THEORY AND TECHNOLOGY OF SOLID DEPOSIT MINING

固体矿床开采理论与技术

蒋国安　秦忠诚　主编

煤炭工业出版社

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THEORY AND TECHNOLOGY OF SOLID DEPOSIT MINING

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内 容 提 要

本书共八章，包括矿山地质、矿图、采矿学原理、壁式开采法、柱式开采法、露天开采法、新型开采方法和采矿方法选择。内容丰富，图文并茂。

本书原文都摘自英文原版教材，经编者按我国采矿工程专业采矿方法课程教材模式编辑而成，主要词语有中文注释。主要供采矿工程专业本科以上学生进行专业课程的双语教学使用，也可供矿业系统从事固体矿床开采的专业技术人员阅读学习参考。

前　言

21世纪的到来，高等学校的教育教学改革进入了新阶段。作者有幸主持和参加获得教育部批准的“世行贷款高等理工科教育教学改革项目《矿业类专业课程体系整体优化与实践》”（项目号：1282B05012）的研究和教学改革实践。在历时两年多的研究中，不仅对采矿工程专业的课程体系进行了整体优化与重组，而且对课程内容和教学方法进行了重大改革，尝试了部分课程的“双语教学”。为了能实现部分课程直接采用英文原版教材进行教学的目的，我们先按照我国采矿工程专业采矿方法课程教材内容和编写模式，从能够收集到的材料中摘录、编辑和注释了这本教材，供采矿工程专业本科以上学生进行专业课程的双语教学使用，也可供矿业系统从事固体矿床开采的专业技术人员阅读学习参考。

本教材共分八章四十二节，包括矿山地质、矿图、采矿学原理、壁式开采法、柱式开采法、露天开采法、新型开采方法和采矿方法选择等。原文摘自《Cummins & Given, SME Mining Engineering Handbook》、《Robert Stefanko, Coal Mining Technology – Theory and Practice》、《Crickmer & Zegeer, Elements of Practical Coal Mining》、《M. J. Rickard, Geological Map Interpretation》、《Howard L. Hartman, Introductory Mining Engineering》等著作。主要词语有中文注释，内容丰富，图文并茂。

本教材是教育部“世行贷款高等理工科教育教学改革项目《矿业类专业课程体系整体优化与实践》”的系列教材，是本项目研究的成果之一。在编写过程中得到我校教务处的大力支持，在此表示诚挚的感谢。

由于编者水平有限，加上时间仓促，一定存在不少问题和错误，敬请广大师生和读者批评指正。

编　者

2003年8月

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1 Geology of Mines（矿山地质）

1.1 Earth Crust and Strata（地壳和岩层）

1.1.1 Origin and Modification of the Earth（地球的起源和演变）

The study of the earth is called geology（地质）. This science attempts to explain the origin of the earth and its relation to the other heavenly bodies（天体）; it attempts to explain the reason for the atmosphere, the waters which flow on or cover parts of the earth, and the rocks（岩石）and minerals（矿物）which form the land surface; and it attempts to reconstruct the history of life, going back beyond the age of man and giving us the story of the animals that first roamed（漫步）the earth and telling us how they lived.

We could not hope to cover（包含）, even half-heartedly（即使不认真地）, the entire study of geology here, but we shall attempt to explain the geology of coal. It must be recognized that the story of coal is but（仅仅）one of the many stories which the geologist has read in（记录）the rocks of the earth, and in discussing it we cannot help but（不得不）treat（处理）some of those other geologic stories which are closely related to the origin of our coal beds (Jones and Hunt, 1952).

1. Origin of the Earth（地球的起源）

Planets（行星）are non-luminous（非发光）(i.e. give off no light of their own) bodies that revolve in orbits（轨道）about an immensely larger（庞大的）body, generally luminous, called a star. The earth is such a planet revolving about a star we call our sun. Eight other planets also circle this sun, and these make up our *solar system*（太阳系）.

One theory about the origin of the earth and the other planets is that masses of gas, and perhaps some solid matter, that have been thrown off from stars have gradually collected into increasingly larger masses. Through the interattraction（相互吸引）of gravity（重力）, smaller masses have been added to larger ones, increasing their size and creating great heat through the force of collision（碰撞）. When any extremely hot object cools, it contracts（收缩）and causes a buckling（起伏不平）or cracking（裂缝）of the surface; thus, we may expect to find places of elevation（抬起）and of depression（凹陷）on the surface of such an object, and this is true of the earth's surface. With the cooling of the earth and the development of an atmosphere from the gases which surround it, we arrive at the beginning of geologic history.

2. Earth Modification（地球的演变）

The atmosphere consists of a gaseous envelope（外壳）(air) extending outward（外延）a distance of over 161 km (100 miles) from the earth's surface. While the atmosphere consists

primarily of 79% nitrogen (N_2) (氮) and 21% oxygen (O_2) (氧), it also contains other small but important gases such as carbon dioxide (CO_2) (二氧化碳), water vapor (水蒸气), and various acids (酸) that aid in the weathering (风化) and disintegration (剥蚀) of rocks and minerals.

We are all familiar with the destructive (破坏性的) force of strong winds which accompany storms. The same powerful action is used to cut away exposed (暴露的) rocks and soil; the wind gathers up dust and small sand particles and uses them much like a sandblast (喷沙清除法) in cutting the exposed rock ledges and steep (陡峭的) soil banks (土堤). Although the results of this action may be very slight in any one location, its total effect over the entire earth is enormous (巨大的). Also, the wind will pick up loose material of small size and carry it to other places where it is deposited (沉积). Sand dunes (沙丘) are deposits of this type; loess (黄土), which is not sandy and is excellent farming soil (可耕作的土壤), is another type of wind-borne deposit.

In discussing the weathering of the rocks and minerals which form the outer crust (外壳) of the earth's surface, several aspects of this action must be considered. Moisture (水分) and certain gases, either separately or in combination, will cause decay (损坏) of rocks; extreme changes of temperature aid in this decay as do acids carried in solution (溶解) in ground water (地下水) and plants and animals. These actions are partly mechanical and partly chemical, and taken altogether they result in the overall effect called *weathering* (风化).

Solid (固体) is a term which misrepresents the true condition of rocks. The bedrock (基岩), which forms the outer shell of the earth, may appear to be solid but it is everywhere more or less (多少) shattered (破坏); that is, there are cracks (裂缝) and fissures (裂隙), both large and small, running through it in all directions. It is in such cracks and fissures that the weathering action of the air takes place. Air enters the openings, carrying with it moisture and the various gases found in the atmosphere. Moisture itself is a good solvent (溶剂) (i.e. it will dissolve (分解) material), but when carbon dioxide or some of the other acid gases are present in the moisture, its solvent action is greatly increased. Oxygen dissolved in the moisture changes the chemical composition of (i.e. chemically it oxidizes (氧化)) certain materials that are insoluble (难溶的) (i.e. they will not dissolve); carbon dioxide in the moisture then converts (转换) these oxidized minerals to different compounds that are soluble in water, and also works on insoluble calcium (钙) compounds. The other acids carried in the moisture contribute to (对…起作用) these changes, with the result that the rock is eaten away along the various cracks and is weakened. Constant repetition of this process results in the rock's breaking into several pieces and the decomposing action continues on each of these.

Heat and cold as agents of weathering must be included with the work of the atmosphere. Rock masses which are subjected to (遭受) extreme (过分的) heat, as in some desert regions (沙漠地区), will expand (膨胀) in the same manner (以同样的方式) as metals; When they cool, they contract to their former size. Constant repetition of this will, of course,

result in the rock masses being broken into a number of small pieces.

The destructive work of the atmosphere, then, consists of breaking up the large rock masses through decomposition and disintegration and providing the material for the forces of erosion (侵蚀) to carry away. In places where erosion is hindered (阻止) by a mat of (一簇) vegetation (植被) (bushes (灌木) or grass) or by forces (interlocking (连结的) roots), we find that weathering of bedrock produces soil which varies in depth with the time during which the weathering process took place. In other places where these protective coverings (保护层) are absent, as on mountains and in arid (干旱的) regions or plains, the process of weathering each year produces much fine material that is carried away by the various forces of erosion.

The weathering of the bedrock produces fine particles and eventually results in the formation of soil over the rock. This soil mantle (覆盖物) appears to be at rest (静止), but it is actually being urged (强烈要求) towards a lower level (至较低位置上) by such actions as running water, dissolution (分解) and frost (冰霜). The term *creep* (蠕变) has been applied to this motion, particles which have been dislodged (移动) fall to a lower level, and their places are taken (取代) by fresh particles resulting from the decay of rocks. Under the urge of rainwash (雨水冲刷), many particles are moved considerable distances and always to a lower level. This continual process is called *erosion*, and the agencies (媒介) taking part include the wind, running water, ice, and sea waves.

The carrying away of soil by rainwash is a common sight (共同的看法). Raindrops (雨点) run together in form rivulets (小河, 溪流); these combine to form streamlets (小溪); and these combine to form larger streams. The sediment (沉积物) which discolors (污染) the water of a stream during and after rainfall is the material eroded from the soil by these actions, both small and large. The amount removed depends, of course, on the nature of the region; in some parts of the country where the bedrock is close to the surface, the rainwash may not carry away as much material as in other areas where the soil is deep and unprotected. Vegetation, which covers the soil in regions of humid climate, retards (阻止) the rapid removal of soil by rainwash to a great extent (在很大程度上). In arid regions, we find that the percentage of water running off the surface to the percentage sinking into the ground is quite large; it is common in such regions to have small streams become raging (狂暴的) rivers after a heavy rainfall, and the amount of soil removed by rainwash under such conditions is enormous.

1.1.2 Three Kinds of Rocks (三种岩石)

The rock (岩石) is the main material which constitutes (构成) the earth's crust (地壳) and is more complex than minerals, because a rock may contain many minerals. Yet (然而), there are only three main types of rocks. This does not mean that there are only three different rocks, but means that there are three methods by which the rocks were made. The three types are named igneous (火成的), sedimentary (沉积的) and metamorphic (变质的).

1. Igneous Rock（火成岩）

Igneous rocks are those that came from a molten（熔融的）condition. The pressure（压力）and heat inside the earth cause some of the "rock stuff（材料）" in the earth to be liquid（液体）. When this hot liquid cools, rock is formed. This rock is called igneous rock. If the "rock stuff" is thrown out（投、掷）upon the surface, it is an extruded rock（喷出岩）. If it is thrust（插入）into the earth's crust and does not reach the surface, it is an intrusive rock（侵入岩）.

The igneous rock usually contains crystals（结晶体）. If the cooling was rapid the crystals will be very small. Sometimes the crystals are so small that they cannot be seen without the help of a magnifying（放大）glass. The molten material from which the cool, hard igneous rock is formed is known as lava（熔岩）or magma（岩浆）. If the molten rock reaches the surface of the earth it is called lava. While it is in the earth, it is called magma. Some of the igneous rocks are granite（花岗岩）, basalt（玄武岩）, porphyry（斑岩）, etc. Granite is the commonest of all the igneous rocks and the one with coarsest grain. It was formed from magma that cooled very slowly. Granite always contains quartz（石英）called feldspar（长石）, it may also contain mica（云母）or amphibole（角闪石）.

2. Sedimentary Rock（沉积岩）

The second type is named sedimentary rock. This kind of rock is formed from sediment（沉积物）which has been deposited（沉积）by water. When rain falls on the land, washes away some of the soil（土壤）, and wears（磨蚀）away some of the rock in the earth's crust, it carries（携带）this material along into the rivers. The rivers carry it into the lakes and oceans. Here the sediment settles（沉淀）down the larger, heavier particles are deposited first, so that the layers are formed. This may be shown by a jar of water to which some sands and pebbles（卵石、小圆石子）have been added, let the water come to rest and do not disturb（搅动）, soon layers will be apparent（可见的）. When a rock shows the presence of horizontal（水平的）layers of material, the rock is sedimentary. Sometimes the layers are not exactly horizontal, because of the forces that lifted the rock at certain point. Some of the sedimentary rocks are sandstone（砂岩）, shale（页岩）, and limestone（石灰岩）. Since most sediments are deposited in more or less regular（规则的）layers, or strata（岩层）, the sedimentary rocks are known as stratified（成层的）rocks.

3. Metamorphic Rock（变质岩）

The third type is named metamorphic rock. Rocks of this kind have been changed by great heat and pressure in the earth. Originally they may have been sedimentary or igneous rocks, but because of the heat and pressure they were changed into something quite different in appearance（外表）. These rocks become even harder and their originally coarse grains take on a smooth（光滑的）, sometimes glassy（玻璃状的）, appearance. For example, marble（大理石）is metamorphic and comes from limestone; slate（板岩）comes from shale; quartzite（石英岩）comes from sandstone. Gneiss（片麻岩）is one of the most common metamorphic rocks. It is coarse-grained made over granite, shale or sandstone. Whatever its origin, it is