KEY CONCEPT

A mineral is identified by its properties.

BEFORE, you learned

- All minerals have four characteristics
- Most minerals in Earth's crust are silicates

NOW, you will learn

- Which mineral properties are most important in identification
- How minerals are identified by their properties

VOCABULARY

streak p. 479 luster p. 480 cleavage p. 481 fracture p. 481 density p. 482 hardness p. 483

THINK ABOUT

What can you tell by looking at a mineral?

The photographs at the right show five pieces of the mineral fluorite (FLUR-YT). As you can see, the pieces are very different in color and size. Fluorite occurs in many colors, even in colorless forms. Its crystals can be well formed or poorly formed. Also, the sides of the crystals may be smooth or rough.

If you came across fluorite while hiking, would you know what it was by just looking at it? Probably not. Read on to find out how you could identify it.

A mineral's appearance helps identify it.

To identify a mineral, you need to observe its properties—characteristic features that identify it. You might begin by looking at the mineral's color. However, many minerals occur in more than one color, so you would need to examine other properties as well. You might also notice how the mineral reflects light, which determines how shiny or dull it is. Most minerals reflect light in characteristic ways. In this section you will read about how the properties of a mineral—including its appearance—are used to identify it.



Why do you need to look at properties other than color to identify a mineral?

READING TIP

The word *characteristic* is used for a feature that is typical of a person or thing. It can be used as a noun or an adjective.

Color and Streak

Some minerals can be almost any color, but most minerals have a more limited color range. For example, a particular mineral may almost always be brown to black.

Three main factors cause minerals to vary in color. First, a mineral may get its color from tiny amounts of an element that is not part of its normal chemical makeup. For example, a sample of pure quartz is clear and colorless, but tiny amounts of iron can give quartz a violet color. This violet variety of quartz is called amethyst. Second, a mineral's color can change when it is at or near Earth's surface and is in contact with the atmosphere or water. Third, mineral crystals can have defects in their crystal structures that change their color.

Some minerals have a different color when they are ground into a fine powder than when they are left whole. A mineral's **streak** is the color of the powder left behind when the mineral is scraped across a surface. Geologists use a tile of unglazed porcelain, called a streak plate, as a tool to identify minerals by their streaks. Streak is a better clue to a mineral's identity than surface color is. Look at the photographs of hematite below. Even though the mineral samples are different colors, both leave a reddish brown streak when scraped across a streak plate. All samples of the same mineral have the same streak.

What is the difference between color and streak?



Streak

CHECK YOUR

READING

These samples are of the mineral hematite. They are different colors, but they have the same streak.



This hematite looks dull because it has tiny crystals that reflect light in all directions.



This hematite looks shiny because it has larger crystals.



Luster

READING TIP

Luster comes from the Latin *lūstrāre*, "to make bright." But luster isn't always bright or shiny. Some minerals have lusters that are waxlike or dull. A mineral's **luster** is the way in which light reflects from its surface. The two major types of luster are metallic and nonmetallic. The mineral pyrite has a metallic luster. It looks as if it were made of metal. A mineral with a nonmetallic luster can be shiny, but it does not appear to be made of metal. An example of a nonmetallic luster is the glassy luster of garnet. Compare the lusters of pyrite and garnet in the photographs below.





Pyrite has a metallic luster. Garnet crys

Garnet crystals in this rock have a nonmetallic luster.

Like a mineral's color, its luster may vary from sample to sample. If a mineral has been exposed to the atmosphere or to water, its surface luster can become dull. However, if the mineral is broken to reveal a fresh surface, its characteristic luster can be seen.

The way a mineral breaks helps identify it.

If you hit a piece of calcite with a hammer, the calcite will break into tilted blocks. You can peel off layers of mica because it splits into thin, flat sheets. Each kind of mineral always breaks in the same way, and this property can help identify a mineral. In fact, the way a mineral breaks is a better clue to its identity than are its color and luster.

Cleavage

Cleavage is a tendency to break along flat surfaces.



It breaks along flat surfaces because the bonds between its atoms are less strong in some directions than in others.



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Cleavage

Cleavage is the tendency of a mineral to break along flat surfaces. The way in which a mineral breaks depends on how its atoms are bonded, or joined together. In a mineral that displays cleavage, the bonds of the crystal structure are weaker in the directions in which the mineral breaks.

When geologists describe the cleavage of a mineral, they consider both the directions in which the mineral breaks and the smoothness of the broken surfaces. Mica has cleavage in one direction and breaks into sheets. The photographs on page 480



show that calcite has cleavage in three directions and breaks into tilted blocks. Because the broken surfaces of both mica and calcite are smooth, these minerals are said to have perfect cleavage.

Fracture

Fracture is the tendency of a mineral to break into irregular pieces. Some minerals such as quartz break into pieces with curved surfaces, as shown below. Other minerals may break differently—perhaps into splinters or into rough or jagged pieces.

In a mineral that displays fracture, the bonds that join the atoms are fairly equal in strength in all directions. The mineral does not break along flat surfaces because there are no particular directions of weakness in its crystal structure.

CHECK YOUR How does the strength of the bonds between atoms determine whether a mineral displays cleavage or fracture?



Fracture

Fracture is a tendency to break into irregular pieces.

Quartz does not have cleavage. It breaks by fracturing. It breaks along irregular surfaces because the bonds between its atoms are about the same strength in every direction.

A mineral's density and hardness help identify it.

A tennis ball is not as heavy or as hard as a baseball. You would be able to tell the two apart even with your eyes closed by how heavy and hard they feel. You can identify minerals in a similar way.

Density

Even though a baseball and a tennis ball are about the same size, the baseball has more mass and so is more dense. A substance's **density** is the amount of mass in a given volume of the substance. For example, 1 cubic centimeter of the mineral pyrite has a mass of 5.1 grams, so pyrite's density is 5.1 grams per cubic centimeter.

Density is very helpful in identifying minerals. For example, gold and pyrite look very similar. Pyrite is often called fool's gold. However, you can tell the two minerals apart by comparing their densities. Gold is much denser than pyrite. The mass of a piece of gold is almost four times the mass of a piece of pyrite of the same size. A small amount of a very dense mineral, such as gold, can have more mass and be heavier than a larger amount of a less dense mineral, such as pyrite. A mineral's density is determined by the kinds of atoms that make up





READING Estimate the size a piece of quartz would have to be to balance the **visuals** zincite sample.

READING TIP

The unit of density is grams per cubic centimeter and is abbreviated as g/cm³.

the mineral, as well as how closely the atoms are joined together. An experienced geologist can estimate the density of a mineral by lifting it. But to get an exact measurement, geologists use special scales.

CHECK YOUR Why does a piece of gold weigh much more than a piece of pyrite that is the same size?

Hardness

One way to tell a tennis ball from a baseball without looking at them is to compare their densities. Another way is to test which one is harder. Hardness is another dependable clue to a mineral's identity.

A mineral's **hardness** is its resistance to being scratched. Like a mineral's cleavage, a mineral's hardness is determined by its crystal structure and the strength of the bonds between its atoms. Harder minerals have stronger bonds.

A scale known as the Mohs scale is often used to describe a mineral's hardness. This scale is based on the fact that a harder mineral will scratch a softer one. As you can see in the chart at the right, ten minerals are numbered in the scale, from softest to hardest. Talc is the softest mineral and has a value of 1. Diamond, the hardest of all minerals, has a value of 10.

A mineral can be scratched only by other minerals that have the same hardness or are harder. To determine the hardness of an unknown mineral, you test whether it scratches or is scratched by the minerals in the scale. For example, if you can scratch an unknown mineral with apatite but not with fluorite, the mineral's hardness is between 4 and 5 in the Mohs scale.

In place of minerals, you can use your fingernail, a copper penny, and a steel file to test an unknown mineral. To avoid damage to the minerals, you can test whether the mineral scratches these items. When using a penny to test hardness, make sure its date is 1982 or earlier. Only older pennies are made mainly of copper, which has a hardness of about 3.



INVESTIGATE Hardness of Minerals

How hard are some common minerals?

PROCEDURE

- 1) Try to scratch each mineral with your fingernail, the penny, and the steel file. Record the results in a chart.
- (2) Assign a hardness range to each mineral.
- In the last column of your chart, rank the minerals from hardest to softest.

WHAT DO YOU THINK?

- Use your results to assign a hardness range in the Mohs scale to each sample.
- If two minerals have the same hardness range according to your tests, how could you tell which is harder?

CHALLENGE If you had a mineral that could not be scratched by the steel file, what else might you test it with to estimate its hardness?



Some minerals have special properties.

The photographs on page 485 show how geologists test some minerals. Such tests help them identify minerals that have unusual properties.

Minerals in the carbonate group, such as calcite, react with acid. Chalk is a familiar item that is made up of carbonate minerals. The test consists of putting a drop of a weak solution of hydrochloric acid on a mineral sample. If the acid reacts with the mineral, carbon dioxide gas will form and bubble out of the acid. The bubbles show that the mineral is a carbonate.

Some minerals have a property known as fluorescence (flu-REHS-uhns). Fluorescent minerals glow when they are exposed to ultraviolet (UHL-truh-VY-uh-liht) light. The word *fluorescence* comes from the name of the mineral fluorite, which has this property. Other minerals that display fluorescence include calcite and willemite. Although fluorescence is an interesting and sometimes dramatic property, it has limited value in mineral identification. Different samples of the same mineral may or may not display fluorescence, and they may glow in different colors.



To identify calcite, why would it be more useful to test with dilute hydrochloric acid than to check for fluorescence?

Special Properties



A few minerals respond to magnets. A magnet is pulled toward these minerals. The mineral magnetite strongly attracts magnets, and some other minerals weakly attract magnets. To test a mineral, hold a magnet loosely and bring it close to the mineral. You will be able to notice if there is even a small pull of the magnet toward the mineral. Magnets are commonly used in laboratories and industries to separate magnetic minerals from other minerals.

Some rare minerals have a property known as radioactivity. They contain unstable elements that change into other elements over time. As this happens, they release energy. Geologists can measure this energy and use it to identify minerals that contain unstable elements.

14.2 Review

KEY CONCEPTS

- **1.** Why is color not a reliable clue to the identity of a mineral?
- **2.** What is the difference between cleavage and fracture?
- **3.** Describe what would happen if you rubbed a mineral with a Mohs hardness value of 7 against a mineral with a value of 5.

CRITICAL THINKING

- **4. Analyze** Which mineralidentification tests would be easy for a person to perform at home? Which would be difficult?
- 5. Draw Conclusions Diamond and graphite contain only carbon atoms. How can you tell which mineral's atoms are bonded more closely?

CHALLENGE

 Apply The mineral topaz has perfect cleavage in one direction. It also displays fracture. Explain why a mineral such as topaz can display both cleavage and fracture.