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.

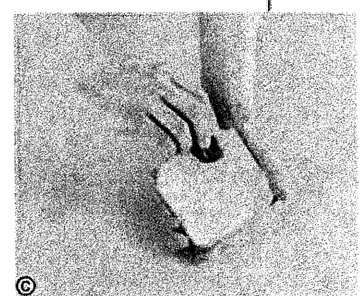
Properties of Minerals

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.



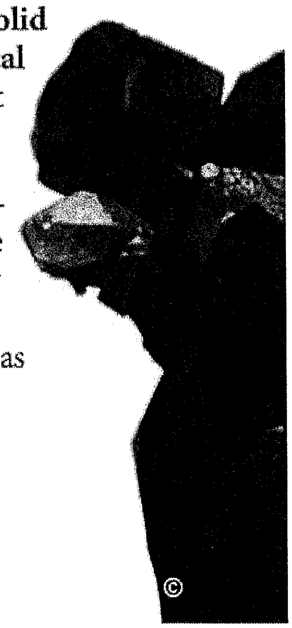
Think It Over

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.

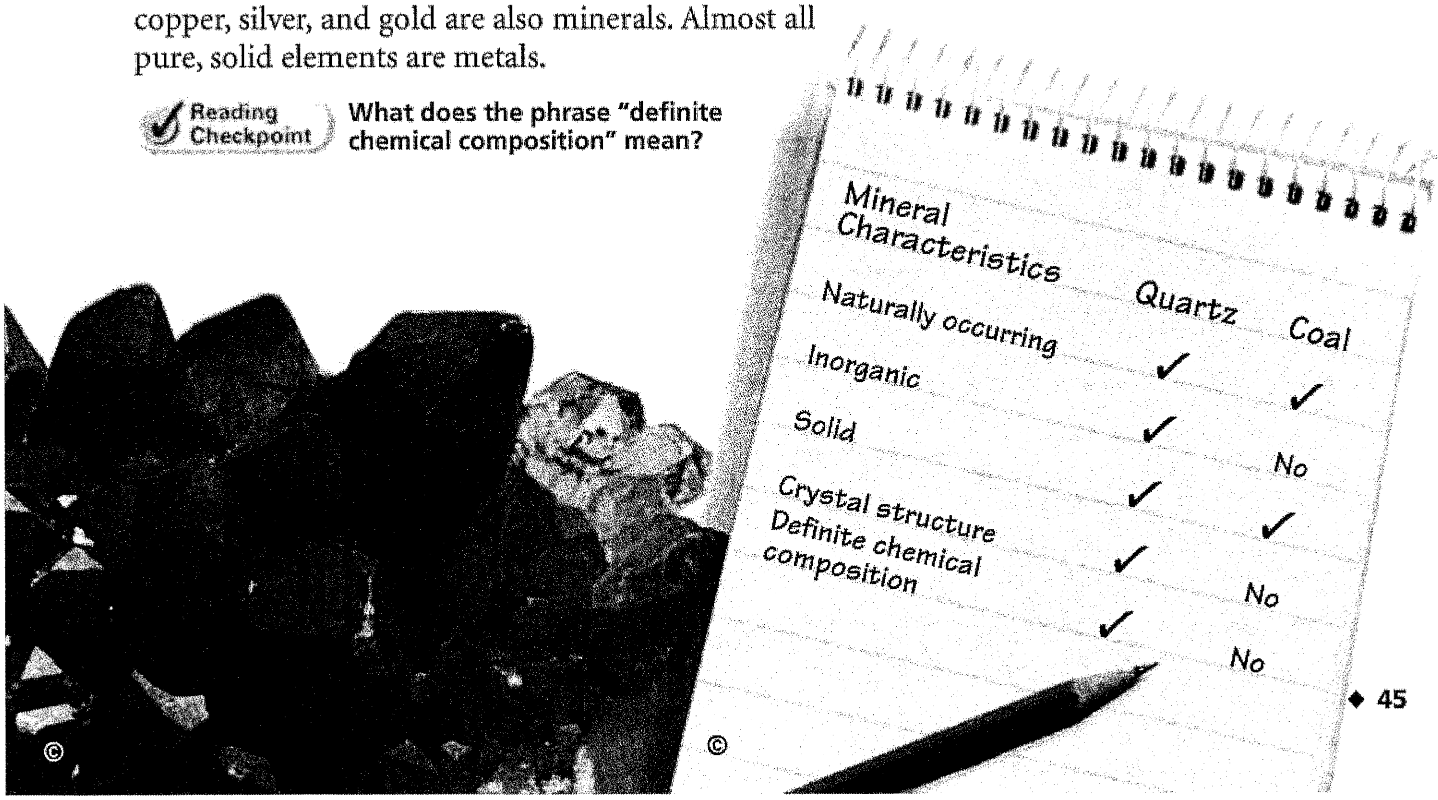
Definite Chemical Composition A mineral has a definite chemical composition or range of compositions. This means that a mineral always contains certain elements in definite proportions.

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.

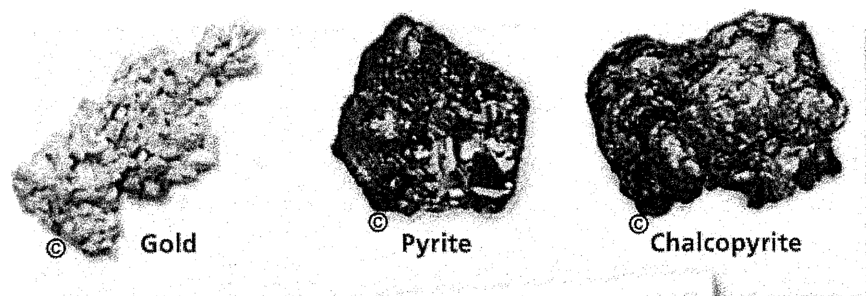
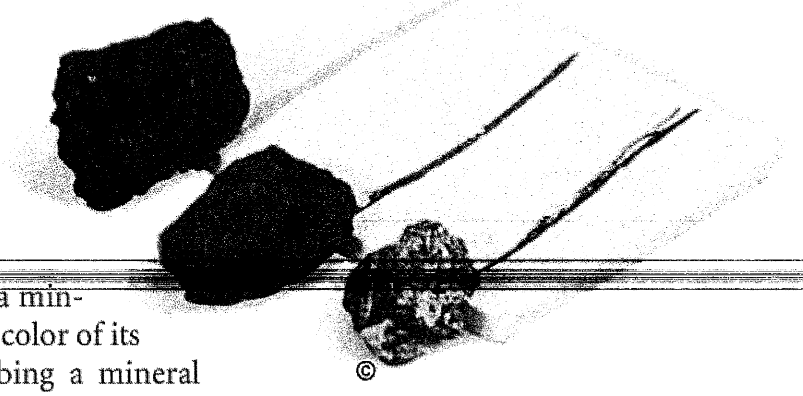


FIGURE 2
Color of Minerals
These women in India are searching for bits of gold in river sand. Just because a mineral is gold in color doesn't mean it really is gold. Chalcopyrite and pyrite, also known as "fool's gold," are similar in color to real gold.

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?*

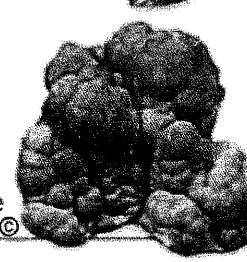
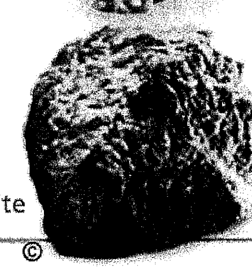


Streak A streak test can provide a clue to a mineral's identity. The **streak** of a mineral is the color of its powder. You can observe a streak by rubbing a mineral against a piece of unglazed porcelain tile, as shown in Figure 3. Even though the color of the mineral may vary, its streak does not. 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?*

Luster of Minerals		
Metallic  Galena	**Glassy**  Topaz	**Waxy, Greasy, or Pearly**  Talc
Submetallic or Dull  Graphite	**Silky**  Malachite	**Earthy**  Hematite

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

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

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.

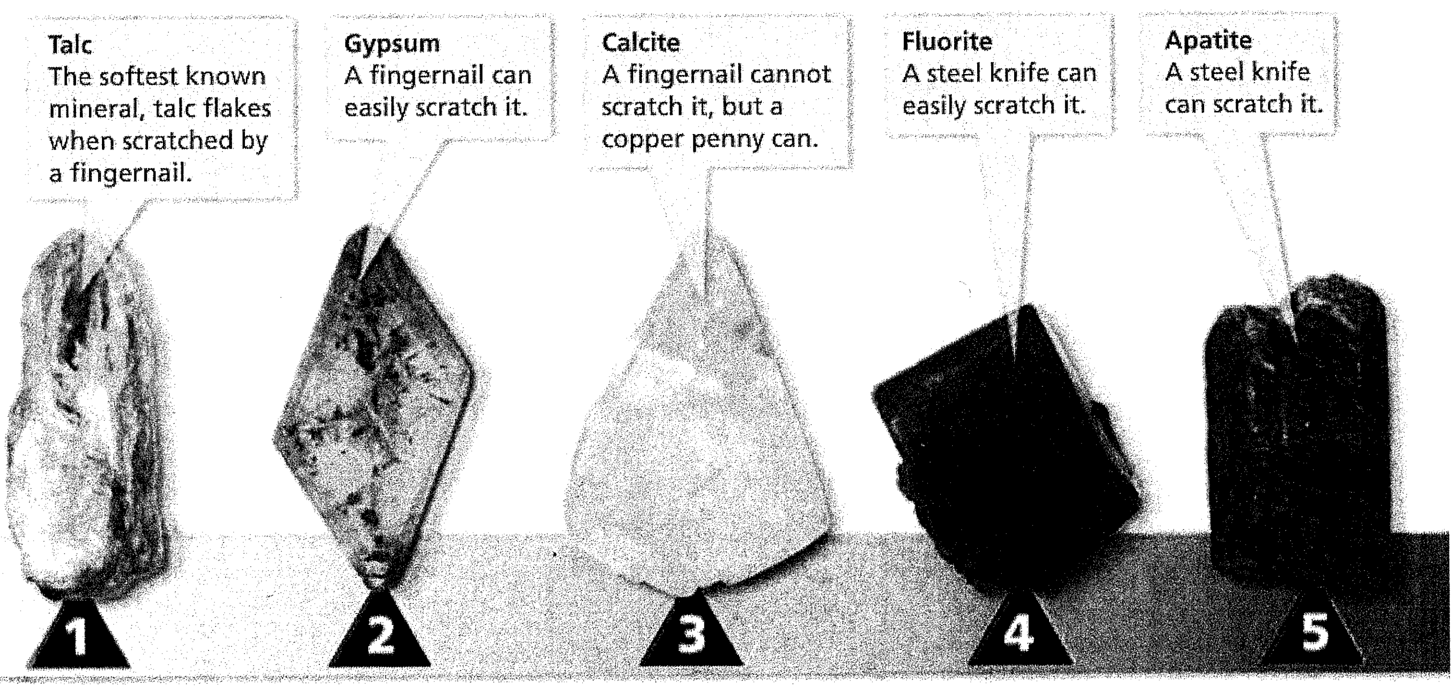
You can compare the density of two mineral samples of about the same size. Just pick them up and heft them, or feel their weight, in your hands. You may be able to feel the difference between low-density quartz and high-density galena. If the two samples are the same size, the galena will be almost three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

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

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.

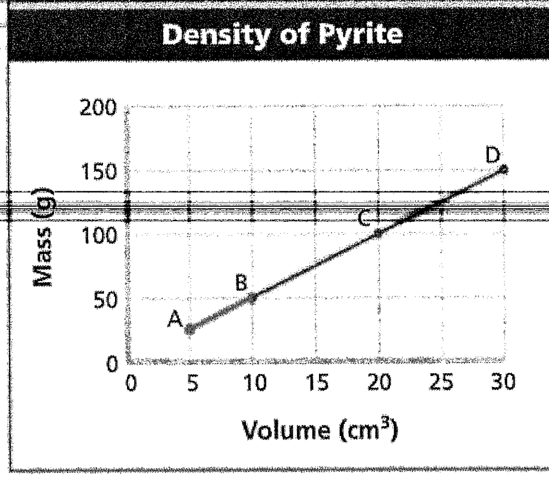


Math Analyzing Data

Mineral Density

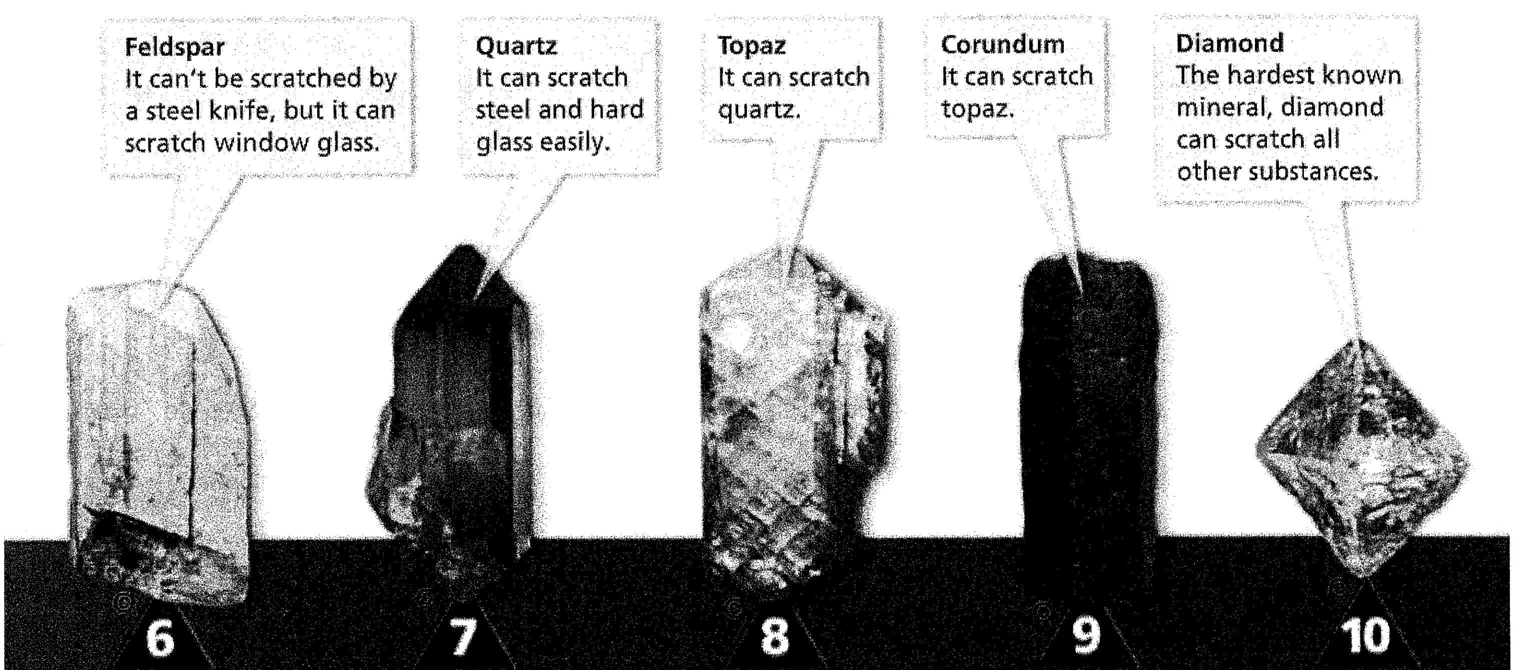
Use the line graph of the mass and volume of pyrite samples to answer the questions.

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.



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?

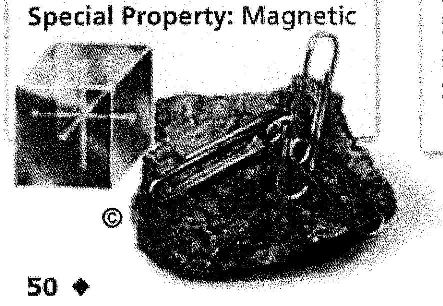
Crystal Systems The crystals of each mineral grow atom by atom to form that mineral's crystal structure. Geologists classify these structures into six groups based on the number and angle of the crystal faces. These groups are called crystal systems. For example, all halite crystals are cubic. Halite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

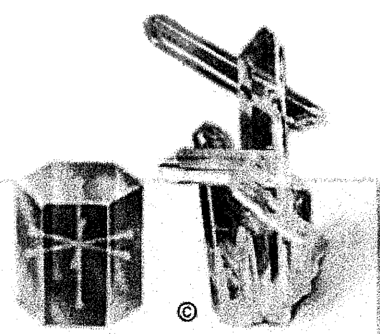
Sometimes, the crystal structure is obvious from the mineral's appearance. Crystals that grow in an open space can be almost perfectly formed. But crystals that grow in a tight space are often incompletely formed. In other minerals, the crystal structure is visible only under a microscope. A few minerals, 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?*

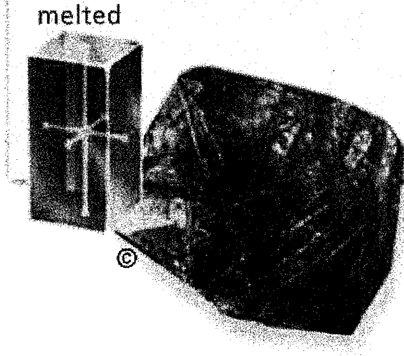
Magnetite
Crystal System: Cubic
Color: Black
Streak: Black
Luster: Metallic
Hardness: 6
Density (g/cm³): 5.2
Special Property: Magnetic





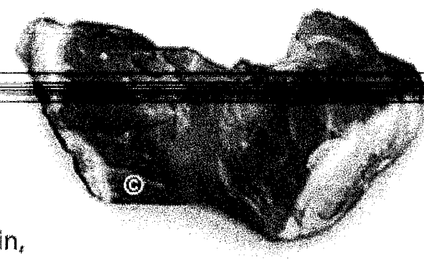
Quartz
Crystal System: Hexagonal
Color: Transparent, various colors
Streak: Colorless
Luster: Glassy
Hardness: 7
Density (g/cm³): 2.6
Special Property: Fractures like broken glass

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.**

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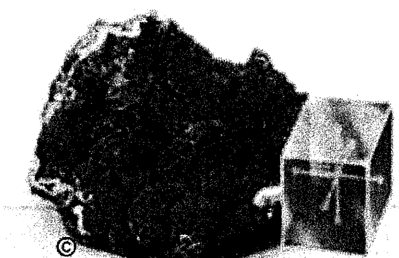
Sulfur
Crystal System: Orthorhombic
Color: Lemon yellow to yellowish brown
Streak: White
Luster: Greasy
Hardness: 2
Density (g/cm³): 2.0–2.1
Special Property: Melts easily

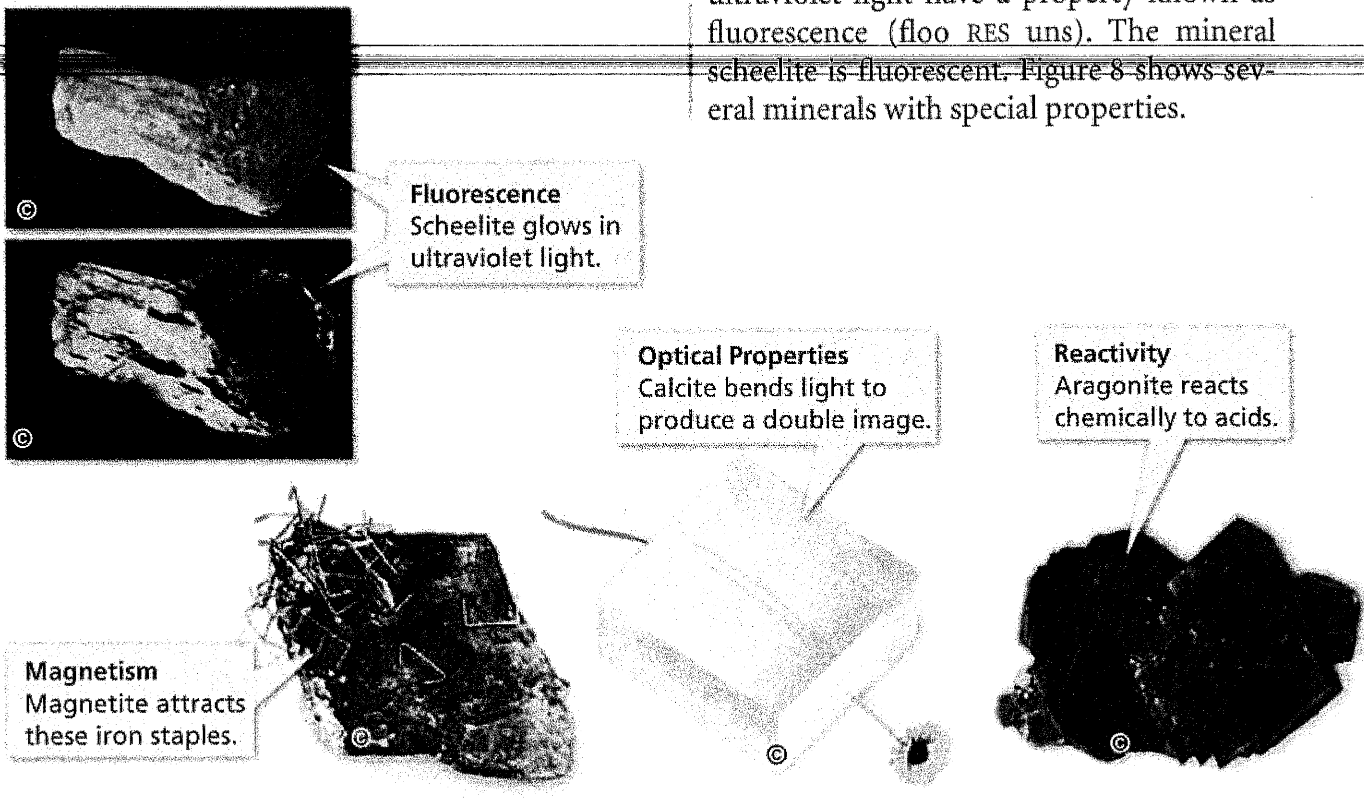


Azurite
Crystal System: Monoclinic
Color: Blue
Streak: Pale blue
Luster: Glassy to dull or earthy
Hardness: 3.5–4
Density (g/cm³): 3.8
Special Property: Reacts to acid

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

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.

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.



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

HINT **1. a. Defining** Write a definition of "mineral" in your own words.

HINT **b. Explaining** What does it mean to say that a mineral is inorganic?

HINT **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.

HINT **2. a. Listing** Name eight properties that can be used to identify minerals.

HINT **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. HINT

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?

Lab zone **Skills Lab**

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Finding the Density of Minerals

Problem

How can you compare the density of different minerals?

Skills Focus

measuring

Materials (per student)

- graduated cylinder, 100-mL
- 3 mineral samples: pyrite, quartz, and galena
- water
- balance

Procedure

1. Check to make sure the mineral samples are small enough to fit in the graduated cylinder.
2. Copy the data table into your notebook. Place the pyrite on the balance and record its mass in the data table.
3. Fill the cylinder with water to the 50-mL mark.
4. Carefully place the pyrite in the cylinder of water. Try not to spill any of the water.
5. Read the level of the water on the scale of the graduated cylinder. Record the level of the water with the pyrite in it.

Data Table

	Pyrite	Quartz	Galena
Mass of Mineral (g)			
Volume of Water Without Mineral (mL)	50	50	50
Volume of Water With Mineral (mL)			
Volume of Water Displaced (mL)			
Volume of Water Displaced (cm^3)			
Density (g/cm^3)			

6. Calculate the volume of water displaced by the pyrite. To do this, subtract the volume of water without the pyrite from the volume of water with the pyrite. Record your answer.
7. Calculate the density of the pyrite by using this formula.

$$\text{Density} = \frac{\text{Mass of mineral}}{\text{Volume of water displaced by mineral}}$$

(Note: Density is expressed as g/cm^3. One mL of water has a volume of 1 cm^3.)

8. Remove the water and mineral from the cylinder.
9. Repeat Steps 2–8 for quartz and galena.

Analyze and Conclude

1. **Interpreting Data** Which mineral had the highest density? The lowest density?
2. **Measuring** How does finding the volume of the water that was displaced help you find the volume of the mineral itself?
3. **Drawing Conclusions** Does the shape of a mineral sample affect its density? Explain.
4. **Predicting** Would the procedure you used in this lab work for a substance that floats or one that dissolves in water?

Designing Experiments

Pyrite is sometimes called "fool's gold" because its color and appearance are similar to real gold. Design an experiment to determine if a sample that looks like gold is in fact real gold.

Section 2

Classifying Rocks

Reading Focus

Key Concepts

- What characteristics do geologists use to identify rocks?
- What are the three main groups of rocks?

Key Terms

- rock-forming mineral
- granite
- basalt
- grains
- texture
- igneous rock
- sedimentary rock
- metamorphic rock

Target Reading Skill

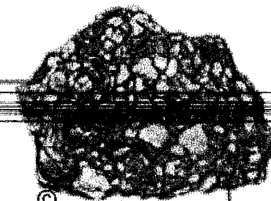
Asking Questions Before you read, preview the red headings. In a graphic organizer like the one below, ask a *what* or *how* question for each heading. As you read, write answers to your questions.

Question	Answer
What does a rock's color tell about the rock?	

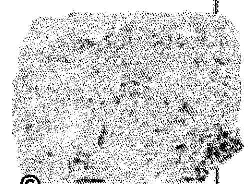
Lab zone Discover Activity

How Do Rocks Compare?

1. Look at samples of conglomerate and marble with a hand lens.
2. Describe the two rocks. What is the color and texture of each?
3. Try scratching the surface of each rock with the edge of a penny. Which rock seems harder?
4. Hold each rock in your hand. Allowing for the fact that the samples aren't exactly the same size, which rock seems denser?



Conglomerate



Marble

Think It Over

Observing Based on your observations, how would you compare the physical properties of marble and conglomerate?

If you were a geologist, how would you examine a rock for the first time? You might use a camera or notebook to record information about the setting where the rock was found. Then, you would use a chisel or the sharp end of a rock hammer to remove samples of the rock. Finally, you would break open the samples with a hammer to examine their inside surfaces. You must look at the inside of a rock because the effects of ice, liquid water, and weather can change the outer surface of a rock.

You can find interesting rocks almost anywhere. The rock of Earth's crust forms mountains, hills, valleys, beaches, even the ocean floor. **When studying a rock sample, geologists observe the rock's mineral composition, color, and texture.**

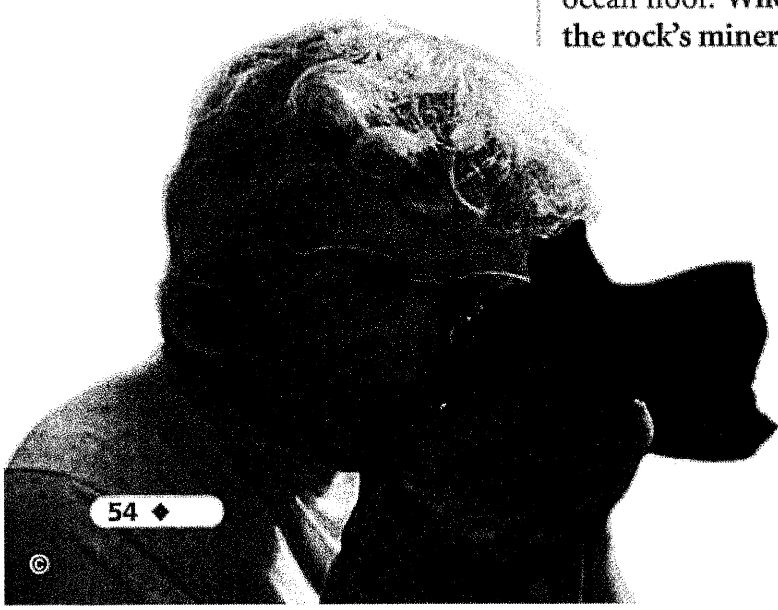
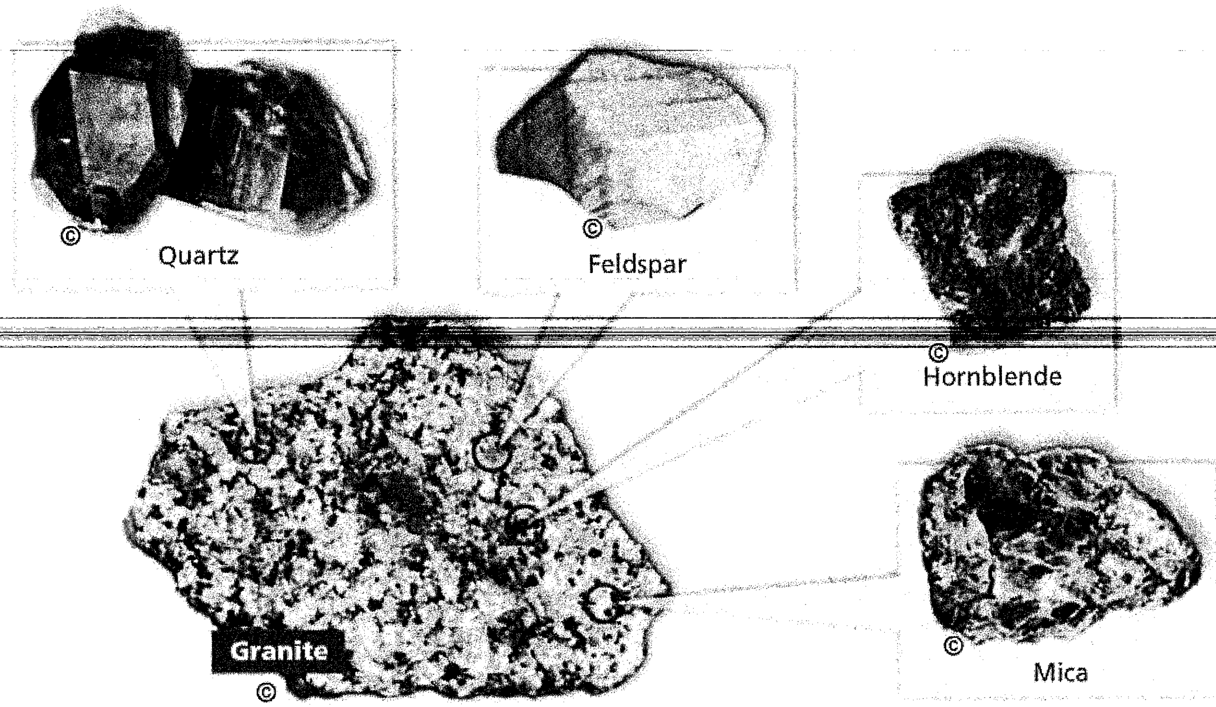


FIGURE 9
Inspecting a Rock
This geologist is using a hand lens to observe a piece of shale.



Mineral Composition and Color

Rocks are made of mixtures of minerals and other materials. Some rocks contain only a single mineral. Others contain several minerals. For example, the granite in Figure 10 is made up of the minerals quartz, feldspar, hornblende, and mica. About 20 minerals make up most of the rocks of Earth's crust. These minerals are known as **rock-forming minerals.** Appendix B at the back of this book lists some of the most common rock-forming minerals.

A rock's color provides clues to the rock's mineral composition. For example, **granite** is generally a light-colored rock that has high silica content. **Basalt,** shown in Figure 11, is a dark-colored rock that is low in silica. But as with minerals, color alone does not provide enough information to identify a rock.

Geologists observe the shape and color of crystals in a rock to identify the minerals that the rock contains. In identifying rocks, geologists also use some of the tests that are used to identify minerals. For example, testing the surface of a rock with acid determines whether the rock includes minerals made of compounds called carbonates.

Reading Checkpoint **How would you define "rock-forming mineral"?**

FIGURE 10
Minerals in Granite
Granite is made up of quartz, feldspar, hornblende, and mica. It may also contain other minerals.
Observing *Which mineral seems most abundant in the sample of granite shown?*

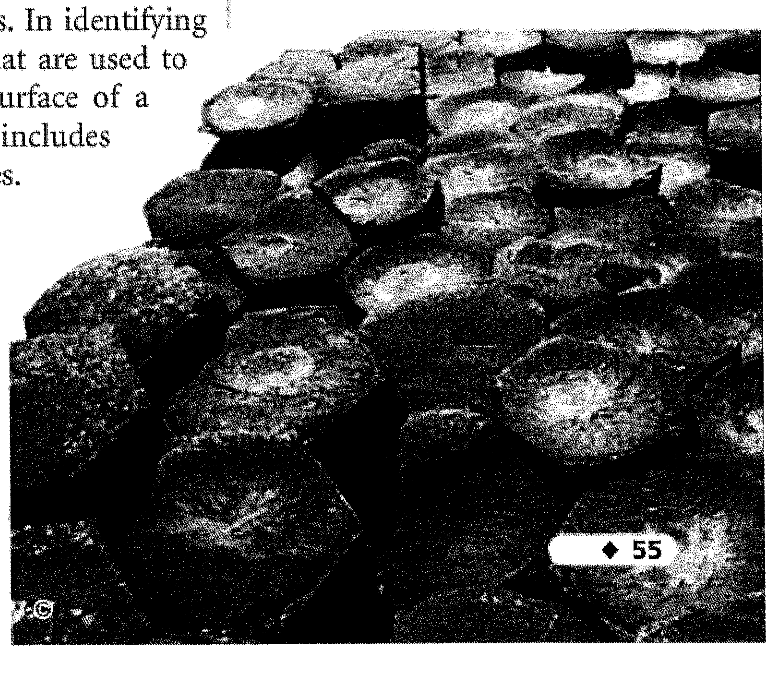
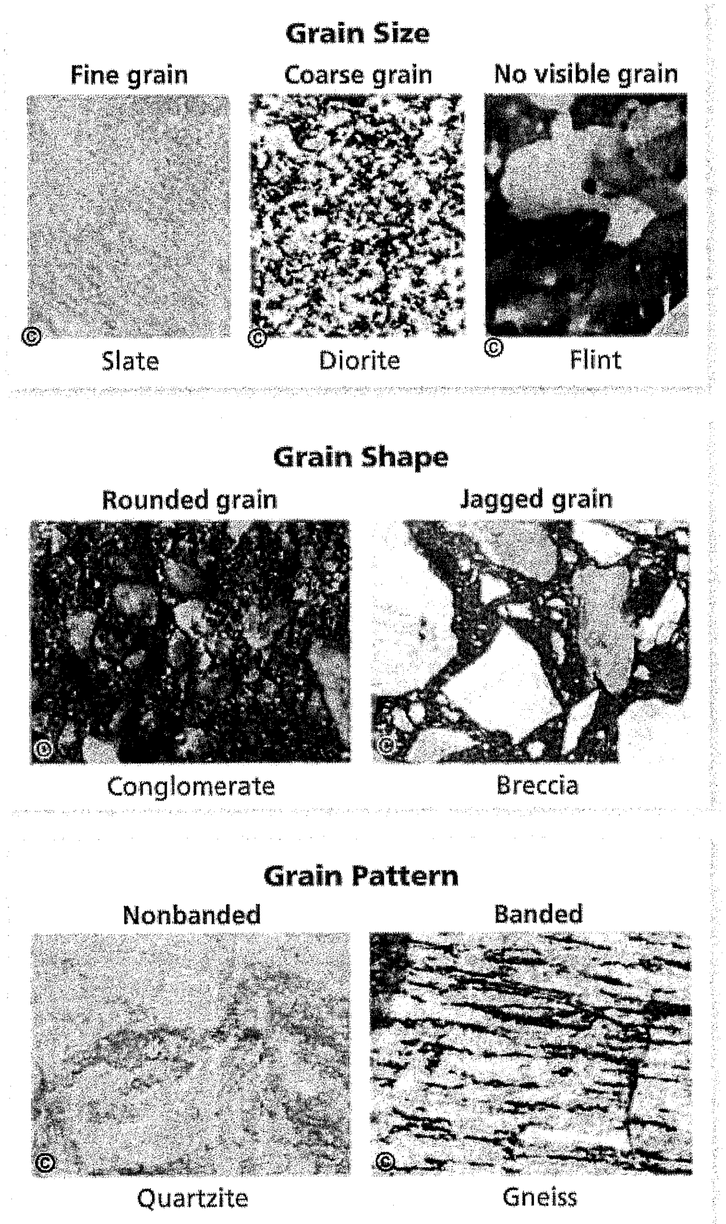


FIGURE 11
Basalt
Basalt is a dark-colored rock that has low silica content. Unlike granite, basalt has mineral crystals that are too small to be seen without a hand lens.

Texture

As with minerals, color alone does not provide enough information to identify a rock. But a rock's texture is very useful in identifying a rock. Most rocks are made up of particles of minerals or other rocks, which geologists call **grains.** Grains give the rock its texture. To a geologist, a rock's **texture** is the look and feel of the rock's surface. Some rocks are smooth and glassy. Others are rough or chalky. To describe a rock's texture, geologists use terms based on the size, shape, and pattern of the grains.

FIGURE 12
Rock Textures
Texture helps classify rocks.
Comparing and Contrasting *How would you compare the texture of diorite with the texture of gneiss?*

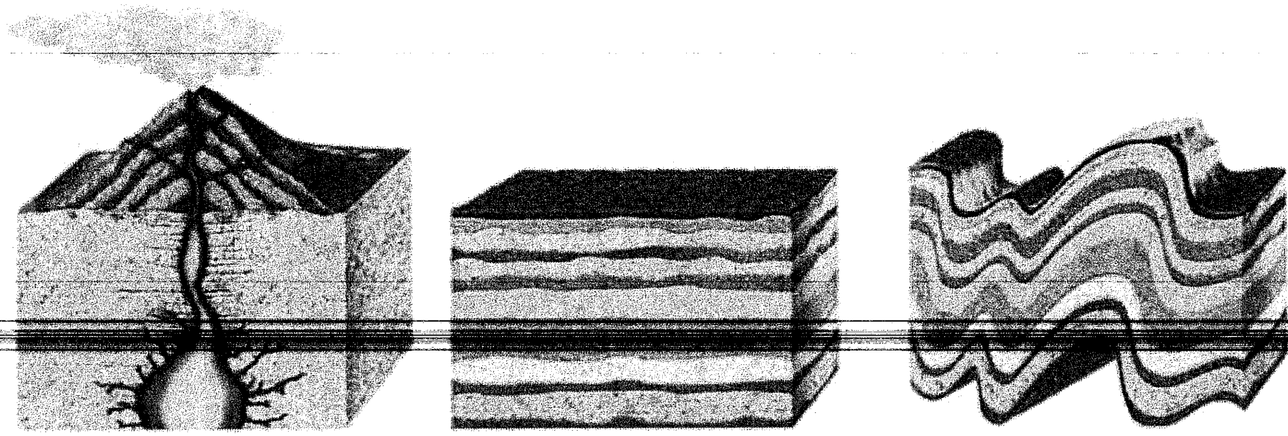


Grain Size Often, the grains in a rock are large and easy to see. Such rocks are said to be coarse-grained. In other rocks, the grains are so small that they can only be seen with a microscope. These rocks are said to be fine-grained. Notice the difference in texture between the fine-grained slate and the coarse-grained diorite in Figure 12 at left. Some rocks have no visible grain even when they are examined under a microscope.

Grain Shape The grains in a rock vary widely in shape. Some grains look like tiny particles of sand. Others look like small seeds or exploding stars. In some rocks, such as granite, the grain results from the shapes of the crystals that form the rock. In other rocks, the grain shape results from fragments of several rocks. These fragments can be smooth and rounded or they can be jagged.

Grain Pattern The grains in a rock often form patterns. Some grains lie in flat layers that look like a stack of pancakes. Other grains form swirling patterns. Some rocks have grains of different colors in bands, like the gneiss (NYS) in Figure 12. In other rocks, the grains occur randomly throughout.

Reading Checkpoint **What does it mean to say that a rock is coarse-grained?**



Igneous Rock forms when magma or lava cools and hardens.

Sedimentary Rock forms when pieces of rock are pressed and cemented together.

Metamorphic Rock forms from other rocks that are changed by heat and pressure.

FIGURE 13
Kinds of Rocks
Rocks can be igneous, sedimentary, or metamorphic, depending on how the rock formed.

How Rocks Form

Using color, texture, and mineral composition, geologists can classify a rock according to its origin. A rock's origin is how the rock formed. **Geologists classify rocks into three major groups: igneous rock, sedimentary rock, and metamorphic rock.**

Each of these groups of rocks forms in a different way. **Igneous rock** (IG nee us) forms from the cooling of magma or lava. Most **sedimentary rock** (seduh MEN turee) forms when particles of other rocks or the remains of plants and animals are pressed and cemented together. Sedimentary rock forms in layers that are buried below the surface. **Metamorphic rock** (metuh MAWR fik) forms when an existing rock is changed by heat, pressure, or chemical reactions. Most metamorphic rock forms deep underground.

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Visit: PHSchool.com
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Section 2 Assessment

Vocabulary Skill Prefixes The prefix *meta-* means "change." How does this infomation help you remember what *metamorphic* rock is?

Reviewing Key Concepts

HINT HINT HINT

1. a. **Naming** What three characteristics do geologists use to identify rocks?
   b. **Defining** What are the grains of a rock?
   c. **Comparing and Contrasting** In your own words, compare the grain size, shape, and pattern of the conglomerate and breccia in Figure 12.

HINT HINT HINT

2. a. **Reviewing** What are the three main groups of rocks?
   b. **Explaining** How do igneous rocks form?
   c. **Classifying** Gneiss is a kind of rock that forms when heat and pressure inside Earth change granite. To what group of rocks does gneiss belong?

Writing in Science

Wanted Poster Write a paragraph for a wanted poster in which you describe the characteristics of granite. In your wanted poster, be sure to describe granite's mineral composition, color, and texture. Also mention the group of rocks to which granite belongs.

Section 3

Igneous Rocks

Reading Focus

Key Concepts

- What characteristics are used to classify igneous rocks?
- How are igneous rocks used?

Key Terms

- extrusive rock
- intrusive rock
- silica

Target Reading Skill

Identifying Main Ideas As you read Classifying Igneous Rocks, write the main idea in a graphic organizer like the one below. Then write three supporting details that further explain the main idea.

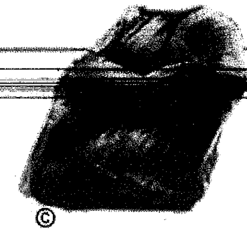
Main Idea

Igneous rocks are classified by origin, texture, and composition.

Detail | Detail | Detail

Lab zone Discover Activity

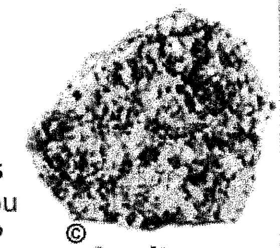
How Do Igneous Rocks Form?



©

Obsidian

1. Use a hand lens to examine samples of granite and obsidian.
2. Describe the texture of both rocks using the terms coarse, fine, or glassy.
3. Which rock has coarse-grained crystals? Which rock has no crystals or grains?



©

Granite

Think It Over

Inferring Granite and obsidian are igneous rocks. From your observations, what can you infer about how each type of rock formed?

The time is 4.6 billion years ago. You are in a spacecraft orbiting Earth. Do you see the blue and green globe of Earth that astronauts today see from space? No—instead, Earth looks like a charred and bubbling marshmallow heated over hot coals.

Soon after Earth formed, the planet's interior became so hot that magma formed. Lava repeatedly flowed over the surface. The lava quickly hardened, forming a rocky crust. Because this early crust was denser than the material beneath it, chunks of crust sank into Earth's interior. This allowed more lava to erupt over the surface and harden to form rock.

Classifying Igneous Rocks

The first rocks to form on Earth probably looked like the igneous rocks that can be seen today. Igneous rock is any rock that forms from magma or lava. The name *igneous* comes from the Latin word *ignis*, meaning "fire." **Igneous rocks are classified according to their origin, texture, and mineral composition.**

Origin Igneous rock may form on or beneath Earth's surface. **Extrusive rock** is igneous rock formed from lava that erupted onto Earth's surface. Basalt is the most common extrusive rock. Basalt is one of the most common rocks on Earth. A layer of basalt forms much of Earth's ocean floors.

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Igneous rock that formed when magma hardened beneath Earth's surface is called **intrusive rock**. The most abundant intrusive rock on Earth's continents is granite. Granite forms the core of many mountain ranges.

Texture The texture of an igneous rock depends on the size and shape of its mineral crystals. The only exceptions to this rule are certain types of rock that have a texture like glass. These igneous rocks lack a crystal structure.

Igneous rocks may be similar in mineral composition and yet have very different textures. Rapidly cooling lava forms fine-grained igneous rocks with small crystals. Slowly cooling magma forms coarse-grained rocks with large crystals. Therefore, intrusive and extrusive rocks usually have different textures.

Intrusive rocks have larger crystals than extrusive rocks. If you examine a coarse-grained rock such as granite, you can easily see that the crystals vary in size and color. Some intrusive rocks, like the porphyry in Figure 14, have a texture that looks like a gelatin dessert with chopped-up fruit mixed in.

Extrusive rocks have a fine-grained or glassy texture. Basalt is a fine-grained extrusive rock. It consists of crystals too small to be seen without a microscope. Obsidian is an extrusive rock that cooled very rapidly without forming crystals. As a result, obsidian has the smooth, shiny texture of a thick piece of glass.

Discovery Channel School

Rocks

Video Preview
▸ Video Field Trip
Video Assessment

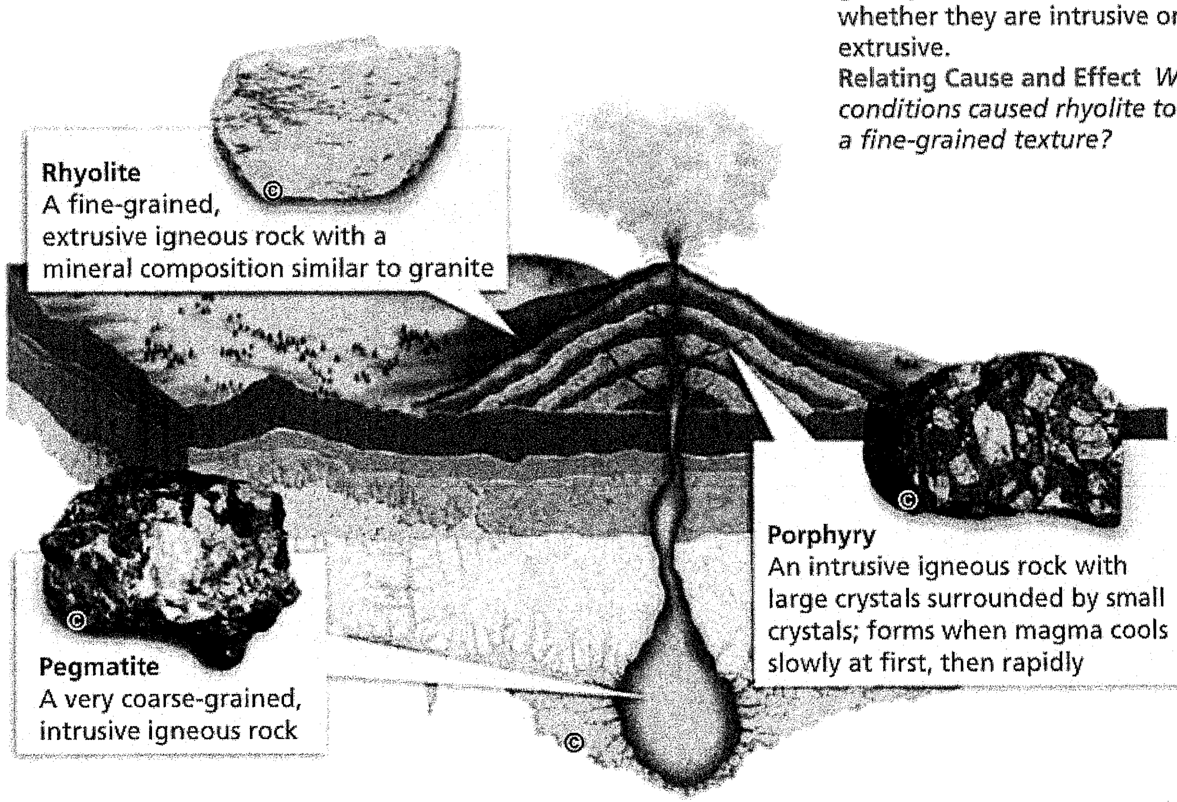


FIGURE 14
Igneous Rock Textures
Igneous rocks such as rhyolite, pegmatite, and porphyry can vary greatly in texture depending on whether they are intrusive or extrusive.
Relating Cause and Effect *What conditions caused rhyolite to have a fine-grained texture?*

Math Analyzing Data

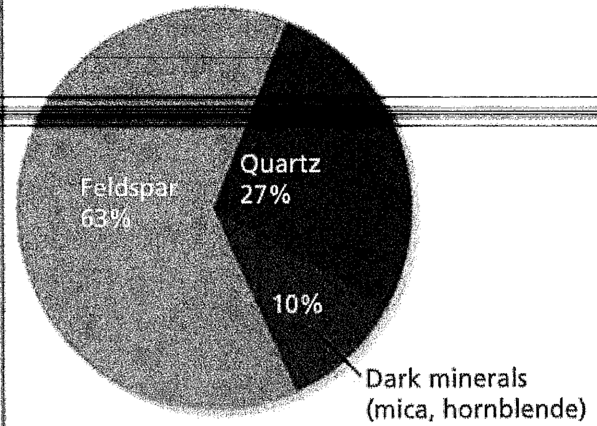
Mineral Mixture

Granite is a mixture of light-colored minerals such as feldspar and quartz and dark-colored minerals including hornblende and mica. But, granite can vary in mineral composition, affecting its color and texture.

Study the circle graph and then answer the questions.

1. **Reading Graphs** What mineral is most abundant in granite?
2. **Reading Graphs** About what percentage of granite is made up of dark minerals?
3. **Calculating** If the amount of quartz increases to 35 percent and the amount of dark-colored minerals stays the same, what percentage of the granite will be made up of feldspar?

Mineral Composition of Granite



4. **Predicting** How would the color of the granite change if it contained less feldspar and more mica and hornblende?

Mineral Composition Most of Earth's minerals contain **silica,** a material formed from oxygen and silicon. The silica content of magma and lava affects the types of rock they form. Lava that is low in silica usually forms dark-colored rocks such as basalt. Basalt contains feldspar as well as certain dark-colored minerals, but does not contain quartz.

Magma that is high in silica usually forms light-colored rocks, such as granite. Granite's mineral composition determines its color—light gray, red, pink, or nearly black. Granite that is rich in reddish feldspar is a speckled pink. But granite rich in hornblende and dark mica is light gray with dark specks. Quartz crystals in granite add light gray or smoky specks.

Geologists can make thin slices of a rock, such as the gabbro in Figure 15. They study the rock's crystals under a microscope to determine the rock's mineral composition.

Reading Checkpoint What is silica?

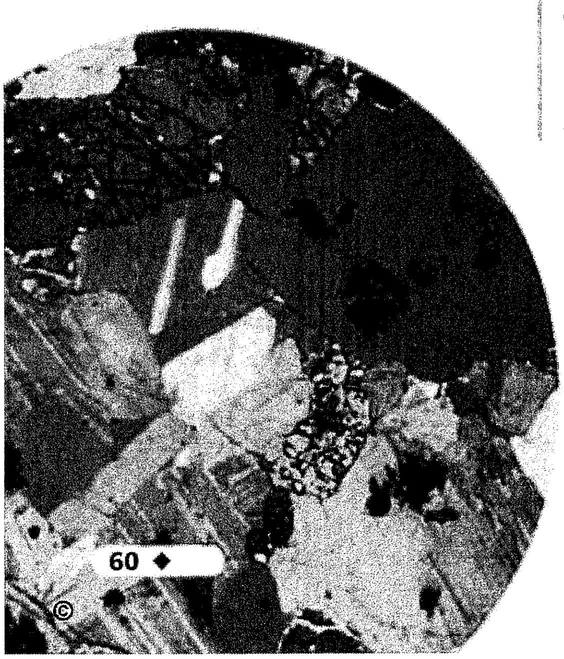


FIGURE 15
Thin Section of a Rock
This thin slice of gabbro, viewed under a microscope, contains olivine, feldspar, and other minerals.

Uses of Igneous Rocks

Many igneous rocks are hard, dense, and durable. **People throughout history have used igneous rock for tools and building materials.**

Building Materials Granite has a long history as a building material. More than 3,500 years ago, the ancient Egyptians used granite for statues like the one shown in Figure 16. About 600 years ago, the Incas of Peru carefully fitted together great blocks of granite and other igneous rocks to build a fortress near Cuzco, their capital city. In the United States during the 1800s and early 1900s, granite was widely used to build bridges and public buildings and for paving streets with cobblestones. Today, thin, polished sheets of granite are used in curbstones, floors, and kitchen counters. Basalt is crushed to make gravel that is used in construction.

Other Uses Igneous rocks such as pumice and obsidian also have important uses. The rough surface of pumice makes it a good abrasive for cleaning and polishing. Ancient native Americans used obsidian to make sharp tools for cutting and scraping. Perlite, formed from the heating of obsidian, is often mixed with soil for starting vegetable seeds.

Reading Checkpoint **What igneous rock is most often used as a building material?**

FIGURE 16
Durable Granite
The ancient Egyptians valued granite for its durability. These statues from a temple in Luxor, Egypt, were carved in granite.

Section 3 Assessment

Vocabulary Skill **Prefixes** Use what you know about prefixes *in-* and *ex-* to help you define the key terms *intrusive rock* and *extrusive rock.*

Reviewing Key Concepts

HINT 1. a. **Explaining** How are igneous rocks classified?
HINT b. **Defining** What are extrusive rocks and intrusive rocks?
HINT c. **Comparing and Contrasting** Compare granite and basalt in terms of their origin and texture. Which is extrusive? Which is intrusive?
HINT 2. a. **Summarizing** What are two common uses of igneous rocks?
HINT b. **Reviewing** What characteristics make igneous rocks useful?
c. Making Judgments Would pumice be a good material to use to make a floor? Explain.

Lab zone At-Home Activity

The Rocks Around Us Many common household products contain minerals found in igneous rock. For example, glass contains quartz, which is found in granite. Research one of the following materials and the products in which it is used: garnet, granite, perlite, pumice, or vermiculite. Explain to family members how the rock or mineral formed and how it is used.

Section 4

Sedimentary Rocks

Reading Focus

Key Concepts
- How do sedimentary rocks form?
- What are the three major types of sedimentary rocks?
- How are sedimentary rocks used?

Key Terms
- sediment
- erosion
- deposition
- compaction
- cementation
- clastic rock
- organic rock
- chemical rock

Target Reading Skill
Outlining As you read, make an outline about sedimentary rocks. Use the red section headings for the main topics and the blue headings for the subtopics.

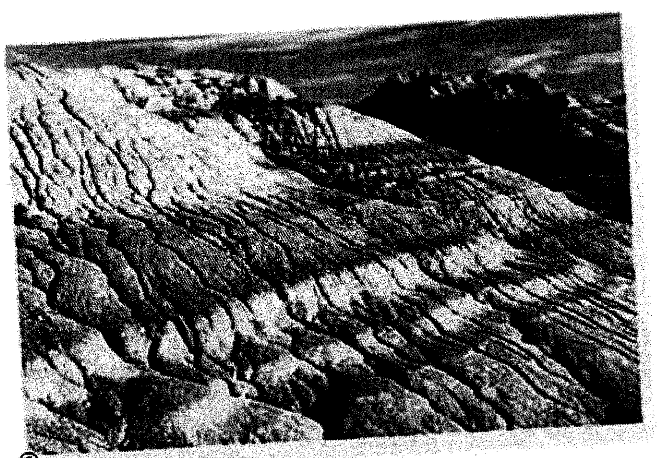
Sedimentary Rocks
I. From sediment to rock
  A. Erosion
  B.
II.
  A.

Lab Zone Discover Activity

How Does Pressure Affect Particles of Rock?
1. Place a sheet of paper over a slice of soft bread.
2. Put a stack of several heavy books on top of the paper. After 10 minutes, remove the books. Observe what happened to the bread.
3. Slice the bread so you can observe its cross section.
4. Carefully slice a piece of fresh bread and compare its cross section to that of the pressed bread.

Think It Over
Observing How did the bread change after you removed the books? Describe the texture of the bread. How does the bread feel? What can you predict about how pressure affects the particles that make up sedimentary rocks?

Visitors to Badlands National Park in South Dakota see some of the strangest scenery on Earth. The park contains jagged peaks, steep cliffs, and deep canyons sculpted in colorful rock that is layered like a birthday cake. The layers of this cake are red, orange, pink, yellow, or tan. These rocks formed over millions of years as particles of mud, sand, and volcanic ash were deposited in thick layers. The mud and sand slowly changed to sedimentary rock. Then, uplift of the land exposed the rocks to the forces that wear away Earth's surface.


Badlands National Park

From Sediment to Rock
If you have ever walked along a stream or beach you may have noticed tiny sand grains, mud, and pebbles. These are particles of sediment. **Sediment** is small, solid pieces of material that come from rocks or living things. In addition to particles of rock, sediment may include shells, bones, leaves, stems, and other remains of living things. Sedimentary rocks form when sediment is deposited by water and wind. **Most sedimentary rocks are formed through a series of processes: erosion, deposition, compaction, and cementation.** Figure 17 shows how sedimentary rocks form.

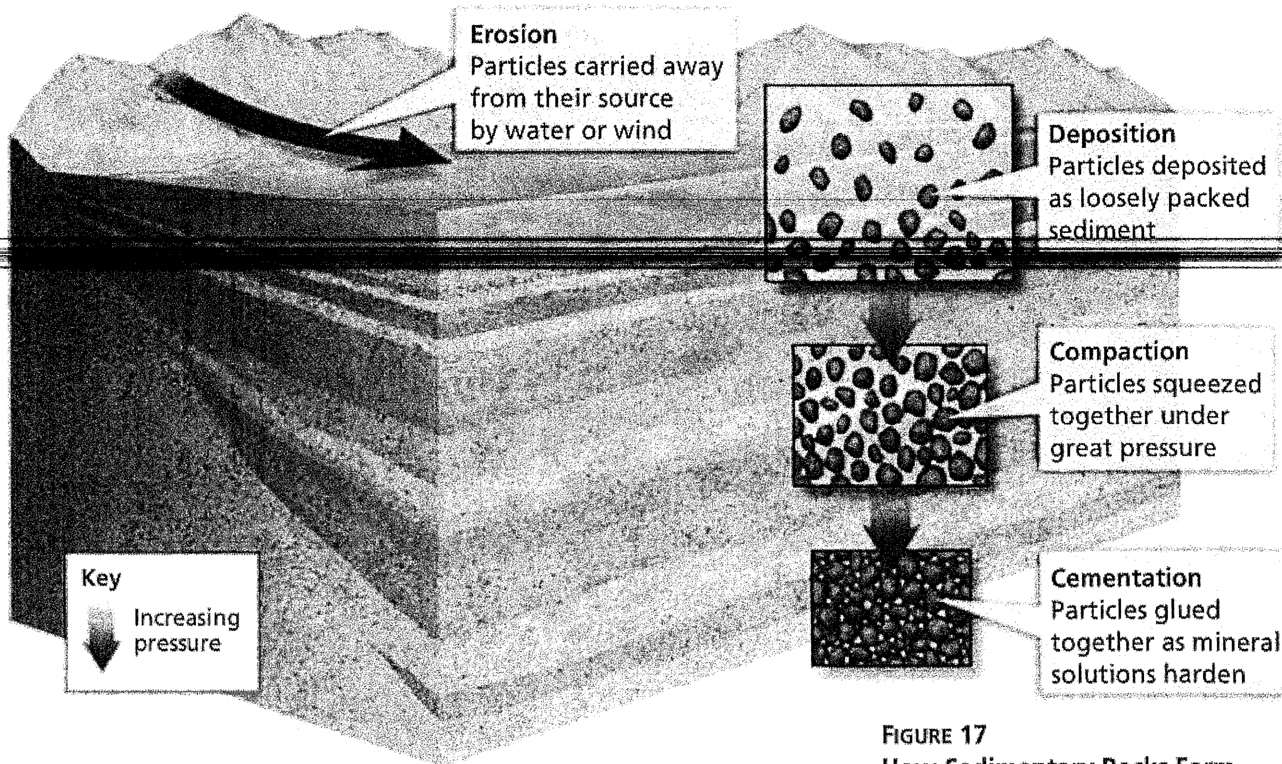


FIGURE 17
How Sedimentary Rocks Form
Sedimentary rocks form through the deposition, compaction, and cementation of sediments over millions of years.
Relating Cause and Effect *What conditions are necessary for sedimentary rocks to form?*

Erosion Destructive forces are constantly breaking up and wearing away all the rocks on Earth's surface. These forces include heat and cold, rain, waves, and grinding ice. The forces of erosion form sediment. In **erosion,** running water, wind, or ice loosen and carry away fragments of rock.

Deposition Eventually, the moving water, wind, or ice slows and deposits the sediment in layers. If water is carrying the sediment, rock fragments and other materials sink to the bottom of a lake or ocean. **Deposition** is the process by which sediment settles out of the water or wind carrying it.

Compaction The process that presses sediments together is **compaction.** Thick layers of sediment build up gradually over millions of years. These heavy layers press down on the layers beneath them. The weight of new layers further compacts the sediments, squeezing them tightly together. The layers often remain visible in sedimentary rock.

Cementation While compaction is taking place, the minerals in the rock slowly dissolve in the water. **Cementation** is the process in which dissolved minerals crystallize and glue particles of sediment together. In cementation, dissolved minerals seep into the spaces between particles and then harden.

Reading Checkpoint **What is deposition?**

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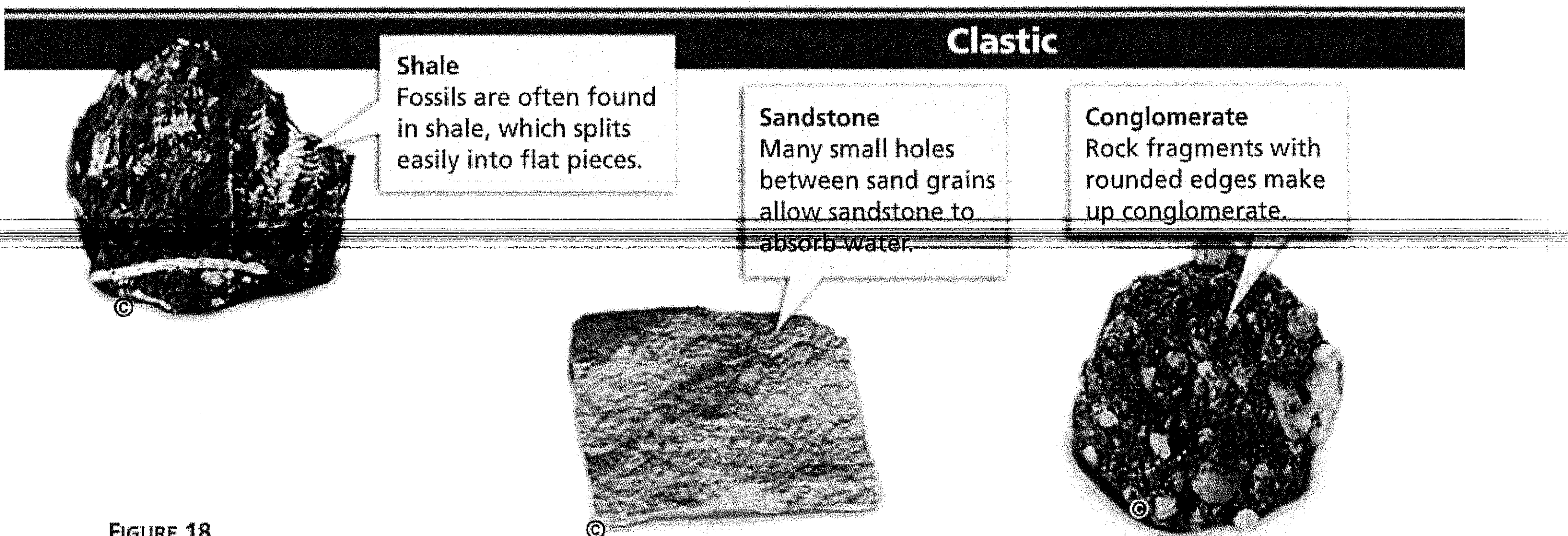


FIGURE 18
Clastic Rocks
Clastic rocks such as shale, sandstone, conglomerate, and breccia are sedimentary rocks that form from particles of other rocks.

Types of Sedimentary Rock

Geologists classify sedimentary rocks according to the type of sediments that make up the rock. **There are three major groups of sedimentary rocks: clastic rocks, organic rocks, and chemical rocks.** Different processes form each of these types of sedimentary rocks.

Clastic Rocks Most sedimentary rocks are made up of broken pieces of other rocks. A **clastic rock** is a sedimentary rock that forms when rock fragments are squeezed together. These fragments can range in size from clay particles that are too small to be seen without a microscope to large boulders that are too heavy for you to lift. Clastic rocks are grouped by the size of the rock fragments, or particles, of which they are made. Common clastic rocks include shale, sandstone, conglomerate, and breccia (BRECH ee uh), shown in Figure 18.

Shale forms from tiny particles of clay. Water must deposit the clay particles in thin, flat layers. Sandstone forms from the sand on beaches, the ocean floor, riverbeds, and sand dunes. Most sand particles consist of quartz.

Some sedimentary rocks contain a mixture of rock fragments of different sizes. If the fragments have rounded edges, they form a clastic rock called conglomerate. A rock made up of large fragments with sharp edges is called breccia.

Organic Rocks Not all sedimentary rocks are made from particles of other rocks. **Organic rock** forms where the remains of plants and animals are deposited in thick layers. The term "organic" refers to substances that once were part of living things or were made by living things. Two important organic sedimentary rocks are coal and limestone, shown in Figure 19.

Lab zone Try This Activity

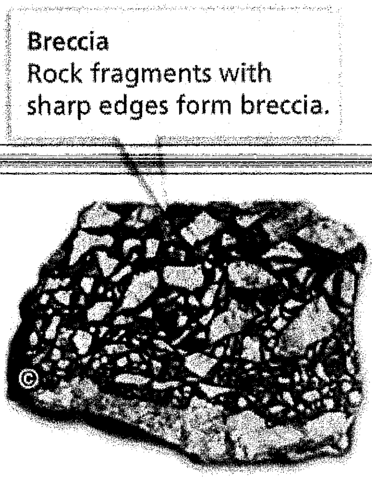
Rock Absorber

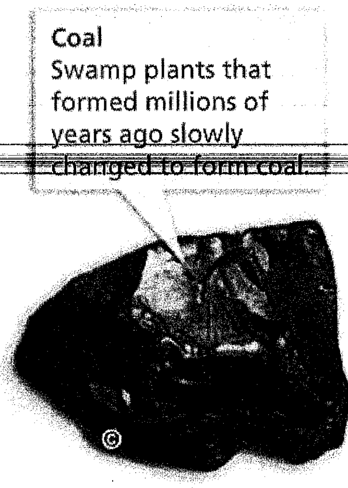
Here's how to find out if water can soak into rock.

1. Using a hand lens, compare samples of sandstone and shale.
2. Use a balance to measure the mass of each rock.
3. Place the rocks in a pan of water and watch closely. Which sample has bubbles escaping? Predict which sample will gain mass.
4. Leave the rocks submerged in the pan overnight.
5. The next day, remove the rocks from the pan and find the mass of each rock.

Drawing Conclusions How did the masses of the two rocks change after soaking? What can you conclude about each rock?

Organic





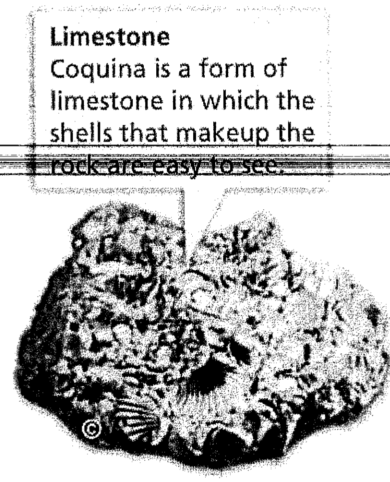


FIGURE 19
Organic Rocks
Organic rocks such as coal and limestone are sedimentary rocks that form from the remains of living things.

Coal forms from the remains of swamp plants buried in water. As layer upon layer of plant remains build up, the weight of the layers squeezes the decaying plants. Over millions of years, they slowly change into coal.

Limestone forms in the ocean, where many living things, such as coral, clams, and oysters, have hard shells or skeletons made of calcite. When these animals die, their shells pile up on the ocean floor. Over millions of years, these layers of sediment can grow to a depth of hundreds of meters. Slowly, compaction and cementation change the sediment to limestone.

Chemical Rocks When minerals that are dissolved in a solution crystallize, **chemical rock** forms. For example, limestone can form when calcite that is dissolved in lakes, seas, or underground water comes out of solution and forms crystals. This kind of limestone is considered a chemical rock. Chemical rocks can also form from mineral deposits left when seas or lakes evaporate. For example, rock salt is made of the mineral halite, which forms by evaporation.

✓ Reading Checkpoint **How does coal form?**

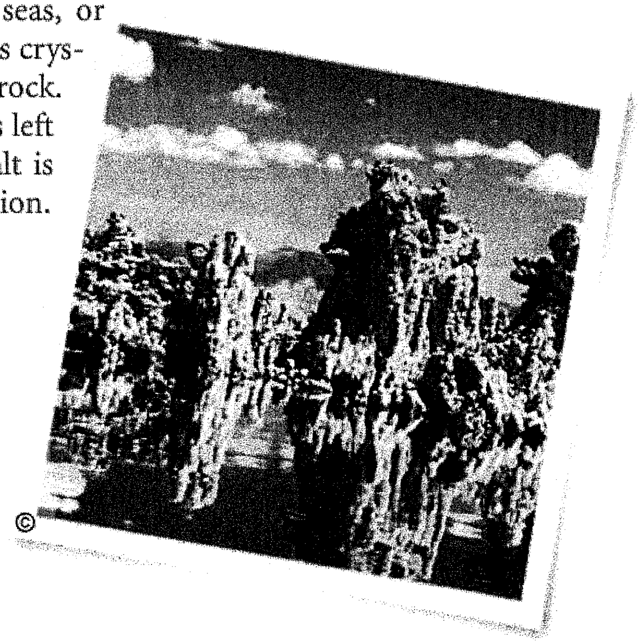


FIGURE 20
Chemical Rocks
These rock "towers" in Mono Lake California, are made of tufa, a form of limestone. Tufa is a chemical rock that forms from solutions containing dissolved materials. **Classifying** *What type of sedimentary rock is tufa?*

FIGURE 21
Carving Limestone
This stone carver is sculpting designs on a sphere of white limestone.

Uses of Sedimentary Rocks

People have used sedimentary rocks throughout history for many different purposes, including building materials and tools. For example, people made arrowheads out of flint for thousands of years. Flint is a hard rock, yet it can be shaped to a point. Flint is formed when small particles of silica settle out of water.

Sedimentary rocks such as sandstone and limestone have been used as building materials for thousands of years. Both types of stone are soft enough to be cut easily into blocks or slabs. You may be surprised to learn that the White House in Washington, D.C., is built of sandstone. Builders today use sandstone and limestone on the outside walls of buildings. Limestone also has many industrial uses. For example, limestone is used in making cement and steel.

Reading Checkpoint **Why are sandstone and limestone useful as building materials?**

Section 4 Assessment

Target Reading Skill Outlining Use the information in your outline about sedimentary rocks to help you answer the questions below.

Reviewing Key Concepts

1. a. **Defining** What is sediment?
   b. **Sequencing** Place these steps in the formation of sedimentary rock in the proper sequence: compaction, erosion, cementation, deposition.
   c. **Inferring** In layers of sedimentary rock, where would you expect to find the oldest sediment? Explain your answer.
2. a. **Listing** What are the three main types of sedimentary rock?
   b. **Explaining** Which type of sedimentary rock forms from the remains of living things? Explain how this sedimentary rock forms.
   c. **Relating Cause and Effect** What process causes deposits of rock salt to form? What type of sedimentary rock is rock salt?
3. a. **Listing** What are some uses of sedimentary rocks?
   b. **Predicting** The particles of sediment that make up shale are not usually well cemented. Would shale be a good choice of building material in a wet climate?

Writing in Science

Explaining a Process Suppose that a large mass of granite lies exposed on Earth's surface. Explain the steps in the process by which the granite could become sedimentary rock. Your answer should also state which of the main types of sedimentary rock will result from this process.

Section 5

Metamorphic Rocks

Reading Preview

Key Concepts

- Under what conditions do metamorphic rocks form?
- How do geologists classify metamorphic rocks?
- How are metamorphic rocks used?

Key Term

- foliated

Target Reading Skill

Previewing Visuals Before you read, preview Figure 22. Then write two questions that you have about metamorphic rocks in a graphic organizer like the one below. As you read, answer your questions.

Metamorphic Rocks

Q.	Why do the crystals in gneiss line up in bands?
A.	
Q.	

Lab Zone Discover Activity

How Do Grain Patterns Compare?

1. Using a hand lens, observe samples of gneiss and granite. Look carefully at the grains or crystals in both rocks.
2. Observe how the grains or crystals are arranged in both rocks. Draw a sketch of both rocks and describe their textures.

Think It Over

Inferring Within the crust, some granite becomes gneiss. What do you think must happen to cause this change?

Every metamorphic rock is a rock that has changed its form. In fact, the word *metamorphic* comes from the Greek words *meta*, meaning "change," and *morphosis*, meaning "form." But what causes a rock to change into metamorphic rock? The answer lies inside Earth.

Heat and pressure deep beneath Earth's surface can change any rock into metamorphic rock. When rock changes into metamorphic rock, its appearance, texture, crystal structure, and mineral content change. Metamorphic rock can form out of igneous, sedimentary, or other metamorphic rock.

Sometimes, forces inside Earth can push the rock down toward the heat of the mantle. Pockets of magma rising through the crust also provide heat that can produce metamorphic rocks. The deeper a rock is buried, the greater the pressure on that rock. Under high temperature and pressure many times greater than at Earth's surface, the minerals in a rock can be changed into other minerals. The rock has become a metamorphic rock.

Types of Metamorphic Rocks

While metamorphic rocks are forming, high temperatures change the size and shape of the grains, or mineral crystals, in the rock. Extreme pressure squeezes rock so tightly that the mineral grains may line up in flat, parallel layers. **Geologists classify metamorphic rocks according to the arrangement of the grains that make up the rocks.**

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Lab zone **Try This Activity**

A Sequined Rock

1. Make three balls of clay about 3 cm in diameter. Gently mix about 25 sequins into one ball.
2. Use a 30-cm piece of string to cut the ball in half. How are the sequins arranged?
3. Roll the clay with the sequins back into a ball. Stack the three balls with the sequin ball in the middle. Set these on a block of wood. With another block of wood, press slowly down until the stack is about 3 cm high.
4. Use the string to cut the stack in half. How are the sequins arranged?

Making Models What do the sequins in your model rock represent? Is this rock foliated or nonfoliated?

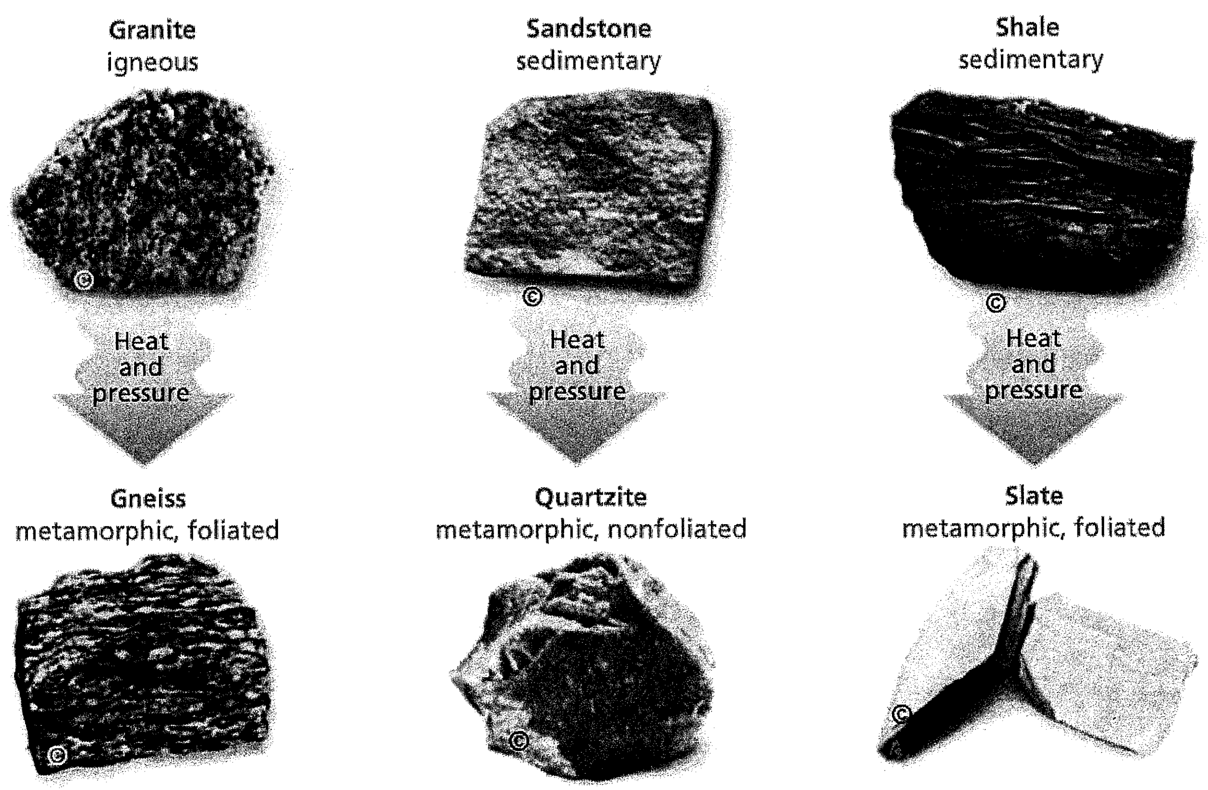
Foliated Rocks Metamorphic rocks that have their grains arranged in parallel layers or bands are said to be **foliated.** The term *foliated* comes from the Latin word for "leaf." It describes the thin, flat layering found in most metamorphic rocks. Foliated rocks—including slate, schist, and gneiss—may split apart along these bands. In Figure 22, notice how the crystals in granite have been flattened to create the foliated texture of gneiss.

One common foliated rock is slate. Heat and pressure change the sedimentary rock shale into slate. Slate is basically a denser, more compact version of shale. During the change, new minerals such as mica form in the slate.

Nonfoliated Rocks Some metamorphic rocks are nonfoliated. The mineral grains in these rocks are arranged randomly. Metamorphic rocks that are nonfoliated do not split into layers. Marble and quartzite are two metamorphic rocks that have a nonfoliated texture. Quartzite forms out of sandstone. The weakly cemented quartz particles in the sandstone recrystallize to form quartzite, which is extremely hard. Notice in Figure 22 how much smoother quartzite looks than sandstone.

Reading Checkpoint What is a foliated rock?

FIGURE 22
Forming Metamorphic Rocks
Great heat and pressure can change one type of rock into another. **Observing** *How does slate differ from shale?*



Uses of Metamorphic Rock

Certain metamorphic rocks are important materials for building and sculpture. Marble and slate are two of the most useful metamorphic rocks. Marble usually forms when limestone is subjected to heat and pressure deep beneath the surface. Because marble has a fine, even grain, it can be cut into thin slabs or carved into many shapes. And marble is easy to polish. These qualities have led architects and sculptors to use marble for many buildings and statues. For example, one of America's most famous sculptures is in the Lincoln Memorial in Washington, D.C. Sculptor Daniel Chester French carved this portrait of Abraham Lincoln in gleaming white marble.

Like marble, slate comes in a variety of colors, including gray, black, red, and purple. Because it is foliated, slate splits easily into flat pieces. These pieces can be used for flooring, roofing, outdoor walkways, chalkboards, and as trim for stone buildings.

Reading Checkpoint **What characteristics of slate make it useful?**

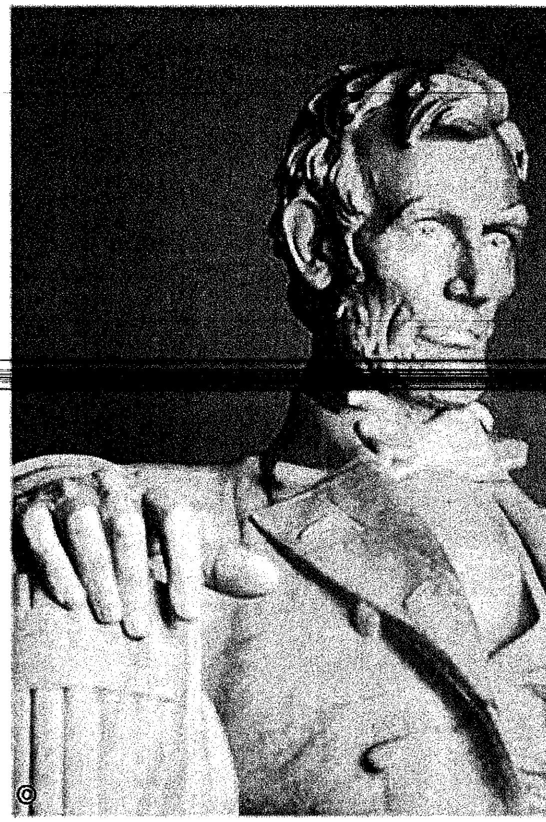


FIGURE 23
The Lincoln Memorial
The statue of Abraham Lincoln in the Lincoln Memorial in Washington, D.C., is made of gleaming white marble.

Section 5 Assessment

Target Reading Skill **Previewing Visuals** Compare your questions and answers about Figure 22 with those of a partner.

Reviewing Key Concepts

HINT HINT 1. a. **Explaining** What does *metamorphic* mean?
   b. **Relating Cause and Effect** Where and under what conditions are metamorphic rocks formed?

HINT 2. a. **Identifying** What characteristic of metamorphic rocks do geologists use to classify them?
   HINT b. **Explaining** How does a foliated metamorphic rock form?
   HINT c. **Classifying** Which of the rocks in Figure 22 is foliated? How can you tell?

HINT 3. a. **Identifying** What is the main use of metamorphic rocks?
   HINT b. **Making Judgments** Which might be more useful for carving chess pieces—marble or slate? Explain your answer.

Lab zone At-Home Activity

Rocks Around the Block How are rocks used in your neighborhood? Take a walk with your family to see how many uses you can observe. Identify statues, walls, and buildings made from rocks. Can you identify which type of rock was used? Look for limestone, sandstone, granite, and marble. Share a list of the rocks you found with your class. For each rock, include a description of its color and texture, where you observed the rock, and how it was used.

Section 6 The Rock Cycle

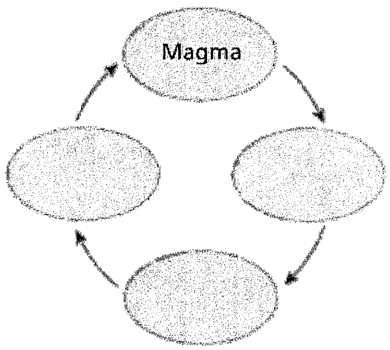
Reading Preview

Key Concepts
- What is the rock cycle?

Key Term
- rock cycle

Target Reading Skill
Sequencing As you read, make a cycle diagram that shows the stages in the rock cycle. Write each stage of the rock cycle in a separate circle in your diagram.

Rock Cycle

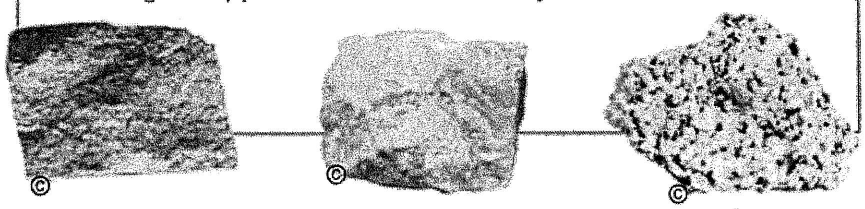


Lab zone Discover Activity

Which Rock Came First?

1. Referring to the photos below, make sketches of quartzite, granite, and sandstone on three index cards.
2. Observe the color and texture of each rock. Look for similarities and differences.
3. To which major group does each rock belong?

Think It Over
Developing Hypotheses How are quartzite, granite, and sandstone related? Arrange your cards in the order in which these three rocks formed. Given enough time in Earth's crust, what might happen to the third rock in your series?



Sandstone **Quartzite** **Granite**

Earth's rocks are not as unchanging as they seem. **Forces deep inside Earth and at the surface produce a slow cycle that builds, destroys, and changes the rocks in the crust.** The **rock cycle** is a series of processes on Earth's surface and in the crust and mantle that slowly change rocks from one kind to another.

A Cycle of Many Pathways

As shown in Figure 24, the rock cycle can follow many different pathways. To take one pathway as an example, you can follow the rock of Stone Mountain, Georgia, through the rock cycle.

Beginning the Rock Cycle In the case of Stone Mountain, the rock cycle began millions of years ago. First, a huge mass of granite formed deep beneath Earth's surface. Then the forces of mountain building slowly pushed the granite upward. Over millions of years, water and weather began to wear away the granite of Stone Mountain, forming sediment. Today, particles of granite sediment still break off the mountain and become sand. Streams carry the sand to the ocean.

FIGURE 24
The Rock Cycle

Igneous, sedimentary, and metamorphic rocks change continuously through the rock cycle.
Interpreting Diagrams *What process leads to the formation of sediment?*

Go Online
active art

For: Rock Cycle activity
Visit: PHSchool.com
Web Code: cfp-1056

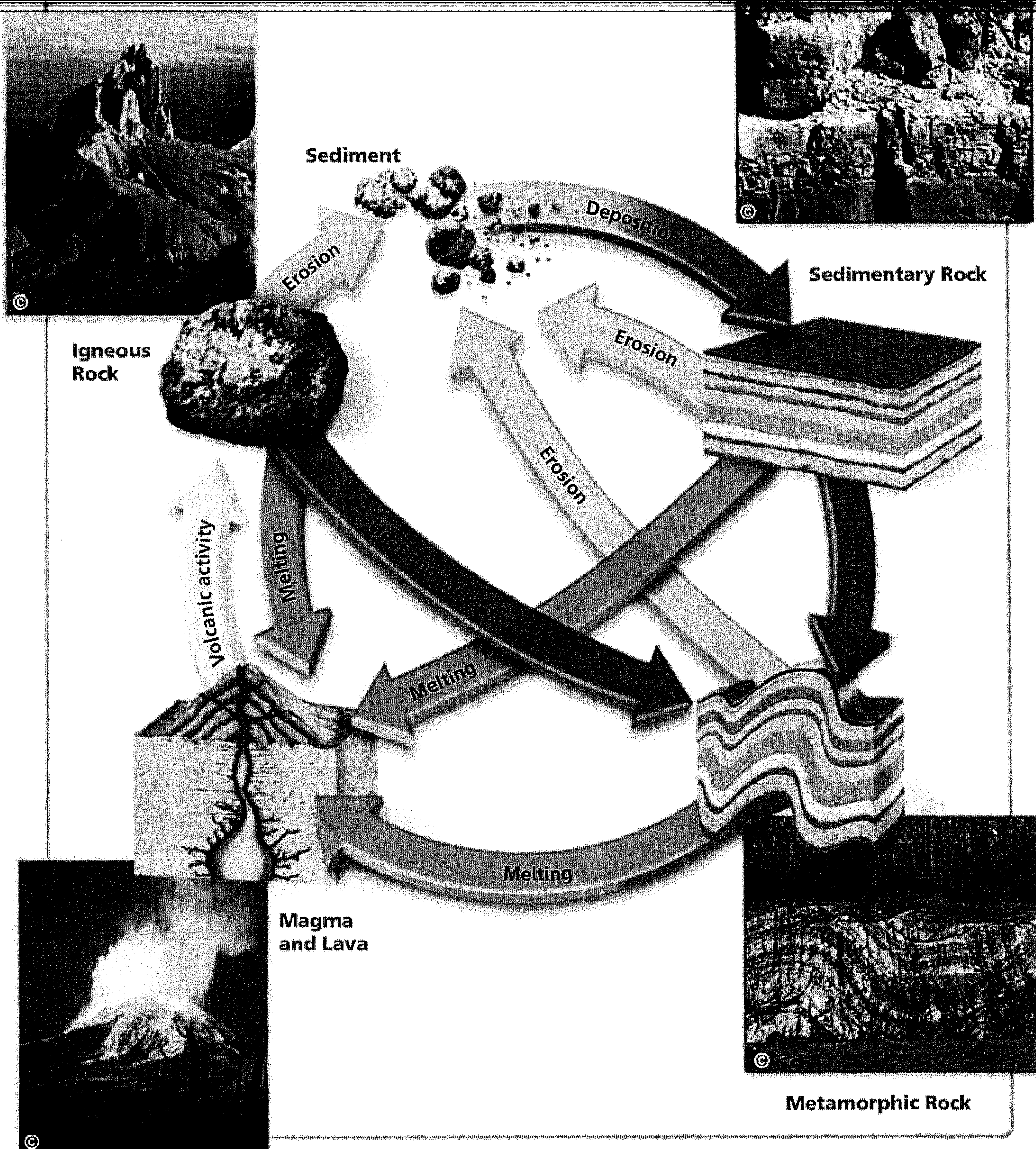
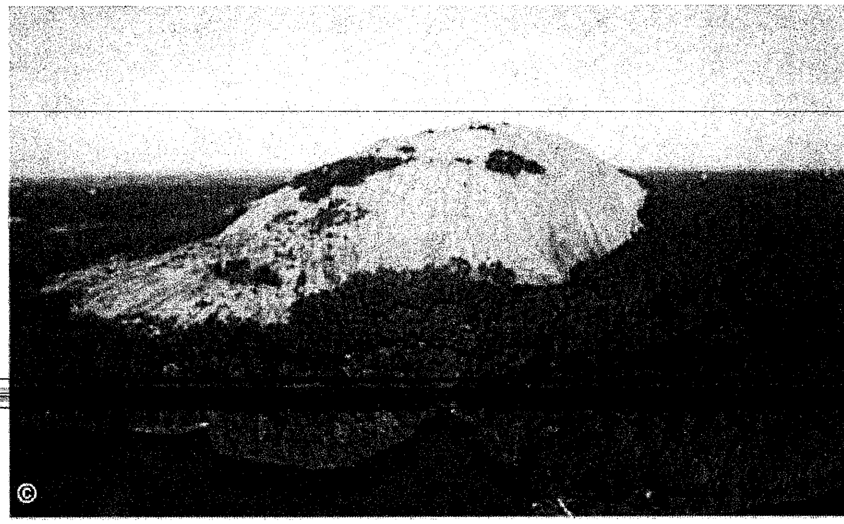


FIGURE 25
Stone Mountain
Stone Mountain, near Atlanta, Georgia, rises 210 meters above the surrounding land.



Continuing the Rock Cycle Over millions of years, layers of sandy sediment will pile up on the ocean floor. Slowly, the sediment will be compacted by its own weight. Dissolved calcite in the ocean water will cement the particles together. Eventually, the quartz that once formed the granite of Stone Mountain will become sandstone, a sedimentary rock.

More and more sediment will pile up on the sandstone. As sandstone becomes deeply buried, pressure on the rocks will increase. The rock will become hot. Pressure will compact the particles in the sandstone until no spaces are left between them. Silica, the main ingredient in quartz, will replace the calcite as the cement holding the rock together. The rock's texture will change from gritty to smooth. After millions of years, the sandstone will have changed into the metamorphic rock quartzite.

The Future of the Rock Cycle What will happen next? You could wait millions of years to find out how the quartzite completes the rock cycle, or you can trace alternative pathways in Figure 24.

Reading Checkpoint **What effect do heat and pressure deep inside Earth have on sandstone?**

Section 6 Assessment

Target Reading Skill Sequencing Review your cycle diagram about the rock cycle with a partner. Add any necessary information.

Reviewing Key Concepts

HINT 1. a. **Defining** Write a definition of the rock cycle in your own words.

HINT b. **Explaining** What must happen in order for any rock in the rock cycle to become a sedimentary rock?

HINT c. **Sequencing** Begin with igneous rock and explain how it could change through two more steps in the rock cycle.

Writing in Science

Rock Legend Pick one type of rock and write a possible "biography" of the rock as it moves through the rock cycle. Your story should state the type of rock, how the rock formed, and how it might change.

Lab zone **Skills Lab**

Mystery Rocks

Problem

What properties can be used to classify rocks?

Skills Focus

inferring, classifying

Materials

- 1 "mystery rock"
- 2 unknown igneous rocks
- 2 unknown sedimentary rocks
- 2 unknown metamorphic rocks
- hand lens

Procedure

1. For this activity, you will be given six rocks and one sample that is not a rock. They are labeled A through G.
2. Copy the data table into your notebook.
3. Using the hand lens, examine each rock for clues that show the rock formed from molten material. Record the rock's color and texture. Observe if there are any crystals or grains in the rock.
4. Use the hand lens to look for clues that show the rock formed from particles of other rocks. Observe the texture of the rock to see if it has any tiny, well-rounded grains.
5. Use the hand lens to look for clues that show the rock formed under heat and pressure. Observe if the rock has a flat layer of crystals or shows colored bands.
6. Record your observations in the data table.

Data Table

Sample	Color	Texture (fine, medium, or coarse-grained)	Foliated or Banded	Rock Group (igneous, metamorphic, sedimentary)
A				
B				

Analyze and Conclude

1. **Inferring** Infer from your observations the group in which each rock belongs.
2. **Classifying** Which of the samples could be classified as igneous rocks? What physical properties do these rock share with the other samples? How are they different?
3. **Classifying** Which of the samples could be classified as sedimentary rocks? How do you think these rocks formed? What are the physical properties of these rocks?
4. **Classifying** Which of the samples could be classified as metamorphic rocks? What are their physical properties?
5. **Drawing Conclusions** Decide which sample is not a rock. How did you determine that the sample you chose is not a rock? What do you think the "mystery rock" is? Explain.
6. **Communicating** What physical property was most useful in classifying rocks? Which physical property was least useful? Explain your answer.

More to Explore

Can you name each rock? Use a field guide to rocks and minerals to find the specific name of each rock sample.

Chapter 2 Study Guide

The BIG Idea

Composition and structure of Earth Rocks are classified as igneous, sedimentary, or metamorphic according to how they form. Rocks are transformed through the rock cycle by forces within Earth or at the surface.

1 Properties of Minerals

Key Concepts

A mineral is a naturally occurring, inorganic solid that has a crystal structure and a definite chemical composition.

Each mineral has characteristic properties that can be used to identify it.

Density can be determined with the following formula:

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

Key Terms

mineral	luster
inorganic	Mohs hardness scale
crystal	cleavage
streak	fracture

2 Classifying Rocks

Key Concepts

When studying a rock sample, geologists observe the rock's mineral composition, color, and texture.

Geologists classify rocks into three major groups: igneous rock, sedimentary rock, and metamorphic rock.

Key Terms

rock-forming mineral	texture
granite	igneous rock
basalt	sedimentary rock
grains	metamorphic rock

3 Igneous Rocks

Key Concepts

Igneous rocks are classified according to their origin, texture, and mineral composition.

People throughout history have used igneous rock for tools and building materials.

Key Terms

extrusive rock	silica
intrusive rock	

4 Sedimentary Rocks

Key Concepts

Most sedimentary rocks are formed through a series of processes: erosion, deposition, compaction, and cementation.

There are three major groups of sedimentary rocks: clastic rocks, organic rocks, and chemical rocks.

People have used sedimentary rocks throughout history for many different purposes, including building materials and tools.

Key Terms

sediment	cementation
erosion	clastic rock
deposition	organic rock
compaction	chemical rock

5 Metamorphic Rocks

Key Concepts

Heat and pressure deep beneath Earth's surface can change any rock into metamorphic rock.

Geologists classify metamorphic rocks according to the arrangement of the grains that make up the rocks.

Certain metamorphic rocks are important materials for building and sculpture.

Key Term

foliated

6 The Rock Cycle

Key Concepts

Forces deep inside Earth and at the surface produce a slow cycle that builds, destroys, and changes the rocks in the crust.

Key Term

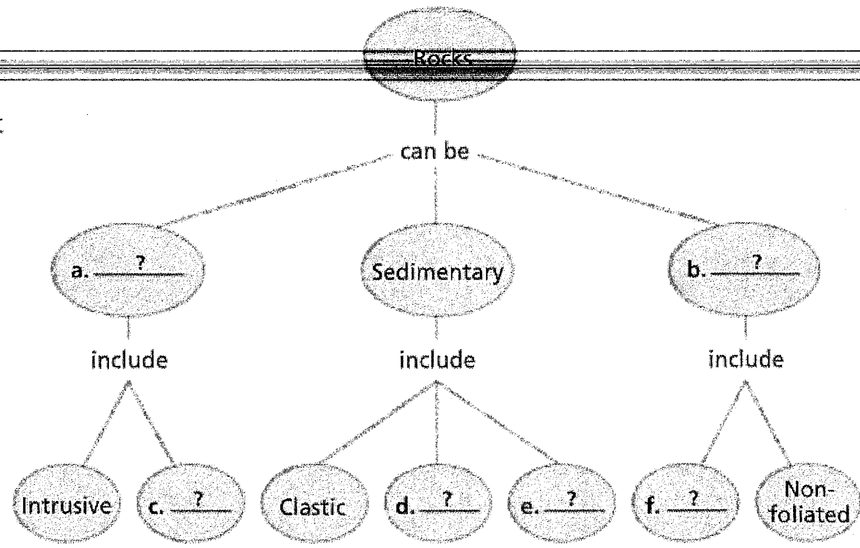
rock cycle

Review and Assessment

Go Online
PHSchool.com
For: Self-Assessment
Visit: PHSchool.com
Web Code: cpa-0002

Organizing Information

Concept Mapping Copy the concept map about classifying rocks onto a separate sheet of paper. Then complete it and give it a title. (For more on concept maps, see the Skills Handbook.)



Reviewing Key Terms

Choose the letter of the best answer.

HINT
1. Which characteristic is used to determine the color of a mineral's powder?
   a. luster **b.** fracture
   c. cleavage **d.** streak

HINT
2. A rock formed from fragments of other rocks is a(n)
   a. metamorphic rock. **b.** extrusive rock.
   c. sedimentary rock. **d.** igneous rock.

HINT
3. An igneous rock containing large crystals is most likely a(n)
   a. chemical rock. **b.** extrusive rock.
   c. foliated rock. **d.** intrusive rock.

HINT
4. A sedimentary rock formed from pieces of other rocks is called a(n)
   a. organic rock. **b.** chemical rock.
   c. clastic rock. **d.** compacted rock.

HINT
5. A metamorphic rock in which the grains line up in parallel bands is a
   a. clastic rock. **b.** nonclastic rock.
   c. nonfoliated rock. **d.** foliated rock.

HINT
6. In the rock cycle, the process by which an igneous rock changes to a sedimentary rock must begin with
   a. cementation.
   b. deposition.
   c. erosion.
   d. compaction.

Writing in Science

Field Guide Research and write a field guide for geologists and visitors to an area such as the Grand Canyon. Describe the types of rocks you might find there, what the rocks look like, and what their properties are. Briefly explain the kinds of forces that shaped the rocks in the area you chose.

Discovery Channel School
Rocks
Video Preview
Video Field Trip
▶ Video Assessment

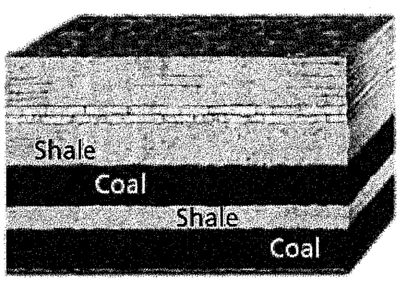
Review and Assessment

Checking Concepts

7. How can the streak test be helpful in identifying minerals?
8. What is the relationship between an igneous rock's texture and where it was formed?
9. Why can water pass easily through sandstone but not through shale?
10. Describe how a rock can form by evaporation. What type of rock is it?
11. How do the properties of a rock change when it becomes a metamorphic rock?
12. What are two things that could happen to a metamorphic rock to continue the rock cycle?

Thinking Critically

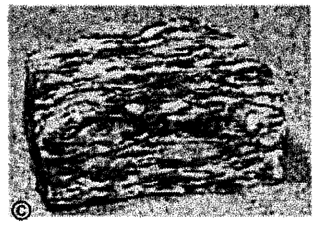
13. **Classifying** Obsidian is a solid that occurs in volcanic areas. Obsidian forms when magma cools very quickly, creating a type of glass. In glass, the particles are not arranged in an orderly pattern as in a crystal. Should obsidian be classified as a mineral? Explain why or why not.
14. **Inferring** A geologist finds an area where the rocks are layers of coal and shale as shown in the diagram below. What kind of environment probably existed in this area millions of years ago when these rocks formed?



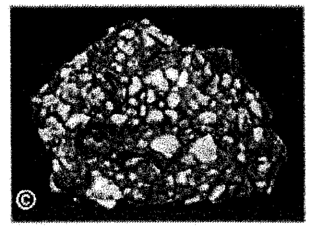
15. **Comparing and Contrasting** How are clastic rocks and organic rocks similar? How are they different?
16. **Predicting** Would you be less likely to find fossils in metamorphic rocks than in sedimentary rocks? Explain your answer.

Applying Skills

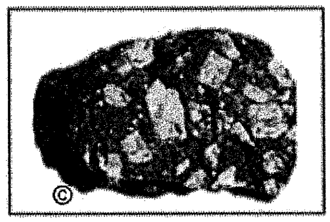
Answer Questions 17–20 using the photos of three rocks.



A



B



C

17. **Observing** How would you describe the texture of each rock?
18. **Classifying** Which of the three rocks would you classify as a metamorphic rock? Why?
19. **Inferring** A rock's texture gives clues about how the rock formed. What can you infer about the process by which Rock B formed?
20. **Relating Cause and Effect** What conditions led to the formation of the large crystals in Rock C? Explain your answer.

Lab zone Chapter Project

Performance Assessment Construct a simple display for your rocks. It should show your classification for each rock sample. In your presentation, describe where you hunted and what kinds of rocks you found. Were any rocks hard to classify? Did you find rocks from each of the three major groups? Can you think of any reason why certain types of rocks would not be found in your area?

Preparing for the CRCT

Test-Taking Tip

Watching for Qualifiers

Many multiple-choice questions use qualifying words such as *most, least, best,* or *always*. For example, you might be asked what is the best conclusion you can draw from experimental data. When you answer that kind of question, read the choices very carefully. Some answers may be partially correct. Look for the best and most complete answer.

Sample Question

Which statement best describes how an intrusive igneous rock forms?

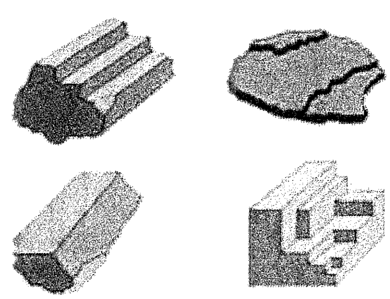
A Slowly cooling magma forms rock with large crystals.
B Slowly cooling magma forms veins of ore.
C Slowly cooling magma forms rock with small crystals.
D Fast-cooling magma forms rock with foliated crystals.

Answer

A is correct. An intrusive igneous rock forms when magma cools slowly, allowing large crystals to form. **B** and **C** are only partly correct. **D** incorrectly identifies the type of magma involved and the type of crystals that form.

Choose the letter of the best answer.

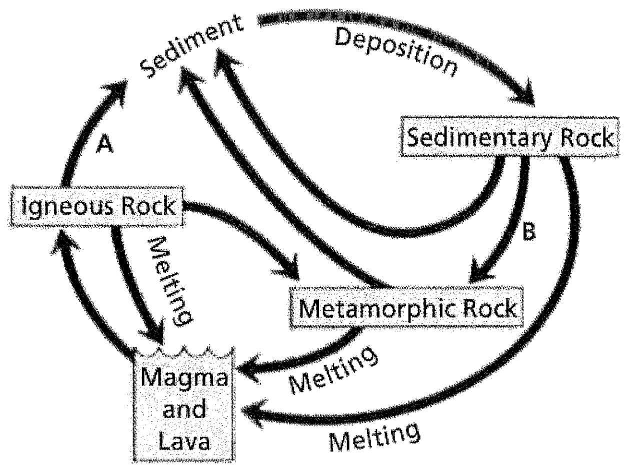
1. The following diagrams show four different mineral samples. Based on these diagrams, what property is the same for all four minerals?



A crystal structure **B** cleavage
C hardness **D** color **S6E5.b**

2. Rock salt, made of the mineral halite, is an organic sedimentary rock. A deposit of rock salt is most likely to be formed when

A magma cools and hardens inside Earth.
B hot water solutions form veins of rock salt.
C the minerals form a solution in magma.
D a solution of halite and water evaporates.
S6E5.b



Use the diagram above to answer Questions 3 and 4.

3. If the heat and pressure inside Earth cause a rock to melt, the material that formed would be

A metamorphic rock. **B** magma.
C sedimentary rock. **D** igneous rock.
S6E5.c

4. How can a metamorphic rock change into a sedimentary rock?

A erosion and deposition
B melting and crystallization
C heat and pressure
D all of the above **S6E5.c**

Constructed Response

5. A geologist finds an unknown mineral while working in a national park. The geologist is carrying a kit that contains a geologic hammer, a jackknife, a hand lens, a piece of tile, and a penny. In a paragraph, describe how the geologist could use these items to determine some of the mineral's properties. **S6E5.b**