedding, rockfall subsidence structures and syndepositional slump structures. There are also abundant marine erosion features, such as sea caves, sea cliffs, wave-cut channels, wave-cut platforms, sand beaches, rock embankments and terraces. The stacks are the result of the marine erosion of basalt blocks that fell onto the basal surge tuff during the eruption. These basalt blocks sit on the tuff and look like stacks or discs (Fig. 10).

Welded Tuff ▶ Ignimbrite

Wenchuan Earthquake Relics Landscape At 14:28:04 on 12 May 2008, a magnitude 8 earthquake occurred in Wenchuan County, Sichuan Province. The epicentre was located in Yingxiu Town. The Wenchuan earthquake was the third strongest recorded earthquake in China after the magnitude 8.5 earthquake in Motuo, Tibet, on 15 August 1950 and the Kunlun Mountain earthquake (magnitude 8.1) in 2001. An area of approximately 100,000 km^2 was seriously affected, causing severe damage to many roads, building collapses, rockfalls, landslides, mudflows and the formation of numerous



Fig. 9 Weishan Lake landscape



Fig. 10 A crater submerged in water on Weizhou Island



Fig. 11 Wenchuan earthquake relics landscape

earthquake-dammed lakes. The Tangjiashan Earthquake Lake was the largest dammed lake in Wenchuan after the earthquake, with a volume of 145 million cubic metres (Fig. 11).

Weng'an Biota Fossils of this biota are mainly distributed in phosphorite rocks in the late Neo-Proterozoic Duoshantuo Formation in the Weng An area, Guizhou Province. The fossils include multicellular algae with a 3-D cell structure and embryos of early animals. The embryo fossils of early animals are made up of cells at the stage of cell division, which is characteristic of early cleavage. This may also represent bilaterally symmetrical invertebrates. The Weng'an biota have provided substantial fossil evidence for studying the early evolution of multicellular organisms.

Wenling Changyudongtian National Mining Park, Zhejiang This park is located in Xinhe Town to the northeast of Wenling

City, Zhejiang Province, and covers an area of 10.09 km^2. It became a national mining park in 2010. The park consists of more than 300 open pits dating back to the Qing Dynasty or earlier. It has more than 1,000 modern underground mining chambers. The mining heritage can be categorised into four major types: mining production, mining activities, mining products and non-material mining activities. There are numerous mining activity features and mining product remains, ranging from 100 to 1,000 pieces, as well as 34 mining production and mining activity heritage sites.

Wensu Yanqiu Geopark, Xinjiang This geopark is located in the southern foothills of the central Tian Shan on the northwestern margin of the Tarim Basin. It became a national geopark in 2011. Its geological heritage can be classified into five major categories, eight categories and 13 sub-categories. The salt diapirs are unique to China and the world. The Aqikekule salt dome, which covers an area of approximately 16 km^2, is a typical salt dome with a height of 500 m, and it is the largest salt dome in China. The salt domes in the park have high scientific and ornamental value. Their types and scales have international significance.

West Lake Landscape in Hangzhou West Lake was previously known as Qiantang Lake, and it is also called Xizi Lake. It is located to the west of Hangzhou City, Zhejiang Province. It is famous for its lake and hill scenery and numerous famous cultural relics. It is a famous scenic attraction for tourists and has long been considered the 'Paradise on Earth'. It has an area of 5.6 km^2 and a volume of 110 million m^3. The average water depth is 1.97 m. The lake is divided into five parts by Sudi (Su Dyke) and Baidi (Bai Dyke), including the Inner Lake, Outer Lake, Yue Lake, West Inner Lake and Xiaonan (Little South) Lake. In 1982, West Lake was accredited as a 'National Scenic Area', and in 1985, it was selected as one of 'China's Top Ten Scenic Areas'. In 2011, it was included on the list of World Cultural Heritage (Fig. 12).

West Norwegian Fjords-Geirangerfjord, Norway This site is located in southwestern Norway, near the Atlantic coast northeast of Bergen. The two fjords are 120 km apart. The site extends for 500 km from Stavanger in the south to Andalsnes in the northeast. The fjords are two of the longest and deepest in the world, and their natural beauty is first-class. The site is the where the fjord landscape was first described.



Fig. 12 West Lake landscape in Hangzhou

Western Caucasus, Russia This site is located in Krasnodar Kraiin the Caucasus region of Russia, near Georgia, 50 km northeast of the Black Sea. It has a core protection area of 2,989 km^2. The Western Caucasus Mountain Reserve is one of the last large mountains in Europe that has not been significantly affected by humans. The sub-alpine and alpine meadow areas are foraging places for wild animals. The undisturbed mountain forests extend from the lowlands to the high subtropical mountains and are a unique natural landscape in Europe. The heritage site has an extremely diverse ecosystem structure that nourishes the important local flora and fauna and is the birthplace and re-introduction area of the European mountain bison.

Western Ghats, India The main part of the Western Ghats Mountain Range is located within the territory of Karnataka, India. The mountains are older than the Himalayas and exhibit unique geomorphological, biological and ecological processes. Its forest ecosystem influences the monsoon climate in India; it mitigates the local climate and is one of the best examples of a monsoon system on Earth. The biodiversity of the heritage site is extremely high, and it contains numerous endemic species. It is considered one of the top eight biodiversity areas in the world. The forests within the site, comprising some of the finest examples of non-equatorial tropical evergreen forests in the world, are home to at least 325 species of globally endangered plants, animals, birds, amphibians, reptiles, and fish.

Western Mountain Huashan This is one of China's Wuyue (Five Peaks) and is also known as Taihuashan. It is located in southern Huayin City, Shaanxi Province, in the eastern Qinling Mountains. It is a fault-block mountain composed of Yanshan granite and includes five peaks: East (Chaoyang), West (Lotus), South (Falling Geese), North (Yuntai) and Middle (Young Lady). The South Peak has an elevation of 2,154.9 m and is the highest peak. The Weihe Plain lies to the north, and the relative height difference is more than 1,500 m. The mountain walls are steep and arduous. Huashan has long been a Taoist holy site, and the locals believed that the creator of Taoism, Laozi (Li Er), visited the mountain. There are numerous Taoist temples on the mountain, such as the famous Yuquan (Jade Spring) Court. Many past literati, such as Li Bai, Du Fu, Cui Hao, Han Yu and Jia Dao, visited and left many famous descriptive writings and stone carvings about this mountain.

Wet Tropics of Queensland, Australia This site, which is a strip of land stretching some 450 km along the Coral Sea in the Pacific Ocean off Queensland in northeastern Australia, covers a core protection area of 8,944 km^2. Its tropical rainforests are home to a particularly extensive and varied array of plants, marsupials, singing birds, and other rare and endangered animals and plant species.

Wetland A wetland is a unique ecosystem of interacting water and land areas, including all natural and artificial seasonal and perennial water areas, swamps, peatlands, wet meadows, lakes, rivers, floodplains, estuaries, deltas, tidal flats, coral reefs, mangroves, reservoirs, ponds, paddy fields and other coastal zones with water depths less than 6 m at low tide. Wetlands account for 6% of the global surface area and play an important role in maintaining the ecological balance, maintaining biodiversity and rare species, conserving water resources, storing flood water, preventing droughts, regulating climate, and supplementing groundwater.

Wetland Ecological Landscape This is a kind of ecological landscape in waterlogged areas, lake shores, riverfronts and coastal areas in half wet and half dry conditions. Wetland landscapes mainly include water body landscapes, aquatic plant landscapes and wetland fauna landscapes (including fish, birds, mammals, reptiles, amphibians, insects and invertebrates). Wetlands are widely distributed in China from the cold temperate zone to the tropics, from the coast to the inland regions, and from the plains to the plateaus and mountainous areas. There is often a variety of wetland types in a single region, and a single type of wetland can exist in several regions.

Wetland Park Wetland parks are a type of geopark. They are specific areas with natural (or human-made) marshes, floodplains, peatlands or marine areas no deeper than 6 m at low tide that are used to for ecological protection and restoration, ecotourism, sightseeing, vacations, science popularisation and scientific research. In China, the Shangdong Yellow River Delta National Geopark and Shanghai Chongming Yangtze River Delta National Geopark are wetland geoparks under the management of the Ministry of Land and Resources. The Ministry of Construction manages urban wetland parks, while the State Forestry Administration and the Ministry of Agriculture manage their respective wetland parks. The Ramsar Convention was an international convention on wetlands. China has 36 wetlands, including the Zhalong Nature Reserve, listed in the List of Wetlands of International Importance (Ramsar sites).

Wetland Tourism Landscape This is a landscape with tourism value in a wetland. Wetlands are important ecosystems. They are the transition zones between terrestrial ecosystems and aquatic ecosystems. In the 'Convention of Wetlands of International Importance', wetlands are defined as natural, artificial, permanent or temporary swamps, peatlands or water areas with static or flowing fresh or brackish water, including areas where the water depth does not exceed 6 m at low tide. Wetlands are closely related to humans and have been called 'the cradle of life', 'kidney of the Earth' and 'bird's paradise'. They can withstand flooding, regulate runoff, control pollution, modify the climate and beautify the landscape. Wetlands are important tourism resources. China has built many national wetland nature reserves and a wetland park. Shanghai has also set up a wetland geopark on Chongming Island.

Whale Sanctuary of El Vizcaino, Mexico This sanctuary is located in the central part of the peninsula of Baja California and the northwestern corner of Baja California Sur, and it covers a core protected area of 3,709 km^2. The sanctuary contains several exceptionally interesting ecosystems. The coastal lagoons of Ojo de Liebre and San Ignacio are important reproduction and wintering sites for grey whales, harbour seals, California sea lions, northern elephant seals and blue whales. The lagoons are also home to four species of the endangered marine turtle.

Whaleback Landscape This is a glacial erosional landscape similar to the morphology of a roche moutonnee. A whaleback stone is characterised by an elongated oval shape and consistent orientation with the long axis parallel to the glacier's flow. In contrast to a roche moutonnee, the slopes on both sides have similar gradients, which indicates that during the formation process, glacial abrasion was dominant, and plucking was insignificant.

White Jade The so-called white jade is a white nephrite that is also known as suet jade. It is a top-grade jade, but its white hue varies, and it can be categorised into suet white, pear flower white, ivory white, paraffin white, fish bone white and moon white. The suet white jade is particularly pure, sleek and clean like suet. The suet jade has only been found in Xinjiang Province, and it is very rare; therefore, it is most valuable and is regarded as a top-grade gemstone. The other types of white jade are lower quality. Some white jade contains impurities on their outer parts, which form shells of different colours when oxidised. They have different characteristics and names, such as 'autumn pear jade', 'tiger skin jade' and 'jujube jade', and they are all famous varieties. Like Hetian jade, white jade is also mined at Altun Mountain and in Qinghai Province; the latter is known as Qinghai White Jade (Fig. 13).

White Stone See ▶ Opal (Fig. 14).

Wild Plant Protection Regulations These regulations were promulgated by Order No. 204 of the State Council in 1996 and came into force on 1 January 1997. They are listed clearly in five chapters: Chapter I, General Provisions; Chapter II, Wild Plant Protection; Chapter III, Wild Plant Management; Chapter IV, Legal



Fig. 13 White jade



Fig. 14 Opal

Liability; and Chapter V, Supplementary Provisions. Under these regulations, protected wild plants are classified as first-class and second-class protected wild plants, and nature reserves are set up to protect these wild plant species.

Wildlife Habitat Wildlife habitat is a typical or seasonal living environment suitable for animals to survive in the wild under the available food and shelter conditions. The five major ecosystems, including forests, wetlands, grasslands, deserts and oceans, provide habitats for wildlife to live, migrate, rest, and reproduce. They have suitable conditions, such as climate, water, and food, to sustainably support animal survival. Habitats can also be classified based on the ecological groups of wild animals, such as terrestrial animal habitats, aquatic animal habitats, bird habitats, and butterfly habitats. They are important sites for tourists, such as the Dali Butterfly Spring in Yunnan Province.

Wildlife Nature Reserve Tourism This refers to wildlife nature reserves that are open to tourists. The reserves can be managed either under a comprehensive protection zone, which protects all types of animals living within the

zone, or a single animal community protection zone. The Nairobi Wildlife Conservation Area in Kenya, which has a radius of 200 km, is an example of a comprehensive protection zone that protects all of the animals living in the tropical grassland. Tourists in cars can observe the daily lives of the wildlife. China's Wolong Panda Natural Reserve in Sichuan, the Salamander Nature Reserve in Jing'an County in Jiangxi and the Long Leg Black Gibbons Nature Reserve in Bawangling in Changjiang County, Hainan, are single animal community protection zones.

Wildlife Protection Law of the People's Republic of China This law was passed at the 4th meeting of the Seventh National People's Congress (NPC) Standing Committee in 1988 and was implemented in 1989. Amendments were made at the Eleventh NPC Standing Committee in 2004. The law contains: Chapter I, General Provisions; Chapter II, Wildlife Conservation; Chapter III, Wildlife Management; Chapter IV, Legal Responsibilities; and Chapter V, Supplementary Provisions. The law stipulates that wildlife under special state protection should be divided into first and second classes and that natural reserves should be designated, strongly protected and managed in areas and waters where wildlife mainly breeds.

Wildlife Tourism This refers to watching and appreciating wildlife. The natural movements, postures, sounds, shapes and colours of animals are aesthetically appealing. These sites can involve activities such as sightseeing, fishing, hunting, nature games and scientific studies. Wildlife landscapes include all types of animals, from penguins, seals and polar bears at the poles to hippopotami and giraffes in equatorial Africa, the Tibetan antelopes in the Qinhai Tibetan Plateau, the pandas in Wolong, Sichuan, the snakes on Snake Island in Dalian and the monkeys of Monkey Mountain in Hainan. These animals form an attractive wildlife landscape tourism resource system.

Willandra Lakes Region, Australia This region is located in southwestern New South Wales, Australia, and has an area of 2,400 km^2. Pleistocene fossils can be found in the lakes and sand dunes. In addition, human sites from 45,000 to 60,000 years ago have been found, which have become unique sites for the study of human evolution on the Australian continent.

William Morris Davis William Morris Davis (1850–1934) was an American geographer, geologist, geomorphologist and meteorologist. He was the one of the earliest American geographers. He graduated from Harvard University in 1869. He also served as a professor at Harvard University, president of the Geological Society of America, professor at California Polytechnic Institute and visiting professor at the University of Berlin, Germany. He applied the genesis viewpoint to explain the formation and development of geomorphology and developed the geographic cycle theory and three stages of river development from youth, maturity to old age, which was called Davisian cycle of erosion theory. His published works include 'Elementary Meteorology', 'Geographical Essays', 'The Coral-Reef Problem', 'Physical Geography', 'Interpretation and Description of Geomorphology', and 'Principles of Modern Physical Geography'.

Wind Erosion – Type Granite Landscape – Guaishigou Type Granite in a dry desert area is subjected to weathering and disintegration caused by thermal expansion and contraction of the rocks as a result of the extreme diurnal temperature variations in the hot dry weather. Powerful wind erodes weak points along joints and carries away the eroded materials. Sand carried by the wind also abrades the rock surface and eventually carves the granite surface on the windward side to become irregular and uneven. Honeycomb-shaped caves of varying forms and mushroom-like features are typical of this landscape. The Bortala Guaishigou Scenic Area in Xinjiang Province and Alxa Global Geopark in Inner Mongolia are typical examples.

Wind-Abraded Geological Action in Landscape Formation Wind is a strong force that can erode and move material from one place to another, shaping various

landforms. In arid regions, wind and the materials carried by wind can create spectacular landforms by erosion, abrasion, transportation and deposition. Yardangs are landforms formed by erosion and abrasion by strong wind in a constant direction. Wind can also create depositional landforms, such as different types of sand dunes. Fine dust can be blown by strong dust storms to high altitudes, transported long distances and then deposited, forming loess layers.

Wind-Erosion Lake Landscape This is a lake landscape in an arid region formed by wind-erosion depressions or depressions between sand dunes that are filled with water. The water can come from rivers or groundwater when the ground surface is eroded deep enough to reach an aquifer. This type of lake is relatively shallow and tends to be intermittent and mobile. The Yueya (Crescent) Lake in Dunhuang, Gansu Province, is a typical wind-erosion lake. It formed from wind erosion of a depression between sand dunes that reached the water table, and groundwater is the main source of water. As such, this lake is a permanent lake filled with water for the entire year, and there is minimal change in the water level. The lake is 455 m long and 65 m wide with a north-south crescent shape, which is where its name originated.

Wind-Erosion Lake Tourism Landscape In dry regions, a lake can form when water fills a depression carved by wind erosion or a depression in a lowland surrounded by sand dunes. The water can be supplied from a river or through groundwater recharge. Most of these lakes are intermittent lakes or wandering lakes, such Lop Nur in Xinjiang Province, Juyanhai in Inner Mongolia and the Crescent Moon Spring in Dunhuang, Gansu Province.

Window ► Fenster

Wolframite Wolframite contains (Fe, Mn) WO_4 and is a transition mineral of the ferberite-huebnerite ore series. It has a monoclinic structure, and the crystals appear as columnar or blocky aggregates. Crystal twinning is common. It is brownish black with reddish brown to black streaks, translucent to opaque diaphaneity, a sub-metallic lustre, a specific gravity of 7.1–7.5, a Mohs hardness of 4–4.5, and uneven fractures. It usually forms in quartz veins of granitic pegmatite and is often associated with cassiterite and arsenopyrite.

Wood Buffalo National Park, Canada This park is located in the borderland south of the northern and northwestern regions of Alberta Province, Canada, and it covers an area of 44,807 km^2. It is the largest national park in Canada and is home to North America's largest population of wild bison. It is also the natural nesting place of the whooping crane. Another of the park's attractions is the world's largest inland delta, which is located at the mouth of the Peace and Athabasca rivers.

World Cultural Heritage In accordance with the World Heritage Convention, world cultural heritage, which is "of outstanding universal value, in line with the principles of authenticity and integrity, and under the management framework of effective protection, refers to the cultural heritage inscribed on the World Heritage List after being nominated by state parties to the Convention, inspected and reviewed by experts from ICOMOS (International Council on Monuments and Sites) specially invited by UNESCO, and finally approved by voting of the World Heritage Committee at its annual session". Article 1 of the World Heritage Convention classifies cultural heritage into monuments, groups of buildings and sites.

World Heritage In accordance with the World Heritage Convention, world heritage is "of outstanding universal value, in line with the principles of authenticity and integrity, and under the management framework of effective protection, refers to natural heritage or cultural heritage inscribed on the World Heritage List after being nominated by state parties to the Convention, inspected and reviewed by special experts from the United Nations Educational, Scientific and Cultural Organization (UNESCO) and finally approved by voting of the World Heritage Committee at its annual session". In theory, world heritage sites that transcend regions,

nations and national boundaries are common heritage that belongs to all mankind in the past, present and in the future; in operation and practise, the legal status and national sovereignty of the countries in which the heritage is located are fully respected.

World Heritage Convention The World Heritage Convention is the simplified name of the 'Convention Concerning the Protection of the World Cultural and Natural Heritage'. To enable all heritage around the world to be appropriately identified, protected, conserved and presented, the World Heritage Convention was approved in 1972 by the General Assembly of UNESCO. The Convention is composed of eight chapters with 38 articles. It prescribes the establishment of the World Heritage Committee and the World Heritage Fund. Both the Committee and the Fund began operations in 1976. The Convention integrates the protection of cultural heritage, natural resources and the environment for the first time. It successfully provides a systematic and complete work mechanism for the effective protection of heritage and the environment around the world with the collective monitoring of the international community, collaborative assistance from international funds and a shared cooperation platform for international protection technologies and cultural resources. It is a product of heritage protection and sustainable utilisation in the context of globalisation.

World Heritage List According to Article 11 of the World Heritage Convention, the World Heritage Committee should establish, keep up to date and publish a World Heritage List. This is a list of properties that form cultural and natural heritage, as defined in Articles 1 and 2 of the Convention, which are considered to have outstanding universal value in terms of such criteria. The World Heritage Committee held its second session in 1978 and published the first World Heritage List, which approved 12 heritage sites in seven countries as world heritage sites, including the Galápagos Islands in Ecuador and Yellowstone National Park in the U.S. Since then, the World Heritage Committee has updated the World Heritage List once every year. Currently, the World Heritage Committee is dedicated to establishing a globally representative, balanced and credible World Heritage List. In May 2018, the list contained a total of 1,073 world heritage sites, including 832 cultural heritage sites, 206 natural heritage sites and 36 mixed natural and cultural heritage sites.

World Natural and Cultural Heritage as A Mixed Property World natural and cultural heritage as a mixed property refers to a property that simultaneously meets some or all of the definitions of cultural and natural heritage specified in Articles 1 and 2 of the World Heritage Convention and is officially inscribed on the World Heritage List.

World Natural Heritage In accordance with the World Heritage Convention, world natural heritage, which is 'of outstanding universal value, in line with the principles of integrity, and under the management framework of effective protection, refers to the natural heritage inscribed on the World Heritage List after being nominated by state parties to the Convention, inspected and reviewed by experts from IUCN (the World Conservation Union, or the former International Union for Conservation of Nature) specially invited by UNESCO, and finally approved by voting of the World Heritage Committee at its annual session'. From the perspectives of science, protection and aesthetics, Article 2 of the World Heritage Convention classifies natural heritage into natural features, geological and physiographical formations and natural sites.

Wormkalk Wormkalk is a typical clastic limestone. It is usually in the form of thin layers composed of flat gravel particles with round or oval shapes in parallel arrays. In vertical cross-section, the gravels look like bamboo leaves; hence, it gets its name from the Chinese words as 'bamboo leaf limestone'. A layer of yellowish or purple iron oxide rings is always present on the edge of the rock. Wormkalk forms in tidal flat beach areas with frequent tidal wave



Fig. 15 Wormkalk

activity, and it is widely distributed in the Cambrian and Ordovician systems in North China (Fig. 15).

Wu'an National Geopark, Hebei Wu'an National Geopark is located in the central-southern part of the eastern slope of the Taihang Mountains in northwestern Wu'an County, Hebei Province. The geopark covers an area of 183 km^2. It became a national geopark in 2005 and is famous for its peaks, precipices, and gorges composed of Proterozoic red quartzite. It also contains Quaternary basalt, water body landscapes and the ancient cultural landscape of Wudang Mountain. It is the setting of *Chaoyanggou*, a famous Henan opera. The geopark consists of several scenic areas, including Jingniang Lake, Wudang Mountain, the Qibugou, the Motianling-Logevity Village, the Chaoyanggou, the Baicaoping and the Lotus Cave.

Wu'an Xishimen Iron National Mining Park, Hebei This park is located at the south-central segment of the eastern Taihang Mountains. The park is 35 km east of Handan and 200 km north of Shijiazhuang. It became a national mining park in 2005. It is a comprehensive mining park that mainly features mining heritage and integrates other geological relics, natural landscapes and cultural and historical landscapes. The park comprises four scenic regions and 13 scenic areas. Five scenic mining sites are in the core area of the park and are embraced for their ecological, cultural and natural landscapes.

Wucheng Loess This is the name for the Early Pleistocene loess layer (Q1) that was proposed by Liu Dongsheng and Zhang Zonghu in 1962. This layer is 17.5 m thick and overlies the red loess. The 15th layer of the palaeosol overlies the Wucheng loess. The typical profile is near Wucheng Town in Xi County, Shanxi Province. The strata is red and contains particles of silty sand, and the silty sand and clay content is higher than that of loess in the later stage. The texture is homogeneous, dense and solid with a high degree of diagenesis and few large pores. It is characterised by several layers of reddish brown palaeosols and calcareous nodules. This loess layer contains fossils of Hipparion sinense (Chinese long-nosed three-toed horse), Equus sameniensis (Sanmen horse), Nyctereutus procyonoides (Chinese raccoon) and Sus lydekkeri (wild boar). The geomagnetic age of the lower boundary of the Wucheng loess is 2.48 million years (Fig. 16).

Wudalianchi (Five Connected Lakes) Volcanic Cluster Landscape This is one of the most famous volcanic landscapes in China. It consists of a volcanic cluster located on the northeastern margin of the Songnen Plain in the southern foothills of the Xiaoxing'an Ridge. It includes 14 volcanoes that extend NE and NW over an area of approximately 800 km^2. This volcanic group is characterised by: (1) volcanic activity from the Pleistocene to the Holocene; the volcanic activities of Laohei Mountain and Huoshao Mountain can be found in historical records. These volcanoes erupted less than 300 years ago from 1719 to 1721 and are among China's few volcanoes with actual historical records (1719 is the 58th year of Kangxi in the Qing Dynasty). (2) The lava flow landscapes are diverse and magnificent. Rope-like lava, block lava, fragment-like lava and flat lava form numerous typical features, such as 'Shilong (Stone Dragon)', 'Shihai (Stone Sea)', 'Rolling Flower Stone', 'Stone Pool',



Fig. 16 Wucheng loess (lower part is the Hipparion red earth) – Luochuan Loess National Geopark

driblet cones and lekoliths, which are rare. Lava tunnels in the cold temperate zone are called ice caves. The erupted volcanic bombs and lava cakes have abundant forms. (3) The Wudalianchi basalt is a leucite rich in potassium. In 1936, it was named shilongite. (4) When a lave flow blocks a river (or lake), a barrier lake or 'warm moor' is formed. A comprehensive miniature Tianchi landscape formed in the crater of the Nangelaqiu Volcano. (5) The mineral water is good for potable or medicinal use. Wudalianchi is now a famous volcanic scenic tourist area and has been approved as a global geopark (Fig. 17).

Wudalianchi Global Geopark, China Wudalianchi Geopark is located in Heilongjiang Province, China. It covers an area of 720 km^2, and its main features are volcanic geological landforms. The Wudalianchi volcanoes are the best preserved, the most typical recent volcanic cluster in China. The geopark area contains 14 conical volcanoes, 11 shield volcanoes and 8 scoria cones. Twelve volcanoes are older and erupted between 12 and 1 million years ago, whereas the other two are the youngest volcanoes in China; they erupted between 1719 and 1721 and cover an area of more than 60 km^2. The old and new volcanoes are collocated. Relatively small-scale cinder cones and shield-shaped volcanoes lie on the relatively large table-like lava platform, which covers an area of 800 km^2. The geopark has extremely rich geodiversity, especially volcanic geology and landscapes. Many types and shapes of volcanic features can be found, including basin-like, round chair-like, and funnel-shaped craters, calderas, compound craters, lava tunnels, caves, block valleys, blockfields, lava cascades, tunnels, stalactites, discs and arches, hornitos and laccoliths, volcanic breccia and bombs, and calcium and magnesium carbonate-rich spring water. The convoluted and incrusted lavas from the recent volcanic eruptions occur together with the large-scale and well-preserved effusive cones and dishes, and this combination is rare around the world. The volcanic eruption that occurred in 1820–1821 blocked river channels to form five ('wu' in Chinese) lakes extending in the form of a string of beads, which are called Wudalianchi. It has been praised by tourists as a 'Natural Volcano Museum'.

Wudalianchi National Geopark, Heilongjiang See ▶ Wudalianchi Global Geopark, China.



Fig. 17 Landscape of firing mountain and rolling lava in Wudalianchi

Wufeng Caifuxi-Type Stone Forest Landscape, Hubei This is a representative type of carbonate rock stone forest landscape. The Wufeng Caifuxi type in Hubei Province is representative of this kind of stone forest. It developed in thick Cambrian dolomitic limestone. The tall stout stone columns have square, pagoda or inverted pagoda (like a club) shapes and are generally 20–30 m high, and the shorter ones can range from 5–10 m. The columns have smooth surfaces with flat tops, and they stand in arrays with a spacing of 5–10 m. They usually exist in groups with 3–5 or 8–10 individual columns in each group, and they form a spectacular and distinctive stone forest landscape. The column bodies are controlled by two groups of joints, along which significant disintegration has occurred (Fig. 18).

Wufeng Geopark, Hubei This geopark is located in Wufeng Tujia Autonomous County in southwestern Hubei Province. The geopark has a total area of 500 km^2, and the main geological features cover an area of 30 km^2. It became a national geopark in 2011. The geopark features complete karst systems with well-developed carbonate rocks that cover more than 70% of the total area. Karst landforms of various shapes that formed through karst processes are located in every scenic area of the geopark. The karst features extend from the surface to underground and from low hills to high mountains. Such complete karst systems and beautiful karst landforms are rare.

Wugongshan National Geopark, Jiangxi This geopark is located in eastern Luxi County, Pingxiang City, in the western part of Jiangxi Province. It is in the northern part of the Luoxiao Mountains. It was designated as one of the fourth group of national geoparks by the Ministry of Land and Resources in August 2005. It features a NNE-SSW-trending tectonic dome, and the massif consists of gneiss and granite. The geopark contains a metamorphic core complex, tectonic fault-block mountains and granite peak landscapes. Wugongshan is known for its unique peaks, steep slopes, strange pine trees, cascading waterfalls, tranquil ponds and fantastic caves.

Wulingyuan Scenic Area See ▶ Zhangjiajie Sandstone Peak Forest National Geopark, China.

Wulong Karst National Geopark, Chongqing This park is located in Wulong County, Chongqing, along the lower reaches of the Wujiang River, a tributary of the Yangtze River. It became a national geopark in 2004. The geopark is composed of two districts with distinctive karst landforms, caverns, tiankengs, arches, vertical shafts and wells, gorges, ground



Fig. 18 Wufeng Caifuxi-type stone forest landscape, Hubei Province

joints, pinnacles, stalactites and stalagmites, clusters of peaks, peak forests, underground streams and hot springs. There are four major attractions for visitors: the Furong Cave Group, Wulong Natural Arch, Wulong Zhongshiyuan Tiankeng, and Wulong Tianxing Shaft Group.

Wulongshan National Geopark, Hunan Wulongshan National Geopark is located in Longshan County, Xiangxi Tujia and Miao Autonomous Prefecture, and covers an area of 142 km^2. It became a national geopark in 2009. It is characterized by karst, Danxia, and fluvial erosion landforms and water landscape. Taiping Mountain is a typical fortress-like Danxia landform. Its peak has an elevation of 642 m, and it is 3–80 m wide and is surrounded by cliffs. The relative elevation reaches 300 m. Potholes have developed in the bed of the Mengdonghe River in Xincheng Country. The Cretaceous red sandstones, pebble sandstones and conglomerates were eroded and formed this landform, which includes waterfalls and karst springs.

Wuyishan, Fujian Wuyishan is located 15 km south of Chongan City. It has a total area of 79 km^2. It has a Danxia landform and is composed of red Cretaceous rocks, predominately sandstone and conglomerates. The structure of the hills is monoclinic with well-developed vertical joints, which have weathered to form cliffs, gorges, sharp peaks, mesas (or fangshans), caves and other unique landforms. The area has been described as one of the world's most interesting landscapes. The highest peak is Sanyangfeng, which is 717 m tall. The area contains more than 400 ancient monuments and cliff inscriptions of the Yue People as well as seven scenic sites, including Taoyuan Cave and Jiuqu.

X

Xenolith A xenolith is a rock fragment that is captured during the process of magma ascent. The captured rock can be a sedimentary rock, metamorphic rock, or a pre-existing magmatic rock. Xenoliths have irregular shapes, and some are lens shaped. Xenoliths are distributed along the edge of the intruding rock mass, and they can occur alone or in swarms. The long axis of a single xenolith or the direction of a swarm array is usually consistent with the magma flow direction. The edges are often marked by a thermally metamorphosed baked margin.

Xi Guo Xi Guo (1023–1085), nicknamed Chunfu, was a native of Wen county in Henan Province. He was a landscape painter. During his career, he developed many brilliant principles of landscape appreciation that contributed to research in landscape culture and nature tourism. He was named the landscape painting master during the Five Dynasties and the Northern Song Dynasty. His surviving works include 'Early Spring', 'Spring Snow in Guanshan', and 'Secluded Valley'. His son, Xi Guo, compiled his painting theories and other details in a collection called 'Lin Quan Gao Zhi' (The Lofty Interests of Forest and Spring).

Xi'an Ground Crack This term refers to the cracks that are exposed on the ground surface in Xian. Their total length exceeds 40 km, and they cover an area of 150 km^2. Their emergence and development have the following characteristics: (1) The movement on the cracks migrated. The cracks in the southern suburb formed first and then migrated north. (2) The movement is cyclical. The first peak period was in the 1920s and 1930s, the second peak was in the 1950s and 1960s, and the third was in the mid-1970s. Since 1985, more frequent cracking has occurred in the northern and northeast suburbs. (3) The cracking is mainly tensional, but it is accompanied by vertical faulting and horizontal twisting. During the peak movement periods, the vertical movement can reach velocities of a few mm to 20 mm per year. (4) The movements are destructive to buildings. Recent studies suggest that the development and movement of the cracks are controlled by a deep fault and are also closely related to the excessive exploitation of groundwater. Similar cracks have also been found in the Weihe River Basin, the Shanxi fault, the Hetao Basin, and the Yinchuan Basin.

Xiake Xu Xiake Xu (1586–1641) was a native of Jiangyin in Jiangsu Province. He was a traveller and geographer during the Ming Dynasty. His name was Hongzu, and his nicknames were Zhenzhi and Xiake. He started his approximately 30 years of travelling at age 22. He covered more than half of China, reaching Yin (northeastern China) and Jin (now Shanxi Province) in the north and Yunnan, Guizhou, Sichuan, Guangdong, and Guangxi in the south. His written works include 'Inspection of Jiangyuan', 'Inspection of the Pan River', 'Treatise on Mount Jizu' and, most importantly, his masterpiece 'The Travelogue of Xiake Xu', which consisted of 19 volumes that described 1106 days of travel. It discussed the features and formation of karst topography in the limestone area of southwest China. He made observations and performed research on the volcanoes and hot springs as well as vegetation distribution patterns, weather, meteorology, social and cultural aspects. He was a pioneer of modern geography in China.

Xian'an-Type Stone Forest Landscape, Baoting, Hainan This is a representative type of carbonate stone forest landscape. A typical example is the Xian'an Stone Forest in Baoting, Hainan Province, which developed in Upper Silurian clastic limestone and grey dolomite. There are stone outcrops of low mounds, slopes, ridges and hill tops with elevations of 625–782 m. Many small karst caves

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exist in the foothills, forming a 3-dimensional stone forest landform. The stone column tops are pointed and sharp, and they can appear like a needle point, sword tip, knife tip or in an angular form. The lower parts of the columns are oval columnar, flat columnar or prismatic. The columns are generally approximately 5 m high and can range from 10 to 15 m, and the highest is 35 m. Because most stone columns have sharp spires, China's stone forest landscapes are characterised by needle-like landforms. The driving factors for the formation of this kind of landform are a tropical rainforest climate, thriving organisms and the associated biological weathering of organic acids. Xian'an Stone Forest is the southernmost stone forest in China (Fig. 1).

Xiangyang Phosphate Ore Deposit, Hubei Along with Kunyang and Kaiyang, the Xiangyang phosphate ore deposit is one of the three largest phosphate ore deposits in China. It is located in Zhongxiang and Yicheng Counties, Hubei Province. The location is under the administration of two district-level cities: Jingzhou City and Xiangyang City. Hence, the deposit is called the 'Jingxiang phosphate deposit' or the 'Xiangyang phosphate deposit'. The district is now a large-scale raw material base for the phosphorous fertiliser industry. The ore bodies are marine sedimentary lamellae in phosphate rock in the lower part of the Upper Sinian Doushantuo Formation. The entire phosphorus-bearing rock sequence is more than 200 m thick. The ores and minerals of the deposit are mainly collophane with a small amount of fluorapatite. The deposit supports a mixed silicon-calcium ore industry in the area (Fig. 2).

Xianning Mount Jiugong-Hot Spring Geopark, Hubei This geopark is located in Xianning, Hubei Province. The park has an area of 212 km^2, and most of the geological features are concentrated in an area of 29 km^2. It became a national geopark in 2011. The geopark is characterised by karst landscapes and hot springs. Abundant rainfall has shaped the local landscape. The Dayatou Waterfall has a drop of 420 m, which is one of the highest waterfalls in China. The Yinshui Cave has a total length of 5,180 m and clearly illustrates the complete development of secondary sediments. The Xianning Hot Spring became famous 1,400 years ago and is a representative hot spring in China.

Xiao Fan Xiao Fan (1954–) is a native of Chongqing City. He is the chief engineer at the Sichuan Regional Geological Survey Institute and a professor grade senior engineer. He once served as secretary-general of the Fourth Council of the Sichuan Tourism Earth Science Research Institute and deputy secretary-general of the Chinese Academy of Tourism Earth Science and Geopark Research, Geological Society of China. He has presided over dozens of tourism resource surveys, tourism



Fig. 1 Xian'an-type stone forest landscape, Baoting, Hainan Province



Fig. 2 Xiangyang phosphate mining town

planning, geopark applications and construction projects, published more than 40 papers on tourism earth science and geoparks, and edited the fifth and sixth volumes of 'Tourism Earth Science Research and Resources Development'.

Xiaoqinling National Geopark, Henan This geopark is located in Lingbao City, Henan Province, and has an area of 124 km^2. It became a national geopark in 2009. The geopark is famous for its structural, granite, metamorphic, fluvial and loess landforms. The metamorphic rocks are mainly composed of Yang Zhaoyu grey gneiss and Sifangou gneissose granite. The Niangniangshan scenic district mainly contains granite, fluvial and water body landscapes, and the rock is mainly Yanshanian granite. The Yellow River Wetland and Loess Scenic District Park mainly contains Yellow River wetlands and loess landforms.

Xiaoshanba Bauxite Deposit, Xiuwen, Guizhou This was the first large bauxite mine in China and is also one of the most important domestic bauxite mining areas. Discovered in 1941, the Xiaoshanba bauxite deposit is located in Xiuwen County, Guizhou Province. The bauxite ore is located in the Lower Carboniferous Xiangbai Formation. The ore is of the 're-deposited ancient weathered karst bauxite bed' or 'depositional bauxite bed' type (Fig. 3).

Xiaotangshan Hot Spring Landscape in Beijing This is the most famous spring in China. It is located in Xiaotangshan Town in the eastern Changping District, Beijing. The water-bearing strata of this hot spring are the Neoproterozoic dolomite below the loose Quaternary strata. This hot spring is related to faults, and the temperature is generally 40–60 °C and can reach 76 °C. The spring water is light yellow and very clear. It has a sweet taste because it contains traces of strontium, barium, boron, iodine and radon (Fig. 4).

Xiaozhai Tiankeng Landscape, Fengjie, Chongqing This is a karst tiankeng limestone landform that formed above an underground river. It is located in Xinglong Town in Fengjie County on the southern bank of the Yangtze River. The associated rocks are the Lower Triassic Jialingjiang Formation limestone. The landform is mainly composed of peak cluster depressions at elevations of 1,300–2,000 m. The tiankengs of Xiaozhai have cave mouth diameters of 537–626 m, and the deepest is 662 m deep. These tiankengs formed above an underground river, and the river at the bottom of the cave (which is 100 to 150 m deep) has a maximum flow rate of 174 m^3/s. This



Fig. 3 Xiaoshanba bauxite mine



Fig. 4 Xiaotangshan Hot Spring landscape in Beijing

section of the underground river flows in from Tianjing Gorge via the tiankeng at Xiaozhai and flows out from the cliff of the Migong (Maze) River Valley. Its total length is 8,500 m, and it has a water level drop of 364 m. The average hydraulic gradient is 42.8%, which provides excellent hydrodynamic conditions for the formation and evolution of the tiankeng of Xiaozhai (Fig. 5).

Xihuashan Tungsten Mine, Dayu This is one of the most important tungsten mines in China. It is located in the mountainous area 9 km northwest of Dayu County in the vicinity of North Dayuling Mountain on the Jiangxi-Guangdong boundary. It contains a quartz vein-type ore that is closely related to the Yanshanian Xihuashan complex granite mass. The Dangping tungsten/beryllium quarry and the Xihuashan, Niuzishi, Xialuoshan, Shenglongkou, and Luokeng tungsten quarries are in the southern area of the mine, which contains a high concentration of tungsten. The largest vein of the mine, the No. 299 Tungsten Vein in the northern district, is 920 m long and up to 3.6 m wide. According to the Dayu County Chronicle, tin miners arrived in this area no later than the Song Dynasty. In 1907, the German missionary



Fig. 5 Xiaozhai sinkhole landscape, Fengjie, Chongqing

Wilhelm discovered tungsten, which was the earliest discovery and mining of tungsten in China.

Xiji Hu-Oshizhai National Geopark, Ningxia This park is located in northern Xiji County in the Ningxia Hui Autonomous Region. It became a national geopark in 2004. It is famous for its North China red sandstone and unique rocks and landforms on the loess plateau, which has a peculiar landscape of red cliffs and red peaks.

Xikuangshan Antimony Deposit, Hunan This is the world's largest antimony deposit. It is located in Lengshuijiang City, Hunan Province, along the southern margin of the Xiang Zhong (Central Hunan) basin (also called the Xiang Zhong sag), the northern margin of Baima Mountain-Xialong Mountain and the western end of the arcuate tectonic belt in Qiyang. The ore field has a NNE trend and is composed of four ore bodies: Laokuangshan, Tongjiayuan, Wuhua and Faishuiyan. The ore bodies are located in the silicified limestone of the Upper Devonian Shetiaqiao Formation. The total proved antimony reserves of the deposit are more than two million tons. The scale of the deposit is so large that it has been called the 'World's Antimony Capital'. When it was discovered at the end of Ming Dynasty, the ore was mistakenly interpreted as tin; hence, it was given the name Xikuangshan, which means 'tin ore mountain'.

Xin Wang Xin Wang (1945–) graduated from the Department of Geology, Taiwan University and obtained a PhD in economic geology from Columbia University. From 1988 to 1996, he served as the director of the Parks of Taiwan and as a professor in the Department of Geography at Taiwan University. He is currently a professor at the Chinese Culture University in Taiwan. He has long been engaged in the study of tourism geology. He is the author of 'Topography and Landscape of Taiwan', 'Landscape Conservation', and 'Special Geographic Landscape in Taiwan'. He contributes significantly to disseminating tourism earth science studies and promoting the establishment of geoparks in Taiwan.

Xinchang Petrified Wood National Geopark, Zhejiang This geopark is located in Xinchang County, Zhejiang Province, and became a national geopark in 2004. It is located in the Xinchang Basin, which formed on the continental margin of southeastern China in the Cretaceous. The geological relics are mainly Danxia landforms and silicified wood, especially ancient Cretaceous forests. Six layers

of silicified wood are buried in the geopark, including more than 300 silicified trees over nearly 6 km^2, with a maximum diameter of 3.50 m and trunk lengths up to 16 m. The trees were buried in different forms, including regular, upright and recumbent, with some preserved roots or branches. The degree of silicification is low, the stone is hard, the trees are in different shapes, and the wood structure and growth rings are clearly preserved.

Xindong Man Site The Xingdong Man site is another discovery in Zhoukoudian, Beijing. It was found in 1967 in a limestone cave in Longgu Hill in Zhoukoudian. This cave had undergone a simple excavation in 1938, during which several fossils and stone artefacts were discovered. In 1967, red guards composed of several local and international secondary school students visited the site and found a new cave; therefore, the site was given the name Xingdong, which literally means 'new cave'. Excavation at spot number 4 began in March 1973. The Xingdong cave is arc-shaped with a deposit that is more than 2 m thick and 10 m wide. The first molar of the left jaw of a human was excavated. The tooth morphology is between those of the Peking Man and the Upper Cave Man, and it belongs to an early Homo sapiens. The cave contains a thick layer of ash with burned stones, bones and hackberry seeds. The mammal fossils include more than 40 species. The fauna combinations indicate an age from the early stage of the Late Pleistocene. Thermoluminescence dating of the ash layer resulted in dates of 135,000–175,000 years ago, indicating that the human activity in this cave might have occurred between 100,000 and 250,000 years ago.

Xingkaihu Lake National Geopark, Heilongjiang This geopark is located in Mishan City, Heilongjiang Province. The geopark was designated as one of the fourth group of national geoparks by the Ministry of Land and Resources in August 2005. The terrain is high in the northwest and low in the southeast at elevations of 68–574 m. Its geological landscapes mainly include two tectonic lakes, five lacustrine deltas, meandering rivers, oxbow lakes, and wetlands. Daxingkaihu Lake is approximately 400 km long from north to south and 100 km wide with an area of 4,380 km^2. Xiaoxingkaihu Lake has an oval shape and is 130 km long from north to south and 80 km wide from east to west; it has a water elevation of 69 m and an average depth of 3.5 m. With a maximum depth of 10 m, Xingkaihu Lake is the largest freshwater lake in East Asia.

Xinglong National Geopark, Hebei Xinglong National Geopark is located in Xinglong County, Hebei Province, and it covers an area of 101 km^2. It became a national geopark in 2009. It contains Yanshan geological structures, karsts and granite landforms. The rock mass of Wuling Mountain is a silica-saturated alkaline-peralkaline A-type granite. It is representative of the Late Yanshannian magmatic activity in northern China and is an important record of the tectonic and thermal events associated with the Mesozoic Yanshan intraplate orogenesis. A complete Precambrian black smoker chimney structure was found in this area. Well-preserved oceanic crustal fragments and ophiolites with an age of 2.5 billion years are located in the Mesoproterozoic Xinglong Karst Cave in the Wumishan Formation, which formed 1.4-1 billion years ago. It is a carbonate rock series and is dominated by dolomite that contains siliceous chert nodules and layers. It is a typical percolation or seepage zone cavern.

Xingtai Earthquake Relics Landscape At 5:29 am on March 8, 1966, a 6.8 magnitude earthquake occurred in eastern Longyao County, Xingtai area, Hebei Province. The earthquake depth was 10 km. Over 21 days, from 8 March to 29 March, there were 5 successive quakes in Xingtai with magnitudes of 6 or above. The damage area was extensive, and the earthquake caused large numbers of cracks, landslides, collapses, dislocations, surging springs, water level changes and ground subsidence; in particular, ground fissures and sand boils were dominant. The ground fissures stretched in a zone along the Fuyang River, the old Ningjin marsh and the



Fig. 6 Xingtai earthquake relics landscape

ancient river course. The sand eruptions occurred mainly in the old river course, depressions and areas with loose soil (Fig. 6).

Xingtai Valley Group Geopark, Hebei This geopark is located in Xingtai County, Hebei Province, on the eastern side of Mount Taihangshan. It has an area of 78 km^2 and was designated a national geopark in 2011. It consists of three scenic districts: the Valley Cluster, Jiulong Valley and Yunmeng Mountain. The geological features in the geopark have been well preserved. The valley and ridge system is massive, rare in China and of great scientific value. Associated with the valley system are waterfalls, typical sedimentary structures and karst landscapes. They have important aesthetic and tourism value and are ideal for science popularisation, ecotourism and adventure tourism activities.

Xingwen Global Geopark, China This geopark is located in Yibin City in Sichuan Province. It is located in the southern part of the Sichuan Basin and in the transition zone to the Yunnan – Guizhou Plateau. The geopark covers an area of 130 km^2 and became a global geopark in 2005. It has four scenic districts, namely, Xiaoyanwan, Yuwangshan, Taian Shilin and Lingyu City. The unique geographic, geological and climatic conditions formed the Xingwen-style karst landforms. It is the location of the earliest tiankeng (sinkhole) research and nomenclature in China and is also the origin of the 'Taian karst landscape', which formed in Middle Ordovician limestone with mud cracks. The park preserves carbonate rocks and carbonate-bearing rock formations dating from approximately 490 million to 250 million years ago. The rocks contain extremely rich marine fossils and sedimentary facies. The geological heritage relics, the unique history and culture of the Dong people and the rich and colourful Miao culture combine to form an ideal natural landscape.

Xingwen Shihai National Geopark, Sichuan See ▶ Xingwen Global Geopark, China.

Xingyi National Geopark, Guizhou This geopark is located in Xingyi City, Guizhou, and became a national geopark in 2004. It features marine reptile fossils and karst landscapes. It is divided into the Dingxiao Keichousaurus Scenic Area, Wusha Keichousaurus Scenic Area, Malinghe Gorge Scenic Area, Wanfenglin Park, and Muddy Stone Forest Park. Keichousaurus fossils have been found in Dingxiao and Wusha. Malinghe Valley is a typical karst valley, and Wanfenglin is a conical peak and forest area. The Muddy Stone Forest is composed of Triassic limestone and is an example of the 'Guizhou muddy stone forest landscape'.

Xinxiang Fenghuangshan National Mining Park, Henan This mining park is located in the Fenghuang Mountain area of Yuwangfen Town in the northern Fengquan District of Xinxiang City, Henan Province. It covers an area of 5.94 km^2 and became a national mining park in 2010. The limestone and marl deposits in the park have a long history. The park includes geological relics such as mineral sites, mining production facilities, equipment and culture associated with mining activities.

Xinyang Jingangtai National Geopark, Henan This geopark is located in southeastern Shangcheng County, Henan Province, and it includes Dabieshan Peak (1,584 m). It became a national geopark in 2005. The geopark consists of the Jingangtai and Tangquanchi scenic districts. The attractions include volcanoes, cones, craters, stone forests, gorges, peak clusters, isolated peaks, peak walls, long cliffs, V-shaped and U-shaped valleys, fractured valleys, narrow passes and waterfalls.

Xiu Pei Xiu Pei (224–271) was a native of Wenxi County, Hedong, Shanxi Province. He was a cartographer during the Western Jin Dynasty with the rank of Minister of Public Services during the reign of Emperor Wu. He was determined to study mapmaking. He verified 'Yu Gong' (China's oldest known book of geography) in great detail and made a set of 18 maps known as the 'Yu Gong Area Map', which was the earliest set of historical maps of China. He summarised the mapmaking experience and promoted six principles of cartography, namely, fen lu (scale), zhun wang (orientation), dao li (distance), gao xia (topography), fang xie (inclination) and yu zhi (straightness). These principles were adopted by Chinese cartographers until the end of the Ming Dynasty. This set of maps occupies an important position in the history of world mapmaking because is considered the earliest foundational scientific theory of planimetric map drawing. In addition to making the 'Yu Gong Area Map', Pei Xiu also produced a simplified version of the topographical map of Jin.

Xiuyan Jade Xiuyan jade is a type of soft jade that is a kind of serpentine produced in Xiuyan County, Liaoning Province. It is mainly composed of soft green fibrous serpentine with low hardness. It can be light green, light yellow and apple green with translucent or opaque bodies. Its surface has a fat-like lustre. It was one of the earliest jade materials used in China, and it is currently abundantly produced. There are several varieties of serpentine jade in the same category, such as the Jiuquan jade mined in the mountainous areas near Jiuquan in Gansu Province, the famous 'Yeguang (noctilucent) Cup', which is composed of translucent green jade that contains black spots, the Yixin jade produced in Guangdong, and the Taiwan jade produced in Taiwan (Fig. 7).

Xixia Dinosaur Eggs This fossil site is located in the Cretaceous strata in the Xiping-Chimei and Sangping Basins in Xixia County, Henan Province. The dinosaur egg strata are mainly in the Zoumagang Formation, Zhaoying Formation and Sangping Formation, and the Zhaoying Formation contains the most abundant fossil eggs. The eggs that have been identified eggs are Macroolithus, Elongatoolithus and Spheroolithus. Most of the eggs are well preserved, and some have remained intact. Many eggs have broken shells, which indicates that the dinosaur babies had hatched. Some eggs contain embryos; they have significant scientific research value (Fig. 8).

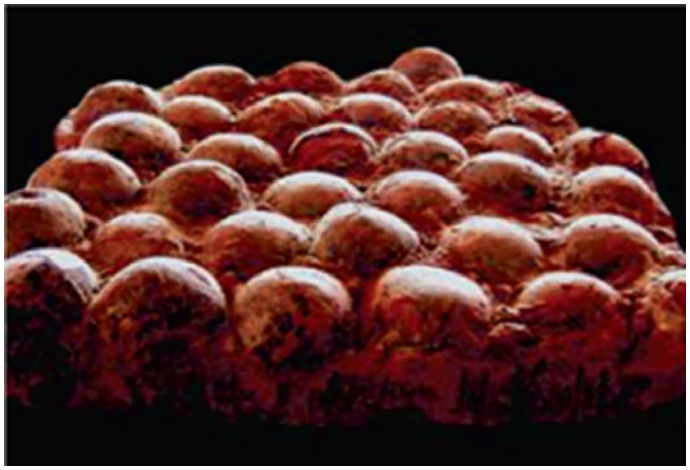
Xixia Funiushan National Geopark, Henan See ► Funiushan Global Geopark, China.

Xuan Zang Xuan Zang (602–664) was called Yi Chen before becoming a monk. He was a native of Yanshi in Luoyang, Henan Province. He was generally known as San Zang (master in Tripitaka) and was a Tang Monk. He was a Buddhist scholar, traveller and translator. In 627 A.D., the first year of the reign of Emperor Taizong of the Tang Dynasty, he commenced a pilgrimage from Chang'an (now Xi'an, capital of Shaanxi Province) and travelled along the Hexi Corridor, west along Tianshan, across the Cong Ling (Pamirs) and Rehai (Hot Water) to Suyeshui (Tokmak, Kyrgyzstan). He passed



Fig. 7 Xiuyan jade raw stone and craft

Fig. 8 Xixia dinosaur eggs



through the Big Snow Mountains (now Hindu Kush) and reached Tianzhu (India). He travelled to 110 countries and returned to Chang'an in 645 AD. 'The Great Tang Dynasty Records of the Western Regions', a narrative of Xuanzang, provides important information about the history, geography and other details of 110 countries, including India, Nepal, Pakistan, and Bangladesh.

Xueyu Cave Landscape in Fengdu, Chongqing This is a canyon-style underground river cave landscape. Located along the lower course of the Long (Dragon) River in Fengdu County, Chongqing City, the main cave of Xueyu Cave is a canyon-style underground river cave with a total length of 1,644 m. Inside the cave, secondary chemical sediments are rich and pure. The sediment is as white as snow, from which the cave gets its name. The associated stalactites are varied, and most are still growing and developing. Characteristic sediments include large pieces of soda straws, jade palms (stalagmites), tower corals, curlstones, stone shields, calcium film crystal cones and roof lotus, which are rare both in China and abroad. There are 4-m-high ground shields, large tower coral groups, 8-m-long king stones and dense soda straw groups, all of which can be regarded as exquisite features of the karst cave landform (Fig. 9).

Xujiayao Man Site The Xujiayao Man site is a site of ancient human fossils that was discovered in 1974, and it is located on the west bank of Leiyigou in Xujiayao Village, Yanggao County, Shanxi Province. Twenty human fossils and more than 10,000 stone artefacts, bones, horn tools and abundant mammal fossils have been excavated at this site. The



Fig. 9 Xueyu Cave in Fengdu, Chongqing

human fossils include parietal bones, occipital bones, temporal bones, upper and lower jaw bones and teeth of more than 10 early Homo sapiens. The stone artefacts include stone cores, stone flakes, sharp-tipped spikes, carving tools, stone drills and stone balls. The mammal fossils are mainly Myospalax fontanieri, Microtus brandtioides, Coelodonta antiquitatis, Equus ferus przewalskii, Gazella subgutturosa, Megaloceros ordosianus, Cervus elaphus, Equus hemionus, Spirocerus peii, and Bos taurus primigenius. They existed from the late stage of the Middle Pleistocene to the early stage of the Late Pleistocene. The uranium dating of a rhinoceros fossil contained in the human fossil-bearing layer provided dates of 100,000 to 125,000 years ago.

Xun Zhao Xun Zhao (1942–2012) graduated from Chengdu Institute of Geology in 1966. In the early 1980s, he went to England to pursue his studies at the University of Birmingham and Cambridge University. After returning to China, he served as the chief engineer of the Guangxi Geology and Mineral Bureau and deputy director of the 13th International Geological Congress. He was the secretary-general of the Geological Society of China, president of the Chinese Academy of Tourism Earth Science and Geopark Research, Geological Society of China, president of the Chinese Academy of Geological Sciences, and consultant expert and member of the Evaluation Committee of the UNESCO Global Geopark. His major works include 'Theory and Practice of Conservation and Development of Natural Heritages' and 'National Geoparks Tours'. He made important contributions to the development of Chinese geoparks, especially the development of global geoparks in China.

Xuyi Xiangshan National Mining Park, Jiangsu This park is located in northern Xuyi County, Jiangsu Province, and it covers an area of 3 km^2. It became a national mining park in 2005. The park is in the low hills of a branch of the Tapieh Mountains. Five scenic sites display mining remains. The park makes use of all kinds of natural and cultural tourist resources, has a layout that was planned rationally under the premise of environmental management and ecological restoration, and provides tourists with a place for tourism, leisure vacations, cultural entertainment and science education.

Y

Yakushima, Japan This site is located in the ocean 80 km south of Kyushu Island, and it covers a core protected area of 107 km^2. Located at the boundary between the palaeo-arctic and oriental biotic regions, Yakushima exhibits rich flora with approximately 1,900 species and subspecies, including ancient specimens of the sugi (Japanese cedar). It also contains a remnant of a warm-temperate ancient forest that is unique in this region.

Yanchuan Yellow River Shequ National Geopark, Shaanxi This park is located in eastern Yanchuan County near the borders with Shaanxi Province and Shanxi Province. It starts in Yanshuiguan in the north and extends to Qingshuiwan in the south, with a total area of 86 km^2. It became a national geopark in 2005. The major geological attractions of the geopark are its river landscapes, such as deep gorges, Shequ (meandering rivers), river terraces and waterfalls. The Yanchuan Yellow River Meander Bends originate in the Qin Jin Grand Canyon and are large incised meanders. They make up the largest, most well-developed and concentrated meander group of all of the major river channels in China.

Yandangshan Global Geopark, China Yandangshan is located in Yueqing City, Wenzhou, Zhejiang Province, as well as in Yongjia County and Wenling City, and it covers an area of 294 km^2. It became a global geopark in 2005. It has scenic areas with different characteristics, such as Lingfeng, Sanzhe Waterfall, Lingyan, Dalongyu, Yanhu West Shiliang Cave, Xianshengmen, Xianqiao Yilong Lake and Yangjiao Cave. The eastern part of the geopark is the location of the famous Fangshan and Changyu. Naxijiang River is located in the western part of the geopark. Yandangshan is a typical Cretaceous volcano of the giant volcanic zone of the Asian continental margin. It recorded the history of volcanic evolutions from 128 million to 108 million years ago, including numerous eruptions, collapses, and reactivations. Its geological evolution is typical of Cretaceous rhyolitic volcanoes and associated volcanic activity with global significance, and it is a valuable relic for studying Mesozoic volcanic rocks. Other volcanic features include volcanic columns, caves and cliffs, and the area is therefore called 'a natural volcanic rock and landform museum'.

Yandangshan National Geopark, Zhejiang See ▶ Yandangshan Global Geopark, China.

Yangbajing Geothermal Spring Landscape This is a famous geothermal spring in Damxung County, 90 km northwest of Lhasa. The geothermal resource is rich and contains large fountains, geysers, hot springs, thermal springs, boiling springs and hot water lakes. The spring water has a high mineral content, which makes it suitable for bathing and therapeutic use. The steam from the hot springs that flow across Yangbajing, which is surrounded by snow-capped mountains, forms a fascinating natural wonder at the roof of the world, making this area a popular tourist destination (Fig. 1).

Yangbajing National Geopark, Tibet Yangbajing National Geopark is located in Lahsa City in the Tibet Autonomous Region. It became a national geopark in 2009. The main geological features are geothermal resources of the Qinghai-Tibet Plateau. This large section of the Qinghai-Tibet Plateau surface is 87 km long and has been called the geological corridor of plateau evolution. The Yangbajing Geothermal Field has diverse geothermal types. The Nyenchen Tanglha Mountains are the centre of development of ancient and modern glaciers. Numerous landforms, including continental glaciers, mountain glaciers, glacier trough valleys,

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Fig. 1 Geothermal Spring Landscape

cirques, aretes and horns, have developed along both sides of its main ridge.

Yangchun Lingxiaoyan National Geopark, Guangdong Yangchun Lingxiaoyan National Geopark is located in Yangchun, Guangdong. In March 2004, it was approved by the Ministry of Land and Resources as one of the third group of national geoparks. The geopark has two scenic districts, called Lingxiao and Chunwan, and is dominated by karst landforms. The major attractions include karst caves, such as Lingxiao Cave, Longgong Cave, Kongtong Cave, and Yuxi Cave, and subsurface streams. The Yuxi Fault Escarpment, Longgong Fault Cliff, Beigua Fault Zone, compound folds, and the Dushizai Ancient Human Site are also geological attractions. Its cultural charm lies in the ancient Tongling County and the iron and coin mould relics.

Yangjia Fluorite Deposit, Wuyi, Zhejiang The Yangjia fluorite deposit is one of China's largest fluorite deposits and is located in northeastern Wuyi County, Zhejiang Province. The ore field contains more than 20 medium to large fluorite mines, such as Yangjia, Houshu, and Yushantou, more than 40 small fluorite mines, and 140 mining locations. The proven fluorite reserves amount to 17 million tons. The ore body consists of veins and lenses in Upper Jurassic and Lower Cretaceous acidic to moderately acidic volcanic rocks. The deposit was formed by the settlement of mid- to low-temperature hydrothermal fluids in fissures after the magmatic period. The major ore components are fluorite and quartz, which form two ore types – fluorite and quartz-fluorite ores.

Yangshan National Geopark, Guangdong Guangdong Yangshan National Geopark is located in Yangshan County, Guangdong Province, and has an area of 29 km^2. It was approved as one of the fifth group of national geoparks by the Ministry of Land and Resources in August 2009. Karst and water landscapes are the main attractions. The park contains peak clusters, peak forests, gorges, karst caves, clints and peristaliths. There are also rivers, waterfalls and hot springs.

Yangshao Culture *Synonym:* ► *Painted pottery culture*

The site of the Yangshao culture was first discovered in China in 1921 as a middle stage Neolithic relic site. It is located in Yangshao Village, Mianchi County, Henan Province. The period of the Yangshao culture (5,000–7,000 years ago) was the main period of development the Chinese culture. It inherited the preceding Peiligang culture and Cishan culture and was succeeded by the Longshan culture, and it played important roles as both a successor and predecessor of

other cultures and illustrates the continuous nature of China's Central Plan culture. During the Yangshao culture period, pottery techniques progressed greatly; hence, this culture is also known as the Painted Pottery culture. Another feature was the advanced development in agriculture. In addition to the production of staple crops such as grains (e.g., rice in the south), vegetables were also grown, and domestic animals such as pigs, dogs and chickens were raised. The productivity level, layout, size and form of village houses and the pattern of tombs reflected the social prosperity, abundance of the population and rapid economic development at that time. This society might have been a matriarchal type.

Yangtze Block This block is equivalent to the 'Yangtze Platform'. The core of this block is mainly composed of ancient metamorphic rock that are overlain by platform-cover type sediments.

Yangtze Platform The Yangtze Platform covers the areas of the middle and lower Yangtze River, including most areas in Sichuan, Hubei, Yunnan, Guizhou, Hunan, Anhui, and Jiangsu Provinces, southern Shaanxi Province and northern Guangxi Province. This platform is surrounded by mountain ranges, including the Daba Mountains and Micang Mountains to the north, the Wuling Mountains and Jiuling Mountains to the east, and the Longmen Mountains to the west. The basement is composed of Proterozoic metamorphic rocks, which are approximately 1.7 billion to 2.3 billion years old. Older rocks may be present beneath the platform. Approximately 800 million years ago, the Jinning movement formed the unified Yangtze Platform. The early Neoproterozoic Era was a period of extensive fracturing, and widespread marine sedimentation began in the Nanhuan Period (Middle Triassic). In addition, extensive basaltic eruptions occurred in the western part of the platform in the middle Permian. Some researchers believe that mantle plume activity occurred during this period. After the Triassic Indo-Chinese movement, the eastern part of the platform became part of an active continental margin of East Asia, while the Sichuan Basin in the west remained stable. Cenozoic activity caused substantial differential uplift of the Yangtze Platform, resulting in numerous unique landscapes eligible to become famous geological parks. Among them, the Yunnan Stone Forest is famous for its karst landforms derived from carbonate rocks. The stone pillars in Zhangjiajie in Hunan Province are mainly Devonian sandstone, and Longmenshan National Geopark is characterised by large-scale nappe structures.

Yanqing Silicified Wood National Geopark, Beijing This geopark is located in northeastern Yanqing County in Beijing. It became a national geopark in 2002 because of its important petrified wood fossils. The petrified wood is located in the Upper Jurassic Tuchengzi Formation, which is approximately 140 million years old. A total of 57 pieces have been discovered. They have clear and hard textures, and growth rings are clearly visible. The wood is 0.60–1.50 m in diameter with a maximum diameter of 2.50 m. They fossils are mostly perpendicular to the ground with heights of 0.40–0.50 m to a maximum of 1 m above the ground. In 2011, dinosaur footprints from the Jurassic Period were also discovered. Yanqing is the only location in Beijing where dinosaur fossils have been found. The park also contains cultural attractions such as the Yan Great Wall, Gujia Fortress, and Chaoyang Temple.

Yanshanian Movement The Yanshanian movement was the crustal movement that occurred extensively in mainland China during the Jurassic and Cretaceous Periods between approximately 200 and 200 million years ago. The Yanshanian movement was characterized by intense folding and fracturing, extensive magmatic activity, dynamic metamorphism and mineralization. In eastern China (Circum-Pacific region), it is represented by a significant pattern of strong movement in the east and weak movement in the west during multiple episodes. The Yanshanian movement was an important tectonic and metallogenic period in China and created the basic tectonic pattern of China. It was also an important intercontinental tectonic event. The Yinshan-Yanshan

orogenic belt is a typical orogenic belt of the Yanshanian Age. The Yinshan-Yanshan orogenic belt did not develop from geosynclines but instead is a typical 'continental orogenic belt' (or 'intraplate orogenic belt').

Yaoru Lu Yaoru Lu (1931–) is a native of Fuzhou City, Fujian Province. He graduated from Beijing Institute of Geology (currently China University of Geosciences) in 1952. He is an expert on hydrogeology and environmental geology. He served as an academician of the Chinese Academy of Engineering, scientific adviser of the Academy of Tourism Earth Science and Geopark Research Branch, the Geological Society of China. He also worked as a researcher at the Institute of Hydrogeology and Environmental Geology of the Chinese Academy of Geological Sciences, as a professor in the Department of Geotechnical and Underground Engineering at the College of Civil Engineering of Tongji University, as honorary president of Guizhou Normal University, and as a board member of the International Research Centre on Karst (under the auspices of UNESCO). He also chaired the Ministry of Education's Joint Research Centre for Urban Environment and Sustainable Development. He was the senior specialist in large-scale hydropower projects of Chinese aid for foreign countries. For the past 50 years, he has conducted extensive research on hydrological, engineering and environmental geology in karst areas. He has published nearly 100 papers in both Chinese and English, including 'Karst in China', 'The Regular Pattern of Karst Development in China and its Hydrogeological Engineering Characteristics', 'Geological and Ecological Environment Map Series of Southern China (mainly in Karst Region)', 'Research on the Evolution of Karst Hydrogeological Environment and Its Engineering Effects', and 'Geological-ecological Environment and Sustainable Development – Approaches for Southwest China and Adjacent Karst Areas'. His 'Karst in China – Landscape, Types, and Pattern' is highly regarded by overseas scholars as a masterpiece. He has won the State Science and Technology Award, Second Class Award of the Geological Science and Technology Award of the Ministry of Geology and Mineral Resources, Second Class Award of the National Science and Technology Book and the Honorary Award of the Siguang Li Geological Scientific Award.

Yaozhou Zhaojin Danxia Geopark, Shanxi This geopark is located in southwestern Tongchuan, Shaanxi Province. It has an area of 60 km^2, and most of the geological features are concentrated in an area of 36 km^2. It became a national geopark in 2011. The Danxia landforms are made up of purplish-grey, reddish-brown and purplish-red thick conglomerates of the lower Cretaceous Yijun Group. Continual soil erosion, gravitational collapses and wind erosion have created mesas, stone walls, stone peaks, stalactites and stalagmites, drum-shaped stone blocks, peak valleys and caves, which are valuable for scientific research. The Danxia red cliffs and Yijun conglomerates are important for scientific research on the development and evolution of the Danxia landforms in the semiarid regions of northern China. The park also provides opportunities for studying the relationship between loess plateau landforms and the Danxia landform.

Yardang Landform See ▶ Yardang Landscape.

Yardang Landscape This is a sandstone landscape found in arid and windy climate regions, in which Quaternary Middle Pleistocene estuarine and lacustrine facies siltstone, mudstone and conglomerate (mainly muddy conglomerate) are the parent rocks. The landform features, including ridge mounds, fort hills and earth pillars, are formed by short rainstorm scouring and strong wind erosion. Yardang landforms are well developed in Xinjiang and Qinghai Provinces. In the Uygur language, 'Yardang' means steep hill. This kind of terrain is widely distributed and typically developed in Lop Nur. From the end of the nineteenth century to the early twentieth century, the Swedish scientist Sven Anders Hedin and his colleagues conducted expeditions in Lop Nur and used the term 'Yardang' to describe this type of landscape; since then, this term has

been used universally. This type of landscape was described in the book 'Han Geography', which was written before the time of Christ. It states 'there is no water and grass in Bailongdui (White Dragon Heap), where a sand ridge sits on the ground like a sleeping dragon'. Bailongdui is part of the Lop Nur area with a typical Yardang landform, where the ridges are 5–10 m tall, and some can be up to 20 m tall. The narrowest ditch is approximately 1–2 m wide, and the widest can be dozens of metres wide. The ridges are dozens to hundreds of metres long. Many small landform features look like animals, birds and other objects. The contrast between the fine black sand on the ground and the blue sky and white clouds plays an important role in the vivid desert scenery. The Dunhuang Yardang National Geopark was established to the east of Lop Nur near Dunhuang (Fig. 2).

Yarlung Zangbo Grand Canyon Landscape This is a giant canyon with a U-turn along the lower course of the Yarlung Zangbo River in Tibet. It starts in Daduka Village (elevation 2,880 m) in Milin County and runs south to Baxika Village (elevation 115 m) in Motuo County. The Yarlung Zangbo Grand Canyon is 504 km long with an average depth of 2,800 m, and the deepest part reaches 6,009 m. It is the largest canyon in the world. This canyon is characterised by nine vertical nature zones ranging from the alpine mountain zone to the tropical monsoon forest valley zone. It brings together a variety of biological resources and is the area with the heaviest rainfall in the world at similar latitudes. It is also the world's most rapidly uplifting region. This canyon holds two titles from the China World Records Association (CWRA): the world's deepest canyon and the world's longest canyon (Fig. 3).

Yashan Geopark, Anhui This geopark is located in Hewan Town in southwestern Nanling County, Wuhu City, Anhui Province. It has a total area of 65 km^2, and the main geological features cover an area of 25 km^2. It became a national geopark in 2011. It has unique karst landscapes, such as the Yashan Stone Forest, peak clusters, depressions, funnels, karst caves, tiankengs (sinkholes), underground rivers and karst lakes. The geopark also features typical Permian-Triassic stratigraphy, the Zhulian waterfall, Triassic waterfalls, the Dulong Valley, which contains peony culture, and Buddhist and folk cultures. By integrating scientific research



Fig. 2 Yardang siltstone landscape – Dunhuang Yardang National Geopark, Gansu Province



Fig. 3 Meander landscape of Yarlung Zangbo Grand Canyon

and popularisation, geotourism, leisure and cultural entertainment, it is a comprehensive geopark with unique and regional characteristics in eastern China.

Yeliu-Type Landscape This is a representative type of sandstone landform found in the tropical rainforest climate zone in the marine facies sandstone of the Neogene Miocene Yeliu Group. This landform contains features such as sea cliffs, sea caves, candle-like rocks, mushroom-like rocks, bean curd stones, pot holes and honeycomb rocks formed by marine erosion. During his visit to the Yeliu area on Taiwan's east coast in 1995, Chen Anze considered this a unique landscape, in particular, the 'Queen's Head' and candle-like rocks were the most distinctive, so it was given the name Yeliu landscape. This landscape is an important tourism resource on Taiwan's east coast (Fig. 4).

Yellow Brown Soil ► Yellow-Brown Earth

Yellow Earth *Synonym:* ► *Yellow soil*

Yellow earth forms by desilication, aluminization (weaker than red earth) and the hydration of large amounts of iron oxide under tropical and subtropical high humidity and high temperature conditions. The soil is acidic, yellow and rich in goethite. Bleached layers may appear in the soil profile. Yellow earth is a zonal soil in subtropical regions of China, and it is located at approximately the same latitudes as red earth.

Yellow Jade This is a yellow nephrite that ranges from light yellow to dark yellow. Based on the characteristics, the colours can also be further labelled as chestnut yellow, okra flower yellow, egg yolk yellow and tiger skin yellow. Yellow nephrite is rare, and the type with a steamed chestnut colour like suet is considered the highest grade, equivalent to suet white jade.

Yellow River Sanmen Gorge Landscape Located between Sanmenxia City in Henan Province and Pinglu County in Shanxi Province, this is a famous landscape along the middle course of the Yellow River (Huanghe). Two hard porphyrite islands are located in the middle of the river in this gorge – Gui (Ghost) Island and Shen (God) Island. These two islands command three waterways, called Gui (Ghost) Gate, Shen (God) Gate and Ren (Man) Gate, which are how the Sanmenxia (Three Gates Gorge) gets its name. The Sanmenxia water conservancy project began in 1957 (Fig. 5).

Yellow River Stone The Yellow River originates in Qinghai and flows through nine provinces (Sichuan, Gansu, Ningxia, Inner Mongolia, Shaanxi, Shanxi, Henan and Shandong). As it



Fig. 4 Yeliu-type mushroom rock landscape – Yeliu, Taiwan



Fig. 5 Yellow River Sanmenxia landscape

flows between the mountain ridges, the water moves large numbers of stone pieces, which are deposited in the riverbed to become Yellow River stones. The main types include Qinghai Yellow River source stones, Lanzhou Yellow River stones, Ningxia Yellow River stones, Inner Mongolia Yellow River stones and Luoyang Yellow River stones. Yellow River stones include various igneous, sedimentary and metamorphic rocks. These rocks are imposing, have different shapes and clear textures, striking colours, moist lustres and smooth lines. Most are painting stones, which can be further divided into pattern stones, character stones, colour stones, and fauna fossils. Because the Yellow River flows through areas with different rock types, the river stones have different characteristics, and those from Xining, Lanzhou and Luoyang are having higher quality (Fig. 6).



Fig. 6 Yellow River stone with bands

Yellow Soil ► Yellow Earth

Yellow Wax Stone This stone is called wax stone and originally was siliceous rock, such as quartz sandstone, that became quartzite due regional metamorphism and was later buried in sand and mud and eroded by acidic material over a long period of time. The resultant material is a waxy colourful stone, usually yellow, and its gets its name from these properties. It is tough and stable and has a Mohs hardness of 6–7 and serrated fractures. It can be categorised into 3 types based on its colour, such as yellow, red and multi-coloured, and into six types based on its texture, such as frozen wax, glue wax, crystal wax, ice wax, fine wax and coarse wax. High-grade wax stone is characterised by its hard, tough, fine, greasy, warm and moist qualities. It is produced in many regions of China, and the famous areas include Liuzhou Sanjiang and Hezhou Babu in Guangxi Province, Chaozhou and Shantou in Guangdong Province, Mount Huangshan in Anhui Province, Wuyi in Zhejiang Province and Anhua in Hunan Province (Fig. 7).

Yellow-Brown Earth *Synonym:* ► *Yellow brown soil*

Yellow-brown earth is slightly acidic soil that forms in sub-tropical deciduous broadleaf forests and evergreen broadleaf mixed forests through weak aluminization and clayification. It is yellowish brown to brown and is a transitional soil between yellow earth, red earth and brown earth. Yellow-brown soil can generally be found in the low-lying and hilly areas along both sides of the middle and lower reaches of the Yangtze River.

Yellowstone Caldera Landscape This volcano has erupted three times over geological time but has not erupted in human history. The main part is located in Wyoming in the northwestern United States. Yellowstone National Park was the first national park in the United States. This area is a giant caldera. The last eruption occurred approximately 600,000 years ago. The erupted materials from the crater covered an area of approximately 10,000 km^2 with a minimum thickness of 1,500 m, forming large tracts of basalt, andesite and rhyolite. Of these rocks, the huge boulders forming Amethyst Mountain are most interesting and vivid. On the northern side of Amethyst Mountain is a 609-m-high rock wall, the upper part of which exposes layers of coarse and fine sands, volcanic ash and solid mixtures. Their coarse appearance forms a wonderful stratigraphic section that serves as a textbook profile showcasing the history of volcanic eruptions (Fig. 8).

Yellowstone National Park, U.S.A. Yellowstone National Park, which is located in Wyoming, Montana and Idaho in the northwestern U.S., covers a core protection area of 8,983.49 km^2 with 96%, 3% and 1% in each of the three states, respectively. In addition to covering a vast area of natural forests, it also contains



Fig. 7 Yellow wax stone of Hezhou Babu

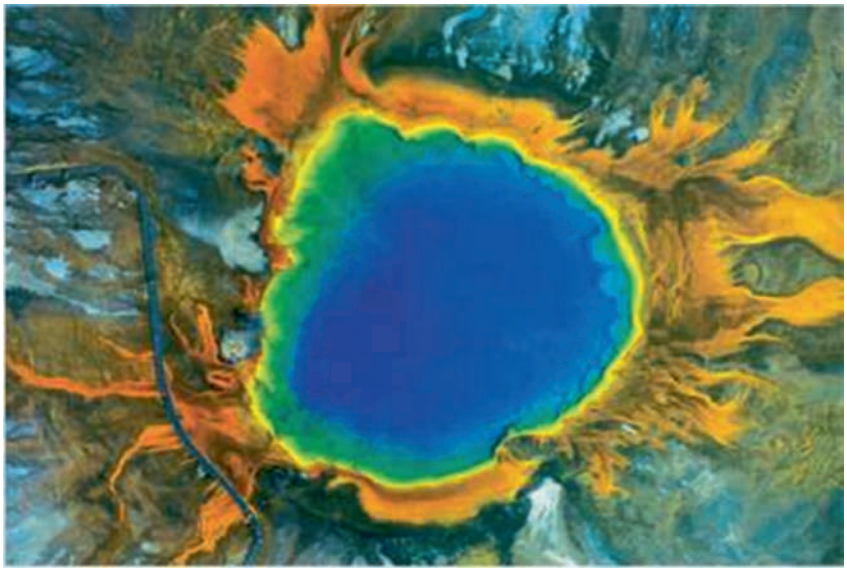


Fig. 8 Volcanic hot spring – Grand Prismatic Spring, Yellowstone National Park, U.S.A.

more than half of the world's known geothermal resources with more than 10,000 geothermal sites. It also has the world's largest concentration of geysers (more than 300, or 2/3 of those on Earth). Established in 1872, Yellowstone is also known for its wildlife preservation, such as grizzly bears, wolves, bison and elk.

Yeshan National Mining Park, Nanjing, Jiangsu This park is located in the Liuhe District, Nanjing City. It was designated as one of the second group of national mining parks by the Ministry of Land and Resources in May 2010. The area around the Yeshan Iron Mine has been used for copper mining and iron smelting since the Western Zhou Dynasty (1046 B.C. – 771 B.C.), which is more than 3,000 years. Because mining began more than 1,800 years earlier than in Europe, the park is praised by geologists as a landmark of the beginning of China's mining industry. The park is the location of the first mining in China, and its history of mining is representative of China's mining history. The underground mining intuitively and vividly illustrates the development of China's mining technologies from the Western Zhou Dynasty to the present day. Featuring 'mining culture,

mining heritage and iron mining', Yeshan National Mining Park is a highly harmonious park that integrates scientific investigations, leisure, entertainment and science popularisation education. It is also the only national mining park in eastern China that focuses on iron mining.

Yichun Granite Stone Forest National Geopark, Heilongjiang Yichun Granite Stone Forest National Geopark is located in northern Xiaoxing'anling, Tangwanghe, Yichun, Heilongjiang, and it has an area of 302 km^2. In March 2004, it was approved by the Ministry of Land and Resources as one of the third group of national geoparks. It is characterised by geological landscapes of Indosinian granites, including stone forest landscapes composed of large joints in different formations as well as fault valleys, rockfalls and accumulations in depressions, fissures, cave springs and granite landscapes formed by weathering. There are also other geological features, such as glacial blockfields, forest wetlands on granite bodies, and the unconformity between the Fengshantun Formation and granite.

Yigong National Geopark, Tibet This geopark is located along the border between Bomi and Nyingchi Counties in the Tibet Autonomous Region. It features the Yigong giant landslide, modern glaciers and mountain gorges. It became a national geopark in 2002. The Yigong giant landslide moved up to 2,580 m, and the accumulation reaches 300 million m^3. The slide is associated with clear slip marks, sandpits due to the rapid sliding, hillock groups, dammed lakes, breaches and other remnant landslide features. The collapse of the Yigong landslide was due to the uplift of the Qinghai-Tibet Plateau during the Cenozoic, the gorge landform, the climatic conditions and the regional geology.

Yimengshan National Geopark, Shandong Mount Yimengshan National Geopark is located in Linyi City in southeastern Shandong Province. It became a national geopark in 2005. The area is part of the Shandong-Huaibei Fault Uplift, which stretches NW-SE for 75 km. The highest peak (Guimeng Summit) has an elevation of 1,150 m and is composed of granite. The geomorphology includes 14 granite peaks above 1,000 m, kimberlites that produce diamonds, ultramafic rocks that produce sapphires, Cambrian limestone karst caves, Upper Cretaceous dinosaur footprints and hot springs.

Yingcheng National Mining Park, Hubei This park is located in Yingcheng City in the northern Jianghan Plain, Hebei Province, and covers an area of 300 km^2. It was designated as one of the second group of national mining parks by the Ministry of Land and Resources in May 2010. The deposits in the park mainly include Palaeogene gypsum, mirabilite and halite deposits, which are evaporates, and the mining history extends over 400 years. The park includes five mining heritage categories: mining geological heritage, mining production heritage, mining product remains, mining social life heritage, and mining development literature and historical records.

Yingde Stone Yingde stone, also known as Ying stone, is a sedimentary carbonate rock. It gets its name because it is mined in the Ying Hill in Wangbu Town, northern Yingde County, Guangdong Province. Yingde stone has a rugged texture with abrupt edges, a wrinkled shape, holes, small peak-like features and natural undulating wrinkle marks that is formed by the abrasion of water over long periods. It can be light cyan, greyish black, light green, black or white. It is hard but brittle with a fine and moist texture. It sounds like metal when struck. In contrast to Lingbi stone and Taihu stone, Yingde stone can be used for landscape gardening as well as for indoor displays, and it is generally divided into large display stones, medium display stones, component display stones and small display stones (Fig. 9).

Yingyu Yang Yingyu Yang (1956–) is a researcher and has participated in numerous tourism planning projects in Guangxi. He has published 'Dynamic Classification and Research of Tourism Landscapes', 'Research on Tourism Development of Karst



Fig. 9 Yingde stone

Landforms', 'Study of Classification of Karst Tourism Landscapes in China', 'Research on the Development of Karst Tourism Landforms in Guangxi' and 'Research on the Guangxi Danxia Landform Regional Development'.

Yixing potter's Clay Deposit, Jiangsu Located in the mountainous areas south of Yixing City, Jiangsu Province, Yixing potter's clay deposit was the earliest clay mining area in China. More than 50 clay mines (ore locations) have been developed in the deposit. The major ore strata are in the Upper Devonian Wutong Formation, the Lower Carboniferous Gaolishan Formation, and the Upper Permian Longtan Formation, while minor ore strata are in the Middle Devonian Maoshan Formation and the Lower Permian Yanqiao Formation. The clay ores are most widely distributed in the Wutong Formation. The ore types include grade-A mud (purple sandy shale, a major raw material for the pottery industry), white mud, purple sandy mud, and tender mud (water-based clay with strong plasticity). The ore field is mainly depositional, and the tender mud was formed by weathering and deposition. Research reveals that clay has been mined in Yixing City for more than 5,000 years. Today, Dingshu County is a well-developed centre of the ceramic industry, supporting and coordinating a wide range of resources, and it provides a full range of products to sustain the industry, including the establishment and operation of the Jiangsu Yixing Ceramic Institute, Jiangsu Yixing Light Industry School and Yixing Ceramics Museum.

Yiyuan Mount Lu Geopark, Shandong This geopark is located in Nanlushan Town in northwestern Qiyuan County, Shandong Province. It has a total area of 132 km^2, and the main geological features are concentrated in an area of 16.50 km^2. It became a national geopark in 2011. The geopark features groups of karst caves and granite landform landscapes with palaeo-anthropological sites and many historic and cultural features. It has the largest underground karst cave group in northern China with colourful karst chemical deposits. Ape man remains have been found in the geopark; they are from the same period as Sinanthropus pekinensis and have been named the Yiyuan Ape Man. In addition, the geopark contains various granite and limestone landforms, unique rocks, waterfalls, streams, highland wetlands, lakes, springs and other water landscapes as well as landslides and rockfalls.

Yizhou Shilin Geopark, Guangxi This geopark is located in Yizhou City, Hechi area, in the Guangxi Zhuang Autonomous Region. The geopark has a planned area of 114 km^2. It was designated as a national geopark by the Ministry of Land and Resources in December 2011. It consists of four scenic districts, including Xiangbei, Xiajian, Longjiang and Shibie. The geopark is dominated by karst landforms such as stone forests in water, karst caves and cave deposits, isolated peaks and monadnocks, karst hills, springs, peak clusters, depressions and underground rivers, typical structural geological features, rare plants, fossils and other natural and human landscapes. These features not only comprehensively illustrate the regional sedimentation and tectonic movements but also provide a broader stage for the development of national culture and crafts. The geopark is important for studying the evolution of landforms, sedimentation and

structure in Guangxi, and it has important scientific research and tourism value.

Yonghe Yellow River Geopark, Shanxi This geopark is located in Yonghe County in Shanxi Province, and it is situated in the Jinxia Valley section of the Yellow River. The geopark has a total area of 105 km^2, and its main geological features are concentrated in an area of 41 km^2. It was designated as a national geopark by the Ministry of Land and Resources in December 2011. The geopark has five scenic areas: Hero Bay, Yonghe Pass Bay, Guojia Bay, Hehuili and Xianren Bay. The main geological features are the incised meandering valleys that developed in the Loess Plateau and the longest yellow riverway in the world. It is the largest, most complete and concentrated meandering system in China. The main attractions include the five large headlands and bays with sand bars in front of the bays, concave erosional collapse cliffs, river terraces, meandering tributaries (including hanging valleys), giant erosional triangular facets and small islands (e.g., Shoe Island). These features are the main geological heritage in the geopark and also create the magnificent, unique and grand scenery. The well-developed loess landforms (e.g., loess tablelands, ridges, hills, gullies, columns, and sinkholes) and the loess palaeosols in the terraces correspond temporally to the Yellow River terraces, indicating close relationships between the tectonic uplift and climate change in the Loess Plateau. These features are crucial for understanding the changes in the palaeoclimate and environment in the Loess Plateau. The natural sculptures on the erosional and collapse cliffs that had been formed by weathering are impressive. The corestones formed by spheroidal weathering and the plant fossils in the sandstone along the banks of the Yellow River are also important geological features.

Yongjing Dinosaur Footprints These footprints are located on the north bank of the Yanguoxia Reservoir in Yongjing County, Gansu Province. They were unearthed by human activities. These fossils are preserved in the Early Cretaceous Hekou Formation, and the footprints are complete, clear and stand out three-dimensionally. Several arrays of footprints remain preserved, including gigantic sauropods, theropods, Ornithischia, Pterosauria, Ornithomimiformes and footprints of birds, including at least eight genera. It is the first time that so many footprints of dinosaurs and birds were discovered at one location in China. This scenario is also rare in other countries. Many dinosaur skeletons have been found in the vicinity of the footprint site, and these fossils have facilitated studies of the classification of dinosaurs, their footprints and the relationship among trace makers (Fig. 10).

Yosemite National Park, U.S.A. Yosemite National Park is located in east-central



Fig. 10 Yongjing dinosaur footprints

California near Nevada. It has a core protection area of 3,082.83 km^2. With its hanging valleys, many waterfalls, cirque lakes, polished domes, moraines and U-shaped valleys, it provides an excellent overview of different kinds of granite relief shaped by glaciation. At elevations of 600–4,000 m, it contains a great variety of flora and fauna.

Youyang Geopark, Sichuan This geopark is located in Youyang County, Chongqing, and has an area of 120 km^2. It became a national geopark in 2011. Youyang National Geopark is a large comprehensive geopark with karst peak clusters and valleys, underground karst caves, river and mountain views, and ethnic culture. The distinctive geology and climate conditions in Youyang also formed many karst sinkholes and stone forests. Youyang is one of the regions in southwestern China with the highest density of karst caves. The ten karst caves in the park have the best stalactite landscape in China.

Yu Gong (The Tribute of Emperor Yu) This book was the earliest regional geographic work in China and is one of the chapters of the Confucian classic 'Shang Shu' (Book of Documents). The author is unknown, and it is estimated to have been written in the late Warring States Period (approximately 200 BC). The book has 1,193 characters and is divided into five parts: Nine Provinces, Mountain Ranges, River Systems, Water Works and Five Uniformities. According to the respective natural conditions, the book uses the regional research approach to divide the entire territory into nine provinces: Ji, Yan, Qing, Xu, Yang, Jing, Yu, Liang and Yong. The mountain ranges, rivers, lakes, soils, minerals and transportation of each province are described. The book has important reference value for understanding the geographical, economic and social conditions of China in the pre-Qin period. It is the earliest regional geography masterpiece in China and is regarded as a pioneering work of Chinese geography.

Yu Gong Area Map (Map of Nine Provinces of Tribute of Emperor Yu) This map was drawn by Xiu Pei in the early Jin Dynasty (approximately 245 AD). It had a total of 18 articles. Pei proposed his six principles of cartography, namely, fen lu (scale), zhun wang (orientation), dao li (distance), gao xia (topography), fang xie (inclination) and yu zhi (straightness). These principles were adopted by Chinese cartographers until the end of the Ming Dynasty. It occupies an important position in the history of world mapmaking and is considered the earliest foundational scientific theory of planimetric map drawing. This reference is from 'Book of Jin: Pei Xiu Biography'.

Yuanmou Man Site ▶ Homo Erectus Yuanmouensis Site

Yuanmou-Type Soil Forest Landscape This is a representative type of sandstone landscape found in the subtropical region in Sichuan and Yunnan Provinces that is influenced by the southwest monsoon from the Indian Ocean. The parent rocks are Neogene, Upper Pliocene-Quaternary Early Pleistocene riverine and lacustrine facies semi-consolidated conglomerate, silty sandstone and mudstone, and the landscape features were formed by rainstorm action into a network of depressions, channels and groups of mixed-level earth pillars that look like a forest from a distance. In 1977, Qian Fang called it the 'soil forest landscape'. The soil pillars are generally 5–20 m tall and can be up to 40 m tall. The top of each pillar has a slightly inclined slope that is actually the original ground surface. There are approximately 14 soil forests in Yuanmou, of which the rocks of Hutiao (Tiger Jumping) Beach and Banguo are mainly sandstone mixed with soils, and the rocks in Langbapu and Baini (White Mud) Bay are dominantly clay and shale. In addition to being extensively distributed in the Yuanmou Basin, the soil-forest landform is also located in the Ali Zanda Basin in Tibet, Jiangchuan, Mouding and Nanjian in Yunnan Province, Huanglianguan in Xichang, Sichuan Province, Yecheng in Xinjiang and Tianshui in Gansu Province (Fig. 11).

Yuhua Stone *Synonym:* ▶ *Rain-flower pebble*

Yuhua stones, also known as five-colour stones, are agate pebbles found in Yuhuatai in



Fig. 11 Yuanmou-type siltstone soil forest landscape – Yuanmou, Yunnan Province

Nanjing. This type of stone has long been considered the 'Queen of Stones'. This term originally referred to agate with rain and flower patterns, but all pebbles found in the gravel layers of the Yuhuatai Formation are now collectively called Yuhua stones. The main component of these stones is silica with small amounts of magnesium, manganese and copper. Yuhua stones include various kinds of agate and chalcedony as well as flint, siliceous rocks, jasper, quartz, conglomerate, silicified limestone, gravels of opal, rock crystals and structure stones. Yuhua stones have a long cultural history; along with beads, tubes, rings and semi-circular decorations, they have been unearthed from the 5,000-year-old Nanjing Yinyang cultural site (Fig. 12).

Yulong-Liming-Laojunshan National Geopark, Yunnan This geopark is located in Yulong Naxi Autonomous County, Lijiang City, Yunnan Province. It became a national geopark in 2004. The main geological relics are the Lashan red sandstone landform landscape and the evidence of ancient and modern glaciers. The Jinsha River valley geological landscape includes the Tiger Leaping Gorge of the Yangtze River and multi-level terraces. The erosion of the mountains created planes, gorges, beaches, hanging cliffs, horns, ridges, cirques, lateral moraine deposits, stone clusters, rock rivers, permafrost, landslides, collapsed boulder stacks, red sandstone peak clusters, pillars, steep cliffs, and joints.

Yuncheng Salt Lake Halite-Sodium Sulphate Deposit, Shanxi This is an inland evaporative and sedimentary salt deposit that formed in the Quaternary in eastern China. Located in the southern part of Yuncheng City, Shanxi Province, Yuncheng Salt Lake is an important saltwater lake in eastern China. It has two parts – a solid deposit and a liquid deposit. Based on the depth and distribution, the solid deposit is divided into the Jiecun mine section, the Dongtan mine section, the Xitan mine section and the Beian mine section, and the liquid deposit is divided into surface brine and interlayer brine. The surface lake water is mainly a sulphate brine. Yuncheng Salt Lake was originally known as Jiechi Lake. The mining history of the lake dates back 4,000 years. Historians believe that because of Yuncheng Salt Lake, the eastern Huanghe River region was among the first areas of development of Chinese culture.

Yungang Grottoes The Yungang Grottoes are one of the largest grottoes in China and are also a World Cultural Heritage Site. They are located in the southern foothills of Wuzhou Mountain, 16 km west of Datong, Shanxi Province. The rocks of Wuzhou Mountain are

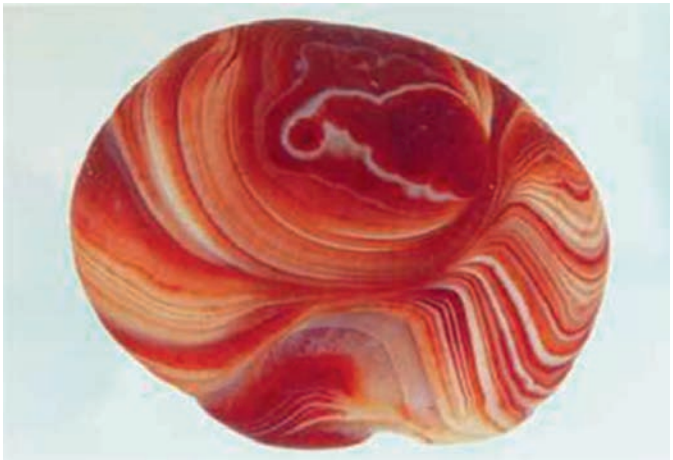


Fig. 12 Yuhua stone (agate with an attractive pattern)

Jurassic feldspar quartz sandstone. The Yungang Formation sandstone is mainly composed of carbonatite, which is hard and has a tight structure. This property facilitates the carving of statues. The Yungang Grottoes were built along an east-west portion of the mountain that is approximately 1 km long. There are 45 existing grottoes, 252 niches of various sizes, and 51,000 statues, representing outstanding Buddhism grotto art of the fifth and sixth century in China. Among them, the Five Tanyao Grottoes have a precise and unified design theme that is a Chinese Buddhism art masterpiece from the peak period (Fig. 13).

Yunju Stone Sutras The Yunju stone sutras were formerly called Fangshan stone sutras. The carving began in a temple in Fangshan, Beijing, built by the monk Jingwan during the Sui Dynasty to continue his master's career of preventing another incident of Buddhism eradication. The carving was continued by his disciples. Over a millennium from the Sui Dynasty Daye years to the Tang Dynasty Zhenguan years, more than one hundred sutras were carved, and more than 14,000 stone sutra blocks were stored in the sutra cave in Shijing (Stone Sutra) Mountain and the sutra cave beneath the south tower in Yunju Temple. Those stone blocks were made of local grey marble or dolomitic limestone. There is not a single mistake on the carved sutra blocks, and every block is a fine piece of calligraphy. The Yunju stone sutras are China's 'national treasure' and precious cultural heritage for the world. To better protect these stone blocks, a concealed storage chamber was built in situ so these valuable blocks can be protected permanently (Fig. 14).

Yuntaishan Global Geopark, China This geopark is located north of Jiaozuo City in the southern foothills of the Taihangshan Mountains, and it has a total area of approximately 556 km^2. It is characterised by rift tectonics, spectacular landscapes formed by hydrodynamic processes, ecological and cultural heritage and attractive scenery. The Yuntai landform is a result of neotectonic movements that occurred approximately 23 million years ago. A sequence of continental sedimentary rocks was deposited on the stable North China craton and records the epicontinental sedimentation from the Middle Proterozoic to the Palaeozoic. The geopark is also a natural reserve for the northernmost group of macaque monkeys in mainland China. The geopark has five scenic districts, including Yuntaishan, Shennongshan, Qinglongxia, Fenglinxia, and Qingtianhe. The main attractions are hanging springs, waterfalls, gorges, clear streams and rivers, towering rock walls and ridges.

Yuntaishan National Geopark, Henan See ► Yuntaishan Global Geopark, China.

Yunting Lu Yunting Lu (1935–2009) was the first member of the Evaluation Committee of



Fig. 13 Yungang Grotto



Fig. 14 Yunju Temple Stone Sutras Cave, Beijing

China Forest Scenery Resources, member of the National Standards Expert Group on Quality Rating and Division of Scenic Spots, National Tourism Administration, and chairman and dean of the Beijing New Record Planning and Design Institute. He engaged in tourism geography and ecotourism, agricultural tourism, and tourism planning research for many years and published more than 100 articles. His main works were 'Modern Tourism Geography', 'Ecotourism', 'Sightseeing Agriculture', 'An Introduction to Tourism Earth Science', 'Tourism Research and Planning' and 'Collection of Tourism Earth Science'. He presided over 200 tourism planning programmes and made important contributions to the development of tourism earth science in China.

Yunxian Dinosaur Eggs This site is located in the Liu Po Economic Development Zone at Qinglong Mountain, Yunxian, Hubei Province. Six strata contain dinosaur eggs. Other than certain individual strata that contain broken eggs, most layers contain fossil eggs in their original nests. These fossil eggs are mainly ovoid, spherical and oblate. The shells are light brown, dark brown or greyish white. They belong to five families Dendroolithidae, Dictyoolithidae, Faveoloolithidae, Elongatoolithdae and Spheroolithidae.

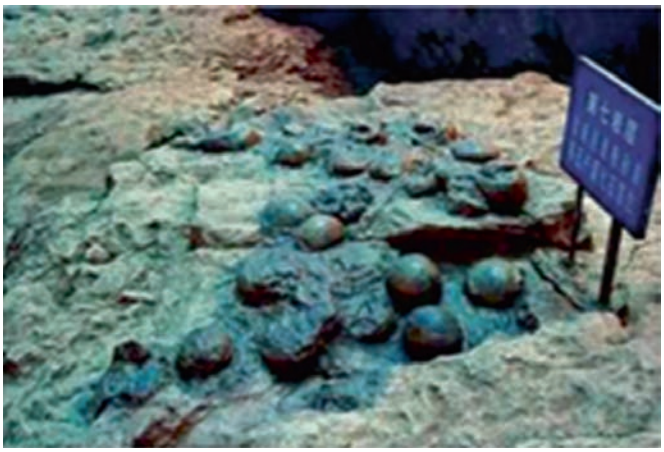


Fig. 15 Yunxian dinosaur eggs

Dendroolithidae are widely distributed and make up the largest proportion of the eggs (approximately 70%). The exposed sequence from the bottom to the top includes the Middle Proterozoic Wu Dang Group, the Upper Cretaceous and the Quaternary. The Upper Cretaceous strata are mainly composed of breccias, brecciated siltstones and fine sandstones, and the dinosaur eggs are mainly embedded in the sandy conglomerate layer (Fig. 15).

Yunxian Dinosaur National Geopark, Hubei This geopark is located in the region of Qinglong Mountain and Hongzhaizi in Liupo Town, Bixian County, Shiyan City, Hubei Province, and in the area of low mountains and hills on the southern bank of the Han River. Yunxian Dinosaur National Geopark was designated as one of the fourth group of national geoparks by the Ministry of Land and Resources in August 2005. The geopark is a concentrated area of Cretaceous dinosaur eggs. Numerous dinosaur fossils and dinosaur egg fossils are located in the same rock layer. In the most concentrated places, the nests are less than 3 m apart, and each nest contains approximately 10 (maximum of 25) eggs. The original conditions of the dinosaur eggs have been preserved. Numerous dinosaur bone fossils have also been found in Caomaoling, the Guangou Karst Caves, Meipu Ape Man Cave and Huxiao Beach. Other interesting geological relics and natural landscapes can also be found in the geopark.

Yunyang Longgang National Geopark, Chongqing This geopark is located in Yunyang County, Chongqing City, Yunyang, and was designated a national geopark in 2005. The terrain is high in the south and low in the north, and the Qiyao Mountains, which have an elevation of 1,625 m, cross the geopark. The difference in elevation between the peak and the bottom of Huangling Gorge, which is the lowest point in the scenic area, reaches 1,400 m. The main geological landscapes include the Longgang Karst Sinkhole, Stalagmite River and Laolongkou Gorge.

Z

Zabuye Lithium-Magnesium-Borate Deposit, Tibet This is a large integrated salt deposit. Located in the basin on the northern side of the Gangdise Mountains in Zhongba County, Shigatse, Tibet, the Zabuye lithium-magnesium-borate deposit is a lake district. The Zabuye Chaka Lake district is divided into north and south regions. North Zabuye Lake holds water for the entire year, whereas South Zabuye Lake is saline. A calcareous gravel embankment is located between the two lakes. The eastern part of the embankment ends in the water, allowing water to flow between the two lakes. Lacustrine chemical sedimentation is widespread. The upper portion of the deposit is an ash-white coarse mirabilite layer, the middle portion is a silty borax layer, and the lower layer is a silty or carbonitic clay layer. The Zabuye Chaka Lake district is rich in solid salt minerals and also has large reserves of liquid salt minerals. In addition to boron, 50 other chemical elements, such as potassium, sodium, lithium, caesium and bromine, can be economically utilised. The deposit has great development prospects and is the only bromine lake in Tibet (Fig. 1).

Zaozhuangshan Xiong'ershan National Geopark, Shandong This geopark is located 8 km northeast of Zaozhuang City, Shandong Province. It became a national geopark in 2002. It is characterised by the karst landform of Xiong'er Mountain and the geomorphology of the surrounding area. This area has been named after the Zaohuang karst landform and the Xiong'er landform. The peaks are staggered and overlapping. The mountains are generally oriented NE-SW, and they are arranged parallel to each other. Xiong'er Mountain, Baoluo Mountain, the Ssangyong Great Rift Valley, the karst caverns, the Longzhua staggered rock cliff (collapsed rocks), the mountain springs, and the surrounding landforms form a unique geological landscape. Baoluo is the highest peak in the geopark; it has an elevation of 584 m and is known as the best of the 72 plateaus in Lunan.

Zesheng Yin Zesheng Yin (1937–) is a researcher at the Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences. He once served as chief planner of the Tourism Centre of the Chinese Institute of Urban Scientific Planning and Design, deputy director of the Geographical Specialised Committee of the Geographical Society of China, member of the National Tourism Technical Committee, and executive director of the Beijing Tourism Institute. From the 1960s to the 1980s, he worked on regional geomorphology, landform mapping, Quaternary paleogeography and historical environmental change. He participated in the drafting of tourism industry standards and national standards, such as the National Tourism Resources Survey Standards (1993), Tourism Areas (Sites) Quality Rating and Assessment (1999), and Tourism Resource Classification Survey and Evaluation (2003). He has been the chief editor of various tourism resources research monographs and large-scale tourism albums.

Zhada Soil Forest National Geopark, Tibet This national park is located in Zhada County, Tibet Autonomous Region, in southwestern Tibet. The Himalayas to the south and the Ayila Mountains to the north form the borders with India and Ga'er County, respectively. It is a neighbour of Pulan County to the east and Kashmir to the west. In August 2005, the Ministry of Land and Resources approved it as one of the 4th group of national geoparks. Geomorphologically, it is in the Zhada Basin, the lake basin of the Tibetan highland, which has an average elevation of 4,500 m. The Zhada Soil Forest is a unique geomorphological combination. Uneven peaks rise along the banks of the Xiangquan River, forming marvellous scenery for visitors.

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Fig. 1 Zabuye lithium-magnesium-borate mine in Tibet

Zhangjiajie Global Geopark, China See ► Zhangjiajie Sandstone Peak Forest National Geopark, China; ► Wulingyuan Scenic Area.

Zhangjiajie Sandstone Peak Forest National Geopark, China *Synonyms:* ► *Zhangjiajie Global Geopark, China*

Zhangjiajie Sandstone Peak Forest National Geopark was accredited as a global geopark in 2004. It is located in northwestern Hunan Province, China, and covers a total area of 398 km^2. It has four main scenic districts, namely, Zhangjiajie National Forest Park, Suoxiyu Valley, Tianzi Mountain and Yangjiajie Nature Reserve, in addition to Huanglong Cave. The peak forest developed in the Devonian Taiyunguan and Huangjiadeng formations and represents a unique landform that formed because of its unique tectonic location and under particular neotectonic conditions and exogenous processes. It has more than 3,000 rock peaks, including 1,000 peaks more than 200 m high, such as Jinbianyan, which exceeds 350 m. The geomorphology includes mesas, platforms, cliffs, peak clusters, peak forests, crosscuts, stone gates, arches, bridges and valleys. Karst landforms are present with features such as caves, depressions, cones, stalagmites, and underground and sinking streams. Ecologically, there are rare plant species, such as maidenhair trees, yew and liriodendrons, which provide direct evidence of the region's natural evolution. The area also has a long history of human activity and widespread ancient relics and sites.

Zhangjiajie-Type Landscape This is a representative sandstone landform in the sub-tropical climatic region of southern China. It formed on near-horizontal Middle and Upper Devonian quartzite strata as a result of geological forces associated with fluvial erosion, gravity collapse and biological weathering of plants. The landform is dominated by representative geomorphological features such as large stone pillars with straight edges, deeply cut gorges, stone walls and natural bridges. In the central part of the Zhangjiajie Global Geopark, there are more than 3,100 stone pillars of heights from tens of metres to 400 m. This landform is spectacular, and as it was first discovered in Zhangjiajie in Hunan Province, it was called the Zhangjiajie sandstone forest landform. During the Zhangjiajie International Workshop on Sandstone Landforms, which was organised by the International Association of Geomorphologists (IAG) and held in November 2010, Mr. Andrew Goudie, past chairman of IAG, Mr. Robert Wray, chairman of the International Geographical Union, and numerous experts agreed that the Zhangjiajie landform is a unique type of



Fig. 2 Zhangjiajie-type sandstone column landscape – Zhangjiajie, Hunan Province

sandstone landform with important scientific and research, educational, aesthetic and tourism value. Thus, Zhangjiajie Global Geopark is one of the best areas to study sandstone landforms (Fig. 2).

Zhangshiyan Landform This book was written by Kang Guo et al. and was published by Science Press in 2007. It explains the geomorphological characteristics, development environment, formation mechanism, evolution process and classification system of the Zhangshiyan landform. It also compares the Zhangshiyan landform to the Danxia landform and the Zhangjiajie landform.

Zhangshiyan-Type Landscape This is a type of sandstone landform found in the semi-arid and semi-humid regions of temperate northern China. This landform develops in Proterozoic quartzite-like sandstone due to tectonic uplift and gravitational collapse. This landscape contains representative landforms, such as long and enormous cliffs, terraced planked footway-like cliffs, box-like gorges, urn-like valleys, canyons, mesas, sierras and pillars. The Zanhuang Zhangshiyan landform in Hebei Province is a famous typical well-developed example (Fig. 3).

Zhangye Danxia Geopark, Gansu This geopark is located in Sunan and Linze Counties, Zhangye City, Gansu Province. The geopark has a total area of 529 km^2, and the main geological features are concentrated in an area of 93 km^2. It became a national geopark in 2011. It has typical high, cold, and arid Danxia landforms and colourful hills. In addition, the Carboniferous marine-continental sediments in the Xiaoqinglong Groove (Little Green Dragon Groove) at the centre of the geopark, the rich coral, ammonoids, odontopterid zoolites and phytoliths in the strata, and the Namurian ammonoid and phytolith belts are continuous and complete. They have become typical profiles for studying life and marine-continental sedimentation during the Carboniferous. The geopark integrates scientific research, science popularisation, tourism, historical and cultural heritage and environmental protection.

Zhangzhou Littoral Volcano National Geopark, Fujian This geopark is located in the coastal area of Zhangpu County and Longhai County in Fuzhou City, Fujian Province. It became a national geopark in 2001. It is mainly composed of Cenozoic basalt volcanic

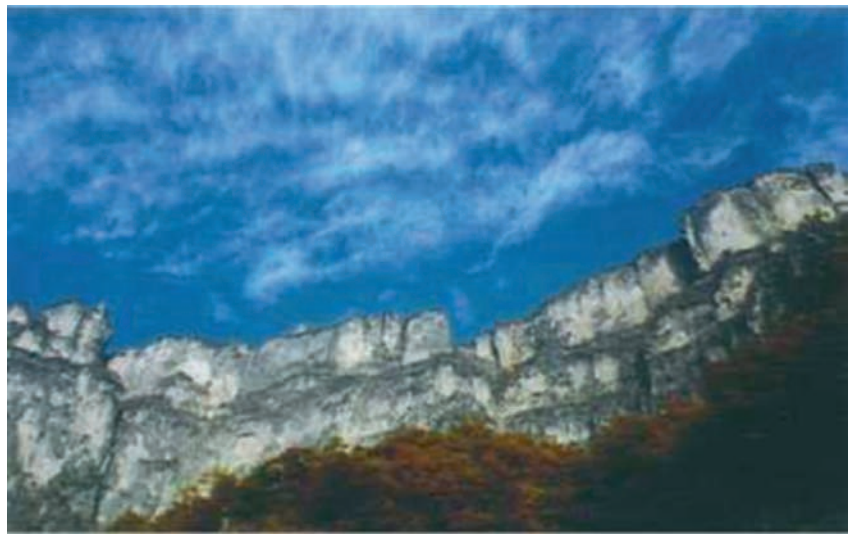


Fig. 3 Zhangshiyan-type landscape – Zanhuang, Hebei Province

geological landscapes. Due to ocean erosion, the volcanic mechanism and eruption sequence are exposed clearly. The crater is typical and well-preserved with numerous volcanic gas release vents, clusters and 1.4 million hexagonal basaltic columnar joints. The park also contains attractive sea caves, beaches and other coastal erosional landforms as well as petrified wood from ancient forests from 8,000 years ago. It is a valuable site for scientific research on the evolution of the volcanic chain in the western Pacific.

Zhangzhou Volcano Landscape, Zhangzhou This is a volcanic landscape located in the Longhai, Futan and Huiliu areas around Fuzhou City and Zhangzhou City. The volcanoes are composed of Miocene basalts. The Niutoushan crater is typical. It is located near the coast, and the exposed basalt columns form the crater. Isotope dating has dated the rocks to 11.7, 13.8, 16.7, 17.9 and 19.2 million years ago (early and middle Miocene). The Zhangzhou volcano landscape is rich in stone columns, and Nanxun Island is completely composed of basalt columns. The associated scenery is breath-taking. There are numerous lava pools with no base, which are typical. The Zhangzhou Volcano erupted concurrently with the adjacent Penghu Volcano; hence, they have many similarities but also unique characteristics (Fig. 4).

Zhanhuang Zhangshiyan National Geopark, Hebei This geopark is located in Zanhuang County, Shijiazhuang City, Hebei Province. It became a national geopark in 2004. It is situated along the upper reaches of the Huaihe River near Taihang Mountain. The most interesting geological features in the geopark are the stratigraphic structures and the Palaeoproterozoic Great Wall sandstone, which includes cross bedding and corrugated structures. Zhangshiyan is a peak in the middle part of the Taihang Mountains with an elevation of 1,774 m. The rocks are Proterozoic metamorphosed quartz sandstone that is 1.8 billion years old. The geomorphic landforms are characterised by long, steep cliffs and concave valleys. The landscape was formed by the uplift of the Taihang Mountains and undercutting and erosion by water along faults.

Zhanjiang Huguangyan National Geopark, Guangdong This geopark is located 20 km southwest of Zhanjiang City and 4 km west of Huguang Town. The national park is under the jurisdiction of the Xiashan District of Zhanjiang. It became a national geopark in 2002. The main geological remains are craters and ring-shaped volcanic hills around the lake. After the eruption of Huguangyan volcano 150,000 years ago, the volcanic crater formed the lake. It is a typical maar volcano, and the deposits are well-preserved and complete. The



Fig. 4 Basalt column landscape on Nanding Island, Zhangpu, Zhangzhou

flow structures of the eruptive materials are clearly exposed. After diagenesis, they were destroyed by faults and can be seen everywhere, providing evidence for studies of volcanic diagenesis and neotectonic movements.

Zhaomian Chen Zhaomian Chen (1938–) is a professor grade senior engineer. In 1965, he graduated from the Beijing Institute of Geology (now known as China University of Geosciences). He primarily engages in mineral surveys, regional geological mapping and management and has been the deputy chief editor and editorial director of the Regional Geology Annals of China. In 1991, he joined the China Tourism Earth Science Research Institute and served as deputy secretary-general and secretary-general. He has engaged in the research and evaluation of geological tourism resources for many years and has published approximately 20 papers. He has presided over the applications and evaluation of numerous national geoparks and wrote and edited 'A Grand Tourism Earth Science Dictionary'.

Zhaozhuang Zhongxin Coal National Mining Park, Shandong This mining park is located in Shizhong, Zaozhuang City, Shandong Province. It became a mining park in 2010 and covers an area of 21.30 km. The park is divided into two parts: north and south. The park is located in the Taozao Basin, which is a substructure of the Luzhong Block, at the eastern end of the Taozao Coalfield. The strata in the mining area are of the North China type. The coal-bearing strata are in the Carboniferous-Permian Taiyuan Formation and Shanxi Formation, which are offshore coal formations containing 18 thick and thin coal seams. The park is dominated by the Zhongxing Coal Mine, which has displays of mineral production equipment and other artefacts. The park represents the world's best mining and processing science and technology and integrates natural and cultural elements to make the mining scientifically valuable and attractive.

Zhashui Karst Cave Geopark, Shanxi This cave geopark is located in Zhashui County, Shangluo City, Shaanxi Province. It has a total area of 140 km^2, and the most important geological features are concentrated in an area of 70 km^2. It became a national geopark in 2011. It has three scenic districts: Zhashui

Karst Cave, Jiutian Mountain and Fenghuang Ancient Town. There are also attractive caves, such as Tianfo Cave, Wind Cave and Baishen Cave, as well as a typical lithofacies profile of the Devonian Shiwengzi Daoling Formation, which is a provincial nature protection site. Other features include the peak cluster of Jiutian Mountain, which is composed of Jiutian Xiaomoling diamictite, waterfalls, river terraces, and small to medium geological structures. Its karst caves, typical lithofacies profiles and the Xiaomoling diamictite are important reference locations in China.

Zhenghe Fozishan Geopark, Fujian This geopark is located in Zhenghe County, Nanping City, Fujian Province, and it has a total area of 146 km^2. Its main geological features are concentrated in an area of 35 km^2. It was designated as a national geopark by the Ministry of Land and Resources in December 2011. The geopark is dominated by volcanic geology, including volcanic rock strata, pyroclastic rocks, sedimentary pyroclastic rocks, pyroclastic flame rocks, volcanic structures, edifices and landforms. The geopark also contains various valley landforms, water landscapes, ecological landscapes and geological disaster heritage landscapes that are of great scientific value for studying the formation and evolution of regional geology and geomorphology. The geological heritage in the geopark completely illustrates the geological characteristics of the Mesozoic Pacific volcanic chain and also serves as a key to understanding the evolution of crustal movements and landforms in China's southeastern coastal areas.

Zhengzhou Yellow River National Geopark, Henan Zhengzhou Yellow River National Geopark is located in Zhengzhou, Henan, and it extends from the Zhengzhou Yellow River Railway Bridge in the east to Niukouyu Valley, Xingyang, in the west. It became a national geopark in 2005. It is characterised by the Yellow River, loess and the Yellow River culture. It contains parts of the Loess Plateau and the Mangshan Loess Plateau, and it is on the southeastern part of the transitional zone between the Loess Plateau and the North China Plain. The Taohua Valley is the boundary between the middle and lower reaches of the Yellow River, and it is also the highest point on the Huanghuai fan-shaped alluvial plain and the starting point of the perched part of the Yellow River. Lateral erosion of the south-flowing Yellow River has formed steep banks and deep gullies on the northern side of the Mangshan Loess Plateau, exposing the thickest section of the Malan Loess in the country. The huge statues of Emperor Yan and Emperor Huang that were built in the geopark symbolise that the Yellow River and the Loess Plateau are the cradles of Chinese culture.

Zhenxi Gao Zhenxi Gao (1907–1991) was a native of Xingyang County, Henan Province. He was a geologist and academician at the Chinese Academy of Sciences. He graduated from Peking University in 1931 and taught at the school. He was senior specialist of the Central Geological Survey of China. After 1950, he served as the director of the Geological Museum of China, the chief engineer, the director of the Science Popularisation Committee of the Geological Society of China, and the scientific adviser of the China Tourism Earth Science Research Institute. He established the Meso- to Neoproterozoic section in Ji County, Tianjin, which has become the basis for studying Proterozoic strata in China. His writings include 'Sinian Strata in Northern China', 'Karst Topography', and 'Mountains, Water System and Coast of Fujian'. He contributed greatly to earth science popularisation and the development of tourism earth science in China.

Zhenyang Wu (Young Ng) Zhenyang Wu (1957–) was born in Myanmar and is a native of Jinjiang City, Fujian Province. He graduated from the Department of Geography and Geology of the University of Hong Kong and obtained his master's degree from Imperial College, London University and a PhD from the School of Geosciences, Sydney University. He is the founder and ex-chairman of the Association for Geoconservation, Hong Kong. He

is a pioneer in geoconservation in the Asia Pacific region and has played important roles in the establishment of the Hong Kong Geopark of China and the dissemination of tourism earth science in China, Hong Kong and Australia.

Zhenzhi Yang Zhenzhi Yang (1965–) is a native of Chongqing City. He is a professor at the Tourism College of Sichuan University, a doctoral tutor, a committee member of the Chinese Academy of Tourism Earth Science and Geopark Research, Geological Society of China, and director of the China Leisure and Tourism Research Centre at Sichuan University. He is also the chairman of the listed Veni Corp, which includes the Chengdu Tourism Planning and Development Corp, Beijing Veni Tourism Corp and Chengdu Veni Architectural Design Corp. He has presided over 160 national scenic areas tourism planning projects. His works include 'Tourism Resources Development and Planning', 'Tourism Project Planning', 'Tourism Original Planning', 'Tourism Development and Its Impact on Social Culture in the Tibetan Areas of the Eastern Qinghai-Tibet Plateau, 'Scenic Area Upgrade and Service Quality Management', 'Coordination of Urban-Rural Development and Rural Tourism', and 'Cultural Memory of Sceneries'.

Zhijindong Cave National Geopark, Guizhou This geopark is located in the western part of Zhijin County, Guizhou, and it covers an area of 170 km^2. It became a national geopark in 2004. The park consists of three scenic areas: Dongfeng Lake, Zhijin Historical City and the Bi Yun Lake. The geopark is characterised by karst geological and geomorphic landscapes as well as the Zhijin caverns, which contain a wide variety of cavern calcareous deposits and unique graceful shapes, such as tall palm-like pillars. There are also peak clusters, stone forests, solitary peaks, residual hills, pillars, sinkholes, gorges, karst lakes, springs, underground rivers, arches, caves and other features.

Zhiyu Man Site The Zhiyu Man site is a site of ancient human fossils. It is located in the gravel layer of the secondary terrace along the Zhiyu River in the Datong Basin, Shanxi Province, and it was discovered in 1963. The site contains many cultural relics, including 15,000 stone artefacts, such as arrows, serrated blades, an 'axe-shaped small stone knife' with a collar, as well as burned stones, burned bones, a graphite decoration and many artificially smashed animal bones. The site includes 15 species of mammals, most of which are typical grassland types, including Equus ferus przewalskii, Equus hemionus, Procapra przewalskii, Gazella subgutturosa, Coelodonta antiquitatis, Wang's wild horse, Megaloceros ordosianus, Cervus elaphus, Crocuta crocuta, tiger and Myospalax fontanieri. They lived during the late stage of the Late Pleistocene. C-14 dating dates them to 28,000 years before present.

Zhongping Fu Zhongping Fu (1941–) is male and is a native of Huai'an City, Jiangsu Province. He is a professor grade senior engineer and has long been engaged in tourism research and teaching. He has edited and compiled 15 books, including 'Rare Treasure in Guangxi', 'Famous Sceneries of China', 'China Tourism Geology and 'Geologists Talk about Landscapes', and has written more than 100 academic papers.

Zhucheng Dinosaur National Geopark, Shangdong Zhucheng (Shangdong) Dinosaur National Geopark was included in the fifth group of national geoparks by the Ministry of Land and Resources in August 2009. It is famous for its Cretaceous dinosaur fossils and geological cross-sections. More than 12,000 dinosaur fossils have been unearthed, including hadrosaur vertebrae fossils, fossils of new species of dinosaurs, and fossils showing pathological changes. The colossal Zhucheng dinosaur fossil is approximately 16.60 m long and 9.10 m high. Other fossils include Mammuthus, Palaeoloxodon, fish, bivalvia, gastropods, conchostracans, ostracods, insecta, and plantae. The Cretaceous Laiyang Group, Qingshan Group and Wangshi Group are also located in the geopark, and laterite layers are widely scattered in the Wangshi Group.

Zigong Dinosaur National Geopark, Sichuan See ►Zigong Global Geopark, China.

Zigong Global Geopark, China This geopark is located in Zigong City, Sichuan Province, and covers an area of 37 km^2. It became a global geopark in 2008. It has three major scenic districts, the Dashanpu Dinosaur Fossil Relic Site, Zigong Salt Industry Park and Ronglong Qinglongshan Dinosaur Fossil Site Relic Site. The geopark has different functional areas for scientific research, popularising science, ecotourism, and historical and cultural exploration. It is a famous salt city and an important dinosaur fossil region of China. Large numbers of precious dinosaur fossils have been discovered in the area, which can be categorised into 3 classes, 11 orders, 15 families, and nearly 20 species. A considerable portion of these fossils are from a new genus and new species, including the longest (20-m-long) Asian dragon, a long herbivorous dinosaur, a fierce predatory dinosaur, a short-bodied dinosaur, and other original fossils. Stegosaurus has high scientific and tourism value.

Zigong Triassic Brine Deposit, Sichuan This is the first brine deposit in China that was drilled to extract underground brine for edible salt. The Zigong Triassic brine deposit is located in the Ziliujing, Gongjing and Da'an Districts of Zigong City, Sichuan Province. Zigong is famous around the world as the 'Millennium Salt Capital' and 'Hometown of Dinosaurs'. The deposit is located in an anticline in the southwestern Sichuan Basin and has a simple geological structure. On the northwestern side, there are three lens-shaped rock salt bodies in Dashanpu, Dafenbao and Guojiaao. The deposit contains both brine and rock salt. Historical records reveal that producing salt from yellow brine in artesian wells began in the First Taikang Year of Emperor Wu in the Western Jin Dynasty (A.D. 280) (Fig. 5).

Zircon Zircon is also known as 'zircon quartz' or 'hyacinth stone', and the chemical formula is $Zr(SiO_4)$. It usually contains hafnium, niobium, tantalum, thorium, and uranium. Its crystals belong to the tetragonal system. The crystals have a tetragonal columnar form or tetragonal twins, and the aggregates are granular. It has an adamantine lustre, a specific gravity of 4.7, and a Mohs hardness of 7–8. It mainly forms in igneous rocks, especially alkaline rocks. Zircon is heat-resistant (melting point of 2,750 °C) and corrosion-resistant. It is generally used in the foundry industry as well as for manufacturing acid-resistant and fire-resistant glassware. It is also the raw material for the extraction of zirconium and hafnium. As it has a high refractive and dispersion index, colourless and transparent zircon has become a substitute for diamond. Gem-grade zircons are mainly clastic minerals found in gravel layers. The major production countries include Sri Lanka, Thailand, Laos and Cambodia.

Zircon Gem Zircon is a gem-grade zirconium silicate that is known as 'zircon quartz' in Chinese. Its composition is $Zr[SiO_4]$, and it has a Mohs hardness of 7–8, a diamond-like vitreous lustre, a refractive index of 1.92–1.98, a birefringence of 0.059 and a high light dispersion index of 0.038. Colourless zircon is a common substitute for diamond. Gem-grade zircon is mostly a clastic mineral found in gravel layers. Famous mining countries include Sri Lanka, Thailand, Laos and Cambodia (Fig. 6).

Zirkustal, Firn Basin; Icehouse Landscape A firn basin is also known as an ice cellar or snow grain basin. It is a landscape composed of a bedrock depression filled with ice at the source of a valley glacier. It has mountains on three sides, a flat bottom and an exit connected with the glacier valley.

Ziyuan National Geopark, Guangxi This geopark is located in the Guangxi Zhuang Autonomous Region and covers an area of 729 km^2. Its northwestern border is close to Xinning County in Hunan Province, and it is characterised by the Danxia landform that highlights the main peak of the mountain. It became a national geopark in 2002. Bajiao Zhai is the main peak, which is a square



Fig. 5 Zigong Triassic brine mine



Fig. 6 Zircon crystal

mesa with an elevation of 814 m and a relative height of 400 m. The eastern, western and northern sides are smooth cliffs. There are also similar attractions in Tianji, Longji, Fengfanshi, Zixinda, Life and Death Valley and the Huangsha River Valley.

Zoisite The composition of zoisite is $Ca_2(Mg, Fe)_5Si_8O_{22}(OH)_2$ and the crystals have a monoclinic crystal structure. The crystals are columnar with obvious longitudinal stripes. The aggregates are blocky, dense and columnar. The colour is white, grey, green, green-brown, pink, colourless, blue or purple. Zoisite has a transparent to translucent diaphaneity, a vitreous lustre, a specific gravity of 3.55, a Mohs hardness of 6.5–7, and uneven to conchoidal fractures. It is mainly found in shallow metamorphic rocks and hydrothermal alteration zones, and it is often a product of altered basic plagioclase. Transparent zoisite can be used as a gemstone.

Zongyangshan Fushan National Geopark, Anhui This geopark is located in Shuyang County on the northern bank of the Minjiang River in Anhui Province. It was approved as a national geopark in 2002. The Fushan volcanic landform is a typical collapsed volcanic depression. It is an ancient volcano that has been extinct for millions of years. It experienced numerous eruptions during the Jurassic (200 million to 145 million years ago) to the early Cretaceous (140 million years ago), which created fascinating volcanic

landscapes, such as compound domes, craters, cones, volcanic slag (pumice) and lava flows, ring fractures, radial fractures, and turtle cracks.

Zoning Map of Geoparks This type of map is based on the scale of the relevant topographical map while considering the size of the geopark. The coordinates of the boundary of the park are measured by surveying and GPS, and they are labelled and marked on the drawings. The map should be the official size approved by government and can be used as a base for reference or calculation of the size of the geopark. The border of the geopark is marked by red dots, and the boundary of its scenic district is marked by a solid red line. The inflection coordinates of the geopark boundary are marked on the boundary, and a list of the inflection coordinates is attached to the bottom of the map.

Zoo Tourism Zoos are tourist attractions and can be categorised into comprehensive or specialised zoos. They allow the close observation of animals and entertain tourists by domestication and performances. They are also venues for animal research, breeding and protection. Famous zoos such as the Beijing Zoo, Tokyo‘s Ueno Zoo, the London Zoo, and New York’s Bronx Zoo receive millions of tourists every year.

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