3.3 Sedimentary Rocks

Reading Focus

Key Concepts

- Describe the major processes involved in the formation of sedimentary rocks.
- What are clastic sedimentary rocks?
- What are chemical sedimentary rocks?
- What features are unique to some sedimentary rocks?

Vocabulary

- erosion
- deposition
- compaction
- cementation
- clastic sedimentary rock
- chemical sedimentary rock

Reading Strategy

Outlining Copy this outline beneath the outline you made for Section 3.2. Complete this outline as you read. Include points about how each of these rocks form, some of the characteristics of each rock type, and some examples of each.

II. Sedimentary Rocks
  A. Clastic Rocks
    1. ____?____
    2. ____?____
  B. Chemical Rocks
    1. ____?____
    2. ____?____

All sedimentary rocks begin to form when existing rocks are broken down into sediments. Sediments, which consist mainly of weathered rock debris, are often transported to other places. When sediments are dropped, they eventually become compacted and cemented to form sedimentary rocks. The structures shown in Figure 9 are made of the sedimentary rock called sandstone. It is only one of many types of sedimentary rocks.

Figure 9 Sedimentary Rocks in Canyonlands National Park, Utah The rocks shown here formed when sand and other sediments were deposited and cemented. Weathering processes created this arch.

Section 3.3

1 FOCUS

Section Objectives

3.8 **Describe** the major processes involved in the formation of sedimentary rocks.

3.9 **Distinguish** between clastic sedimentary rocks and chemical sedimentary rocks.

3.10 **Identify** the features that are unique to some sedimentary rocks.

Reading Focus

Build Vocabulary

L2

LINCS Have students **L**ist the parts of the vocabulary words that they know. For example, *cement* is part of *cementation*. Next, they should **I**magine a mental picture of the term's meaning and describe the image in their own words. Sediments held together by cement might be an image for cementation. Students should then make a **N**ote of a familiar "sound-alike" word. They can **C**onnect the terms by making up a short story about the meaning of the term that incorporates the sound-alike word. Lastly, students should conduct a **S**elf-test by quizzing themselves on the vocabulary terms.

Reading Strategy

L2

A.1. rock made up of weathered bits of rocks and minerals
A.2. Common example of clastic sedimentary rock is shale.
B.1. rock that forms when dissolved minerals precipitate from water
B.2. Common example of chemical sedimentary rock is limestone.

2 INSTRUCT

Build Reading Literacy L1

Refer to **p. 64D** in **Chapter 3**, which provides the guidelines for directed reading/thinking activity (DRTA).

DRTA Before students read this section, have them preview the key concepts, vocabulary terms, and headings. Ask: **What do you think you will learn in this section?** *(Sample answer: about sedimentary rock formation, clastic sedimentary rocks, and chemical sedimentary rocks)* **What type of questions might a teacher ask about this topic?** *(Sample answer: How do sedimentary rocks form? How are sedimentary rocks classified?)* List these questions on the board. As students read the section, pause to discuss the answers to the questions.
Verbal

Formation of Sedimentary Rocks

Address Misconceptions L2

Some students may think that rocks are stronger than the agents of mechanical and chemical weathering. To help dispel this misconception, place a few drops of vinegar on a sample of limestone. Have students observe the resulting chemical reaction. Ask: **What do you think would happen if the acid continued to drip on the rock over a long period?** (*The rock would eventually break down or be chemically weathered.*)
Visual, Logical

Build Science Skills L2

ACTIVITY

Observing Provide small groups of students with 250-mL beakers, stirrers, sand, water, gravel, and soil. Tell students to half-fill the beakers with water. They should then pour about a handful of each material into the water. Have them stir the mixture, then observe what happens to the materials. Ask: **Which materials settled on the bottom? Which settled on the top?** *(The heavier materials settled on the bottom; the smaller, lighter materials settled on the top.)* **What does this activity model?** *(the settling out of sediments from a fluid, such as water or air)*
Kinesthetic, Visual

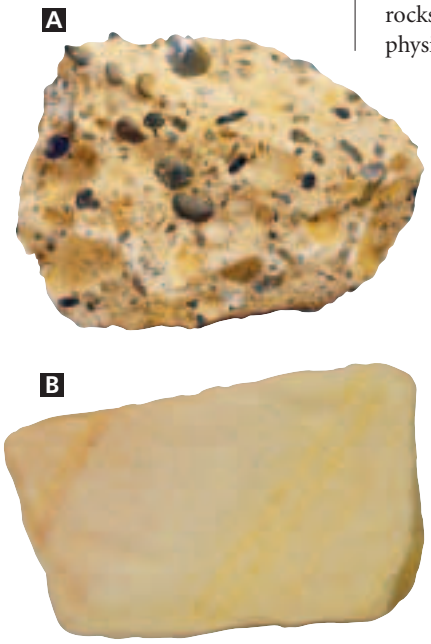


Figure 10 Although these two rocks appear quite different, both formed when sediments were dropped by moving water. **A** Conglomerate is made of rounded pebbles cemented together. **B** Sandstone is made of sand grains cemented together.

Formation of Sedimentary Rocks

The word *sedimentary* comes from the Latin word *sedimentum*, which means "settling." Sedimentary rocks form when solids settle out of a fluid such as water or air. The rocks shown in Figure 10 formed when sediments were dropped by moving water. The sediments eventually became cemented to form rocks. Several major processes contribute to the formation of sedimentary rocks.

Weathering, Erosion, and Deposition Recall that weathering is any process that breaks rocks into sediments. Weathering is often the first step in the formation of sedimentary rocks. Chemical weathering takes place when the minerals in rocks change into new substances. Weathering also takes place when physical forces break rocks into smaller pieces. Living things, too, can cause chemical and physical weathering.

Weathered sediments don't usually remain in place. Instead, water, wind, ice, or gravity carries them away. **Erosion involves weathering and the removal of rock. When an agent of erosion—water, wind, ice, or gravity—loses energy, it drops the sediments. This process is called deposition.** Sediments are deposited according to size. The largest sediments, such as the rounded pebbles in the conglomerate in Figure 10A, are deposited first. Smaller sediments, like the pieces of sand that make up the sandstone in Figure 10B, are dropped later. Some sediments are so small that they are carried great distances before being deposited.

Compaction and Cementation After sediments are deposited, they often become lithified, or turned to rock. **Compaction** and **cementation** change sediments into sedimentary rock. **Compaction is a process that squeezes, or compacts, sediments.** Compaction is caused by the weight of sediments. During compaction, much of the water in the sediments is driven out.

Cementation takes place when dissolved minerals are deposited in the tiny spaces among the sediments. Much of the cement in the conglomerate shown in Figure 10A can be seen with the unaided eye. The cement holding the sand grains together in the sandstone in Figure 10B, however, is microscopic.

Reading Checkpoint *Briefly describe the five major processes involved in the formation of sedimentary rocks.*

Customize for English Language Learners

Compile a classroom library using up-to-date magazines and newspaper articles. Select reading materials that correspond to chapter content. For example, try to find articles that discuss different types of rocks. Avoid academic journals and reference materials with high reading levels. Provide opportunities for ELL students to read the articles in class. This will give them a broader context in which to place this chapter's vocabulary terms and key concepts.

Classification of Sedimentary Rocks

Just like igneous rocks, sedimentary rocks can be classified into two main groups according to the way they form. The first group includes rocks that are made of weathered bits of rocks and minerals. These rocks are called **clastic sedimentary rocks.** The second group forms when dissolved minerals precipitate from water solutions. These rocks are called **chemical sedimentary rocks.**

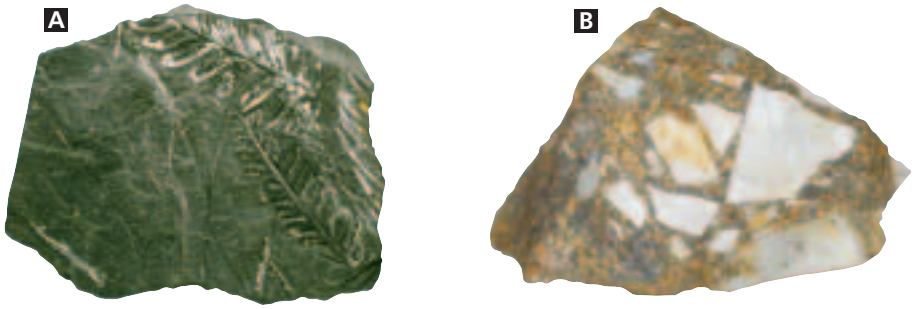


Figure 11 **A** Shale and **B** breccia are common clastic sedimentary rocks. This sample of shale contains plant fossils.
Formulating Hypotheses ***How do you think this breccia might have formed?***

Clastic Sedimentary Rocks

Many different minerals are found in clastic rocks. The most common are the clay minerals and quartz. This is because clay minerals, like those that make up much of the shale in Figure 11A, are the most abundant products of chemical weathering. Quartz, which is a major mineral in the breccia shown in Figure 11B, is a common sedimentary mineral for a different reason. It is very durable and resistant to chemical weathering.

Clastic sedimentary rocks can be grouped according to the size of the sediments in the rocks. When rounded, gravel-size or larger particles make up most of the rock, the rock is called conglomerate. If the particles are angular, the rock is called breccia. Sandstone is the name given to rocks when most of the sediments are sand-size grains. Shale, the most common sedimentary rock, is made of very fine-grained sediment. Siltstone is another fine-grained rock.

Reading Checkpoint *Describe the major types of clastic sedimentary rocks.*

Chemical and Biochemical Sedimentary Rocks

Chemical sedimentary rocks form when dissolved substances precipitate, or separate, from water solution. This precipitation generally occurs when the water evaporates or boils off leaving a solid product. Examples of this type of chemical rock are some limestones, rock salt, chert, flint, and rock gypsum.

Go Online NSTA SciLinks
For: Links on sedimentary rocks
Visit: www.SciLinks.org
Web Code: cjn-1034

Classification of Sedimentary Rocks

Teacher Demo

Chemical Weathering L2

Purpose Students will observe how chemical weathering can change the minerals in rocks.

Materials calcium tablet, 250-mL beaker, vinegar

Procedure Half-fill the beaker with vinegar. Place the calcium tablet into the vinegar. Allow students to observe the reaction.

Expected Outcome Students will observe that the calcium fizzes, foams, and eventually dissolves in the vinegar. Explain that chemical weathering breaks down rocks in a similar, though slower, fashion.
Visual

Go Online NSTA SciLinks

Download a worksheet on sedimentary rocks for students to complete, and find additional teacher support from NSTA SciLinks.

Answer to . . .

Figure 11 *Rocks were weathered. The larger fragments were deposited. Fine-grained sediments were deposited later. Little compaction occurred because of the size of the angular sediments. Dissolved minerals entered the spaces among the sediments and held them together to form the breccia.*

Reading Checkpoint *Weathering breaks existing rocks into smaller pieces. Erosion is the process whereby sediments are moved from place to place. Deposition occurs when sediments are dropped by erosional agents. Compaction is the process of squeezing sediments. Cementation is a process that "glues" sediments together to form sedimentary rocks.*

Reading Checkpoint *Conglomerates and breccias are made mostly of gravel-sized sediments. Sandstone is made mostly of sand-size grains. Shale and siltstone are fine-grained rocks in which clay-size or smaller particles are the major components.*

Build Science Skills

L2

Designing Experiments

Have students work in small groups to design an experiment to show how sedimentary rocks form when dissolved minerals precipitate from water. Students should develop a hypothesis and procedure, listing controls, safety measures, and materials to be used. A sample experiment might involve placing table salt in water, then heating the water until it evaporates. If time permits, allow students to carry out their experiments. **Logical, Interpersonal**

Features of Some Sedimentary Rocks

Use Visuals

L1

Figure 13 Ask: **Based on its appearance, what can you infer about the rock labeled A?** *(It may have formed along a beach or stream bed.)* **What can you infer about the rock labeled B?** *(It may have formed when wet mud or clay dried and shrank.)* **Visual**

Figure 12 This biochemical rock, called coquina, is a type of limestone that is made of hundreds of shell fragments.

About 90 percent of limestones are formed from biochemical sediments. Such sediments are the shells and skeletal remains of organisms that settle to the ocean floor. The coquina in Figure 12 is one obvious example. You can actually see the shells cemented together. Another biochemical rock is chalk, the material used to write on a chalkboard.

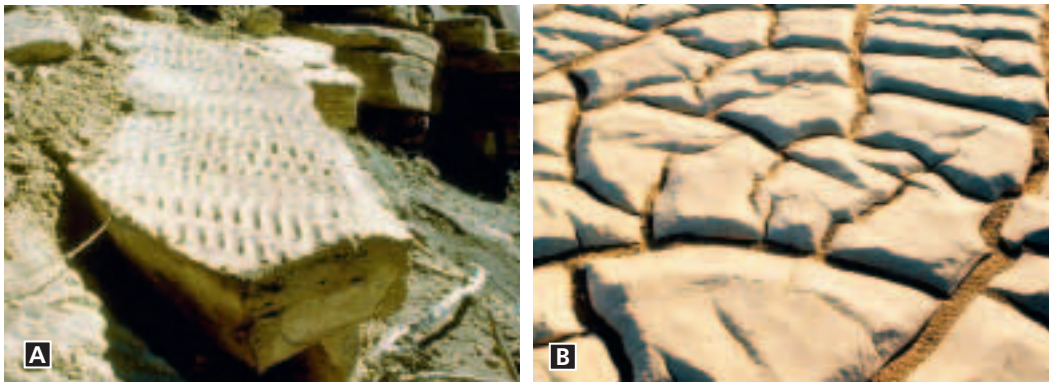
Features of Some Sedimentary Rocks

Sedimentary rocks, like other types of rocks, are used to unravel what may have happened in Earth's long history. **The many unique features of sedimentary rocks are clues to how, when, and where the rocks formed.** Each layer of a sedimentary rock, for example, records a period of sediment deposition. In undisturbed rocks, the oldest layers are found at the bottom. The youngest layers are found at the top of the rocks. Ripple marks like the ones shown in Figure 13A may indicate that the rock formed along a beach or stream bed. The mud cracks in Figure 13B formed when wet mud or clay dried and shrank, leaving a rock record of a dry environment.

Fossils, which are the traces or remains of ancient life, are unique to some sedimentary rocks. Fossils can be used to help answer many questions about the rocks that contain them. For example, did the rock form on land or in the ocean? Was the climate hot or cold, rainy or dry? Did the rock form hundreds, thousands, millions, or billions of years ago? Fossils also play a key role in matching up rocks from different places that are the same age.

To summarize, sedimentary rocks are rocks that form as the result of four major processes. *Weathering* produces particles called sediments. Wind, water, ice, and gravity *erode* and *deposit* these sediments. Over time, the sediments are *compacted and cemented* to form rocks. Sedimentary rocks can be classified according to how they form. A general classification scheme based on a rock's formation, texture, and composition is shown in Table 2.

Figure 13 **A** Ripple marks and **B** mud cracks are features of sedimentary rocks that can be used to learn about the environments in which the rocks formed.



Facts and Figures

Unlike other chemical sedimentary rocks, which are rich in calcite or silica, coal is made mostly of organic matter. When coal is viewed under a magnifying glass, chemically altered leaves, bark, and wood are visible. The materials provide evidence that coal is the end product of the burial of large amounts of plant materials over long periods of time. The initial stage of coal formation is the accumulation of large quantities of plant remains in a swampy environment. Coal then undergoes successive stages of formation. With each stage, higher temperatures and pressures drive off impurities and volatiles.

Table 2 Classification of Major Sedimentary Rocks

Clastic Sedimentary Rocks			
Texture (grain size)		Sediment Name	Rock Name
Coarse (over 2 mm)		Gravel (rounded fragments)	Conglomerate
		Gravel (angular fragments)	Breccia
Medium (1/16 to 2 mm)		Sand	Sandstone
Fine (1/16 to 1/256 mm)		Mud	Siltstone
Very fine (less than 1/256 mm)		Mud	Shale

Chemical Sedimentary Rocks			
Composition	Texture (grain size)	Rock Name	
Calcite, $CaCO_3$	Fine to coarse crystalline	Crystalline Limestone	
		Travertine	
	Visible shells and shell fragments loosely cemented	Coquina	Biochemical Limestone
	Various size shells and shell fragments cemented with calcite cement	Fossiliferous Limestone	
	Microscopic shells and clay	Chalk	
Quartz, SiO_2	Very fine crystalline	Chert (light colored) Flint (dark colored)	
Gypsum $CaSO_4 \cdot 2H_2O$	Fine to coarse crystalline	Rock Gypsum	
Halite, NaCl	Fine to coarse crystalline	Rock Salt	
Altered plant fragments	Fine-grained organic matter	Bituminous Coal	

Section 3.3 Assessment

Reviewing Concepts

1. Contrast weathering, erosion, and deposition.
2. Name four clastic sedimentary rocks and explain how these rocks form.
3. Name four chemical sedimentary rocks and explain how these rocks form.
4. Explain how three different features of sedimentary rocks can be used to determine how, where, or when the rocks formed.
5. What is compaction?
6. Where do the cements that hold sediments together come from?

Critical Thinking

7. **Applying Concepts** Briefly describe how the rock shown in Figure 12 may have formed.
8. **Predicting** Which type of sediments do you think would undergo more compaction—grains of sand or grains of clay? Explain your choice.
9. **Formulating Conclusions** Suppose you found a sedimentary rock in which ripple marks were pointing toward the ground. What could you conclude about the rock?

Connecting Concepts

Sedimentary Rocks Choose one of the sedimentary rocks pictured in this section. Find out how the rock is useful to people.

Use Visuals

L1

Table 2 Ask: **How does the texture of gravel compare with that of sand?** *(Gravel has a coarse texture; grain size is more than 2 mm. Sand has a medium texture; grain size is 1/16 to 2 mm.)* **What type of detrital sedimentary rock has a very fine texture?** *(shale)* **What is the chemical composition of chalk?** *(calcite)* **Which chemical sedimentary rock is made up of halite?** *(rock salt)*
Visual

3 ASSESS

Evaluate Understanding

L2

Give students samples of sandstone, siltstone, shale, breccia, and conglomerate. Have them use magnifying glasses to classify the rocks according to grain size.

Reteach

L1

Review Table 2. As you discuss the different types of textures and chemical compositions, explain how each sedimentary rock likely formed.

Connecting Concepts

Sample answer: Shale is used in construction. Coal is used as an energy resource.

Section 3.3 Assessment

1. Weathering is any process in which rocks are broken down into smaller pieces. Erosion involves the weathering and removal of sediments. Deposition is the dropping of sediments by agents of erosion.
2. Conglomerate, breccia, sandstone, shale, and siltstone are clastic rocks. Clastic rocks form when bits of weathered materials are compacted and cemented together.
3. Most limestones, rock salt, rock gypsum, flint, and chert are chemical sedimentary rocks that form when dissolved minerals precipitate from water.
4. Each layer of a sedimentary rock records a period of deposition. Ripple marks indicate that a rock bed formed in water. Mud cracks are indicative of unusually dry periods. Fossils can be used to determine if a rock formed on land or in the ocean, if the climate was hot or cold, or rainy or dry, and when the rock containing them formed.
5. Compaction is the process that squeezes, or compacts, sediments.
6. Cements are dissolved minerals that are deposited in the tiny places among the sediments.
7. Animals with shells died. The shells accumulated and became cemented to form a sedimentary rock.
8. Because they are smaller, clay particles undergo more compaction than sand-size particles.
9. Ripple marks indicate that a rock formed in water. And, because the ripple marks were pointing down, one can infer that the rock has been overturned from its original position.