Chapter 11
Water and Weathering

In Unit 2, you learned about energy in the Earth system. In Unit 3, you learned about plate tectonics, earthquakes, and volcanoes. These are examples of Earth systems that are driven by internal energy—energy that comes from the heat of Earth's core. This chapter describes how rock is weathered (broken down) and moved from place to place by water. These processes are driven by external energy—energy from the Sun.

Key Questions

1. *What does a young mountain look like?*
2. *What does a meandering river look like?*
3. *In what kind of rock are most fossils found?*

11.1 Weathering

Energy from the Sun warms and cools Earth's surface. It melts and freezes water. It even helps grow the tree roots that eventually can split rocks into pieces. In this section, you will learn how tall mountain ranges eventually break down into the smallest rock particles.

Mountains

Mountains change over time Mountains—because they are so big and impressive—seem to be unchanging features in a landscape. However, mountains wear down over time. In fact, due to the Sun's energy, wind, and water, mountains begin to crumble as soon as they are formed.

Old versus young mountains An good example of old mountains are the Smoky Mountains which are part of the Appalachian Mountain range (Figure 11.1). These mountains are very old. The Rocky Mountains in the western United States are younger mountains (Figure 11.2). How do these two mountain ranges differ?

What happens as mountains age? At one time, the Smokies were as tall as the Rockies and also had sharp peaks. But, since the Smokies are 680 millions of years old (hundreds of millions years older than the Rockies) the peaks have worn down. Eventually, the Smokies will be no more than rolling hills, and the Rockies will look like the Smokies do now.

Figure 11.1: *The rounded peaks of the Smoky Mountains near Linville, Tennessee. Vegetation covers the mountains all the way to their peaks.*

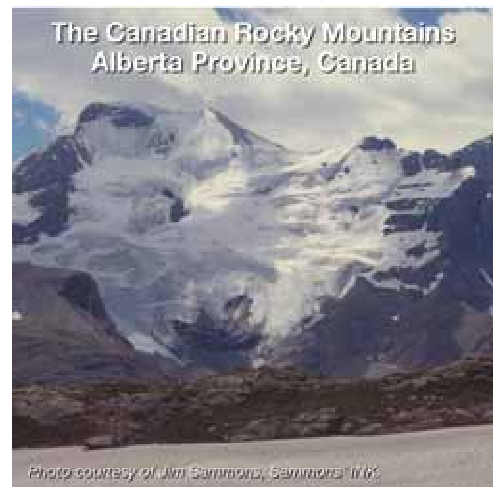


Figure 11.2: *Sharp peaks of the Canadian Rocky Mountains near Jasper, Alberta Province, Canada.*

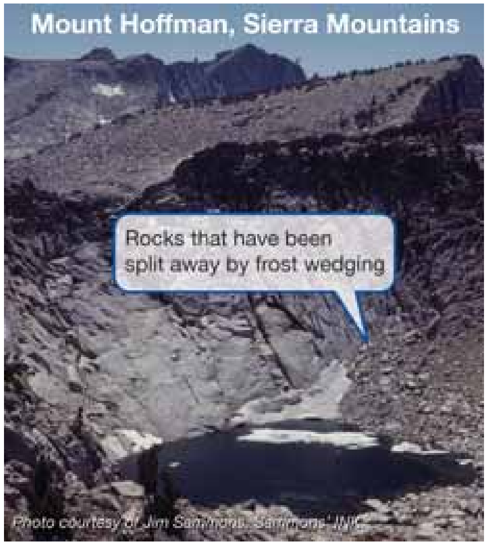
Physical weathering

Weathering How is a large mountain broken down into tiny grains of sand? The process of breaking down rock is called **weathering** (Figure 11.3).

Physical weathering Physical forces may break or chip rocks into smaller pieces. This process is called **physical weathering**. Physical weathering may break large blocks loose or chip away tiny grains, one at a time.

Liquid water Liquid water is a physical weathering agent. Rocks break up quickly when running water knocks them against each other. Even running water alone wears away rock. You can see physical weathering by looking at rocks at the base of a waterfall. Running water rounds and smooths the rocks there.

Frost wedging



Water weathers rock in other ways too. **Frost wedging** is a powerful physical weathering agent. When water cools, it contracts like other matter. But just before it freezes, it expands a little bit! Say a small amount of water enters a tiny crack in the rock. When the water freezes, it expands, making the crack a little wider. More water enters the crack, freezes, and widens the crack even more. Eventually frost wedging splits apart the two sides of the crack. The photo above shows an example of frost wedging near the crest of Mount Hoffman in the Sierra Mountains. Many hand-sized rocks have been split away by frost wedging.

VOCABULARY

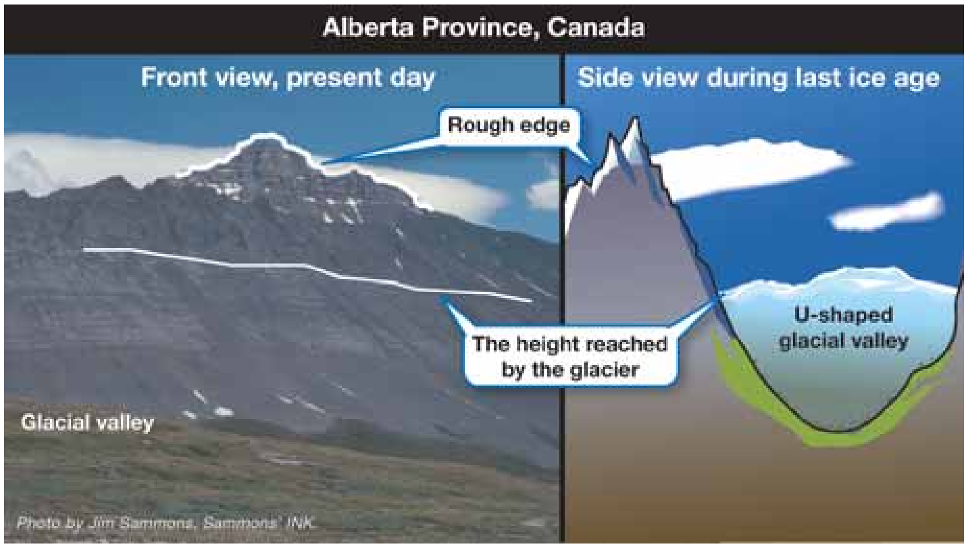
weathering - the process of breaking down rock.

physical weathering - physical forces that break rocks down into smaller pieces.

frost wedging - physical weathering that results from freezing water.

Figure 11.3: *This course sand and gravel is all that remains of a once-tall peak in the Sierra Mountains.*

Glaciers Frozen water in the form of glaciers is another powerful physical weathering agent. The ice that forms glaciers is a *plastic solid* (a solid that flows). As the ice of a glacier flows down a valley, it grinds the valley floor with pieces of rock caught up in the ice (Figure 11.4). This grinding changes the shape of the valley so that its bottom is rounded.



A U-shaped glacial valley The image above is of a large valley that held a glacier during the last ice age. The valley floor rises up smoothly in a gentle curve to the ridge above. From the side, this glacial valley is U-shaped. Notice that the highest part of the ridge is rough. This is because the glacier didn't get that high up before it melted. The change from smooth to rough rock is the "bathtub ring" left by the glacier that shows the highest point the glacier reached on the mountain.

Wind Even wind is a physical weathering agent. Wind-blown sand chips away tiny bits of rock from the surface of exposed rock. During this process, the remaining rock can take on unusual shapes and the removed bits eventually become sand (Figure 11.5).

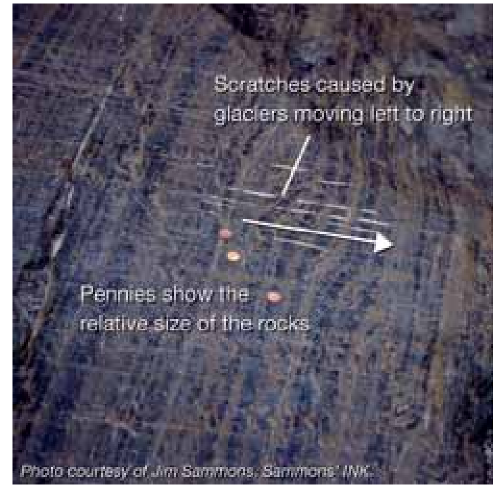


Figure 11.4: *A glacier passed over this rock moving from left to right. The scratches were made by rocks caught in the moving ice.*

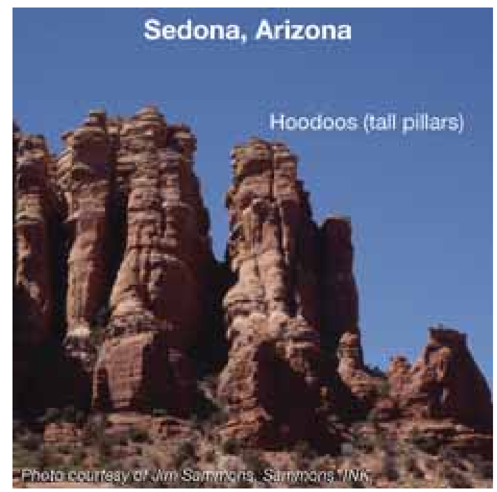


Figure 11.5: *Wind-blown sand has physically weathered this sandstone into tall pillars called Hoodoos.*

Chemical weathering

Chemical weathering

Rock is also reduced to smaller pieces by chemical reactions between water and rock grains. This process is called **chemical weathering**. Some kinds of rock are more easily eroded by chemical weathering than others. For example, marble is chemically weathered much faster than granite. Chemical weathering has worn away the surfaces of many old marble statues (Figure 11.6). This is seen more often in Europe than in the United States because the statues in Europe are older. They have been exposed to chemical weathering for a longer time than most marble statues in the United States.

VOCABULARY

chemical weathering - weathering of rock that involves chemical reactions.

Physical and chemical weathering

Both physical and chemical weathering can affect rock at the same time. Look at the picture below. Originally there were a few tiny cracks in the rock. Frost wedging probably opened up these cracks. Now chemical weathering is changing the rock mineral so that the sides of the crack are filled with loose grains. You can see the tufts of plants growing in the loose grains of rock.

Figure 11.6: *An old marble statue. Notice that the face of the statue has been worn down by chemical weathering.*

Root wedging and rockfalls

Root wedging Plant roots may grow into small crevices. If these plants are sturdy, like trees, they exert force on the rock as they grow. This force is often strong enough to split the rock. This process, called *root wedging*, is a kind of physical weathering (Figure 11.7). However, roots also produce enzymes that attack rock minerals. So root wedging is really a combination of physical and chemical weathering.

Rockfalls Falling rock can break into very small pieces when it hits the ground. The graphic below shows an example of rocks (and trees!) affected by falling rock. Rockfalls can occur when a big chunk of rock is split off of a large landform by frost wedging or root wedging. Rockfalls speed up the weathering process by quickly breaking up large pieces of a rock formation.

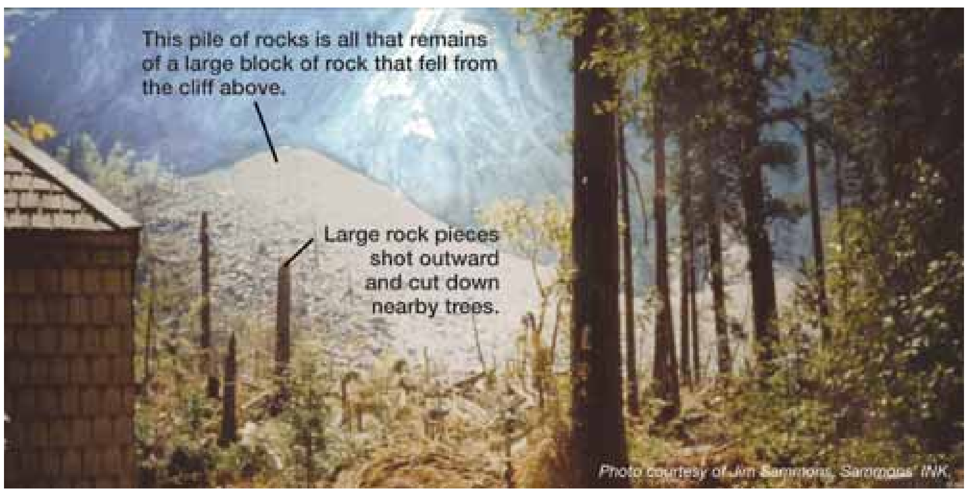


Figure 11.7: *For the moment, the climbers are happy to secure their rope to the small pine tree. Over time, the tree's roots will split away their rocky perch from the cliff by root wedging.*

11.1 Section Review

1. You have learned that mountains form when two continents collide. How do mountains turn into small rocks, soil, and sand?
2. Does the Sun play a role in weathering? Explain your answer.
3. Name two differences between old and young mountains.
4. How long does it take for a mountain's sharp peaks to wear down? Chose an answer below and explain your reasoning.

   a. millions of years   b. hundreds of years
   c. about 10 years   d. one year

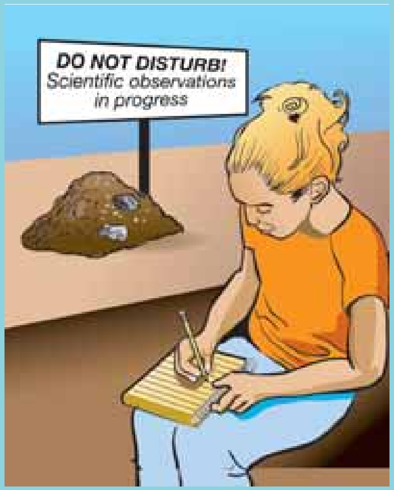
5. Describe how liquid water and ice affect rocks.
6. What causes a glacial valley to be U-shaped? Write your answer as a short, detailed paragraph.
7. How is frost wedging similar to root wedging?
8. For the following examples, state whether physical or chemical weathering is occurring:
   a. a bicycle left in the rain becomes rusty
   b. your sand castle gets blown away by wind
9. What happens to a rock that experiences physical weathering?
10. What happens to a rock that experiences chemical weathering?
11. Over time, how might the grass growing up through a crack in a sidewalk affect the sidewalk? Use the terms "physical weathering" and "chemical weathering" in your answer.

MY JOURNAL

Find an outdoor place near your house that will not get disturbed. Make a pile of soil and rocks. You may want to put a sign near your pile that says "Do Not Disturb!"

Over the next few days, make regular observations of the pile.

How did the pile change over time? How was the pile affected by physical and chemical weathering?



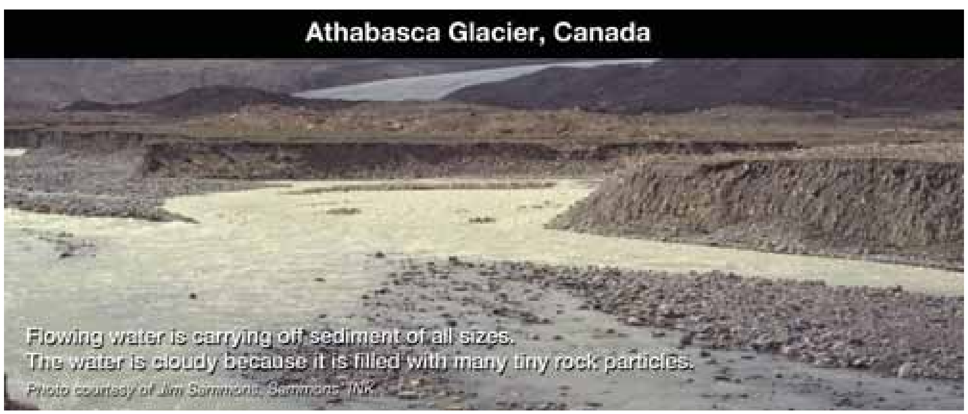
11.2 Moving Sediment

In Chapter 10, you learned about the water cycle. Water rises in the form of water vapor from oceans, rivers, and even volcanoes! The vapor returns to Earth as rain. The water cycle continues as rain water enters rivers and streams and flows to the oceans, moving sediment along with it. In time, the flowing water moves mountains!

What is sediment?

Where does sediment come from? Weathering breaks rock into bits and pieces called **sediment** (Figure 11.8). When you sit on a sandy beach, you are sitting on sediment that was once a rocky mountain top. How does sediment get from a mountain peak to a beach?

Rivers and streams Wind erodes mountains and moves sediment, but not as well as flowing water. Rivers and streams are bodies of flowing water that carry sediment. A **river** is a large flowing body of water. A **stream** is a small river. The path that a river or stream follows is called a **channel**. As you will learn later, rivers and streams can have one or more channels. Sediment carried by flowing water eventually arrives at the lowest place that it can reach, such as a beach. Then, the sediment is carried into the ocean water by waves.



VOCABULARY

sediment - small pieces and grains of weathered rock; also, small pieces of material from living things.

river - a large body of water that flows into an ocean or lake.

stream - a small river.

channel - the path that a river or stream follows.

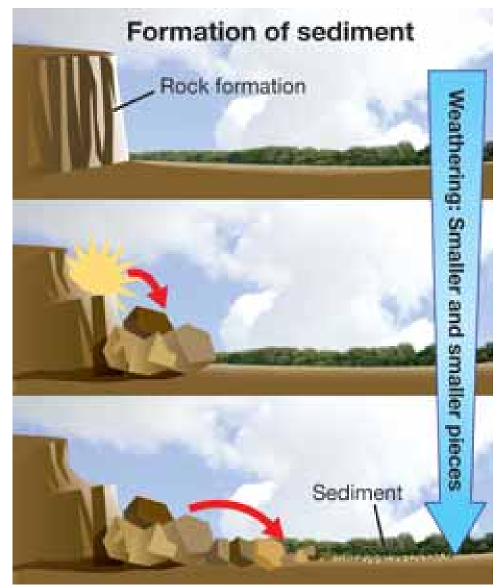


Figure 11.8: *Rocks become sediment because weathering causes them to break down into smaller and smaller pieces.*

Graded bedding

The speed of flowing water

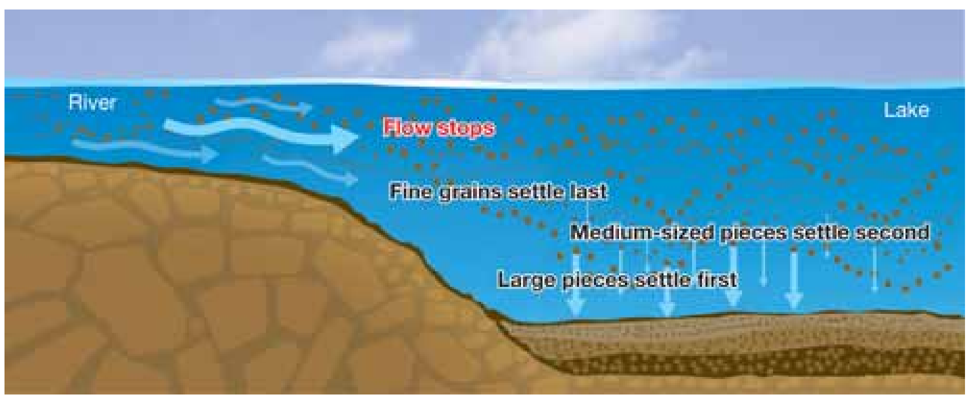
Figure 11.9 shows that you can tell the speed of flowing water by the size of the rock pieces found on a stream bottom. A few years before this picture was taken, knee-deep water was rushing around the stump. Since then, the stream channel has shifted and the old, now dry channel shows clues to how the stream once flowed.

Fast versus slow water

We can tell where the water flowed rapidly in the stream by the pebbles. Fast-moving water carries pebbles. The ground is cut away on both sides of the stump. This means that water moved fast as it flowed around the stump. In front of the stump though, the water was very slow. Small grains of rock settled to the bottom of the slow-moving water forming the *sand shadow* that you see here.

Sediment is sorted by water

When flowing water enters a lake or a pond, the flow stops and the water drops its sediment. First the largest grains settle to the bottom. Next the medium-sized grains settle. Finally the tiniest grains settle. The grains settle in order, making a pattern called **graded bedding**. It's common to find graded bedding in repeating layers, one of top of the other. For example, a stream that feeds into a lake may run fast only during thunderstorms. The stream lays down a graded bed of sediments after each storm.



VOCABULARY

graded bedding - the order of rocks from large to small that settle on a lake or pond bottom when water flow slows down.

Figure 11.9: *The stream now (in the background) and the place where it used to flow are shown. The pebbles show where the river flowed quickly. The sand shadow shows where the water flowed slowly.*

Meandering rivers and braided streams

Meanders Some rivers form S-shaped curves called **meanders** (Figure 11.10). Water flows at different speeds at different parts of the meanders. The fastest flow is on the outside of each curve while the slowest flow is on the inside. Fast-moving water picks up particles. Slow-moving water drops particles so that they settle to the bottom of the river. The fast-moving water wears away the outside river bank and at the same time, slower water adds to the inside bank by dropping sediment. The sediment that settles near the inside bank forms a *point bar*. The point bar adds to the inside of the meander curve and extends it. A *channel bar* is formed by sediment that is eroded from the river bank. The extra sediment is too much for the stream to transport so it settled near the bank.

How rivers move The combination of cutting on the outside bank and extending the inside bank moves the whole meander slowly down a river valley. This process goes on continuously at each meander. If you could watch a meandering river for a hundred years, you would see the meanders making side-to-side looping motions as the meandering river moves slowly down the valley.

VOCABULARY

meanders - S-shaped curves in a river.

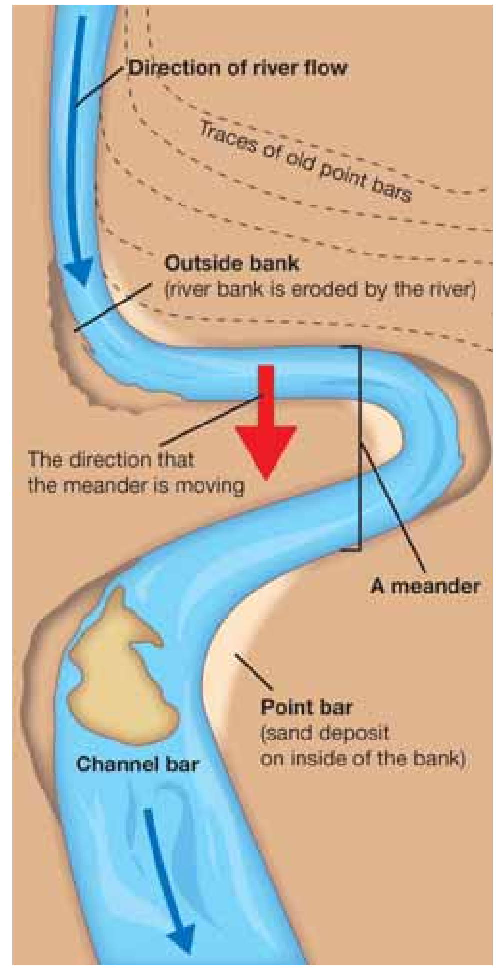


Figure 11.10: *A diagram of a meandering river.*

Meandering scars

This is a picture of the Tuolumne River Valley. Tuolumne is pronounced "two-all-oh-me." Can you see the dark traces of old meanders in the field to the right of the river? These dark traces are called *meandering scars*.

Tuolumne River Valley, Yosemite National Park

Photo courtesy of Jim Sammons, Sammons' INK

What is a braided stream?

The channel of a meandering stream moves downhill with time, but it remains a single channel. In contrast, a **braided stream** has many channels that criss-cross each other. Braided streams get their name from the braided appearance of their many channels. The channels of braided streams are constantly changing. New channels are cut and old ones are abandoned in a matter of days or weeks.

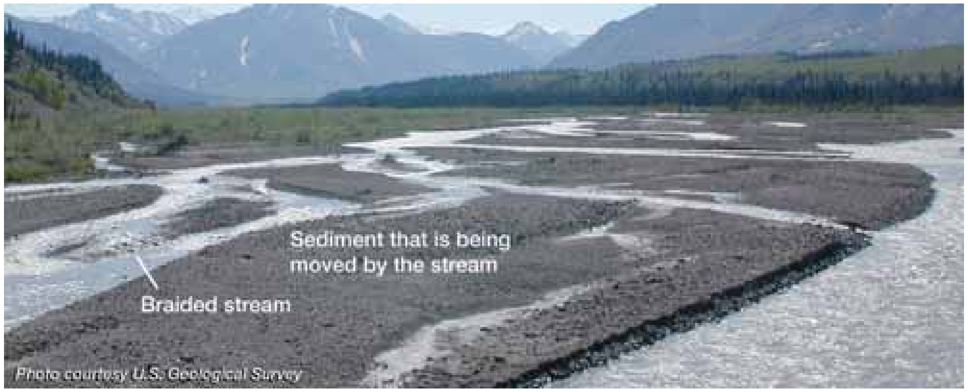


Photo courtesy U.S. Geological Survey

VOCABULARY

braided stream - a stream that has many channels that criss-cross each other.

SOLVE IT!

Here is a map of the Tuolumne River. Use the scale at the bottom of the map to answer these questions. First measure the scale bar using a ruler and then use your ruler to carefully measure the distances on the map.

1. How many kilometers of the river are located in Yosemite National Park?
2. How far would sediment have to travel to go from Modesto to San Francisco?

11.2 Section Review

1. Which of the following would be considered sediment?

   a. mud b. sand
   c. bits of shells d. rock pieces
   e. none of the above f. all of the above

2. How is the water cycle involved in moving rock and sediment from a mountain top to a beach?
3. Is it possible for a piece of a mountain to end up at the bottom of an ocean? Explain your answer.
4. A summary of how water moves rocks is given in Figure 11.11. However, some of the words are missing from this summary. Fill in the blanks using the terms below.

   - small, light grains of rock
   - large, heavy pieces of rock
   - larger rocks
   - fast-moving
   - slow-moving
   - smaller rocks

5. You notice that the bottom of a stream has large pebbles. What does this mean about the speed at which the water is flowing?
6. A lake has one graded bedding pattern. Then, a rain storm causes a stream to flow faster and deposit more sediment into the lake. Draw what this would look like. Hint: Your drawing should have two patterns, one on top of the other.
7. Imagine you could visit a meandering stream 200 years from now. Make a drawing that shows what it would look like today and then what it might look like in 200 years.
8. Now imagine that you could visit a braided stream 200 years from now. Make a drawing that shows what it would look like today and then what it might look like 200 years from now.

Water Can Move Rocks!

a. Slow-moving water has lower energy and can only carry _____.
b. Fast-moving water has higher energy and can carry _____.
c. When slow-moving water speeds up, it can pick up _____ from the stream bottom or stream bank.
d. When _____ water slows down, the larger rocks suspended in the water fall to the bottom of the stream.

Figure 11.11: *Fill in the blanks of this summary box with the correct terms from question 4.*

CHALLENGE

In this section, you learned that sand on the bottom of a stream indicates slow-moving water. But, when you visit a beach, you often see lots of sand and fast-moving waves. Why might sand be found on a beach even though the waves move fast?

11.3 Sedimentary Rocks

Sedimentary rocks are made of sediments—the rock particles that are produced by weathering. First, wind or water transports the particles to a location like the bottom of a valley or the bottom of a stream. Then pressure and chemical changes cement the particles together to form sedimentary rock.

VOCABULARY

sedimentary rocks - rocks that are made of sediments.

Types of sedimentary rocks

The size of particles Sedimentary rocks are identified by the size of the particles that form them. The finest particles are clay and silt. These particles form *mudstone*. Sand particles, larger particles than clay or silt, form *sandstone*. *Conglomerate* is formed by large pebbles and smaller particles. The pebbles make conglomerate look lumpy.

Shell particles form rocks Sedimentary rock can also be formed from the tiny shells of marine plants and animals. As these organisms die, their shells sink to the ocean floor and form layers of *shell mud*. Over millions of years, these shell mud layers thicken and eventually become sedimentary rock. *Limestone*, a sedimentary rock, is formed this way.

Fossils in sedimentary rocks Most fossils are found in sedimentary rock layers. This is true for two reasons. First, the processes that bring sediment together also bring together the remains of once-living things. Second, the process of making a sedimentary rock is good for preserving fossils.

Fossil formation Fossil formation begins when an organism's body is quickly covered in sediments from an event like a mud slide or a sand storm. Body parts that do not rot quickly, like bones and teeth, are buried under sediment layers. After a long time, chemicals in the bones and teeth are replaced with minerals. This process results in a heavy, rock-like copy of the original object—a fossil. Eventually, the sediments and fossil are compressed into sedimentary rock (Figure 11.12).

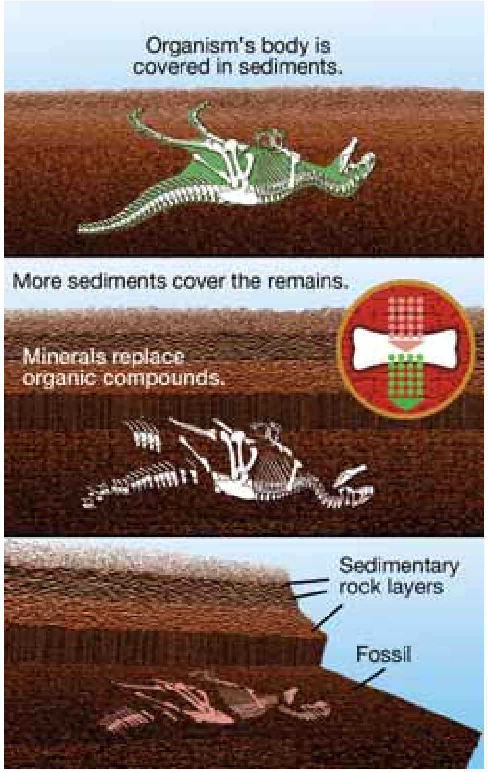


Figure 11.12: *The process that forms sedimentary rocks also preserves fossils. Most fossils are found in sedimentary rocks.*

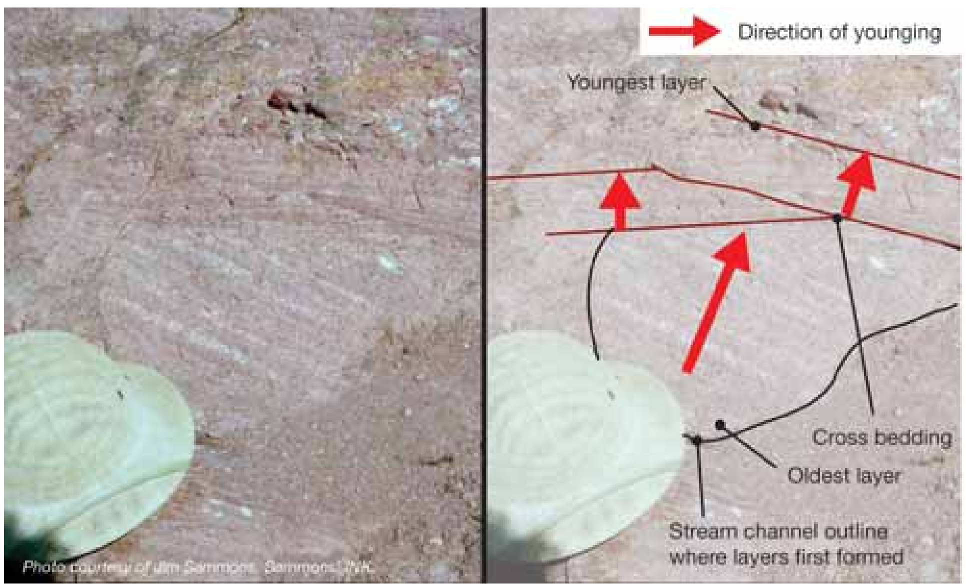
Interpreting layers of sediment

Direction of younging

Sedimentary rocks hold clues to their past. One of these clues is "the up direction." You learned that large particles settle before small particles, forming *graded bedding*. Figure 11.13 shows three graded bedding patterns. A layer of finest particles is on the top of each pattern. This layer of fine particles helps you know which direction is "up." If you know the up direction, you know the **direction of younging**—this is the direction of younger layers. Graded bedding is preserved when sediments become sedimentary rock.

Cross bedding

Sometimes bedded sediment is cut away by fast-running water. Then, more sediment is laid over the cut layer. This leaves a layer that ends abruptly as another layer passes over it. This pattern of **cross bedding** is common in sedimentary rocks that formed in stream and riverbeds.



VOCABULARY

direction of younging - the order in which sedimentary rock layers are formed—from larger to finer particles.

cross bedding - when a graded bedding pattern in a sedimentary rock is cut off and covered with another graded bedding pattern running in another direction.

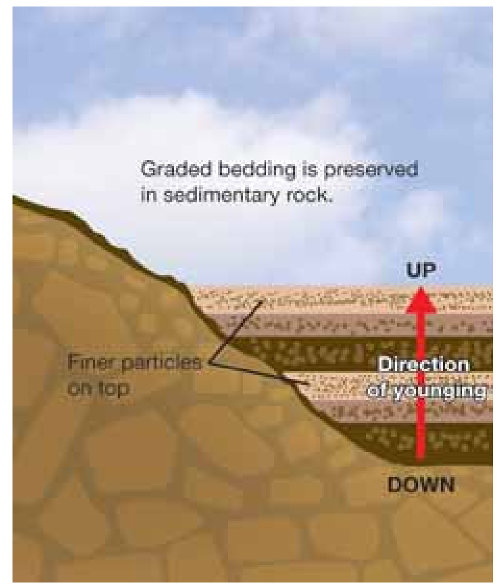


Figure 11.13: *Direction of younging. This graphic shows three graded bedding patterns.*

11.3 Section Review

1. Which location would most likely produce sedimentary rocks, a dried-up lake bed or the side of a volcano? Explain your answer.
2. Make a sketch of what you think the following sedimentary rocks would look like: mudstone, sandstone, and conglomerate. Be careful about drawing correctly-sized particles for each type of rock, but don't worry about the colors.
3. What kinds of sediments form limestone? How does this sedimentary rock form?
4. Why are many fossils found in sedimentary rocks?
5. State whether these statements are true or false. If a statement is false, rewrite the sentence so that it is true.
    a. When sediment settles on the bottom of a lake, the largest pieces of rock settle last.
    b. In a graded bedding pattern, the finest particles are the top layer.
    c. The direction of younging is the direction in which the top layer is the largest particles and the bottom layer is the finest particles.
6. The graphic on the previous page illustrates a rock that has a cross bedding pattern. Where were the layers of this cross bedding pattern formed long ago?

    a. at the bottom of a stream   b. in Earth's mantle
    c. inside a volcano   d. on a glacier

STUDY SKILLS

One way to learn new words is to write sentences using the words.

To help you learn the new words in this chapter, write a story about the life of a rock.

Your story should begin with the rock as part of a mountain top.

Use at least three new words that you learned in this chapter.

CHALLENGE

You have learned about sedimentary rocks in this chapter. In previous chapters, you learned about igneous and metamorphic rocks.

How are these types of rocks different from one another?

Write a paragraph that answers this question.

GEOLOGY CONNECTION

A World Heritage Site: Carlsbad Cavern

What do Cave Man, Christmas Tree, Texas Toothpick, and Witch's Finger have in common? They are sights you can see in New Mexico at Carlsbad Caverns National Park, which includes Carlsbad Cavern and more than 100 known caves. A cavern is a large cave or a large chamber in a cave. The Carlsbad park was designated a national park in 1930.


NPS Photo by Peter Jones

Ben Sublette was the first recorded explorer of Carlsbad Cavern. In 1883 he lowered his 12-year-old son, Rolth, into the cave on a rope. Later, a curious cowboy named Jim White spent years exploring the cave. He took photographer Ray V. Davis with him on one trip and posted the photos in the town of Carlsbad in 1915. People were amazed by the images, and White offered tours. He became the park's first chief ranger. Today, more than 500,000 people visit Carlsbad Caverns National Park each year.

How was Carlsbad Cavern formed?

Carlsbad Cavern is in the Guadalupe Mountains, a Permian-aged fossil reef. The Permian age is a geological period of time 230 million to 286 million years ago, when all the continents were joined together into one landmass called Pangaea. In the region of Carlsbad Cavern, there was an inland sea surrounded by a 400-mile-long reef called Capitan Reef. It was formed from sponge, algae, and seashell remains. The reef also contained the mineral calcite. Over time, the sea dried up and the reef was covered by thousands of feet of sediment. Sediment can be sand, gravel, dirt, or anything that sinks to the bottom of a sea.

Several million years ago, Earth's crust moved and the land rose up to form the Guadalupe range, which is made of Capitan Reef limestone. Weather caused erosion and exposed the buried limestone reef.


NPS Photo by Peter Jones

Most limestone caves are created when surface water seeps into cracks and dissolves the limestone. Surface water includes rives, lakes, and oceans, and it contains carbonic acid, which erodes limestone.

Limestone caves are usually wet and contain streams, lakes, or waterfalls. But the caves in the Guadalupe Mountains are dry. So how did the chambers of Carlsbad Cavern form?

Rain, mixed with acid from the air and soil, dissolved the limestone to create chambers. Acid rain alone did not do all the work. Oil and gas deposits located under the reef contained hydrogen sulfide, which mixed with groundwater to create sulfuric acid. Strong sulfuric acid dissolved the limestone, creating large pathways. As the mountains lifted, the land rose above the groundwater. The water drained away—leaving behind all the caves and chambers.

The Big Room

Carlsbad Cavern contains the Big Room, one of the world's largest underground chambers. The Big Room is the largest room in the cavern and the largest cave chamber in the United States. It is located 754 feet below the surface, is 25 stories high, and is one-third of a mile wide. Just how big is the Big Room? According to the National Park Service, it could hold about six football fields. Visitors reach the chamber by elevator. Once there, they can walk a one-mile path that circles the Big Room.

Cave formations

The entrance to Carlsbad Cavern was created over the last few million years. Erosion and collapsing land created a natural opening. Then air was able to enter the cave. Water from rain and snow combined with the air to dissolve the cavern's calcite. Water also deposited calcite to create the formations that decorate the cave. This process of creating cave formations, or *speleothems*, began 500,000 years ago.

There are many types of speleothems including stalactites and stalagmites. Stalactites are also called dripstones and form on the ceilings and walls of the cave. Stalagmites form from cave floors.

Other U.S. caves

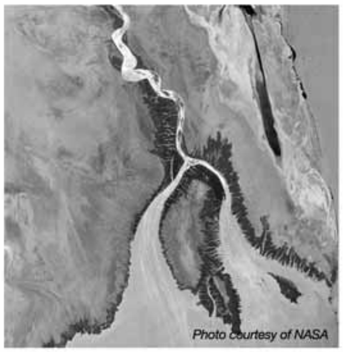
There are more than 40,000 known caves in the United States. Mammoth Cave in Kentucky is the world's longest cave with more than 350 miles of passageways. Black Chasm Cavern in Volcano, California, has a variety of formations, many of them with unusual twisted shapes. Moaning Caverns in Vallecito, Calif., has a vertical chamber so large it could hold the Statue of Liberty. It may also contain the oldest human remains in North America.

Questions:

1. Describe how Carlsbad Cavern was formed.
2. What is a speleothem? List and describe two kinds of speleothems.
3. What impact has weather had on the formation of Carlsbad Cavern?

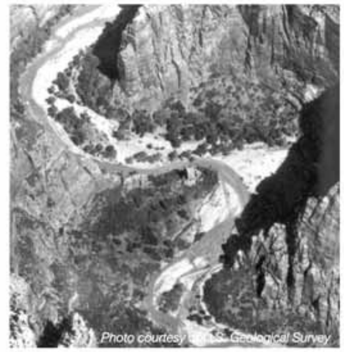
CHAPTER ACTIVITY Features of Rivers and Streams

Running water is a powerful force that shapes the landscape. The power of running water is related to the slope and shape of the river, and the volume of water flowing in the river. Flowing water erodes sediment from the bottom and sides of the river and moves the sediment farther downstream. Study the images below to learn the names of river and stream features and then go on a scavenger hunt to find where on the globe you will find these features. Use the Internet and other resources to look for images and information.



River delta: The mouth of a river that flows into an ocean or lake.

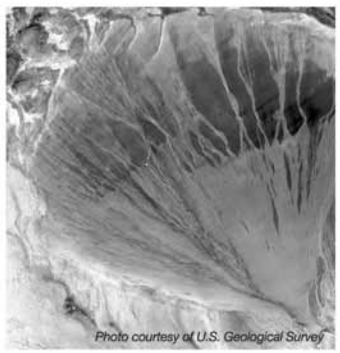
V-shape valley: When a river cuts a mountain it forms a V-shaped valley (a U-shaped valley is formed when a glacier moves through mountains).



Meander: S-shaped curves in a river.

Waterfall: Falling water that results when a river flows from a high to a low place in its path (such as over a cliff).

Oxbow lake: A meander that breaks off from the main river channel.



Alluvial fan: A fan-shaped area of sediment caused by a fast-flowing stream slowing down as it flows onto flatter land.

Flood plain: Flat land nearest a river that usually occurs at a distance from the source of the river. A flood plain is very good land for growing plants because the flooding of the river deposits nutrients in the land. However, flood plains are not good places for building because of the flooding.

Chapter 11 Assessment

Vocabulary

Select the correct term to complete the sentences.

weathering	physical weathering	sedimentary rocks
frost wedging	chemical weathering	meanders
river	graded bedding	cross bedding
stream	direction of younging	channel
braided stream		

Section 11.1

1. _____ is when rock is broken down into smaller pieces.
2. Frost wedging is an example of _____.
3. The process of breaking rock down chemically is called _____.
4. _____ occurs when water enters a crack in a rock, freezes, and expands so that the rock splits in two pieces.

Section 11.2

5. A _____ is a small river.
6. The path that a river or stream follows is called a _____.
7. The channel of a meandering _____ is S-shaped.
8. _____ is a pattern of large to small sediment pieces that results when sediment settles to the bottom of a lake or pond.
9. S-shaped curves in a river are called _____.
10. A _____ has many channels that criss-cross.

Section 11.3

11. _____ are made of layers of sediments.
12. The _____ for a sedimentary rock indicates which way is "up" for the rock—in other words, which layer formed first (the bottom layer) and which sediment layer formed last (the top layer).
13. _____ occurs when graded bedding patterns cut off and cover each other.

Concepts

Section 11.1

1. What is one clue that tells you that a mountain is young versus being very old?
2. Explain the difference between physical and chemical weathering.
3. Do physical and chemical weathering cause the same results? Explain your answer.
4. How is water involved in physical weathering? How is water involved in chemical weathering?
5. How do glaciers weather valleys?
6. How do trees weather rocks?

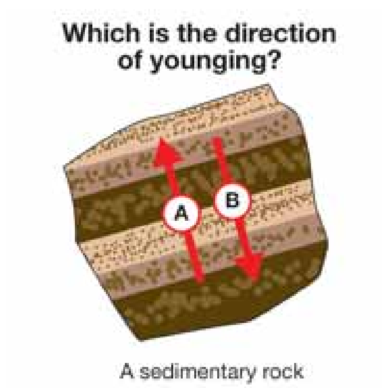
Section 11.2

7. What kinds of things could you do to turn a large piece of rock into sediment?
8. Under what kind of river conditions is a sand shadow created?
9. Why do storms cause a new graded bed pattern to form on the bottom of a lake or river?
10. What is the difference between a point bar and a channel bar?

11. Is this an image of a meandering river or a braided stream? Explain your answer.

Section 11.3

12. Name one feature of sedimentary rocks that is used to tell one from another.
13. Which of these sedimentary rocks has the smallest particles: conglomerate or mudstone?
14. Why are fossils often found in sedimentary rocks?
15. Which direction is the direction of younging for this sedimentary rock?



Math and Writing Skills

Section 11.1

1. Pretend you are a journalist for your local newspaper's *Health and Science* section. There has been recent buzz about the increase in acid rain in the local area. From studying earth science in school, you know that acid rain causes chemical weathering. However, many citizens do not understand the impact of acid rain.
   a. Research acid rain and its effects on the environment on the Internet or in your school library.
   b. Write a newspaper article explaining how acid rain could impact local geologic features and important stone statues in your town.
   c. Make sketches to illustrate your article or include images that you find in your research.

2. You have learned that the Sun's energy in combination with wind and water cause weathering of mountains to sediment. There is one other important factor that contributes to weathering—gravity! Why might gravity play a role in weathering? You can read about gravity in Chapter 5.

3. Over a few days time, a student collected data on how a pile of soil eroded. One measurement made was the height of the pile of soil. Here is her data:

Day	Height of pile (centimeters)
1	25
2	23
3	20
4	10
5	8
6	7
7	6
8	5

a. Make a graph of the student's data. Be sure to label the *x*- and *y*- axes and give your graph a title.

b. From the graph, what can you say about how the pile of soil eroded?

c. From this graph, write a story about what happened to the pile over the 8-day period?

Section 11.2

4. Answer true or false to the following statements. If the statement is false, rewrite it so that it is true.

a. Slow-moving water tends to carry larger rocks.

b. Fast-moving water has higher energy than slower-moving water.

c. When slow-moving water speeds up, it can pick up larger rocks from the stream bottom or stream bank.

d. Larger rocks carried by fast-moving water stay suspended in the water when this water slows down.

5. The table below shows how a river's volume of water flow (in cubic meters per second) and amount of transported sediment (in metric tons per day) change over eight months.

Month	Volume of water flow (m^3/second)	Sediment Load (metric tons/day)
December	1.0	125
January	1.2	175
February	1.6	300
March	3.0	675
April	4.6	1500
May	3.2	1000
June	2.8	800
July	2.2	525

a. Construct a line graph comparing the month and the volume of flow.

b. Construct a line graph comparing the month and the load.

c. When was the river's volume of flow the greatest? When was the river's volume of flow the least? When was the river's sediment load the least?

d. Is there any relationship between the volume of flow and the load? If so, explain.

e. Propose a hypothesis to explain the changes over the months in the volume of flow and the load.

Section 11.3

6. Two processes that are important for sediments to become sedimentary rock are *compaction* and *cementation*. Research these terms to find out what they mean and write a definition for them in your own words.
7. There are different types of sedimentary rocks. Rocks made of layers of rock particles are called *clastic* sedimentary rocks. Rocks made of bits of living material like shells are called *biological* sedimentary rocks. And some sedimentary rocks are made when minerals crystallize—these are called *chemical* sedimentary rocks. In the chapter you learned about the following sedimentary rocks. Identify each as being clastic, biological, or chemical.
   a. Mudstone
   b. Sandstone
   c. Conglomerate
   d. Limestone
8. A thin layer of sedimentary rocks covers much of Earth's land surface. Underneath this thin layer are igneous rocks (andesite and granite, for example) and metamorphic rocks. Why does this pattern of rocks on Earth's surface make sense?

Chapter Project—Sedimentary Rock Hunt

Sediment is everywhere! For this chapter project you will go on a geological "dig" to find five sedimentary rocks. First, research sedimentary rocks to find out where they might be found in nature and what they look like. Then, go on your "dig" to find the rocks. It may take a while to find this many rocks in your area so be patient. Keep in mind that rocks are not only outdoors. Your house, the mall, local stores, benches, playgrounds and other areas may also have many sedimentary rocks for you to find.

As you find a sample, bring it or a photograph of it to class.