Mining and Mineral Resources

CHAPTER 16

READING WARM-UP

Before you read this chapter, take a few minutes to answer the following questions in your ***EcoLog.***

1. What are some of the ways in which you use minerals in your daily life?
2. Can you think of some ways in which minerals are mined?

Obtaining the minerals humans need requires removing large amounts of rock at mines like this open-pit copper mine in Arizona. The challenge is to satisfy the increasing demand for mineral resources while minimizing the cost to the environment.

SECTION 1

Minerals and Mineral Resources

Take a look at the human-made objects that surround you. As you may notice, almost every solid object you see is made of minerals. As shown in **Figure 1,** we depend on the use of mineral resources in almost every aspect of our daily lives. However, our dependence on minerals has not come without a price. The current challenge is to obtain the minerals that an ever-increasing world population demands at minimal cost to the environment. In this chapter you will learn about how we use our mineral resources and how we deal with the environmental effects of mining.

Objectives

- Define the term *mineral.*
- Explain the difference between a metal and a nonmetal, and give two examples of each.
- Describe three processes by which ore minerals form.

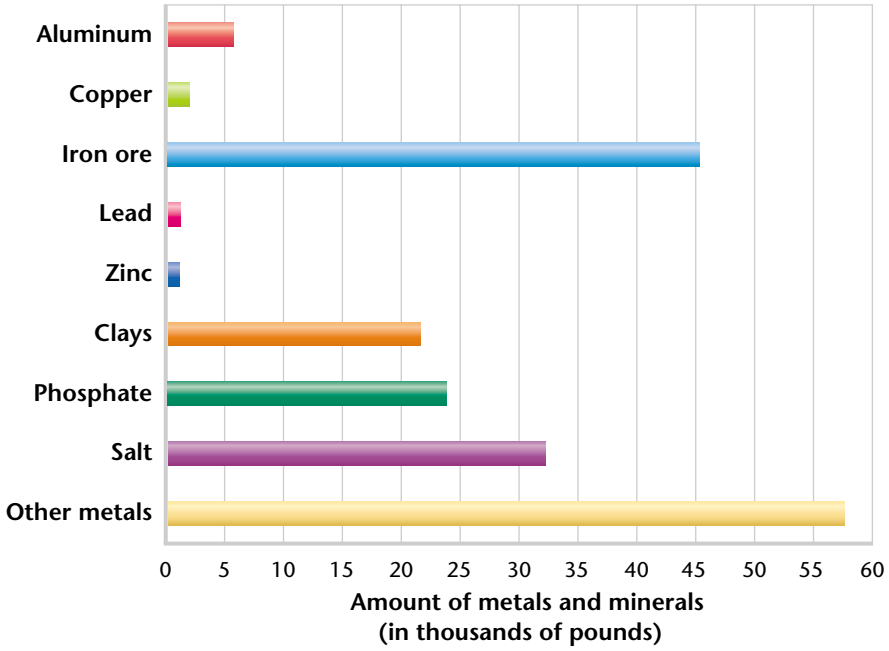
Key Terms

mineral
ore mineral

What Is a Mineral?

A **mineral** is a naturally occurring, usually inorganic solid that has a characteristic chemical composition, an orderly internal structure, and a characteristic set of physical properties. Minerals are made up of atoms of a single element, or of *compounds*—two or more atoms chemically bonded together. The atoms that make up minerals are arranged in regular, repeating geometric patterns. The physical arrangement of the atoms, along with the strength of the chemical bonds between them, determine the physical properties of minerals.

The elements gold, silver, and copper are considered minerals. These types of minerals are called *native elements*. However, most minerals are compounds. For example, the mineral quartz is made up of silica, a compound consisting of one silicon atom and two oxygen atoms. When combined with other elements, silica forms most of the minerals that make up Earth's crust.



Source: Mineral Information Institute.

FIELD ACTIVITY

Identifying Objects Made of Minerals Take a walk around your neighborhood or through your home with a notebook and pencil. Pick an object such as a car, an appliance, or a computer. List as many materials that make up that object as you can. Be as specific as possible. Repeat the procedure for several other objects. Which of these objects do you think are made from minerals? Write to the company that made one of your objects, and ask what materials are used to make the object. Record your observations, along with the company's response, in your ***EcoLog.***

Figure 1 ▶ Mineral consumption is greatest in developed countries, such as the United States. This graph shows the average amount of minerals a person in the U.S. will consume over his or her lifetime.

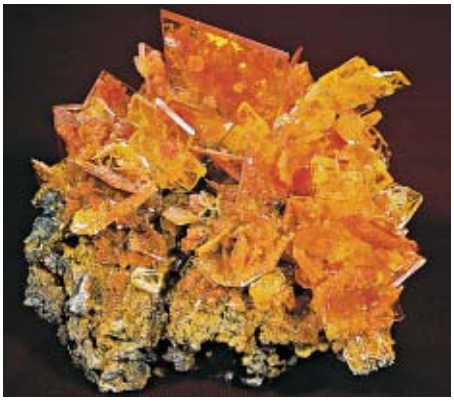


Figure 2 ▶ Certain minerals are mined because of the valuable metals they contain, as shown in the table. Wulfenite (above) is a minor ore of lead. Nice specimens of wulfenite are much sought after by mineral collectors.

Table 1 ▼

Common Elements and Their Ore Minerals	
Element	**Important ore minerals**
Aluminum (Al)	gibbsite, boehmite, diaspore (bauxite)
Beryllium (Be)	beryl
Chromium (Cr)	chromite
Copper (Cu)	bornite, cuprite, chalcocite, chalcopyrite
Iron (Fe)	goethite, hematite, magnetite, siderite
Lead (Pb)	galena
Manganese (Mn)	psilomelane, pyrolusite
Mercury (Hg)	cinnabar
Molybdenum (Mo)	molybdenite
Nickel (Ni)	pentlandite
Silver (Ag)	acanthite
Tin (Sn)	cassiterite
Titanium (Ti)	ilmenite, rutile
Uranium (U)	carnotite, uraninite
Zinc (Zn)	sphalerite

Ore Minerals

Minerals that are valuable and economical to extract are known as **ore minerals.** As shown in **Table 1,** ore minerals contain elements, many of which are economically valuable. During the mining process, ore minerals, along with minerals that have no commercial value, or *gangue* (GANG) *minerals,* are extracted from the host rock. After extraction, mining companies use various methods to separate ore minerals from the gangue minerals. The ore minerals are then further refined to extract the valuable elements they contain. For mining to be profitable, the price of the final product must be greater than the costs of extraction and refining.

Metallic Minerals Ore minerals are either metallic or nonmetallic. Metals conduct electricity, have shiny surfaces, and are opaque. Many valuable metallic minerals are native elements such as gold, shown in **Figure 3.** Silver and copper are also important native elements. Other important ore minerals are compounds in which metallic elements combine with nonmetallic elements, such as sulfur or oxygen.

Nonmetallic Minerals Nonmetals tend to be good insulators, may have shiny or dull surfaces, and may allow light to pass through them. Nonmetallic minerals can also be native elements or compounds.

Figure 3 ▶ Gold is one of the most economically important metallic minerals.

How Do Ore Minerals Form?

As shown in **Figure 4,** economically important ore deposits form in a variety of ways, both on and beneath Earth's surface. The types of minerals that form depend on the environment in which they form. For example, metallic minerals form below ground when magma cools and hardens. The metallic minerals tend to form early in the cooling process and sink to the lower part of the magma body because they are denser. This process concentrates important ore minerals that can be extracted economically.

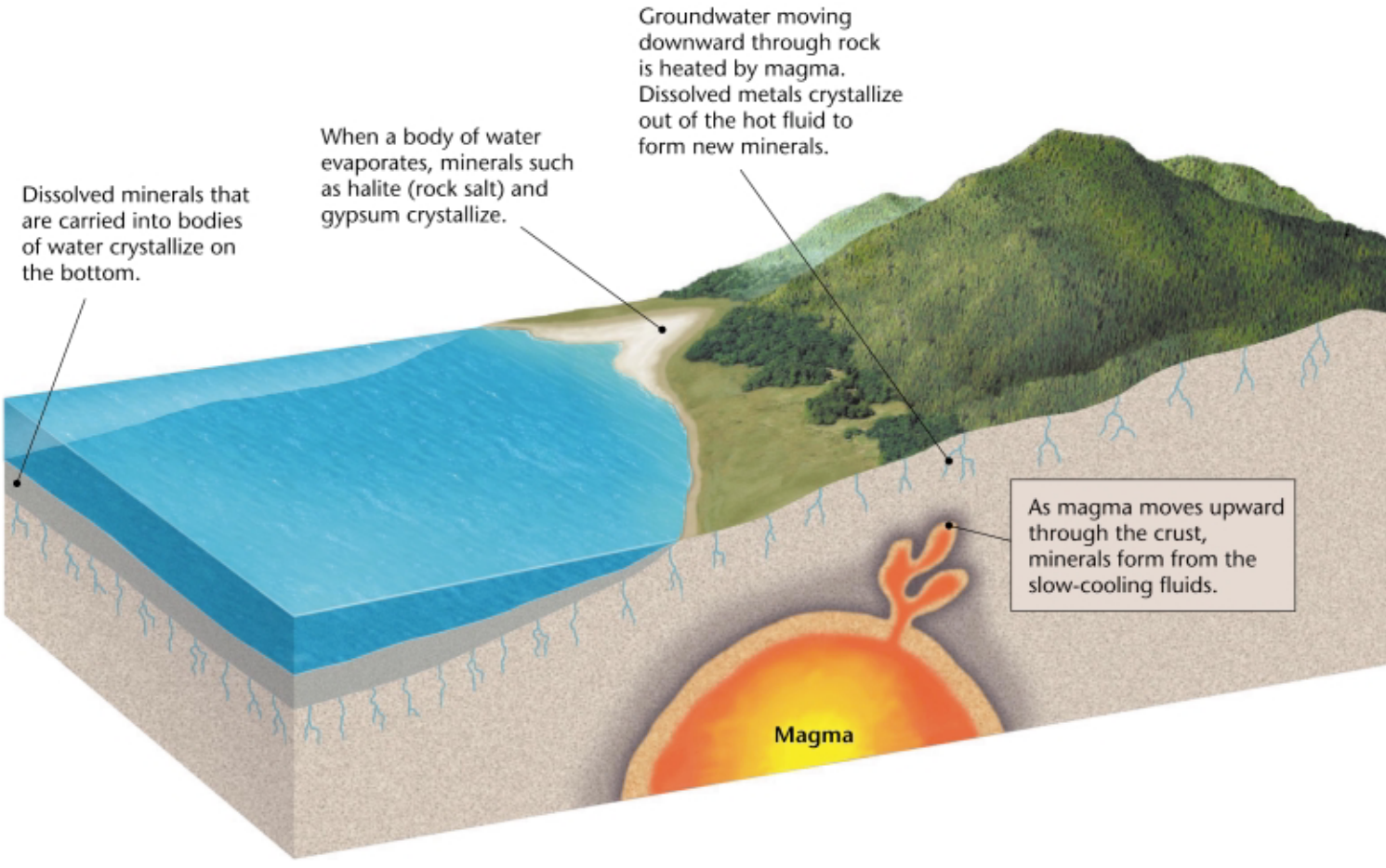
Hydrothermal Solutions Hot, subsurface waters that contain dissolved minerals are called *hydrothermal solutions.* As hydrothermal solutions flow through cracks in rocks, they dissolve minerals they come in contact with. New minerals crystallize out of these solutions and then fill fractures to form ore deposits called *veins.* Many economically valuable deposits of metallic ores form in this way.

Evaporites As rivers and streams wash over land surfaces, they dissolve salts and carry them into the sea or inland lakes. When the water in these seas or lakes evaporates, deposits of these salts, called *evaporites,* are left behind. Evaporites form in arid regions where rates of evaporation are high. Important evaporite minerals include halite (rock salt) and gypsum.

Geofact

Bauxite The major ore of aluminum is a rock called *bauxite.* Bauxite is a mixture of three aluminum oxide minerals. It forms in humid, tropical climates by the weathering of rocks or soil that contain aluminum. Deposits of bauxite are called *aluminum laterites.* Australia, Guinea, and Jamaica are the major world sources of bauxite.

Figure 4 ▶ Mineral Environments Ore deposits form in different ways upon and beneath Earth's surface, and at the bottom of lakes and oceans.



Mineral Resources and Their Uses

Certain metals are of major economic and industrial importance, as shown in **Table 2.** Some metals can be pounded or pressed into various shapes or stretched very thinly without breaking. Other metals are good conductors of heat and electricity, or are prized for their durability and resistance to corrosion. Often, two or more metals are combined to form *alloys*. Alloys are important because they often combine the most desirable properties of the metals used to make them. As shown in **Figure 5,** many new technologies depend on the mining of metallic minerals.

Nonmetals are among the most widely used minerals in the world. For example, gypsum has many applications in the construction industry. It is used to make Sheetrock™, or wallboard, for homes and commercial buildings. It is also a major component of concrete, which is used to build roads, buildings, and other structures. Industrial sand and gravel have uses that range from glassmaking to the manufacture of computer chips. Some nonmetallic minerals, called *gemstones*, are prized purely for their beauty, rarity, or durability. Important gemstones include diamond, ruby, sapphire, emerald, aquamarine, topaz, and tourmaline.

Table 2 ▼

Uses of Important Metallic and Nonmetallic Elements
Aluminum: cans, foil; windows, doors, siding; appliances, cooking utensils; automobiles, aircraft
Copper: cables, wires; electrical and electronic products; plumbing, heating; alloys; coinage
Gold: computers; communications equipment; spacecraft; dentistry, medicine; jewelry
Iron: steel making
Lead: batteries; ammunition; glass; ceramics
Silicon: computer chips; glass; ceramics
Silver: photography; electrical and electronic products; mirrors; chemistry
Sulfur: Sulfuric acid; gunpowder; rubber; fungicides
Titanium: jet engines, aircraft bodies, spacecraft, missiles; pigments
Zinc: coatings on steel; brass; chemical compounds in rubber and paints

Figure 5 ▶ The mineral ilmenite (inset) is an important source of titanium. Because titanium is both strong and lightweight, it is used in aircraft such as this stealth fighter.

SECTION 1 Review

1. **Define** the term *mineral.*
2. **Explain** the difference between a metal and a nonmetal, and give examples of each.
3. **Describe** three processes by which minerals form.
4. **List** five properties that make metals economically and industrially important.

CRITICAL THINKING

5. **Analyzing Relationships** A mineral is a naturally occurring substance. Are synthetic minerals produced in laboratories minerals? Explain your answer.
6. **Making Comparisons** Unlike metals, nonmetals are not good conductors of heat and electricity. How might these properties influence the use of nonmetals in industry? Write a paragraph to explain your answer. WRITING SKILLS