Mines Ores that are located deep within Earth's crust are removed by underground mining. Ores that are near Earth's surface are obtained from large, open-pit mines. When a mine is excavated, unwanted rock and dirt, known as gangue, are dug up along with the valuable ore. The overburden must be separated from the ore before the ore can be used. Removing the overburden can be expensive and, in some cases, harmful to the environment, as you will learn in Chapters 24 and 26. If the cost of removing the overburden becomes higher than the value of the ore itself, the mineral will no longer be classified as an ore. It would no longer be economical to mine.

Gems What makes a ruby more valuable than mica? Rubies are rarer and more visually pleasing than mica. Rubies are thus considered gems. **Gems** are valuable minerals that are prized for their rarity and beauty. They are very hard and scratch resistant. Gems such as rubies, emeralds, and diamonds are cut, polished, and used for jewelry. Because of their rareness, rubies and emeralds are more valuable than diamonds. **Figure 4.18** shows a rough diamond and a polished diamond.

In some cases, the presence of trace elements can make one variety of a mineral more colorful and more prized than other varieties of the same mineral. Amethyst, for instance, is the gem form of quartz. Amethyst contains traces of iron, which gives the gem a purple color. The mineral corundum, which is often used as an abrasive, also occurs as rubies and sapphires. Rubies contain trace amounts of chromium, while sapphires contain trace amounts of cobalt or titanium.

Figure 4.18 The real beauty of gemstones is revealed once they are cut and polished.

Section 4.2 Assessment

Section Summary

- In silicates, one silicon atom bonds with four oxygen ions to form a tetrahedron.
- Major mineral groups include silicates, carbonates, oxides, sulfides, sulfates, halides, and native elements.
- An ore contains a valuable substance that can be mined at a profit.
- Gems are valuable minerals that are prized for their rarity and beauty.

Understand Main Ideas

1. MAIN Idea **Formulate** a statement that explains the relationship between chemical elements and mineral properties.
2. **List** the two most abundant elements in Earth's crust. What mineral group do these elements form?
3. **Hypothesize** what some environmental consequences of mining ores might be.

Think Critically

4. **Hypothesize** why the mineral opal is often referred to as a mineraloid.
5. **Evaluate** which of the following metals is better to use in sporting equipment and medical implants: titanium—specific gravity = 4.5, contains only Ti; or steel—specific gravity = 7.7, contains Fe, O, Cr.

WRITING in Earth Science

6. Design a flyer advertising the sale of a mineral of your choice. You might choose a gem or industrially important mineral. Include any information that you think will help your mineral sell.

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ON SITE: CRYSTALS AT LARGE IN MEXICO

Cave of Crystals, part of Naica Cave in Chihuahua, Mexico is known for its large crystals.

Eloy and Javier Delgado walk slowly into the Naica Cave in Chihuahua, Mexico. The cave is very hot, making it difficult for them to breathe. They enter a room in the cave and before them are huge 4.5-m crystals that are clear and brilliant. How did these crystals grow this large? What kinds of conditions make these crystals possible?

The climate inside the cave The large gypsum minerals are present in the Cave of Crystals, a room in Naica Cave, located 300 m below Earth's surface. Temperatures there hover around 58°C. The air here has a relative humidity of 100 percent. These extreme conditions mean that anyone entering the cave can remain only for a few minutes at a time.

Crystal formations in the cave The crystals in the Naica Cave are a crystalline form of gypsum called selenite. The crystals in this cave grow into three distinct shapes. Crystals that grow from the floor of the cave are plantlike in appearance. They are grayish in color from the mud that seeps into them as they grow. Swordlike crystals cover the walls of the cave. These crystals grow to lengths of 0.5 m to 1 m and are opaque white in color. Within the main room of the cave, there are crystals with masses of up to 27 kg and up to 8.25 m long and 1 m wide.

How did these crystals form? Crystals need several things in order to form. First, they need a space—in this case, a cave. Caves form as a result of water circulating along weak planes in a rock. Over time, the rock dissolves and a cave is formed. Second, crystals need a source of water that is rich in dissolved minerals. Crystal formation also depends on factors such as pressure, temperature, level of water in the cave, and the chemistry of the mineral-rich water.

In 2006, geologists determined that the crystals' massive sizes resulted from the steady temperature of about 58°C while the cave was full of mineral-rich water. As long as the crystals remained in this environment, they continued to grow. Because the crystals are so large, scientists think that the Cave of Crystals had these conditions for thousands of years.

WRITING in Earth Science

Research Visit glencoe.com to conduct research about the processes that form crystals in a cave. Pick a cave and make a brochure describing and illustrating the types of crystals found there.

GEOLAB

DESIGN YOUR OWN: MAKE A FIELD GUIDE FOR MINERALS

Background: Have you ever used a field guide to identify a bird, flower, rock, or insect? If so, you know that field guides include more than photographs. A typical field guide for minerals might include background information about minerals in general and specific information about the formation, properties, and uses of each mineral.

Question: *Which mineral properties should be included in a field guide to help identify unknown minerals?*

Materials

Choose materials that would be appropriate for this lab.

mineral samples
magnifying lens
glass plate
streak plate
the Mohs scale of mineral hardness
steel file or nail
piece of copper
paper clip
magnet
dilute hydrochloric acid
dropper
Reference Handbook

Safety Precautions

Procedure

1. Read and complete the lab safety form.
2. As a group, list the steps that you will take to create your field guide. Keep the available materials in mind as you plan your procedure.
3. Should you test any of the properties more than once for any of the minerals? How will you determine whether certain properties indicate a specific mineral?
4. Design a data table to summarize your results. Be sure to include a column to record whether or not a particular test will be included in the guide. You can use this table as the basis for your field guide.
5. Read over your entire plan to make sure that all steps are in a logical order.
6. Have you included a step for additional research? You might have to use the library or glencoe.com to gather all the necessary information for your field guide.
7. What additional information will be included in the field guide? Possible data include how each mineral formed, its uses, its chemical formula, and a labeled photograph or drawing of the mineral.
8. Make sure your teacher approves your plan before you proceed.

Analyze and Conclude

1. **Interpret** Which properties were most reliable for identifying minerals? Which properties were least reliable? Discuss reasons that one property is more useful than others.
2. **Observe and Infer** What mineral reacted with the hydrochloric acid? Why did the mineral bubble? Write the balanced equation that describes the chemical reaction that took place between the mineral and the acid.
3. **Summarize** What information did you include in the field guide? What resources did you use to gather your data? Describe the layout of your field guide.
4. **Evaluate** the advantages and disadvantages of field guides.
5. **Conclude** Based on your results, is there any one definitive test that can always be used to identify a mineral? Explain your answer.

WRITING in Earth Science

Peer Review Trade field guides with another group and test them out by using them to identify a new mineral. Provide feedback to the authors of the guide that you use.

CHAPTER 4

Study Guide

STUDY TO GO — Download quizzes, key terms, and flash cards from glencoe.com.

BIG Idea Minerals are an integral part of daily life.

Vocabulary	Key Concepts
Section 4.1 What is a mineral?	
• cleavage (p. 92) • crystal (p. 87) • fracture (p. 93) • hardness (p. 91) • luster (p. 90) • mineral (p. 86) • specific gravity (p. 95) • streak (p. 93)	**MAIN Idea** Minerals are naturally occurring, solid, inorganic compounds or elements. • A mineral is a naturally occurring, inorganic solid with a specific chemical composition and a definite crystalline structure. • A crystal is a solid in which the atoms are arranged in repeating patterns. • Minerals form from magma or from supersaturated solutions. • Minerals can be identified based on their physical and chemical properties. • The most reliable way to identify a mineral is by using a combination of several tests.
Section 4.2 Types of Minerals	
• gem (p. 101) • ore (p. 100) • silicate (p. 96) • tetrahedron (p. 96)	**MAIN Idea** Minerals are classified based on their chemical properties and characteristics. • In silicates, one silicon atom bonds with four oxygen ions to form a tetrahedron. • Major mineral groups include silicates, carbonates, oxides, sulfides, sulfates, halides, and native elements. • An ore contains a valuable substance that can be mined at a profit. • Gems are valuable minerals that are prized for their rarity and beauty.