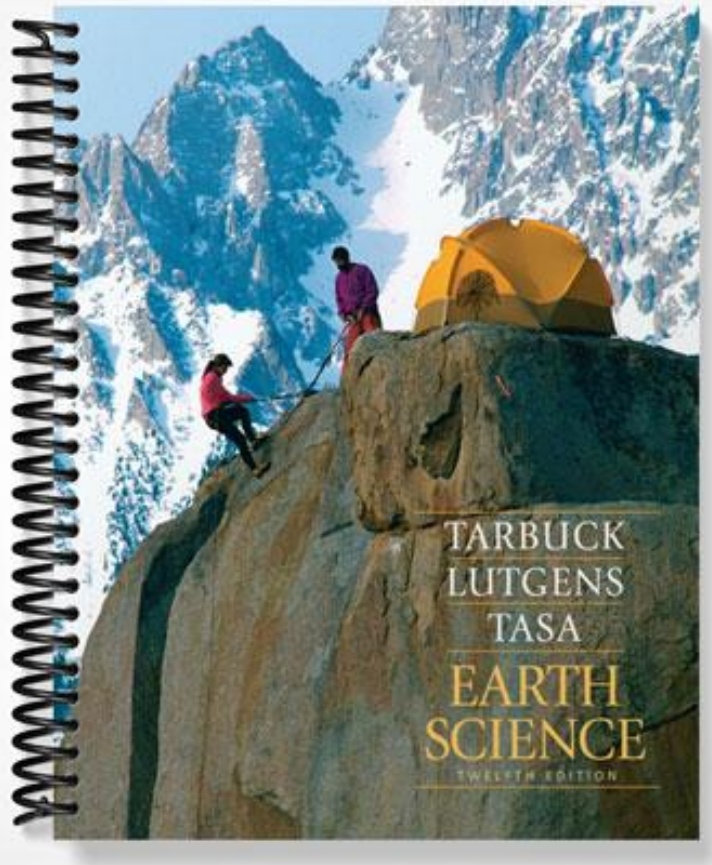
SOLUTIONS MANUAL



Chapter 2

Minerals: Building Blocks of Rocks

Minerals: Building Blocks of Rocks begins with an explanation of the difference between rocks and minerals. The brief comparison is followed by a formal definition of a mineral. Elements, atoms, compounds, ions, and atomic bonding are discussed. Also investigated are isotopes and radioactivity. Following descriptions of the properties used in mineral identification, the silicate and non-silicate mineral groups are examined. The chapter concludes with a presentation of mineral resources, reserves, and ores.

Learning Objectives

After reading, studying, and discussing the chapter, students should be able to:

- Explain the difference between a mineral and a rock.
- Describe the basic structure of an atom and explain how atoms combine.
- List the most important elements that compose Earth's continental crust.
- Explain isotopes and radioactive decay.
- Describe the physical properties of minerals and how they can be used for mineral identification.
- List the basic compositions and structures of the silicate minerals.
- List the economic use of some nonsilicate minerals.
- Distinguish among mineral resources, reserves, and ores.

Chapter Outline

I. Minerals: the building blocks of rocks
  A. Definition of mineral
    1. Naturally occurring
    2. Inorganic
    3. Solid
    4. Possess an orderly internal structure of atoms
    5. Have a definite chemical composition
  B. Rocks are aggregates (mixtures) of minerals

II. Composition and structure of minerals
  A. Elements
    1. Basic building blocks of minerals
    2. More than 100 are known
  B. Atoms
    1. Smallest particles of matter
    2. Have all the characteristics of an element

III. Structure of atoms
  A. Nucleus contains
    1. Protons—positive electrical charge
    2. Neutrons —electrically neutral
  B. Energy levels, or shells
    1. Surround nucleus
    2. Contain electrons—negative electrical charge
  C. Atomic number, the number of protons in an atom's nucleus, identifies element
  D. Bonding of atoms
    1. Compounds are formed from two or more elements
    2. Ions are atoms that have gained or lost electrons
  E. Isotopes
    1. Vary in the number of neutrons
    2. Have different mass numbers—the sum of the neutrons plus protons

3. Many isotopes are radioactive and emit energy and particles

IV. Minerals
A. Properties of minerals
1. Crystal form
2. Luster
3. Color
4. Streak
5. Hardness
6. Cleavage
7. Fracture
8. Specific gravity
9. Other properties
a. Taste
b. Smell
c. Elasticity
d. Malleability
e. Feel
f. Magnetism
g. Double refraction
h. Reaction to hydrochloric acid

B. A few dozen minerals are called the *rock-forming minerals*
1. The eight elements that compose most rock-forming minerals are oxygen (O), silicon (Si), aluminum (Al), iron (Fe), calcium (Ca), sodium (Na), potassium (K), and magnesium (Mg)
2. The most abundant atoms in Earth's crust are
a. Oxygen (46.6% by weight)
b. Silicon (27.7% by weight)

C. Mineral groups
1. Rock-forming silicates
a. Most common mineral group
b. Contain the silicon–oxygen tetrahedron
1. Four oxygen atoms surrounding a much smaller silicon atom
2. The silicon–oxygen tetrahedra join together in a variety of ways
c. Feldspars are the most plentiful group
d. Most silicate minerals crystallize from molten rock as it cools
2. Nonsilicate minerals
a. Major groups
1) Oxides
2) Sulfides
3) Sulfates
4) Halides
5) Carbonates
6) "Native" elements
b. Carbonates
1) Major rock-forming group
2) Found in limestone and marble
c. Halite and gypsum—found in sedimentary rocks
d. Many have economic value

C. Mineral resources
1. Reserves—profitable, identified deposits
2. Ores—metallic minerals that can be mined at a profit
3. Economic factors may change

Answers to Review Questions

1. To be considered a mineral, a substance must exhibit the following characteristics: (1) be naturally occurring, (2) be a solid, (3) have an orderly crystalline structure, (4) have a definite chemical composition, and (5) generally be inorganic.

2. A rock is a more or less hardened (lithified) aggregate of minerals and/or amorphous solids, such as natural glass and organic matter.

3. The particles are electrons, protons, and neutrons. The latter two are heavy particles found in the nucleus of an atom. Electrons are tiny, very lightweight particles that form a "cloud" surrounding the nucleus. The mass and charge data are as follows:

proton—one atomic mass unit, +1 electrical charge
neutron—one atomic mass unit, electrically neutral
electron—tiny fraction of one atomic mass unit, –1 electrical charge

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4. (a) The number of protons—a neutral atom with 35 electrons has 35 protons. (b) The atomic number—the atomic number is 35, equal to the number of protons in the nucleus. (c) The number of neutrons—the mass number (80) is the sum of protons (35) and neutrons. Thus the nucleus contains 45 (80 – 35) neutrons.

5. Isotopes of an element have varying numbers of neutrons in the nucleus and, hence, different atomic weights.

6. An ion is produced when an atom gains or loses one or more electrons and becomes either negatively charged (if electrons are gained) or positively charged (if electrons are lost).

7. Crystal form refers to the geometrically regular, external growth shape that minerals can exhibit if crystal growth is free and unobstructed by other minerals (the crystal grows into a fluid-filled cavity, for example). Most crystal growth in nature is obstructed (not free), so crystals showing their characteristic, geometric forms are uncommon.

8. Impurities often cause the same mineral to have many colors. For example, fluorite can be purple, clear, or yellow, and quartz can be practically any color.

9. The hardness test might help you make a determination, since diamond is the hardest mineral in nature.

10. Any mineral listed on the Mohs scale (Figure 2.13), corundum for example, will scratch softer minerals (those with lower hardness values) and will not scratch harder minerals. Corundum will scratch virtually all other minerals, diamond being the lone exception. Thus corundum is widely used in abrasives and polishing compounds.

11. The specific gravity of water is 1 by definition. Thus the weights of equal volumes of water and gold will be in the ratio 1:20. Because 5 gallons of water weighs 40 pounds, 5 gallons of gold will weigh almost 800 pounds (5 gallons x 160 pounds/gallon = 800 pounds).

12. The two most abundant elements in Earth's crust (by weight) are oxygen (46.6%) and silicon (27.7%). The basic building block of all silicate minerals is the silicon–oxygen tetrahedron.

13. Feldspars are by far the most plentiful group of silicate minerals, constituting more than 50 percent of Earth's crust. Quartz is the second most abundant mineral in the continental crust.

14. Three non-silicate minerals that are commonly found in rocks are calcite, halite, and gypsum.

15. Mineral reserves are identified deposits from which minerals can be extracted profitably. A mineral resource has a broader definition. In addition to including reserves, it also includes known deposits that are not yet economically or technologically recoverable, as well as deposits that are inferred to exist but have not yet been discovered.

16. One way a mineral deposit can become profitable to extract is through an economic change (e.g., the demand for a metal may increase and cause a price increase). Also, if a technological advance allows the metal to be extracted at a lower cost, it may become profitable to extract and thus be reclassified as an ore.

Answers to the Earth System Questions

1. (Answers will vary depending on the mineral commodity selected)

2. (Answers will vary depending on the mineral commodity selected)

Lecture outline, art-only, and animation PowerPoint presentations for each chapter of *Earth Science*, 12e are available on the IRC DVD (ISBN 0-13-604918-4).

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