CHAPTER 4

Minerals

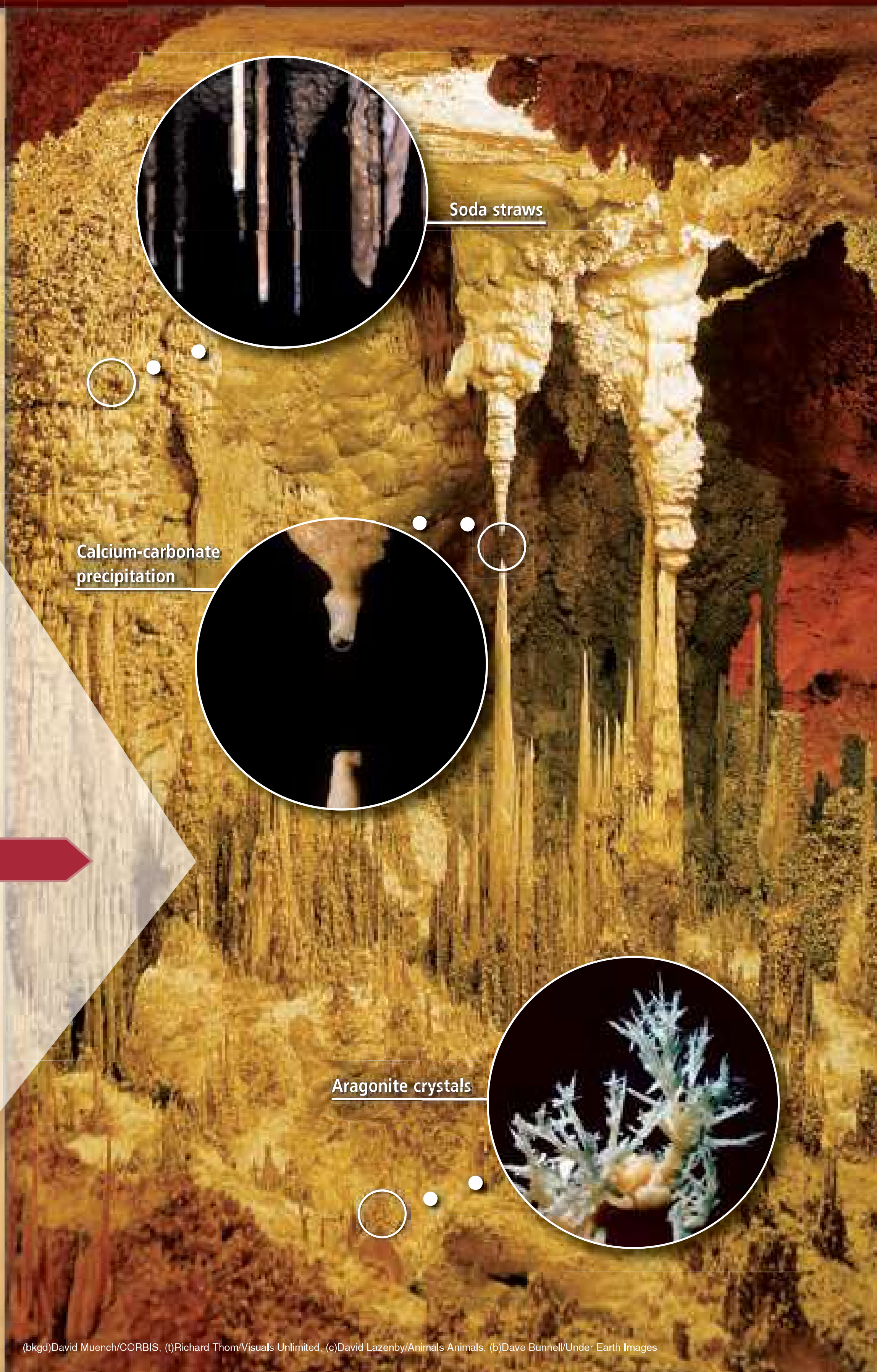
BIG Idea Minerals are an integral part of daily life.

4.1 What is a mineral?

MAIN Idea Minerals are naturally occurring, solid, inorganic compounds or elements.

4.2 Types of Minerals

MAIN Idea Minerals are classified based on their chemical properties and characteristics.



GeoFacts

- Stalactites and other cave formations take thousands of years to form. One estimate is that a stalactite will grow only 10 cm in 1000 years. That is equal to 0.1 mm each year!
- The diameter of a soda straw is equal to the droplets of water that form them.
- The longest soda straws discovered measure more than 9 m long.

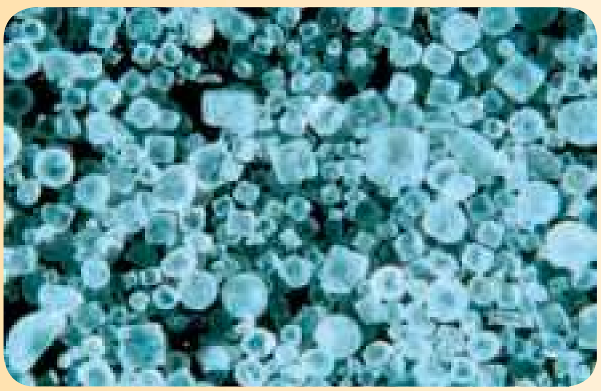
(bkgd)David Muench/CORBIS, (t)Richard Thom/Visuals Unlimited, (c)David Lazenby/Animals Animals, (b)Dave Bunnell/Under Earth Images

Start-Up Activities

LAUNCH Lab

What shapes do minerals form?

Although there are thousands of minerals in Earth's crust, each type of mineral has unique characteristics. These characteristics are clues to a mineral's composition and to the way it formed. Physical properties can also be used to distinguish one type of mineral from another.



Procedure

1. Read and complete the lab safety form.
2. Place a few grains of **table salt** (the mineral halite) on a **microscope slide.** Place the slide on the **microscope** stage. Or, observe the grains with a **magnifying lens.**
3. Focus on one grain at a time. Count the number of sides of each grain. Make sketches of the grains.
4. Next, examine a **quartz crystal** with the microscope or magnifying lens. Count the number of sides of the quartz crystal. Sketch the shape of the quartz crystal.

Analysis

1. **Compare and contrast** the shapes of the samples of halite and quartz.
2. **Describe** some other properties of your mineral samples.
3. **Infer** what might account for the differences you observed.

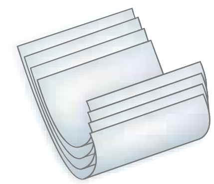
Holt Studios International Ltd/Alamy

FOLDABLES™ Study Organizer

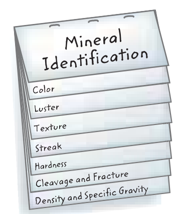
Mineral Identification Make the following Foldable to explain the tests used to identify minerals.

STEP 1 Collect four sheets of paper and layer them 2 cm apart vertically. Keep the left and right edges even.

STEP 2 Fold up the bottom edges of the sheets to form seven equal tabs. Crease the fold to hold the tabs in place.



STEP 3 Staple along the fold. Label the tabs with the names of the tests used to identify minerals.



FOLDABLES Use this Foldable with Section 4.2. As you read this section, describe the chemical or physical properties of minerals that are used in each test.

Earth Science Online

Visit glencoe.com to

- **study entire chapters online;**
- **explore Concepts in Motion animations:**
  - **Interactive Time Lines**
  - **Interactive Figures**
  - **Interactive Tables**
- **access Web Links for more information, projects, and activities;**
- **review content with the Interactive Tutor and take Self-Check Quizzes.**

Section 4.1

Objectives

- **Define** a mineral.
- **Describe** how minerals form.
- **Classify** minerals according to their physical and chemical properties.

Review Vocabulary

element: a pure substance that cannot be broken down into simpler substances by chemical or physical means

New Vocabulary

mineral
crystal
luster
hardness
cleavage
fracture
streak
specific gravity

What is a mineral?

MAIN Idea **Minerals are naturally occurring, solid, inorganic compounds or elements.**

Real-World Reading Link Look around your classroom. The metal in your desk, the graphite in your pencil, and the glass in the windows are just three examples of how modern humans use products made from minerals.

Mineral Characteristics

Earth's crust is composed of about 3000 minerals. Minerals play important roles in forming rocks and in shaping Earth's surface. A select few have helped shape civilization. For example, great progress in prehistory was made when early humans began making tools from iron.

A **mineral** is a naturally occurring, inorganic solid, with a specific chemical composition and a definite crystalline structure. This crystalline structure is often exhibited by the crystal shape itself. Examples of mineral crystal shapes are shown in **Figure 4.1.**

Naturally occurring and inorganic Minerals are naturally occurring, meaning that they are formed by natural processes. Such processes will be discussed later in this section. Thus, synthetic diamonds and other substances developed in labs are not minerals. All minerals are inorganic. They are not alive and never were alive. Based on these criteria, salt is a mineral, but sugar, which is harvested from plants, is not. What about coal? According to the scientific definition of minerals, coal is not a mineral because millions of years ago, it formed from organic materials.

Figure 4.1 The shapes of these mineral crystals reflect the internal arrangement of their atoms.

Pyrite

Calcite

Definite crystalline structure The atoms in minerals are arranged in regular geometric patterns that are repeated. This regular pattern results in the formation of a crystal. A **crystal** is a solid in which the atoms are arranged in repeating patterns. Sometimes, a mineral will form in an open space and grow into one large crystal. The well-defined crystal shapes shown in **Figure 4.1** are rare. More commonly, the internal atomic arrangement of a mineral is not apparent because the mineral formed in a restricted space. **Figure 4.2** shows a sample of quartz that grew in a restricted space.

Reading Check **Describe** the atomic arrangement of a crystal.

Figure 4.2 This piece of quartz most likely formed in a restricted space, such as within a crack in a rock.

Solids with specific compositions The fourth characteristic of minerals is that they are solids. Recall from Chapter 3 that solids have definite shapes and volumes, while liquids and gases do not. Therefore, no gas or liquid can be considered a mineral.

Each type of mineral has a chemical composition unique to that mineral. This composition might be specific, or it might vary within a set range of compositions. A few minerals, such as copper, silver, and sulfur, are composed of single elements. The vast majority, however, are made from compounds. The mineral quartz (SiO_2), for example, is a combination of two atoms of oxygen and one atom of silicon. Although other minerals might contain silicon and oxygen, the arrangement and proportion of these elements in quartz are unique to quartz.

VOCABULARY

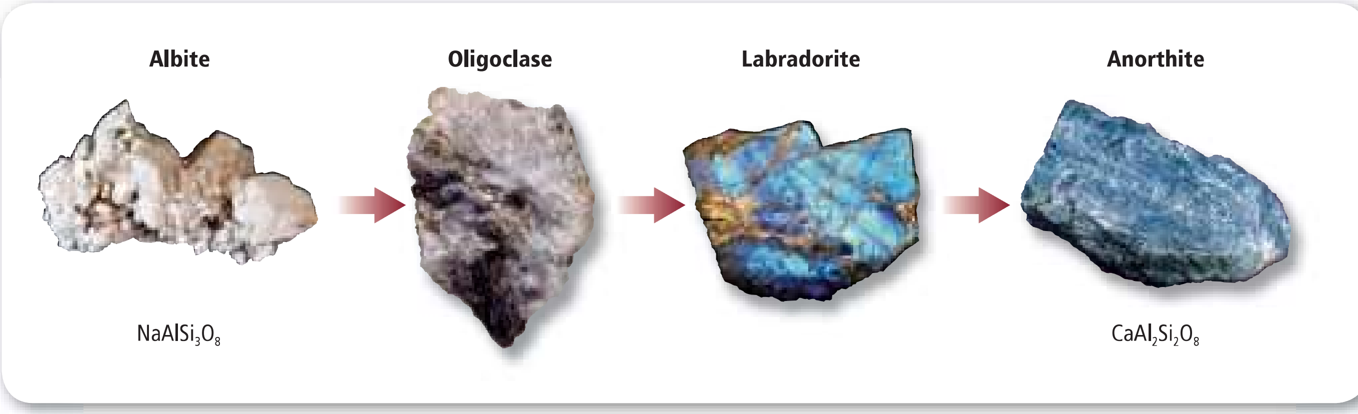
ACADEMIC VOCABULARY

Restricted
small space; to have limits
The room was so small that it felt very restricted.

Quartz

Aquamarine

(tr)Biophoto Associates/Photo Researchers, (bl)GC Minerals/Alamy Images, (bc)Lawrence Lawry/Photo Researchers



■ **Figure 4.3** The range in composition and resulting appearance is specific enough to identify numerous feldspar varieties accurately.

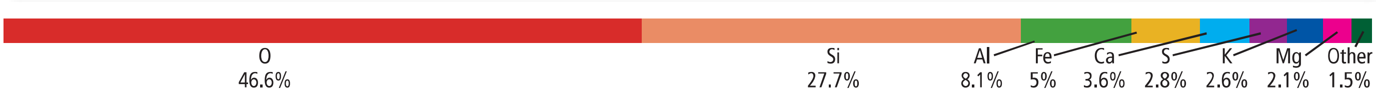
Variations in composition In some minerals, such as the ones shown in **Figure 4.3,** chemical composition can vary within a certain range depending on the temperature at which the mineral crystallizes. For example, plagioclase feldspar ranges from white albite (AHL bite) to gray anorthite (ah NOR thite). This color difference is due to a slight change in the mineral's chemical composition from sodium-rich to calcium-rich. At high temperatures, calcium is primarily incorporated, and at low temperatures sodium is primarily incorporated. At intermediate temperatures, a mixture of calcium and sodium is incorporated in the crystal structure producing a range of colors, as shown in **Figure 4.3.**

Rock-Forming Minerals

Although about 3000 minerals occur in Earth's crust, only about 30 of these are common. Eight to ten of these minerals are referred to as rock-forming minerals because they make up most of the rocks in Earth's crust. They are primarily composed of the eight most common elements in Earth's crust. This is illustrated in **Table 4.1.**

Table 4.1 Most Common Rock-Forming Minerals

Quartz	Feldspar	Mica	Pyroxene*
SiO_2	$NaAlSi_3O_8 - CaAl_2Si_2O_8$ & $KAlSi_3O_8$	$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$ $KAl_2(AlSi_3O_{10})(OH)_2$	$MgSiO_3$ $CaMgSi_2O_6$ $NaAlSi_2O_6$
Amphibole*	**Olivine**	**Garnet***	**Calcite**
$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$ $Fe_7Si_8O_{22}(OH)_2$	$(Mg,Fe)_2SiO_4$	$Mg_3Al_2Si_3O_{12}$ $Fe_3Al_2Si_3O_{12}$ $Ca_3Al_2Si_3O_{12}$	$CaCO_3$



*representative mineral compositions

Minerals from magma Molten material that forms and accumulates below Earth's surface is called magma. Magma is less dense than the surrounding solid rock, so it can rise upward into cooler layers of Earth's interior. Here, the magma cools and crystallizes. The type and number of elements present in the magma determine which minerals will form. The rate at which the magma cools determines the size of the mineral crystals. If the magma cools slowly within Earth's heated interior, the atoms have time to arrange themselves into large crystals. If the magma reaches Earth's surface, comes in contact with air or water, and cools quickly, the atoms do not have time to arrange themselves into large crystals. Thus, small crystals form from rapidly cooling magma, and large crystals form from slowly cooling magma. The mineral crystals in the granite shown in **Figure 4.4** are the result of cooling magma. You will learn more about crystal size in Chapter 5.

Reading Check **Explain** how contact with water affects crystal size.

Minerals from solutions Minerals are often dissolved in water. For example, the salts that are dissolved in ocean water make it salty. When a liquid becomes full of a dissolved substance and it can dissolve no more of that substance, the liquid is saturated. If the solution then becomes overfilled, it is called supersaturated and conditions are right for minerals to form. At this point, individual atoms bond together and mineral crystals precipitate, which means that they form into solids from the solution.

Minerals also crystallize when the solution in which they are dissolved evaporates. You might have experienced this if you have ever gone swimming in the ocean. As the water evaporated off your skin, the salts were left behind as mineral crystals. Minerals that form from the evaporation of liquid are called evaporites. The rock salt in **Figure 4.4** was formed from evaporation. **Figure 4.5** shows Mammoth Hot Springs, a large evaporite complex in Yellowstone National Park.

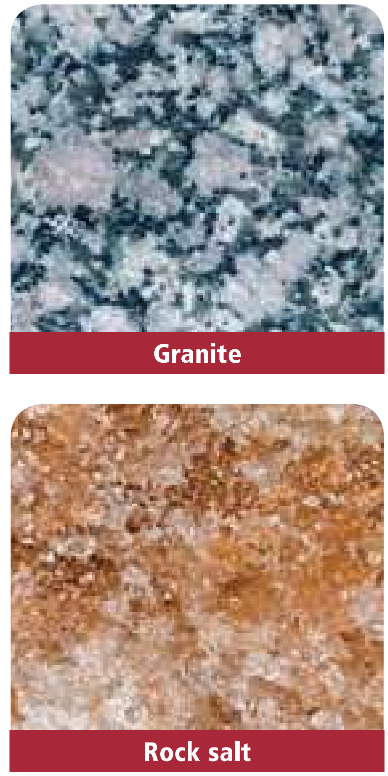


Figure 4.4 The crystals in these two samples formed in different ways. **Describe** *the differences you see in these rock samples.*

Figure 4.5 This large complex of evaporite minerals is in Yellowstone National Park. The variation in color is the result of the variety of elements that are dissolved in the water.

(tr)Albert Copley/Visuals Unlimited, (cr)Scientifica/Visuals Unlimited, (bl)John Elk III/Getty Images

Identifying Minerals

Geologists rely on several simple tests to identify minerals. These tests are based on a mineral's physical and chemical properties, which are crystal form, luster, hardness, cleavage, fracture, streak, color, texture, density, specific gravity, and special properties. As you will learn in the GeoLab at the end of this chapter, it is usually best to use a combination of tests instead of just one to identify minerals.

Crystal form Some minerals form such distinct crystal shapes that they are immediately recognizable. Halite—common table salt—always forms perfect cubes. Quartz crystals, with their double-pointed ends and six-sided crystals, are also readily recognized. However, as you learned earlier in this section, perfect crystals are not always formed, so identification based only on crystal form is rare.

Luster The way that a mineral reflects light from its surface is called **luster.** There are two types of luster—metallic luster and nonmetallic luster. Silver, gold, copper, and galena have shiny surfaces that reflect light, like the chrome trim on cars. Thus, they are said to have a metallic luster. Not all metallic minerals are metals. If their surfaces have shiny appearances like metals, they are considered to have a metallic luster. Sphalerite, for example, is a mineral with a metallic luster that is not a metal.

Minerals with nonmetallic lusters, such as calcite, gypsum, sulfur, and quartz, do not shine like metals. Nonmetallic lusters might be described as dull, pearly, waxy, silky, or earthy. Differences in luster, shown in **Figure 4.6,** are caused by differences in the chemical compositions of minerals. Describing the luster of nonmetallic minerals is a subjective process. For example, a mineral that appears waxy to one person might not appear waxy to another. Using luster to identify a mineral should usually be used in combination with other physical characteristics.

Reading Check **Define** the term *luster.*

CAREERS IN EARTH SCIENCE

Lapidary A lapidary is someone who cuts, polishes, and engraves precious stones. He or she studies minerals and their properties in order to know which minerals are the best for certain projects. To learn more about Earth science careers, visit glencoe.com.

Talc

Kaolinite

Figure 4.6 The flaky and shiny nature of talc gives it a pearly luster. Another white mineral, kaolinite, contrasts sharply with its dull, earthy luster.

Table 4.2	Mohs Scale of Hardness	**Concepts In Motion** Interactive Table To explore more about Mohs scale of hardness, visit glencoe.com.
Mineral	**Hardness**	**Hardness of Common Objects**
Diamond	10	
Corundum	9	
Topaz	8	
Quartz	7	streak plate = 7
Feldspar	6	steel file = 6.5
Apatite	5	glass = 5.5
Fluorite	4	iron nail = 4.5
Calcite	3	piece of copper = 3.5
Gypsum	2	fingernail = 2.5
Talc	1	

Hardness One of the most useful and reliable tests for identifying minerals is hardness. **Hardness** is a measure of how easily a mineral can be scratched. German geologist Friedrich Mohs developed a scale by which an unknown mineral's hardness can be compared to the known hardness of ten minerals. The minerals in the Mohs scale of mineral hardness were selected because they are easily recognized and, with the exception of diamond, readily found in nature.

Reading Check **Explain** what hardness measures.

Talc is one of the softest minerals and can be scratched by a fingernail; therefore, talc represents 1 on the Mohs scale of hardness. In contrast, diamond is so hard that it can be used as a sharpener and cutting tool, so diamond represents 10 on the Mohs scale of hardness. The scale, shown in **Table 4.2,** is used in the following way: a mineral that can be scratched by your fingernail has a hardness equal to or less than 2. A mineral that cannot be scratched by your fingernail and cannot scratch glass has a hardness value between 5.5 and 2.5. Finally, a mineral that scratches glass has a hardness greater than 5.5. Using other common objects, such as those listed in the table, can help you determine a more precise hardness and provide you with more information with which to identify an unknown mineral. Sometimes more than one mineral is present in a sample. If this is the case, it is a good idea to test more than one area of the sample. This way, you can be sure that you are testing the hardness of the mineral you are studying. **Figure 4.7** shows two minerals that have different hardness values.

Figure 4.7 The mineral on top can be scratched with a fingernail. The mineral on the bottom easily scratches glass.
Determine *Which mineral has greater hardness?*

Matt Meadows

Figure 4.8 Halite has perfect cleavage in three directions; it breaks apart into pieces that have 90° angles. The strong bonds in quartz prevent cleavage from forming. Conchoidal fractures are characteristic of microcrystalline minerals such as flint.

(l)E.R. Degginger/Animals Animals, (c)Doug Martin, (r)Science Museum/SSPL/The Image Works

Cleavage and fracture Atomic arrangement also determines how a mineral will break. Minerals break along planes where atomic bonding is weak. A mineral that splits relatively easily and evenly along one or more flat planes is said to have **cleavage.** To identify a mineral according to its cleavage, geologists count the number of cleaved planes and study the angle or angles between them. For example, mica has perfect cleavage in one direction. It breaks in sheets because of weak atomic bonds. Halite, shown in **Figure 4.8,** has cubic cleavage, which means that it breaks in three directions along planes of weak atomic attraction.

MiniLab

Recognize Cleavage and Fracture

How is cleavage used? Cleavage forms when a mineral breaks along a plane of weakly bonded atoms. If a mineral has no cleavage, it exhibits fracture. Recognizing the presence or absence of cleavage and determining the number of cleavage planes is a reliable method of identifying minerals.

Procedure

Part 1

1. Read and complete the lab safety form.
2. Obtain five **mineral samples** from your teacher. Separate them into two sets—those with cleavage and those without cleavage.
3. Arrange the minerals that have cleavage in order from fewest to most cleavage planes. How many cleavage planes does each sample have? Identify these minerals if you can.
4. Examine the samples that have no cleavage. Describe their surfaces. Identify these minerals if you can.

Part 2

5. Obtain two more samples from your teacher. Are these the same mineral? How can you tell?
6. Use a **protractor** to measure the cleavage plane angles of both minerals. Record your measurements.

Analysis

1. **Record** the number of cleavage planes or presence of fracture for all seven samples.
2. **Compare** the cleavage plane angles for Samples 6 and 7. What do they tell you about the mineral samples?
3. **Predict** the shape each mineral would exhibit if you were to hit each one with a hammer.

Quartz, shown in **Figure 4.8,** breaks unevenly along jagged edges because of its tightly bonded atoms. Minerals that break with rough or jagged edges are said to have **fracture.** Flint, jasper, and chalcedony (kal SEH duh nee) (microcrystalline forms of quartz) exhibit a unique fracture with arclike patterns resembling clamshells, also shown in **Figure 4.8.** This fracture is called conchoidal (kahn KOY duhl) fracture and is diagnostic in identifying the rocks and minerals that exhibit it.

Streak A mineral rubbed across an unglazed porcelain plate will sometimes leave a colored powdered streak on the surface of the plate. **Streak** is the color of a mineral when it is broken up and powdered. The streak of a nonmetallic mineral is usually white. Streak is most useful in identifying metallic minerals.

Sometimes, a metallic mineral's streak does not match its external color, as shown in **Figure 4.9.** For example, the mineral hematite occurs in two different forms, resulting in two distinctly different appearances. Hematite that forms from weathering and exposure to air and water is a rusty red color and has an earthy feel. Hematite that forms from crystallization of magma is silver and metallic in appearance. However, both forms make a reddish-brown streak when tested. The streak test can be used only on minerals that are softer than a porcelain plate. This is another reason why streak cannot be used to identify all minerals.

Reading Check **Explain** which type of mineral can be identified using streak.

Color One of the most noticeable characteristics of a mineral is its color. Color is sometimes caused by the presence of trace elements or compounds within a mineral. For example, quartz occurs in a variety of colors, as shown in **Figure 4.10.** These different colors are the result of different trace elements in the quartz samples. Red jasper, purple amethyst, and orange citrine contain different amounts and forms of iron. Rose quartz contains manganese or titanium. However, the appearance of milky quartz is caused by the numerous bubbles of gas and liquid trapped within the crystal. In general, color is one of the least reliable clues of a mineral's identity.

Figure 4.9 Despite the fact that these pieces of hematite appear remarkably different, their chemical compositions are the same. Thus, the streak that each makes is the same color.

FOLDABLES

Incorporate information from this section into your Foldable.

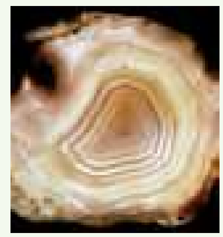
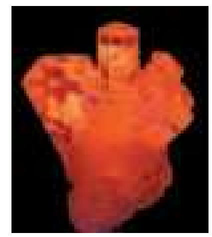
Figure 4.10 These varieties of quartz all contain silicon and oxygen. Trace elements determine their colors.

(tr)Fundamental Photographs, (bl)Nikreates/Alamy Images, (bcl)Richard Carlton/Visuals Unlimited, (bcr)Mark A. Schneider/Photo Researchers, (br)E. R. Degginger/Photo Researchers

Concepts In Motion

Interactive Table To explore more about the special properties of minerals, visit glencoe.com.

Table 4.3 Special Properties of Minerals

Property	**Double refraction** occurs when a ray of light passes through the mineral and is split into two rays.	**Effervescence** occurs when reaction with hydrochloric acid causes calcite to fizz.	**Magnetism** occurs between minerals that contain iron; only magnetite and pyrrhotite are strongly magnetic.	**Iridescence**—a play of colors, caused by the bending of light rays.	**Fluorescence** occurs when some minerals are exposed to ultraviolet light, which causes them to glow in the dark.
Mineral	Calcite—Variety Iceland Spar	Calcite	Magnetite Pyrrhotite	Agate	Fluorite Calcite
Example					

Special properties Several special properties of minerals can also be used for identification purposes. Some of these properties are magnetism, striations, double refraction, effervescence with hydrochloric acid, and fluorescence, shown in **Figure 4.3**. For example, Iceland spar is a form of calcite that exhibits double refraction. The arrangement of atoms in this type of calcite causes light to be bent in two directions when it passes through the mineral. The refraction of the single ray of light into two rays creates the appearance of two images.

DATA ANALYSIS LAB

Based on Real Data*

Make and Use a Table

What information should you include in a mineral identification chart?

Mineral Identification Chart

Mineral Color	Streak	Hardness	Breakage Pattern
copper red		3	hackly, fracture
	red or reddish brown	6	irregular fracture
pale to golden yellow	yellow		
	colorless	7.5	conchoidal fracture
gray, green or white			two cleavage planes

Analysis

1. Copy the data table and use the *Reference Handbook* to complete the table.
2. Expand the table to include the names of the minerals, other properties, and uses.

Think Critically

3. **Determine** which of these minerals will scratch glass? Explain.
4. **Identify** which of these minerals might be present in both a painting and your desk.
5. **Identify** any other information you could include in the table.

*Data obtained from: Klein, C. 2002. *The Manual of Mineral Science.*

Herve Berthoule/Photo Researchers

Texture Texture describes how a mineral feels to the touch. This, like luster, is subjective. Therefore, texture is often used in combination with other tests to identify a mineral. The texture of a mineral might be described as smooth, rough, ragged, greasy, or soapy. For example, fluorite, shown in **Figure 4.11,** has a smooth texture, while the texture of talc, shown in **Figure 4.6,** is greasy.

Density and specific gravity Sometimes, two minerals of the same size have different weights. Differences in weight are the result of differences in density, which is defined as mass per unit of volume. Density is expressed as follows.

$$D = \frac{M}{V}$$

In this equation, D = density, M = mass and V = volume. For example, pyrite, has a density of 5.2 g/cm^3, and gold has a density of 19.3 g/cm^3. If you had a sample of gold and a sample of pyrite of the same size, the gold would have greater weight because it is more dense.

Density reflects the atomic mass and structure of a mineral. Because density is not dependent on the size or shape of a mineral, it is a useful identification tool. Often, however, differences in density are too small to be distinguished by lifting different minerals. Thus, for accurate mineral identification, density must be measured. The most common measure of density used by geologists is **specific gravity,** which is the ratio of the mass of a substance to the mass of an equal volume of water at 4°C. For example, the specific gravity of pyrite is 5.2. The specific gravity of pure gold is 19.3.

Figure 4.11 Textures are interpreted differently by different people. The texture of this fluorite is usually described as smooth.

Section 4.1 Assessment

Section Summary

- A mineral is a naturally occurring, inorganic solid with a specific chemical composition and a definite crystalline structure.
- A crystal is a solid in which the atoms are arranged in repeating patterns.
- Minerals form from magma or from supersaturated solutions.
- Minerals can be identified based on their physical and chemical properties.
- The most reliable way to identify a mineral is by using a combination of several tests.

Understand Main Ideas

1. MAIN Idea **List** two reasons why petroleum is not a mineral.
2. **Define** *naturally occurring* in terms of mineral formation.
3. **Contrast** the formation of minerals from magma and their formation from solution.
4. **Differentiate** between subjective and objective mineral properties.

Think Critically

5. **Develop** a plan to test the hardness of a sample of feldspar using the following items: glass slide, copper penny, and streak plate.
6. **Predict** the success of a lab test in which students plan to compare the streak colors of fluorite, quartz, and feldspar.

MATH in Earth Science

7. Calculate the volume of a 5-g sample of pure gold.

Section 4.2

Objectives

- **Identify** different groups of minerals.
- **Illustrate** the silica tetrahedron.
- **Discuss** how minerals are used.

Review Vocabulary

chemical bond: the force that holds two atoms together

New Vocabulary

silicate
tetrahedron
ore
gem

Types of Minerals

MAIN Idea Minerals are classified based on their chemical properties and characteristics.

Real-World Reading Link Everything on Earth is classified into various categories. Food, animals, and music are all classified according to certain properties or features. Minerals are no different; they, too, are classified into groups.

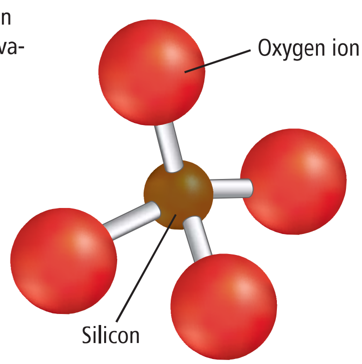
Mineral Groups

You have learned that elements combine in many different ways and proportions. One result is the thousands of different minerals present on Earth. In order to study these minerals and understand their properties, geologists have classified them into groups. Each group has a distinct chemical nature and specific characteristics.

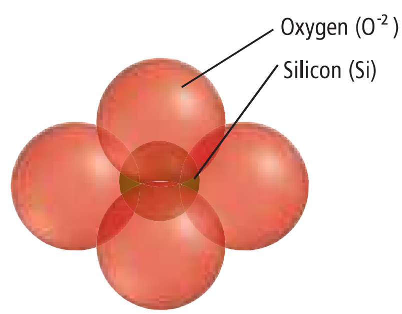
Silicates Oxygen is the most abundant element in Earth's crust, followed by silicon. Minerals that contain silicon and oxygen, and usually one or more other elements, are known as **silicates.** Silicates make up approximately 96 percent of the minerals present in Earth's crust. The two most common minerals, feldspar and quartz, are silicates. The basic building block of the silicates is the silica tetrahedron, shown in **Figure 4.12.** A **tetrahedron** (plural, tetrahedra) is a three-dimensional shape that resembles a pyramid. Recall from Chapter 3 that the electrons in the outermost energy level of an atom are called valence electrons. The number of valence electrons determines the type and number of chemical bonds an atom will form. Because silicon atoms have four valence electrons, silicon has the ability to bond with four oxygen atoms. As shown in **Figure 4.13,** silica tetrahedra can share oxygen atoms. This structure allows tetrahedra to combine in a number of ways, which accounts for the large diversity of structures and properties of silicate minerals.

Figure 4.12 The silicate polyatomic ion SiO_4^{-2} forms a tetrahedron in which a central silicon atom is covalently bonded to oxygen ions.
Specify ***How many atoms are in one tetrahedron?***

Ball-and-Stick Model



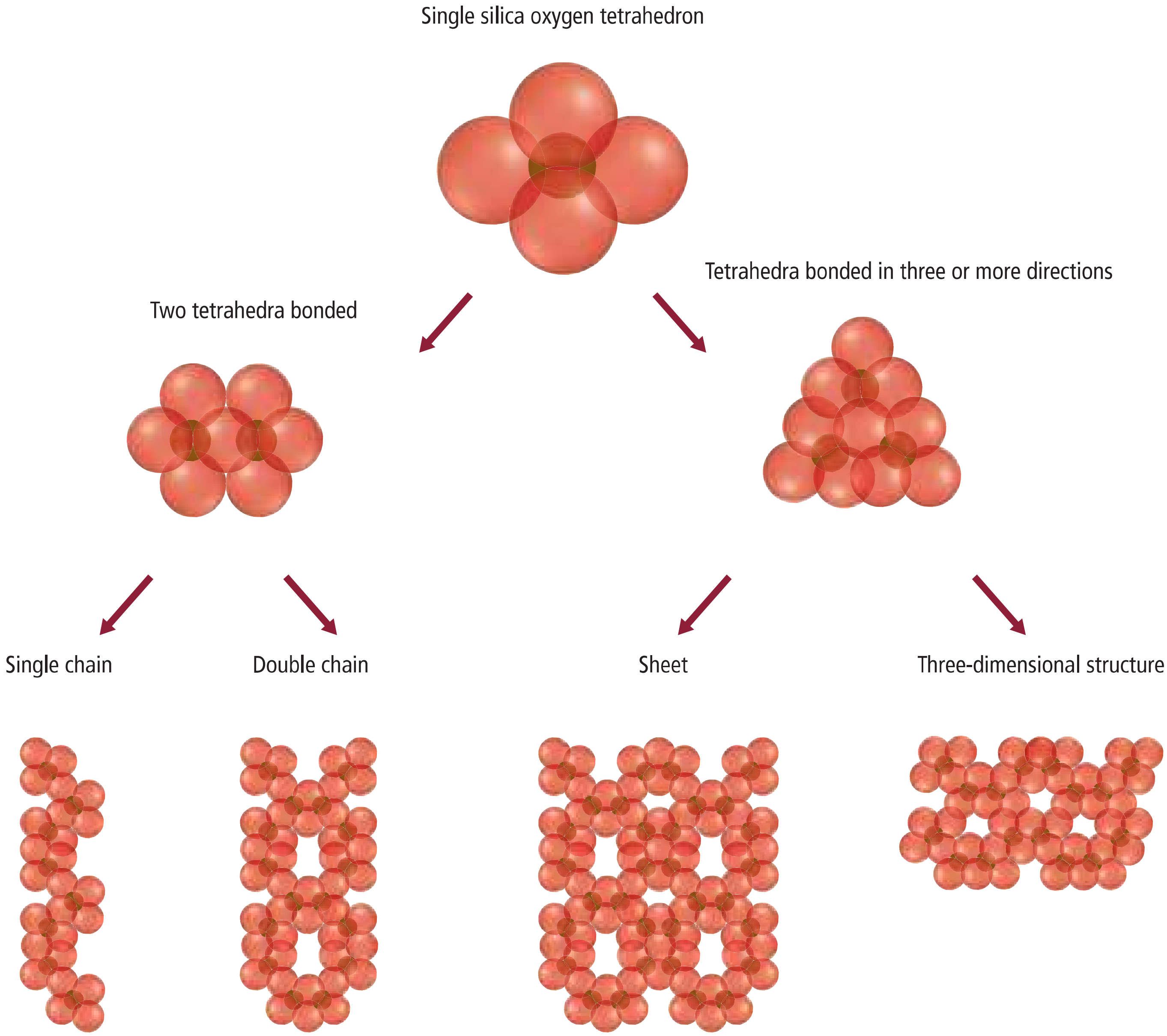
Space-Filling View



Visualizing the Silica Tetrahedron

NATIONAL GEOGRAPHIC

Figure 4.13 The tetrahedron formed by silicates contains four oxygen ions bonded to a central silicon atom. Chains, sheets, and complex structures form as the tetrahedra bond with other tetrahedra. These structures become the numerous silicate minerals that are present on Earth.



Concepts In Motion To explore more about the bonding behavior of the silica tetrahedron, visit glencoe.com.

Earth Science Online

■ **Figure 4.14** The differences in silicate minerals are due to the differences in the arrangement of their silica tetrahedra. Certain types of asbestos consist of weakly bonded double chains of tetrahedra, while mica consists of weakly bonded sheets of tetrahedra.


Asbestos


Mica

VOCABULARY
SCIENCE USAGE V. COMMON USAGE
Phyllo
Science usage: the sheets of silica tetrahedra

Common usage: sheets of dough used to make pastries and pies

Individual tetrahedron ions are strong. They can bond together to form sheets, chains, and complex three-dimensional structures. The bonds between the atoms help determine several mineral properties, including a mineral's cleavage or fracture. For example, mica, shown in **Figure 4.14,** is a sheet silicate, also called a phyllosilicate, where positive potassium or aluminum ions bond the negatively charged sheets of tetrahedra together. Mica separates easily into sheets because the attraction between the tetrahedra and the aluminum or potassium ions is weak. Asbestos, also shown in **Figure 4.14,** consists of double chains of tetrahedra that are weakly bonded together. This results in the fibrous nature shown in **Figure 4.14.**

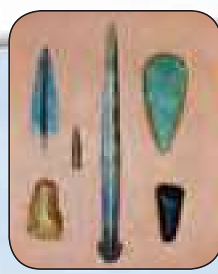
Carbonates Oxygen combines easily with many other elements, and thus forms other mineral groups, such as carbonates. Carbonates are minerals composed of one or more metallic elements and the carbonate ion CO_3^{2-}. Examples of carbonates are calcite, dolomite, and rhodochrosite. Carbonates are the primary minerals found in rocks such as limestone and marble. Some carbonates have distinctive colorations, such as the colorful varieties of calcite and the pink of rhodochrosite shown in **Figure 4.16.**

■ **Figure 4.15**
Mineral Use Through Time
The value and uses of minerals have changed over time.

10,000 B.C.
3000 B.C.
500 B.C.

12,000–9000 B.C. The demand for obsidian—a hard volcanic glass used for tools—produces the first known long-distant trade route.

3300–3000 B.C. Bronze weapons and tools become common in the Near East as large cities and powerful empires arise.



1200–1000 B.C. In the Near East, bronze becomes scarce and is replaced by iron in tools and weapons.

800 B.C. Diamond use spreads from India to other parts of the world to be used for cutting, engraving, and in ceremonies.

506 B.C. Rome takes over the salt industry at Ostia. The word *salary* comes from *salarium argentums,* the salt rations paid to Roman soldiers.

Calcite

Rhodochrosite

■ **Figure 4.16** Carbonates such as calcite and rhodochrosite occur in distinct colors due to trace elements found in them.

Oxides Oxides are compounds of oxygen and a metal. Hematite (Fe_2O_3) and magnetite (Fe_3O_4) are common iron oxides and good sources of iron. The mineral uraninite (UO_2) is valuable because it is the major source of uranium, which is used to generate nuclear power.

Other groups Other major mineral groups are sulfides, sulfates, halides, and native elements. Sulfides, such as pyrite (FeS_2), are compounds of sulfur and one or more elements. Sulfates, such as anhydrite ($CaSO_4$), are composed of elements with the sulfate ion SO_4^{2-}. Halides, such as halite (NaCl), are made up of chloride or fluoride along with calcium, sodium, or potassium. A native element such as silver (Ag) or copper (Cu), is made up of one element only.

Economic Minerals

Minerals are virtually everywhere. They are used to make computers, cars, televisions, desks, roads, buildings, jewelry, beds, paints, sports equipment, and medicines, in addition to many other things. You can learn about the uses of minerals throughout history by examining **Figure 4.15.**

800–900 Chinese alchemists combine saltpeter with sulfur and carbon to make gunpowder, which is first used for fireworks and later used for weapons.

1546 South American silver mines help establish Spain as a global trading power, supplying silver needed for coinage.

2006 There are 242 uranium-fueled nuclear power plants in operation worldwide with a net capacity of 369.566 GW(e).

A.D. 500 — 1500 — 2000

A.D. 200–400 Iron farming tools and weapons allow people to migrate across Africa clearing and cultivating land for agricultural settlement and driving out hunter-gatherer societies.

1927 The first quartz clock improves timekeeping accuracy. The properties of quartz make it instrumental to the development of radio, radar, and computers.

Concepts in Motion

Interactive Time Line To learn more about these discoveries and others, visit glencoe.com. Earth Science Online

Concepts in Motion
Interactive Table To explore more about major mineral groups, visit glencoe.com.

Table 4.4 Major Mineral Groups

Group	Examples	Economic Use
Silicates	mica (biotite) olivine (Mg_2SiO_4) quartz (SiO_2) vermiculite	furnace windows gem (as peridot) timepieces potting soil additive; swells when wet
Sulfides	pyrite (FeS_2) marcasite (FeS_2) galena (PbS) sphalerite (ZnS)	used to make sulfuric acid; often mistaken for gold (fool's gold) jewelry lead ore zinc ore
Oxides	hematite (Fe_2O_3) corundum (Al_2O_3) uraninite (UO_2) ilmenite ($FeTiO_3$) chromite ($FeCr_2O_4$)	iron ore, red pigment abrasive, gemstone uranium source titanium source; pigment-replaced lead in paint chromium source, plumbing fixtures, auto accessories
Sulfates	gypsum ($CaSO_4 \cdot 2H_2O$) anhydrite ($CaSO_4$)	plaster, drywall; slows drying in cement plaster; name indicates absence of water
Halides	halite (NaCl) fluorite (CaF_2) sylvite (KCl)	table salt, stock feed, weed killer, food preparation and preservative steel manufacturing, enameling cookware fertilizer
Carbonates	calcite ($CaCO_3$) dolomite ($CaMg(CO_3)_2$)	Portland cement, lime, cave deposits Portland cement, lime; source of calcium in vitamin supplements
Native elements	gold (Au) copper (Cu) silver (Ag) sulfur (S) graphite (C)	monetary standard, jewelry coinage, electrical wiring, jewelry coinage, jewelry, photography sulfa drugs and chemicals; distinct yellow color and odor, burns easily pencil lead, dry lubricant

Figure 4.17 Parts of this athlete's wheelchair are made of titanium. Its lightweight and extreme strength makes it an ideal metal to use.

Ores Many of the items just mentioned are made from ores. A mineral is an **ore** if it contains a useful substance that can be mined at a profit. Hematite, for instance, is an ore that contains the element iron. Consider your classroom. If any items are made of iron, their original source might have been the mineral hematite. If there are items in the room made of aluminum, their original source was the ore bauxite. A common use of the metal titanium, obtained from the mineral ilmenite, is shown in **Figure 4.17.** **Table 4.4** summarizes the mineral groups and their major uses.

The classification of a mineral as an ore can also change if the supply of or demand for that mineral changes. Consider a mineral that is used to make computers. Engineers might develop a more efficient design or a less costly alternative material. In either of these cases, the mineral would no longer be used in computers. Demand for the mineral would drop substantially, and the mineral would no longer be considered an ore.

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

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

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

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

Section 4.2 Assessment

Section Summary

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

Understand Main Ideas

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

Think Critically

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

WRITING in Earth Science

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

NATIONAL GEOGRAPHIC **eXpeditions!**

ON SITE:

CRYSTALS AT LARGE IN MEXICO

Figure 1: Naica Cave in Chihuahua, Mexico is known for its large crystals.

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

The climate inside the cave The large gypsum minerals present in Naica Cave are located 700 m below Earth's surface. Temperatures there reach 71°C (160°F). The air at this point in the cave has a relative humidity of 100 percent. These extreme conditions mean that anyone entering the cave can remain only for a few minutes at a time.

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

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

Geologists think that 30 mya, mineral-rich fluid from magma forced its way up approximately 3 to 5 km along a fault into limestone bedrock. Gypsum precipitated out of the fluid, thus forming the selenite crystals. Geologists think it can take as little as 30 years to grow such crystals if the conditions of the cave remain constant.

WRITING in Earth Science

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

GEOLAB

DESIGN YOUR OWN: MAKE A FIELD GUIDE FOR MINERALS

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

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

Materials

Choose materials that would be appropriate for this lab.

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

Safety Precautions

Procedure

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

Analyze and Conclude

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

WRITING in Earth Science

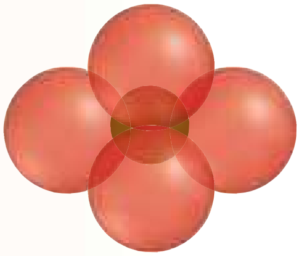
Peer Review Trade field guides with another group and test them out by using them to identify a new mineral. Provide feedback to the authors of the guide that you use.

CHAPTER 4

Study Guide

Download quizzes, key terms, and flash cards from glencoe.com.

BIG Idea Minerals are an integral part of daily life.

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

Earth Science Online Vocabulary PuzzleMaker glencoe.com

Assessment

Vocabulary Review

Use what you know about the vocabulary terms listed on the Study Guide to answer the following questions.

1. What is a naturally occurring, solid, inorganic compound or element?
2. What term refers to the regular, geometric shapes that occur in many minerals?
3. What is the term for minerals containing silicon and oxygen?

Explain the relationship between the vocabulary terms in each pair.

4. ore, gem
5. silicate, tetrahedron

Complete the sentences below using vocabulary terms from the Study Guide.

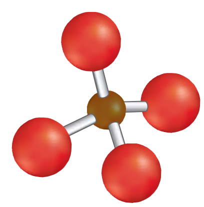
6. Minerals that break randomly exhibit _________.
7. The _________ test determines what materials a mineral will scratch.

Understand Key Concepts

Use the photo below to answer Question 8.

8. Which mineral property is being tested?
   A. texture **C.** cleavage
   B. hardness **D.** streak
9. Which property causes the mineral galena to break into tiny cubes?
   A. density **C.** hardness
   B. crystal structure **D.** luster
10. What characteristic is used for classifying minerals into individual groups?
    A. internal atomic structure
    B. presence or absence of silica tetrahedrons
    C. chemical composition
    D. density and hardness
11. A mineral has a mass of 100 g and a volume of 50 cm^3. What is its density?
    A. 5000 g/cm^3
    B. 2 g/cm^3
    C. 5 g/cm^3
    D. 150 g/cm^3
12. What is the correct chemical formula for a silica tetrahedron?
    A. SiO_2
    B. $Si_2O_2^{+4}$
    C. SiO_4^{-4}
    D. Si_2O_2

Use the diagram below to answer Questions 13 and 14.



13. Where do the tetrahedra bond to each other?
    A. the center of the silicon atom
    B. at any oxygen atom
    C. only the top oxygen atom
    D. only the bottom oxygen atoms
14. What group of minerals is composed mainly of these tetrahedra?
    A. silicates **C.** carbonates
    B. oxides **D.** sulfates
15. Which is an example of a mineral whose streak cannot be determined with a porcelain streak plate?
    A. hematite
    B. gold
    C. feldspar
    D. magnetite

Earth Science Online Chapter Test glencoe.com

Matt Meadows

Chapter 4 Assessment

16. Which is one of the three most common elements in Earth's crust?
    A. sodium
    B. silicon
    C. iron
    D. carbon

Use the table below to answer Question 17.

Mineral Formulas	
Name	**Formula**
Quartz	SiO_2
Feldspar	$NaAlSi_3O_8$— $CaAl_2Si_2O_8$ & $KAlSi_3O_8$
Amphibole	$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$ $Fe_7Si_8O_{22}(OH)_2$
Olivine	$(Mg,Fe)_2SiO_4$

17. What determines the variation in chemical composition among the minerals listed in the table?
    A. rate of magma cooling
    B. temperature of the magma
    C. presence or absence of water
    D. changes in pressure

18. Calcite is the dominant mineral in the rock limestone. In which mineral group does it belong?
    A. silicates
    B. oxides
    C. carbonates
    D. sulfates

19. What mineral fizzes when it comes in contact with hydrochloric acid?
    A. quartz
    B. gypsum
    C. calcite
    D. fluorite

20. *Dull, silky, waxy, pearly,* and *earthy* are terms that best describe which property of minerals?
    A. luster
    B. color
    C. streak
    D. cleavage

21. For a mineral to be considered an ore, which requirement must it meet?
    A. It must be in demand.
    B. Its production must not generate pollution.
    C. It must be naturally occurring.
    D. Its production must generate a profit.

Constructed Response

22. **Explain** why rubies and sapphires, which are both forms of the mineral corundum, are different colors.

23. **Describe** the visual effect of placing a piece of clear, Iceland spar on top of the word *geology* in a textbook.

24. **Summarize** the formation of sugar crystals in a glass of sugar-sweetened hot tea.

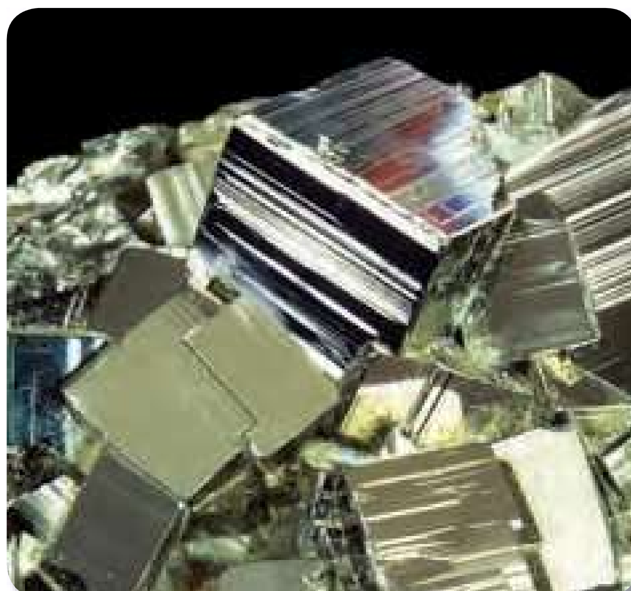
25. **Hypothesize** which mineral properties are the direct result of the arrangement of atoms or ions in a crystal. Explain your answer.

26. **Compare and Contrast** Diamond and graphite have the same chemical composition. Compare and contrast these two to explain why diamond is a gem and graphite is not.

Think Critically

27. **Describe** the differences that might be exhibited by the garnets listed in **Table 4.1.**

Use the figure below to answer Question 28.



28. **Illustrate** what the atomic structure might be if the crystal shape is an external reflection of it.

29. **Recommend** which minerals, other than diamond, would be best for making sandpaper. Explain your answer. Refer to **Table 4.2.**

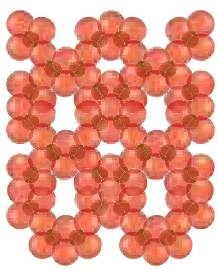
Earth Science Online Chapter Test glencoe.com

30. **Decide** which of the following materials are not minerals, and explain why: petroleum, wood, coal, steel, concrete, and glass.

31. **Infer** how early prospectors used density to determine whether they had found gold or pyrite in a mine.

32. **Assess** Imagine that a new gem is discovered that is more beautiful than the most stunning diamond or ruby. Assess the factors that will determine its cost compared to other known gems.

Use the figure below to answer Questions 33–34.



33. **Infer** Mica is a mineral with a sheet silicate structure. The atomic arrangement is shown above. Infer what is holding these sheets, which consist of negatively charged silicon-oxygen tetrahedra, together.

34. **Describe** the type of fracture that occurs in minerals with the atomic arrangement shown.

Concept Mapping

35. Create a concept map using the following terms: *silicates, oxides, halides, sulfates, sulfides, native elements,* and *carbonates.* Add any other terms that are helpful. For more help, refer to the *Skillbuilder Handbook.*

Challenge Question

36. **Arrange** In addition to sheet silicates, there are chain silicates, tectosilicates, and cyclosilicates. Arrange six silica tetrahedra in a cyclosilicate form. Be sure to bond the oxygen atoms correctly.

Additional Assessment

37. WRITING in **Earth Science** Imagine that you are planning a camping trip. What tools should you pack if you want to identify interesting minerals? How would you use these tools?

DBQ Document–Based Questions

Data obtained from: Plunkert, P.A. 2005. Mineral resource of the month: Aluminum. *Geotimes* 50:57.

Aluminum is the second most-abundant metallic element in Earth's crust. It is lightweight, bendable, corrosion resistant, and a good conductor of electricity. It is used most often in the manufacture of cars, buses, trailers, ships, aircraft, railway and subway cars. Other uses include beverage cans, aluminum foil, machinery, and electrical equipment.

Aluminum is produced from bauxite (hydrated aluminum-oxide) deposits, located mostly in Guinea, Australia, and South America. The United States does not have bauxite deposits; it imports it from Brazil, Guinea, and Jamaica. Total world aluminum production is approximately 30 million metric tons per year. U.S. aluminum production is less than U.S. aluminum consumption. Leading aluminum producers are China and Russia. A major part (3 million metric tons per year) of the U.S. aluminum supply comes from recycling.

38. Interpret the relationship between aluminum's resistance to corrosion and its use in transportation vehicles.

39. Propose a plan for how the United States can increase aluminum production without increasing the amount it imports.

40. Predict the possible effects an increase in U.S. production would have on Guinea, Jamaica, and China.

Cumulative Review

41. How do different isotopes of an element differ from each other? **(Chapter 3)**

42. Why is an understanding of the study of Earth science important to us as residents of Earth? **(Chapter 1)**

Standardized Test Practice

Multiple Choice

1. What is the second most abundant element in Earth's crust?
   A. nitrogen
   B. oxygen
   C. silicon
   D. carbon

Use the table below to answer Questions 2 and 3.

Mineral Characteristics			
Mineral	**Hardness**	**Specific Gravity**	**Luster/Color**
Feldspar	6–6.5	2.5–2.8	nonmetallic/colorless or white
Fluorite	4	3–3.3	nonmetallic/yellow, blue, purple, rose, green, or brown
Galena	2.5–2.75	7.4–7.6	metallic/grayish black
Quartz	7	2.65	nonmetallic/colorless in pure form

2. What is the hardest mineral in the table?
   A. feldspar
   B. fluorite
   C. galena
   D. quartz

3. Which mineral most likely has a shiny appearance?
   A. feldspar
   B. fluorite
   C. galena
   D. quartz

4. What can be inferred about an isotope that releases radiation?
   A. It has unstable nuclei.
   B. It has stable nuclei.
   C. It has the same mass number as another element.
   D. It is not undergoing decay.

5. How do electrons typically fill energy levels?
   A. from lowest to highest
   B. from highest to lowest
   C. in no predictable pattern
   D. all in one energy level

6. What is the most reliable clue to a mineral's identity?
   A. color
   B. streak
   C. hardness
   D. luster

Use the table below to answer Questions 7 and 8.

Mineral	Hardness
Talc	1
Gypsum	2
Calcite	3
Fluorite	4
Apatite	5
Feldspar	6
Quartz	7
Topaz	8
Corundum	9
Diamond	10

7. Which mineral will scratch feldspar but not topaz?
   A. quartz
   B. calcite
   C. apatite
   D. diamond

8. What can be implied about diamond based on the table?
   A. It is the heaviest mineral.
   B. It is the slowest mineral to form.
   C. It has the most defined crystalline structure.
   D. It cannot be scratched by any other mineral.

9. A well-planned experiment must have all of the following EXCEPT
   A. technology
   B. a control
   C. a hypothesis
   D. collectible data

10. What name is given to the imaginary line circling Earth halfway between the north and south poles?
   A. prime meridian
   B. equator
   C. latitude
   D. longitude

Standardized Test Practice glencoe.com

Short Answer

Use the conversion factor and table below to answer Questions 11–13.

1.0 carat = 0.2 grams

Diamond	Carats	Grams
Uncle Sam: largest diamond found in United States	40.4	?
Punch Jones: second largest; named after boy who discovered it	?	6.89
Theresa: discovered in Wisconsin in 1888	21.5	4.3
2001 diamond production from western Australia	21,679,930	?

11. List the three diamonds from least to greatest according to carats, and list the carats.

12. How many kilograms of diamonds were produced in western Australia in 2001?

13. Why would a diamond excavator want to convert the diamond measurement from carats to grams?

14. Why are map scales important parts of a map?

15. Discuss how a scientist might use a Landsat satellite image to determine the amount of pollution being produced by a city.

16. How might a mineral no longer be classified as an ore?

Reading for Comprehension

Silicon Valley

Silicon (Si) is the second most abundant element in Earth's crust, but we didn't hear much about it until Silicon Valley. It is present in measurable amounts in nearly every rock, in all natural waters, as dust in the air, in the skeletons of many plants and some animals, and even in the stars. Silicon is never found in the free state like gold or silver, but is always with oxygen (O), aluminum (Al), magnesium (Mg), calcium (Ca), sodium (Na), potassium (K), iron (Fe), or other elements in combinations called the silicates. It is the largest and most complicated of all rock-forming minerals. It is dull gray in appearance and has a specific gravity of 2.42. It has valence electrons like carbon (C) and can form a vast array of chemical compounds like silicon carbide abrasive, silicon rubber and caulking, oils and paints. Pure silicon is used in semiconductors, as solar panels to generate electricity from light, and in microchips for transistors.

Article obtained from: Ellison, B. Si and SiO_2...or what a difference a litte O makes. (online resource accessed October 2006.)

17. According to the text, what is the most challenging aspect of silicon?
A. It has valence electrons.
B. It is dull gray in appearance.
C. It is never found in its free state.
D. It is present in many places.

18. Which is NOT a use of silicon as a chemical compound given in this passage?
A. silicon rubber and caulking
B. silicon carbide abrasive
C. microchips for transistors
D. oils and paints

19. Why was silicon not widely known until Silicon Valley?

NEED EXTRA HELP?																
If You Missed Question . . .	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Review Section . . .	4.2	4.1	4.1	3.1	3.6	4.1	4.1	4.1	1.2	2.1	4.2	4.2	1.2	2.2	2.3	3.2