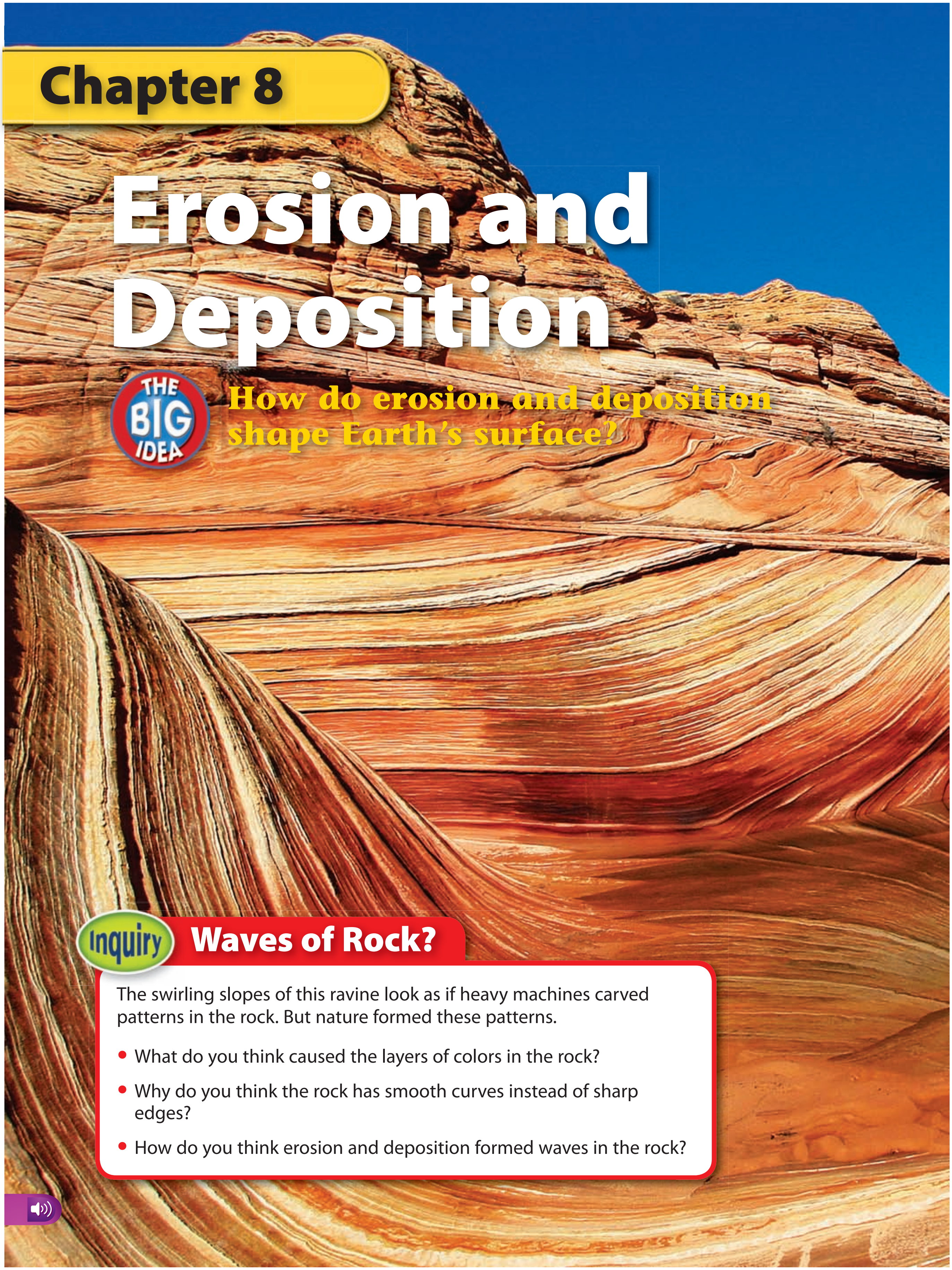


Chapter 8

Erosion and Deposition

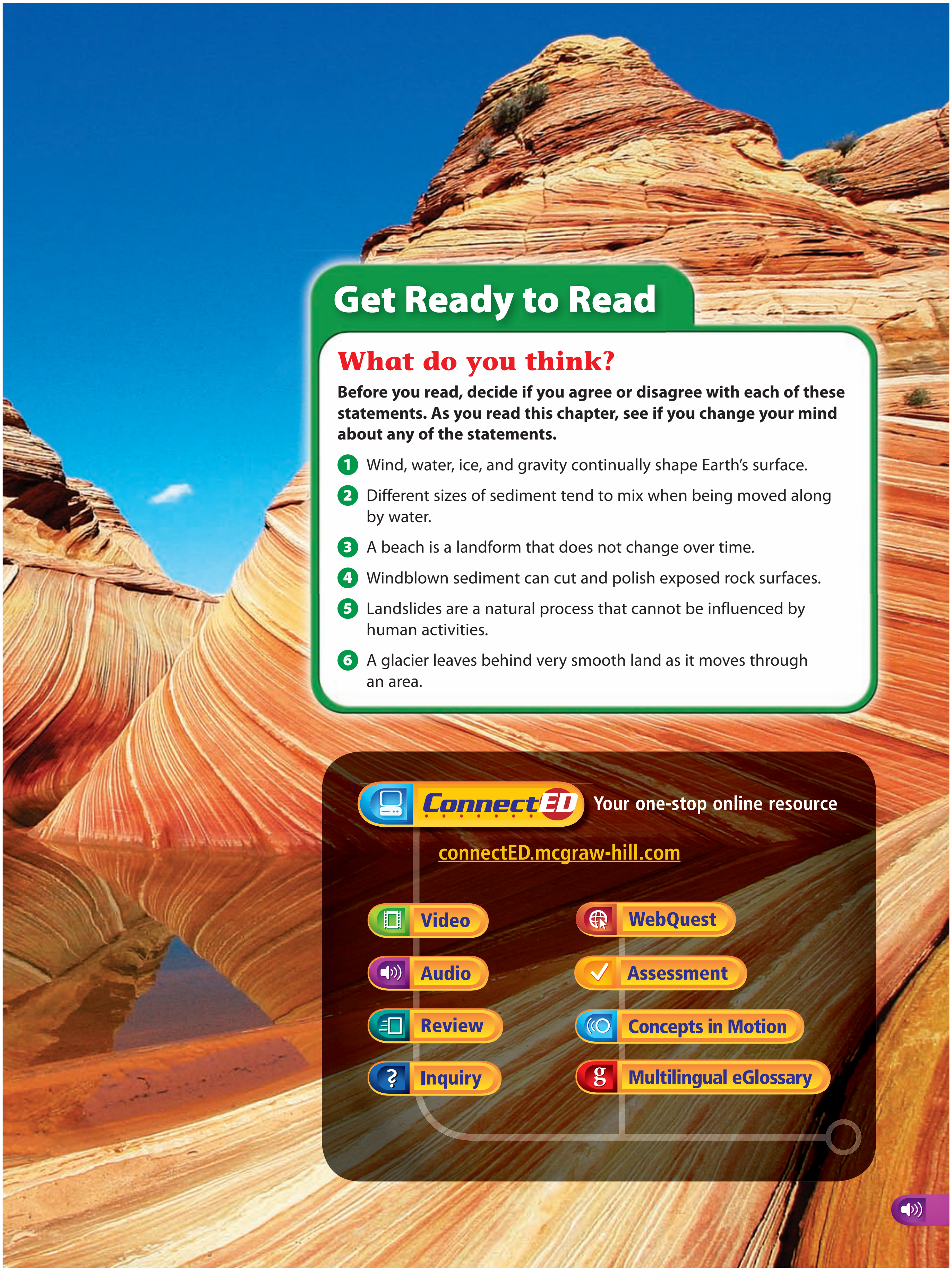
THE BIG IDEA

How do erosion and deposition shape Earth's surface?

Inquiry Waves of Rock?

The swirling slopes of this ravine look as if heavy machines carved patterns in the rock. But nature formed these patterns.

- What do you think caused the layers of colors in the rock?
- Why do you think the rock has smooth curves instead of sharp edges?
- How do you think erosion and deposition formed waves in the rock?



Get Ready to Read

What do you think?

Before you read, decide if you agree or disagree with each of these statements. As you read this chapter, see if you change your mind about any of the statements.

1. Wind, water, ice, and gravity continually shape Earth's surface.
2. Different sizes of sediment tend to mix when being moved along by water.
3. A beach is a landform that does not change over time.
4. Windblown sediment can cut and polish exposed rock surfaces.
5. Landslides are a natural process that cannot be influenced by human activities.
6. A glacier leaves behind very smooth land as it moves through an area.

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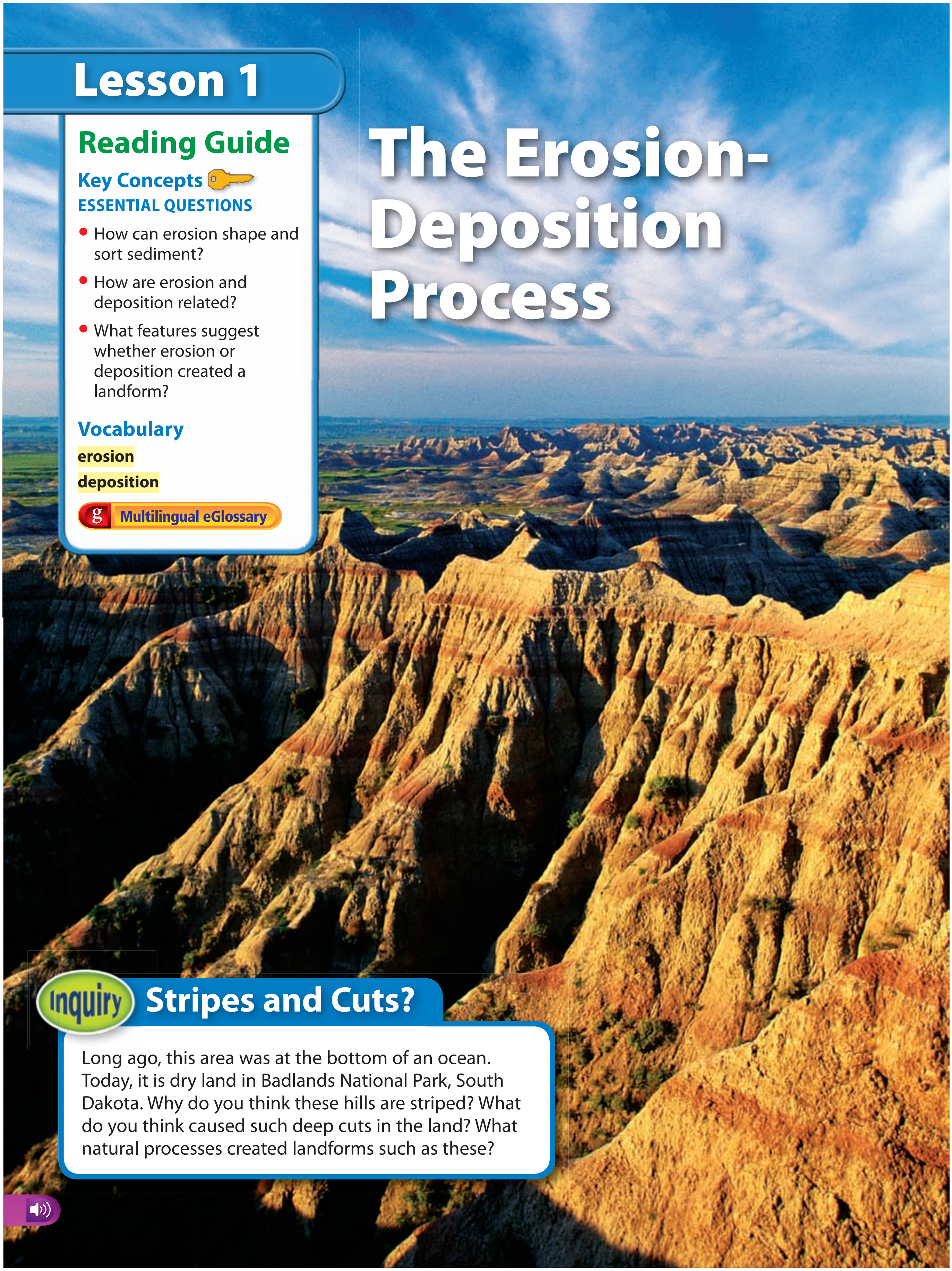


Lesson 1

The Erosion-Deposition Process

Reading Guide

Key Concepts

ESSENTIAL QUESTIONS

- How can erosion shape and sort sediment?
- How are erosion and deposition related?
- What features suggest whether erosion or deposition created a landform?

Vocabulary

erosion

deposition

Multilingual eGlossary

Inquiry Stripes and Cuts?

Long ago, this area was at the bottom of an ocean. Today, it is dry land in Badlands National Park, South Dakota. Why do you think these hills are striped? What do you think caused such deep cuts in the land? What natural processes created landforms such as these?

Inquiry Launch Lab

10 minutes

How do the shape and size of sediment differ?

Sediment forms when rocks break apart. Wind, water, and other factors move the sediment from place to place. As the sediment moves, its shape and size can change. In this activity, you will observe the different shapes and sizes of sediment.

1. Read and complete a lab safety form.
2. Obtain a **bag of sediment** from your teacher. Pour the sediment onto a **sheet of paper.**
3. Use a **magnifying lens** to observe the differences in shape and size of the sediment.
4. Divide the sediment into groups according to its size and whether it has rounded or sharp edges.

Think About This

1. What were the different groups you used to sort the sediment?
2. **Key Concept** How do you think movement by wind and water might affect the shape and size of the sediment?

Reshaping Earth's Surface

Have you ever seen bulldozers, backhoes, and dump trucks at the construction site of a building project? You might have seen a bulldozer smoothing the land and making a flat surface or pushing soil around and forming hills. A backhoe might have been digging deep trenches for water or sewer lines. The dump trucks might have been dumping gravel or other building materials into small piles. The changes that people make to a landscape at a construction site are small examples of those that happen naturally to Earth's surface.

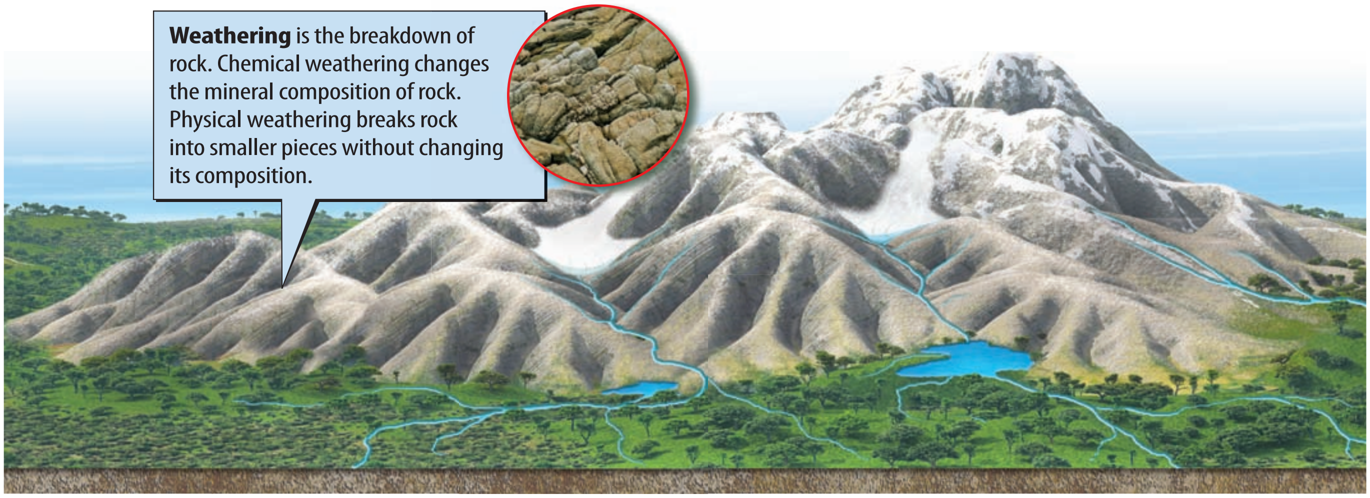
A combination of constructive **processes** and destructive processes produce landforms. Constructive processes build up features on Earth's surface. For example, lava erupting from a volcano hardens and forms new land on the area where the lava falls. Destructive processes tear down features on Earth's surface. A strong hurricane, for example, can wash part of a shoreline into the sea. Constructive and destructive processes continually shape and reshape Earth's surface.

ACADEMIC VOCABULARY
process
(noun) an ongoing event or a series of related events

Weathering, Erosion, and Deposition

Review Personal Tutor

Figure 1 The continual weathering, erosion, and deposition of sediment occurs from the top of a mountain and across Earth's surface to the distant ocean.



Visual Check How do you think weathering and erosion will affect the mountains over the next thousand years?

A Continual Process of Change

Imagine standing on a mountain, such as one shown in **Figure 1.** In the distance you might see a river or an ocean. What was this area like thousands of years ago? Will the mountains still be here thousands of years from now? Landforms on Earth are constantly changing, but the changes often happen so slowly that you do not notice them. What causes these changes?

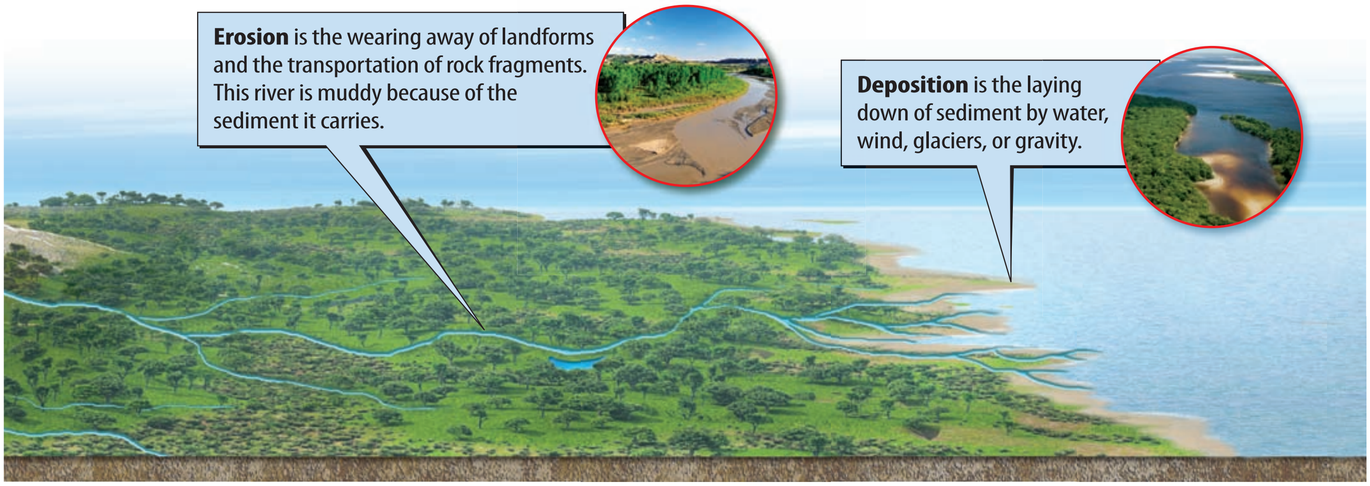
Weathering

One destructive process that changes Earth's surface is weathering, the breakdown of rock. Chemical weathering changes the chemical composition of rock. Physical weathering breaks rock into pieces, called sediment, but it does not change the chemical composition of rock. Gravel, sand, silt, and clay are different sizes of sediment.

Weathering Agents Water, wind, and ice are called agents, or causes, of weathering. Water, for example, can dissolve minerals in rock. Wind can grind and polish rocks by blowing particles against them. Also, a rock can break apart as ice expands or as plant roots grow within cracks in the rock.

Different Rates of Weathering The mineral composition of some rocks makes them more resistant to weathering than other rocks. The differences in weathering rates can produce unusual landforms, as shown in **Figure 2.** Weathering can break away less resistant parts of the rock and leave behind the more resistant parts.

Figure 2 Different rates of weathering of rock can produce unusual rock formations.



Erosion

What happens to weathered material? This material is often transported away from its source rock in another destructive process called erosion. **Erosion** *is the removal of weathered material from one location to another.* Agents of erosion include water, wind, glaciers, and gravity. The muddy water shown in **Figure 1**, for example, is evidence of erosion.

The Rate of Erosion Like weathering, erosion occurs at different rates. For example, a rushing stream can erode a large quantity of material quickly. However, a gentle stream might erode a small amount of material slowly. Factors that affect the rate of erosion include weather, climate, topography, and type of rock. For example, strong wind transports weathered rock more easily than a gentle breeze does. Weathered rock moves faster down a steep hill than across a flat area. The presence of plants and the way humans use the land also affect the rate of erosion. Erosion occurs faster on barren land than on land covered with vegetation.

Reading Check What are some factors that affect the rate of erosion?

Inquiry MiniLab

15 minutes

Can weathering be measured?

You can measure the weathering of rocks.

1. Read and complete a lab safety form.
2. Obtain **pieces of broken rock.** Rinse the rocks and pat completely dry with **paper towels.**
3. Measure the rocks' mass using a **balance.** Record your data in your Science Journal.
4. Place the rocks in a **plastic bottle.** Cover the rocks with water, and seal the bottle. Shake the bottle vigorously for 5 minutes.
5. Rinse the rocks and pat completely dry with paper towels. Record the mass again.

Analyze and Conclude

1. **Compare and contrast** the mass of the rocks before and after shaking.
2. **Key Concept** What evidence suggests that weathering has occurred?

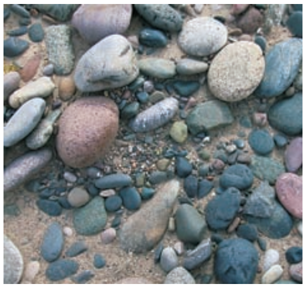


Figure 3 Erosion can change poorly rounded rocks (top) to well-rounded rocks (bottom).

Rate of Erosion and Rock Type The rate of erosion sometimes depends on the type of rock. Weathering can break some types of rock, such as sandstone, into large pieces. Other rock types, such as shale or siltstone, can easily break into smaller pieces. These smaller pieces can be removed and transported faster by agents of erosion. For example, large rocks in streams usually move only short distances every few decades, but silt particles might move a kilometer or more each day.

Rounding Rock fragments bump against each other during erosion. When this happens, the shapes of the fragments can change. Rock fragments can range from poorly rounded to well-rounded. The more spherical and well-rounded a rock is, the more it has been polished during erosion. Rough edges break off as the rock fragments bump against each other. Differences in sediment rounding are shown in **Figure 3**.

Key Concept Check How can erosion affect the shape of sediment?

Sorting Erosion also affects the level of sorting of sediment. Sorting is the separating of items into groups according to one or more properties. As sediment is transported, it can become sorted by grain size, as shown in **Figure 4.** Sediment is often well-sorted when it has been moved a lot by wind or waves. Poorly sorted sediment often results from rapid transportation, perhaps by a storm, a flash flood, or a volcanic eruption. Sediment left at the edges of glaciers is also poorly sorted.

Key Concept Check How can erosion sort sediment?

Sediment Sorting by Size

Figure 4 Erosion can sort sediment according to its size.

Poorly sorted sediment has a wide range of sizes.

Moderately sorted sediment has a small range of sizes.

Well-sorted sediment is all about the same size.

Deposition

You have read about two destructive processes that shape Earth's surface—weathering and erosion. After material has been eroded, a constructive process takes place. **Deposition** *is the laying down or settling of eroded material.* As water or wind slows down, it has less energy and can hold less sediment. Some of the sediment can then be laid down, or deposited.

Key Concept Check How are erosion and deposition related?

Depositional Environments Sediment is deposited in locations called depositional environments. These locations are on land, along coasts, or in oceans. Examples include **swamps,** deltas, beaches, and the ocean floor.

Reading Check What is a depositional environment?

Environments where sediment is transported and deposited quickly are high-energy environments. Examples include rushing rivers, ocean shores with large waves, and deserts with strong winds. Large grains of sediment tend to be deposited in high-energy environments.

Small grains of sediment are often deposited in low-energy environments. Deep lakes and areas of slow-moving air or water are low-energy environments. The swamp shown in **Figure 5** is an example of a low-energy environment. The material that makes up a fine-grained sedimentary rock, such as shale, was probably deposited in a low-energy environment.

Sediment Layers Sediment deposited in water typically forms layers called beds. Some examples of beds appear as "stripes" in the photo at the beginning of this lesson. Beds often form as layers of sediment at the bottom of rivers, lakes, and oceans. These layers can be preserved in sedimentary rocks.

WORD ORIGIN

deposition
from French *deposer,* means "put down"

REVIEW VOCABULARY

swamp
a wetland occasionally or partially covered with water

A Low-Energy Depositional Environment

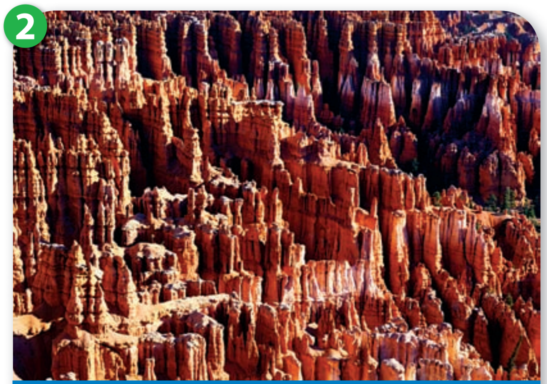
Figure 5 Silt and clay are deposited in low-energy environments such as swamps. Swamp deposits also include dark, organic material from decaying trees and other plants.

Figure 6 The tall, steep, somewhat sharp features shown in these photographs are common in landforms carved by erosion.

1

The Tepees in the Painted Desert of Arizona

2



Hoodoos at Bryce Canyon National Park

3

Glacier National Park in Montana

Visual Check How did the passage of glaciers through these mountains change the shape of the valleys?

Interpreting Landforms

What do landform characteristics, such as structure, elevation, and rock exposure, suggest about the development of landforms? Examples of landforms include mountains, valleys, plains, sea cliffs, and beaches. These landforms are always changing, although you might not observe these changes in your lifetime. Landform characteristics can be observed to determine whether destructive forces, such as erosion, or constructive forces, such as deposition, produced the landforms.

Landforms Created by Erosion

Landforms can have features that are clearly produced by erosion. These landforms are often tall, jagged structures with cuts in layers of rock, as shown in the photographs in **Figure 6.**

1 Landforms formed by erosion can expose several layers of rock. The Tepees in the Painted Desert of Arizona contain several layers of different materials. Over time, erosion wore away parts of the land, leaving behind multicolored mounds.

2 Recall that different rates of erosion can result in unusual landforms when some rocks erode and leave more erosion-resistant rocks behind. For example, tall, protruding landforms called hoodoos are shown in the middle photograph of **Figure 6.** Over time, water and ice eroded the less-resistant sedimentary rock. The remaining rocks are more resistant. If you would like to examine hoodoos more closely, look back at **Figure 2.**

3 Glacial erosion and coastal erosion also form unique landforms. Glacial erosion can produce ice-carved features in mountains. The U-shaped valleys of Glacier National Park in Montana, shown in the bottom photograph, formed by glacial erosion. Coastal erosion forms picturesque landforms, such as sea cliffs, caves, and sea arches.

Landforms Created by Deposition

Landforms created by deposition are often flat and low-lying. Wind deposition, for example, can gradually form deserts of sand. Deposition also occurs where mountain streams reach the gentle slopes of wide, flat valleys. An apron of sediment, called an alluvial fan, often forms where a stream flows from a steep, narrow canyon onto a flat plain at the foot of a mountain, as shown in **Figure 7.**

▲ **Figure 7** An alluvial fan is a gently sloping mass of sediment that forms where a stream empties onto flat land at the foot of a steep slope.

Reading Check How does an alluvial fan develop?

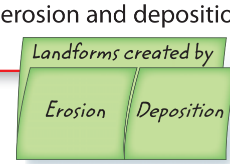
Water traveling in a river can slow due to friction with the edges and the bottom of the river channel. An increase in channel width or depth also can slow the current and promote deposition. Deposition along a riverbed occurs where the speed of the water slows. This deposition can form a sandbar, as shown in **Figure 8.** The endpoint for most rivers is where they reach a lake or an ocean and deposit sediment under water. Wave action along shorelines also moves and deposits sediment.

◀ **Figure 8** A sandbar is a depositional feature in rivers and near ocean shores.

As glaciers melt, they can leave behind piles of sediment and rock. For example, glaciers can create long, narrow deposits called eskers and moraines. In the United States, these features are best preserved in northern states such as Wisconsin and New York. You will read more about glacial deposition in Lesson 3.

FOLDABLES®

Make a two-tab book and label it as shown. Use your book to describe and identify some landforms created by the processes of erosion and deposition.



Comparing Landforms

Look again at the landforms shown in **Figure 6, Figure 7,** and **Figure 8.** Notice how landforms produced by erosion and deposition are different. Erosion produces landforms that are often tall and jagged, but deposition usually produces landforms on flat, low land. By observing the features of a landform, you can infer whether erosion or deposition produced it.

Key Concept Check What features suggest whether erosion or deposition produced a landform?

Lesson 1 Review

Assessment Online Quiz

Visual Summary

Erosion occurring at different rates can carve rock into interesting landforms.

Rock fragments with rough edges are rounded during transportation.

Landforms produced by deposition are often flat and low-lying.

FOLDABLES

Use your lesson Foldable to review the lesson. Save your Foldable for the project at the end of the chapter.

What do you think NOW?

You first read the statements below at the beginning of the chapter.

1. Wind, water, ice, and gravity continually shape Earth's surface.
2. Different sizes of sediment tend to mix when being moved along by water.

Did you change your mind about whether you agree or disagree with the statements? Rewrite any false statements to make them true.

Use Vocabulary

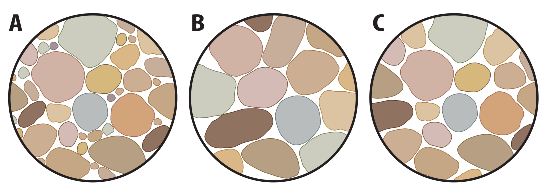
1. **Define** *deposition* in your own words.
2. **Use the term** *erosion* in a complete sentence.

Understand Key Concepts

3. Which would most likely leave behind well-sorted sediment?
   - **A.** flash flood
   - **B.** melting glacier
   - **C.** ocean waves
   - **D.** volcanic eruption
4. **Describe** some features of an alluvial fan that suggest that it was formed by deposition.
5. **Explain** how erosion and deposition by a stream are related.

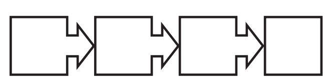
Interpret Graphics

6. **Examine** the illustration of sediment particle sizes shown below.



Classify each set of particles as well-sorted, moderately sorted, or poorly sorted. Explain.

7. **Sequence** Copy and fill in the graphic organizer below to describe a possible history of a grain of the mineral quartz that begins in a boulder at the top of a mountain and ends as a piece of sand on the coast.



Critical Thinking

8. **Decide** Imagine a river that deposits only small particles where it flows into a sea. Is the river current most likely fast or slow? Why?

HOW NATURE WORKS

American Museum of Natural History

Clues from the Canyon

Rocks of the majestic Grand Canyon tell a story about Earth's past.

Visitors to the Grand Canyon in Arizona are awestruck by its magnificent size and depth. But to many scientists, the canyon's walls are even more impressive. The soaring walls hold about 40 layers of colorful rocks in shades of red, yellow, brown, and gray. Each layer is like a page in a history book about Earth's past—and the deeper the layer, the older it is. The different layers reflect the particular types of environments in which they formed.

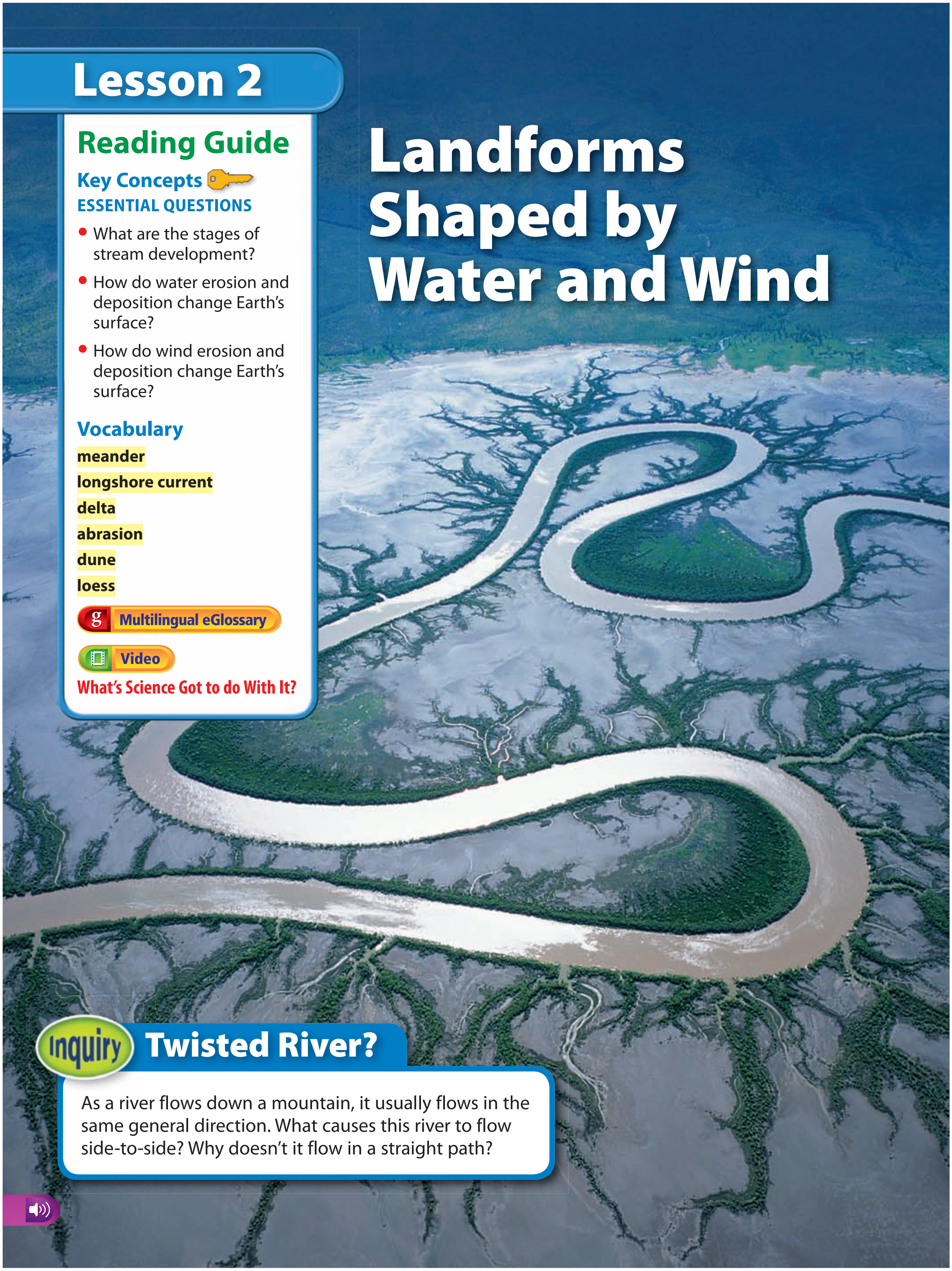
Weathering **The canyon walls continue to weather and erode today. Rockfalls and landslides are common. Harder rock such as sandstone weathers in big chunks that break off, forming steep cliffs. The softer rocks weather and erode more easily. This forms gentle slopes.**

Deposition **These rock layers formed 280 to 260 million years ago. During the early part of this period, the region was covered by sand dunes and wind-deposited layers of sand. Later, shallow seas covered this area and layers of shells settled on the seafloor. Gradually, the sediments were compacted and cemented together and these multicolored layers of sedimentary rock were formed.**

Erosion **Several million years ago, the movement of tectonic plates pushed up the layers of rock. This formed what is called the Colorado Plateau. As the rocks rose higher, the slope of the Colorado River became steeper and its waters flowed faster and with greater force. The Colorado River cut through the weathered rock and carried away sediment. Over millions of years, this erosion formed the canyon.**

It's Your Turn

DIAGRAM With a partner, find a photo of a local natural land formation. Research and write short descriptions explaining how parts of the formation were created. Attach your descriptions to the appropriate places on the photo.



Lesson 2

Landforms Shaped by Water and Wind

Reading Guide

Key Concepts
ESSENTIAL QUESTIONS

- What are the stages of stream development?
- How do water erosion and deposition change Earth's surface?
- How do wind erosion and deposition change Earth's surface?

Vocabulary

meander
longshore current
delta
abrasion
dune
loess

g Multilingual eGlossary

Video
What's Science Got to do With It?

Inquiry Twisted River?

As a river flows down a mountain, it usually flows in the same general direction. What causes this river to flow side-to-side? Why doesn't it flow in a straight path?

Inquiry Launch Lab

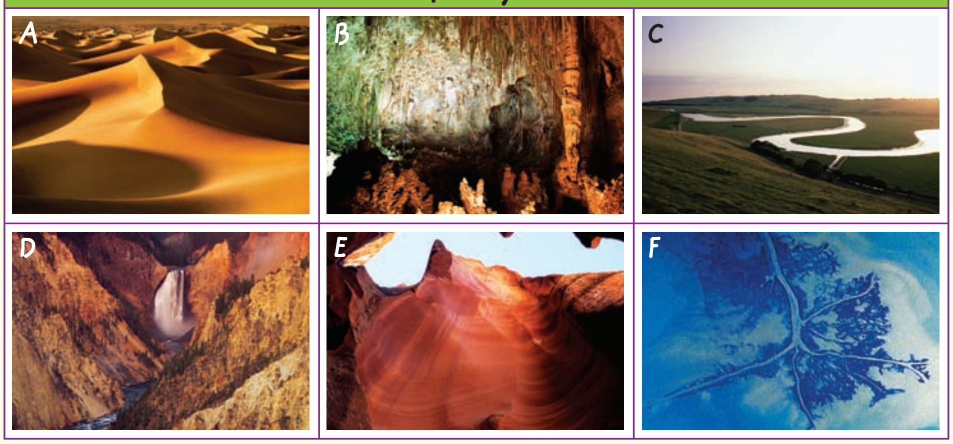
15 minutes

How do water and wind shape Earth?

Imagine a fast-moving river rushing over rocks or a strong wind blowing across a field. What changes on Earth do the water and the wind cause?

1. Form into groups and discuss the pictures below with others in your group.
2. Can you recognize evidence of ways water and wind have changed the land—through both erosion and deposition?

Landforms Shaped by Water and Wind



Think About This

1. What are some examples of erosion and deposition in the pictures?
2. **Key Concept** Describe ways you think water might have changed the land in the pictures. What are some ways wind might have changed the land?

Shaping the Land with Water and Wind

Recall that landforms on Earth's surface undergo continual change. Weathering and erosion are destructive processes that shape Earth's surface. These destructive processes often produce tall, jagged landforms. Deposition is a constructive process that also shapes Earth's surface. Constructive processes often produce flat, low-lying landforms.

What causes these processes that continually tear down and build up Earth's surface? In this lesson, you will read that water and wind are two important agents of weathering, erosion, and deposition. The cliffs shown in **Figure 9** are an example of how erosion by water and wind can change the shape of landforms. In the next lesson you will read about ways Earth's surface is changed by the downhill movement of rocks and soil and by the movement of glaciers.

Figure 9 Erosion by water and wind formed these cliffs along Lake Superior.

Figure 10 Water erosion carved this V-shaped valley at Lower Falls, Yellowstone National Park, in Wyoming.

Water Erosion and Deposition

Water can shape landforms on and below Earth's surface. The speed of water movement and the depositional environment often affect the shape of landforms.

Water Erosion

If you have ever had a chance to wade into an ocean and feel the waves rushing toward shore, you know that moving water can be incredibly strong. Moving water causes erosion along streams, at beaches, and underground.

Stream Erosion Streams are active systems that erode land and transport sediment. The erosion produced by a stream depends on the stream's energy. This energy is usually greatest in steep, mountainous areas where young streams flow rapidly downhill. The rushing water often carves V-shaped valleys, such as the one shown in **Figure 10.** Waterfalls and river rapids are common in steep mountain streams.

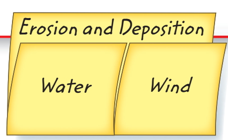
Water in a young stream slows as it reaches gentler slopes. The stream is then called a mature stream, such as the one shown in **Figure 11.** Slower moving water erodes the sides of a stream channel more than its bottom, and the stream develops curves. *A* **meander** *is a broad, C-shaped curve in a stream.*

When a stream reaches flat land, it moves even slower and is called an old stream. Over time, meanders change shape. More erosion occurs on the outside of bends where water flows faster. More deposition occurs on the inside of bends where water flows slower. Over time, the meander's size increases.

Key Concept Check Describe the stream development stages.

FOLDABLES®

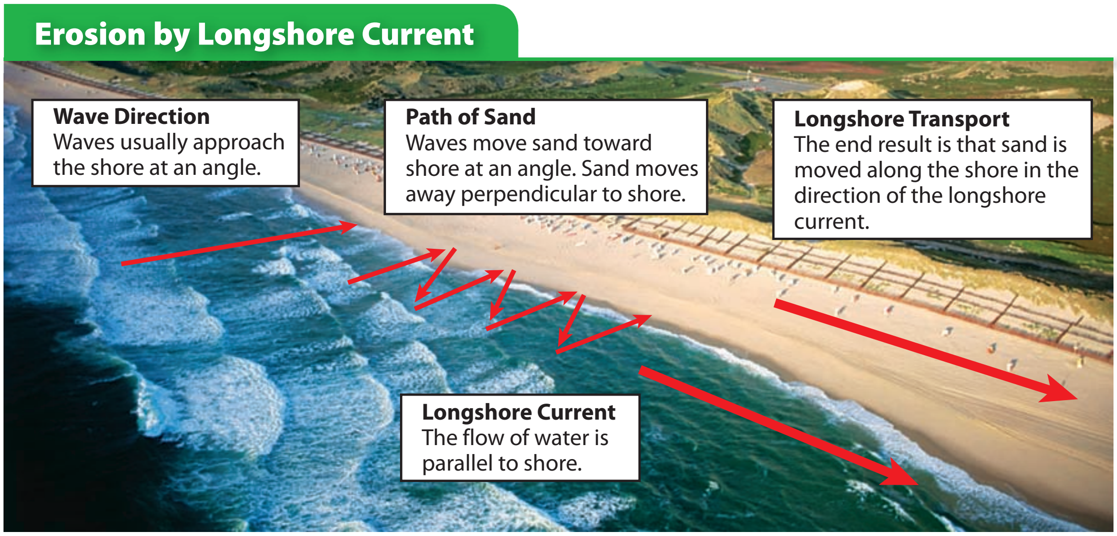
Make a two-tab book and label it as shown. Use your book to organize information about landforms and features created by erosion and deposition by water and wind.



Stages of Stream Development

Concepts in Motion Animation

Figure 11 Streams change as they flow from steep slopes to gentle slopes and finally to flat plains.



▲ **Figure 12** A longshore current erodes and deposits large amounts of sediment along a shoreline.

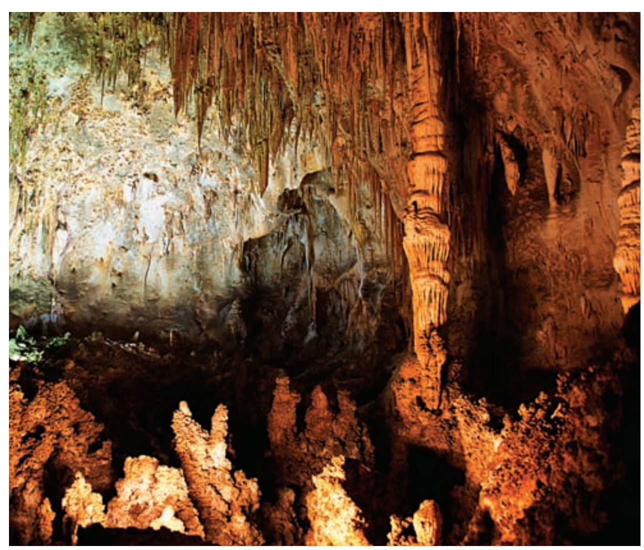
Visual Check What causes the sand to move away perpendicular to shore?

Coastal Erosion Like streams, coastlines continually change. Waves crashing onto shore erode loose sand, gravel, and rock along coastlines. One type of coastal erosion is shown in **Figure 12.** *A* **longshore current** *is a current that flows parallel to the shoreline.* This current moves sediment and continually changes the size and shape of beaches. Coastal erosion also occurs when the cutting action of waves along rocky shores forms sea cliffs. Erosional features such as sea caves, sea stacks (tall pillars just offshore), and sea arches (rock bridges extending into the sea) can form when waves erode less resistant rocks along the shore.

Key Concept Check How does water erosion change Earth's surface?

Groundwater Erosion Water that flows underground can also erode rock. Have you ever wondered how caves form? When carbon dioxide in the air mixes with rainwater, a weak acid forms. Some of this rainwater becomes groundwater. As acidic groundwater seeps through rock and soil, it can pass through layers of limestone. The acidic water dissolves and washes away the limestone, forming a cave, as shown in **Figure 13.**

Reading Check How does water erosion form a cave?



▲ **Figure 13** Carlsbad Caverns in New Mexico was formed by water erosion.

Figure 14 This delta formed by deposition of sediment when water flowed from a river into an ocean.

Inquiry MiniLab 20 minutes

How do stalactites form?

A stalactite forms when minerals are deposited as crystals. In this lab, you will model the formation of a stalactite.

1. Read and complete a lab safety form.
2. Use **scissors** to poke a hole in the bottom of a **small paper cup.**

3. Tie a **washer** to one end of a 25-cm length of **yarn.** Thread the other end through the hole in the cup and a hole in the top of a **box.** Place the cup on the box with the holes aligned.
4. Half-fill **another cup** with **Epsom salts.** Add **warm water** until the cup is full. Stir with a **spoon.** Pour the salt water into the cup with yarn so that it drips down the yarn into a **bowl.**
5. Record in your Science Journal observations of your model each day for one week.

Analyze and Conclude

1. **Describe** daily changes in your model.
2. **Key Concept** How did this activity model the formation of a stalactite?

Water Deposition

Flowing water deposits sediment as the water slows. A loss of speed reduces the amount of energy that the water has to carry sediment.

Deposition Along Streams Deposition by a stream can occur anywhere along its path where the water's speed decreases. As you read earlier, slower-moving water deposits sediment on the inside curves of meanders. A stream also slows and deposits sediment when it reaches flat land or a large body of water, such as a lake or an ocean. An example is the delta shown in **Figure 14.** *A* **delta** *is a large deposit of sediment that forms where a stream enters a large body of water.*

Deposition Along Coastlines Much of the sand on most ocean beaches was originally deposited by rivers. Longshore currents transport the sand along ocean coasts. Eventually, sand is deposited where currents are slower and have less energy. Sandy beaches often develop at those locations.

Key Concept Check How does water deposition change Earth's surface?

Groundwater Deposition Weathering and erosion produce caves, but deposition forms many structures within caves. Look again at **Figure 13.** The cave contains landforms that dripping groundwater formed as it deposited minerals. Over time, the deposits developed into stalactites and stalagmites. Stalactites hang from the ceiling. Stalagmites build up on the cave's floor.

Land Use Practices

Damage caused by water erosion can be affected by the ways people use land. Two areas of concern are beaches along coasts and surface areas within continental interiors.

Beach Erosion Ocean waves can erode beaches by removing sediment. To reduce this erosion, people sometimes build structures such as retaining walls, or groins, like those shown in **Figure 15.** A row of groins is constructed at right angles to the shore. They are built to trap sediment and reduce the erosive effects of longshore currents.

▲ **Figure 15** These shoreline groins prevent beach erosion by trapping sediment.

Some ways people affect beaches are unintended. For example, people build dams on rivers for purposes of flood control and other reasons. However, dams on rivers prevent river sand from reaching beaches. Beach sand that is washed out to sea by waves is not replaced.

Surface Erosion Reducing the amount of vegetation or removing it from the land increases surface erosion. Agricultural production, construction activities, and cutting trees for lumber and paper production are some reasons that people remove vegetation.

Reading Check What are some ways human activities affect water erosion?

A floodplain is a wide, flat area next to a river. It is usually dry land but can be flooded when the river overflows. Heavy rain or rapid melting of snow can cause a river to flood. Building within a floodplain is risky, as shown in **Figure 16.** However, floods supply mineral-rich soil that is ideal for farming. One way to decrease flooding on a floodplain is to build a levee. A levee is a long, low ridge of soil along a river. However, decreasing flooding also decreases the renewed supply of mineral-rich soil for farming.

◀ **Figure 16** This 2005 levee break in New Orleans caused extensive flood damage.

▲ **Figure 17** Wind abrasion carved this unusual landform in the red sandstone of Nevada's Valley of Fire region.

Wind Erosion and Deposition

If you think about a gentle wind that blows leaves in the autumn, it seems unlikely that the wind can cause land erosion and deposition. But strong or long-lasting winds can significantly change the land.

Wind Erosion

As wind carries sediment along, the sediment cuts and polishes exposed rock. **Abrasion** *is the grinding away of rock or other surfaces as particles carried by wind, water, or ice scrape against them.* Examples of rock surfaces carved by wind abrasion are shown in **Figure 17** and at the beginning of this chapter.

Wind Deposition

Two common types of wind-blown deposits are dunes and loess (LUHS). *A* **dune** *is a pile of windblown sand.* Over time, entire fields of dunes can travel across the land as wind continues to blow the sand. Some dunes are shown in **Figure 18.** **Loess** *is a crumbly, windblown deposit of silt and clay.* One type of loess forms from rock that was ground up and deposited by glaciers. Wind picks up this fine-grain sediment and redeposits it as thick layers of dust called loess.

Word Origin
loess
from Swiss German *Lösch*, means "loose"

Key Concept Check How do wind erosion and deposition change Earth's surface?

Land Use Practices

People contribute to wind erosion. For example, plowed fields and dry, overgrazed pastures expose soil. Strong winds can remove topsoil that is not held in place by plants. One way to slow the effects of wind erosion is to leave fields unplowed after harvesting crops. Farmers can also plant rows of trees to slow wind and protect the farmland.

Wind Erosion and Deposition

Figure 18 Dunes, such as these in Death Valley, California, formed by the deposition of wind-blown sand. ▶

Visual Check What are two effects wind has had on this landscape?

Lesson 2 Review

Assessment Online Quiz
Inquiry Virtual Lab

Visual Summary

Water erosion changes Earth's surface. An example of this is the change in features of a stream over time.

Water transports sediment and deposits it in places where the speed of the water decreases.

Wind erosion can change Earth's surface by moving sediment. A dune and loess are two types of wind deposition.

FOLDABLES®

Use your lesson Foldable to review the lesson. Save your Foldable for the project at the end of the chapter.

What do you think NOW?

You first read the statements below at the beginning of the chapter.

3. A beach is a landform that does not change over time.

4. Windblown sediment can cut and polish exposed rock surfaces.

Did you change your mind about whether you agree or disagree with the statements? Rewrite any false statements to make them true.

Use Vocabulary

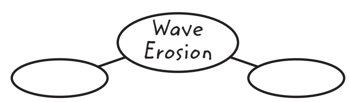
1. **Distinguish** between loess and a dune.
2. **Use the term** *delta* in a complete sentence.
3. Sediment is transported parallel to the shoreline by a ________.

Understand Key Concepts

4. Which feature would a young river most likely have?
   A. meander **C.** waterfall
   B. slow movement **D.** wide channel
5. **Explain** how wind erosion might affect exposed rock.
6. **Compare and contrast** the advantages and disadvantages of farming on a floodplain.

Interpret Graphics

7. **Determine Cause and Effect** Copy and fill in the graphic organizer below to identify two ways waves cause seashore erosion.



8. **Examine** the image below.

How have erosion and deposition shaped the stream?

Critical Thinking

9. **Suppose** the amount of sand in front of a large, beachfront hotel is slowly disappearing. Explain the process that is likely causing this problem. Suggest a way to avoid further loss of sand.
10. **Recommend** What are some steps a farmer could take to avoid wind erosion and water erosion of farmland?

Inquiry **Analyze** 40 minutes

How do water erosion and deposition occur along a stream?

Water flowing in a stream erodes the land it flows over. As stream water slows down, it deposits sediments. You can learn about this type of erosion and deposition by analyzing how water shapes land.

Materials


sand


paper cup


craft sticks


tub


stream table


small rock

Also needed: drain tube

Safety

Learn It

When you **analyze** an event, such as erosion or deposition, you observe the different things that happen. You also consider the effects of changes. In this activity, you will analyze how erosion and deposition occur along a stream.

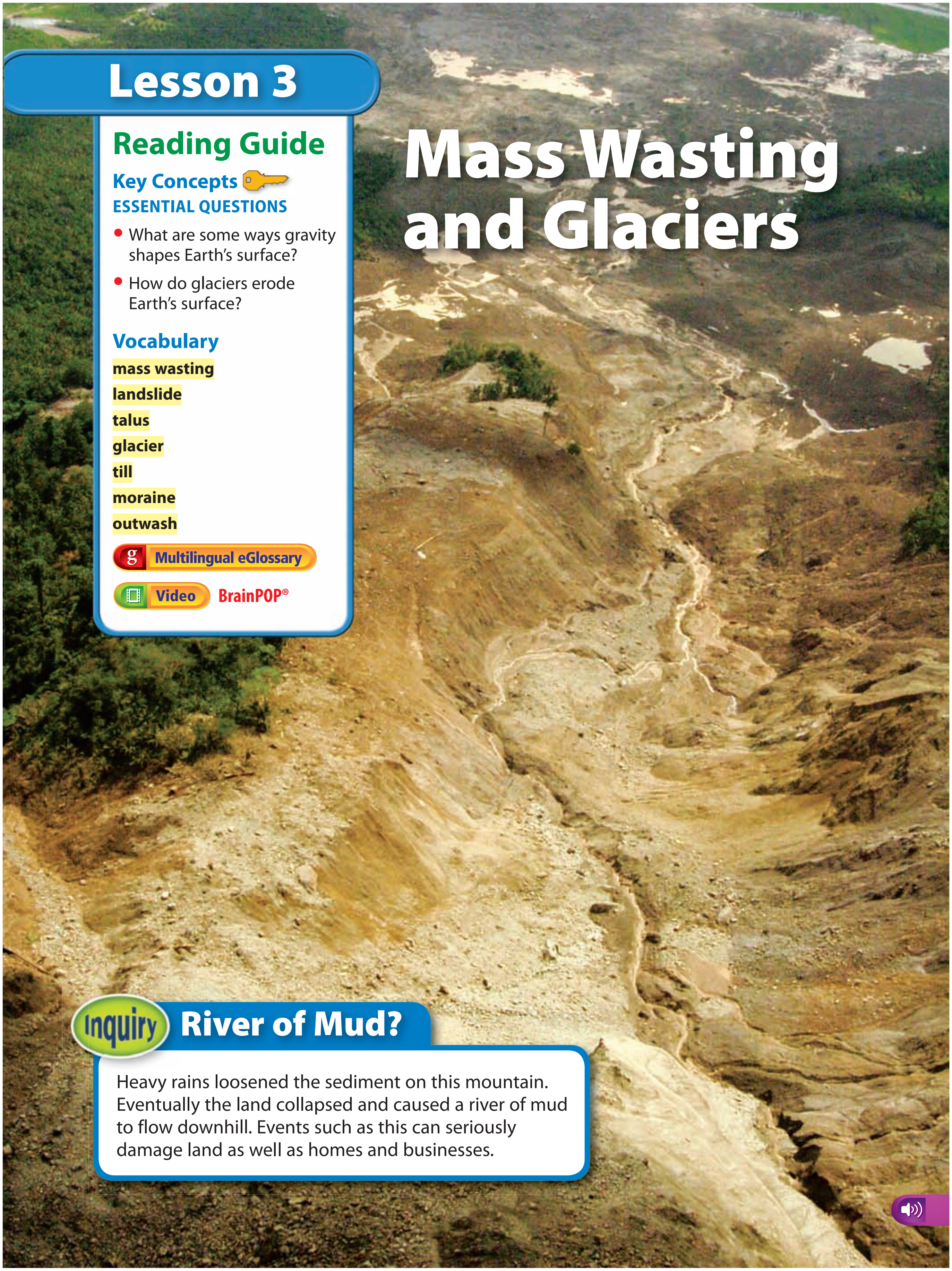
Try It

1. Read and complete a lab safety form.
2. Half-fill a stream table with sand. Add water to dampen the sand. Tilt the table slightly, and put the drain tube in a tub.
3. Flatten the sand into a gentle slope. Slowly pour water from a paper cup onto the high end of the sand. Notice the movement of sand along the water's path. Record your observations in your Science Journal.
4. Flatten the sand again. Use a craft stick to make a straight channel for the water. Pour water into the channel slowly and then faster. Analyze the movement of sand along the channel.

Apply It

5. Test the effect of having an object, such as a rock, in the water's path. Analyze how this affects the path of the water and the movement of sand.
6. Think about how flowing water affects the shape of a meander. Test this with your damp sand and water. Describe your results.
7. **Key Concept** How did water erosion and deposition occur along the stream?

3



Lesson 3

Reading Guide

Key Concepts

ESSENTIAL QUESTIONS

- What are some ways gravity shapes Earth's surface?
- How do glaciers erode Earth's surface?

Vocabulary

mass wasting
landslide
talus
glacier
till
moraine
outwash

Multilingual eGlossary

Video BrainPOP®

Mass Wasting and Glaciers

Inquiry River of Mud?

Heavy rains loosened the sediment on this mountain. Eventually the land collapsed and caused a river of mud to flow downhill. Events such as this can seriously damage land as well as homes and businesses.

Inquiry Launch Lab

15 minutes

How does a moving glacier shape Earth's surface?

A glacier is a huge mass of slow-moving ice. The weight of a glacier is so great that its movement causes significant erosion and deposition along its path. In this lab, you will use a model glacier to observe these effects.

1. Read and complete a lab safety form.
2. Half-fill an **aluminum pan** with **dirt** and **gravel.** Mix enough water so that the dirt holds together easily. Use **two books** to raise one end of the pan.
3. Sprinkle **colored sand** at the top of the dirt hill.
4. Place a **model glacier** at the top of the hill. Slowly move the glacier downhill, pressing down gently.

Think About This

1. What happened to the colored sand as the glacier moved downhill?
2. **Key Concept** What kinds of erosion and deposition did your model glacier cause?

Mass Wasting

Have you ever seen or heard a news report about a large pile of boulders that has fallen down a mountain onto a road? This is an example of a mass wasting event. **Mass wasting** *is the downhill movement of a large mass of rocks or soil because of the pull of gravity.* There are two important parts to this definition:

- material moves in bulk as a large mass
- gravity is the dominant cause of movement. For example, the mass moves all at once, rather than as separate pieces over a long period of time. Also, the mass is not moved by, in, on, or under a transporting agent such as water, ice, or air.

Reading Check Describe two characteristics of a mass wasting event.

Look again at the photo on the previous page. It is a photo of a mass wasting event called a mud flow. Even though water did not transport the mud, it did contribute to this mass wasting event. Mass wasting commonly occurs when soil on a hillside is soaked with rainwater. The water-soaked soil becomes so heavy that it breaks loose and slides down the hillside.

Recall that vegetation on a steep slope reduces the amount of water erosion during a heavy rainfall. The presence of thick vegetation on a slope also reduces the likelihood of a mass wasting event. Root systems of plants help hold sediment in place. Vegetation also reduces the force of falling rain. This minimizes erosion by allowing water to gently soak into the soil.

Examples of Mass Wasting

Rockfall | Slump | Creep

Figure 19 A rockfall, slump, and creep are examples of mass wasting.

Visual Check What evidence do you see in the figure that mass wasting has occurred?

Erosion by Mass Wasting

There are many types of mass wasting events. For example, *a* **landslide** *is the rapid downhill movement of soil, loose rocks, and boulders.* Two types of landslides are a rockfall, such as the one shown in **Figure 19,** and a mudslide, shown on the first page of this lesson. Slump is a type of mass wasting where the material moves slowly, in a large mass. If the material moves too slowly to be noticeable, causing trees and other objects to lean over, the event is called creep, also shown in **Figure 19.**

The amount of erosion that occurs during a mass wasting event depends on factors such as the type of rock, the amount of water in the soil, and how strongly the rock and soil are held together. Erosion also tends to be more destructive when the mass wasting occurs on steep slopes. For example, landslides on a steep hillside can cause extensive damage because they transport large amounts of material quickly.

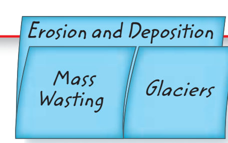
Key Concept Check What are some ways gravity shapes Earth's surface?

Deposition by Mass Wasting

The erosion that occurs during mass wasting continues as long as gravity is greater than other forces holding the rock and soil in place. But when the material reaches a stable location, such as the base of a mountain, the material is deposited. **Talus** *is a pile of angular rocks and sediment from a rockfall,* like the pile of rock at the base of the hill in **Figure 19.**

FOLDABLES®

Make a two-tab book and label it as shown. Use your book to organize information about landforms and features created by erosion and deposition by mass wasting and by glaciers.



Math Skills

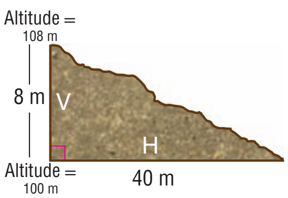
Use Ratios

Slope is the ratio of the change in vertical height over the change in horizontal distance. The slope of the hill in the drawing is

$$\frac{(108\text{ m} - 100\text{ m})}{40\text{ m}} = \frac{8\text{ m}}{40\text{ m}} = 0.2$$

Multiply the answer by 100 to calculate percent slope.

$$0.2 \times 100 = 20\%$$



Practice

A mountain rises from 380 m to 590 m over a horizontal distance of 3,000 m. What is its percent slope?

Review

- Math Practice
- Personal Tutor

Figure 20 Building on steep slopes can increase the risk of a landslide. Construction or removal of vegetation makes the hillside even less stable.

Land Use Practices

Human activities can affect both the severity of mass wasting and the tendency for it to occur. The homes in **Figure 20** were built on steep and unstable slopes and were damaged during a landslide. Removing vegetation increases soil erosion and can promote mass wasting. The use of heavy machines or blasting can shake the ground and trigger mass wasting. In addition, landscaping can make a slope steeper. A steep slope is more likely to undergo mass wasting.

Reading Check What are some ways human activities can increase or decrease the risk of mass wasting?

Inquiry MiniLab

20 minutes

How does the slope of a hill affect erosion?

1. Read and complete a lab safety form.
2. Use **scissors** to poke holes in one end of an **aluminum pan.** Prop the other end up with a **book.** Place a **second pan** under the low end. Pile **300 mL of soil** in the high end.
3. Quickly pour **400 mL of water** over the soil. Drain the water from the second pan. Use a **balance** to measure the mass of the soil that was washed into the second pan.
4. Clean the pans. Using fresh soil, repeat steps 2 and 3 with **three books** holding up the pan.

Analyze and Conclude

1. **Predict** what your results would have been if you had sprinkled the water on slowly.
2. **Key Concept** How did the slope of the hill affect the amount of erosion?

▲ **Figure 21** The Mendenhall Glacier in Alaska is an alpine glacier.

Glacial Erosion and Deposition

You have read about erosion and deposition caused by mass wasting events. Glaciers can also cause erosion and deposition. *A* **glacier** *is a large mass of ice that formed on land and moves slowly across Earth's surface.* Glaciers form on land in areas where the amount of snowfall is greater than the amount of snowmelt. Although glaciers appear to be motionless, they can move several centimeters or more each day.

There are two main types of glaciers—alpine glaciers and ice sheets. Alpine glaciers, like the one shown in **Figure 21,** form in mountains and flow downhill. More than 100,000 alpine glaciers exist on Earth today. Ice sheets cover large areas of land and move outward from central locations. Continental ice sheets were common in past ice ages but only exist today on Antarctica and Greenland.

Glacial Erosion

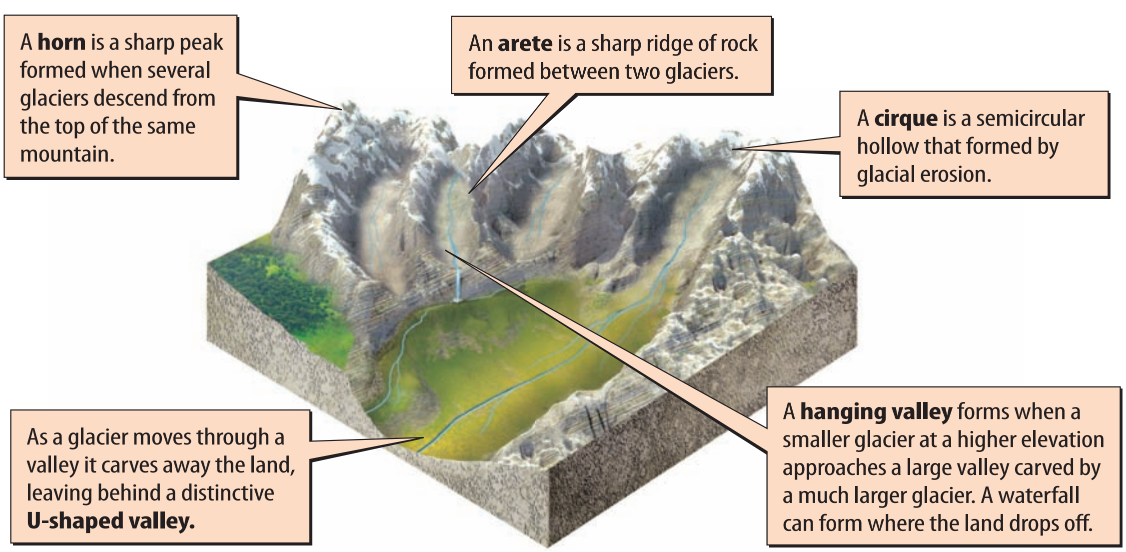
Glaciers erode Earth's surface as they slide over it. They act as bulldozers, carving the land as they move. Rocks and grit frozen within the ice create grooves and scratches on underlying rocks. This is similar to the way sandpaper scratches wood. Alpine glaciers produce distinctive erosional features like the ones shown in **Figure 22.** Notice the U-shaped valleys that glaciers carved through the mountains.

Key Concept Check How do glaciers erode Earth's surface?

Figure 22 Alpine glaciers produce distinctive erosion features.

Visual Check How would the mountains and the valley be different if a glacier had not passed through? ▼

Glacial Erosion



Glacial Deposition

Concepts in Motion Animation

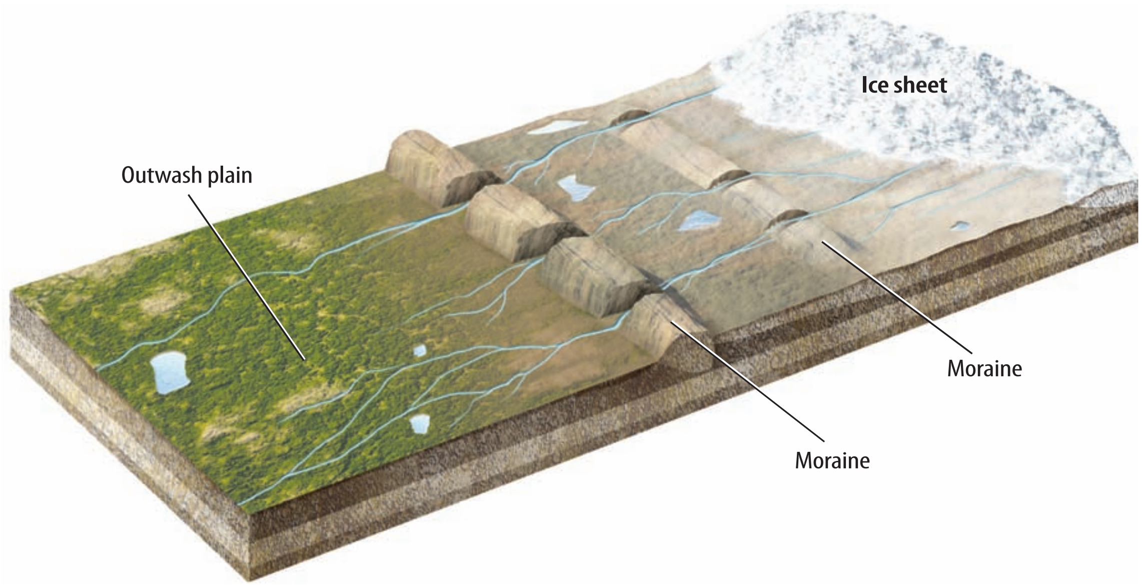


Figure 23 Melting glaciers form various land features as they deposit rock and sediment.

Science Use v. Common Use

till

Science Use rock and sediment deposited by a glacier

Common Use to work by plowing, sowing, and raising crops

Word Origin

moraine

from French *morena*, means "mound of earth"

Glacial Deposition

Glaciers slowly melt as they move down from high altitudes or when the climate in the area warms. Sediment that was once frozen in the ice eventually is deposited in various forms, as illustrated in **Figure 23.** **Till** *is a mixture of various sizes of sediment deposited by a glacier.* Deposits of till are poorly sorted. They commonly contain particles that range in size from boulders to silt. Till often piles up along the sides and fronts of glaciers. It can be shaped and streamlined into many features by the moving ice. For example, *a* **moraine** *is a mound or ridge of unsorted sediment deposited by a glacier.* **Outwash** *is layered sediment deposited by streams of water that flow from a melting glacier.* Outwash consists mostly of well sorted sand and gravel.

Reading Check How does outwash differ from a moraine?

Land Use Practices

At first, it might not seem that human activities affect glaciers. But in some ways, the effects are more significant than they are for other forms of erosion and deposition. For example, human activities contribute to global warming—the gradual increase in Earth's average temperature. This can cause considerable melting of glaciers. Glaciers contain about two-thirds of all the freshwater on Earth. As glaciers melt, sea level rises around the world and coastal flooding is possible.

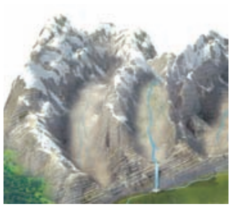
Lesson 3 Review

Assessment Online Quiz

Visual Summary

Mass wasting can occur very fast, such as when a landslide occurs, or slowly over many years.

Material moved by a mass wasting event is deposited when it reaches a relatively stable location. An example is talus deposited at the base of this hill.



A glacier erodes Earth's surface as it moves and melts. Glaciers can form U-shaped valleys when they move past mountains.

FOLDABLES®

Use your lesson Foldable to review the lesson. Save your Foldable for the project at the end of the chapter.

What do you think NOW?

You first read the statements below at the beginning of the chapter.

5. Landslides are a natural process that cannot be influenced by human activities.

6. A glacier leaves behind very smooth land as it moves through an area.

Did you change your mind about whether you agree or disagree with the statements? Rewrite any false statements to make them true.

Use Vocabulary

1 **Define** *mass wasting* in your own words.

2 **Use the term** *talus* in a complete sentence.

3 Erosion by the movement of a ________ can produce a U-shaped valley.

Understand Key Concepts

4 Which is the slowest mass wasting event?

A. creep **C.** rockfall
B. landslide **D.** slump

5 **Classify** each of the following as features of either erosion or deposition: (a) arete, (b) outwash, (c) cirque, and (d) till.

Interpret Graphics

6 **Examine** the drawing. What feature formed by the glacier is indicated by the arrow?

7 **Compare and Contrast** Copy and fill in the table below to compare and contrast moraine and outwash.

Similarities	Differences

Critical Thinking

8 **Compose** a list of evidence for erosion and deposition that you might find in a mountain park that would indicate that glaciers once existed in the area.

Math Skills

Review Math Practice

9 A mountain's base is 2,500 m high. The peak is 3,500 m high. The horizontal distance covers 4,000 m. What is the percent slope?

Inquiry Lab

40 minutes

Avoiding a Landslide

Materials


aluminum pan


sand


cup


model house


paper


collection of grass, small sticks, and pebbles

Safety

The damage caused by landslides can be costly to humans. Sometimes landslides are even deadly. Landslides occur most often after a period of heavy rain in regions prone to earthquakes. In this lab, you will analyze ways to protect a house from a landslide.

Ask a Question

What are some ways to reduce the risk of a landslide?

Make Observations

1. Read and complete a lab safety form.
2. In a pan, mix two parts sand to one part water. There should be 2–3 cm of damp sand in the pan.
3. Shape the damp sand into a hill. Place a model house on top of the hill.

3

4. Using a cup, pour water over the hill, as if it were raining. Record your observations in your Science Journal.
5. Rebuild the hill and the house. This time, gently shake the pan, as if there were an earthquake. Record your observations.

Landslide Test Observations		
Setup	Action	Observations
damp sand hill, no ground cover	pour on water with no shaking	
damp sand hill, no ground cover	pour water and shake the pan	

Form a Hypothesis

6. Suppose someone built a house on the top of a hill. What are three ways to reduce the risk of a landslide? For each way, develop a hypothesis to save the house from a landslide.

Test Your Hypothesis

7. Develop a plan for testing each hypothesis. Present your plans to your teacher. When they are approved, obtain additional materials from your teacher to implement the plans.
8. Test your plans with both rain and an earthquake. Rebuild the hill and replace the house between tests, if necessary.

Analyze and Conclude

9. **Describe** the results of your tests. For each test, was your hypothesis correct? What might have worked better?
10. **Analyze** What is the relationship between the amount of water in the soil and the likelihood of a landslide? Use specific examples from the lab in your explanation.
11. **The Big Idea** What are some ways people can alter Earth's surface to reduce the risk of a landslide?

Communicate Your Results

People who live in areas prone to landslides need to take precautions to protect their homes. Write and perform a 30-second public service announcement that describes your results and how they can help people protect their homes.

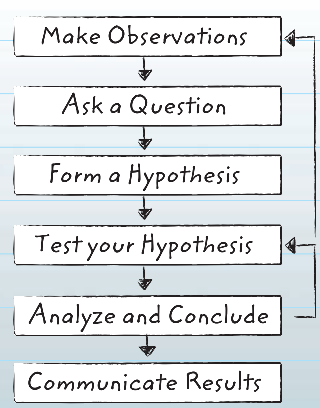
Inquiry Extension

Evaluate your home for risk of a landslide. Is it on a slope? Do you get a lot of rain? Do you live in an area prone to earthquakes?

Lab Tips

- Mix the sand and water completely, but allow water to drain out to make a strong hill.
- Before testing your hypotheses, predict which method will be most effective in reducing the risk of a landslide.

Remember to use scientific methods.



Chapter 8 Study Guide

WebQuest

THE BIG IDEA

Erosion and deposition shape Earth's surface by building up and tearing down landforms.

Key Concepts Summary

Lesson 1: The Erosion-Deposition Process

- **Erosion** is the wearing away and transportation of weathered material. **Deposition** is the laying down of the eroded material.
- Erosion tends to make rocks more rounded. Erosion can sort sediment according to its grain size.
- Landforms produced by deposition are usually on flat, low land. Landforms produced by erosion are often tall and/or jagged.

Vocabulary

erosion
deposition

Lesson 2: Landforms Shaped by Water and Wind

- A young stream moves quickly down steep slopes. A mature stream moves more slowly and develops **meanders.** An old stream is wider and moves slowly.
- Water erosion can form V-shaped valleys. **Longshore currents** reshape beaches. Deposition of sediment from water can form **deltas.**
- Wind **abrasion** can change the shape of rock. Wind deposition can form a **dune** or **loess.**

Vocabulary

meander
longshore current
delta
abrasion
dune
loess

Lesson 3: Mass Wasting and Glaciers

- Gravity can shape Earth's surface through **mass wasting.** Creep is an example of mass wasting.
- A **glacier** erodes Earth's surface as it moves by carving grooves and scratches into rock.

Vocabulary

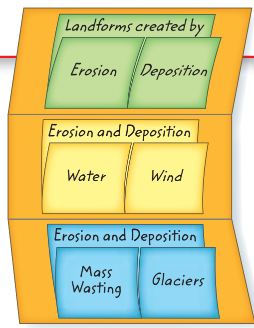
mass wasting
landslide
talus
glacier
till
moraine
outwash

Study Guide

Review
- Personal Tutor
- Vocabulary eGames
- Vocabulary eFlashcards

FOLDABLES Chapter Project

Assemble your lesson Foldables as shown to make a Chapter Project. Use the project to review what you have learned in this chapter.



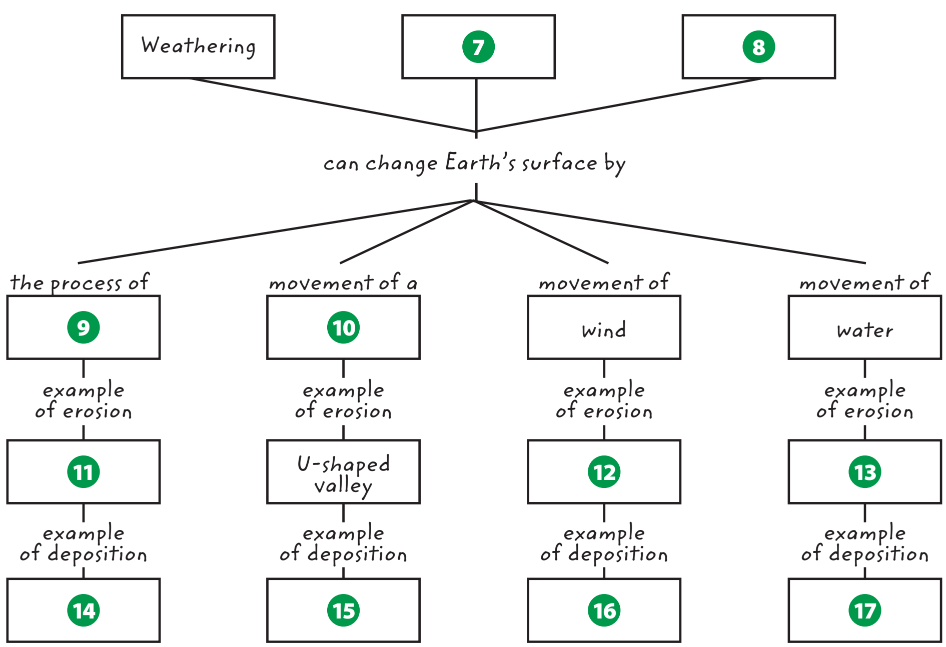
Use Vocabulary

1. Water moving sediment down slopes and a glacier forming a U-shaped valley as it moves past mountains are examples of ________.
2. Wind has less energy as it slows, and ________ of sediment occurs.
3. The grinding of rock as water, wind, or glaciers move sediment is ________.
4. An apron of sediment known as a(n) ________ forms where a stream enters a lake or an ocean.
5. A landslide and creep are types of ________.
6. A large pile of rocks formed from a rockfall is ________.

Link Vocabulary and Key Concepts

Concepts in Motion Interactive Concept Map

Copy this concept map, and then use vocabulary terms from the previous page to complete the concept map.



Chapter 8 Review

Understand Key Concepts

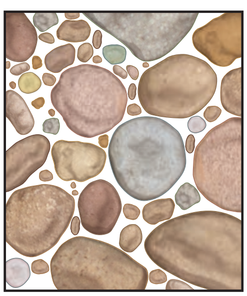
1. Which is a structure created mostly by deposition?
   A. cirque
   B. hoodoo
   C. sandbar
   D. slump

2. Which shows an example of sediment that is both poorly rounded and well-sorted?

A.

C.

B.



D.

3. Which is typically a low-energy depositional environment?
   A. a fast-moving river
   B. an ocean shore with waves
   C. a stream with meanders
   D. a swamp with decaying trees

4. Which would most likely produce a moraine?
   A. a glacier
   B. an ocean
   C. a river
   D. the wind

5. The illustration below shows a type of mass wasting.

Which was produced by this event?
   A. cirque
   B. moraine
   C. talus
   D. till

6. What is the main difference between slump and creep?
   A. the type of land that is affected
   B. the place where they occur
   C. the speed at which they occur
   D. the amount of rain that causes them

7. Which best describes the difference between a dune and loess?
   A. They are produced in different places.
   B. One is erosion, and the other is deposition.
   C. They are deposits of different-sized particles.
   D. One is caused by wind, and the other is caused by water.

8. Where would you most likely find a meander?
   A. in a cave
   B. in a mature stream
   C. under a glacier
   D. beside a waterfall

9. Which is built to prevent beach erosion?
   A. delta
   B. groin
   C. levee
   D. sandbar

Chapter Review

Assessment
Online Test Practice

Critical Thinking

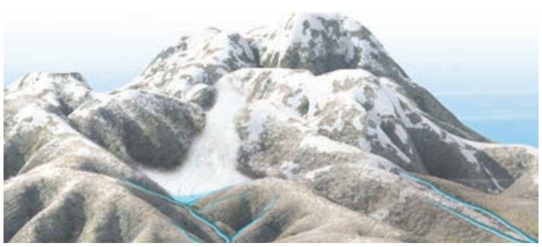
10 **Describe** one erosion feature and one deposition feature you might expect to find (a) in a valley, (b) in a desert, and (c) high in the mountains.

11 **Classify** these landforms as formed mostly by erosion or deposition: (a) cirque, (b) sand dune, (c) alluvial fan, (d) hoodoo.

12 **Construct** a chart that lists three careless land uses that result in mass wasting that could be dangerous to humans. Include in your chart details about how each land use could be changed to be safer.

13 **Produce** a list of at least three hazardous erosion or deposition conditions that would be worse during a particularly stormy, rainy season.

14 **Predict** several ways the mountains and the valleys shown below might change as the glaciers slide down slopes.



15 **Contrast** the rounding and sorting of sediment caused by a young stream to that caused by an old stream.

Writing in Science

16 **Write** Imagine you are planning to build a home on a high cliff overlooking the sea. Write a paragraph that assesses the potential for mass wasting along the cliff. Describe at least four features that would concern you.

REVIEW THE BIG IDEA

17 How do erosion and deposition shape Earth's surface?

18 The photo below shows a landform known as The Wave in Arizona. Explain how erosion and deposition might have produced this landform.

Math Skills

Review
Math Practice

Use Ratios

19 Calculate the average percent slope of the mountains in parts a and b.

a. Mountain A rises from 3,200 m to 6,700 m over a horizontal distance of 10,000 m.

b. Mountain B rises from 1,400 m to 9,400 m over a horizontal distance of 2.5 km.

c. If mountains A and B are composed of the same materials, which mountain is more likely to experience mass wasting?

20 If the slope of a hill is 10 percent, how many meters does the hill rise for every 10 m of horizontal distance?

Standardized Test Practice

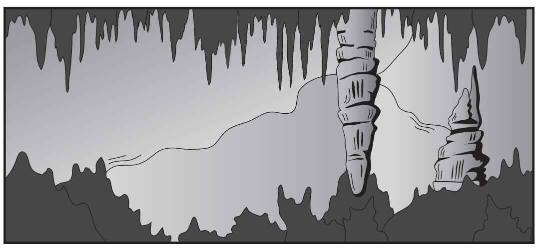
Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

Multiple Choice

1 Which landform is created by deposition?

A alluvial fan
B glacial valley
C mountain range
D river channel

Use the diagram below to answer question 2.



2 Which process formed the features shown in the diagram above?

A A stream eroded and deposited sediment.
B Groundwater deposited minerals in a cave.
C Groundwater dissolved several layers of rock.
D Wind and ice wore away soft sedimentary rock.

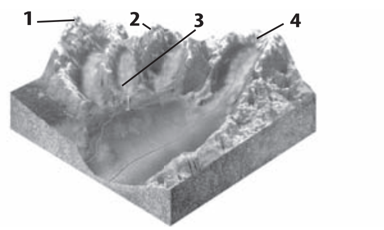
3 Which causes movement in mass wasting?

A gravity
B ice
C magnetism
D wind

4 Which typically is NOT a depositional environment?

A delta
B mountain peak
C ocean floor
D swamp

Use the diagram below to answer questions 5 and 6.



5 Which landform on the diagram above is a cirque?

A 1
B 2
C 3
D 4

6 How did structure *1* form in the diagram above?

A A glacier deposited a large amount of land as it moved.
B A small glacier approached a valley carved by a large glacier.
C Several glaciers descended from the top of the same mountain.
D Two glaciers formed on either side of a ridge.

7 Which agent of erosion can create a limestone cave?

A acidic water
B freezing and melting ice
C growing plant roots
D gusty wind

8 Which deposit does mass wasting create?

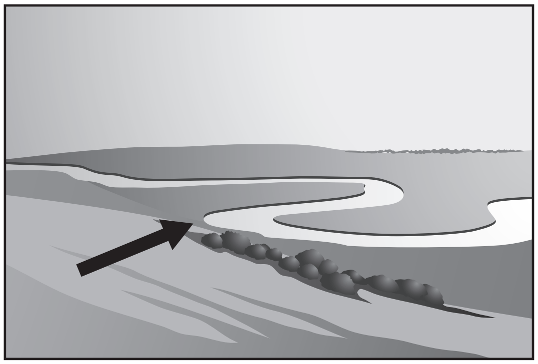
A loess
B outwash
C talus
D till

Standardized Test Practice

Assessment

Online Standardized Test Practice

Use the diagram below to answer question 9.



9 Which river feature does the arrow point to in the diagram above?

A a current

B a meander

C a valley

D an alluvial fan

10 Which is true of a longshore current?

A It ALWAYS flows perpendicular to the shoreline.

B It can form large underground caves.

C It continually changes the size and shape of beaches.

D It creates stretches of sand dunes along the beach.

11 Which geological process is often caused by the growth of plant roots?

A deposition

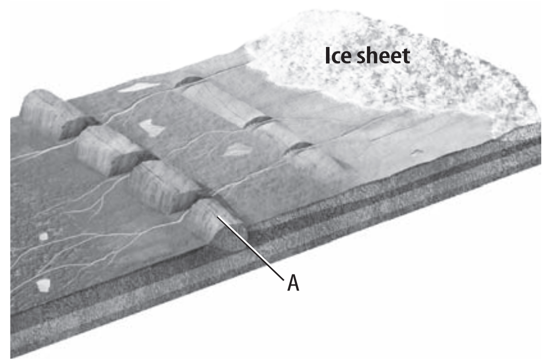
B erosion

C sorting

D weathering

Constructed Response

Use the diagram below to answer questions 12 and 13.



12 Describe the characteristics of deposits found in the feature labeled *A*.

13 How did feature *A* form?

14 A sedimentary rock formation contains alternating layers of fine-grained rock and conglomerate rock, which contains smooth pebble-sized sediments. What is the process that most likely deposited the sediments that make up this rock formation?

15 What factors determine the amount of erosion that occurs during a mass wasting event? How does slope affect the destructive power of this event?

16 What is the typical appearance of a landform formed by erosion?

NEED EXTRA HELP?																
If You Missed Question...	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Go to Lesson...	1	2	3	1	3	3	2	3	2	2	1	3	3	1, 2	3	1