CHAPTER

2 Minerals

the BIG idea

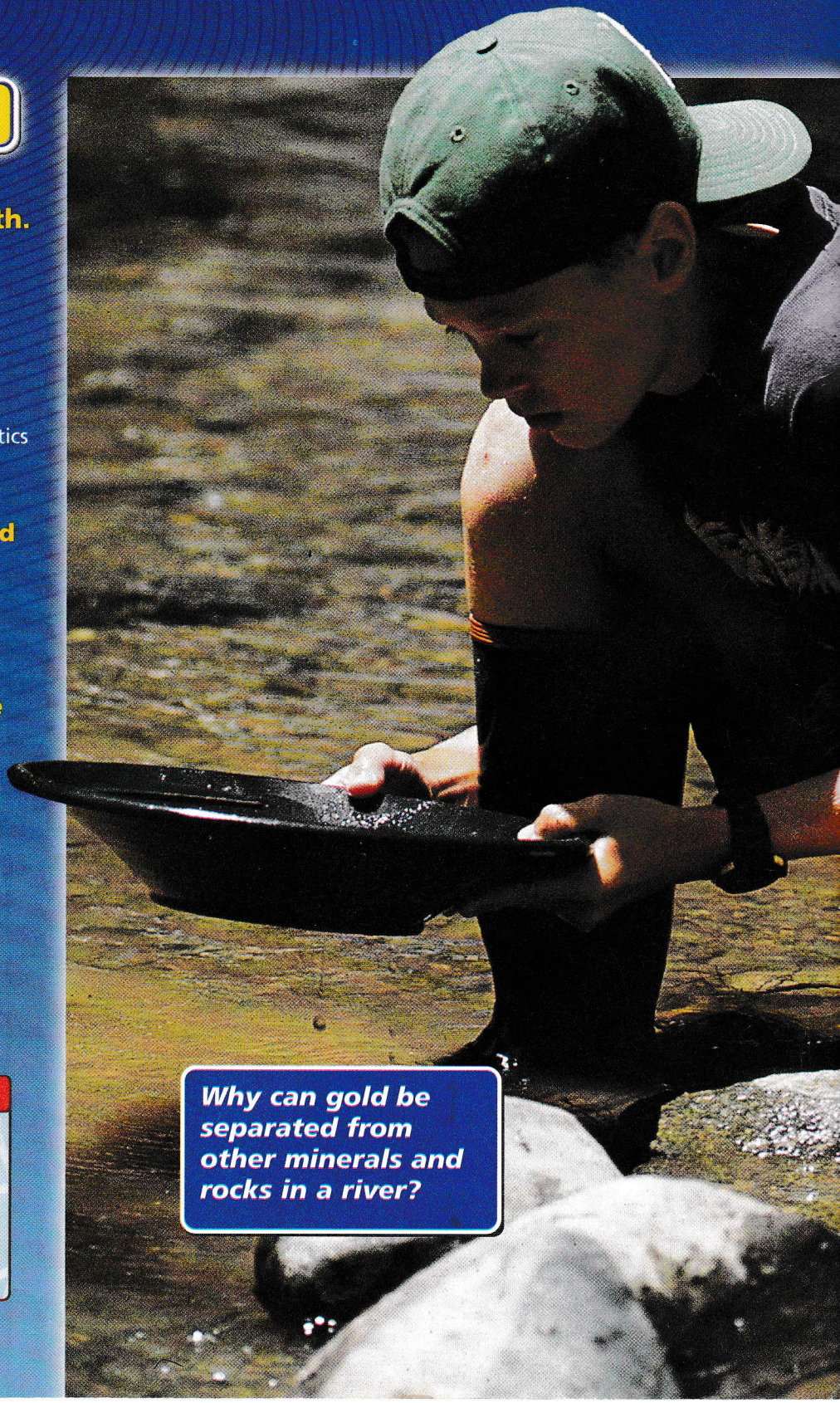
Minerals are basic building blocks of Earth.

Key Concepts

SECTION 1
Minerals are all around us.
Learn about the characteristics all minerals share.

SECTION 2
A mineral is identified by its properties.
Learn how to identify minerals by observing and testing their properties.

SECTION 3
Minerals are valuable resources.
Learn how minerals form, how they are mined, and how they are used.



Why can gold be separated from other minerals and rocks in a river?

Internet Preview

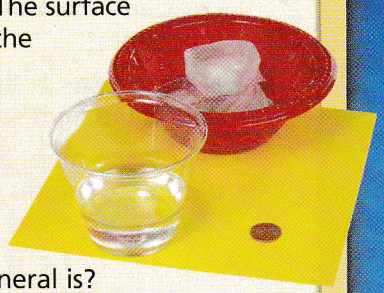
CLASSZONE.COM

Chapter 2 online resources: Content Review, Visualization, three Resource Centers, Math Tutorial, Test Practice

EXPLORE the BIG idea

How Do You Turn Water into a Mineral?

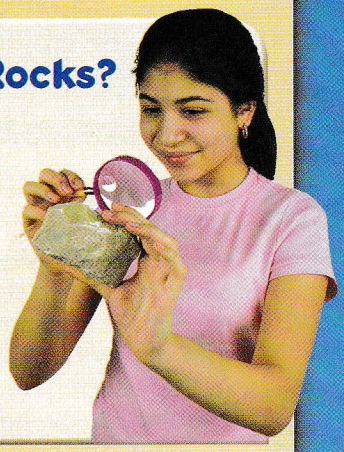
Freeze some water into ice cubes. Then compare water, an ice cube, and a penny. Liquid water is not a mineral, but ice is. The surface of the penny is made of the mineral copper.



Observe and Think
How are the water, ice cube, and penny similar? How are they different? What do you think one of the properties of a mineral is?

What Makes Up Rocks?

Find three different rocks near your home or school. Examine them closely with a magnifying glass.



Observe and Think
Describe the rocks. How many materials can you see in each rock? How do you think they got there?

Internet Activity: Minerals

Go to **ClassZone.com** to find out more about minerals that are also precious metals.

Observe and Think
In addition to jewelry, how many different uses can you find for gold?

NSTA scilinks.org SCILINKS
Identifying Minerals **Code: MDL014**

CHAPTER 2

Getting Ready to Learn

CONCEPT REVIEW

- Earth has four main layers: crust, mantle, outer core, and inner core.
- Matter exists in the forms of gas, liquid, and solid.
- People use maps to show many different features of Earth.

VOCABULARY REVIEW

atom *See Glossary.*

geosphere p. 12

CONTENT REVIEW
CLASSZONE.COM
Review concepts and vocabulary.

TAKING NOTES

SUPPORTING MAIN IDEAS

Make a chart to show each main idea and the information that supports it. Copy each blue heading. Below each heading, add supporting information, such as reasons, explanations, and examples.

VOCABULARY STRATEGY

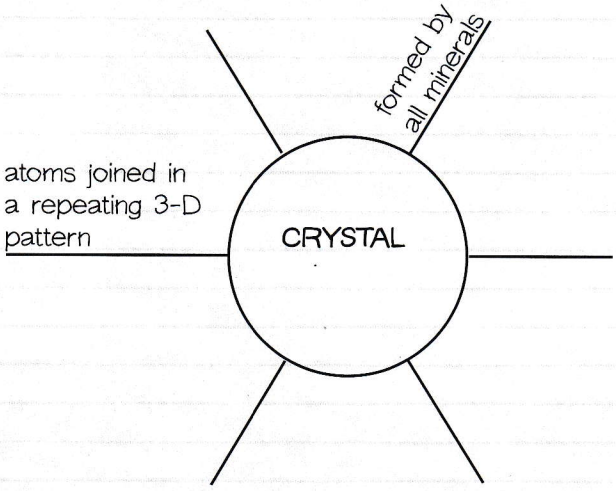
Place each vocabulary term at the center of a **description wheel.** On the spokes write some words explaining it.

See the Note-Taking Handbook on pages R45–R51.

SCIENCE NOTEBOOK

Minerals have four characteristics.

- Minerals form naturally.
- All minerals are solids.
- Each mineral is always made of the same element or elements.
- All minerals have crystal structures.



KEY CONCEPT

2.1 Minerals are all around us.

BEFORE, you learned

- Earth is made of layers
- Earth's outermost rocky layer is the crust

NOW, you will learn

- What the characteristics of minerals are
- How minerals are classified into groups
- Which mineral group is most common

VOCABULARY

mineral p. 43
element p. 45
crystal p. 46

EXPLORE Minerals

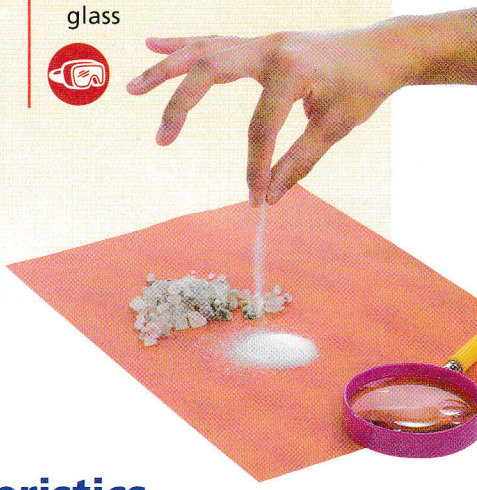
What are some characteristics of a mineral?

PROCEDURE

1. Sprinkle some table salt on a sheet of colored paper. Look at a few grains of the salt through a magnifying glass. Then rub a few grains between your fingers.
2. In your notebook, describe all the qualities of the salt that you observe.
3. Examine the rock salt in the same way and describe its qualities in your notebook. How do the two differ?

MATERIALS

- colored paper
- table salt
- rock salt
- magnifying glass



WHAT DO YOU THINK?

Salt is a mineral. From your observations of salt, what do you think are some characteristics of minerals?

Minerals have four characteristics.

You use minerals all the time. Every time you turn on a microwave oven or a TV, you depend on minerals. The copper in the wires that carry electricity to the device is a mineral. Table salt, or halite (HAYL-YT), is another mineral that you use in your everyday life.

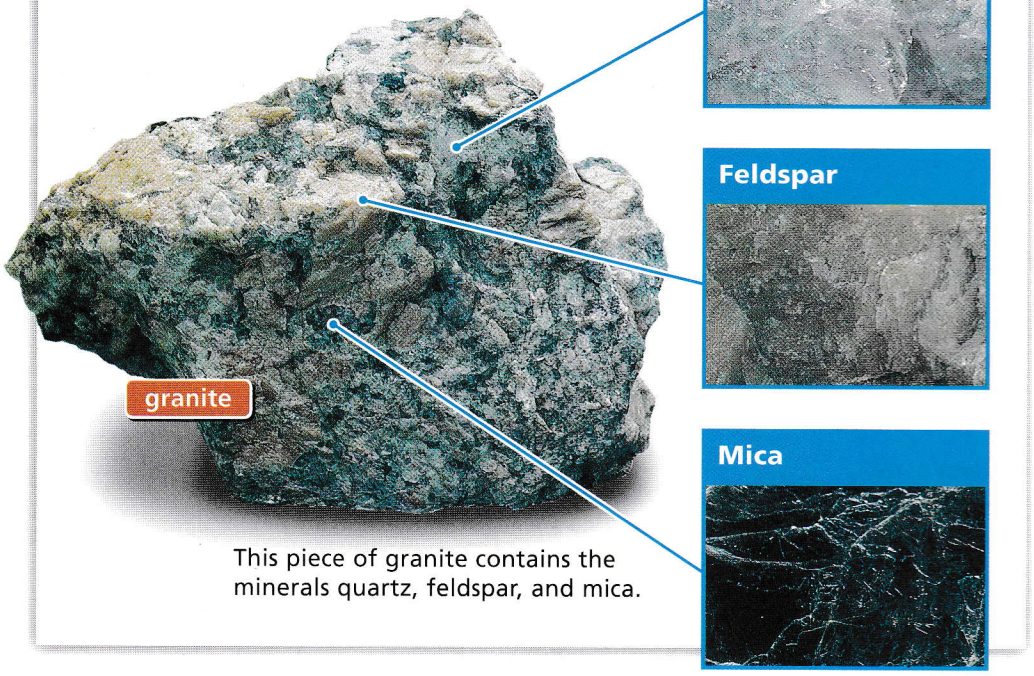
Minerals have four characteristics. A **mineral** is a substance that

- forms in nature
- is a solid
- has a definite chemical makeup
- has a crystal structure

VOCABULARY
Add a description wheel for *mineral* in your notebook.

Minerals in Rocks

Most rocks are made up of minerals.



This piece of granite contains the minerals quartz, feldspar, and mica.

You might think that minerals and rocks are the same things. But a mineral must have the four characteristics listed on page 43. A rock has only two of these characteristics—it is a solid and it forms naturally. A rock usually contains two or more types of minerals.

READING TiP

Proportions show relationships between amounts. For example, a quartz crystal always has two oxygen atoms for every silicon atom.

Two samples of the same type of rock may vary greatly in the amounts of different minerals they contain. Minerals, however, are always made up of the same materials in the same proportions. A ruby is a mineral. Therefore, a ruby found in India has the same makeup as a ruby found in Australia.

CHECK YOUR READING How are minerals different from rocks?

Formed in Nature

Minerals are formed by natural processes. Every type of mineral can form in nature by processes that do not involve living organisms. As you will read, a few minerals can also be produced by organisms as part of their shells or bones.

READING TiP

Molten rock refers to rock that has become so hot that it has melted.

Minerals form in many ways. The mineral halite, which is used as table salt, forms when water evaporates in a hot, shallow part of the ocean, leaving behind the salt it contained. Many types of minerals, including the ones in granite, develop when molten rock cools. Talc, a mineral that can be used to make baby powder, forms deep in Earth as high pressure and temperature cause changes in solid rock.

Solid

A mineral is a solid—that is, it has a definite volume and a rigid shape. Volume refers to the amount of space an object takes up. For example, a golf ball has a smaller volume than a baseball, and a baseball has a smaller volume than a basketball.

A substance that is a liquid or a gas is not a mineral. However, in some cases its solid form is a mineral. For instance, liquid water is not a mineral, but ice is.

Definite Chemical Makeup

Each mineral has a definite chemical makeup: it consists of a specific combination of atoms of certain elements. An **element** is a substance that contains only one type of atom. In turn, an atom is the smallest particle an element can be divided into.

Everything you can see or touch is made up of atoms. Some substances, including the minerals gold and copper, consist of just one element. All the atoms in gold or copper are of the same type. However, most substances contain atoms of more than one element. Most minerals are compounds, substances consisting of several elements in specific proportions. Halite, for example, has one atom of sodium for every atom of chlorine.

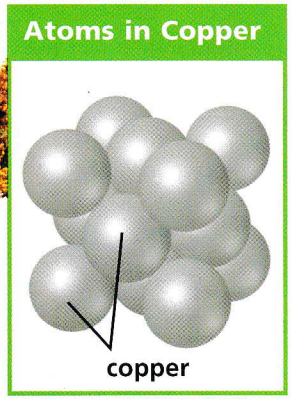
The types of atoms that make up a mineral are part of what makes the mineral unique. The way in which the atoms are bonded, or joined together, is also important. As you will read, many properties of minerals are related to how strong or weak the bonds are.

READING TiP

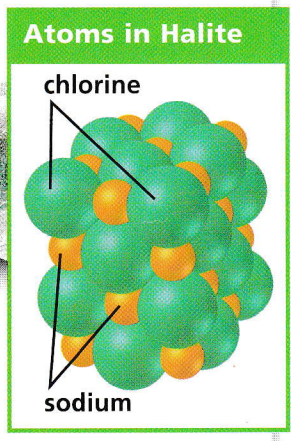
You may remember *compound* from compound words—words formed by joining together smaller words: *note* + *book* = *notebook*. Likewise, a chemical compound has two or more elements joined together.

Atoms in Minerals

The mineral copper is made up only of copper atoms.



The mineral halite is made up of equal numbers of sodium and chlorine atoms.



READING VISUALS How do the diagrams show that copper consists of only one element and halite is a compound?

Crystal Structure

VISUALIZATION
CLASSZONE.COM
Explore an animation of crystal growth.

If you look closely at the particles of ice that make up frost, you will notice that they have smooth, flat surfaces. These flat surfaces form because of the arrangement of atoms in the ice, which is a mineral. Such an internal arrangement is a characteristic of minerals. It is the structure of a **crystal,** a solid in which the atoms are arranged in an orderly, repeating three-dimensional pattern.

Each mineral has its own type of crystal structure. In some cases, two minerals have the same chemical composition but different crystal structures. For example, both diamond and graphite consist of just one element—carbon. But the arrangements of the carbon atoms in these two minerals are not the same, so they have different crystal structures and very different properties. Diamonds are extremely hard and have a brilliant sparkle. Graphite is soft, gray, and dull.

In nature, a perfect crystal is rare. One can grow only when a mineral is free to form in an open space—a condition that rarely exists within Earth's crust. The photographs on page 47 show examples of nearly perfect crystals. The amount of space available for growth influences the shape and size of crystals. Most crystals have imperfect shapes because their growth was limited by other crystals forming next to them.

INVESTIGATE Crystal Shape

How do crystals differ in shape?

SKILL FOCUS
Observing

MATERIALS
- tablespoon
- 2 mixing cups
- 2 stirring rods
- 1 tbs table salt
- 1 tbs Epsom salts
- 60 mL water
- 2 pie plates
- 2 sheets black paper
- scissors

TIME
20 minutes for setup

PROCEDURE

1. Cut sheets of paper so that they fit inside the pie plates as shown. Place one sheet in each pie plate.
2. Add the table salt to 30 mL of water in the cup. Stir the water until the salt has dissolved.
3. Pour enough salt solution into one of the pie plates to completely cover the paper with a small film of liquid. Be careful not to pour into the plate any undissolved salt that may be in the bottom of the cup.
4. Repeat steps 2 and 3 with the Epsom salts. Let the plates dry overnight.

WHAT DO YOU THINK?
- Compare and describe the shapes of the crystals.
- What do you think accounts for any differences you observe?

CHALLENGE Why are the shapes of the crystals the same as or different from the shapes in the materials you started with?

Crystal Groups

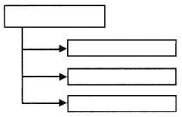
Crystal groups are named by their shapes and the angles formed by imaginary lines through their centers. Crystals take many shapes, but all belong to these six groups.

Minerals are grouped according to composition.

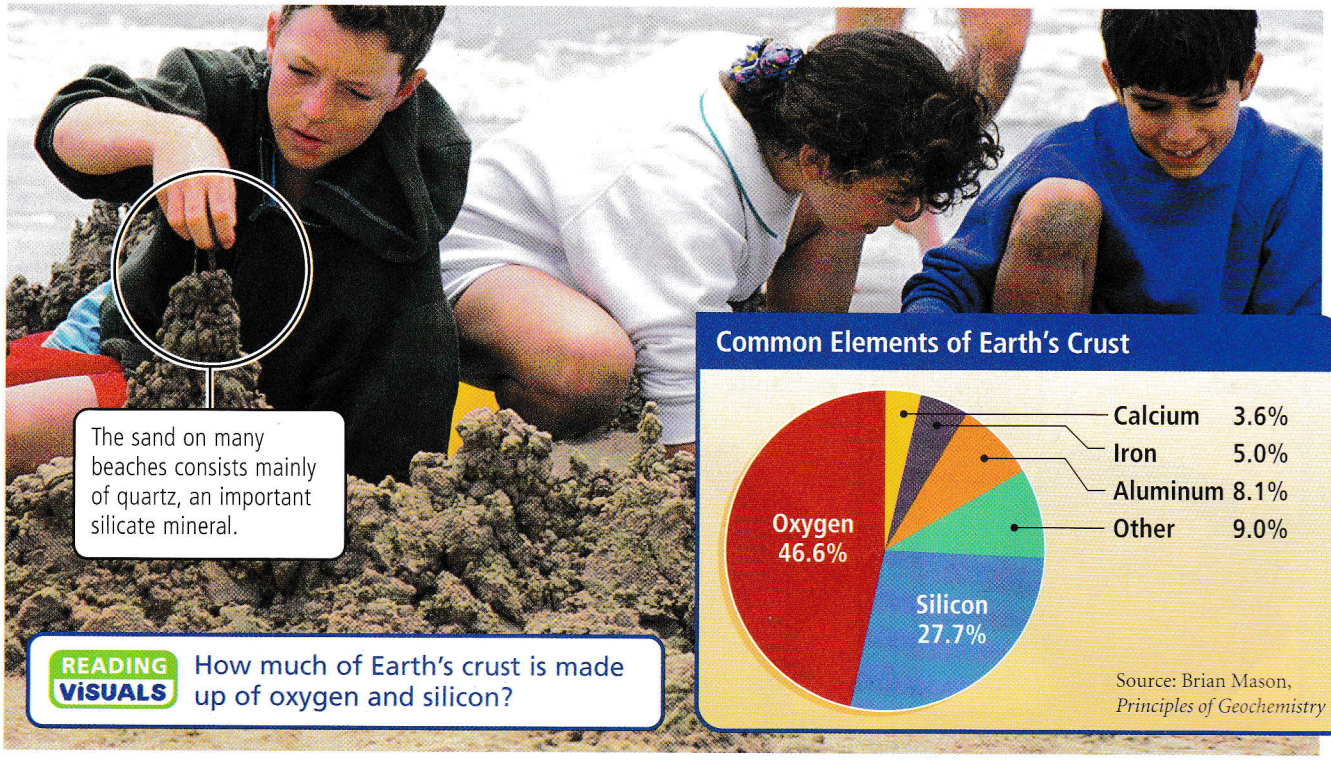
Scientists classify minerals into groups on the basis of their chemical makeups. The most common group is the silicates. All the minerals in this group contain oxygen and silicon—the two most common elements in Earth's crust—joined together.

Though there are thousands of different minerals, only about 30 are common in Earth's crust. These 30 minerals make up most rocks in the crust. For that reason, they are called rock-forming minerals. Silicates, which make up about 90 percent of the rocks in Earth's crust, are the most common rock-forming minerals. Quartz, feldspar, and mica (MY-kuh) are common silicates.

SUPPORTING MAIN IDEAS
Enter this blue heading in a chart and record supporting information.



CHECK YOUR READING Which mineral group do most rock-forming minerals belong to?



The sand on many beaches consists mainly of quartz, an important silicate mineral.

READING VISUALS How much of Earth's crust is made up of oxygen and silicon?

Common Elements of Earth's Crust

Source: Brian Mason, *Principles of Geochemistry*

The second most common group of rock-forming minerals is the carbonates. All the minerals in this group contain carbon and oxygen joined together. Calcite (KAL-syt), which is common in seashells, is a carbonate mineral.

There are many other mineral groups. All are important, even though their minerals may not be as common as rock-forming minerals. For instance, the mineral group known as oxides contains the minerals from which most metals, such as tin and copper, are refined. An oxide consists of an element, usually a metal, joined to oxygen. This group includes hematite (HEE-muh-tyt), a source of iron.

RESOURCE CENTER CLASSZONE.COM
Find information on minerals.

CHECK YOUR READING Why is the oxide mineral group important?

2.1 Review

KEY CONCEPTS

1. What are the four characteristics of a mineral?
2. On what basis do scientists classify minerals?
3. What is the most common group of minerals? What percentage of the crust do they make up?

CRITICAL THINKING

4. **Classify** Can oil and natural gas be classified as minerals? Why or why not?
5. **Apply** When a piece of quartz is heated to a very high temperature, it melts into a liquid. Is it still a mineral? Why or why not?

CHALLENGE

6. **Interpret** You can see perfect crystals lining the inside of certain rocks when they are broken open. How do you think the crystals were able to form?

MATH in SCIENCE

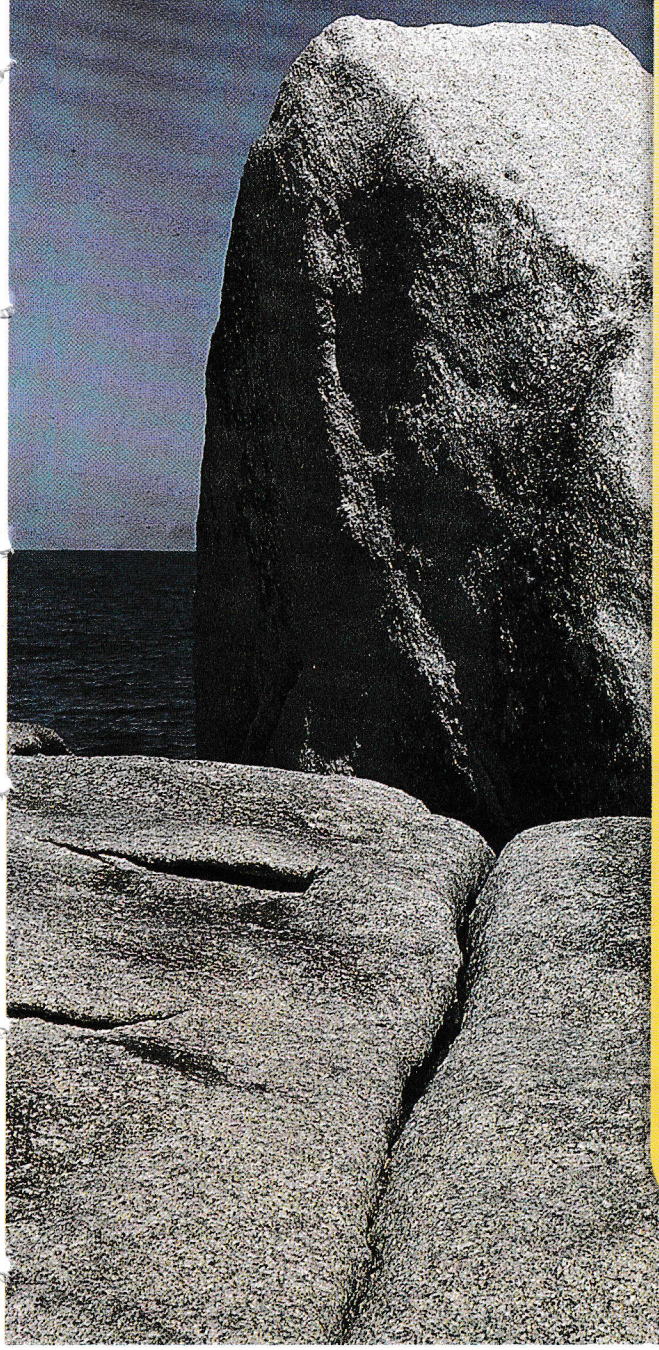
SKILL: WRITING FRACTIONS AS PERCENTS

Minerals in Rocks

Granite

Like most rocks, granite is a mixture of several minerals. Each mineral makes up a certain proportion, or fraction, of the granite. You can compare mineral amounts by expressing each mineral's fraction as a percentage.

MATH TUTORIAL
CLASSZONE.COM
Click on Math Tutorial for more help with percents and fractions.



Example

To change a fraction to a percentage, you must find an equivalent fraction with 100 as the denominator. Suppose, for example, you want to change the fraction $\frac{1}{5}$ to a percentage. First, divide 100 by the denominator 5, which gives you 20. Then, multiply both the numerator and denominator by 20 to find the percentage.

$\frac{1}{5} \cdot \frac{20}{20} = \frac{20}{100}$ or 20% $\frac{1}{5}$ is 20%

The table below shows the fraction of each mineral in a granite sample.

Minerals in Granite Sample

Mineral	Fraction of Granite Sample	Percentage of Granite
Quartz	$\frac{1}{4}$	?
Feldspar	$\frac{13}{20}$	?
Mica	$\frac{3}{50}$	?
Dark minerals	$\frac{1}{25}$	?

Answer the following questions.

1. On your paper, copy the table and fill in the percentage of each mineral in the granite sample above.
2. Which minerals make up the greatest and smallest percentages of the granite?
3. In another granite sample, feldspar makes up $\frac{3}{5}$ and mica makes up $\frac{2}{25}$. What is the percentage of each mineral in the rock?

CHALLENGE The mineral hornblende is often one of the dark minerals in granite. If hornblende makes up $\frac{1}{32}$ of a granite sample, what percentage of the rock is hornblende?

KEY CONCEPT

2.2 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

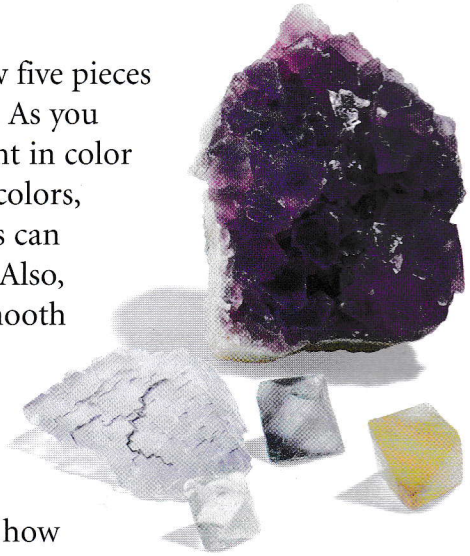
VOCABULARY

streak p. 51
luster p. 52
cleavage p. 53
fracture p. 53
density p. 54
hardness p. 55

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.

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.

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.

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

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.

READING TiP
A geologist is a scientist who studies Earth.

CHECK YOUR READING What is the difference between color and streak?

Streak

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.

READING VISUALS What is a clue that both samples are of the same mineral?

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.

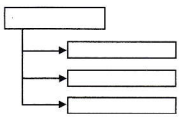
Pyrite has a metallic luster.

Garnet 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.

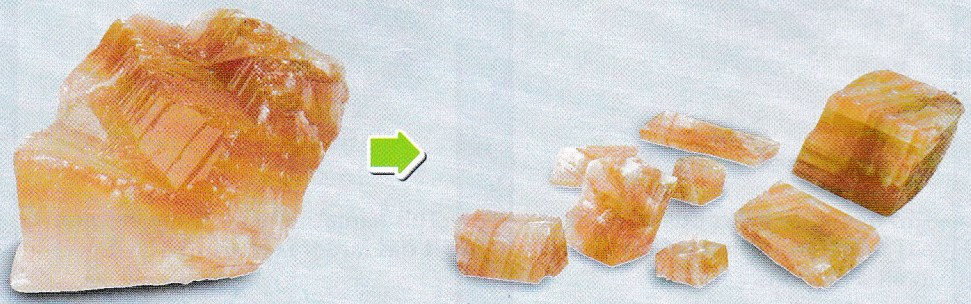
SUPPORTING MAIN IDEAS
Enter this blue heading in a chart and record supporting information.



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.



Calcite has cleavage.

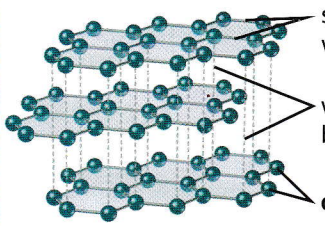
It breaks along flat surfaces because the bonds between its atoms are less strong in some directions than in others.

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 52 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.

Carbon Bonds in Graphite



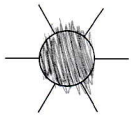
In graphite, carbon atoms are arranged in layers. Graphite has cleavage because the weak bonds between the layers break easily.

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.

VOCABULARY
Add a description wheel for *fracture* in your notebook.



CHECK YOUR READING 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

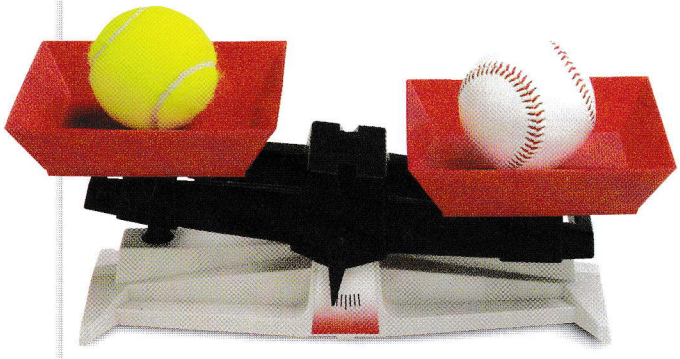
Even though a baseball and a tennis ball are about the same size, the baseball has more mass and so is more dense. A substance's **density** is the amount of mass in a given volume of the substance. For example, 1 cubic centimeter of the mineral pyrite has a mass of 5.1 grams, so pyrite's density is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

READING TiP
The unit of density is grams per cubic centimeter and is abbreviated as g/cm^3.

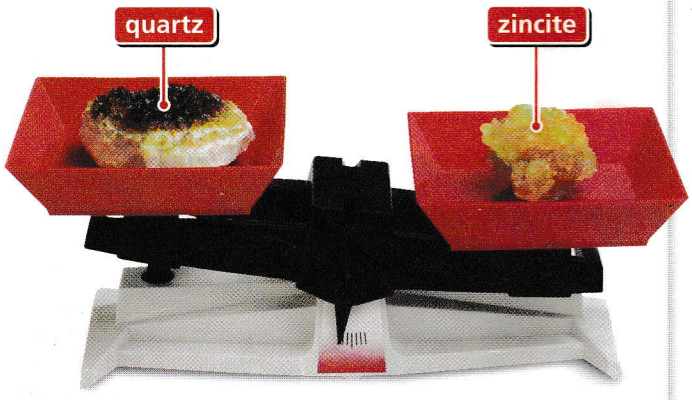
Density is very helpful in identifying minerals. For example, gold and pyrite look very similar. Pyrite is often called fool's gold. However, you can tell the two minerals apart by comparing their densities. Gold is much denser than pyrite. The mass of a piece of gold is almost four times the mass of 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

Comparing Densities

Differences in density can be used to tell minerals apart.



The baseball on the right has more mass, and so is denser, than a tennis ball that is about the same size.



The zincite sample on the right is about twice as dense as the quartz sample.

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

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 READING 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?

SKILL FOCUS
Classifying

MATERIALS
- samples of 5 minerals
- copper penny (1982 or earlier)
- steel file

TIME
20 minutes

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.
3. 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 57 show how geologists test some minerals. Such tests help them identify minerals that have unusual properties.

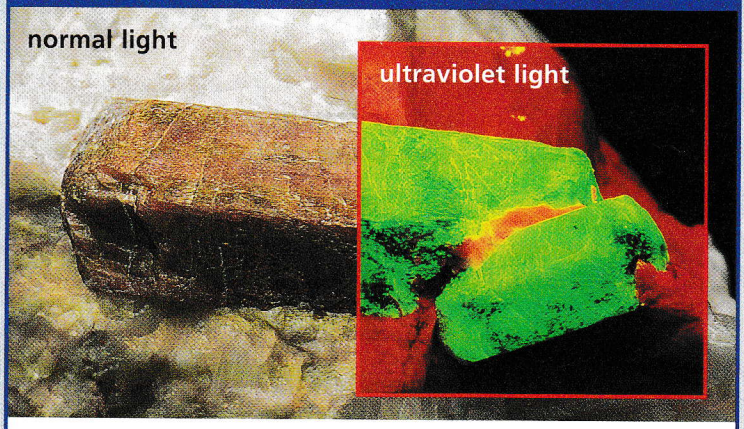
Minerals in the carbonate group, such as calcite, react with acid. Chalk is a familiar item that is made up of carbonate minerals. The test consists of putting a drop of a weak solution of hydrochloric acid on a mineral sample. If the acid reacts with the mineral, carbon dioxide gas will form and bubble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

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

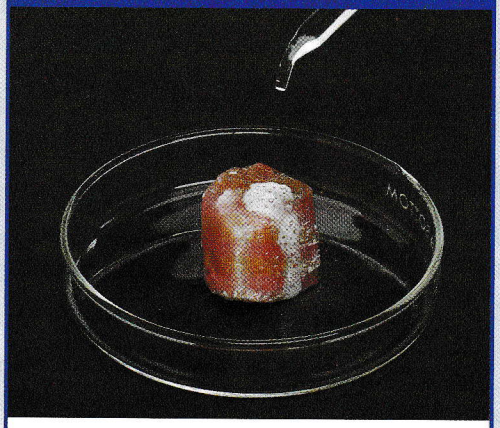
Special Properties

Fluorescence



These minerals look ordinary in normal light but display red and green fluorescence under ultraviolet light.

Acid Test



Acid in contact with carbonate minerals, such as calcite, forms bubbles.

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.

2.2 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 mineral-identification 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

6. **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.

CHAPTER INVESTIGATION

Mineral Identification

OVERVIEW AND PURPOSE In this activity, you will observe and perform tests on minerals. Then you will compare your observations to a mineral identification key.

MATERIALS

- numbered mineral samples
- hand lens
- streak plate
- copper penny
- steel file
- magnet
- dilute hydrochloric acid
- eyedropper
- Mohs scale
- Mineral Identification Key

Procedure

1. Make a data table like the one shown in the notebook on the next page.

2. You will examine and identify five minerals. Get a numbered mineral sample from the mineral set. Record the number of your sample in your table.

3. First, observe the sample. Note the color and the luster of the sample. Write your observations in your table. In the row labeled "Luster," write *metallic* if the mineral appears shiny like metal. Write *nonmetallic* if the sample does not look like metal. For example, it may look glassy, pearly, or dull.

4. Observe the sample through the hand lens. Look to see any signs of how the crystals in the mineral broke. If it appears that the crystals have broken along straight lines, put a check in the row labeled "Cleavage." If it appears that the sample has fractured, put a check in the appropriate row of your table.

5. **CAUTION: Keep the streak plate on your desktop or table while you are doing the streak test. A broken streak plate can cause serious cuts.** Rub the mineral sample on the streak plate. If the sample does not leave a mark, the mineral is harder than the streak plate. Write *no* in the row labeled "Streak." If the sample does leave a mark on the streak plate, write the color of the streak in that row.

6 Test each sample for its hardness on the Mohs scale. Try to scratch the sample with each of these items in order: a fingernail, a copper penny, and a steel file. In the Mohs scale, find the hardness number of the object that first scratches the sample. Write in the table that the mineral's hardness value is between that of the hardest item that did not scratch the sample and that of the item that did scratch it.

7 Test the sample with the magnet. If the magnet is attracted to the sample, put a check in the row labeled "Magnetic."

8 Repeat steps 2 through 7 for each of the other numbered samples.

Observe and Analyze

Write It Up

1. **INTERPRET DATA** Use the Mineral Identification Key and the information in your data table to identify your samples. Write the names of the minerals in your table.

2. **COLLECT DATA** **CAUTION: Before doing the acid test, put on your safety glasses, protective gloves, and lab apron. Acids can cause burns.** If you identified one of the samples as a carbonate mineral, such as calcite, you can check your identification with the acid test. Use the eyedropper to put a few drops of dilute hydrochloric acid on the mineral. If the acid bubbles, the sample is a carbonate.

Conclude

Write It Up

1. **COMPARE AND CONTRAST** How are the minerals calcite and halite alike? Which property can you use to test whether a sample is calcite or halite?

2. **INTERPRET** Look at the data in your table. Name any minerals that you could identify on the basis of a single property.

3. **APPLY** Examine a piece of granite rock. On the basis of your examination of granite and your observations of the samples, try to determine what the light-colored, translucent mineral in the granite is and what the flaky, darker mineral is.

INVESTIGATE Further

Specific gravity is another property used to identify minerals. The specific gravity of a mineral is determined by comparing the mineral's density with the density of water.

Find the specific gravity of an unknown mineral chosen from your teacher's samples. Attach your mineral with a string to a spring scale. Record its mass and label this value *M1*. Then suspend the mineral in a beaker of water. Record the measurement of the mineral's mass in water. Label this value *M2*. To determine the mineral's specific gravity, use the following equation:

$$\frac{M1}{M1 - M2} = \text{specific gravity}$$

Do all the other steps to identify the sample. Does the specific gravity you measured match the one listed for that mineral in the identification key?

Mineral Identification

Table 1. Mineral Properties

Property	Sample Number				
	1	2	3	4	5
Color					
Luster					
Cleavage					
Fracture					
Streak					
Hardness					
Magnetic					
Acid test					
Name of mineral					

KEY CONCEPT

2.3 Minerals are valuable resources.

BEFORE, you learned

- Minerals are classified according to their compositions and crystal structures
- A mineral can be identified by its properties

NOW, you will learn

- How minerals are used in industry and art
- How minerals form
- How minerals are mined

VOCABULARY

magma p. 62
lava p. 62
ore p. 64

EXPLORE Minerals at Your Fingertips

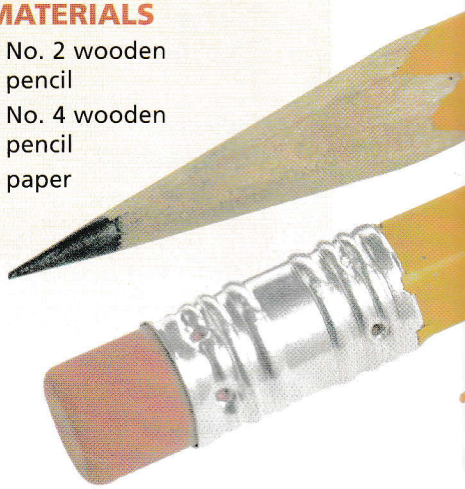
What is an everyday use of minerals?

PROCEDURE

1. Observe the core of a wooden pencil. Even though it is called lead, it is made of a mixture of minerals—clay and graphite. A No. 4 pencil has more clay in its lead.
2. Use each pencil to draw something, noticing how each marks the page.

MATERIALS

- No. 2 wooden pencil
- No. 4 wooden pencil
- paper



WHAT DO YOU THINK?

- How is using a pencil similar to a streak test?
- When would a No. 4 pencil be more useful than a No. 2 pencil?

Minerals have many uses in industry.

Minerals are necessary to our modern way of life. Mineral deposits are sources of

- metals for cars and airplanes
- quartz and feldspar for glass
- fluorite and calcite for toothpaste
- silver compounds for photographic film
- mica and talc for paint

These examples illustrate just a few of the many ways we depend on minerals.

CHECK YOUR READING Give three examples of the use of minerals in familiar products.

Minerals have many uses in the arts.

RESOURCE CENTER
CLASSZONE.COM
Learn more about gemstones.

No matter what month you were born in, there is a mineral associated with it—your birthstone. The tradition of birthstones is hundreds of years old. It is one example of the value that people place on the particularly beautiful minerals known as gemstones. In fact, the ancient Egyptians used gems in necklaces and other jewelry at least 4000 years ago.

When gemstones are found, they are usually rough and irregularly shaped. Before a gemstone is used in jewelry, a gem cutter grinds it into the desired shape and polishes it. This process increases the gemstone's beauty and sparkle. The material used to shape and polish a gemstone must be at least as hard as the gemstone itself. Metals, such as gold and silver, also are used in jewelry making and other decorative arts. Both gold and silver are usually combined with copper to increase their hardness.

READING TIP
Corundum and diamond are the two hardest minerals in the Mohs scale. They are often used to grind and polish gemstones.

CHECK YOUR READING How are minerals prepared for use in jewelry? What other questions do you have about how minerals are used?

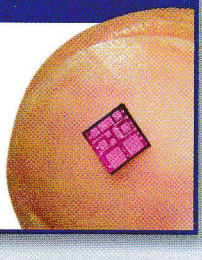
Uses of Minerals

Common Uses of Minerals

Mineral	Products
Quartz (source of silicon)	Optics, glass, abrasives, gems
Hematite (source of iron)	Machines, nails, cooking utensils
Gibbsite (source of aluminum)	Soda cans, shopping carts
Dolomite (source of magnesium)	Insulators, medicines
Chromite (source of chromium)	Automobile parts, stainless steel
Galena (source of lead)	Batteries, fiber optics, weights
Kaolinite (found in clay)	Ceramics, paper, cosmetics
Beryl (source of beryllium)	Aircraft frames, gems (green form is emerald)

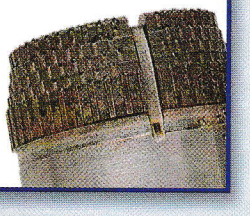
Technology

A clear quartz crystal was sliced to make this computer chip. Minerals such as copper, silver, and gold are commonly used in electronics.



Industry

Diamonds are used as abrasives, as in this drill tip. Minerals are also used in such products as insulators and water filters.



Arts

Cinnabar is ground up to make the pigment known as vermilion. Other minerals are also used as pigments in dyes and paints. Gemstones are used in jewelry, as are platinum and gold.

Minerals form in several ways.

REMINDER

An element is a substance that contains only one type of atom. For instance, oxygen is an element. Pure oxygen contains only oxygen atoms.

Minerals form within Earth or on Earth's surface by natural processes. Minerals develop when atoms of one or more elements join together and crystals begin to grow. Recall that each type of mineral has its own chemical makeup. Therefore, what types of minerals form in an area depends in part on which elements are present there. Temperature and pressure also affect which minerals form.

Water evaporates. Water usually has many substances dissolved in it. Minerals can form when the water evaporates. For example, when salt water evaporates, the atoms that make up halite, which is used as table salt, join to form crystals. Other minerals form from evaporation too, depending on the substances dissolved in the water. The mineral gypsum often forms as water evaporates.

Hot water cools. As hot water within Earth's crust moves through rocks, it can dissolve minerals. When the water cools, the dissolved minerals separate from the water and become solid again. In some cases, minerals are moved from one place to another. Gold can dissolve in hot water that moves through the crust. As the water cools and the gold becomes solid again, it can fill cracks in rocks. In other cases, the minerals that form are different from the ones that dissolved. Lead from the mineral galena can later become part of the mineral wulfenite as atoms join together into new minerals.

Molten rock cools. Many minerals grow from magma. **Magma**—molten rock inside Earth—contains all the types of atoms that are found in minerals. As magma cools, the atoms join together to form different minerals. Minerals also form as lava cools. **Lava** is molten rock that has reached Earth's surface. Quartz is one of the many minerals that crystallize from magma and lava.

Heat and pressure cause changes. Heat and pressure within Earth cause new minerals to form as bonds between atoms break and join again. The mineral garnet can grow and replace the minerals chlorite and quartz as their atoms combine in new ways. The element carbon is present in some rocks. At high temperatures carbon forms the mineral graphite, which is used in pencils.

Organisms produce minerals. A few minerals are produced by living things. For example, ocean animals such as oysters and clams produce calcite and other carbonate minerals to form their shells. Even you produce minerals. Your body produces one of the main minerals in your bones and teeth—apatite.

CHECK YOUR READING How is the formation of minerals as molten rock cools similar to the formation of minerals as water evaporates?

Mineral Formation

Minerals form at Earth's surface and within Earth.

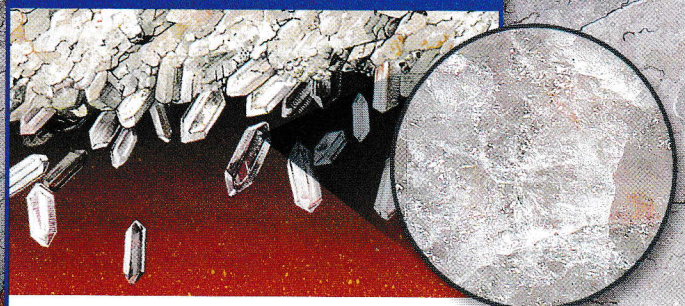
Water evaporates.

As water evaporates along a shoreline, it leaves behind substances that were dissolved in it. Here, gypsum is forming.

Hot water cools.

Gold dissolved in hot water can fill cracks in rocks as the water cools.

Molten rock cools.



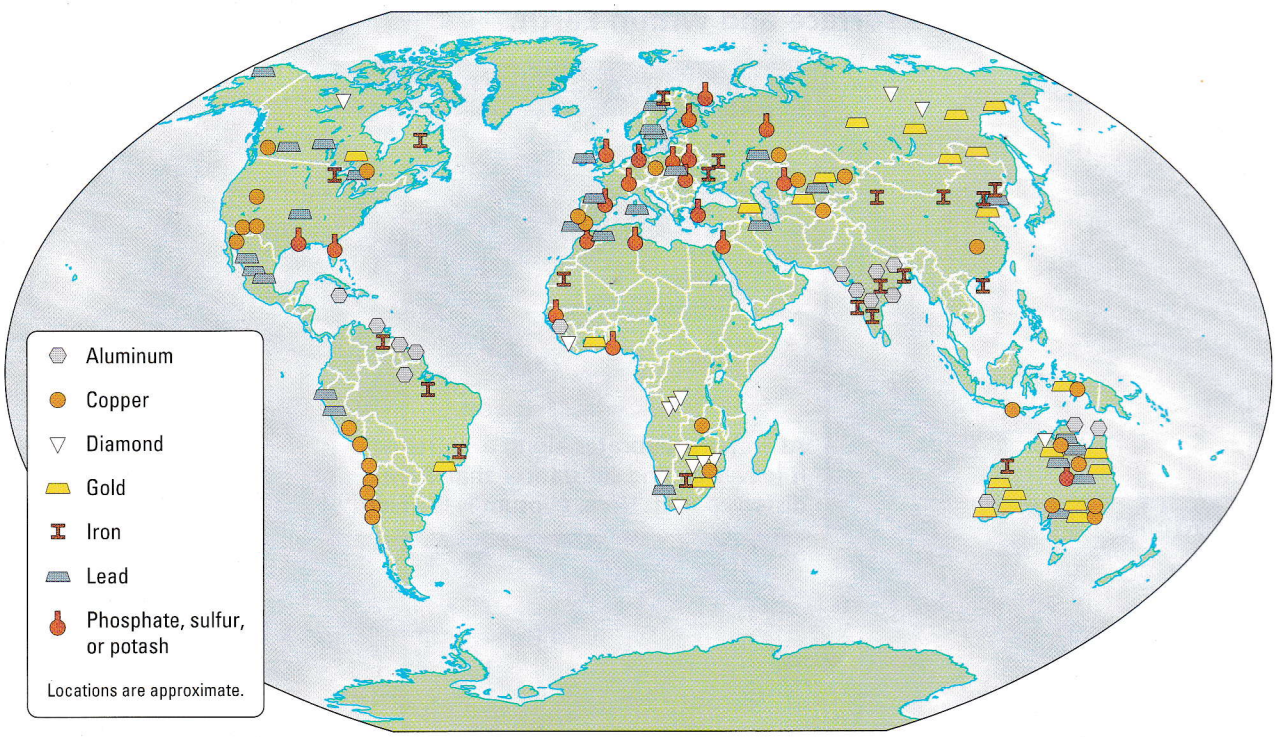
Minerals such as quartz grow as molten rock cools.

Heat and pressure cause changes.

Graphite forms inside Earth when carbon is subjected to great heat.

READING VISUALS Each of the four processes shown involves heat. What is the heat source for rapid evaporation of water at Earth's surface?

Minerals and Ores Around the World



READING VISUALS Which mineral resource is most common in the western areas of North America and South America?

Many minerals are mined.

Before minerals can be used to make products, they must be removed from the ground. Some minerals are found near Earth's surface, while others lie deep underground. Some minerals are found at a wide range of depths, from the surface to deep within Earth.

Most minerals are combined with other minerals in rocks. For any mineral to be worth mining, there must be a fairly large amount of the mineral present in a rock. Rocks that contain enough of a mineral to be mined for a profit are called **ores.**

READING TIP
To make a profit, mine owners must be able to sell ores for more than it cost them to dig the ores out.

Surface Mining

Minerals at or near Earth's surface are recovered by surface mining. Some minerals, such as gold, are very dense. These minerals can build up in riverbeds as less dense minerals are carried away by the water. In a method called panning, a miner uses a pan to wash away unwanted minerals that are less dense. The gold and other dense minerals stay in the bottom of the pan and can then be further separated. In bigger riverbed mining operations, miners use machines to dig out and separate the valuable minerals.

Another method of surface mining is strip mining. Miners strip away plants, soil, and unwanted rocks from Earth's surface. Then they use special machines to dig out an ore.

Like strip mining, open-pit mining involves removing the surface layer of soil. Miners then use explosives to break up the underlying rock and recover the ore. As they dig a deep hole, or pit, to mine the ore, they build roads up the sides of the pit. Trucks carry the ore to the surface. Ores of copper and of iron are obtained by open-pit mining.

CHECK YOUR READING How are strip mining and open-pit mining similar? How are they different?

If an Olympic-sized swimming pool were filled with rock from this mine, it might contain enough copper to make a solid "beach ball" 146 cm (60 in.) in diameter.

INVESTIGATE Mining

What are the benefits and costs of mining ores?

SKILL FOCUS
Drawing conclusions

MATERIALS
- 1 pound wild-birdseed mix with sunflower seeds
- shallow pan
- 2 small red beads
- 4 small green beads
- 8 small blue beads
- 3 medium yellow beads

TIME
25 minutes

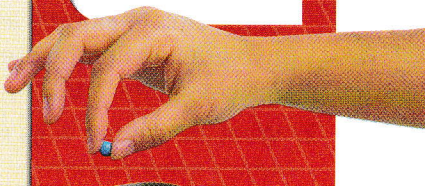
PROCEDURE

1. Put the birdseed into a pan. Add the beads to the birdseed and mix well.
2. Search through the seeds and separate out the beads and sunflower seeds, placing each kind in a different pile. Take no more than 3 minutes.
3. Assign a value to each of the beads and seeds: red bead, $5; green bead, $4; blue bead, $3; sunflower seed, $2. Count up the value of your beads and seeds. For every yellow bead, subtract $100, which represents the cost of restoring the land after mining.

WHAT DO YOU THINK?

- How does the difficulty of finding the red beads relate to the difficulty of finding the most valuable ores?
- How does the total value of the blue beads and the sunflower seeds compare to the total value of the red and green beads? What can you conclude about deciding which materials to mine?

CHALLENGE The sunflower seeds and the red, green, and blue beads could represent minerals that contain copper, gold, iron, and silver. Which bead or seed is most likely to represent each mineral? Explain your choices.



Deep Mining

Deep-mining methods are needed when an ore lies far below Earth's surface. These methods are used to obtain many minerals. Miners dig an opening to reach a deep ore. When the ore is inside a mountain or hill, miners can cut a level passage to reach the mineral they want. Miners dig a vertical passage to reach an ore that lies underground in a flat area or under a mountain.

From the main passage, miners blast, drill, cut, or dig the ore. If the passage is horizontal, they keep digging farther and farther into the hill or mountain. If it is vertical, they remove the ore in layers.

These gold miners are working underground near Carlin, Nevada. The world's deepest gold mine is in South Africa and extends almost 3 km (2 mi) underground.

2.3 Review

KEY CONCEPTS

1. Give two examples of the use of minerals in industry and two examples of the use of minerals in the arts.
2. What are the five ways in which minerals form?
3. What is required for rocks to be considered ores?

CRITICAL THINKING

4. **Infer** Would an ore at Earth's surface or an ore deep underground be more expensive to mine? Explain.
5. **Apply** The mineral quartz has been used as a gemstone for thousands of years. What minerals could jewelry makers use to grind and polish quartz?

CHALLENGE

6. **Analyze** Both strip mining and open-pit mining are types of surface mining. When might miners choose to use open-pit mining rather than strip mining to obtain an ore?

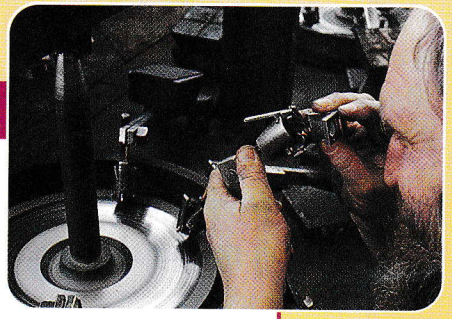
SCIENCE on the JOB

GEM CUTTER

Geometry for Gems

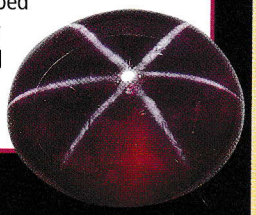
If you found a gemstone in nature, it would probably look dull and rough. You might want to take it to a gem cutter, who would use a grinding wheel to shape and polish your rough stone into a beautiful gem. You would also discover that a lot of the rough gemstone is ground away into powder.

Gem cutters use geometry to help them choose the best final shapes of gems. Geometry also helps them to shape gems with many small, flat surfaces at specific angles. These surfaces are called facets, and they make the gems sparkle.



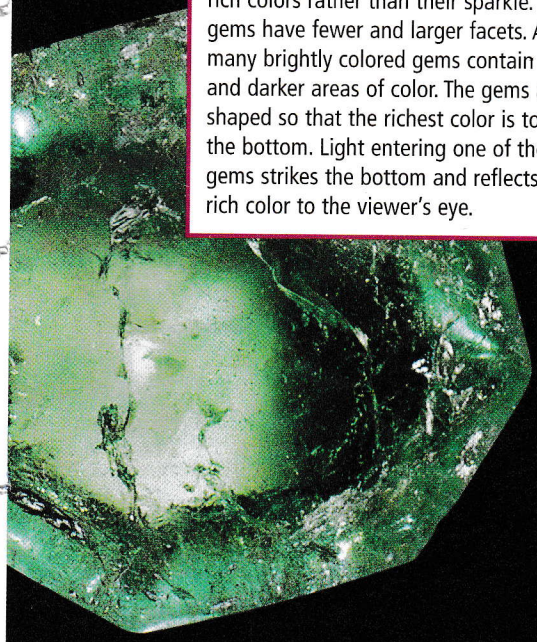
Starred Gems

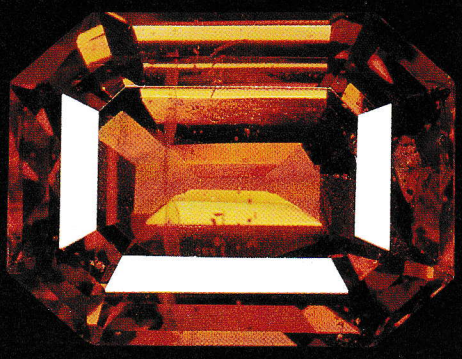
Some gems—such as certain rubies, sapphires, and forms of quartz—show a six-pointed star when cut in a rounded shape instead of facets. These gems contain tiny flaws aligned at 120-degree angles. When light hits the flaws, it scatters in a star-shaped pattern. The star ruby shown here is a good example of these beautiful gems.



Deeply Colored Gems

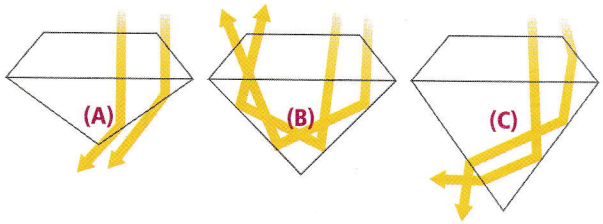
Some gems are shaped to show off their rich colors rather than their sparkle. These gems have fewer and larger facets. Also, many brightly colored gems contain lighter and darker areas of color. The gems are shaped so that the richest color is toward the bottom. Light entering one of these gems strikes the bottom and reflects the rich color to the viewer's eye.





Sparkling Gems

How much a gem sparkles depends on the geometric angles at which it is cut. If the overall angle of the bottom part of a gem is too shallow **(A)** or too steep **(C)**, light will go through the gem.



However, if the angles are correct **(B)**, light will bounce around inside the gem as it is reflected to the viewer's eye.The more facets a gem has, the more the light will bounce, and the more the gem will sparkle.

EXPLORE

1. **COMPARE** Table salt, which is the mineral halite, sparkles as light is reflected from its crystal faces. Snow, which is the mineral ice, also sparkles in sunlight. How are the crystal faces of salt and snow similar to facets? How are they different?
2. **CHALLENGE** When would it be best for a gem cutter to split an irregularly shaped crystal into two or more smaller stones before grinding them into finished gems? Remember, one larger stone is usually more valuable than two smaller ones.

2 Chapter Review

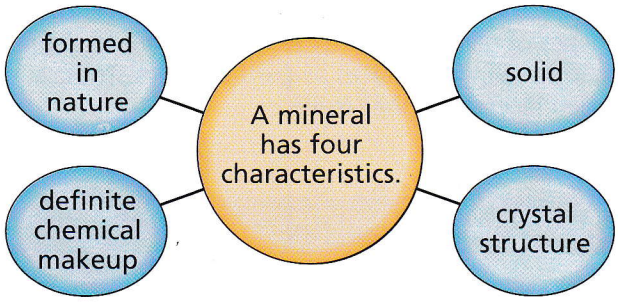
the BIG idea

Minerals are basic building blocks of Earth.

CONTENT REVIEW
CLASSZONE.COM

KEY CONCEPTS SUMMARY

1 Minerals are all around us.



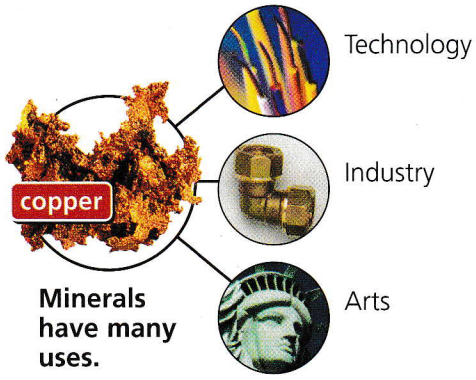
VOCABULARY
mineral p. 43
element p. 45
crystal p. 46

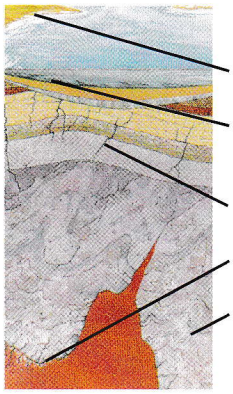
2 A mineral is identified by its properties.

Mineral Properties	wulfenite
color	orange
streak	white
luster	nonmetallic
cleavage	yes
density	6.9
hardness	3

VOCABULARY
streak p. 51
luster p. 52
cleavage p. 53
fracture p. 53
density p. 54
hardness p. 55

3 Minerals are valuable resources.





Mineral Formation

Water evaporates.

Organisms form shells or bones.

Hot water cools.

Molten rock cools.

Heat and pressure cause changes.

VOCABULARY
magma p. 62
lava p. 62
ore p. 64

Reviewing Vocabulary

On a separate sheet of paper, write a sentence describing the relationship between the two vocabulary terms.

1. mineral, crystal
2. cleavage, fracture
3. magma, lava
4. element, density
5. mineral, ore
6. element, magma

Reviewing Key Concepts

Multiple Choice *Choose the letter of the best answer.*

7. A mineral is a substance that forms
   - **a.** from rocks
   - **b.** in nature
   - **c.** from one element
   - **d.** in liquid

8. A crystal structure is characteristic of
   - **a.** an element
   - **b.** a rock
   - **c.** magma
   - **d.** a mineral

9. A mineral is made up of one or more
   - **a.** ores
   - **b.** rocks
   - **c.** compounds
   - **d.** elements

10. How is it possible for two different minerals to have the same chemical composition?
    - **a.** They have different crystal structures.
    - **b.** One is formed only by organisms.
    - **c.** Only one is a rock-forming mineral.
    - **d.** They have different appearances.

11. Most minerals in Earth's crust belong to the silicate mineral group because this group contains the
    - **a.** rarest elements on Earth
    - **b.** most common elements on Earth
    - **c.** most valuable metals on Earth
    - **d.** largest crystals on Earth

12. Which of the following is the least reliable clue to a mineral's identity?
    - **a.** color
    - **b.** density
    - **c.** hardness
    - **d.** luster

13. Many properties of a mineral are related to the
    - **a.** number of elements of which it is made
    - **b.** other types of minerals present as it formed
    - **c.** strength of bonds between its atoms
    - **d.** speed at which it formed

14. What types of minerals form in an area depends in part on
    - **a.** which elements are present
    - **b.** the types of rock present
    - **c.** the density of rocks present
    - **d.** whether crystals can form

15. Open-pit mining is used to obtain ores that lie
    - **a.** under flat land
    - **b.** deep in Earth's crust
    - **c.** near the surface of Earth
    - **d.** in riverbeds

16. Gemstones are used in
    - **a.** building materials
    - **b.** paper products
    - **c.** automobile parts
    - **d.** jewelry making

Short Answer *Write a short answer for each question.*

17. Why aren't all solids minerals? Include the term *crystal structure* in your answer.

18. Why is a mineral's streak more useful in identifying it than its color?

19. If you drop dilute hydrochloric acid on the mineral aragonite, it bubbles. What mineral group do you think aragonite belongs to? Why?

20. Describe how the strength of the bonds between atoms in a mineral determines whether the mineral displays cleavage or fracture.

Thinking Critically

Properties such as hardness and density are used to identify minerals. Use the information from the chart to answer the next five questions.

Mineral	Hardness	Density (g/cm^3)
platinum	4.5	19.0
aragonite	4	3
topaz	8	3.5
quartz	7	2.7
arsenic	3.5	5.7

21. **COMPARE** Platinum can combine with arsenic to form the mineral sperrylite. How do you think the density of sperrylite compares with the densities of platinum and arsenic?

22. **APPLY** Gems made of topaz are much more valuable than those made of quartz, even though the two minerals can look similar. Describe two methods you could use to identify quartz.

23. **APPLY** Would a miner be more likely to use the method of panning to find platinum or to find topaz? Why?

24. **INFER** Aragonite forms very attractive crystals, yet this common mineral is rarely used in jewelry. Why do you think this is?

25. **DEDUCE** About how many times heavier than a piece of quartz would you expect a piece of platinum of the same size to be? Show your work.

26. **HYPOTHESIZE** *Halite* is the mineral name for table salt. Thick layers of halite are mined near Detroit, Michigan. At one time, an ocean covered the area. Write a hypothesis that explains how the halite formed there.

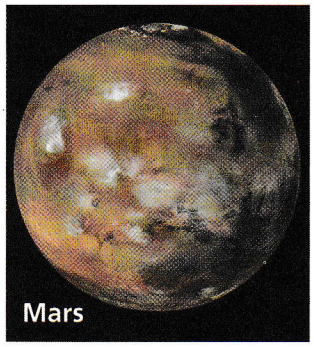
27. **PREDICT** The mineral chromite is the main ore of the metal chromium. What might happen after all the chromite on Earth is mined?

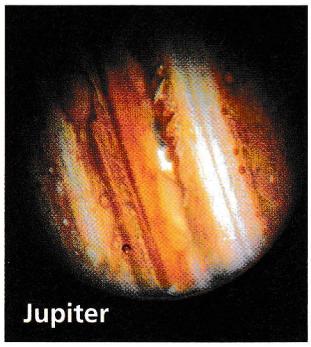
28. **PREDICT** The mineral apatite is a compound in your bones and teeth. Apatite contains the elements phosphorus and calcium. How might your bones be affected if you do not have enough of these elements in your diet?

29. **DRAW CONCLUSIONS** You live on the surface of Earth's crust. The average density of the crust is about 2.8 grams per cubic centimeter. Most metal ores have densities greater than 5 grams per cubic centimeter. How common do you think metal ores are in the crust? Why?

the BIG idea

30. **ANALYZE** Minerals are basic components of planets such as Earth and Mars. Other planets in our solar system, such as Jupiter and Saturn, are called gas giants because they are composed mainly of the gases hydrogen and helium. They do not have solid surfaces. Do you think that minerals are basic components of gas giants? Why or why not?


Mars


Jupiter

31. **INFER** Minerals make up much of Earth. People use minerals as sources of many materials, such as metals. Some metals are used to make machine parts or build houses. How would your life be different if minerals that contain metals were rare in Earth's crust?

UNIT PROJECTS

If you need to do an experiment for your unit project, gather the materials. Be sure to allow enough time to observe results before the project is due.

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Analyzing a Table

This table shows characteristics of four minerals. Use it to answer the questions below.

Sample	Cleavage or Fracture	Density (g/cm^3)	Hardness (in Mohs scale)	Magnetic
E	cleavage	3.7	8.5	no
F	fracture	5.2	5.5	yes
G	fracture	2.7	7.0	no
H	cleavage	2.7	3.0	no

1. Which sample is most dense?

a. E **c.** G
b. F **d.** H

2. Which sample is hardest?

a. E **c.** G
b. F **d.** H

3. What will happen if G is rubbed against each of the other samples?

a. It will scratch only E.
b. It will scratch only F.
c. It will scratch only H.
d. It will scratch F and H.

4. Which statement accurately describes how one of the samples will affect a magnet?

a. E will attract the magnet.
b. F will attract the magnet.
c. G will be pushed away from the magnet.
d. H will be pushed away from the magnet.

5. Which sample or samples have a crystal structure?

a. E, F, G, and H **c.** E and H
b. only F **d.** F and G

6. Which samples are likely to break along flat surfaces?

a. E and G **c.** G and H
b. F and G **d.** E and H

7. An unidentified mineral sample has a density of 2.9 grams per cubic centimeter and a hardness of 6.7. Which mineral is it most like?

a. E **c.** G
b. F **d.** H

8. Which is true about one-cubic-centimeter pieces of these samples?

a. Each would have the same weight.
b. E would be heaviest.
c. F would be heaviest.
d. H would be heaviest.

Extended Response

Answer the two questions below in detail. Include some of the terms shown in the word box. In your answers underline each term you use.

chemical makeup	element	compound
crystal structure	Mohs scale	hardness

9. Describe the characteristics of minerals that make them different from rocks.

10. Describe the type of mineral that would work best on the tip of a drill designed to make holes in hard materials.