



高等学校教材

An Outline of Earth Sciences

地球科学概论

吕洪波 编著

中国石油大学出版社



TEACHING MATERIALS FOR COLLEGE STUDENTS

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内 容 简 介

《地球科学概论》(*An Outline of Earth Sciences*)是为地学类相关专业编写的地质学基础课程双语教学用书。全书共 19 章,包括宇宙与行星地质学、元素与矿物、岩浆作用与火成岩、外力地质作用与沉积岩、变质作用与变质岩、地质年代和地球演化史、地震与地球层圈、地壳运动与地质构造、海底扩张与板块构造学、风化与剥蚀作用、河流及其地质作用、冰川与冰川作用、地下水及其地质作用、海洋地质作用与海洋地质学、湖泊与沼泽、风与荒漠、块体运动、人类生存与地球环境等内容。

为方便读者使用,书中大部分专业术语后都直接加注了相应的中文词汇,并在每章末列出主要参考文献、资料来源和相关网站链接。全书内容丰富、图文并茂、趣味生动,试图让读者能较轻松地步入地学的新天地。

本书不仅可以作为地学类各相关专业本科生或研究生的专业英语教材或阅读材料,也可供地学类教师和相关研究人员参考。

前 言

《地球科学概论》(*An Outline of Earth Sciences*)是为地质学专业的地球科学概论、地质学基础课程编写的双语教学用书。地球科学概论是地质学专业本科生的地学入门课程,也是专业基础课。因此,本书的编写具有双重目标:一是介绍地球科学相关分支的基础理论,二是适当介绍地学相关学科的最新进展,并尽量做到与国际上相同学科接轨。

考虑到近年来入学本科生英语水平的逐步提高,学生已经有能力接受双语教学,所以作者以英文的形式编写了本书。本书不仅可以作为地学类各相关专业本科生或研究生的专业英语阅读材料,也可供地学类教师和相关研究人员参考。

书中各章节最基本的概念主要依据作者以往讲授地球科学概论课程的手稿改编而成。由于课时的限制,作者对讲义内容进行了适当调整。为使教材更加充实,作者参考、节选了国外最新原版教材和大量网络资源中的精彩内容,并在书中融入了作者最新的科研成果,争取做到既能保持教学用书的体系完整和表述的简明扼要,又能体现出地球科学的最新进展。

作者对参考的国外最新英文原版教材或网站上的内容都进行了严格推敲与精心修编。重要的段落尽量直接引用。这样不仅保持了原有的英文韵味,给学生提供了学习英语的机会,同时也让读者充分体会国外教材的风格,而这也是双语教学的目的之一。所选原文中明显的语法和用词错误,作者都进行了修改。另外,书中大部分专业词汇和重要单词后都直接加注了中文参考词汇,以帮助学生节省查阅字典的时间,从而尽快掌握教材的要点。这样设计也是考虑了双语教材的需要,在与国际接轨的同时,避免与国内脱轨。

书中的插图或照片,有的来源于专业地学网站。对于这些图件或照片,作者都在图题下部注明了出处。凡未注明出处的图件或照片,都是作者绘制或实地拍摄的。

由于本书涉及不同分支学科的内容太多,因此,很难在短期内将各个章节都编写到令人十分满意的程度。部分章节的论述较为简单,还有待今后逐步补充和完善。

尊重他人的劳动成果是对学者学术道德的基本要求。作者在编写本教材的过程中对这一点特别留意。书中有的部分是作者在近二十年的教学过程中长期积累并不断补充修改和完善的成果。这些部分或许与相关教材中的表述相似,但绝非出自某一本或几本教材。书中引用他人资料的部分,作者都在适当的地方进行了注释和说明,并在各章末列出了资料来源及主要的参考文献(含网址),但也难免会存在遗漏之处。读者如有发现,望告知作者以便及时补充更正。

作者感谢中国石油大学(华东)地球资源与信息学院的领导和同事们的鼓励和理解,并感谢中国石油大学(华东)教务处与中国石油大学出版社等部门的支持与合作。中国石油大学(华东)研究生杨超、王秀玲、朱晓青协助整理了本书的索引部分,作者在此向他们表示谢意。

本书于 2004 年由中国石油大学(华东)校内印刷,已作为双语教材连续试用两年。在此基础上,作者进行了全面的修改和补充,特别是加入了大量的素描图和典型的照片。尽管如此,由于时间紧迫,错误和疏漏在所难免,望读者发现后予以指正,作者将不胜感谢。

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Chapter 1

Introduction to Earth Sciences

地球科学简介

1.1 EARTH SCIENCES AND SOME RELATED CONCEPTS

地球科学及相关概念

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)—mainly study the natural conditions for all the living things.
- **Astronomy** (天文学)—mainly studies the 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.

1.1.1 What is Geology 什么是地质学

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 (地球的起源、物质、形态、历史及作用).

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 (大地)”, while the suffix “-logy” means “subject—a course or area of study (学科)”.

1.1.2 The Objective (Aim, Purpose, Goal) of Geology 地质学的研究目的

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 (索宝与防护).

a. To **discover useful materials** within the Earth (maybe outside the Earth in the future) such as metals (e. g. Fe, Al, Cu, Pb, Zn, Au, Ag, etc.) and **nonmetals** (rocks), **energy resources** (coal, oil and gas, nuclear fuels, water power etc.) and **other materials**.

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 mudflow, and subsidence of land surface etc. (地震、火山喷发、洪水、滑坡、泥石流和地面沉陷等).

c. To protect environments and improve our living conditions (such as to prevent and diminish the pollution of air and water).

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 relics 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).

b. Geologic theories strongly depend on the basic scientific disciplines of physics, chemistry, biology and others, depending on technology advances/progresses (地质学对物理学、化学、生物学等其他基础学科有着强烈的依赖性). Geology has a short history of only 220 years from the time when Saussure invented the word "geology" in 1779. It was born under the demand of industry and military usage for raw materials in the 18th century. This short history has revealed a fact—there would have not been modern geology if there had not been progresses in physics, chemistry or biology. Ocean exploration, as a good example, shows the dependence of geology on basic scientific disciplines and technology.

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 (莱伊尔, 1797—1875) in his book—*The Principles of Geology* in 1830.

1.1.4 Geologic Process and Its Energy 地质作用及其能量

Geologic process is any natural process that causes the change in composition, morphology and

other aspects of the Earth.

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, volcanism and metamorphism are 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**.
- Weathering, erosion, transportation and deposition are all exogenic processes.

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).

1.2 THE HARDSHIP AND THE PLEASURES OF GEOLOGISTS

地质工作者的苦与乐

My students, the prospective geologists, often ask me what hardship I have endured and what pleasure I have experienced. Different geologists have different answers, but as for me, I would rather say: the hardship is that I have to leave home to work in the field and the pleasure is that I can work in the field. Is this self-contradictory? No. A real geologist is always related to the field-work. No fieldwork, no geologist. Only working in the field can a geologist discover the secrets of nature!

As geologists, we have to bear the extreme hardship and, at the same time, we can enjoy the special pleasure from nature. Here I would love to show you two poems related to geologists.

There is a very sad poem published in 1984 in the newspaper to describe a geologist's life:

If you have a daughter,

Don't marry her to a geologist.

She will be lonely at home all the year round.

When the husband comes back occasionally from the field,

All belonging to her are the tattered clothes and dirty socks in the bed.

(translated by Hongbo Lu)

The following is the original Chinese version published in the newspaper—*Geology of China* in 1984:

有女不嫁地质郎，
一年四季守空房。
有朝一日回家转，
破衣烂袜堆满床！

(1984年发表于《中国地质报》)

However, when you visit a place in a remote area where only a few people on Earth can reach, and luckily you are among the extraordinarily beautiful sceneries in nature. What would you think about? You will forget all the hardship you have endured in your life and be proud of yourself as a geologist.

Here I am glad to show you a poem I wrote in Tibetan Plateau in 1997:

Talk to Suobucha Hot Spring

In the remote paradise on the Tibetan Plateau,

A clean stream is running quietly down the deep valley around the snow peaks.

Who is singing under the sunshine?

The yellow ducks flying over the white clouds!

Who is cooking at the bottom and making the vapor rising over the banks?

The grass with light-green blades enjoying the warmth of the immortal fountains ...

Who is lucky to come and see the beautiful scenery?

Only Altair (Alpha—Shepherd Star) might graze here during early autumns.

Who can use the resort?

Only the Girl Weaver could wash her blouse stained with her endless tears at mid-night moments.

Who built the fountains on the highest cold land of the Earth?

The Gods! The Gods! The Gods!

For whom did they make the abode?

The Goddess from the Moon taking shower at the cloudy nights!

I would dare to ask: "Are you lonely?"

"Yes. You must be!"

"Are you tired of waiting for the goddess during the dark nights?"

"Yes. You must be!"

"Then why don't you go with me to the southeast of the country,

where you will not be lonely again and

you can enjoy the cheering from serving the people ..."

...

Do you think the hot spring would go with the author to the southeast of China?

"No!" The Hot Spring might say, "If I went with you, I would die immediately after I reached the land of the populated area!"

(by Hongbo Lu in 1997)

Here is the Chinese version of the poem and a photo of the spring (Figure 1.1), as well as the author's experience described in Chinese.

索布查温泉

高原尽处绝壁间，
清溪寂寞绕寒川。
黄鸭云头鸣丽日，
绿草谷底弄炊烟。

牛郎秋初牧河畔，
织女夜半洗泪衫。
瑶池只为嫦娥浴，
何不随我去江南？

正是作为地质学家才有幸到藏北高原无人区进行实地考察，才能在寒风中同时沐浴着明媚的阳光和清澈的温泉，也正是这种特殊的经历激发了作者的创作欲望，才有了这首不寻常的诗。以下是这首诗的创作背景：

位于藏北羌塘无人区的索布查温泉，藏身于海拔 4 700 m 的山谷中。1997 年 5 月的一天上午，我和南京大学藏北科学考察队的其他队员一起走进这鲜为人知的温泉河谷。当时气温仍在 -10°C 左右，然而温泉附近则是另一种景象了：远远望去，索布查沟上方笼罩着浓浓的雾气，好似下面有个很大的村落，走近时才发现是沸腾着的喷泉。喷泉覆盖的谷地由于长年不断的温水浸润，长满了绿绿的青苔。河谷中成对的野鸭正在静静地戏水，突然受到我们这些不速之客的干扰而飞向高空，眨眼之间已经在白云之巅翩翩起舞，那清脆悦耳的叫声在空旷的山谷中久久地回荡。这是多么优美的画卷啊——不是仙境，胜似仙境。激动地拍摄了一阵照片之后，大家纷纷脱衣下水，享受一番大自然的恩赐。淋浴过后，忽见岸上有两个抱小孩的藏家妇女早已偷偷地将下面的春光尽收眼底了。惊叹之余，众人攀岩上岸，才发现有两间简易土屋坐落在河岸之上，算是这空旷的谷地中唯一的村落了。土屋的男主人去远方放牧了，要到夏末附近长出绿草才赶着羊群回来与家人短聚。女主人则在家照顾小孩，算是这里仅有的永久居民。守护温泉是她们每天的义务工作，欣赏温泉自然也成了她们一生的精神寄托。然而，她们除了偶尔到温泉洗衣外，却从不在温泉洗澡。在她们心目中，好像这温泉是特意为月宫中的嫦娥夜里沐浴而建造的，从未见凡人在此更衣。我们成了唯一胆敢光天化日之下在此享乐的凡夫俗子，也因此打扰了她们心中的神圣与安宁。

我呼大地，此泉缘何造在这人迹罕至的深山谷底？山谷中重复着我自己的声音：缘何——缘何——缘何？

我叹苍穹，谁才有权享用这永恒的宝贵资源？蓝天中白云不断变换着面孔，用沉默回答我的无知。

突然有感，遂作此诗。



Figure 1.1 Suobucha Hot Spring

KEY POINTS OR QUESTIONS

1. What are the Earth sciences?
2. What is geology?
3. State the two key objectives of geology.
4. Try to explain why we should treat the nature as our best laboratory.
5. Illustrate with an example that geology strongly depends on other basic scientific disciplines and progresses in technology.
6. State the principle of actualism and try to understand “the present is the key to the past”.
7. What is geological process?
8. State the differences between endogenic geological process and exogenic geological process, considering their origin and energy.
9. What do you think about the hardship and the pleasure a geologist will face?

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Chapter 2

Universe and Planetary Geology

宇宙与行星地质学

2.1 THE HISTORY OF UNIVERSE EXPLORATION 宇宙探索的历史

Our interests in visible stars date back to prehistory. The Greeks called the “moving star” **planet** (行星) and “non-moving star” **fixed star** (恒星). Romans named the planets after their gods: Saturn, Jupiter, Mars, Venus and Mercury. At that time, people could only see the planets through naked eyes. Chinese ancient religion also related gods with stars and planets.

The first person to view the sky through a telescope was Galileo (伽利略) in Italy in 1609. He was born at Pisa on February 15, 1564 and died at Arcetri on January 8, 1642. He was a mathematician, astronomer and physicist, made several significant contributions to modern scientific thought.

When we talk about the history of exploring space, we think about spaceship, satellite and rocket etc.

The evolution of the rocket has made it an indispensable tool in the exploration of space. For centuries, rockets have provided ceremonial and warfare uses starting with the ancient Chinese, the first to create rockets. The rocket apparently made its debut (开张, 登场) on the pages of history as a fire arrow used by the Chinese Tartars in 1232 AD (Anno Domini) for fighting off a Mongol assault on Kaifengfu. The lineage (后代) to the immensely larger rockets now used as space launch vehicles is unmistakable. But for centuries rockets were in the main rather small, and their use was confined principally to weaponry, the projection of lifelines in sea rescue, signaling, and fireworks displays. Not until the 20th century did a clear understanding of the principles of rockets emerge, and only then did the technology of large rockets begin to evolve. Thus, as far as spaceflight and space science are concerned, the story of rockets up to the beginning of the 20th century was largely prologue (序言). (<http://inventors.about.com/library/inventors/blrocket.htm>)

When the first artificial (man-made) satellite was placed in orbit around the Earth in 1957, a new science—Planetology (行星学)—was born. From that moment on, man has studied planets