chapter 3

Minerals

section 1 Minerals

What You'll Learn

- what all minerals have in common
- how minerals form

Before You Read

Think about a diamond that you have seen. Describe what the diamond looked like on the lines below.

_____

_____

Read to Learn

What is a mineral?

You use minerals every day. In fact, minerals are all around you. The diamond you wrote about is a mineral. The glass in your windows is made from a mineral. The pencil lead, or graphite, you write with is also a mineral.

A **mineral** is a solid, non-living substance that is found in nature. A mineral is made up of atoms that are arranged in a certain, set way.

How are minerals alike?

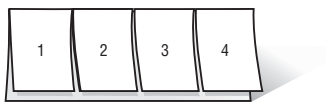
There are about 4,000 different minerals on Earth. All minerals have four things in common. First, all minerals are formed by natural processes. These processes occur on or inside the Earth with no help from humans. For example, diamonds are formed by the pressure deep within Earth. Second, minerals are inorganic, or not living. They are made from non-living substances, like the material that makes up a diamond. Third, minerals are made up of one element or a combination of elements. The finest diamonds, for example, are made up of one element—carbon. The mineral halite is made up of two elements—sodium and chlorine. Fourth, all minerals are solids. A solid keeps a set shape. Minerals are a special type of solid because their atoms are arranged in a specific way.

Study Coach

Two-Column Notes As you read, organize your notes in two columns. In the left-hand column, write the main idea of each paragraph. Next to it, in the right-hand column, write details about it.

FOLDABLES™

A Identify Make a four tab Foldable to identify the four characteristics of minerals.

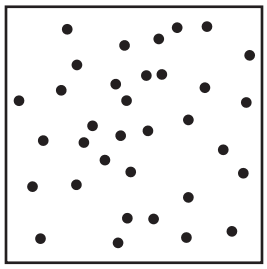


Picture This

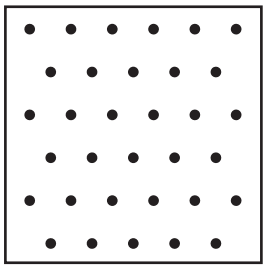
1. **Draw** In the box below, draw at least 10 dots that show how the atoms in a crystal might be arranged. Each dot is one atom.

How are atoms in minerals arranged?

Atoms in a mineral are arranged in an orderly pattern that repeats itself over and over again. This repeated pattern of atoms is called a crystalline pattern. For example, the atoms in the mineral graphite are arranged in layers. All true minerals are crystalline solids. But not all solids are minerals. Opal, for example, is not a true mineral because its atoms are not arranged in a definite repeating pattern. In the first box below, the atoms are scattered. In the second box the atoms are arranged in a crystalline pattern.



Scattered Pattern



Crystalline Pattern

The Structure of Minerals

All minerals are crystals. A **crystal** is a solid that has atoms arranged in an orderly, repeating pattern. For example, a diamond is a crystal. A diamond has many flat sides, or faces. The flat faces are evidence for the orderly arrangement of atoms in the diamond.

Reading Check

2. **Determine** How are the atoms arranged in a crystal?

_____

_____

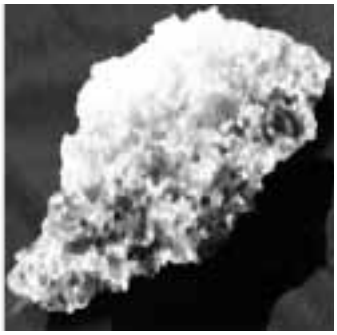
What affects the shape of crystals?

Like diamonds, the crystalline form of quartz can also be seen. The clear quartz crystal shown in the figure on the left on the next page has atoms arranged in flat layers. The clear quartz crystals formed in an open space and their crystalline form can be seen easily.

Sometimes crystal shapes are not seen so easily. The second figure shows a block of rose quartz. This rose quartz looks uneven on the outside. Yet it is a mineral with atoms arranged in a repeating pattern. The rose quartz crystals look this way because they formed in a tight space.

Crystals form in many ways. There are two ways in which crystals form most often from magma and from solution.

Clear quartz



Rose quartz

How do crystals form from magma?

Magma is the melted rock inside Earth. When magma rises to Earth's surface, it cools. As the magma cools, the atoms in the magma start to move closer together. The atoms begin to combine to form compounds. As they combine, some of the atoms of different compounds form orderly, repeating patterns. When they are completely cooled, these atoms have formed crystals.

When magma cools slowly, large crystals form. The crystal form can be seen easily in these minerals. When magma cools quickly, smaller crystals form. These small mineral crystals are much harder to see.

Magma is made of different elements. The type and amount of the elements that make up magma partly determine which minerals will form.

How do crystals form from solution?

When minerals dissolve in water, the result is called a solution. In a solution, the mineral's atoms are spread evenly through the water. As the water evaporates, ions come together to form crystals. For example, if you place a bowl of very salty water in the sun, the water soon evaporates. When the water has evaporated, salt crystals are left at the bottom of the bowl.

Crystals also may form when there is too much of a mineral in a solution. Because there is so much of the mineral, the ions come together and begin to form crystals in the solution. Minerals can form from a solution in this way without the need for evaporation.

Picture This

3. **Identify** Under each piece of quartz, write *tight space* or *open space* to show where each mineral formed.

Reading Check

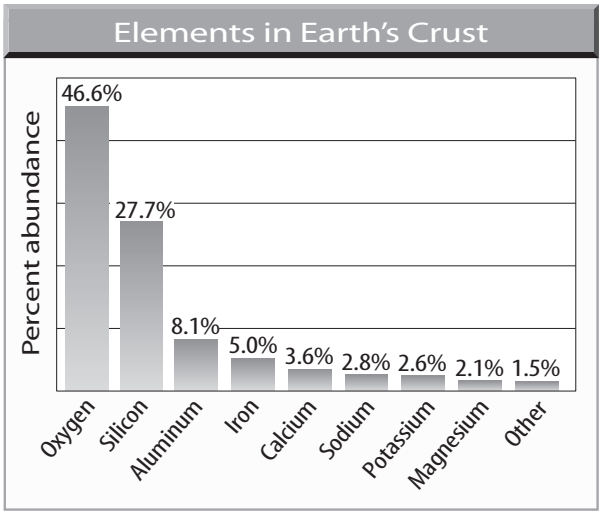
4. **Define** What is magma?

Think it Over

5. **Explain** What is one of the ways that crystals form from solution?

Applying Math

6. **Calculate** Look at the graph. Elements other than silicon and oxygen make up about what percent of Earth's crust? Show your work.



Mineral Compositions and Groups

There are ninety elements that make up Earth's crust. About 98 percent of the crust is made up of only eight of these elements. These common elements are shown above.

There are thousands of known minerals. However, only a few dozen minerals are common. These common minerals are made up mostly of the eight most common elements in Earth's crust.

How are minerals grouped?

Minerals are often grouped by the elements they are made of. Silicon and oxygen are the two most abundant elements in Earth's crust. They form the basic building blocks of most minerals.

The most common rock-forming minerals in Earth's crust are called silicates. A **silicate** is a mineral made up of the element silicon, the element oxygen, and usually one or more other elements. For example, quartz, a silicate, is a common rock-forming mineral in Earth's crust made of silicon and oxygen. Feldspar, another silicate, is made of silicon, oxygen, aluminum, and either potassium, sodium, calcium, or barium.

Another group of rock-forming minerals is the carbonates. Carbonates contain carbon and oxygen. They can include other elements. For example, calcite is a carbonate made of carbon, oxygen, and calcium. Dolomite is a carbonate made of carbon, oxygen, magnesium, and calcium. Other mineral groups are also defined according to the elements from which they are made.

Reading Check

7. **Determine** What two elements always make up silicates?

After You Read

Mini Glossary

crystal: solid in which the atoms are arranged in an orderly, repeating pattern

magma: hot, melted rock material beneath Earth's surface

mineral: solid material made in Earth, whose atoms are arranged in a set, repeating pattern

silicate: mineral that contains silicon and oxygen and usually one or more other elements

1. Review the terms and their definitions in the Mini Glossary. Then write a sentence that explains why all minerals are crystals. Use at least two terms in your sentence.

_____

_____

2. Fill in the boxes to tell how some crystals form.

_____ **cools**

_____ **move closer together**

compounds form _____

3. You organized your notes in two columns, one for main ideas and one for details. How did this strategy help you learn the information?

_____

_____

_____

ScienceOnline Visit **earth.msscience.com** to access your textbook, interactive games, and projects to help you learn more about minerals.

End of Section

chapter 3

Minerals

section 2 Mineral Identification

What You'll Learn

- the physical properties of minerals
- how to use physical properties to identify minerals

Before You Read

Someone hands you a gold ring and a lump of rock salt. Both gold and rock salt are minerals. On the lines below, describe the differences between the gold ring and rock salt.

_____

_____

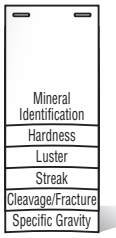
_____

Mark the Text

Highlight Key Terms
Highlight the key terms and their meanings as you read this section.

FOLDABLES™

B Identification Make a Foldable from 3 half sheets of notebook paper. Use it to list and explain the physical properties of minerals.



Read to Learn

Physical Properties

You can tell one person from another because people look different. People or things look different because they have different physical properties. Height, hair color, eye color, and face shape are some of a person's physical properties. Minerals have physical properties, too. You can identify minerals by their different physical properties.

What do different minerals look like?

Different minerals may look different in several ways. Some minerals may have smooth surfaces, while others may be rough. Different minerals may have different colors. A mineral's appearance is one way to begin to identify a mineral.

Looking only at a mineral's color can trick you. For example, gold is gold colored. Gold is valuable. Pyrite is a mineral that also has a bright gold color but has little value. In fact, pyrite is often called fool's gold.

To identify a mineral correctly, you need to look at other physical properties of the mineral. Some other physical properties to study are a mineral's hardness, how a mineral breaks, and its color when it is crushed into a powder.

How is the hardness of a mineral measured?

A mineral's **hardness** is a measure of how easily the mineral can be scratched. Diamond is the hardest mineral known. A diamond can be scratched only by another diamond. Diamonds are so hard that they are used to cut through other materials. They are used often as the blades of saws that cut through rock.

A mineral's hardness has nothing to do with how easily a mineral will break. Some minerals shatter easily, yet they still may be very hard.

What is Mohs scale of hardness?

The Mohs scale compares the hardness of different minerals. In 1824, a scientist named Friedrich Mohs tested the hardnesses of many minerals. He then listed the minerals in order. Talc, the softest mineral, was given the number 1. Diamond, the hardest mineral, was given the number 10. The hardness of each mineral was compared with the hardnesses of talc and diamond. Each mineral was given a number. The higher its number, the harder a mineral is.

Mineral Hardness

Mohs Scale	Hardness	Hardness of Common Objects	
Talc (softest)	1		
Gypsum	2	fingernail	(2.5)
Calcite	3	piece of copper	(2.5 to 3.0)
Fluorite	4	iron nail	(4.5)
Apatite	5	glass	(5.5)
Feldspar	6	steel file	(6.5)
Quartz	7	streak plate	(7.0)
Topaz	8		
Corundum	9		
Diamond (hardest)	10		

The table above will help you understand the Mohs scale of hardness. The table shows that topaz has a hardness of 8. Quartz has a hardness of 7. Topaz is harder than quartz. That means topaz can scratch quartz, but quartz cannot scratch topaz. The table also lists the hardnesses of some common objects.

Reading Check

1. **Apply** What does the Mohs scale measure?

_____

Picture This

2. **Interpret Data** Look at the table on this page. List three minerals that feldspar can scratch.

_____

_____

_____

How is the Mohs scale used?

Here's how the Mohs scale helps identify minerals. Suppose you are given a white mineral to identify. You know it is either fluorite or quartz. Your fingernail does not scratch it. But, you can scratch it with an iron nail. So the unknown mineral must have a hardness between 2.5 (your fingernail) and 4.5 (an iron nail). Now look at the Mohs scale. Because quartz has a hardness of 7 and fluorite has a hardness of 4, the unknown mineral must be fluorite.

What is luster?

An important physical property that is used to identify minerals is called luster. **Luster** is the way a mineral reflects light. There are two types of luster. A mineral that shines like a bright piece of metal has a metallic luster. The mineral graphite has a metallic luster.

Reading Check

3. Explain Why does graphite have a metallic luster?

A mineral that does not shine like metal has a nonmetallic luster. A nonmetallic luster may appear to be glassy, pearly, or dull. The mineral fluorite has nonmetallic luster.

What is gravity?

Picture a one-inch cube of lead and a one-inch cube of wood. Both cubes are the same size. Yet the cube of lead weighs more than the cube of wood. Lead has a greater specific gravity than wood. The **specific gravity** of a mineral is the ratio of its weight compared with the weight of an equal volume of water. A mineral's specific gravity is given as a number.

Reading Check

4. Identify Specific gravity is the weight of a mineral compared to the weight of an equal volume of what?

Specific gravity can be used to tell the difference between minerals that look similar. Gold and pyrite look alike. Gold has a specific gravity of 19. That means that gold is 19 times heavier than water. Pyrite has a specific gravity of 5. It is 5 times heavier than water. If you held equal-sized cubes of gold and pyrite, the gold would feel much heavier than the pyrite. The term *heft* can be used to describe this difference in weight. Gold has greater heft than pyrite.

How is streak used to identify minerals?

A mineral's **streak** is the color of the mineral in a powdered form. To find a mineral's streak, rub the mineral across a white, unglazed porcelain tile, and look at the streak of powered mineral left behind. For example, gold has a yellow streak and pyrite has a greenish-black streak.

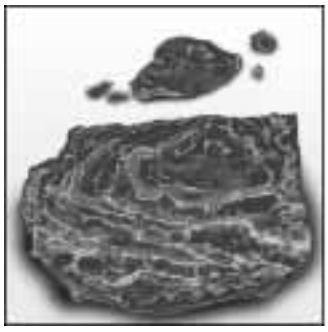
When can a streak test be used?

A streak test works only when the mineral being tested is softer than the porcelain tile. A softer mineral will leave a streak. A harder mineral will leave a scratch, not a streak. A streak test cannot be used to identify a diamond because the diamond is much harder than the tile.

How do minerals break?

Different minerals break apart in different ways. How a mineral breaks is another way to identify it. **Cleavage** is the physical property of minerals that break along smooth, flat surfaces. The way atoms are arranged in the minerals partly determines cleavage. The mica shown in the figure below breaks along flat cleavage surfaces. If you took a layer cake and separated its layers, you would show that the cake has cleavage.

Not all minerals have cleavage. **Fracture** is the property that causes minerals to break with rough, jagged surfaces. Quartz, a mineral with fracture, is shown in the figure below. If you grabbed a chunk out of the side of that cake, it would be like breaking a mineral that has a fracture.



Mica

Quartz

What other physical properties are used to identify minerals?

Some minerals have interesting physical properties. Magnetite is a mineral that acts like a magnet. Another mineral, calcite, affects light. When light passes through calcite, two separate light rays form. Calcite also fizzes when hydrochloric acid is placed on it.

Remember, a mineral's appearance and color may not be enough information to identify it. Minerals have other physical properties to help identify them. You may need to test hardness, luster, specific gravity, streak, and cleavage or fracture.

Reading Check

5. **Observe** How does a mineral with cleavage look when it breaks apart?

_____

_____

Picture This

6. **Identify** Look at the figure. Circle the mineral with fracture.

After You Read

Mini Glossary

cleavage: physical property of some minerals that causes them to break along smooth, flat surfaces

fracture: physical property of some minerals that causes them to break with uneven, rough, or jagged surfaces

hardness: measure of how easily a mineral can be scratched

luster: how a mineral reflects light from its surface

specific gravity: ratio of a mineral's weight compared with the weight of an equal volume of water

streak: color of a mineral when it is in powdered form

1. Review the terms and definitions in the Mini Glossary. Think about a time you saw a glass break. Does glass break with cleavage or with fracture? Explain your answer.

_____

_____

2. Use the table below to identify three "mystery" minerals that have the following physical properties:

Properties of Minerals

Mineral	Hardness	Streak
Copper	2.5–3	copper-red
Galena	2.5	dark gray
Gold	2.5–3	yellow
Hematite	5.5–6.5	red to brown
Magnetite	6–6.5	black
Silver	2.5–3	silver-white

1. • mineral has a hardness of 2.5
• mineral has dark gray streak

Mineral is _____.

2. • mineral has hardness of 6
• mineral has reddish brown streak

Mineral is _____.

3. • mineral has hardness of 3
• mineral has silver streak

Mineral is _____.

3. This section contained several new vocabulary words. You highlighted the key terms and their meanings. Describe another strategy to remember definitions of new words.

_____

_____

End of Section

ScienceOnline Visit **earth.msscience.com** to access your textbook, interactive games, and projects to help you learn more about the physical properties of minerals.

chapter 3

Minerals

section 3 Uses of Minerals

Before You Read

What do you think of when you hear the word *metal?* On the lines below describe things made from metal.

_____

_____

_____

What You'll Learn

- how gems are used
- what minerals contain useful elements

Read to Learn

Gems

Gems are often used in jewelry. A **gem** is a valuable mineral that is both rare and beautiful. When it is cut and polished, a gem has a beautiful color and shine. Most gems are special types of common minerals. They are clearer, brighter, or more colorful than common samples of that mineral.

Why are some gems important?

All gems are valuable. Sometimes gems are valuable because of their size. A carat is a unit used to measure the weight of gems. In 1905, a huge diamond was found in South Africa. The diamond, called the Cullinan diamond, was the largest ever discovered. It weighed 3,106.75 carats. That is equal to 621 grams.

Sometimes gems are valuable because of their unusual color. Most diamonds are colorless. The Hope diamond, the world's most famous diamond, has a slight blue color. In 1830, Henry Hope bought the diamond, which was then named after him. Today, the 45.52 carat (9 gram) Hope diamond is on display at the Smithsonian Institution in Washington, D.C.

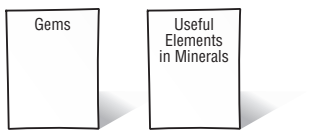
Study Coach

Think-Pair-Share Work with a partner. As you read the text, discuss what you already know about the topic and what you learn from the text.

FOLDABLES™

Organize Information

Use two quarter sheets of notebook paper. On one write about gems. On the other write about useful elements in minerals.



Think it Over

1. **Infer** What physical property of diamonds makes them useful for cutting stone and metal?

Which gems are useful?

Some gems are as useful as they are beautiful. Diamonds are the hardest minerals which makes them very useful. In industry, diamonds are used on blades to cut through stone or metal. Today, most diamonds used in industry are artificial, or synthetic. They are made by humans. Scientists have studied the structure of natural diamonds and copied it to make synthetic diamonds that are just as hard.

Rubies are used to produce laser light. Laser light helps with many different tasks. It sends television signals, guides machinery, and even helps doctors in the operating room.

Quartz crystals are used in electronics and in clocks and watches. When an electric field comes in contact with quartz crystals, the quartz vibrates steadily. This vibration helps control electronic devices and keeps timepieces accurate.

Useful Elements in Minerals

Gemstones are perhaps the best-known use of minerals, but they are not the most important. Look around your home. How many things made from minerals can you name? Do you see anything made from iron?

What is an ore?

Reading Check

2. **Identify** Iron comes from what ore?

You probably have many things that are made out of iron. Frying pans, nails, and other objects may contain iron. Iron is obtained from its ore, hematite. An **ore** is a mineral or rock that contains a useful substance that is mined at a profit.

Picture This

3. **Apply** another item made from aluminum.

Aluminum comes from the ore bauxite. Before it can be used, the aluminum in bauxite must be refined. In the refining process, aluminum oxide powder is separated from unwanted materials. The aluminum oxide powder is changed to aluminum by a process called smelting. Aluminum can be made into soft drink cans, bikes, cars, airplanes, and many other useful things. Some items made from aluminum are shown in the figure above.

What are vein minerals?

Under some conditions, metallic elements can dissolve in liquids. The liquid flows through weaknesses in rocks and forms mineral deposits. Weaknesses in rocks include natural fractures or cracks, faults, and surfaces between layered rock formations. Mineral deposits left behind that fill in the open spaces created by the weaknesses are called vein mineral deposits.

Sometimes vein mineral deposits fill in the empty spaces after rocks collapse. Sphalerite is a mineral that sometimes fills in spaces in collapsed limestone. Sphalerite is a source of the element zinc, which is used in batteries.

Which minerals contain titanium?

Titanium is a metallic element. It comes from minerals that contain this metal in their crystal structures. Two minerals, ilmenite (IHL muh nite) and rutile (rew TEEL), are sources of titanium. Ilmenite and rutile are found in rocks that form when magma cools and solidifies.

How is titanium used?

Titanium is used in many products, like the ones shown below, because it is lightweight, strong, and long lasting. It is used to make some parts of automobiles and aircraft, frames for eyeglasses, wheelchair parts, bicycles, golf clubs, and tennis rackets. It is used in hip or knee replacements. Titanium is a useful element that improves the lives of many humans.

Products Made from Titanium

Reading Check

4. **Describe** Where do vein mineral deposits form?

Think it Over

5. **Infer** Why might a tennis player use a racket made of titanium instead of one made of wood?

After You Read

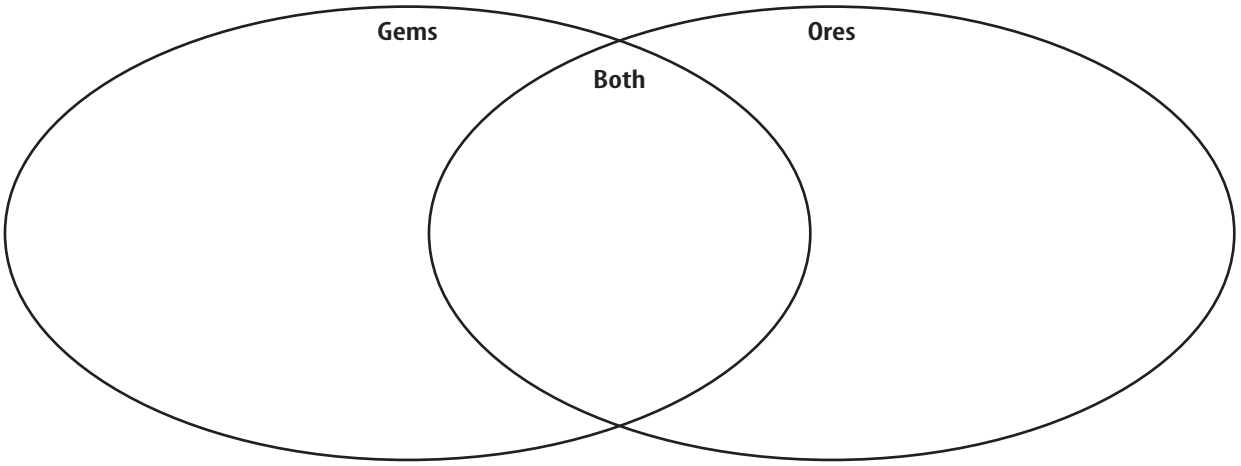
Mini Glossary

gem: valuable mineral that is both rare and beautiful, often used in jewelry

ore: mineral or rock that contains a useful substance that can be mined for profit

1. Review the terms and their definitions in the Mini Glossary. Why do people value gemstones?

2. Use the Venn diagram below to show how gems and ores are the same and how they are different. In the outside circles, write how each is different. In the center, write how they are both the same.



3. You and your partner talked about gems and ores. How did this help you understand what you read?

End of Section

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