Section 1

# Properties of Minerals

## Reading Focus

### Key Concepts

- What is a mineral?
- How are minerals identified?

### Key Terms

- mineral • inorganic
- crystal • streak • luster
- Mohs hardness scale
- cleavage • fracture

### Target Reading Skill

**Outlining** An outline shows the relationship between major ideas and supporting ideas. As you read, make an outline about the properties of minerals. Use the red headings for the main topics and the blue headings for the subtopics.

**Properties of Minerals**

I. What is a mineral?
  A. Naturally occurring
  B. Inorganic
  C.
  D.
  E.
II. Identifying minerals

Lab zone **Discover Activity**

### What Is the True Color of a Mineral?

1. Examine samples of magnetite and black hematite. Both minerals contain iron. Describe the color and appearance of the two minerals. Are they similar or different?
2. Rub the black hematite across the back of a porcelain or ceramic tile. Observe the color of the streak on the tile.
3. Wipe the tile clean before you test the next sample.
4. Rub the magnetite across the back of the tile. Observe the color of the streak.

**Think It Over**

**Observing** Does the color of each mineral match the color of its streak? How could this streak test be helpful in identifying them as two different minerals?

Look at the two different substances in Figure 1. On the left are beautiful quartz crystals. On the right is a handful of coal. Both are solid materials that form beneath Earth's surface. But only one is a mineral. To determine which of the two is a mineral, you need to become familiar with the characteristics of minerals. Then you can decide what's a mineral and what's not!

## What Is a Mineral?

**A mineral is a naturally occurring, inorganic solid that has a crystal structure and a definite chemical composition.** For a substance to be a **mineral,** it must have all five of these characteristics.

**Naturally Occurring** To be classified as a mineral, a substance must be formed by processes in the natural world. The mineral quartz forms naturally as molten material cools and hardens deep beneath Earth's surface. Materials made by people, such as plastic, brick, glass, and steel, are not minerals.

**Inorganic** A mineral must also be **inorganic.** This means that the mineral cannot form from materials that were once part of a living thing. For example, coal forms naturally in the crust. But geologists do not classify coal as a mineral because it comes from the remains of plants that lived millions of years ago.

**Solid** A mineral is always a solid, with a definite volume and shape. The particles that make up a solid are packed together very tightly, so they cannot move like the particles that make up a liquid.

**Crystal Structure** The particles of a mineral line up in a pattern that repeats over and over again. The repeating pattern of a mineral's particles forms a solid called a **crystal.** A crystal has flat sides, called faces, that meet at sharp edges and corners. The quartz in Figure 1 has a crystal structure. In contrast, most coal lacks a crystal structure.

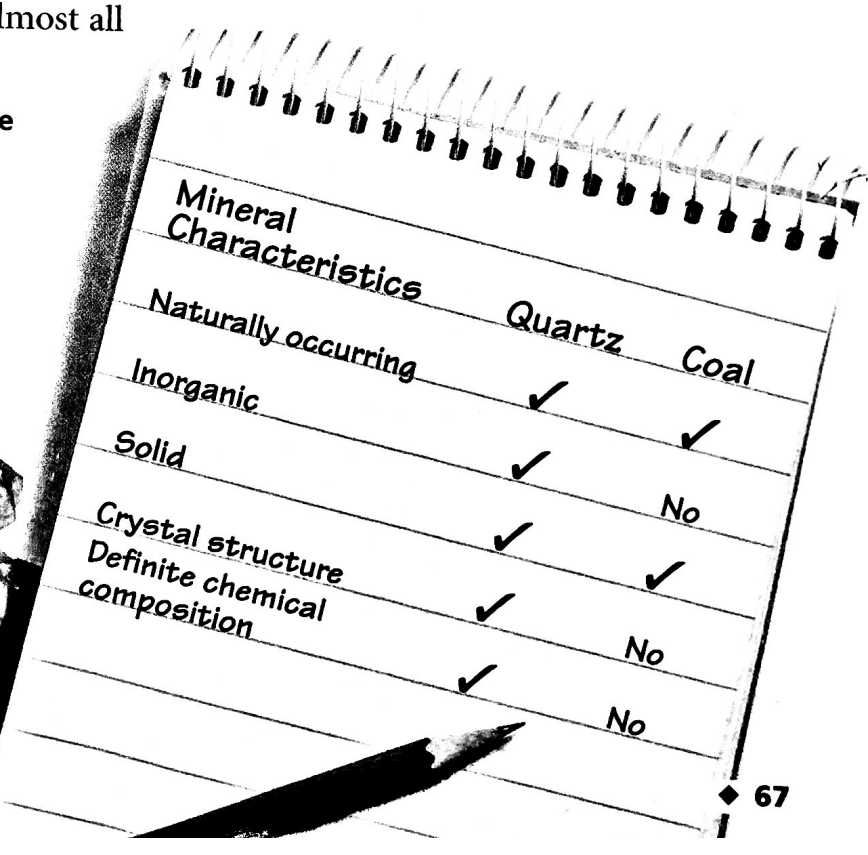
**Definite Chemical Composition** A mineral has a definite chemical composition or range of compositions. This means that a mineral always contains certain elements in definite proportions.

Almost all minerals are compounds. For example, a crystal of the mineral quartz has one atom of silicon for every two atoms of oxygen. Each compound has its own properties, or characteristics, which usually differ greatly from the properties of the elements that form it.

Some elements occur in nature in a pure form, and not as part of a compound with other elements. Elements such as copper, silver, and gold are also minerals. Almost all pure, solid elements are metals.

**Reading Checkpoint** **What does the phrase "definite chemical composition" mean?**

**FIGURE 1**
**Quartz and Coal**
Quartz (below) has all the characteristics of a mineral. But coal (above) is formed from the remains of plants, lacks a crystal structure, and has no definite chemical composition.



## Identifying Minerals

Geologists have identified about 3,800 minerals. Because there are so many different kinds of minerals, telling them apart can often be a challenge. **Each mineral has characteristic properties that can be used to identify it.** When you have learned to recognize the properties of minerals, you will be able to identify many common minerals around you.

You can see some of the properties of a mineral just by looking at a sample. To observe other properties, however, you need to conduct tests on that sample. As you read about the properties of minerals, think about how you could use them to identify a mineral.

**Color** The color of a mineral is an easily observed physical property. But the color of a mineral alone often provides too little information to make an identification. All three minerals in Figure 2 are the color gold, yet only one is the real thing. Color can be used to identify only those few minerals that always have their own characteristic color. The mineral malachite is always green. The mineral azurite is always blue. No other minerals look quite the same as these.

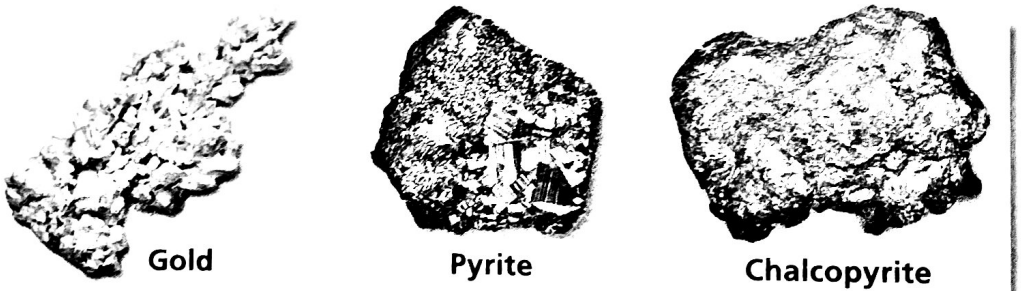
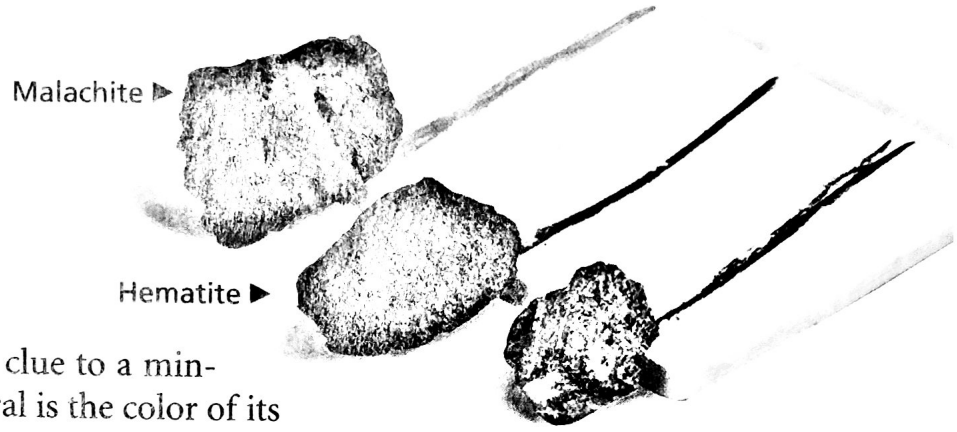



**FIGURE 2**
**Color of Minerals**
These women in India are searching for bits of gold in river sand. Just because a mineral is gold in color doesn't mean it really is gold. Chalcopyrite and pyrite, also known as "fool's gold," are similar in color to real gold.

**FIGURE 3**
**Streak**
A mineral's streak can be the same as or quite different from its color.
**Observing** *How do the streaks of these minerals compare with their colors?*



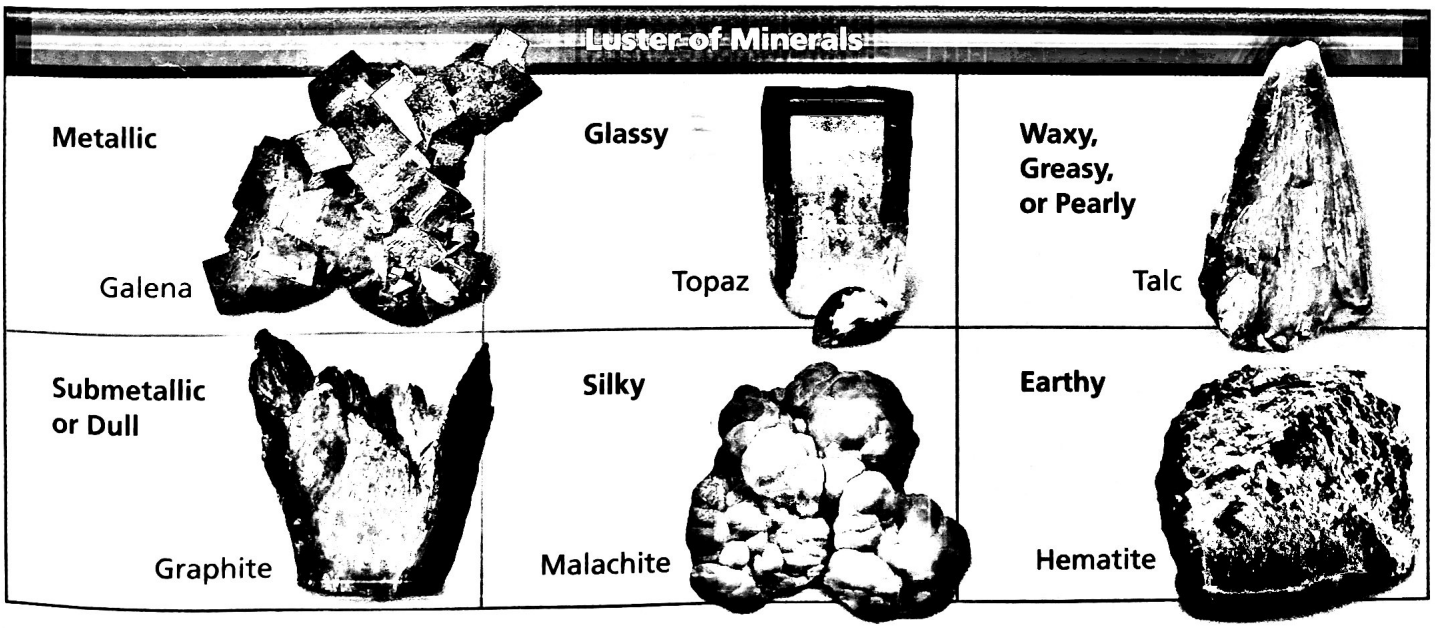

▲ Galena

**Streak** A streak test can provide a clue to a mineral's identity. The **streak** of a mineral is the color of its powder. You can observe a streak by rubbing a mineral against a piece of unglazed porcelain tile, as shown in Figure 3. Even though the color of the mineral may vary, its streak does not. Surprisingly, the streak color and the mineral color are often different. For example, although pyrite has a gold color, it always produces a greenish black streak. Real gold, on the other hand, produces a golden yellow streak.

**Luster** Another simple test to identify a mineral is to check its luster. **Luster** is the term used to describe how light is reflected from a mineral's surface. Minerals containing metals are often shiny. For example, galena is an ore of lead that has a bright, metallic luster. Quartz has a glassy luster. Some of the other terms used to describe luster include earthy, waxy, and pearly. Figure 4 shows the luster of several minerals.

**Reading Checkpoint** **What characteristic of minerals does the term *luster* describe?**

**FIGURE 4**
Geologists use many different terms to describe the luster of minerals.
**Interpreting Tables** *Which mineral has an earthy luster?*



**Math Skills**

## Calculating Density

To calculate the density of a mineral, divide the mass of the mineral sample by its volume.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

For example, if a sample of olivine has a mass of 237 g and a volume of 72 $cm^3$, then the density is

$$\frac{237\ g}{72\ cm^3} = 3.3\ g/cm^3$$

**Practice Problem** A sample of calcite has a mass of 324 g and a volume of 120 $cm^3$. What is its density?

**Density** Each mineral has a characteristic density. Recall that density is the mass in a given space, or mass per unit volume. No matter what the size of a mineral sample, the density of that mineral always remains the same.

You can compare the density of two mineral samples of about the same size. Just pick them up and heft them, or feel their weight, in your hands. You may be able to feel the difference between low-density quartz and high-density galena. If the two samples are the same size, the galena will be almost three times as heavy as the quartz.

But heft provides only a rough measure of density. When geologists measure density, they use a balance to determine the precise mass of a mineral sample. Then they place the mineral in water to determine how much water the sample displaces. The volume of the displaced water equals the volume of the sample. Dividing the sample's mass by its volume gives the density of the mineral:

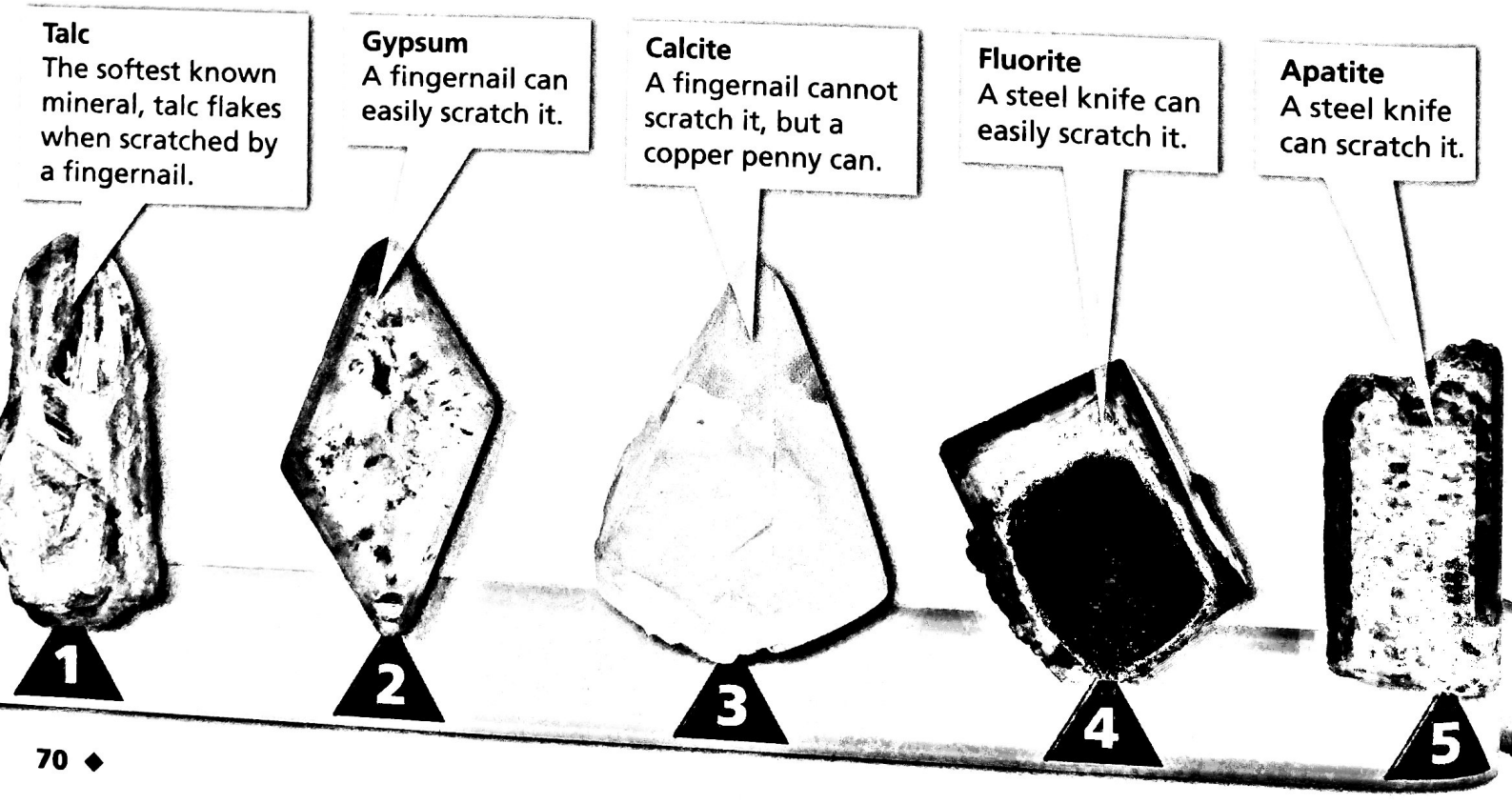
$$\textbf{Density} = \frac{\textbf{Mass}}{\textbf{Volume}}$$

**Hardness** When you identify a mineral, one of the best clues you can use is the mineral's hardness. In 1812, Friedrich Mohs, an Austrian mineral expert, invented a test to describe the hardness of minerals. Called the **Mohs hardness scale,** this scale ranks ten minerals from softest to hardest. Look at Figure 5 to see which mineral is the softest and which is the hardest.

FIGURE 5

## Mohs Hardness Scale

Geologists determine a mineral's hardness by comparing it to the hardness of the minerals on the Mohs scale.

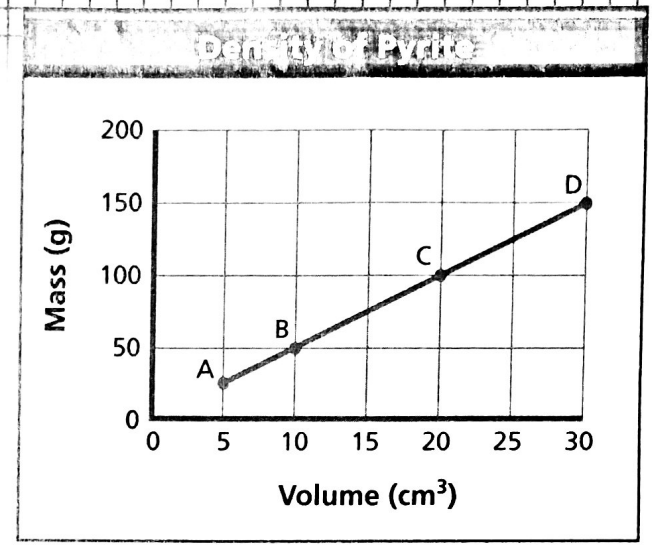


## Math Analyzing Data

### Mineral Density

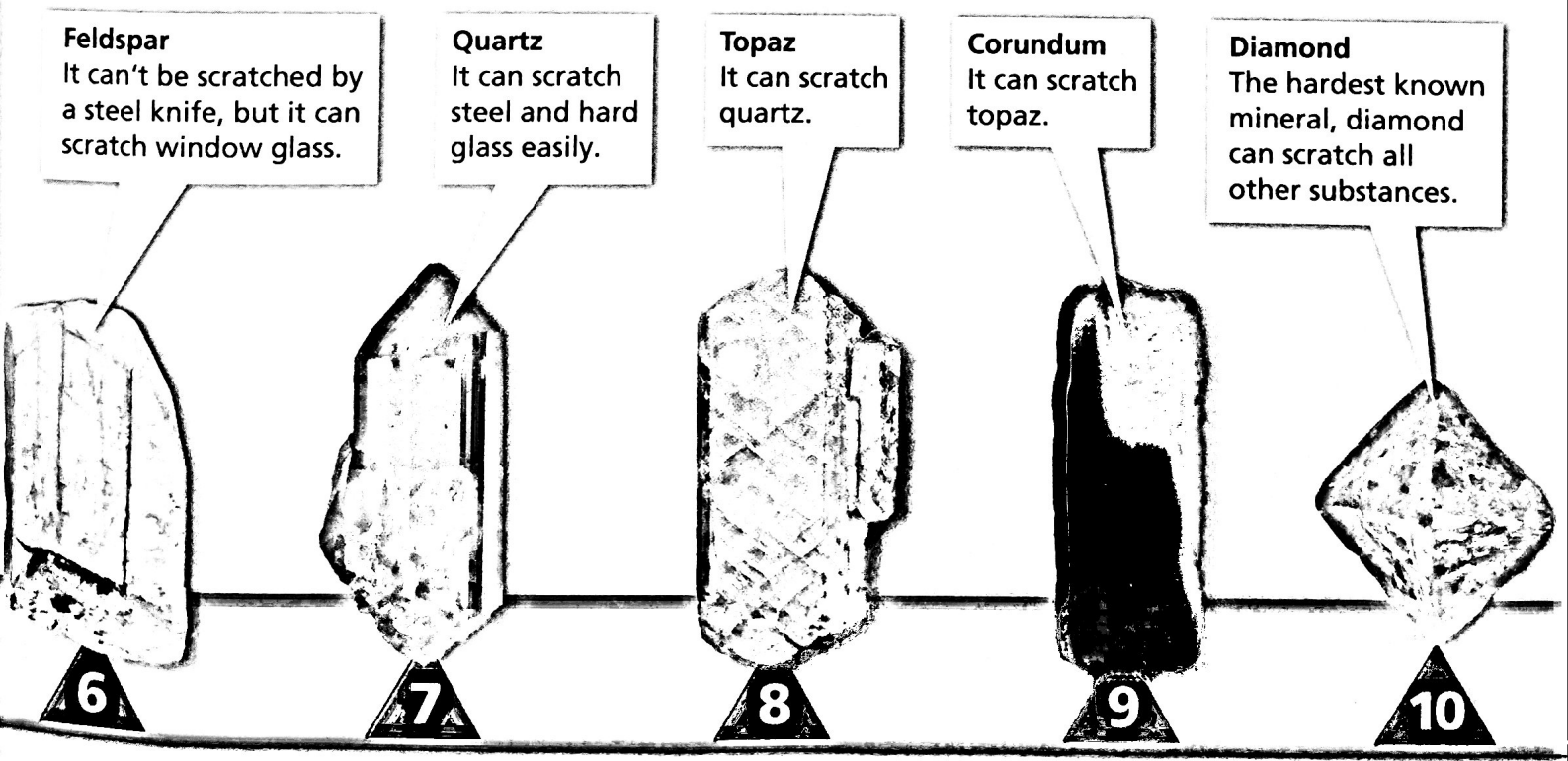
Use the line graph of the mass and volume of pyrite samples to answer the questions.

1. **Reading Graphs** What is the mass of Sample B? What is the volume of Sample B?
2. **Calculating** What is the density of Sample B?
3. **Reading Graphs** What is the mass of Sample C? What is the volume of Sample C?
4. **Calculating** What is the density of Sample C?
5. **Comparing and Contrasting** Compare the density of Sample B to that of Sample C.
6. **Predicting** A piece of pyrite has a volume of 40 $cm^3$. What is its mass?




7. **Drawing Conclusions** Does the density of a mineral depend on the size of the mineral sample? Explain.

Hardness can be determined by a scratch test. A mineral can scratch any mineral softer than itself, but can be scratched by any mineral that is harder. To determine the hardness of azurite, a mineral not on the Mohs scale, you could try to scratch it with talc, gypsum, or calcite. But none of these minerals scratch azurite. Apatite, rated 5 on the scale, does scratch azurite. Therefore, azurite's hardness is about 4.



**Lab zone Skills Activity**

## Classifying

1. Use your fingernail to try to scratch talc, calcite, and quartz. Record which minerals you were able to scratch.
2. Now try to scratch the minerals with a penny. Were your results different? Explain.
3. Were there any minerals you were unable to scratch with either your fingernail or the penny?
4. In order of increasing hardness, how would you classify the three minerals?

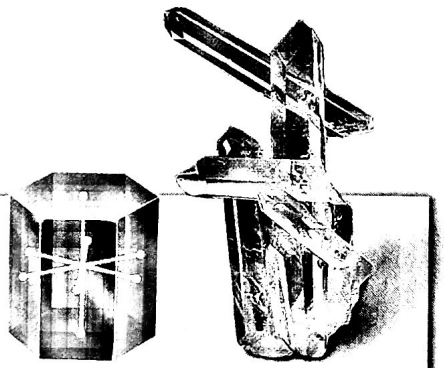
**Crystal Systems** The crystals of each mineral grow atom by atom to form that mineral's crystal structure. Geologists classify these structures into six groups based on the number and angle of the crystal faces. These groups are called crystal systems. For example, all halite crystals are cubic. Halite crystals have six square faces that meet at right angles, forming a perfect cube.

Sometimes, the crystal structure is obvious from the mineral's appearance. Crystals that grow in an open space can be almost perfectly formed. But crystals that grow in a tight space are often incompletely formed. In other minerals, the crystal structure is visible only under a microscope. A few minerals, such as opal, are considered minerals even though their particles are not arranged in a crystal structure. Figure 6 shows minerals that belong to each of the six crystal systems.

**Cleavage and Fracture** The way a mineral breaks apart can help to identify it. A mineral that splits easily along flat surfaces has the property called **cleavage.** Whether a mineral has cleavage depends on how the atoms in its crystals are arranged. The arrangement of atoms in the mineral causes it to break apart more easily in one direction than another. Look at the photo of mica in Figure 7. Mica separates easily in only one direction, forming flat sheets. Therefore, mica has cleavage. Feldspar is another common mineral that has cleavage.

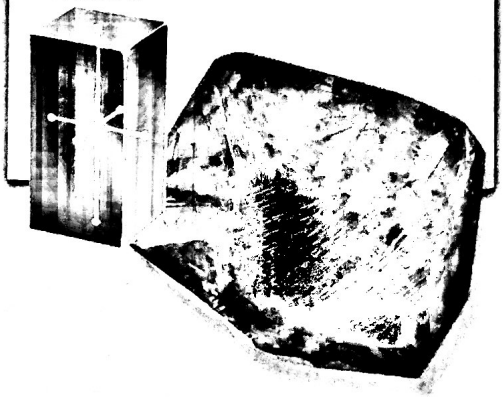
**FIGURE 6**
**Properties of Minerals**
All crystals of the same mineral have the same crystal structure. Each mineral also has other characteristic properties.
Interpreting Data *Which mineral has the lowest density?*

**Magnetite**
**Crystal System:** Cubic
**Color:** Black
**Streak:** Black
**Luster:** Metallic
**Hardness:** 6
**Density (g/cm³):** 5.2
**Special Property:** Magnetic



**Quartz**
**Crystal System:** Hexagonal
**Color:** Transparent, various colors
**Streak:** Colorless
**Luster:** Glassy
**Hardness:** 7
**Density (g/cm³):** 2.6
**Special Property:** Fractures like broken glass

**Rutile**
**Crystal System:** Tetragonal
**Color:** Black or reddish brown
**Streak:** Light brown
**Luster:** Metallic or gemlike
**Hardness:** 6–6.5
**Density (g/cm³):** 4.2–4.3
**Special Property:** Not easily melted



**Cleavage**

Mica cleaves into thin, flat sheets that are almost transparent.

**Fracture**

When quartz fractures, the break looks like the surface of a seashell.

**FIGURE 7**
**Cleavage and Fracture**
How a mineral breaks apart can help to identify it.
**Applying Concepts** *How would you test a mineral to determine whether it has cleavage or fracture?*

Most minerals do not split apart evenly. Instead, they have a characteristic type of fracture. **Fracture** describes how a mineral looks when it breaks apart in an irregular way. Geologists use a variety of terms to describe fracture. For example, quartz has a shell-shaped fracture. When quartz breaks, it produces curved, shell-like surfaces that look like chipped glass. Pure metals, like copper and iron, have a hackly fracture—they form jagged points. Some soft minerals that crumble easily like clay have an earthy fracture. Minerals that form rough, irregular surfaces when broken have an uneven fracture.

**Reading Checkpoint** **Compare the fracture of quartz to the fracture of a pure metal, such as iron.**

**Go Online**
**active art**

**For:** Crystal Systems activity
**Visit:** PHSchool.com
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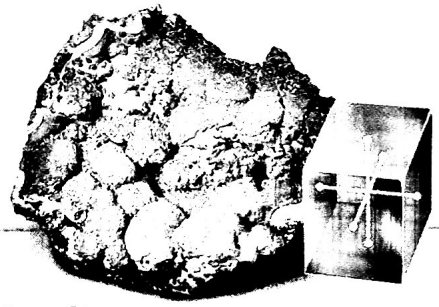
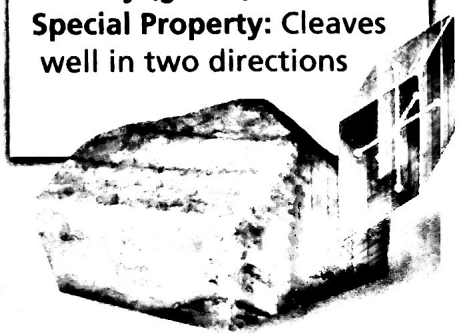


**Azurite**
**Crystal System:** Monoclinic
**Color:** Blue
**Streak:** Pale blue
**Luster:** Glassy to dull or earthy
**Hardness:** 3.5–4
**Density (g/cm³):** 3.8
**Special Property:** Reacts to acid

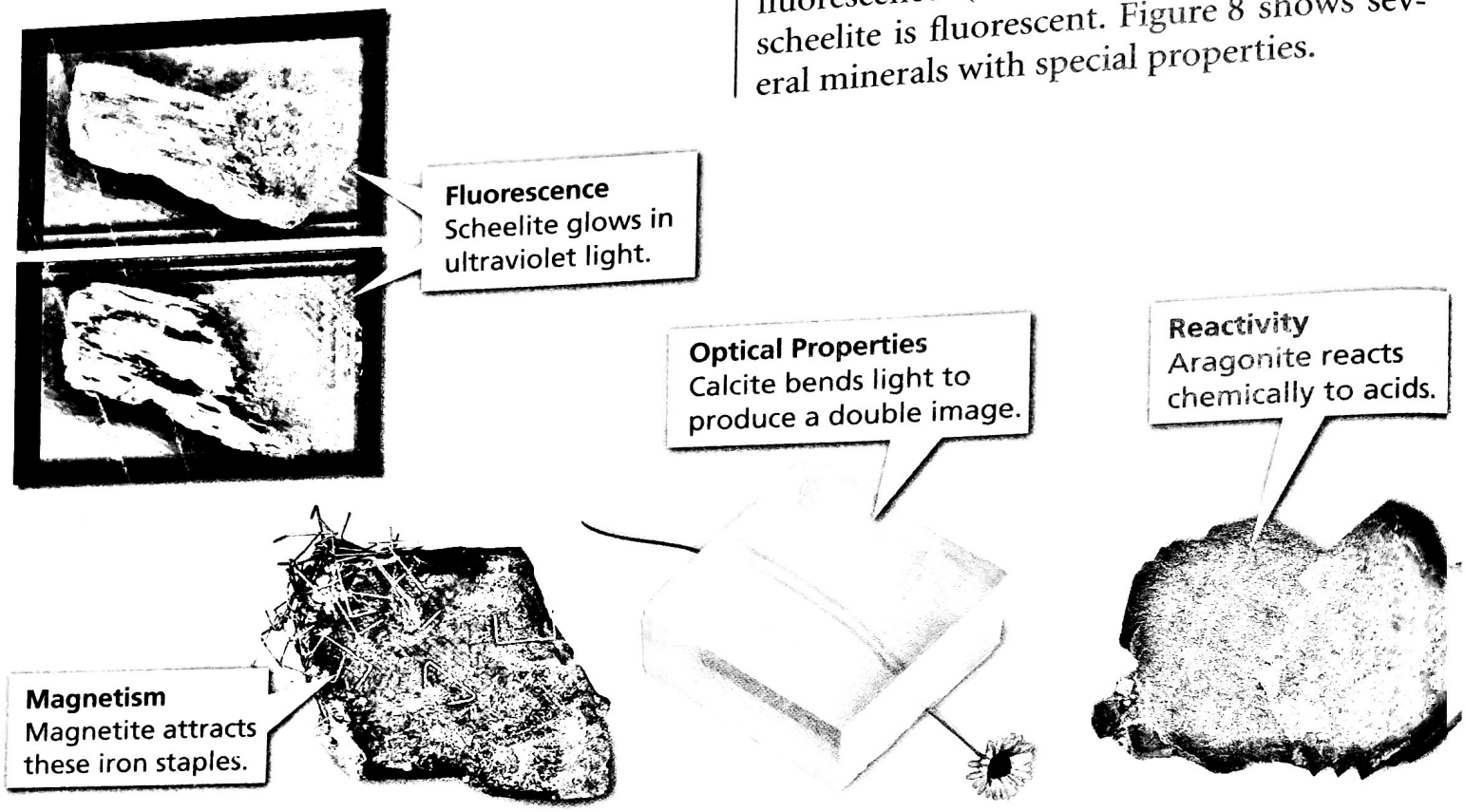
**Sulfur**
**Crystal System:** Orthorhombic
**Color:** Lemon yellow to yellowish brown
**Streak:** White
**Luster:** Greasy
**Hardness:** 2
**Density (g/cm³):** 2.0–2.1
**Special Property:** Melts easily

**Microcline Feldspar**
**Crystal System:** Triclinic
**Color:** Pink, white, red-brown, or green
**Streak:** Colorless
**Luster:** Glassy
**Hardness:** 6
**Density (g/cm³):** 2.6
**Special Property:** Cleaves well in two directions



**Special Properties** Some minerals can be identified by special physical properties. For example, magnetism occurs naturally in a few minerals. Minerals that glow under ultraviolet light have a property known as fluorescence (floo RES uns). The mineral scheelite is fluorescent. Figure 8 shows several minerals with special properties.

**FIGURE 8**
**Special Properties**
The special properties of minerals include fluorescence, magnetism, radioactivity, and reaction to acids. Other minerals have useful optical or electrical properties.




## Section 1 Assessment

**Target Reading Skill Outlining** Use the information in your outline about the properties of minerals to help you answer the questions.

### Reviewing Key Concepts

1. a. **Defining** Write a definition of "mineral" in your own words.
   b. **Explaining** What does it mean to say that a mineral is inorganic?
   c. **Classifying** Amber is a precious material used in jewelry. It forms when the resin of pine trees hardens into stone. Is amber a mineral? Explain.
2. a. **Listing** Name eight properties that can be used to identify minerals.
   b. **Comparing and Contrasting** What is the difference between fracture and cleavage?
   c. **Predicting** Graphite is a mineral made up of carbon atoms that form thin sheets. But the sheets are only weakly held together. Predict whether graphite will break apart with fracture or cleavage. Explain.

### Math Practice

3. **Calculating Density** The mineral platinum is an element that often occurs as a pure metal. If a sample of platinum has a mass of 430 g and a volume of 20 $cm^3$, what is its density?