An Introduction of Earth Sciences (地球科学概论）

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Semester: 2016-2017 Autumn
College: College of International Education
Time: 2016-9-1

Introduction to Me

- **Yao，Ph.D，Pro.**

From YiLi，Xinjing, China. I got my bachelor-master-doctor degree in China University of Geosciences. I became a teacher in June, 2006, and then entered into the Center for Post-doctoral Studies of Northwest University from the Sept. 2007 to Dec. 2009，at same time, got the first aid of China Postdoctoral Science Foundation. 2013.7~2014.7，Visiting Scholar, studied in Energy & Geoscience Institute, Utah University, U.S.A.. My interest includes Petroleum Comprehensive Geological Research and Geochemistry.

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Course Name: Introduction to Earth Sciences

- Textbook: HongBo Lu, An Outline of Earth Sciences, China University of Petroleum Press, 2006
- Jiao ShuQiang,Kong Hua. Foundations of Earth Science, Wuhan: China University of Geosciences Press, 2006
- **Introduction to Physical Geology - Thompson-Turk.**
- References or bibliography:
- 1. http://geology.com
- 2. Song Chunqing, etc． Geology Foundation（3rd Edition）． Beijing： Advanced Education Publishing． 2002
- Requirement in class: Make important notes
- Requirement after school: Preview and review
- Tests and Scores: 30% Average Grade, 70% Finial Test

Homework

- What are the Earth sciences and geology?.
- State the two key objectives of geology.
- State the principle of actualism and try to understand "the present is the key to the past".
- What is geological process? State the differences between endogenic geological process and exogenic geological process, considering their origin and energy.
- Reciting the geological time scale.
- What are planets of the solar system? Which are the terrestrial planets and Jovian planets?

Chapter 1 Preface—Introduction to Earth Sciences

What Is Earth Science? The study of Earth and its neighbors in space. Learn more!

1.1 Earth Sciences and Some Related Concepts

Earth Sciences （地球科学）are the sciences related to the Earth, including many branches, such as

Geology （地质学）and its branches—mainly study the solid Earth—lithosphere

Geography（地理学）—mainly studies the surface of the Earth

Biology（生物学）—mainly studies the biosphere of the Earth

Meteorology（气象学）—mainly studies the atmosphere of the Earth

Environmental sciences（环境科学）—natural conditions for all the living things

Astronomy（天文学）—Universe—Solar System—planets and so on.

Marine geology（海洋地质学） is a branch of geology, mainly researching oceans and their processes.

Petroleum geology（石油地质学）, Structural geology（构造地质学）… …

In fact, Earth Sciences study everything about Earth. It encompasses everything from outer space to the Earth's fiery core, from the most ancient fossils to the landslides and earthquakes of today.

Introduction to Earth Science

What is Earth Science?

- **The study of the Earth and the universe around it…**

- **The study of Earth systems and systems in space; including weather and climate systems, and the study of nonliving things such as rocks, oceans, and planets.**

Introduction to Earth Science

Introduction to Earth Science

Earth's Systems

1.1.1 What is Geology

What is Geology? - The study of Earth materials, structures, processes and life over time.

- Geology is the study of the planet Earth
- It is concerned with the origin of the planet, the material and morphology of the Earth and its history and the processes acted/acting on it.
- The word “geology” was first used by a Swiss scholar—H.B. De Saussure (1740-1799) in 1779.
- The prefix “geo-” , means “Earth or land”, while the suffix “-logy” means “subject- a course or area of study”. For example, sedimentology, geochemistry.

1.1.2 The Objective of Geology

- The knowledge obtained through the study of the planet is aimed at the service of mankind. It has only two basic purposes: to get material from the Earth and to prevent damages.
- A. To discover useful materials within the Earth (maybe outside the Earth in the future) such as, metals (e.g., Fe, Al, Cu, Pb etc.) and nonmetals (rocks), energy resources (coal, oil and gas, gas hydrates, nuclear fuels, solar energies etc.) and other materials.

What is LNG? The use of LNG as an energy source is growing rapidly. Learn more about LNG.

The Many Uses of Gold - Unique properties make gold one of the most useful metals.

The Uses of Marble are numerous and diverse. You will be surprised by how it is used.

1.1.2 The Objective of Geology

- The knowledge obtained through the study of the planet is aimed at the service of mankind. It has only two basic purposes: to get material form the Earth and to prevent damages.
- B. To provide a foreknowledge of dangers associated with the mobile forces of a dynamic Earth (to avoid dangers related to the Earth), such as earthquake, volcanic eruption, flood, slide and mudflow, subsidence of land surface etc.

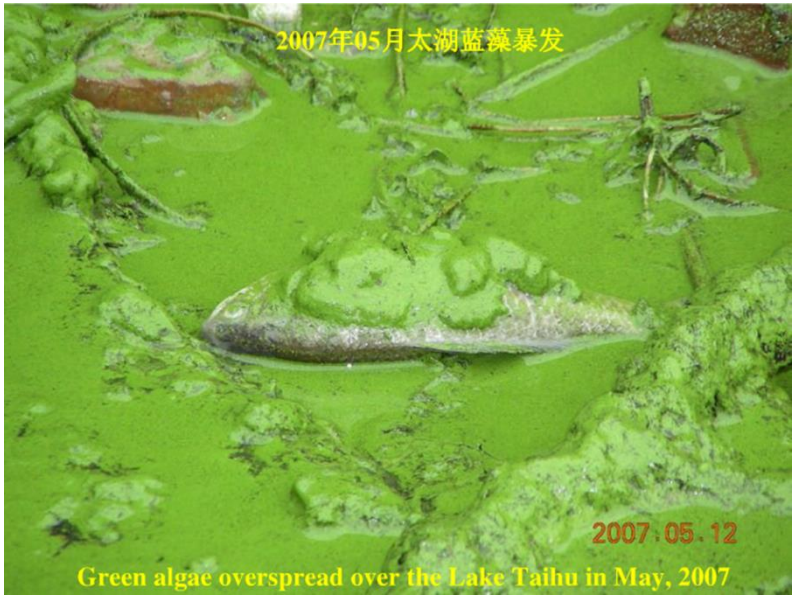
Volcanic Explosivity - Rating volcanic eruptions based upon the volume of tephra ejected.

Landslide Incidence Map - A USGS map showing landslide incidence in the United States.

Earthquake

1.1.2 The Objective of Geology

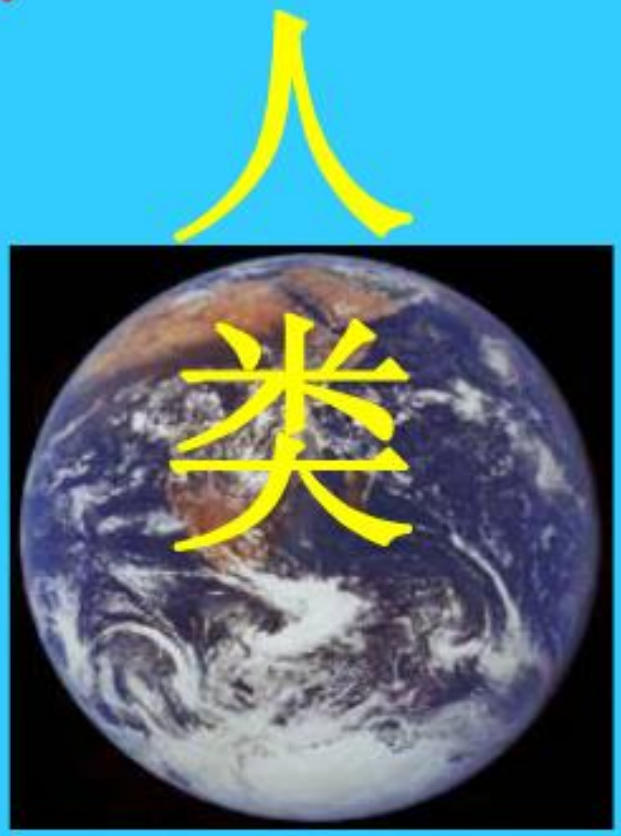
- The knowledge obtained through the study of the planet is aimed at the service of mankind. It has only two basic purposes: to get material form the Earth and to prevent damages.
- C. To protect environments and improve our living conditions (such as to prevent and diminish the pollution of air and water).
- How to solve this problem?



Firework factory explosion in Guangdong (2008.02.15)

The Earth—our only home—smaller, weaker, and more vulnerable!
Mankind—stronger! =? (selfish, greedy, stupid…)
Clever enough to be in harmony with the nature?

人类：足够强大！
足够聪明否？
如何更聪明？



地球：我们唯一的家园

We need knowledge in Earth Sciences!

The scientific study of the Earth has never been so important a concern for all the people as it has become today. The four essential determinants of human well-being –energy, food ,health and water are all topics directly or indirectly discussed in the course of Earth sciences. The Earth provides us with all the essential elements for human endeavor, but the activity of human being has exerted such a huge impact on the Earth that we are now talking about “future of human being”.

And therefore, a knowledge and understanding of our planet is critical to our social well-being and indeed, vital to our survival.

1.1.3 The method of geology (methodology)（地质学的研究方法）

The Earth was formed about 4.6 billion (4,600 million) years ago. It has been changed greatly (from the beginning) and is still changing. According to the result from the change, geologists want to know the events happened in the Earth's history. This is very difficult. Like detectives and historians, geologists use the result to analyze its origin, or collect the relic or even traces to reveal the past events. Thus, geology is a special science, because:

a. **The world in which we live is the best laboratory**. Either the scale of space and time needed for the experiments are too large, or the experiments would cause the environment to change in some unfortunate way. We must treat nature as the best laboratory and museum.（大自然是地质学最好的实验室和博物馆：我们所知道的自然奥秘仅是微小的部分，因此地质学是我们一生的学科，实践越多，知识就越多。Geologists = fieldwork + laboratory + reasoning）

b. **Geologic theories** strongly depend on the basic scientific disciplines of physics and chemistry, biology and others, depending on technology advances (progress). 对科技的依赖与促进（如：测年）

c. **The principle of actualism**. 现实主义原则、 将今论古原理

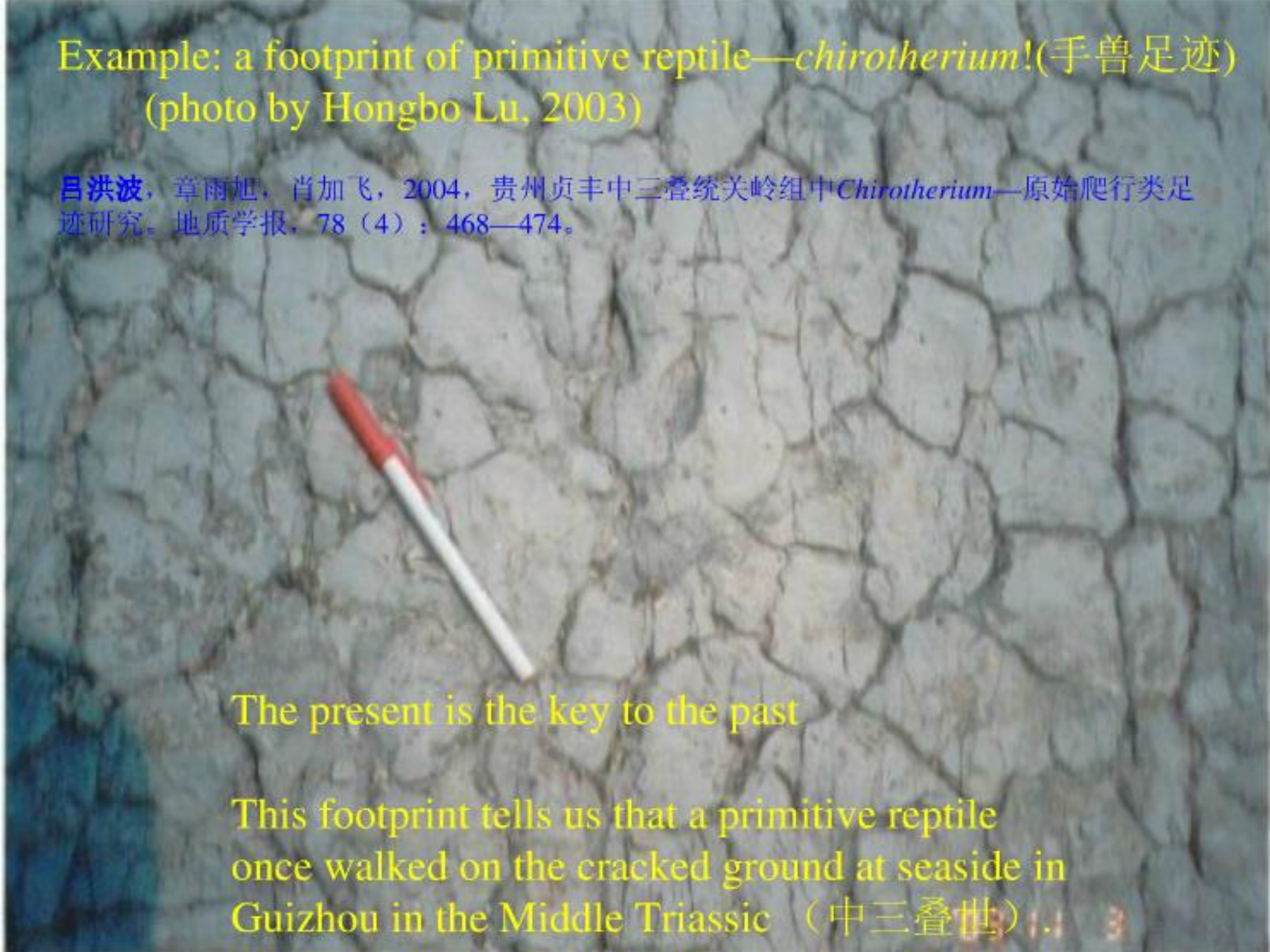
"The present is the key to the past." 现在是认识过去的钥匙

The doctrine is that: geologic processes and natural laws now operating to modify the Earth's crust have acted in the same regular manner and with essentially the same intensity throughout geologic time, and that past geologic events can be explained by phenomena and forces observable today. The doctrine does not imply that any change has a uniform rate, and does not include minor local catastrophes. The doctrine is called **Uniformitarianism**（均变论）, originated by **C. Lyell** (1797—1875) in his book **<The principles of Geology>** in 1830. （大自然不是简单的重复，而是演化的，人类可以从过去的历史中学到某些有用的东西，在将今论古的同时，也要以古鉴今。如：动物演化问题）

Geology is a young science (only 200 years). It was born under the demand of industry and military usage for raw materials in the 18th century. So we have a lot to do in the future.

Example: a footprint of primitive reptile—*chirotherium*!(手兽足迹)
(photo by Hongbo Lu, 2003)

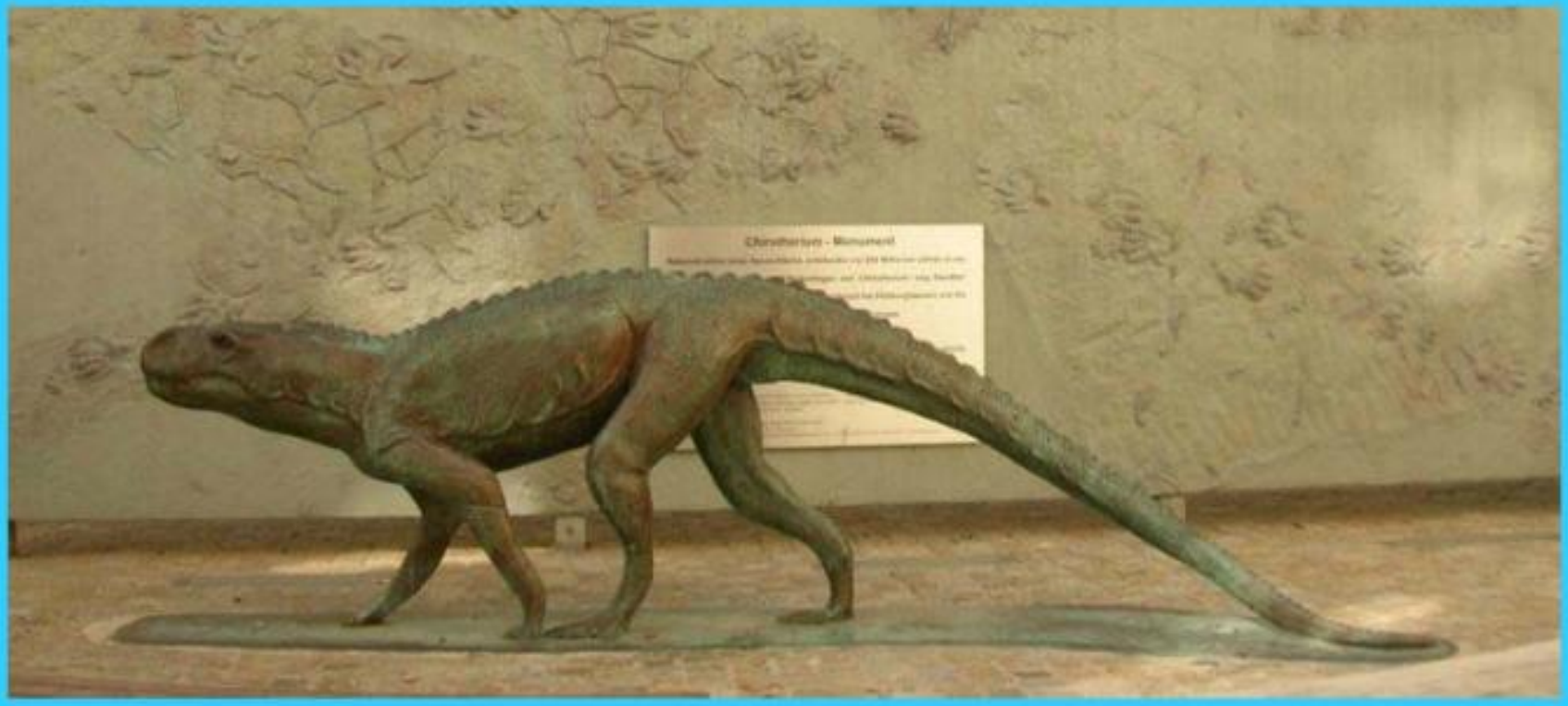
吕洪波，章雨旭，肖加飞，2004，贵州贞丰中三叠统关岭组中*Chirotherium*—原始爬行类足迹研究。地质学报，78（4）：468—474。



The present is the key to the past

This footprint tells us that a primitive reptile once walked on the cracked ground at seaside in Guizhou in the Middle Triassic （中三叠世）

A imagined primitive body of "*Chirotherium*"



Downloaded from the Internet

Introduction to Earth Science

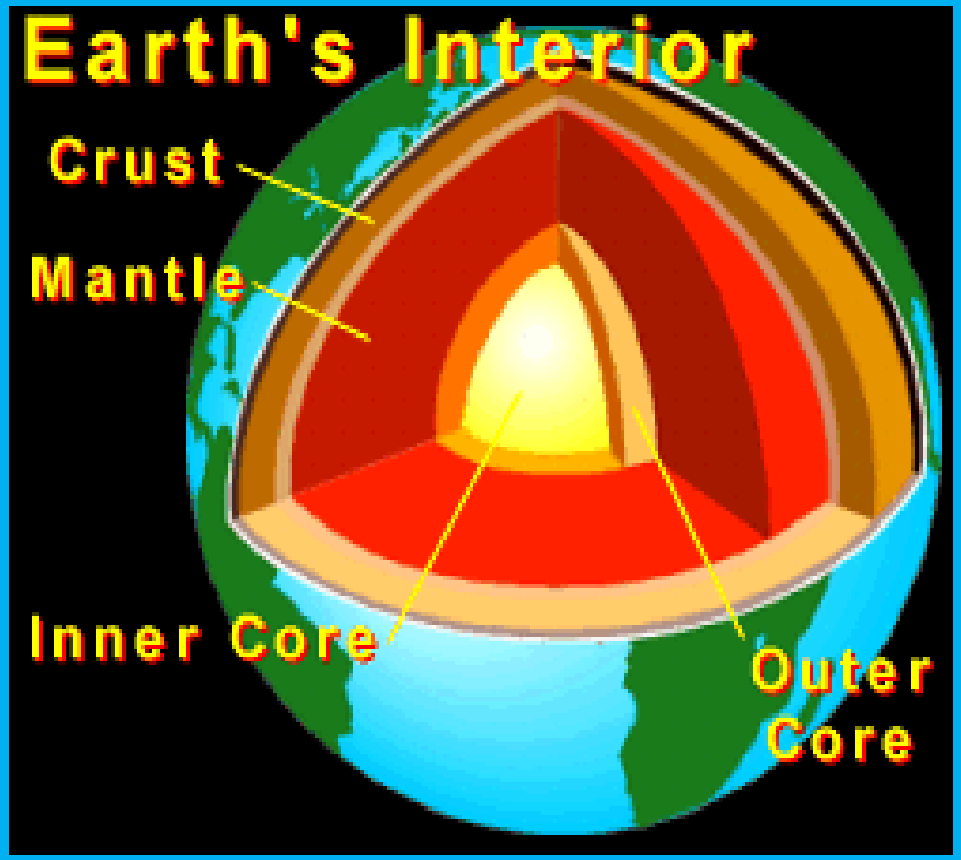
一. Spheres of the Earth

1. Geosphere:

the area from the surface of Earth down to its center.

Three main parts:

- Crust
- Mantle
- Core
  - Inner core
  - Outer core



Introduction to Earth Science

Earth consists on layers;

Average depth of Earth layers:

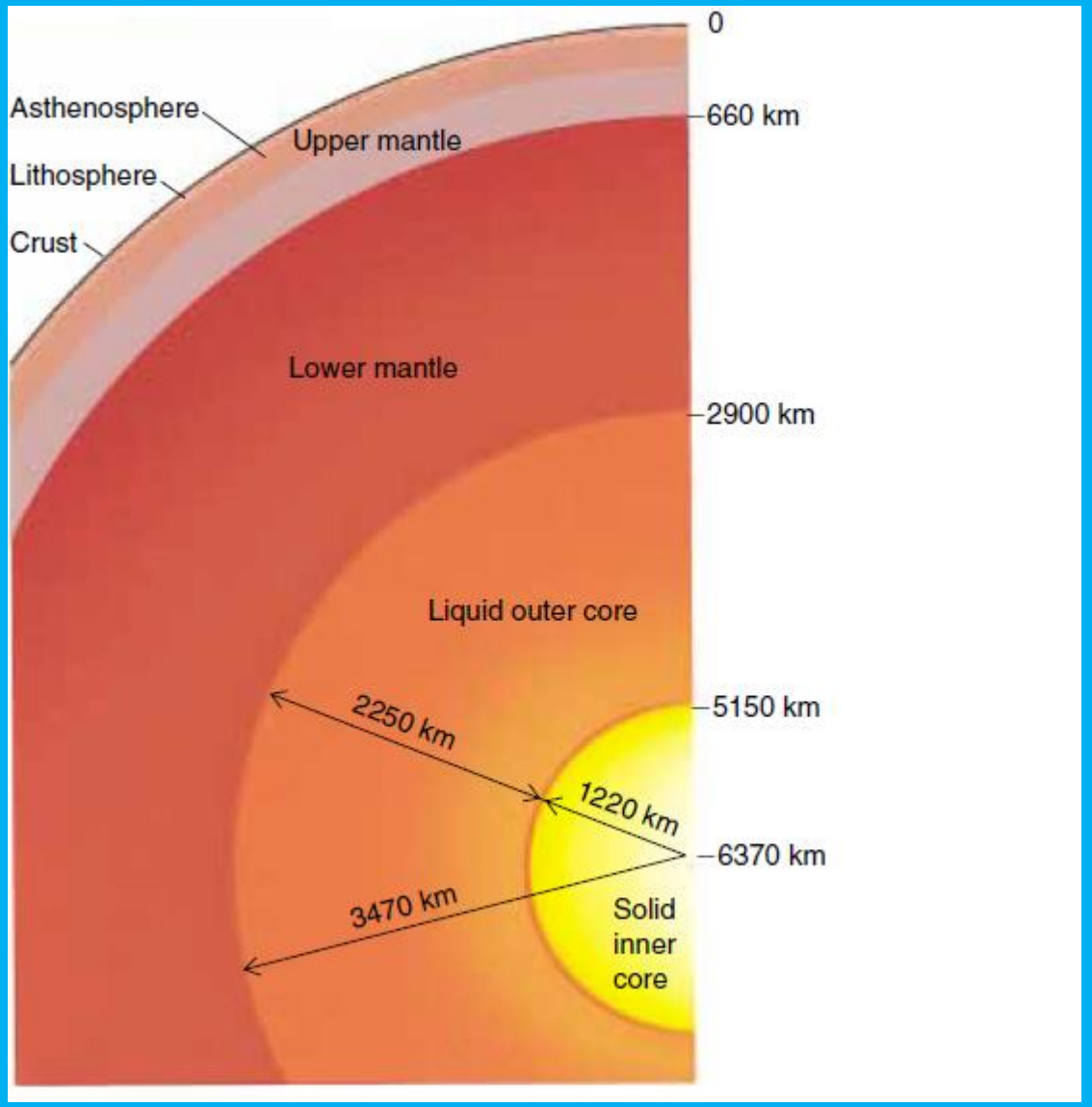
Crust 30-40 km

Upper mantle Up to 660 km

Lower mantle 660-2900 km

Outer core 2900-5150 km

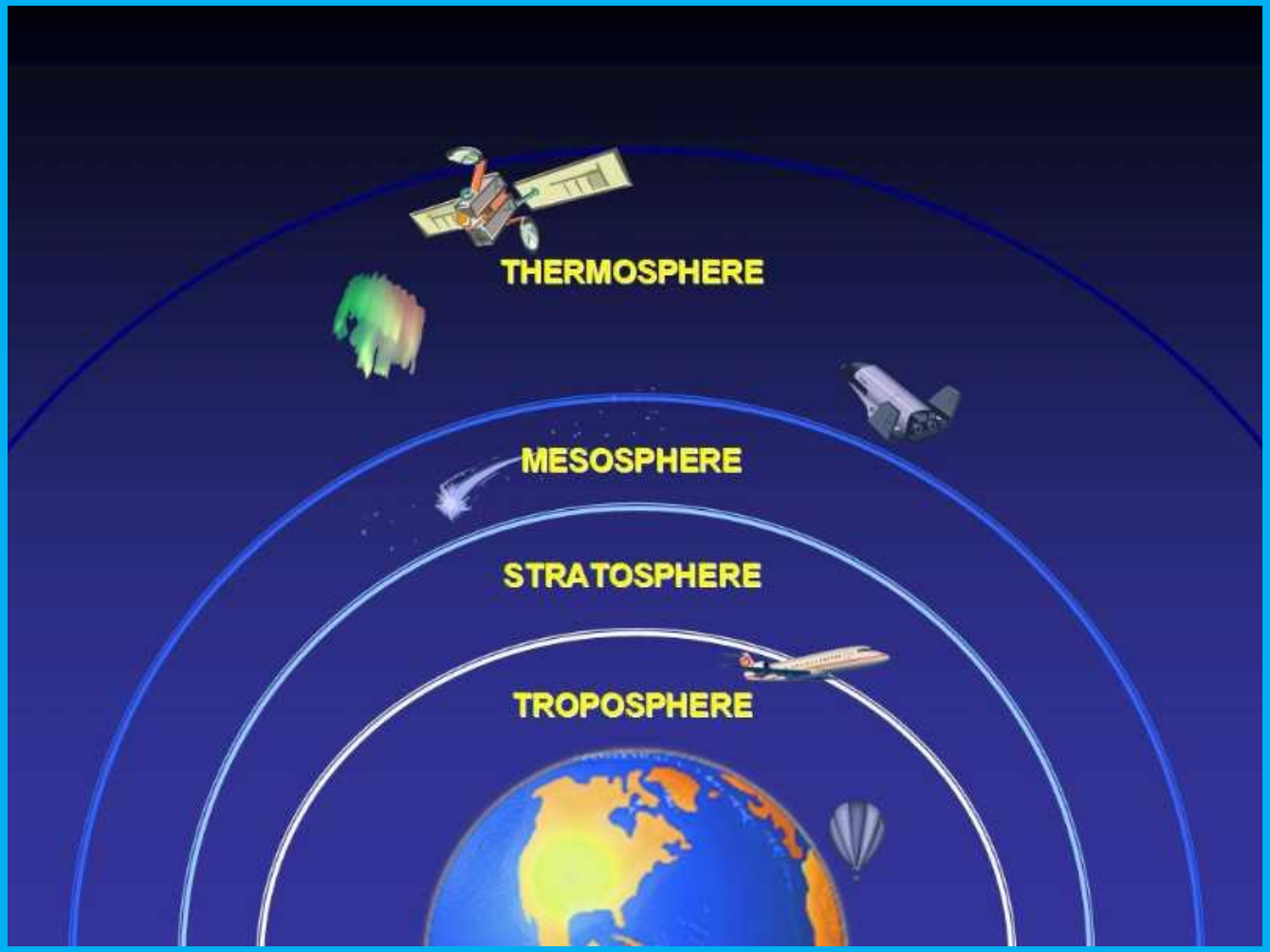
Inner core 5150-6370 km



Introduction to Earth Science

2. Atmosphere:

The blanket of gases that surrounds our planet.



Introduction to Earth Science

3. Hydrosphere:

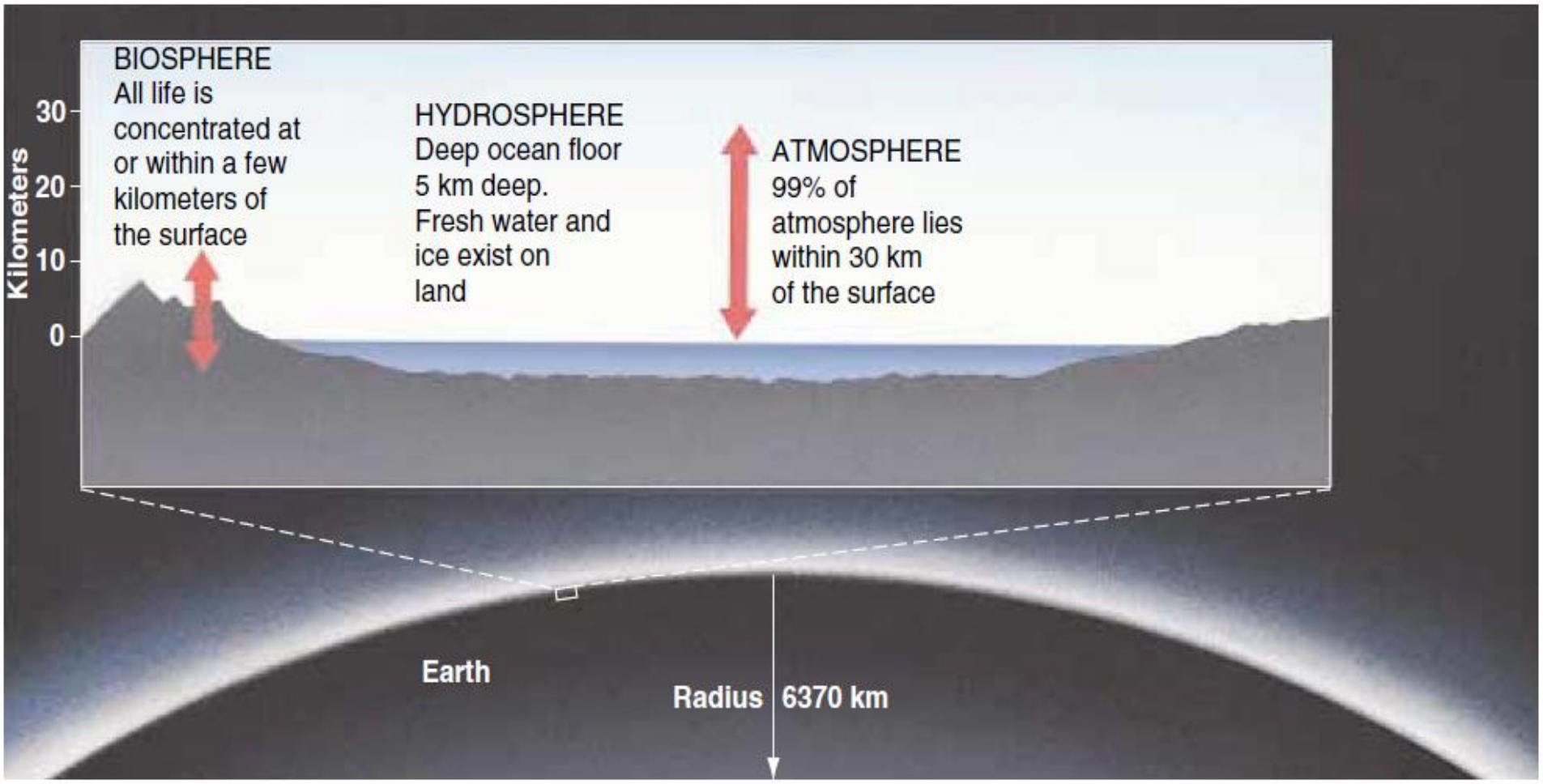
All the water on the Earth. About 71 percent of the Earth's surface is water-covered, and the oceans hold about 96.5 percent of all Earth's water.

Introduction to Earth Science

4. Biosphere:

All organisms on Earth and the environments in which they live.

Introduction to Earth Science



Introduction to Earth Science

二、What is Geology?

Geology is the study of the Earth, including the materials that it is made of, the physical and chemical changes that occur on its surface and in its interior, and the history of the planet and its life forms.

Most of the Earth is composed of rocks. Rock outcrops form some of our planet's most special scenery. Rocks, in turn, are composed of minerals. Although more than 3500 different minerals exist, fewer are very common. Geologists study the origins, properties, and compositions of both rocks and minerals.

Introduction to Earth Science

What a Geologist do?

Geologists explore the Earth for the resources needed in our technological world: fossil fuels such as coal, petroleum, and natural gas; mineral resources such as metals; sand and gravel and fertilizers. Some search for water in reservoirs beneath Earth's surface.

Introduction to Earth Science

Branches Of Geology:

Geology is the science which is devoted to the study of earth. It deals with all of the earth's surface and with the origin, composition, structure and inhabitants of the earth.

1. Economic geology: Economic geology is concerned with earth materials that can be used for economic and/or industrial purposes. These materials include precious and base metals, nonmetallic minerals, construction-grade stone, petroleum minerals, coal, and water.

Introduction to Earth Science

Branches Of Geology:

2. Crystallography: is the experimental science of determining the arrangement of atoms in the crystalline solids.

3. Mineralogy: The study of minerals, its composition and properties.

4. Physical geology (Geophysics): concerned with the physical processes and physical properties of the Earth and its surrounding space environment, and the use of quantitative methods for their analysis.

Introduction to Earth Science

Branches Of Geology:

5. Petrology: studies the origin, composition, distribution and structure of rocks.

6. Structural geology (Tectonics): the study of the three-dimensional distribution of rock units with respect to their deformational histories.

7. Stratigraphy: studies rock layers (strata) and layering (stratification). It is primarily used in the study of sedimentary and layered volcanic rocks.

8. Paleontology: is simply the study of ancient life; the study of fossils to determine organisms' evolution and interactions with each other and their environments (their paleoecology).

Introduction to Earth Science

Branches Of Geology:

9. Mining geology: an applied science which combines the principles of economic geology and mining engineering to the development of a defined mineral resource.

10. Geology engineering (Geotechnics): is the application of scientific methods and engineering principles to the acquisition, interpretation, and use of knowledge of materials of the Earth's crust and earth materials for the solution of engineering problems and the design of engineering works.

11. Geochemistry: is the science that uses the tools and principles of chemistry to explain the mechanisms behind major geological systems such as the Earth's crust and its oceans, even the entire solar system.

Introduction to Earth Science

Branches Of Geology:

12. Hydrology: study of the movement, distribution, and quality of water on Earth and other planets, including the hydrologic cycle, water resources and environmental watershed sustainability.

13. Sedimentology: is the study of modern sediments such as sand, silt, and clay, and the processes that result in their formation (erosion and weathering), transport, deposition and diagenesis.

14. Volcanology: is the study of volcanoes, lava, magma, and related geological, geophysical and geochemical phenomena.

Introduction to Earth Science

Geologic processes

The term "geological processes" describes the natural forces that shape the physical makeup of a planet. Plate tectonics, erosion, chemical weathering and sedimentation are all examples of forces that significantly affect the Earth's surface and account for its major features. These processes are closely studied by geologists and earth scientists to improve their understanding of the planet's history; to help locate useful resources, such as metal ores; and to aid the prediction of potentially disastrous events, such as earthquakes, tsunamis and volcanic eruptions.

1.1.4 Geologic process and its energy（地质作用及其能）

Geologic process is any natural process that causes the change in composition, morphology and other aspects of the Earth.

地质作用包罗万象，大到火山喷发（内力），小到细菌繁殖、蚂蚁掘洞，当然还有人类活动（外力）。

Geologic process can be divided into

a. **Endogenic geologic processes** (internal processes)（内力地质作用）:

Mainly happen inside **the solid Earth**.

Major Energy that drives the processes comes from **the Earth's internal heat**.

For example, volcanic eruption, earthquake, metamorphism are all endogenic processes.

b. **Exogenic geologic processes** (external processes)（外力地质作用）:

Happen outside the solid Earth, mainly at **the Earth's surface**.

The main energy comes from **the Sun's heat**.

The examples are: weathering, erosion, transportation, sedimentation etc.

There are some auxiliary energies（辅助能）: gravity, rotation force, gravitation from the Sun and the Moon etc.（重力、自转力、日月引力等）

Introduction to Earth Science

Earth's internal processes

Processes that originate deep in the Earth's interior are called internal processes. These are the driving forces that raise mountains, cause earthquakes, and produce volcanic eruptions.

Builders, engineers, and city planners might consult geologists, asking, "What is the probability that an earthquake or a volcanic eruption will damage our city? Is it safe to build different structures in the area?"

Introduction to Earth Science

Earth's surface processes

Surface processes are all of those processes that sculpt (shape) the Earth's surface. Most surface processes are driven by water, although wind, ice, and gravity are also significant.

Introduction to Earth Science

UNIFORMITARIANISM AND CATASTROPHISM:

Uniformitarianism:

The principle states that geologic change occurs over long periods of time, by a sequence of almost imperceptible (unable to notice) events. James Hutton guessed that geologic processes operating today also operated in the past. Thus, scientists can explain events that occurred in the past by observing changes occurring today. Sometimes this idea is summarized in the statement "The present is the key to the past."

Introduction to Earth Science

UNIFORMITARIANISM AND CATASTROPHISM:

Catastrophism:

William Whewell, another early geologist, agreed that the Earth is very old, but he argued that geologic change was sometimes rapid. He wrote that the geologic past may have "consisted of catastrophic action (sudden actions)." Whewell was unable to give examples of such catastrophes. He argued that they happen so infrequently that none had occurred within human history.

Introduction to Earth Science

UNIFORMITARIANISM AND CATASTROPHISM:

Today, geologists know that both Hutton's uniformitarianism and Whewell's catastrophism are both correct.

In geological research, we always want to know how these subsurface deposits of resources are located and when they generated.

Introduction to Earth Science

三、GEOLOGIC TIME SCALE:

Today, geologists estimate that the Earth is about 4.6 billion years old.

Geologists have divided Earth history into units displayed in the geologic time scale. The units are called eons, eras, periods, and epochs and are identified primarily by the types of life that existed at the various times. The two earliest eons, the Hadean and Archean, cover the first 2.5 billion years of Earth history. Life originated during Archean time. Living organisms then evolved and proliferated during the Proterozoic Eon (protero is from a Greek root meaning "earlier" or "before" and zoon is from the Greek word meaning "life").

GEOLOGIC TIME SCALE

The geologic time scale was formulated during **the early 1800s** on the basis of information gained by relative age dating of sedimentary rocks and fossils in Europe. The largest divisions of geologic time are called eons. Eons are **subdivided into** eras, eras into periods, periods into epochs, and epochs into ages. The geologic time scale is presented in the Table above.

GEOLOGIC TIME SCALE

Eon	Era	Millions of years ago
Phanerozoic	Cenozoic	66
	Mesozoic	251
	Paleozoic	542
Precambrian	Proterozoic: Late	1000
	Proterozoic: Middle	1600
	Proterozoic: Early	2500
	Archean: Late	3000
	Archean: Middle	3400
	Archean: Early	3800
	Hadean	4600

Origin of Earth

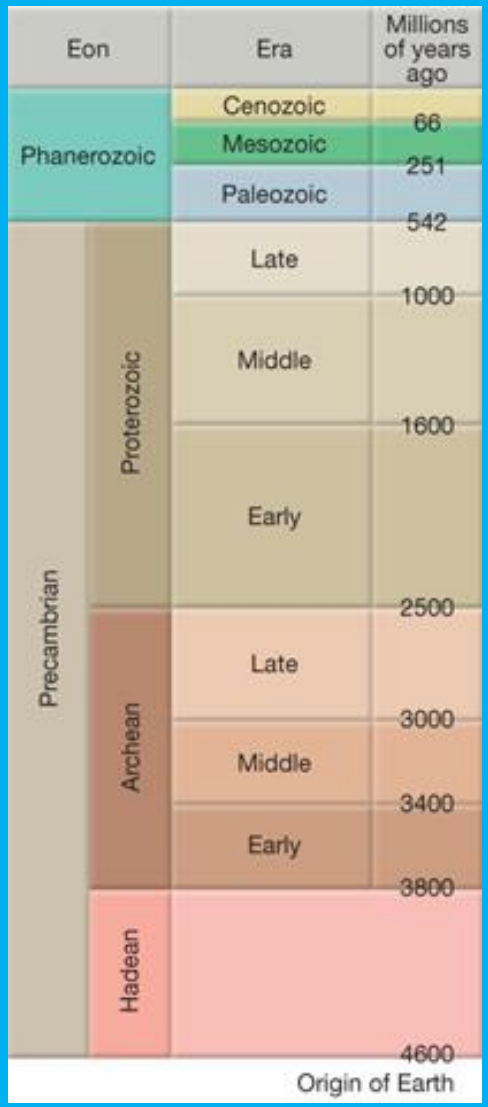
Era	Period	Epoch	Millions of years ago	Significant events in development of life
Cenozoic	Quaternary	Holocene	0.01	Humans develop
		Pleistocene	2.6	
	Tertiary: Neogene	Pliocene	5.3	
		Miocene	23.0	
	Tertiary: Paleogene	Oligocene	33.9	
		Eocene	55.8	
		Paleocene	65.5	Extinction of dinosaurs and many other species
Mesozoic	Cretaceous		145.5	First flowering plants
	Jurassic		201.6	First birds
	Triassic		251	Dinosaurs dominant
Paleozoic	Permian		299	Extinction of trilobites and many other marine animals
	Carboniferous: Pennsylvanian		318	First reptiles
	Carboniferous: Mississippian		359	Large coal swamps
	Devonian		416	Amphibians abundant
	Silurian		444	First insects
	Ordovician		488	First land plants
	Cambrian		542	First fish
Precambrian/ Proterozoic	Ediacaran		630	Trilobites dominant First organisms with shells Odd mesh-like creatures of uncertain affinity

GEOLOGIC TIME SCALE

Evidence from **radiometric** dating indicates that the Earth is about 4,570 million years old . Geologists have **divided** Earth's history **into** a series of time intervals. These time intervals **are not equal in** length like the hours in a day. Instead the time intervals are variable in length. Different spans of time on the time scale are usually **delimited** by major geological or paleontological events, such as mass extinctions. **For example**, the boundary between the Cretaceous period and the Paleogene period is defined by the extinction event that marked the demise of the dinosaurs and of many marine species. **Another example** is the boundary between the Precambrian and the Paleozoic which is marked by the first appearance of animals with hard parts.

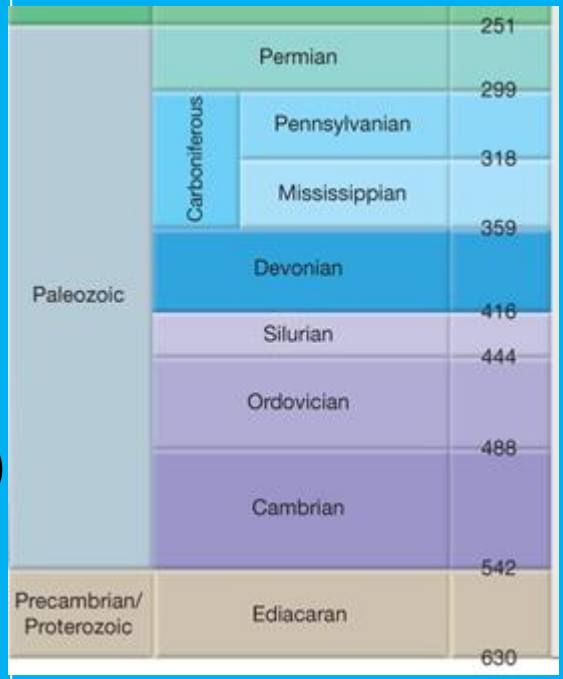
GEOLOGIC TIME SCALE

Eons are hundreds of millions of years in duration. In the time scale you can see the Phanerozoic (phaneros=“ evidence“) Eon is the most recent eon and began more than 540 million years ago. Eons are divided into smaller time intervals known as **eras**. the Phanerozoic is divided into three eras: Paleozoic (“ancient life”, Mesozoic (“middle life”) and Cenozoic (“recent life”). Very significant events in Earth's history are used to determine the boundaries of the eras.



GEOLOGIC TIME SCALE

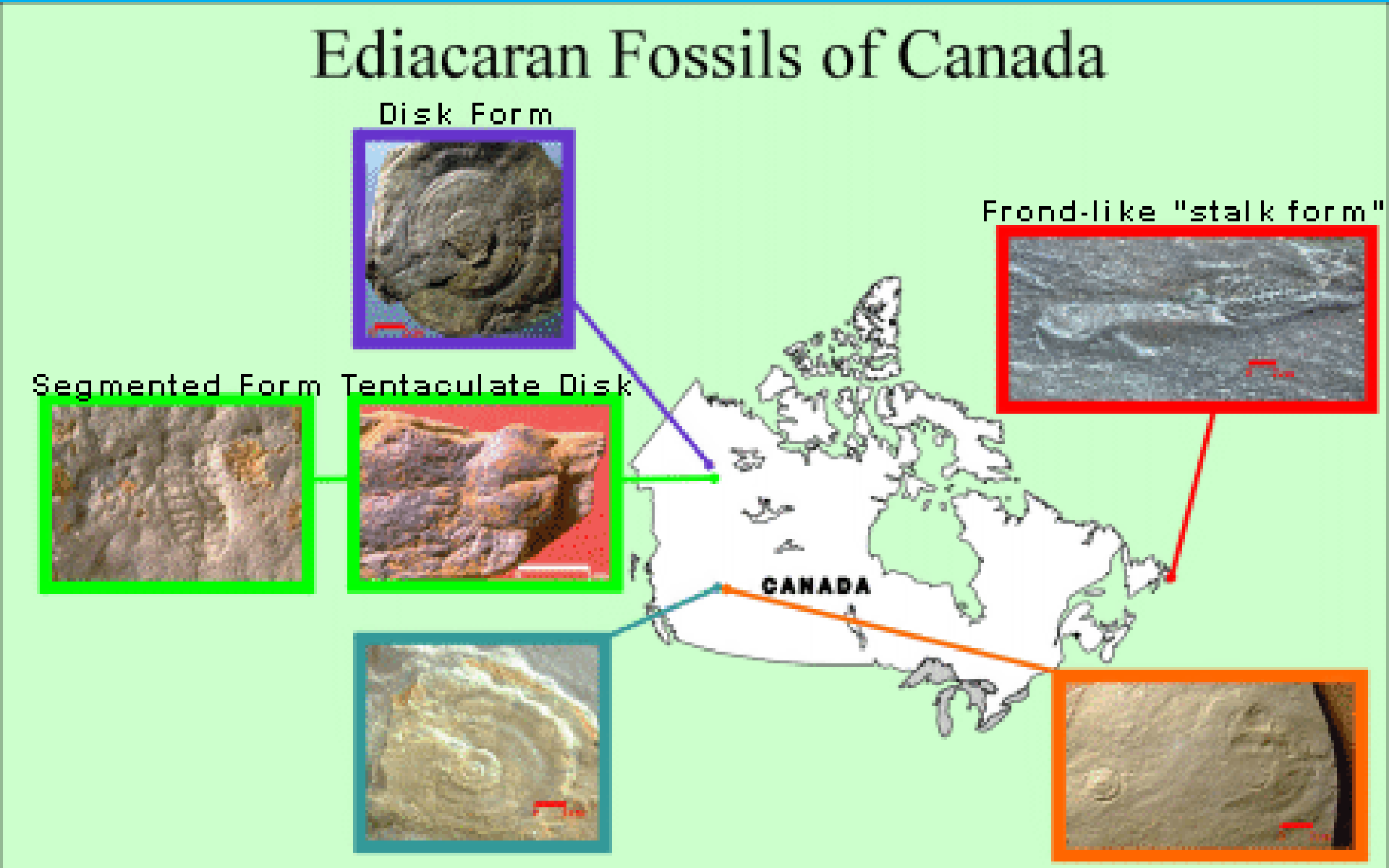
Eras are subdivided into periods. The events that bound the periods are wide-spread in their extent but are not as significant as those which bound the eras. In the time scale you can see that the Paleozoic is subdivided into the Permian, Carboniferous (Mississippian and Pennsylvanian), Devonian, Silurian, Ordovician and Cambrian periods. Each unit of the Phanerozoic interval (～542 Ma to present) and the base of the Ediacaran is defined by a Global Standard Section and Point (GSSP), whereas the Precambrian interval is formally subdivided by absolute age, radioactive age.



Ediacaran: 埃迪卡拉纪

The Ediacaran Period is the last geological period of the Neoproterozoic Era, just preceding the Cambrian Period of the Paleozoic Era. It is named after the Ediacara Hills of South Australia. Its status as an official geological period was ratified in March 2004 by the International Union of Geological Sciences (IUGS) and announced on May 13, 2004, the first new geological period declared in 120 years. The type section is in the Flinders Ranges (弗林德斯山脉) in South Australia. The age range of the Ediacaran Period is from 635 to 542 million years. The base age of approximately 635 million years ago is based on U-Pb (uranium-lead) isochron dating.

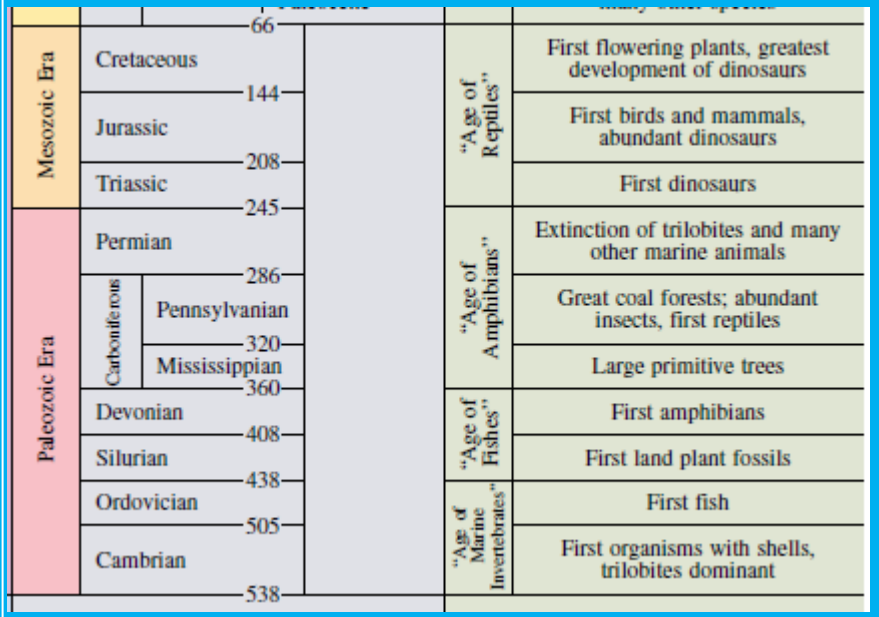
Ediacaran: 埃迪卡拉纪



GEOLOGIC TIME SCALE

The fossil record shows that at the Paleozoic Era, a great abundance of diverse plants and animals were living in the ocean. During the Ordovician, the next period in the Paleozoic, fish evolved. Plants and animals evolved to life on the land in the next period, the Silurian.

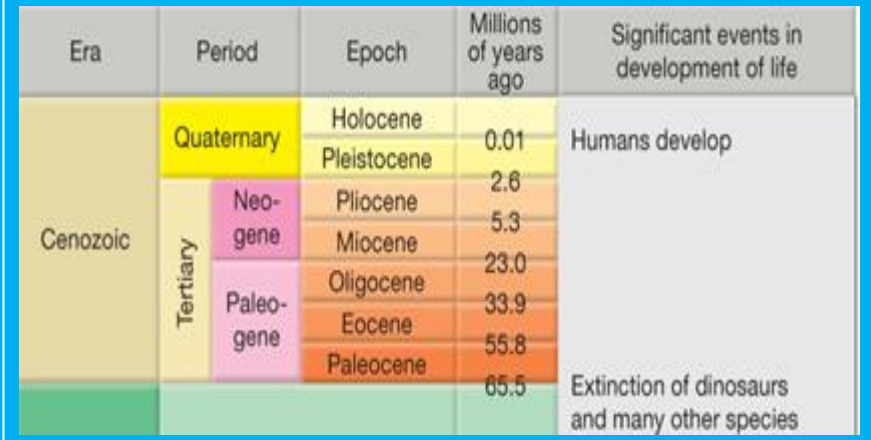
The Mesozoic Era, starting about 250 million years ago, is known as the age of dinosaurs and reptiles.



During the Jurassic, the middle period of the Mesozoic, mammals and birds evolved but were apparently dominated by the reptiles throughout the Mesozoic

GEOLOGIC TIME SCALE

Finer subdivisions of time are possible and the periods of the Cenozoic are frequently subdivided into epochs. Subdivision of periods into epochs can be done only for the most recent portion of the geologic time scale.



Era	Period		Epoch	Millions of years ago	Significant events in development of life
Cenozoic	Quaternary		Holocene	0.01	Humans develop
			Pleistocene	2.6	
	Tertiary	Neogene	Pliocene	5.3	
			Miocene	23.0	
		Paleogene	Oligocene	33.9	
			Eocene	55.8	
			Paleocene	65.5	Extinction of dinosaurs and many other species

This is because older rocks have been buried deeply, intensely deformed and severely modified by long-term earth processes. As a result, the history contained within these rocks can not be clearly interpreted.

The Cenozoic is composed of Tertiary and Quaternary. The Tertiary is divided into two periods, the Paleogene and Neogene, and they are in turn divided into epochs. The Paleogene consists of the Paleocene, Eocene, and Oligocene epochs, and the Neogene consists of the Miocene and Pliocene epochs. The Quaternary consists of the Pleistocene and Holocene epochs, the last of which is ongoing.

GEOLOGIC TIME SCALE

The geological time scale is used by geologists and other scientists to describe the timing and relationships between events that have occurred during the history of Earth. The table of geologic periods presented here agrees with the dates and nomenclature proposed by the International Commission on Stratigraphy（ICS）, and ratified by the International Union of Geological Sciences (IUGS).

* Subdivisions of the global geological record are formally defined by their lower boundary. Each unit of the Phanerozoic intervals (-542 Ma to present) and the base of the Ediacaran is defined by a Global Standard Section and Point (GSSP) and its base, whereas the Precambrian Interval is formally subdivided by absolute age, Global Standard Stratigraphic Age (GSSA).

GEOLOGIC TIME SCALE

Abbreviation and Pronunciation

Cretaceous [krɪ'teʃəs]	白垩纪	K
Jurassic [dʒu'ræsik]	侏罗纪	J
Triassic [traɪ'æsɪk]	三叠纪	T
Permian ['pə:miən]	二叠纪	P
Carboniferous [,kɑrbə'nɪfərəs]	石炭纪	C
Devonian [de'vəunjən]	泥盆纪	D
Silurian [sai'ljuəriən; si-]	志留纪	S
Ordovician [,ɔ:dəu'viʃən; -ʃiən]	奥陶纪	O
Cambrian ['kæmbriən]	寒武纪	∈

The Names of International Organizations Related to Geology

IUGS: International Union of Geological Sciences,

国际地质科学联合会，简称，地科联

GSSA: Global Standard Stratigraphic Age,

国际标准地层学年龄

ICU: International Commission on Stratigraphy,

国际地层学委员会

GSSP: Global Standard Section and Point,

全球标准剖面和地质界面，俗称，地质金钉子。

Introduction to Earth Science

四、PLATE TECTONIC THEORY:

Over geologic time, mountain ranges rise and then erode away, continents migrate around the globe, and ocean basins open and close.

Before 1960, no single theory explained all of these manifestations of the active Earth. In the early 1960s, geologists developed the *Plate Tectonics Theory*, which provides a single, unifying framework that explains earthquakes, volcanic eruptions, mountain building, moving continents, and many other geologic events. It also allows geologists to identify many geologic hazards before they affect humans.

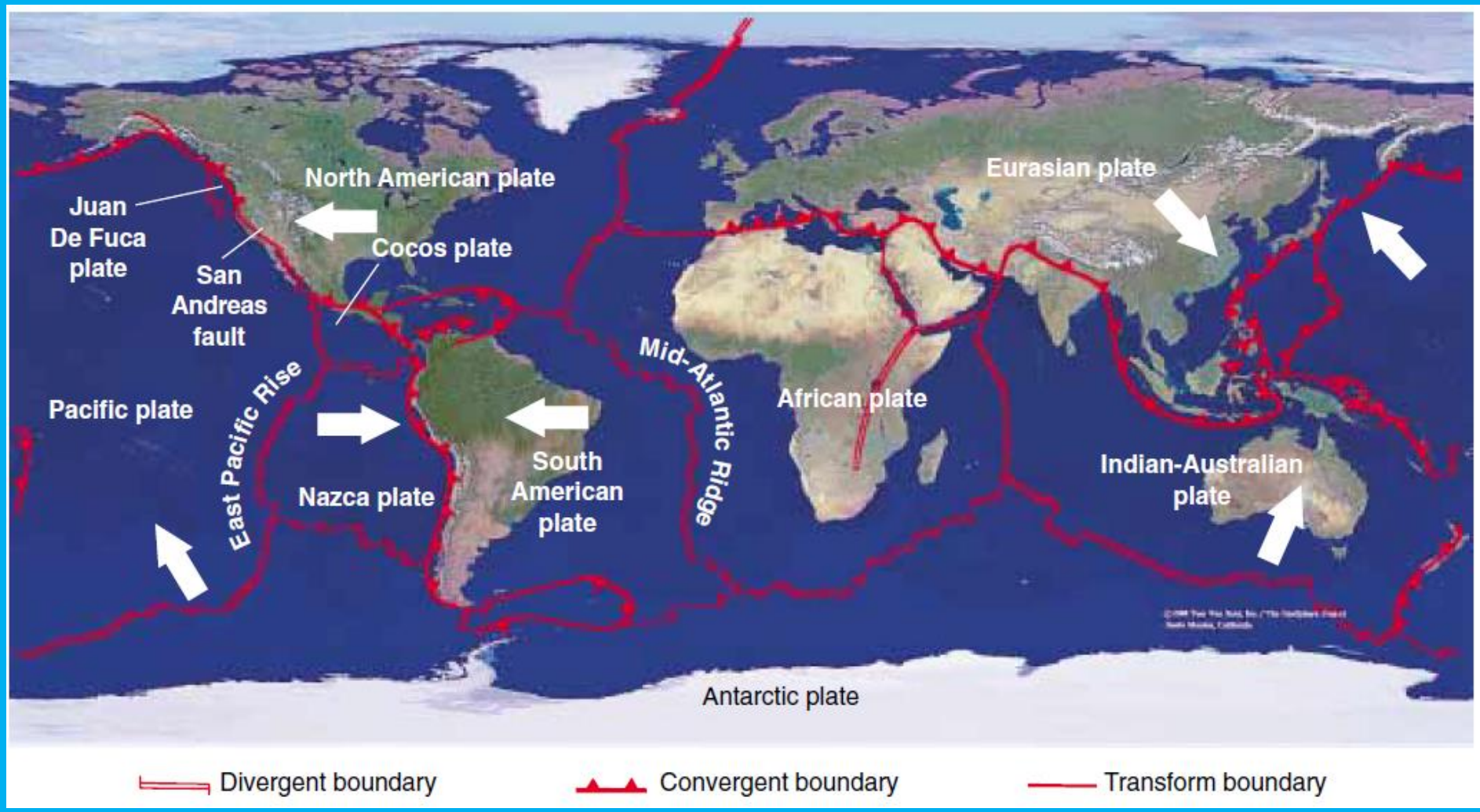
Introduction to Earth Science

四、PLATE TECTONIC THEORY:

Briefly, it describes the Earth's outer layer, called the lithosphere, as a shell of hard, strong rock. This shell is broken into seven large (and several smaller) segments called *Tectonic Plates* (also called *Lithospheric Plates*). The tectonic plates float on the layer below, called the asthenosphere. The asthenosphere, like the lithosphere, is rock. But the asthenosphere is so hot that 1 to 2 percent of it is melted. As a result, it is plastic, and weak. The lithospheric plates glide slowly over the asthenosphere like sheets of ice drifting across a pond.

Introduction to Earth Science

四、PLATE TECTONIC THEORY:



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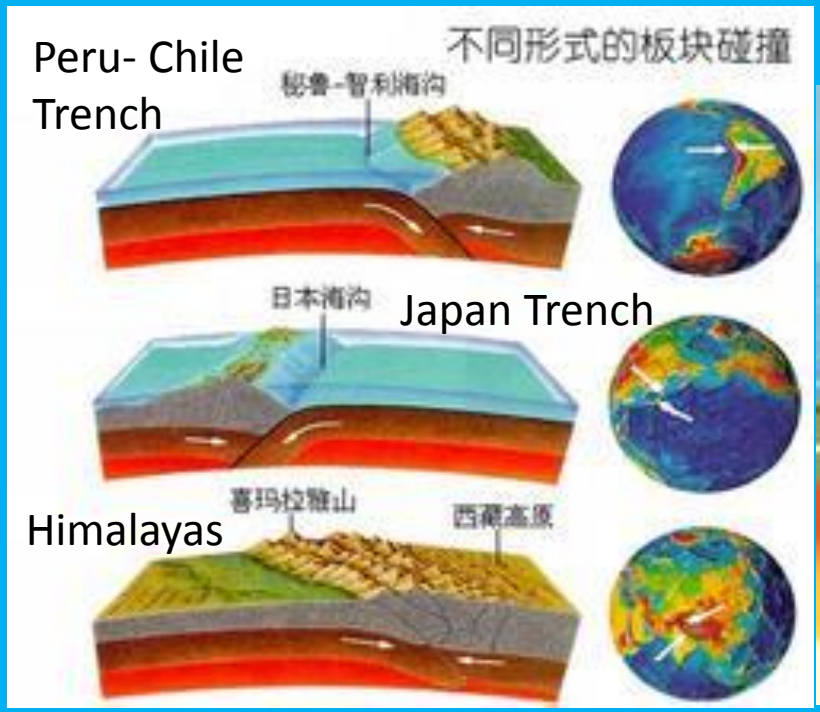
四、PLATE TECTONIC THEORY:

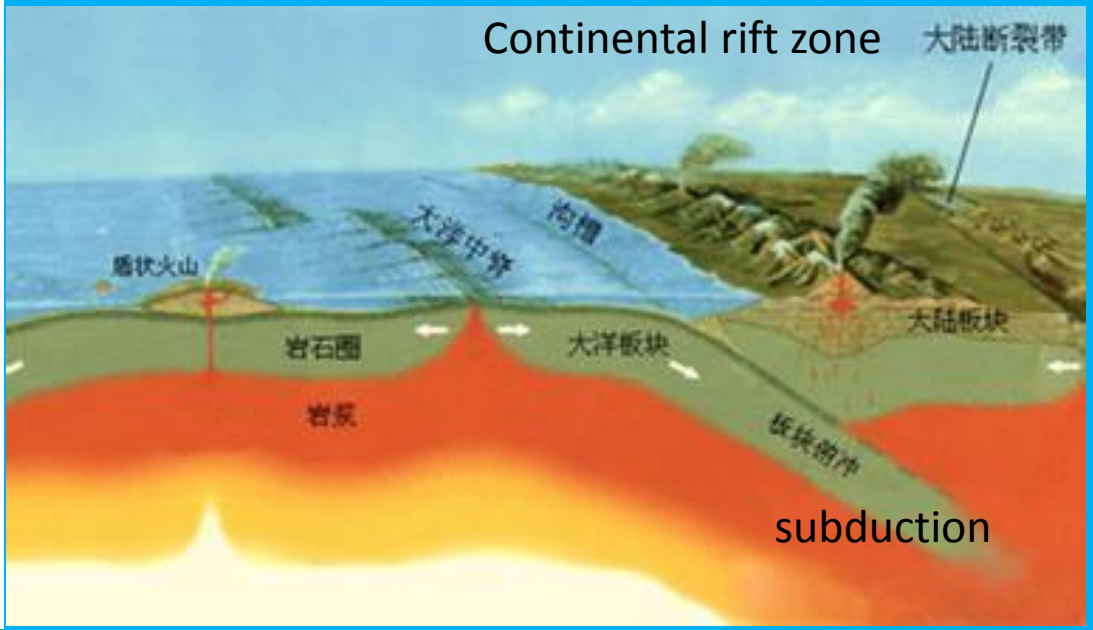


Peru- Chile Trench

Japan Trench

Himalayas

plateau



Continental rift zone

subduction

Introduction to Earth Science

四、PLATE TECTONIC THEORY:

Most of the Earth's major geological activity occurs at plate boundaries, the zones where tectonic plates meet and interact. Neighboring plates can move relative to one another in three different ways. At a divergent boundary, two plates move apart, or separate. At a convergent boundary, two plates move toward each other, and at a transform boundary, they slide horizontally past each other.

Table, given below, summarizes characteristics and examples of each type of plate boundary.

Introduction to Earth Science

四、PLATE TECTONIC THEORY:

Table 2–1 • CHARACTERISTICS AND EXAMPLES OF PLATE BOUNDARIES

TYPE OF BOUNDARY	TYPES OF PLATES INVOLVED	TOPOGRAPHY	GEOLOGIC EVENTS	MODERN EXAMPLES
Divergent	Ocean-ocean	Mid-oceanic ridge	Sea-floor spreading, shallow earthquakes, rising magma, volcanoes	Mid-Atlantic ridge
	Continent-continent	Rift valley	Continents torn apart, earthquakes, rising magma, volcanoes	East African rift
Convergent	Ocean-ocean	Island arcs and ocean trenches	Subduction, deep earthquakes, rising magma, volcanoes, deformation of rocks	Western Aleutians
	Ocean-continent	Mountains and ocean trenches	Subduction, deep earthquakes, rising magma, volcanoes, deformation of rocks	Andes
	Continent-continent	Mountains	Deep earthquakes, deformation of rocks	Himalayas
Transform	Ocean-ocean	Major offset of mid-oceanic ridge axis	Earthquakes	Offset of East Pacific rise in South Pacific
	Continent-continent	Small deformed mountain ranges, deformations along fault	Earthquakes, deformation of rocks	San Andreas fault

Introduction to Earth Science

五、GEOLOGICAL FEATURES:

The unusual landforms for the City of Rocks are the result of three processes acting rocks. These processes are distinguished as follows: weathering, mass wasting, and erosion.

Weathering: Weathering defines the set of physical, chemical, and/or biological processes which decay and break rock down into smaller pieces. Weathering processes can act independently.

Mass Wasting: Mass wasting, also known as slope movement or mass movement, is the geomorphic process by which soil and rock move downslope under the force of gravity. When the gravitational force acting on a slope exceeds its resisting force, slope failure (mass wasting) occurs.

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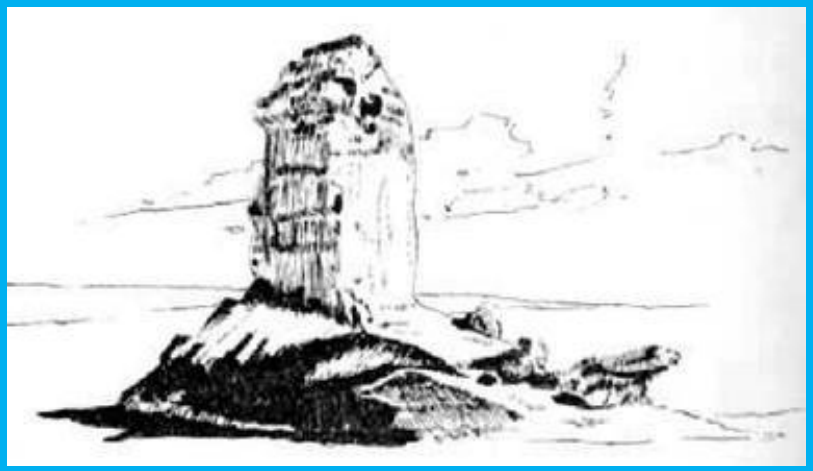
五、GEOLOGICAL FEATURES:



Introduction to Earth Science

五、GEOLOGICAL FEATURES:

Erosion: Erosion is the process that transports the products of weathering and mass wasting away from their source. It usually occurs due to transport by wind, water, or ice; by down-slope creep of soil and other material under the force of gravity.

Deposition: is the geological process in which sediments, soil and rocks are added to a landform or land mass. Wind, ice, water and gravity are the main transporting agents. These agents transport previously eroded sediment, which is deposited, building up layers of sediment.

Joint: is a fracture dividing rock into two sections that have not moved away from each other. A joint sees little or no displacement.

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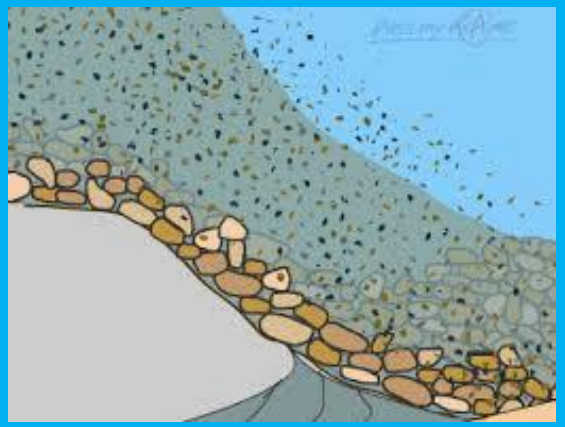
五、GEOLOGICAL FEATURES:

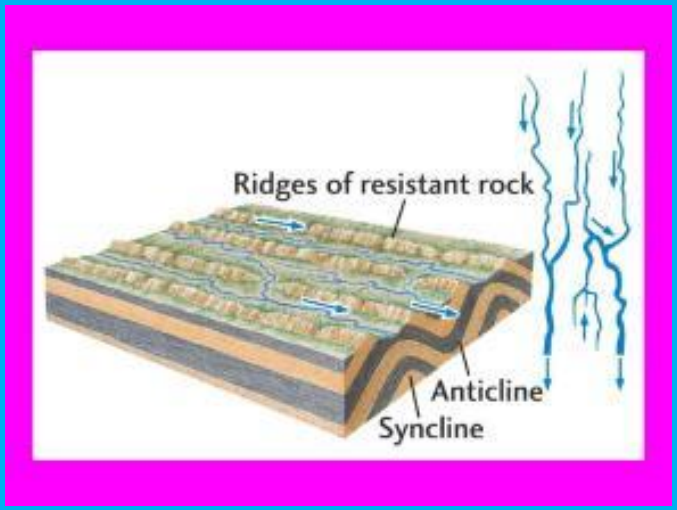


Introduction to Earth Science

五、GEOLOGICAL FEATURES:

Fracture: is any separation in a geologic formation, such as a joint or a fault that divides the rock into two or more pieces. A fracture will sometimes form a deep fissure or crevice in the rock.

Fold: A geological fold occurs when one or a stack of originally flat and planar surfaces, are bent or curved as a result of permanent deformation.



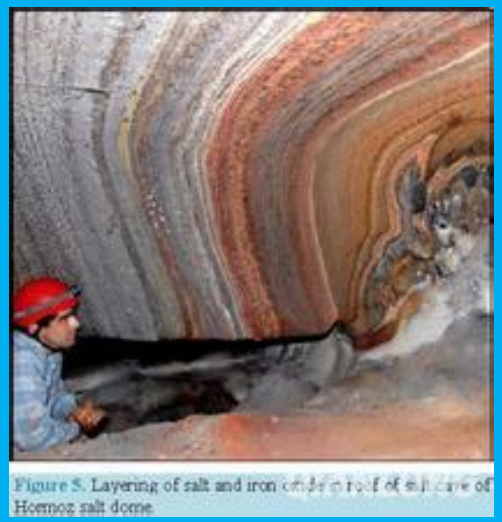


Figure 5. Layering of salt and iron oxides in roof of salt cave of Hormoz salt dome

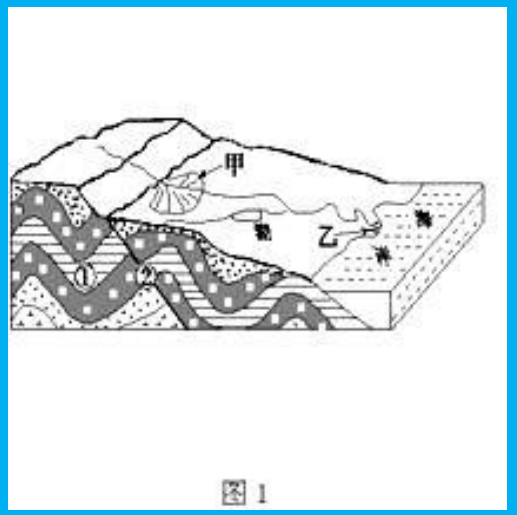


图 1

Introduction to Earth Science

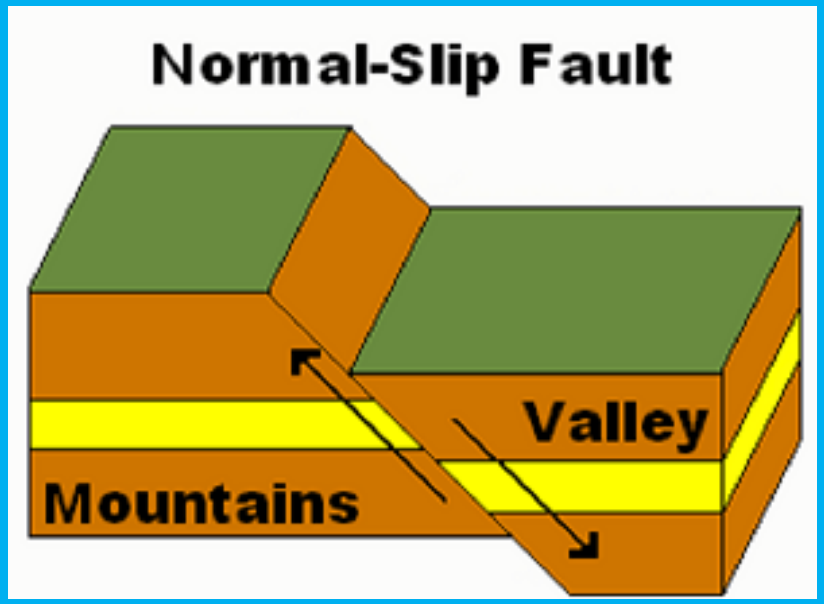
五、GEOLOGICAL FEATURES:

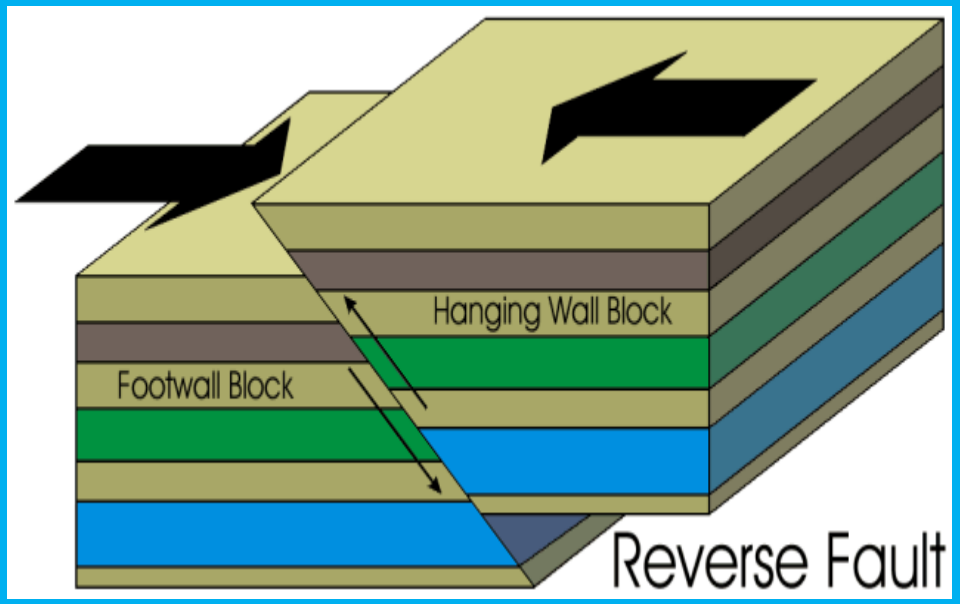
Introduction to Earth Science

五、GEOLOGICAL FEATURES:

Fault: is a break in the rocks that make up the Earth's crust, along which rocks on either side have moved past each other.

Normal Fault: A geologic fault in which the hanging wall has moved downward relative to the footwall. Normal faults occur where two blocks of rock are pulled apart, as by tension. Compare reverse fault



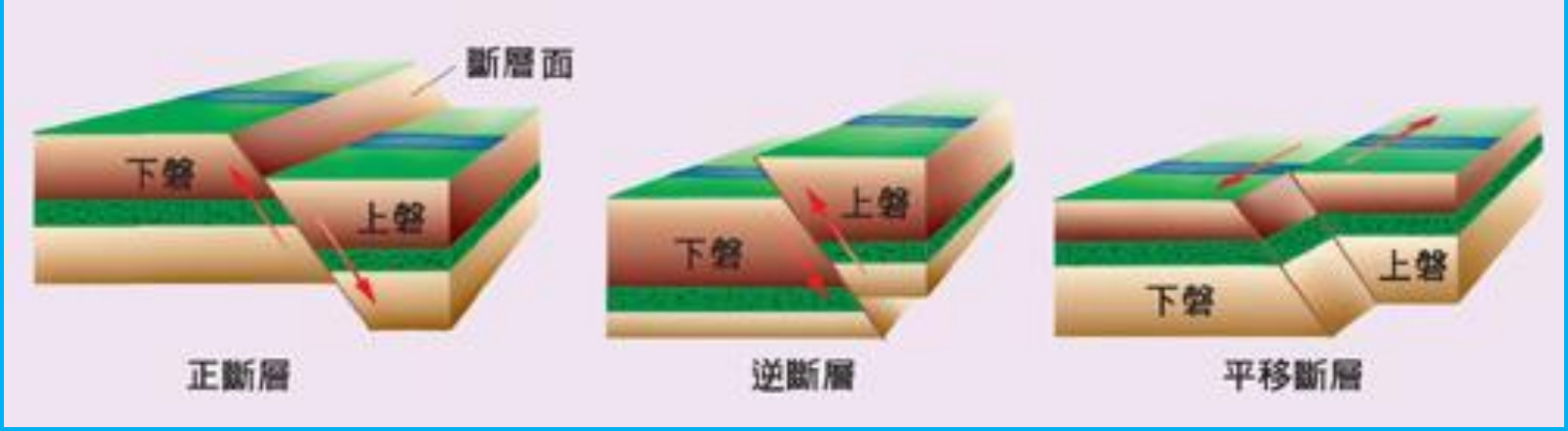


Introduction to Earth Science

五、GEOLOGICAL FEATURES:

Reverse faults: opposite of normal faults, If the hanging wall rises relative to the footwall. Reverse faults occur in areas undergoing compression.

Strike-slip fault: are vertical (or nearly vertical) fractures where the blocks have mostly moved horizontally. If the block opposite an observer looking across the fault moves to the right, the slip style is termed right lateral; if the block moves to the left, the motion is termed left lateral.



Introduction to Earth Science

五、GEOLOGICAL FEATURES:

Intrusion: is any formation of intrusive igneous rock; rock formed from magma that cools and solidifies within the crust of the planet.

Extrusion: consists of extrusive rock; rock formed above the surface of the crust.

Volcanism: is the phenomenon of eruption of molten rock (magma) onto the surface of the Earth, where lava and volcanic gases erupt through a break in the surface called a vent.

Introduction to Earth Science

六、THE EARTH'S ORIGIN:

The hypothesis given here is based on calculations about the behavior of dust and gas in space and on observations of stars and dust clouds in our galaxy.

The hypothesis states that about 5 billion years ago the matter that became our Solar System was an immense, diffuse, frozen cloud of dust and gas rotating slowly in space. This cloud formed from matter ejected from an exploding star. More than 99 percent of the cloud consisted of hydrogen and helium, the most abundant elements in the Universe. The temperature of this cloud was about 270ºC.

Introduction to Earth Science

六、THE EARTH'S ORIGIN:

The hypothesis about the formation of the Solar System and the Earth:

About 5 billion years ago the matter that became our Solar System was in immense, diffuse, frozen cloud of dust and gas rotation slowly in space.

Introduction to Earth Science

六、THE EARTH'S ORIGIN:

This dust and gas began to coalesce due to gravity.

Introduction to Earth Science

六、THE EARTH'S ORIGIN:

The shrinking mass began to rotate and formed a disk.

Introduction to Earth Science

六、THE EARTH'S ORIGIN:

The mass broke up into a discrete protosun orbited by large protoplanets..

Introduction to Earth Science

六、THE EARTH'S ORIGIN:

The Sun heated until fusion temperatures were reached. The heat from the Sun drove most of the hydrogen and helium away from the closest planets, leaving small, solid cores behind.

Introduction to Earth Science

THE MODERN SOLAR SYSTEM:

Heat from the Sun boiled most of the hydrogen, helium, and other light elements away from the inner Solar System. As a result, the four planets closest to the Sun— Mercury, Venus, Earth, and Mars —are now mainly rocky with metallic centers. These four are called the terrestrial planets because they are "Earthlike." In contrast, the four outer planets— Jupiter, Saturn, Uranus, and Neptune —are called the Jovian planets and are composed primarily of liquids and gases with small rocky and metallic cores. Pluto, the outermost known planet, is anomalous. It is the smallest planet in the Solar System and is composed of rock mixed with frozen water and methane.

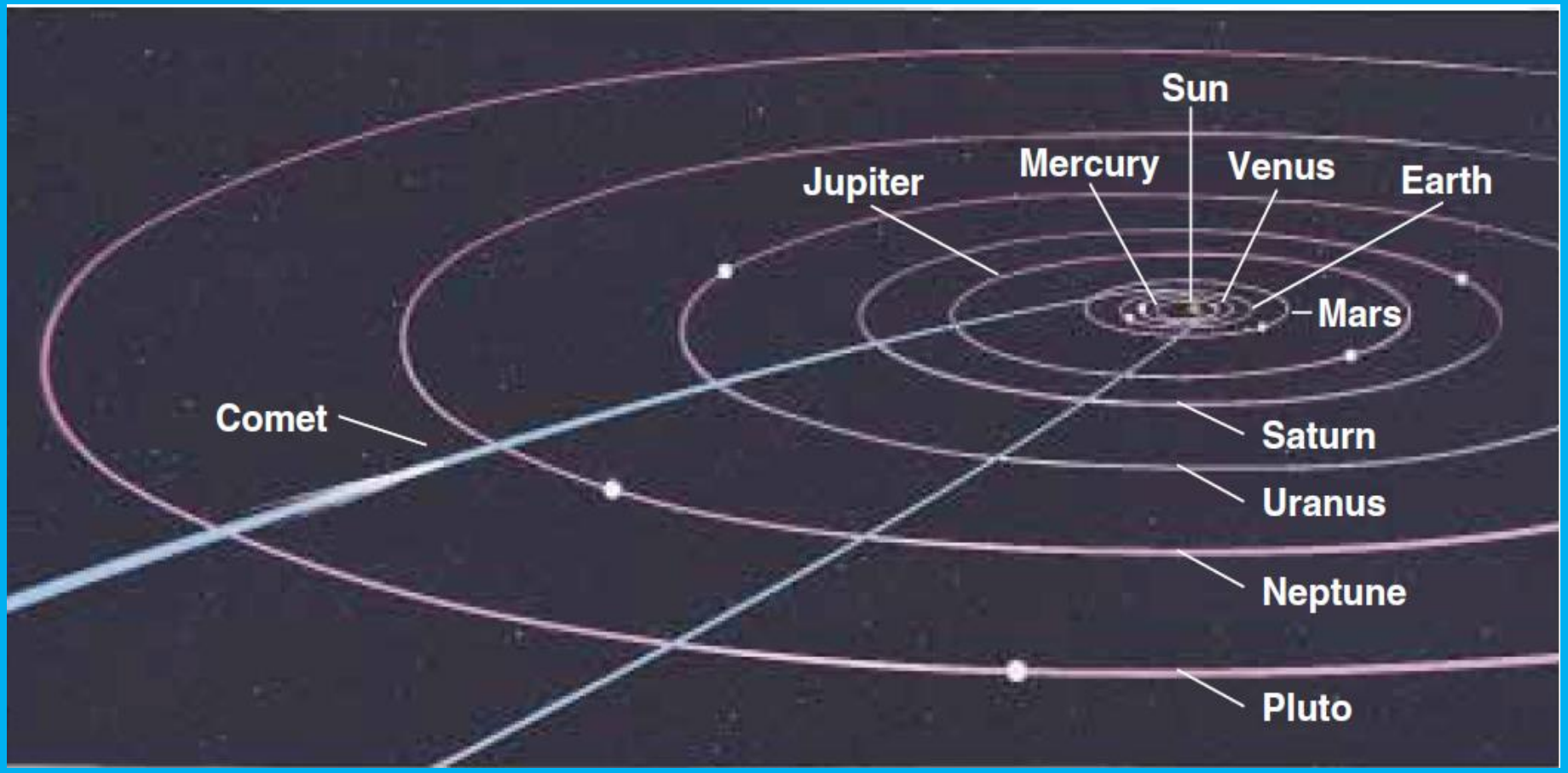
Introduction to Earth Science

MEMBERS OF SOLAR SYSTEM:

The Solar System formed 4.6 billion years ago from the gravitational collapse of a giant interstellar molecular cloud. The vast majority of the system's mass is in the Sun, with most of the remaining mass contained in Jupiter. The four smaller inner planets, Mercury, Venus, Earth and Mars, are terrestrial planets, being primarily composed of rock and metal. The four outer planets are giant planets, being substantially more massive than the terrestrials. The two largest, Jupiter and Saturn, are gas giants, being composed mainly of hydrogen and helium; the two outermost planets, Uranus and Neptune, are ice giants, being composed mostly of substances with relatively high melting points compared with hydrogen and helium, called ices, such as water, ammonia and methane. All planets have almost circular orbits that lie within a nearly flat disc called the ecliptic.

Introduction to Earth Science

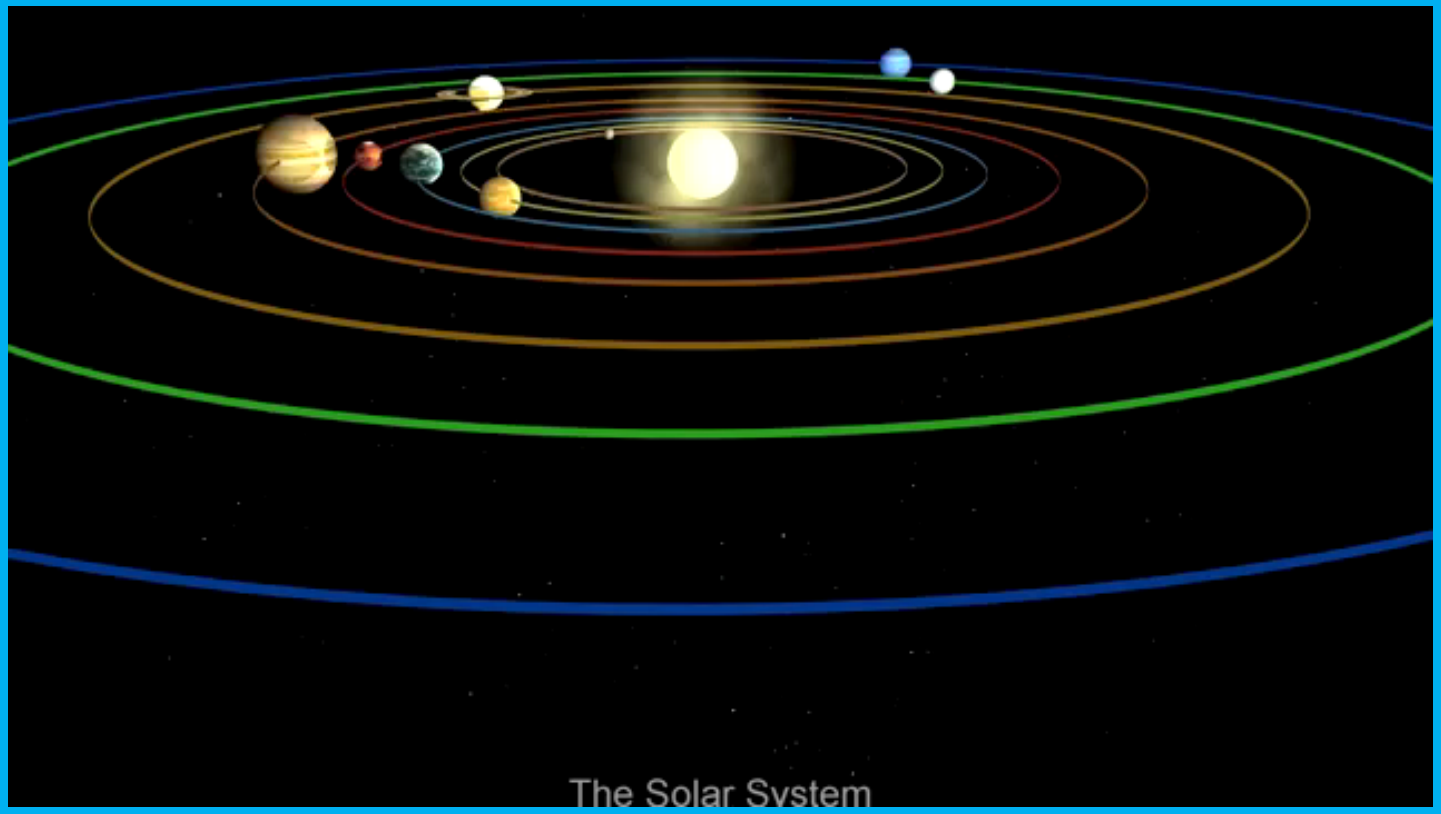
MEMBERS OF SOLAR SYSTEM:



Introduction to Earth Science

MEMBERS OF SOLAR SYSTEM:

All planets of the Solar System lie very close to the ecliptic. The closer they are to the Sun, the faster they travel



Introduction to Earth Science

PLANETARY GEOLOGY:

Planetary geology is the study of surface and interior processes on solid objects in the solar system: planets, satellites, asteroids, comets, and rings. It is a particularly appropriate subject for inclusion in a text on remote sensing, as the vast majority of our current knowledge on the geology of solar system objects has been derived from remote sensing measurements. These measurements have been obtained either using ground-based or Earth-orbital telescopes or robotic space probes equipped with sophisticated cameras or spectrometers.

Introduction to Earth Science

PLANETARY GEOLOGY:

Why is it important to study the geology and surface processes of other objects in the solar system? There are several important reasons. The first reason involves the quest (inquiry) for knowledge. The second reason involves evolution, not necessarily in the biologic sense but in the sense of the physical and chemical evolution of the solar system over time. The third, and perhaps most important, reason to study planetary geology is comparative planetology, or the ability to understand processes on or the evolution of one solar system object, frequently the Earth, through comparisons to others.

Introduction to Earth Science

PLANETARY GEOLOGY:

Specific measurements:

Planetary geology remote sensing data are acquired using many different techniques, but the specific types of measurements and information to be obtained via these techniques fall into five general categories:

1. Gross physical characterization. Physical characterization includes determining the mass, shape, size, and density of solar system objects or of specific morphologic features on these bodies. These measurements are obtained from broadband visible, thermal, or radar systems that produce images of objects at various lighting and viewing angles, from radar or laser ranging.

Introduction to Earth Science

PLANETARY GEOLOGY:

Specific measurements:

2. Major surface modification processes. Detailed morphologic study of planetary surfaces can yield substantial insights into the major surface modification processes that are currently active or that have been active at some time in the past.

3. Ages of surfaces. Ages are determined from remote sensing images either by observation of superposition and other stratigraphic relations between different surface units or by comparing the relative abundances and size distributions of impact craters between units.

(http://marswatch.tn.cornell.edu/rsm.html)

Introduction to Earth Science

PLANETARY GEOLOGY:

Specific measurements:

4. Surface composition and mineralogy. Determination of the composition of planetary surfaces provides information on their origin and geologic/geochemical evolution. This information can be obtained remotely in many ways, including spectroscopic analysis of sunlight reflected from the surface at visible and near-IR wavelengths.

5. Atmospheric conditions. Assessment of atmospheric pressure, temperature, circulation, and composition can provide important constraints for use in analyzing planetary geology measurements.

Key points for Chapter 1 本章要点

- Earth Sciences and some branches.
  (geology, geography, biology, and meteorology etc.)
- Definition of geology.
  (Geo-, -logy)
- Objectives of geology.
  (Get something good, prevent something bad.
  Material, foreknowledge of danger, protect environment…)
- Methods of geology.
  (Nature—best laboratory, depending on basic scientific discipline, principle of actualism)
- Geologic process and its energy
  (any process, endogenic: inside the solid Earth, internal heat;
  exogenic: outside the solid Earth, Sun's heat:
  Auxiliary energies: gravity, rotation force, and gravitation etc.)


Thanks
for your attention!