Historical Geology 8th edition Wicander Solutions Manual

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CHAPTER 2

MINERALS AND ROCKS

OUTLINE

INTRODUCTION
MATTER—WHAT IS IT?
    Elements and Atoms
    Bonding and Compounds
MINERALS—THE BUILDING BLOCKS OF ROCKS
    How Many Minerals Are There?
    Rock-Forming Minerals and the Rock Cycle
IGNEOUS ROCKS
    Composition and Texture
    Classifying Igneous Rocks
SEDIMENTARY ROCKS
    Sediment Transport, Deposition, and Lithification
    Classification of Sedimentary Rocks
METAMORPHIC ROCKS
    What Causes Metamorphism?
    Metamorphic Rock Classification
PLATE TECTONICS AND THE ROCK CYCLE
ECONOMIC GEOLOGY
    ♦ PERSPECTIVE *The Industrial Minerals*
SUMMARY

CHAPTER OBJECTIVES

The following content objectives are presented in Chapter 2:

- Chemical elements are composed of atoms, all of the same kind, whereas compounds form when different atoms bond together. Most minerals are compounds, which are naturally occurring, inorganic, crystalline solids.
- Of the 3,800 or so minerals known, only a few, perhaps two dozen, are common in rocks, but many others are found in small quantities in rocks, and some of these are important natural resources.
- Cooling and crystallization of magma or lava and the consolidation of pyroclastic materials such as volcanic ash account for the origin of igneous rocks.
- Geologists use mineral content (composition) and textures to classify plutonic rocks (intrusive igneous rocks) and volcanic rocks (extrusive igneous rocks).
- Mechanical and chemical weathering of rocks yields sediment that is transported, deposited, and then lithified to form detrital and chemical sedimentary rocks.

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- Texture and composition are the criteria geologists use to classify sedimentary rocks.
- Any type or rock may be altered by heat, pressure, fluids, or any combination of these to form metamorphic rocks.
- One feature used to classify metamorphic rocks is foliation—that is, a platy or layered aspect—but some lack this feature and are said to be nonfoliated.
- The fact that Earth materials are continually recycled and that the three groups of rocks are interrelated is summarized in the rock cycle.
- Many minerals and some rocks are important natural resources or contain resources such as petroleum and natural gas.

LEARNING OBJECTIVES

To exhibit mastery of this chapter, students should be able to demonstrate comprehension of the following:

- the nature of minerals, including the classification of substances as mineral or not mineral
- the basic atomic structure, and the formation of elements and compounds
- the types of minerals and their roles in the various types of rocks
- the rock cycle, including how each type of rock can yield the other rock types
- the formation and classification of igneous rocks
- sediment production through weathering, transportation, environments of deposition, and lithification
- the classification of sedimentary rocks
- the formation and classification of metamorphic rocks
- the effects of plate tectonics on the rock cycle

ENRICHMENT TOPICS

Enrichment Topic 1. Gemstones
Some minerals qualify as collectible and valuable. Your students can investigate the various types of gemstones through this PBS website (http://www.pbs.org/wgbh/nova/diamond/gemprimer.html). The formulas of gemstones can be accessed at http://pubs.usgs.gov/gip/gemstones/formulas.html , and from these you may want to consider having your students classify gemstones into their corresponding mineral groups. Physical properties of minerals are listed at http://www.webmineral.com/determin.shtml#.U9kP4Fbu6xE, whereas environments of formation of gemstones are discussed at http://pubs.usgs.gov/gip/gemstones/environment.html.

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Enrichment Topic 2. "Your House Comes Out of a Mine."

Rocks and minerals provide many of the natural resources for the physical structures we build. "If you don't grow it, you mine it." Have students investigate the variety of rocks and minerals supplied as raw materials by the mining industry to the building industry. The USGS mineral website (http://minerals.usgs.gov/minerals/) discusses various commodities. Some mined natural resources are discussed within a collection of fact sheets (http://www.usgs.gov/science/science.php?thcode=2&term=749). The Mineral Information Institute (http://www.mii.org/commonminerals.php) also lists the common minerals and their uses.

Students can investigate the materials within their own dwellings, and identify them as far as the mineral or rock type, and the location from which items are mined. Some possibilities include aluminum, gypsum (for sheetrock/wallboard), clay, and sand.

The more obvious "rock" building materials—such as that used as flooring material, countertops, or fireplace hearths—are usually classified by building contractors as "marble" or "granite." However, there are a variety of rocks that are used in construction that are not marble or granite! Students can investigate these various rock countertops and floor tiles, and correctly classify them using the information in the chapter.

One helpful activity is to plan a "field trip" around your campus observing the various rocks used in campus buildings. Many campuses have fine examples of granite, but other building materials may include travertine, limestone, basalt, gabbro, sandstone, breccia, gneiss, etc.

LECTURE SUGGESTIONS

The Nature of Minerals and Rocks

Students can explore the characteristics that substances must possess in order to be classified as minerals. In particular, the instructor may explore organic composition, liquid phases, and man-created gemstones.

1. Is the element mercury a mineral by our definition? Why or why not? Does glacial ice classify as a mineral?

2. If a laboratory gemstone has identical composition and physical properties as a substance found in nature, is it a mineral? Does coal classify as a mineral? Ask students to think of examples where a substance may classify as a rock, but it is not made of minerals.

Common Rock-Forming Minerals

Students can learn more about the common rock-forming minerals. Although there are over 3,500 different minerals, only a few are common within rocks. About.com Geology lists the common minerals that are abundant and widespread, the accessory minerals that are widespread but rarely abundant, and interesting but uncommon minerals. (http://www.mii.org/commonminerals.php) Each mineral has a clickable link that

includes a photograph of the mineral, as well as a general description. Ask your students to locate the formulas of the common rock-forming minerals, and then classify them into the mineral groups recognized by geologists (Table 2.1). ATHENA mineralogy (http://athena.unige.ch/athena/mineral/mineral.html) is another good resource for researching minerals.

Rock Types

If students are presented with an assortment of rocks, how would they begin determining which were sedimentary, which were metamorphic, and which were igneous? Discuss the characteristics of the rock groups, including clastic texture, foliation, and crystalline composition.

The Nature of Sedimentary Rocks

Detrital sedimentary rocks are classified primarily by the size of the included particle, not composition. Students should discuss the common meaning of the words “sand” and “clay.” “Sand” and “clay” are used as categories of particle size, although we commonly use “sand” to convey “quartz composition.” (If the green beach sands of Hawaii, which are composed partly of the mineral olivine, were lithified, olivine sandstone would result. Conversely, a sedimentary rock composed of sand-sized feldspar grains is commonly referred to as an “arkose.”) “Clay” is another term that can be used as both a size category and a mineral group.

The Rock Cycle

Discuss the various paths that rocks can take within the rock cycle, and how one rock type can be transformed into all the other rock types.

1. Can a sedimentary rock form metamorphic rock and igneous rock? Discuss a pathway by which an existing sedimentary rock can become a new sedimentary rock. Discuss the “cross-paths” within the rock cycle.

2. How does the processing of Earth materials through the various transitions of the rock cycle affect the aspects of the rocks that allow us to date them? In which types of rocks do we find fossils? Are these fossils preserved if the rock containing the fossils is transformed to other rock types within the rock cycle?

Economic Geology–Rare Earth Elements

Rare earth elements are critically important to developing the technologies we have come to rely upon such as smaller electronics, green energy, medical technologies, and telecommunication and defense systems. There are seventeen rare earths– scandium, yttrium, and the lanthanide series. Despite their name, rare earths are relatively abundant in Earth’s crust. Mining of rare earth elements is complicated because they are typically found with the radioactive elements thorium and uranium. Because China is the primary producer of rare earth elements, it controls the global market. Explore

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rare earth elements in general at http://topics.nytimes.com/top/reference/timestopics/subjects/r/rare_earths/index.html and explore the economic statistics at http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/. Read Keith Bradsher's article about mining of rare earth elements in China at http://www.nytimes.com/2009/12/26/business/global/26rare.html?ref=rareearths&_r=1& and a discussion of whether the United States can compete with China's production of rare earth elements at http://www.nytimes.com/roomfordebate/2010/11/08/can-the-us-compete-on-rare-earths?ref=science.

1. Why is the world concerned that China is the primary supplier of rare earth minerals? Is this concern justified?

2. It's ironic that the materials needed for some "green" technologies are mined in an environmentally harmful way. Do you think the trade-off is worthwhile?

3. The two articles linked are from 2009 and 2010. Have students research through *The New York Times* how, or if, the economic and political landscape around rare earth elements has changed.

CONSIDER THIS

1. How can you identify a nonfoliated metamorphic rock, such as marble, from the original rock? What characteristics might nonfoliated metamorphic rocks have that make their identification easier? Would nonfoliated metamorphic rocks be easier to identify in the field, rather than in the laboratory as an assortment of samples?

2. Can we identify specific environments associated with plate tectonic boundaries in which various rock types would form? Are igneous rocks associated with convergent, divergent, and transform plate boundaries? In which environments are metamorphic, and sedimentary, rocks produced?

IMPORTANT TERMS

atom
atomic mass number
atomic number
bonding
carbonate mineral
carbonate rock
chemical sedimentary rock
compound
contact metamorphism
crystalline solid
detrital sedimentary rock
dynamic metamorphism
economic geology
element
evaporite
extrusive igneous rock
geologic record
igneous rock
intrusive igneous rock
lava
lithification
magma
metamorphic rock
mineral

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plutonic rock
pyroclastic materials
regional metamorphism
rock
rock cycle
rock-forming mineral
sedimentary rock
silicate
volcanic rock

SUGGESTED MEDIA

Videos

1. Minerals: The Materials of Earth, Earth Revealed #12, Annenberg/CPB
2. Intrusive Igneous Rocks, Earth Revealed #14, Annenberg/CPB
3. Metamorphic Rocks, Earth Revealed #18, Annenberg/CPB
4. Rocks and Minerals, Cambridge Educational Products
5. Standard Deviants School Geology, Minerals, Cerebellum Corporation
6. Standard Deviants School Geology, Sedimentary & Metamorphic Rocks, Cerebellum Collection
7. Core Geology, Ambrose Video
8. Igneous Rocks, Ambrose Video
9. Introduction to Rocks and Minerals, Ambrose Video
10. Metamorphic Rocks, Ambrose Video
11. Sedimentary Rocks, Ambrose Video

Software

1. Hands-On Mineral Identification, Tasa Graphics Arts, Inc.
2. The Study of Minerals, Tasa Graphics Arts, Inc.
3. Tasa Photo CD-ROM, Rock Cycle I, Tasa Graphics Arts, Inc.
4. The Wonders of Rocks and Minerals, Tasa Graphics Arts, Inc.
5. Study of Minerals, RockWare, Inc.
6. Explore Silicate Minerals, Geological Society of America

Slides and Demonstration Aids

1. Rocks and Topography, slide set, Educational Images, Ltd.
2. Rock Specimens and Crystals, slide set, Educational Images, Ltd.
3. Introductory Earth Science Rocks and Minerals, Science Stuff
4. Natural Crystal Collection, Science Stuff
5. Ores of Common Metals, rock collection, Science Stuff
6. Advanced Rock & Minerals Collection, Science Stuff

CHAPTER 2 - ANSWERS TO QUESTONS IN TEXT

Multiple Choice Review Questions

1. **c**
2. **b**
3. **a**
4. **b**
5. **e**

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Short Answer Essay Review Questions

6. Deposits of mud and sand would lithify to form detrital sedimentary rocks. After deposition, the clasts would undergo compaction from the pressure exerted by overlying sediments. For mud-sized particles, compaction only would likely be sufficient to cause lithification. For sand-sized clasts, minerals would precipitate to fill the pore spaces, gluing the sand grains together in a process called cementation. The processes of compaction and cementation would result in lithification for the sand particles.

7. Ionic bonding is a type of bonding where one atom transfers an electron to another atom, so that each atom has a complete outer shell. The formation of sodium chloride provides an excellent example of ionic bonding. Sodium has one electron in its outer shell, whereas chlorine has seven electrons. By losing one electron, sodium becomes a positive ion with a full outer shell. By taking one electron, chlorine becomes a negative ion with a full outer shell. An attractive force between the positive and negative ions exists, which forms the ionic bond.

8. Ice is a mineral because it is a naturally occurring, inorganic crystalline solid. While water vapor and water are naturally occurring and inorganic, they are not crystalline solids. Water vapor is a gas, and water is a liquid.

9. Contact metamorphism occurs when heat and chemical fluids from an igneous body alter adjacent rocks. The degree of metamorphism decreases with increasing distance from the body of magma until the surrounding rocks are unaffected. A type of rock that forms from contact metamorphism is hornfels.

Regional metamorphism takes place over large but elongated areas as the result of tremendous pressure, elevated temperatures, and fluid activity. This type of metamorphism is most obvious along convergent plate boundaries where the rocks are intensely deformed during convergence and subduction. It can also occur along divergent boundaries. Gneiss is found in areas with regional metamorphism.

10. It is difficult to determine from a picture alone the identity of a mineral, as characteristic properties like hardness and streak cannot be measured. Based on the picture, these specimens could be ruled not diamond based on their luster. Diamond has an adamantine luster, which means it is exceptionally sparkly. Fluorite, as pictured, has a vitreous luster, which means it reflects like more like glass, and with less brilliance than diamond. Color would not be a good indicator, since both diamonds and fluorite can be gray, white, or yellow.

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