高等学校“十一五”规划教材

English for Geology

林明月 主编

地质专业英语

中国矿业大学出版社
China University of Mining and Technology Press

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内 容 提 要

本书为高等学校“十一五”规划教材，主要内容包括矿物、三大类岩石、地质构造、沉积环境、火山作用、地震、风化作用、地质年代、块体运动、喀斯特等地质基础知识，相当于一本英文版的《普通地质学》。本书共编排了二十篇课文，所有课文均选材于国外出版的专业书籍，在课文后增加了生词表和练习题。

本书适合于高等院校地质及相关专业本科生学习。

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前　言

编写本书是为了满足高等院校地质及相关专业加强专业外语教学的需要。本书主要内容包括矿物、三大类岩石、地质构造、沉积环境、火山作用、地震、风化作用、地质年代、块体运动、喀斯特等地质基础知识，相当于一本英文版的《普通地质学》。

本书共编排了二十篇课文，所有课文均选材于国外出版的专业书籍，在课文后增加了生词表和练习题。课文和练习题的难易程度经过多年的教学试用调整最终确定下来。教学进度为每一课安排两个学时。

本书适合于高等院校地质及相关专业本科生学习。

本书由林明月任主编，王雨和郝彬任副主编。由于编者水平所限，书中难免存在缺点和错误，恳请读者批评指正。

编　者

2010 年 8 月

CONTENTS

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Lesson 1 The Earth System

1. If you were to ask the earth, if the earth could speak, "How is your **geology** today," or "How is your **biosphere**," the reply in all likelihood would be, "How's my what?" Just as the elements of human physiological systems are connected and interdependent, so on earth there are linkages and interactions between the rocky surface and the **atmosphere** and oceans, and between these systems and all plant and animal life. Our interest extends from the **ecosphere**, where life evolves, to the reactions between the crust and its fluid and gaseous envelopes, and even to the earth's core, where magnetic fields that protect most organisms from lethal radiation are generated. An example of a little-known connection is the one that exists between dust storms in the Gobi and Takla Makan deserts in China and the North Pacific Ocean. **Airborne silt** from those deserts is carried all the way to the North Pacific, where it increases the nutrient content and fertility of this otherwise barren oceanic realm. The periodic weather phenomenon known as El Nino, which heavily impacts the west coasts of South and North America, has its origins in ocean-atmosphere interaction called the Southern **Oscillation** in the western Pacific thousands of miles away. We now know that ENSO-the acronym for El Nino-Southern Oscillation-is a global weather event whose effects are not limited to floods along the west coasts of the Americas.

2. A system is defined as a set of concepts or parts that work together to perform a particular function. A system may comprise many subsystems. Transportation is an easily understood system, whether it is by plane, train, or car. Drive the freeways in a large city and see how they are designed as a system with subsystems such as interchanges and **on-and-off ramps**. All must work, or the system will start to break down. The five interconnected reservoirs, or subsystems, of the complete earth system are.

◎ The solid earth, which includes soil, the rocks beneath our feet, the

lithosphere (the earth's rocky outer shell), and the very hot, mushy interior;

◎ The **hydrosphere**, all water on and in the earth, including oceans, lakes, rivers, clouds, underground water, and glaciers;

◎ The biosphere, all living and dead organic components of the planet. The ecosphere is a subsystem of the biosphere that includes the biosphere and its interactions with the other reservoirs;

◎ The atmosphere, the gaseous envelope surrounding the earth;

◎ The **extraterrestrial**, which includes such things as energy from the sun, meteors, tides, back-radiation of energy from the earth to space, and the ozone layer.

3. Most of earth's systems are closed systems; that is, there are no additions to or subtractions from the system. Energy is an exception; it is part of an open system. Energy from the sun drives many earth systems, and some of earth's energy is back-radiated to space.

4. The solid-earth sciences attempt to understand the past, present, and future behavior of the whole earth system; that is, they take a planetary approach to the study of global change by studying the present and the past. The spheres of the earth system are all linked, and separate disciplines such as **oceanography**, geology, **hydrology**, and atmospheric physics have simply developed in order to organize information and award academic degrees. Over the past century the sciences have become increasingly segmented and specialized, going in the exact opposite direction of what is needed for solving today's environmental problems. Strong disciplinary studies are needed, but we also need a systems approach for understanding how the earth works and how a sustainable environment can be provided for future generations.

5. The surface of the lithosphere is a major boundary in the earth system, as this is where energy from the sun is transferred to the planet and its inhabitants. It is also at this boundary that we find **landslides**, volcanic activity, earthquakes, severe weather, and long-term global weather changes that impact humans. The earth is a dynamic system, so there is nothing new about global change. What is new is how fast change seems to be taking place today. Temperatures changed at a rate of about 0.05 ℃ per century during the Little Ice Age as best as we can determine from written records and ice cores. The rate of temperature change today is about ten times faster, even in the

most conservative models. We must learn how much of this increase is **anthropogenic** (due to human activities). This is the first time humans have had the luxury of being able to look into the future and predict ten years in advance what the climate will be like-and humans today have the intellect, technology, and obligation to **mitigate** or at least to slow **adverse** anthropogenic changes.

6. The reservoirs, except for energy, represent closed systems in which the mass movements of material that we call geologic cycles (rock and hydrologic cycles) and biogeochemical cycles (cycling of life-forming elements such as carbon and nitrogen) occur. The most readily understood of these cycles is probably the hydrologic cycle, by which water on land and at the sea surface is evaporated to the atmosphere and transported as clouds, which then redistribute the moisture around the earth . It is a short-term cycle. The rock cycle, on the other hand, is a long-term cycle involving slow changes, some of them taking millions of years. Less obvious is the recycling of the elements hydrogen, oxygen, carbon, nitrogen, and potassium, the main players in biogeochemical cycles. The atmosphere and hydrosphere get carbon, nitrogen, and oxygen by interacting with the solid earth and oceans, by weathering, and by volcanic action, and the cycle is completed when animals and plants give up these elements to the atmosphere, lithosphere, and hydrosphere by their life processes or after death by decomposition. Current knowledge of the carbon cycle is woefully inadequate, as scientists cannot account for about 25 percent of **sequestered** carbon (carbon that is isolated from the environment by burial or other means). The assumption is that it is buried beneath sediment in the oceans and in soil on land. Knowledge of the carbon cycle is of major importance in predicting future global climate and, specifically, the amount of global warming that can be caused by anthropogenic carbon dioxide (CO_2) and **methane** (CH_4), so-called greenhouse gases.

NEW WORDS AND EXPRESSIONS

geology [dʒiˈɔlədʒi] n. 地质学
biosphere [ˈbaiəsfiə] n. 生物圈
atmosphere [ˈætməsfiə] n. 大气圈

ecosphere ['iːkəuˌsfiə] n. 生态圈
airborne ['ɛəbɔːn] a. 空运的,空中传播的
silt [silt] n. 粉砂
El Nino 厄尔尼诺
oscillation [ˌɔsi'leiʃən] n. 振动,动摇
on-and-off ramps 上下斜坡
lithosphere ['liθəsfiə] n. 岩石圈
hydrosphere ['haidrəsfiə] n. 水圈
extraterrestrial [ˌekstrətə'restriəl] a. 地球(或其大气圈)外的
oceanography [ˌəuʃiə'nɔgrəfi] n. 海洋学
hydrology [hai'drɔlədʒi] n. 水文学
landslide ['lændslaid] n. 山崩
ʔanthropogenic [ˌænθrəpə'dʒenik] a. 人为的
mitigate ['mitigeit] v. 缓和
adverse ['ædvəːs] a. 不利的
sequester [si'kwestə] vt. 使……隔绝
methane ['meθein] n. 甲烷

EXERCISES

Part one: Answer the following questions

1. What function do magnetic fields have?
2. What is a system?
3. What are the names of the five earth's subsystems?
4. What have happened about the solid earth sciences over the past century?
5. What is a geologic cycle?

Part two: Fill in the blanks

1. Where are magnetic fields generated? ________

a. crust

b. mantle

c. lithosphere

d. outer core

2. EL NINO is ________.

a. a periodic weather phenomenon

b. the place in Pacific ocean

c. the name of a famous scientist

d. the acronym for a global weather event

3. The lithosphere is ________.

a. a part of the earth's crust

b. including the earth's crust and upper part of the mantle

c. the solid earth

d. a part of the mantle

4. The cycling of life-forming elements such as carbon and nitrogen is called ________.

a. geologic cycle

b. element cycle

c. hydrologic cycle

d. biogeochemical cycle

5. Which of following anthropogenic gas is called greenhouse gas? ______

a. water vapor

b. hydrogen

c. methane

d. carbon monoxide

Lesson 2 What Is a Mineral

1. **Minerals** are naturally occurring inorganic solids consisting of chemical elements in specific proportions whose atoms are arranged in a systematic internal pattern. An element is a form of matter that cannot be broken down into a simpler form by heating, cooling, or reacting with other chemical elements. To be classified as a mineral, a substance must meet five requirements:

① It must be naturally formed;

② It must be a solid;

③ It must have been formed by inorganic processes;

④ It must have a specific chemical composition;

⑤ It must have a characteristic **crystal** structure.

2. Let's briefly review these characteristics before going on to discuss the specific properties of minerals in mote detail.

3. Naturally formed: The requirement that minerals be naturally formed excludes any substance that is produced by artificial means, such as steel, plastic, or any of the laboratory-produced **crystalline** materials that have no natural equivalents. Technically, none of these substances is a mineral.

4. Solid: All liquids and gases-including naturally occurring ones such as oil and natural gas-are also excluded because minerals are solids. This requirement is based on the state of the material, not on its composition. For example, ice in a glacier is a mineral but water in a stream is not, even though both are made of the same chemical compound, H_2O.

5. Formed by inorganic processes: Materials such as leaves, which are derived from living organisms and contain organic compounds, are not minerals. Coal, for example, is not a mineral because it is derived from the remains of plant material and contains organic compounds. The teeth and bony parts of dead animals as well as the shells of sea creatures present a trickier

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case. The materials in bones, teeth, and shells are the same as those in minerals, but by definition, such materials are not minerals because they are formed by organic processes. However, when the bone or shell is **fossilized**, the original materials are usually replaced by minerals, an inorganic process called **mineralization.** If you were to perform a chemical analysis of a dinosaur bone, for example, you would find few or no organic compounds, only minerals formed by inorganic processes, even though the internal structure of the bone may have been preserved by mineralization.

6. Specific chemical composition: The requirement that a mineral must have a specific chemical composition has several implications. Most importantly, it means that minerals are either chemical elements (gold and diamond are examples) or chemical compound in which atoms are present in specific ratios. **Quartz**, with the formula SiO_2, is an example of a chemical compound. The ratio of Si to O in quartz is always 1 to 2. Many minerals have much more complicated formulas than quartz, for example, the chemical formula of the mineral **phlogopite**, a common form of **mica**, is $KMg_3Si_3O_{10}(OH)_2$, other minerals have even more complicated formulas, but in all cases the elements in compounds combine in specific ratios.

7. A complication involving mineral compositions arises from a property called **atomic substitution.** Atoms of different elements that are similar in size and bonding properties can substitute for each other in a mineral. For example, Mg^{2+} and Fe^{2+} are so similar in size and electrical charge that extensive substitution of Fe^{2+} for Mg^{2+} can occur in the mineral **olivine**, Mg_2SiO_4. Atomic substitution does not change the combining ratios of the elements involved or the kinds of bonds involved. Atomic substitution is indicated in a chemical formula by putting brackets around the substituting elements and a comma between them; the formula for olivine, therefore, becomes $(Mg, Fe)_2SiO_4$.

8. The composition requirements for minerals serve to exclude materials whose composition varies within a range that cannot be expressed by an exact chemical formula. An example of such a material is glass, which is a mixture of many elements and can have a wide range of compositions.

9. Characteristic crystal structure: Glass-even naturally formed volcanic glass-is further excluded from being called a mineral by the requirement that a

mineral must have a characteristic crystal structure. This term has to do with the arrangement of atoms in the material. Technically, glass is a frozen liquid. The atoms in liquids are randomly **jumbled**, while the atoms in minerals are organized in regular, repetitive geometric patterns. The geometric pattern of atoms in a mineral is referred to as the crystal structure. Because minerals have a crystal structure, they are said to be **crystalline.** Solids such as glass that lack a crystal structure are called amorphous solids (from the Greek for "without form"); they are not minerals. All minerals are crystalline, and the crystal structure of any mineral is a unique characteristic of that mineral.

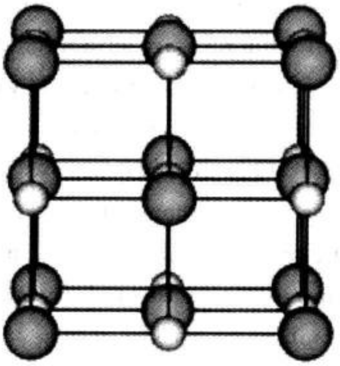

Fig. 2-1 Crystal structure of NaCl

10. All specimens of a given mineral have an identical crystal structure. Extremely sensitive, ultra-high-resolution microscopes enable scientists to look at the crystal structures of minerals and actually see the orderly arrangement of atoms in the minerals.

11. Two minerals may have the same chemical composition but different crystal structures because they formed under different temperature or pressure conditions. Such minerals are known as **polymorphs** ("many forms"). **Graphite** (the "lead" in your pencil) and **diamond**, for example are polymorphs that consist entirely of carbon. Graphite's structure forms under the low pressure prevalent at shallow depths (only a few kilometers below the Earth's surface), whereas diamond's much more compressed structure results from intense pressure at depths greater than 150 kilometers.

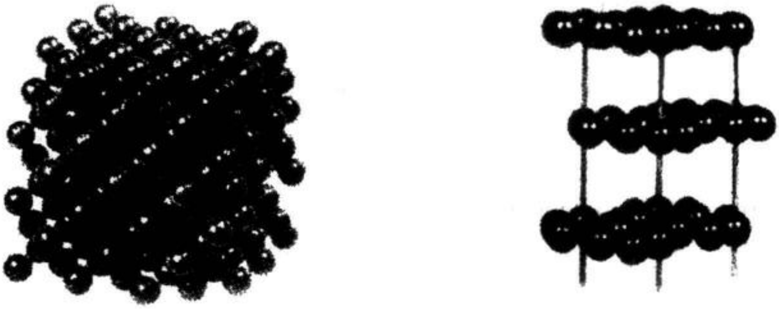

Fig. 2-2 Polymorphs of diamond (left) of graphite (right)

NEW WORDS AND EXPRESSIONS

mineral ['minərəl] n. 矿物 a. 矿物的
crystal ['kristl] a. 晶体的 n. 水晶
crystalline ['kristəlain] a. 结晶的，透明的
fossilize ['fɔsilaiz] v. 使成化石，变成化石
mineralization ['minərəl'zeiʃən] n. 矿化，矿化作用
quartz [kwɔːts] n. 石英
phlogopite ['flɔgəpait] n. 金云母
mica ['maikə] n. 云母
atomic substitution n. 原子替代
olivine [ˌɔli'viːn] n. 橄榄石，黄绿
serve to 对……有用
jumble ['dʒʌmbl] v. 掺杂，混杂 n. 混杂，混乱
crystalline ['kristəlain] n. 结晶体
polymorph ['pɔlimɔːf] n. 多形体，同质异象体
graphite ['græfait] n. 石墨
diamond ['daiəmənd] n. 金刚石

EXERCISES

Part one: Answer the following questions

1. What requirements must a substance meet to be classified as a mineral?

2. Is steel a mineral? Why?

3. Is a dinosaur bone found in Jurassic system a mineral?

4. What accounts for the fact that some minerals have a range of chemical compositions?

5. How does a crystalline solid differ from a liquid?

Part two: Fill in the blanks

1. Which of following substance is a mineral? ________

a. ice

b. coal

c. glass

d. animal teeth

2. Two minerals which have the same chemical composition but different crystal structure are called ________.

a. crystals

b. minerals

c. solids

d. polymorphs

3. An amorphous solid is ________.

a. the solid without a form

b. the solid without a crystal structure

c. the solid produced by artificial means

d. the solid formed naturally

4. The geometric pattern of atoms in a mineral is referred to as ________.

a. the crystalline

b. the crystal

c. the crystal structure

d. the crystal form

5. All minerals are ________.

a. crystal

b. crystalline

c. ionic compounds

d. composed of a single element

Lesson 3 The Properties of Minerals

1. Crystal form: The planar surfaces that bound a crystal are called crystal faces, and the geometric arrangement of crystal faces is called the crystal form. During the seventeenth century, crystal form was a subject of intense study. Scientists discovered that crystal form could be used to identify minerals. But they were unable to explain certain features such as the wide variation in the relative sizes if crystal faces from one sample to another. Under some circumstances, a mineral species may grow a thin crystal; under others, the same mineral species may grow a fat crystal. It is apparent from the figure that overall crystal size and relative sizes of crystal faces are not the same for these two crystals of quartz; crystal size and the relative sizes of crystal faces are not definitive for any mineral.

2. The person who solved the mystery was a Danish physician, Nicolaus Steno. In 1669 Steno demonstrated that an important property of a given mineral is not the size of its faces, but rather the angles between the faces. The angle between any designated pair of crystal faces of a given mineral species is constant, he wrote, and it is the same for all specimens of a mineral, regardless of overall shape or size.

3. Steno and other early scientists suspected that a mineral must have some kind of internal order that enables it to form crystals with constant interfacial angles. However, the particles on which that order depends-atoms-were too small for them to see, so they could only speculate. Proof that crystal form reflects internal order was finally achieved in 1912. In that year the German scientist Max von Laue, using X rays, demonstrated that crystals must be made up of atoms packed in fixed geometric arrays.

4. Crystal faces can form only when mineral grains can grow freely in an

open space. Because most mineral grains do not form in open, unobstructed spaces, crystals are uncommon in nature. Instead, most mineral grains grow in limited spaces where other mineral grains get in the way. As a result, most mineral grains are irregularly shaped. However, in both a crystal and an irregularly shaped grain of the same mineral, all the atoms present are packed in the same strict geometric pattern; that is, the crystals and the irregular grains have identical crystal structures, and both are crystalline. The term crystal structure, rather than crystal, is therefore used in the definition of a mineral.

5. Habit and cleavage: Some minerals grow such **distinctively** shaped grains that the grain shape-called the mineral's habit-can sometimes be used as an identification tool. For example, the mineral **pyrite** (FeS_2) is commonly found as a collection of **intergrown** cubes.

Fig. 3-1 Pyrite and its crystal habit

6. The tendency of certain minerals to break in preferred directions along brightly reflective planar surfaces is called **cleavage**. If you break such a mineral with a hammer or drop it on the floor so that it shatters, some of the broken fragments will be founded by surfaces that are smooth and planar, and in that respect they are like crystal faces. The "books" of **muscovite** cleave easily into thin sheets but do not cleave at all in any other direction. In certain

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