

## CHAPTER 4 Rocks: Mineral Mixtures

## SECTION

## 1

## The Rock Cycle

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What is a rock?
- How are rocks classified?
- What does the texture of a rock reveal about how it was formed?

**National Science  
Education Standards**  
ES 1c, 1d

**Why Are Rocks Important?**

You know that you can recycle paper, aluminum, and plastic. Did you know that the Earth also recycles? One thing the Earth recycles is rock. A **rock** is a naturally occurring solid mixture of one or more minerals. Some rocks also contain the remains of living things.

Rock is an important resource for human beings. Early humans used rocks as hammers and other tools. They shaped rocks like chert and obsidian into spear points, knives, and scrapers. Rock is also used in buildings, monuments, and roads. The figure below shows how rock has been used as a building material in ancient and modern civilizations.



The ancient Egyptians used a rock called **limestone** to build the pyramids at Giza (left-hand figure). The Texas state capitol building in Austin is constructed of a rock called **granite** (right-hand figure).

It may seem like rocks never change, but this is not true. In fact, rocks are changing all the time. Most of these changes are slow, which is why it seems like rocks do not change. The processes by which new rocks form from older rock material is called the **rock cycle**.

**STUDY TIP**

**Describe** As you read this section, make a chart describing the processes of weathering, erosion, and deposition.

**TAKE A LOOK**

**1. Identify** What are two kinds of rocks that people have used for constructing buildings?

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**SECTION 1** The Rock Cycle *continued*

## What Processes Shape the Earth’s Surface?

Many different processes are part of the rock cycle. These processes shape the features of our planet. They form the mountains and valleys that we see around us. They also affect the types of rock found on the Earth’s surface.

**STANDARDS CHECK**

**ES 1c** Land forms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and deposition of sediment, while destructive forces include weathering and erosion.

**2. Explain** How does weathering shape the Earth’s surface?

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### WEATHERING, EROSION, AND DEPOSITION

*Weathering* happens when water, wind, ice, and heat break down rock into smaller fragments. These fragments are called *sediment*. Sediment can move over the Earth’s surface through erosion and deposition.

**Erosion** happens when water, wind, ice, or gravity move sediment over the Earth’s surface. Over time, sediment that has been eroded stops moving and is deposited. When sediment stops moving, it is called **deposition**. Sediment can be deposited in bodies of water and other low-lying areas.

### TAKE A LOOK

**3. Identify** Give two things that may have caused the weathering and erosion in Bryce Canyon.

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The rocks in Bryce Canyon, Utah, have been shaped by weathering and erosion. Although these processes can be slow, they can cause large changes in the Earth’s surface.

### HEAT AND PRESSURE

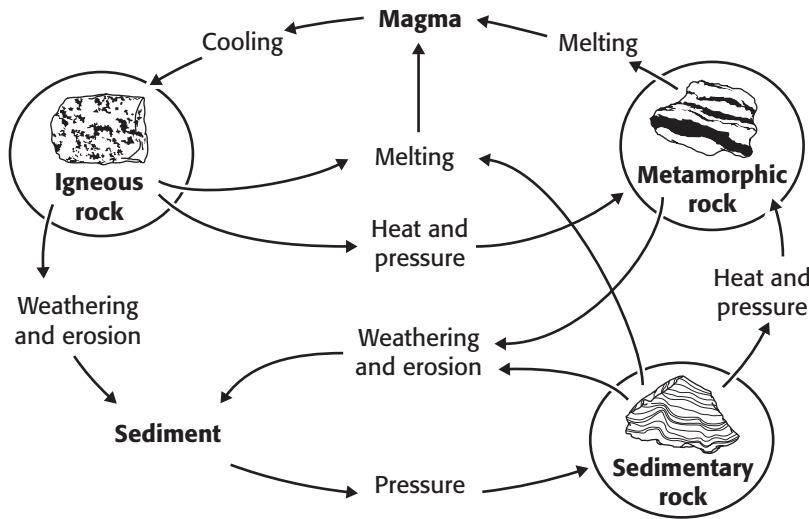
Rock can also form when buried sediment is squeezed by the weight of the layers above it. In addition, temperature and pressure can change the minerals in the rocks. In some cases, the rock gets hot enough to melt. This melting produces liquid rock, or *magma*. When the magma cools, it hardens to form new rock. The new rock contains different minerals than the rock that melted.

**SECTION 1** The Rock Cycle *continued*

**THE ROCK CYCLE**

Geologists put rocks into three main groups based on how they form. These groups are igneous rock, sedimentary rock, and metamorphic rock. *Igneous rock* forms when melted rock cools and hardens. *Sedimentary rock* is made of pieces of other rock (sediment). *Metamorphic rock* forms when heat and pressure change the chemical composition of a rock.

Remember that the rock cycle is made of all of the processes that make new rock out of older rock material. Weathering, erosion, deposition, heat, and pressure are some of the processes that are part of the rock cycle. The figure below shows how the processes in the rock cycle can change rocks from one kind to another.



As you can see, rocks do not have to follow a single path through the rock cycle. An igneous rock may be weathered to form sediment, which then forms sedimentary rock. The igneous rock could also melt and cool to form a new igneous rock.

The path that a rock takes through the rock cycle depends on the forces that act on the rock. These forces change depending on where the rock is located. For example, high pressures and temperatures below the Earth's surface can cause metamorphic rock to form.

*Critical Thinking*

**4. Compare** How are igneous rocks different from metamorphic rocks?

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**TAKE A LOOK**

**5. Use a Model** Find two paths through the rock cycle that lead from sedimentary rock to igneous rock. Use a colored pen or marker to trace both paths on the figure.

**SECTION 1** The Rock Cycle *continued*

## How Do Geologists Classify Rocks?

Remember that rocks can be divided into three groups based on how they form. Each main group of rock can be divided into smaller groups. These divisions are also based on the ways rocks form. For example, all igneous rock forms when magma cools and hardens. However, different kinds of igneous rock form when magma cools above the ground and when it cools underground.

Each kind of rock has specific features that make it different from other kinds of rock. Geologists can learn how a rock formed by studying its features. Two features that are especially helpful for classifying rocks are composition and texture

**READING CHECK**

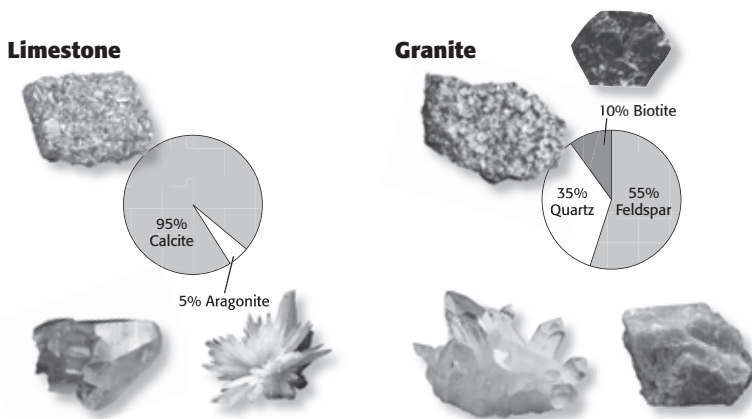
**6. Explain** How do geologists learn how a rock formed?

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### COMPOSITION

The combination of elements or compounds that make up a rock is the rock's **composition**. The minerals in a rock determine the rock's composition. For example, the sedimentary rock limestone is made mainly of the minerals calcite and aragonite. In contrast, the igneous rock granite contains the minerals feldspar, quartz, and biotite. These two rocks contain different minerals and have different compositions.



Limestone, a sedimentary rock, contains the minerals calcite and aragonite.

Granite, an igneous rock, contains the minerals biotite, feldspar, and quartz.

## Math Focus

**7. Calculate** Rock A contains 10% quartz and 45% calcite. The rest of the rock is mica. What percentage of the rock is mica?

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Composition can help geologists classify rocks. This is because different minerals form under different conditions. For example, remember that the mineral garnet forms under high temperatures and pressures. Therefore, a rock with garnet in it probably formed under high temperature and pressure. Such a rock is probably a metamorphic rock.

**SECTION 1** The Rock Cycle *continued*

**TEXTURE**

The sizes, shapes, and positions of the grains that make up a rock are the rock's **texture**. The texture of a rock can be affected by different things. The texture of a sedimentary rock is mainly affected by the sediment that formed it. For example, a sedimentary rock that forms from small sediment pieces will have a fine-grained texture. The figures below show some examples of sedimentary rock textures.

**Fine-grained**



Siltstone

Siltstone is made of tiny pieces of sediment, such as silt and clay. Therefore, it has a fine-grained texture. It feels smooth when you touch it.

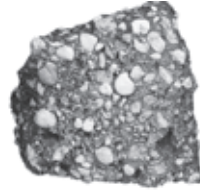
**Medium-grained**



Sandstone

Sandstone is made of pieces of sand. It has a medium-grained texture. It feels a bit rough, like sandpaper.

**Coarse-grained**



Conglomerate

Conglomerate is made of sediment pieces that are large, such as pebbles. Therefore, it has a coarse-grained texture. It feels bumpy.

**TAKE A LOOK**

**8. Explain** What determines the texture of a sedimentary rock?

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The texture of an igneous rock depends on how fast the melted rock cools. As melted rock cools, mineral crystals form. When melted rock cools quickly, only very small mineral crystals can form. Therefore, igneous rocks that cool quickly tend to have a fine-grained texture. When melted rock cools slowly, large crystals can form, which make a coarse-grained igneous rock.

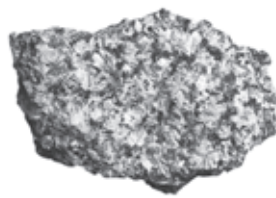
**Fine-grained**



Basalt

Basalt forms when melted rock cools quickly on the Earth's surface. It has a fine-grained texture because the mineral crystals in it are very small.

**Coarse-grained**



Granite

Granite forms when melted rock cools slowly underground. It has a coarse-grained texture because the mineral crystals in it are large.

**TAKE A LOOK**

**9. Describe** How does granite form?

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# Section 1 Review

NSES ES 1c, 1d

## SECTION VOCABULARY

<p><b>composition</b> the chemical makeup of a rock; describes either the minerals or other materials in the rock</p> <p><b>deposition</b> the process in which material is laid down</p> <p><b>erosion</b> the process by which wind, water, ice, or gravity transports soil and sediment from one location to another</p>	<p><b>rock</b> a naturally occurring solid mixture of one or more minerals or organic matter</p> <p><b>rock cycle</b> the series of processes in which rock forms, changes from one type to another, is destroyed, and forms again by geologic processes</p> <p><b>texture</b> the quality of a rock that is based on the sizes, shapes, and positions of the rock's grains</p>
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**1. Compare** What is the difference between weathering and erosion?

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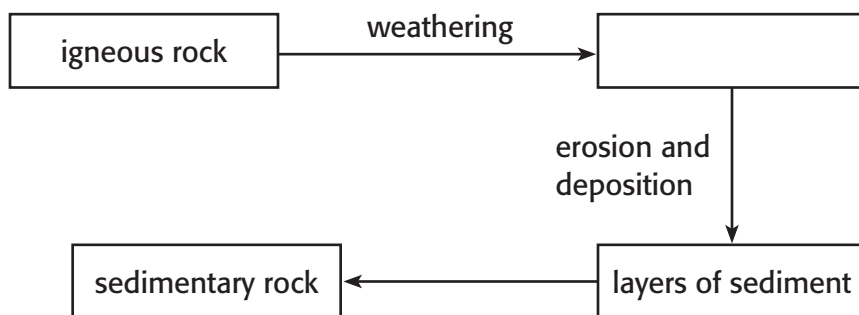


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**2. Identify** Complete the diagram to show how igneous rock can turn into sedimentary rock.



**3. List** What are two features that geologists use to classify rocks?

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**4. Describe** What determines the texture of an igneous rock?

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**5. Explain** How can a rock's composition help geologists to classify the rock?

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**CHAPTER 4** Rocks: Mineral Mixtures

**SECTION 2** **Igneous Rock**

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- How do igneous rocks form?
- What factors affect the texture of igneous rock?

**National Science Education Standards**  
ES 1c, 1d

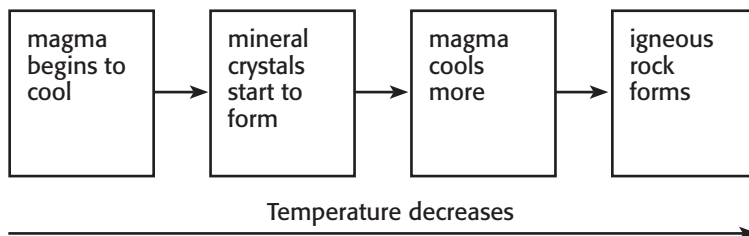
**How Does Igneous Rock Form?**

Igneous rocks form when hot, liquid rock, or *magma*, cools and hardens. There are three main ways that magma can form.

- An *increase in temperature*: when temperature increases, the minerals in a rock can melt.
- A *decrease in pressure*: hot rock can remain solid if it is under high pressure deep within the Earth. When the hot rock rises to the surface, the pressure goes down, and the rock can melt.
- An *addition of fluids*: when fluids, such as water, mix with rock, the melting temperature of the rock decreases and the rock can melt. ✓

When magma cools enough, mineral crystals form. This is similar to how water freezes. When you put water into the freezer, the water cools. When its temperature gets low enough, crystals of ice form. In the same way, crystals of different minerals can form as magma cools.

Water is made of a single compound. Therefore, all water freezes at the same temperature (0°C). However, magma is made of many different compounds. These compounds can combine to form different minerals. Each mineral becomes solid at a different temperature. Therefore, as magma cools, different parts of it become solid at different temperatures. Magma can become solid, or freeze, between 700°C and 1,250°C. ✓



**STUDY TIP**

**Compare** After you read this section, make a table comparing the properties of intrusive igneous rock and extrusive igneous rock.

**READING CHECK**

**1. Identify** Give three ways that magma can form.

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**READING CHECK**

**2. Explain** Why do different parts of magma become solid at different times?

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**SECTION 2** Igneous Rock *continued*

## How Do Geologists Classify Igneous Rocks?

Geologists group igneous rocks by how they form. Geologists use clues from the rocks' compositions and textures to guess how they formed.

### COMPOSITION

Based on composition, there are two main groups of igneous rocks—felsic rocks and mafic rocks. *Felsic* igneous rocks are rich in elements such as sodium, potassium, and aluminum. These elements combine to form light-colored minerals. Therefore, most felsic igneous rocks are light-colored. Granite and rhyolite are examples of felsic rocks.

*Mafic* igneous rocks are rich in elements such as iron, magnesium, and calcium. These elements combine to form dark-colored minerals. Therefore, most mafic igneous rocks are dark-colored. Gabbro and basalt are examples of mafic rocks.

### TEXTURE

Remember that the texture of a rock is determined by the sizes of the grains in the rock. The texture of an igneous rock depends on how fast the magma cooled.

When magma cools quickly, mineral crystals do not have time to grow very large. Therefore, the rock that forms has a fine-grained texture. When magma cools slowly, large mineral crystals can form. Therefore, the rock that forms has a coarse-grained texture.

## Critical Thinking

**3. Compare** Give two differences between felsic and mafic igneous rocks.

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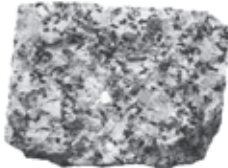

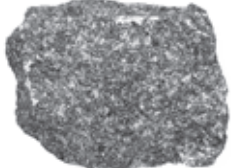

## TAKE A LOOK

**4. Identify** Give an example of a felsic, fine-grained igneous rock.

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**5. Identify** Give an example of a mafic, coarse-grained igneous rock.

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	Coarse-grained	Fine-grained
Felsic	 Granite	 Rhyolite
Mafic	 Gabbro	 Basalt

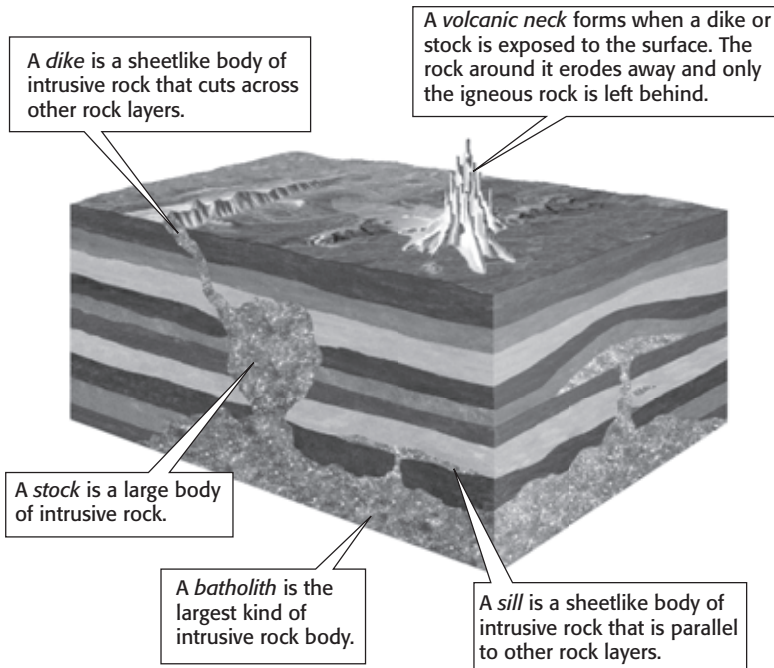
**SECTION 2** Igneous Rock *continued*

**Rock's Texture?**

Many people know that volcanoes form from melted rock. Therefore, they may think that igneous rocks only form at volcanoes on the Earth's surface. However, some igneous rocks form deep within the Earth's crust.

**INTRUSIVE IGNEOUS ROCKS**

**Intrusive igneous rock** forms when magma cools below the Earth's surface. Because the magma cools slowly, intrusive igneous rock usually has a coarse-grained texture. The minerals can grow into large, visible crystals. Bodies of intrusive igneous rock are grouped by their sizes and shapes. ✓



✓ **READING CHECK**

**6. Define** Write your own definition for intrusive igneous rock.

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**TAKE A LOOK**

**7. Identify** Give four kinds of intrusive rock bodies.

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**EXTRUSIVE IGNEOUS ROCKS**

Magma that reaches the Earth's surface is called *lava*. **Extrusive igneous rock** forms when lava cools. Extrusive igneous rock is common around volcanoes. Because extrusive rock cools quickly, it contains very small crystals or no crystals. ✓

When lava erupts from a volcano, it forms a *lava flow*. Lava flows can cover the land and bury objects on the Earth's surface.

Sometimes, lava erupts and flows along long cracks in Earth's crust called *fissures*. Many fissures are found on the ocean floor. Lava can also flow out of fissures onto land and form a *lava plateau*.

✓ **READING CHECK**

**8. Explain** Why do extrusive rocks have very small crystals or no crystals?

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# Section 2 Review

NSES ES 1c, 1d

## SECTION VOCABULARY

**extrusive igneous rock** rock that forms from the cooling and solidification of lava at the Earth's surface

**intrusive igneous rock** rock formed from the cooling and solidification of magma beneath the Earth's surface

**1. Compare** How are intrusive and extrusive igneous rocks different?

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**2. Identify** Give two examples of fine-grained igneous rocks.

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**3. Describe** How does a volcanic neck form?

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**4. Compare** What is the difference between a dike and a sill?

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**5. Predict** An igneous rock forms from slowly cooled magma deep beneath the surface of the Earth. Is the rock intrusive or extrusive? What type of texture does the rock probably have? Explain your answer.

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**6. Apply Concepts** Complete the table below. (Hint: What is the texture of each rock?)

Rock Name	Composition	Intrusive or Extrusive?
basalt	mafic	
gabbro	mafic	
granite	felsic	
rhyolite	felsic	

# Sedimentary Rock

## BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- How do sedimentary rocks form?
- How do geologists classify sedimentary rocks?
- What are some sedimentary structures?

**National Science Education Standards**  
ES 1c, 1d

## How Does Sedimentary Rock Form?

Remember that wind, water, ice, and gravity can cause rock to break down into fragments. These fragments are called *sediment*. During erosion, sediment is moved across the Earth's surface. Then the sediment is deposited in layers on the Earth's surface. As new layers are deposited, they cover older layers. The weight of the new layers *compacts*, or squeezes, the sediment in the older layers.

Water within the sediment layers can contain dissolved minerals, such as calcite and quartz. As the sediment is compacted, these minerals can crystallize between the sediment pieces. The minerals act as a natural glue and hold the sediment pieces together. As the loose sediment grains become bound together, a kind of sedimentary rock forms.

Unlike igneous and metamorphic rocks, sedimentary rock does not form at high temperatures and pressures. Sedimentary rock forms at or near the Earth's surface. ✓

Sediment is deposited in layers. Therefore, most sedimentary rocks contain layers called **strata** (singular, *stratum*).



These "monuments" in Monument Valley, Arizona, formed as sedimentary rock eroded over millions of years.

## STUDY TIP

**Reading Organizer** As you read this section, create an outline of this section using the headings from this section.

## Say It

**Infer and Discuss** In what kinds of areas are you likely to find sediment? Write down four places that sediment can be found. Think about the size of the sediment pieces that may be found at each place. Then, discuss your ideas with a small group.

## READING CHECK

**1. Describe** Where does sedimentary rock form?

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**SECTION 3** Sedimentary Rock *continued*

### How Do Geologists Classify Sedimentary Rock?

Like other kinds of rock, sedimentary rock is classified by how it forms. Some sedimentary rock forms when rock or mineral fragments are stuck together. Some forms when minerals crystallize out of water. Other sedimentary rock forms from the remains of plants and animals.

#### CLASTIC SEDIMENTARY ROCK

Most sedimentary rock is clastic sedimentary rock. *Clastic sedimentary rock* forms when fragments of other rocks are cemented together. In most cases, the cement is a mineral such as calcite or quartz. The sediment pieces in different rocks can be of different sizes. Geologists group clastic sedimentary rocks by the sizes of the sediment pieces in them. ✓

**READING CHECK**

**2. Identify** Give two minerals that can act as cement in sedimentary rocks.

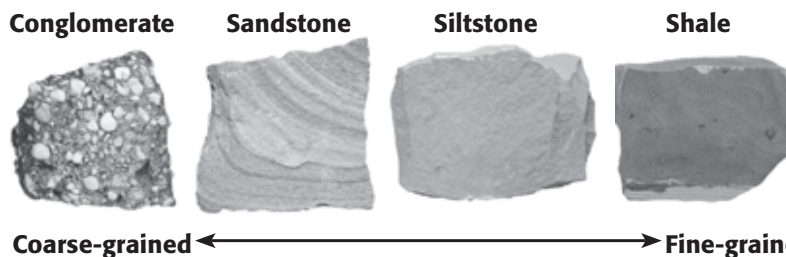
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#### TAKE A LOOK

**3. Describe** What is the texture of conglomerate?

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Coarse-grained sedimentary rocks, such as conglomerate, contain large sediment pieces. Fine-grained rocks, such as shale, are made of tiny sediment pieces.

#### CHEMICAL SEDIMENTARY ROCK

*Chemical sedimentary rock* forms when minerals crystallize out of water. Water moves over rocks on the Earth's surface. As the water moves, it dissolves some of the minerals in the rocks. When the water evaporates, the dissolved minerals can crystallize to form chemical sedimentary rocks. ✓

Many chemical sedimentary rocks contain only one or two kinds of mineral. For example, evaporite is a chemical sedimentary rock. Evaporite is made mainly of the minerals halite and gypsum. These minerals crystallize when water evaporates.

**READING CHECK**

**4. Explain** How do chemical sedimentary rocks form?

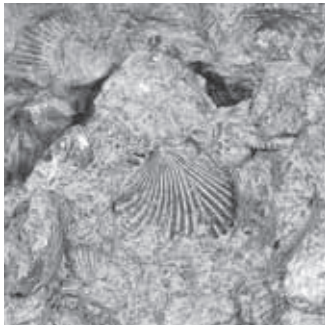
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**SECTION 3** Sedimentary Rock *continued***ORGANIC SEDIMENTARY ROCK**

*Organic sedimentary rock* forms from the remains of plants and animals. Coal is one type of organic sedimentary rock. Coal forms from plant material that has been buried deep underground. Over millions of years, the buried plant material turns into coal.

Some organic sedimentary rock forms from the remains of sea creatures. For example, some limestone is made from the skeletons of creatures called *coral*. Coral are tiny creatures that make hard skeletons out of calcium carbonate. These skeletons and the shells of other sea creatures can be glued together to form *fossiliferous limestone*.



The shells of sea creatures can be cemented together to form fossiliferous limestone.

**TAKE A LOOK**

**5. Define** What is fossiliferous limestone?

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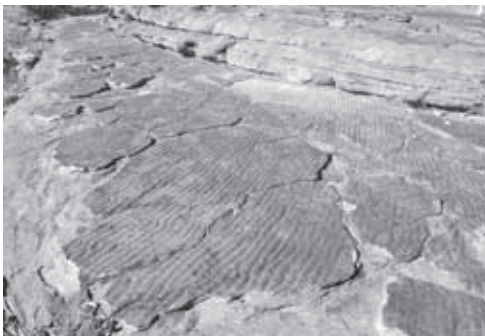


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**What Are Some Features of Sedimentary Rock?**

The features of sedimentary rocks can give you clues about how the rocks formed. For example, many clastic sedimentary rocks show **stratification**. This means that they contain strata. Clastic sedimentary rocks show stratification because sediment is deposited in layers. ✓

Some sedimentary rock features show the motions of wind and water. For example, some sedimentary rocks show ripple marks or mud cracks. *Ripple marks* are parallel lines that show how wind or water has moved sediment. *Mud cracks* form when fine-grained sediment dries out and cracks.



These ripple marks show how sediment was moved by flowing water.

**READING CHECK**

**6. Explain** Why do many clastic sedimentary rocks show stratification?

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# Section 3 Review

NSES ES 1c, 1d

## SECTION VOCABULARY

<b>strata</b> layers of rock (singular, <i>stratum</i> )	<b>stratification</b> the process in which sedimentary rocks are arranged in layers
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**1. Define** Write your own definition for stratification.

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**2. List** Give three examples of clastic sedimentary rocks.

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**3. Compare** How are clastic and organic sedimentary rocks different?

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**4. Describe** How does evaporite form?

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**5. Describe** How does fossiliferous limestone form?

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**6. Infer** Imagine that a geologist finds a sedimentary rock with ripple marks in it. What can the geologist guess about the environment in which the sediment was deposited? Explain your answer.

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SECTION 4 **Metamorphic Rock**

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- How do metamorphic rocks form?
- How do geologists classify metamorphic rocks?

**National Science Education Standards**  
ES 1c

**How Does Metamorphic Rock Form?**

*Metamorphic* rock forms when the chemical composition of a rock changes because of heat and pressure. This change is called *metamorphism*. Metamorphism can happen to any kind of rock.

Most metamorphism happens at temperatures between 150°C and 1,000°C. Some metamorphism happens at even higher temperatures. Many people think that all rocks must melt at such high temperatures. However, these rocks are also under very high pressure, so they do not melt.

High pressure can keep a hot rock from melting. Even very hot rocks may not melt if the pressure is high. Instead of melting, the minerals in the rock react with each other to form new minerals. In this way, the composition of the rock can change, even though the rock remains solid. ✓

High pressure can also affect the minerals in a rock. It can cause minerals to react quickly. It can also cause minerals to move slowly through the rock. In this way, different minerals can separate into stripes in the rock. The figure below shows an example of these stripes.



The bands in this metamorphic rock formed as molecules of different minerals moved together.

**STUDY TIP**

**Ask Questions** Read this section quietly to yourself. As you read, write down any questions you have. When you finish reading, try to figure out the answer to your questions in a small group.

**READING CHECK**

**1. Describe** How does the composition of a rock change during metamorphism?

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**TAKE A LOOK**

**2. Identify** How did the bands in the rock in the figure form?

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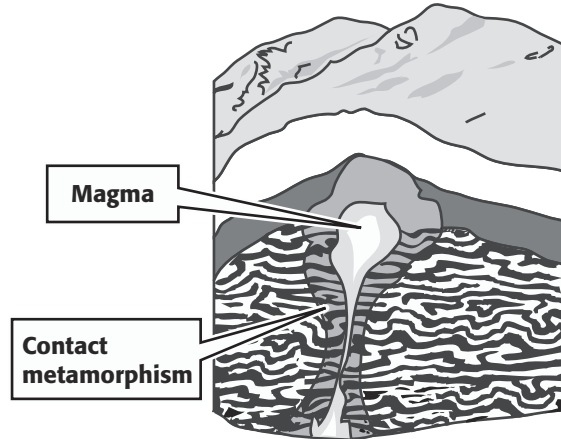
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**SECTION 4** Metamorphic Rock *continued*

**CONTACT METAMORPHISM**

There are two main ways that rock can go through metamorphism—contact metamorphism and regional metamorphism. *Contact metamorphism* happens when rock is heated by nearby magma. As the magma moves through the crust, the rocks in the crust heat up. The minerals in those rocks can react to produce new minerals.



Contact metamorphism happens when magma heats nearby rock.

**TAKE A LOOK**

**3. Define** What is contact metamorphism?

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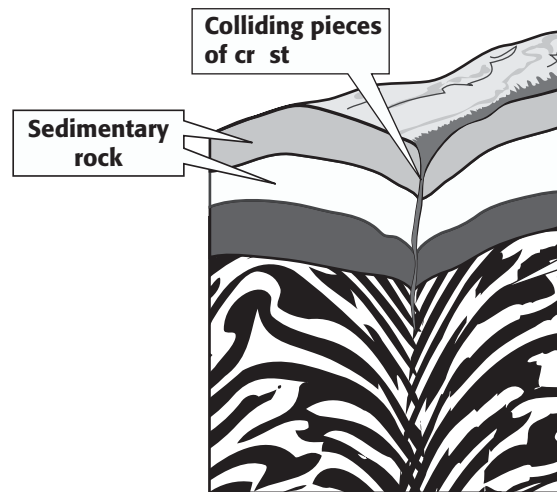
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Rock that is very near the magma changes the most during contact metamorphism. The farther the rock is from the magma, the smaller the changes. This is because the temperature decreases with distance from the magma. Contact metamorphism usually only affects rock in a small area.

**REGIONAL METAMORPHISM**

During *regional metamorphism*, high pressures and temperatures cause the rock in a large area to change. Regional metamorphism can happen where rock is buried deep below the surface or where pieces of the Earth's crust collide.



**Regional metamorphism**

Regional metamorphism happens when rock changes because of high pressures and temperatures.

**TAKE A LOOK**

**4. Describe** Give two places where regional metamorphism can happen.

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**SECTION 4** Metamorphic Rock *continued*

**METAMORPHIC STRUCTURES**

Both contact and regional metamorphism can cause deformation. *Deformation* is a change in the shape of a rock. When forces act on a rock, they may cause the rock to be squeezed or stretched.

*Folds* are features of a rock that show that the rock has been deformed. Some folds are so small that they can only be seen with a microscope. Other folds, like the ones below, are visible to the naked eye.



These folds formed during metamorphism. The rocks in this picture are found in Labrador, Canada.

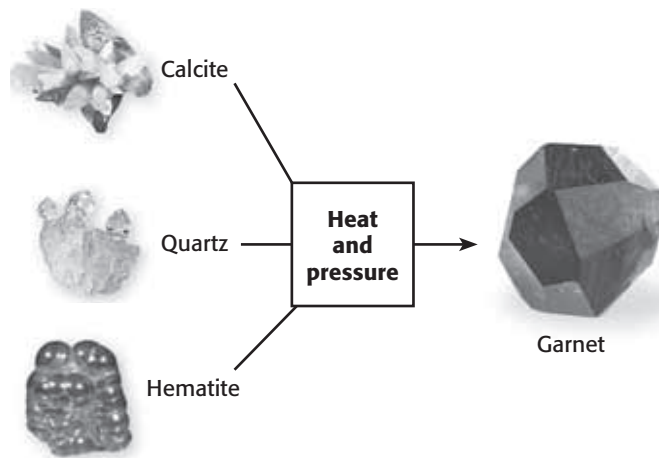
**TAKE A LOOK**

**5. Infer** Were these folds probably caused by squeezing the rock or by stretching it?

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**What Are Metamorphic Rocks Made Of?**

Remember that different minerals form under different conditions. Minerals that form near the Earth’s surface, such as calcite, may not be stable under higher temperatures and pressures. During metamorphism, these minerals are likely to react and produce new minerals. The new minerals are stable under high temperatures and pressures. The figure below shows how new minerals can form from unstable minerals.



Calcite, quartz, and hematite are not stable under high temperatures and pressures. They react to form garnet in metamorphic rocks.

*Critical Thinking*

**6. Predict** The mineral gypsum forms at low temperatures and pressures. The mineral sillimanite forms at high temperatures and pressures. Which mineral would most likely be found in a metamorphic rock? Explain your answer.

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**SECTION 4** Metamorphic Rock *continued*

**Critical Thinking**

**7. Infer** Why can't geologists use minerals like quartz to determine the temperature and pressure that a rock formed at?

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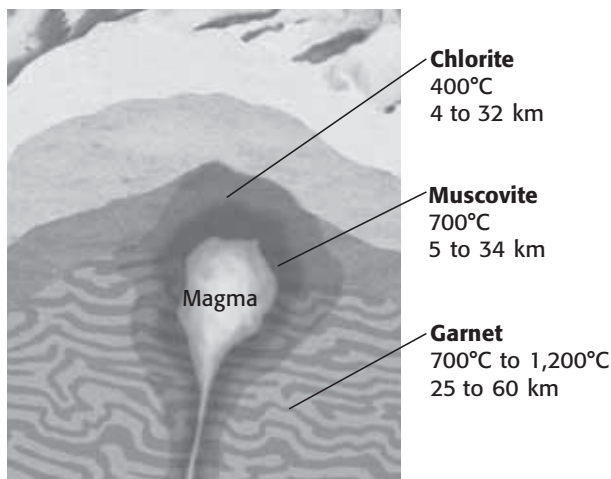
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**INDEX MINERALS**

Some minerals, such as quartz, can form at many different temperatures and pressures. Other minerals, such as garnet, form only at certain temperatures and pressures. Therefore, rocks that contain minerals like garnet probably also formed at those temperatures and pressures. Geologists can use such minerals as index minerals.

*Index minerals* can indicate the temperature and pressure or depth at which a rock formed. These minerals help geologists learn the temperature and pressure at which a rock formed. Chlorite, muscovite, and garnet are index minerals for metamorphic rocks.



Geologists can use some minerals as index minerals. These minerals help geologists learn the temperature and pressure at which a rock formed. For example, a rock containing garnet most likely formed at a higher temperature and pressure than a rock containing chlorite.

**TAKE A LOOK**

**8. Identify** Which index mineral in the figure forms at the lowest temperature?

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**How Do Geologists Classify Metamorphic Rocks?**

Texture is an important feature that is used in classifying metamorphic rock. The texture of a metamorphic rock refers to the arrangement of the minerals in the rock. All metamorphic rocks have one of two textures—foliated or nonfoliated.

**FOLIATED METAMORPHIC ROCK**

In a **foliated** metamorphic rock, the minerals are arranged in stripes or bands. Most foliated rocks contain crystals of flat minerals, such as mica. These crystals are lined up with each other and form the bands in the rock. ✓

The figure on the next page shows how one kind of foliated rock, gneiss, can form. Gneiss may start out as the sedimentary rock shale. Heat and pressure can change shale to slate, phyllite, schist, or gneiss.

**READING CHECK**

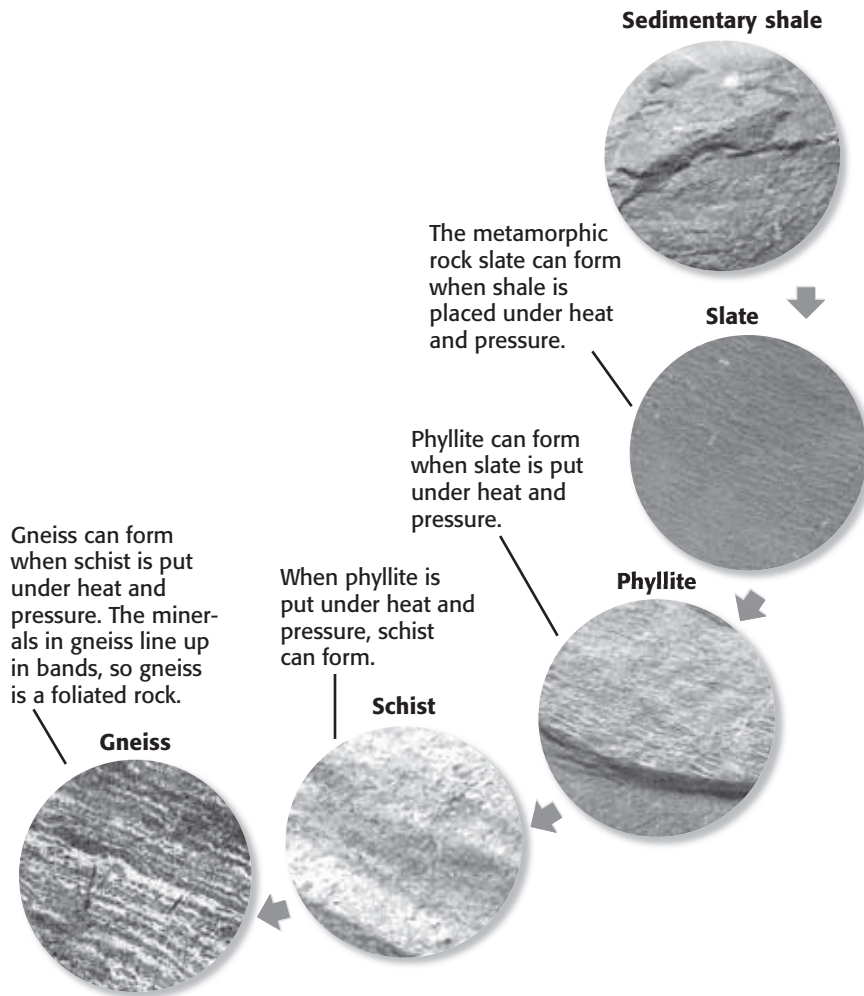
**9. Define** What is a foliated metamorphic rock?

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**SECTION 4** Metamorphic Rock *continued*



**TAKE A LOOK**

**10. Infer** Which rock in the figure has been put under the most heat and pressure?

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**UNFOLIATED METAMORPHIC ROCK**

In a **nonfoliated** metamorphic rock, the mineral crystals are not arranged in bands or stripes. Most nonfoliated rocks are made of only a few minerals. Metamorphism can cause the mineral crystals in a rock to get bigger. ✓

Quartzite is an example of a nonfoliated metamorphic rock. Quartzite can form from the sedimentary rock quartz sandstone. Quartz sandstone is made of grains of quartz sand that have been cemented together. The quartz crystals in these grains can grow larger during metamorphism. The quartz crystals in quartzite can be much larger than those in quartz sandstone.

**READING CHECK**

**11. Describe** What can happen to the sizes of mineral crystals during metamorphism?

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Type of Metamorphic Rock	Description	Example
Foliated		gneiss
Nonfoliated		quartzite

**TAKE A LOOK**

**12. Define** Fill in the blank spaces in the table.

# Section 4 Review

NSES ES 1c

## SECTION VOCABULARY

**foliated** describes the texture of metamorphic rock in which the mineral grains are arranged in planes or bands

**nonfoliated** describes the texture of metamorphic rock in which the mineral grains are not arranged in planes or bands

**1. Compare** How are foliated metamorphic rocks different from nonfoliated metamorphic rocks?

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**2. Define** What is regional metamorphism?

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**3. Describe** What is an index mineral? Give two examples of index minerals for metamorphic rocks.

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**4. Explain** How do index minerals help geologists?

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**5. Describe** How does quartzite form?

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**6. Apply Concepts** A geologist finds two metamorphic rocks. One contains chlorite. The other contains garnet. Which rock probably formed at the greatest depth? Explain your answer.

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