Section 1

Changing Earth's Surface

Reading Preview

Key Concepts

- What processes wear down and build up Earth's surface?
- What causes the different types of mass movement?

Key Terms

- erosion
- sediment
- deposition
- gravity
- mass movement

Target Reading Skill

Comparing and Contrasting As you read, compare and contrast the different types of mass movement by completing a table like the one below.

Mass Movement

Type of Mass Movement	Speed	Slope
Landslide		

Lab zone Discover Activity

How Does Gravity Affect Materials on a Slope?

1. Place a small board flat on your desk. Place a marble on the board and slowly tip one end of the board up slightly. Observe what happens.
2. Place a block of wood on the board. Slowly lift one end of the board and observe the result.
3. Next, cover the board and the wood block with sandpaper and repeat Step 2.

Think It Over

Developing Hypotheses How do the results of each step compare? Develop a hypothesis to explain the differences in your observations.

The ground you stand on is solid. But under certain conditions, solid earth can quickly change to thick, soupy mud. For example, high rains soaked into the soil and triggered the devastating mudflow in Figure 1. A river of mud raced down the mountainside, burying homes and cars. Several lives were lost. In moments, the mudflow moved a huge volume of soil mixed with water and rock downhill.

Wearing Down and Building Up

A mudflow is a spectacular example of erosion. **Erosion** is the process by which natural forces move weathered rock and soil from one place to another. You may have seen water carrying soil and gravel down a driveway after it rains. That's an example of erosion. A mudflow is a very rapid type of erosion. Other types of erosion move soil and rock more slowly. Gravity, running water, glaciers, waves, and wind are all causes, or agents, of erosion. In geology, an agent is a force or material that causes a change in Earth's surface.

FIGURE 1
Mudflow
A mudflow caused by heavy rains in San Bernardino, California, brought this ambulance to a stop.

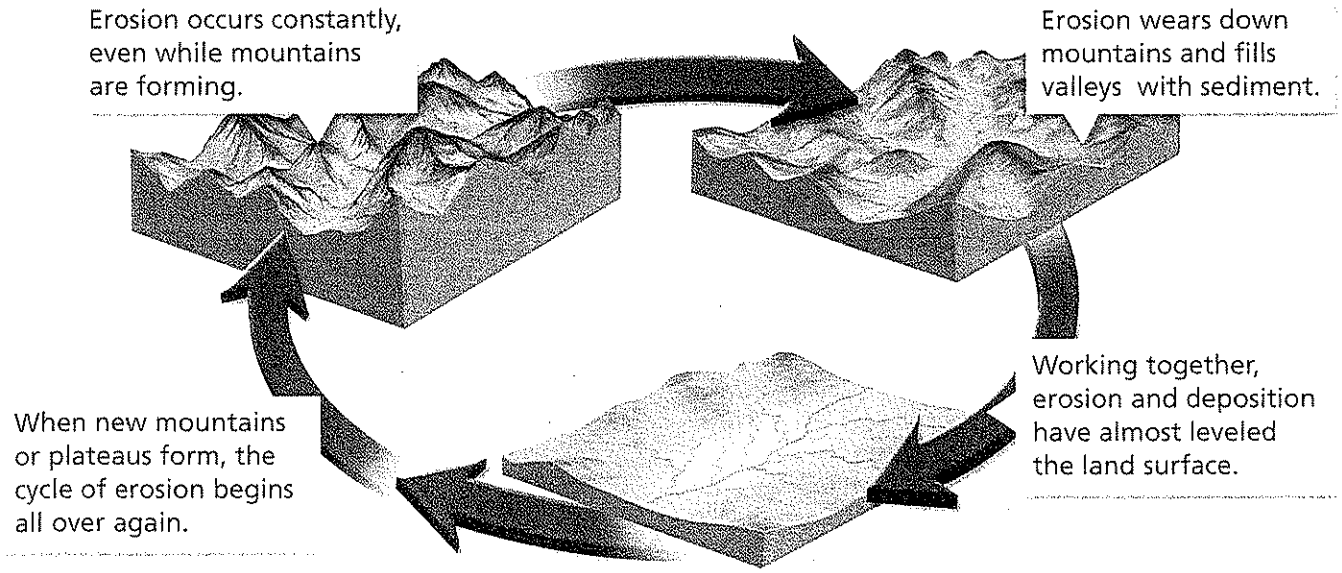


FIGURE 2
Cycle of Erosion and Deposition Over millions of years, erosion gradually wears away mountains while deposition fills in valleys with sediment.
Predicting *What would happen to the surface of the land if uplift did not occur?*

The material moved by erosion is **sediment.** Sediment may consist of pieces of rock or soil or the remains of plants and animals. Both weathering and erosion produce sediment. **Deposition** occurs where the agents of erosion, deposit, or lay down, sediment. Deposition changes the shape of the land. You may have watched a playing child who picked up several toys, carried them across a room, and then put them down. This child was acting something like an agent of erosion and deposition.

Weathering, erosion, and deposition act together in a cycle that wears down and builds up Earth's surface. Erosion and deposition are at work everywhere on Earth. As a mountain wears down in one place, new landforms build up in other places. The cycle of erosion and deposition is never-ending.

Reading Checkpoint **What is sediment?**

Mass Movement

Imagine that you are sitting on a bicycle at the top of a hill. With only a slight push, you can coast down the hill. If the slope of the hill is very steep, you will reach a high speed before reaching the bottom. The force that pulls you and your bicycle downward is gravity. Gravity pulls everything toward the center of Earth.

Gravity is the force that moves rock and other materials downhill. Gravity causes **mass movement**, any one of several processes that move sediment downhill. **The different types of mass movement include landslides, mudflows, slump, and creep.** Mass movement can be rapid or slow.

Lab zone Skills Activity

Making Models

You can make a model of mass movement. Design a plan to model one of the types of mass movement using sand, pebbles, and water. With your teacher's approval, make and test your model.

How well did your model represent the type of mass movement you chose? How could you improve your model?

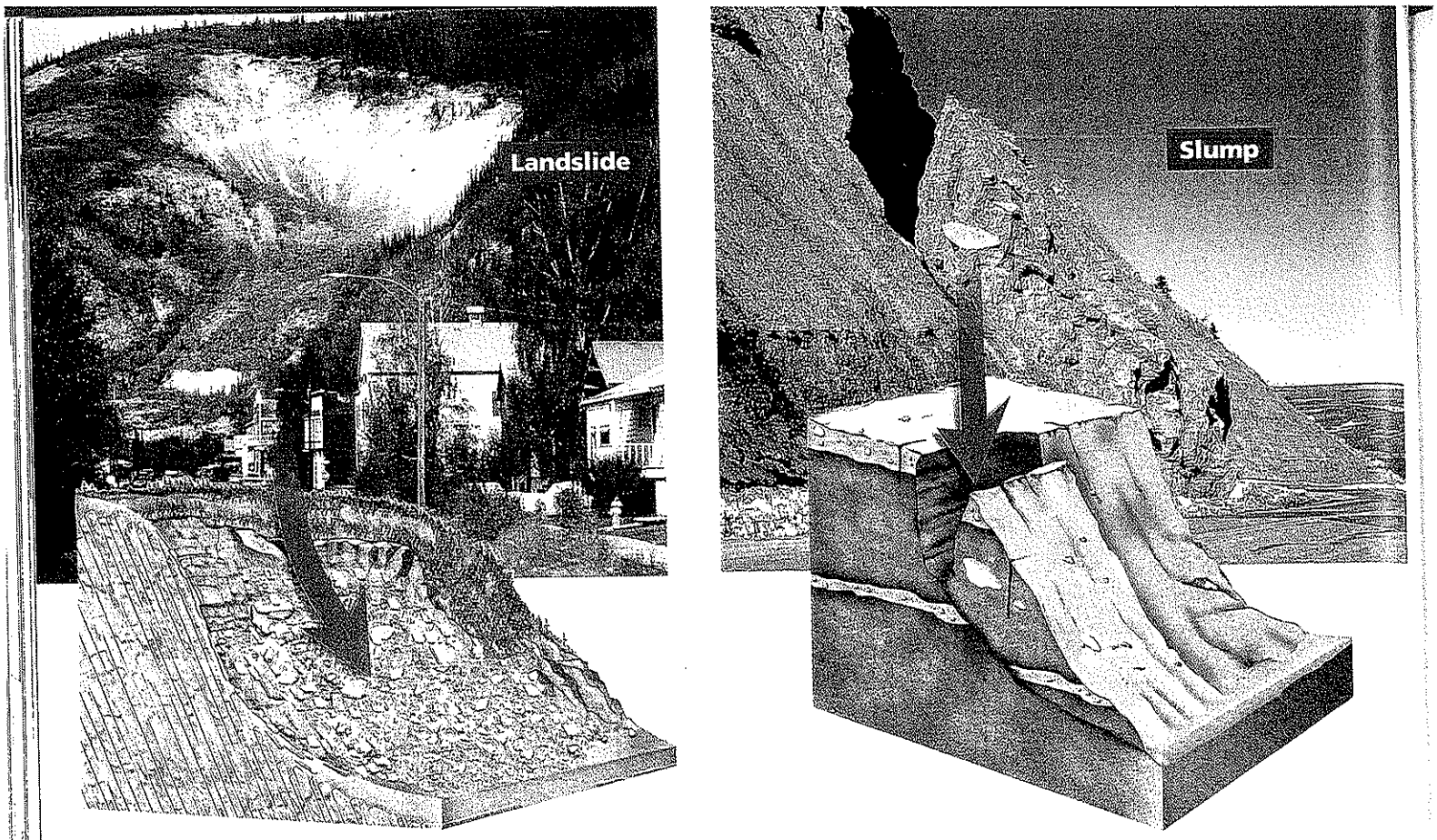
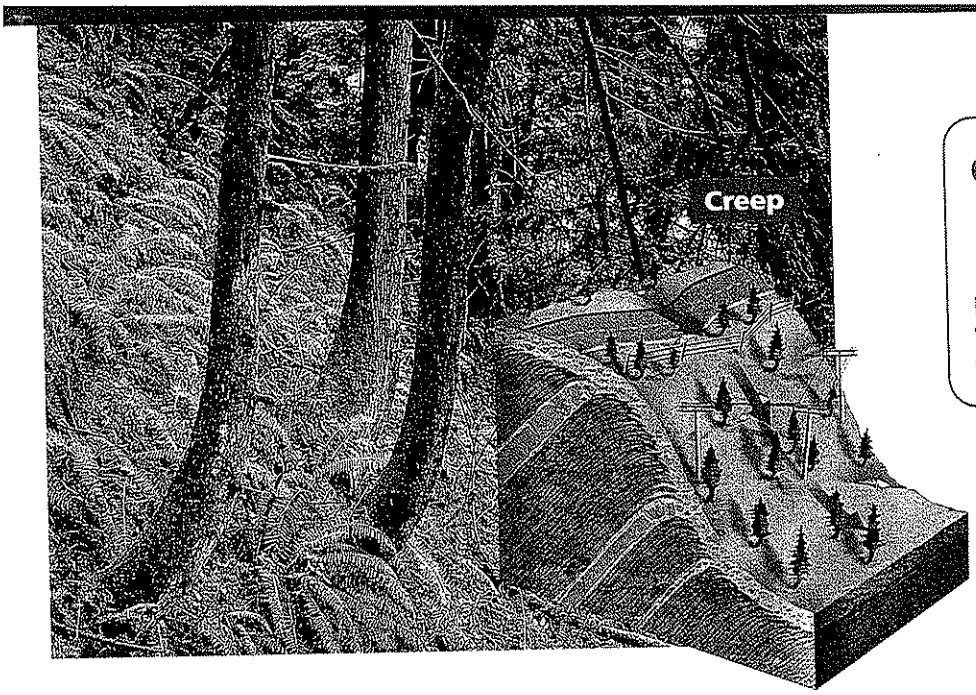


FIGURE 3
Mass Movement
In addition to mudflows, types of mass movement include landslides, slump, and creep.
Making Judgments *Which form of mass movement produces the most drastic change in the surface?*

Landslides The most destructive kind of mass movement is a landslide, which occurs when rock and soil slide quickly down a steep slope. Some landslides contain huge masses of rock. But many landslides contain only a small amount of rock and soil. Some landslides occur where road builders have cut highways through hills or mountains. Figure 3 shows an example of a landslide.

Mudflows A mudflow is the rapid downhill movement of a mixture of water, rock, and soil. The amount of water in a mudflow can be as high as 60 percent. Mudflows often occur after heavy rains in a normally dry area. In clay soils with a high water content, mudflows may occur even on very gentle slopes. Under certain conditions, clay soils suddenly turn to liquid and begin to flow. An earthquake can trigger both mudflows and landslides. Mudflows can be very dangerous.

Slump If you slump your shoulders, the entire upper part of your body drops down. In the type of mass movement known as slump, a mass of rock and soil suddenly slips down a slope. Unlike a landslide, the material in a slump moves down in one large mass. It looks as if someone pulled the bottom out from under part of the slope. A slump often occurs when water soaks the bottom of soil that is rich in clay.



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Creep Creep is the very slow downhill movement of rock and soil. It can even occur on gentle slopes. Creep often results from the freezing and thawing of water in cracked layers of rock beneath the soil. Like the movement of an hour hand on a clock, creep is so slow you can barely notice it. But you can see the effects of creep in objects such as telephone poles, gravestones, and fenceposts. Creep may tilt these objects at spooky angles. Landscapes affected by creep may have the eerie, out-of-kilter look of a funhouse in an amusement park.

Reading Checkpoint **What is the main difference between a slump and a landslide?**

Section 1 Assessment

Target Reading Skill Comparing and Contrasting Use the information in your table to help you answer Question 2 below.

Reviewing Key Concepts

1. a. **Listing** What are five agents of erosion?
   b. **Defining** In your own words, write a definition of *deposition*.
   c. **Predicting** Over time, how will erosion and deposition affect a mountain range? Explain.
2. a. **Listing** What are the four types of mass movement?
   b. **Relating Cause and Effect** What force causes all types of mass movement?
   c. **Inferring** A fence runs across a steep hillside. The fence is tilted downhill and forms a curve rather than a straight line. What can you infer happened to the fence? Explain.

Lab zone At-Home Activity

Evidence of Erosion After a rainstorm, take a walk with an adult family member around your neighborhood. Look for evidence of erosion. Try to find areas where there is loose soil, sand, gravel, or rock. **CAUTION:** *Stay away from any large pile of loose sand or soil—it may slide without warning.* Which areas have the most erosion? The least erosion? How does the slope of the ground affect the amount of erosion? Sketch or take photographs of the areas showing evidence of erosion.

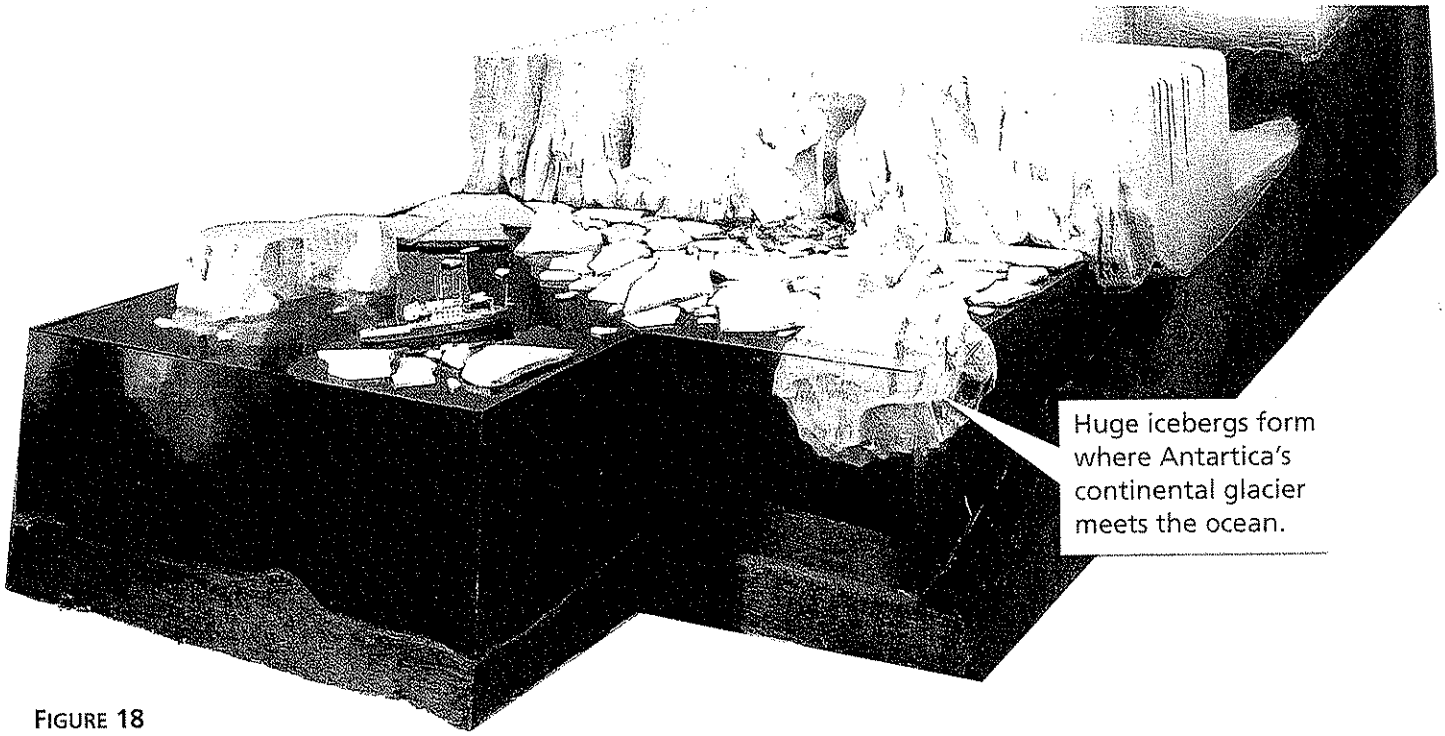
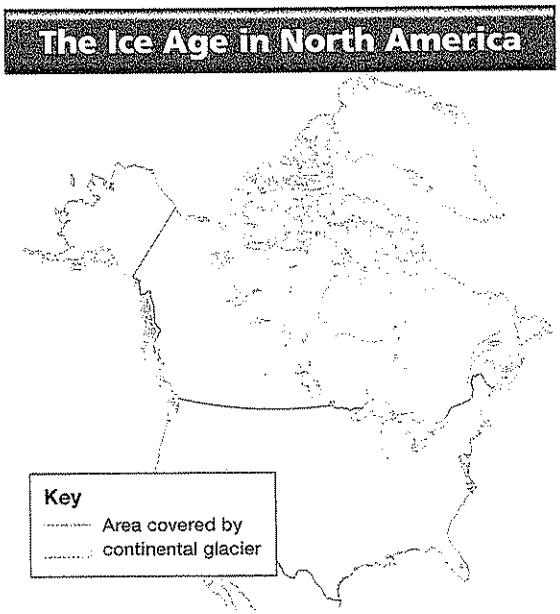


FIGURE 18
Continental Glaciers
Today, huge icebergs form where a continental glacier (above) meets the ocean. During the last ice age (below), a continental glacier covered most of northern North America.



How Glaciers Form and Move

Geologists define a **glacier** as any large mass of ice that moves slowly over land. **There are two kinds of glaciers—continental glaciers and valley glaciers.**

Continental Glaciers A **continental glacier** is a glacier that covers much of a continent or large island. They can spread out over millions of square kilometers. Today, continental glaciers cover about 10 percent of Earth's land. They cover Antarctica and most of Greenland. In places, the glacier covering Antarctica is over 3 kilometers thick. Continental glaciers can flow in all directions as they move. Continental glaciers spread out much as pancake batter spreads out in a frying pan.

Many times in the past, continental glaciers have covered larger parts of Earth's surface. These times are known as **ice ages.** For example, beginning about 2.5 million years ago, continental glaciers covered about one third of Earth's land. The glaciers advanced and retreated, or melted back, several times. They finally retreated about 10,000 years ago.

Valley Glaciers A **valley glacier** is a long, narrow glacier that forms when snow and ice build up high in a mountain valley. The sides of mountains keep these glaciers from spreading out in all directions. Instead, they usually move down valleys that have already been cut by rivers. Valley glaciers are found on many high mountains. Although they are much smaller than continental glaciers, valley glaciers can be tens of kilometers long.

High in mountain valleys, temperatures seldom rise above freezing. Snow builds up year after year. The weight of more and more snow compacts the snow at the bottom into ice. **Glaciers can form only in an area where more snow falls than melts. Once the depth of snow and ice reaches more than 30 to 40 meters, gravity begins to pull the glacier downhill.**

Valley glaciers flow at a rate of a few centimeters to a few meters per day. But sometimes a valley glacier slides down more quickly in what is called a surge. A surging glacier can flow as much as 6 kilometers a year.

Reading Checkpoint **On what type of landform are valley glaciers found?**

How Glaciers Shape the Land

The movement of a glacier changes the land beneath it. Although glaciers work slowly, they are a major force of erosion. **The two processes by which glaciers erode the land are plucking and abrasion.**

Glacial Erosion As a glacier flows over the land, it picks up rocks in a process called **plucking.** Beneath a glacier, the weight of the ice can break rocks apart. These rock fragments freeze to the bottom of the glacier. When the glacier moves, it carries the rocks with it. Figure 19 shows plucking by a glacier. Plucking can move even huge boulders.

Many rocks remain on the bottom of the glacier, and the glacier drags them across the land. This process, called abrasion, gouges and scratches the bedrock. You can see the results of erosion by glaciers in Figure 19.

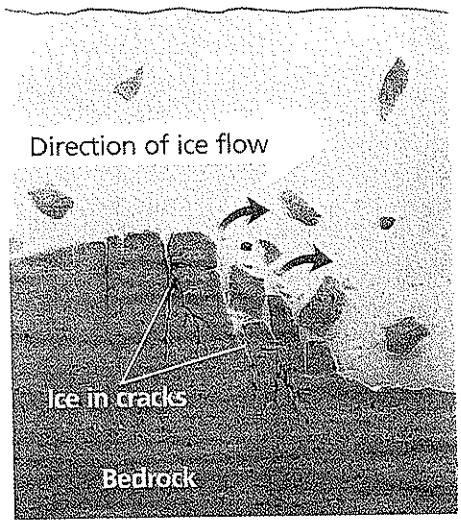
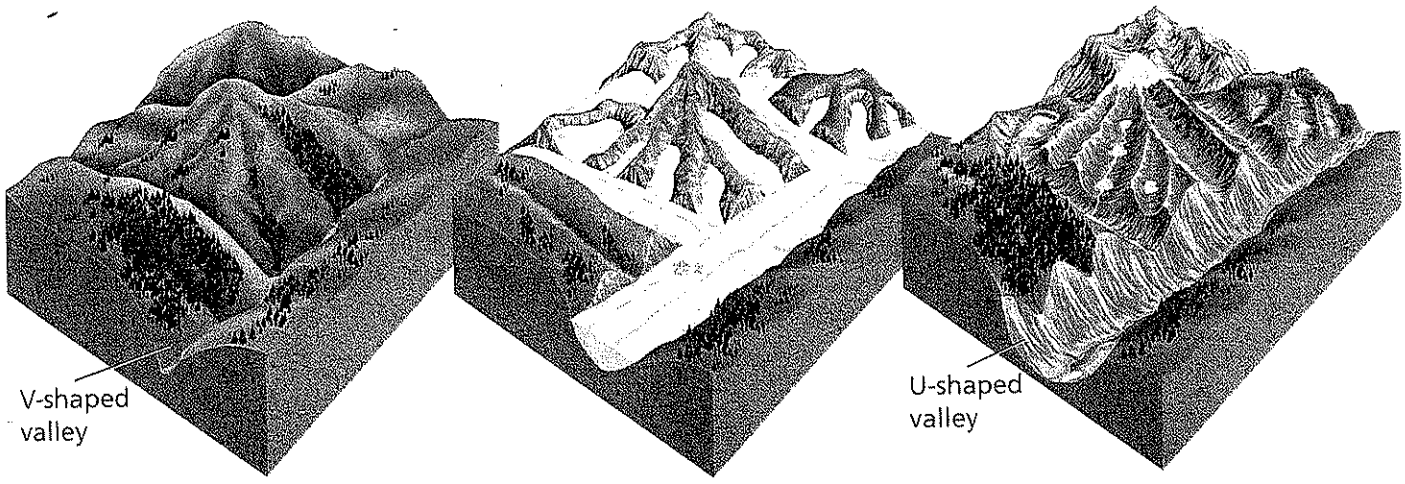


FIGURE 19
Glacial Erosion
As a glacier moves (above), plucking breaks pieces of bedrock from the ground. Erosion by glaciers (below) can carve a mountain peak into a sharp horn and grind out a **V**-shaped valley to form a **U**-shaped valley.
Observing *What other changes did the glacier produce in this landscape?*



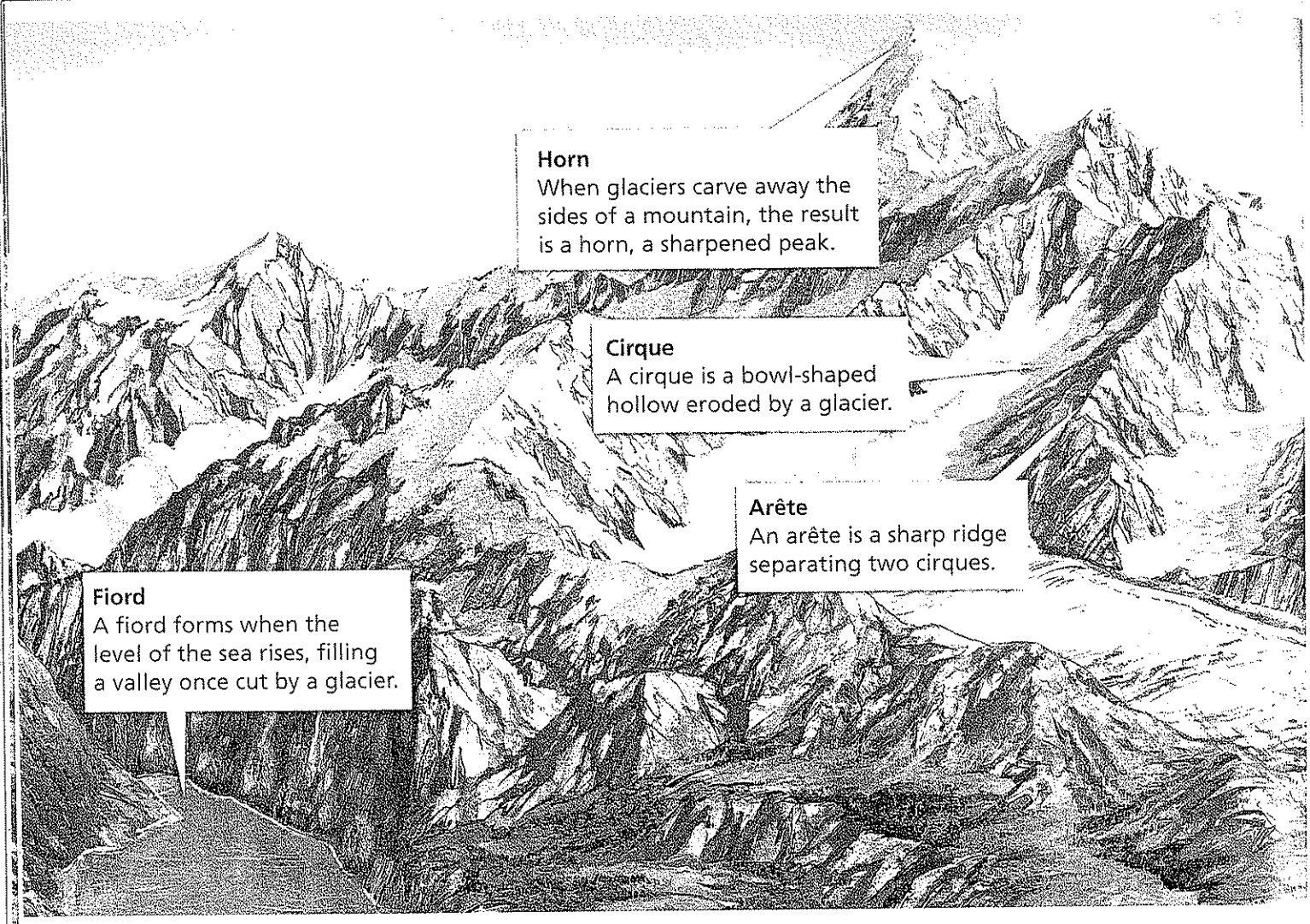


FIGURE 20
Glacial Landforms
As glaciers advance and retreat, they sculpt the landscape by erosion and deposition.
Classifying *Classify these glacial features according to whether they result from erosion or deposition: drumlin, horn, cirque, moraine, U-shaped valley.*

Glacial Deposition A glacier gathers a huge amount of rock and soil as it erodes the land in its path. **When a glacier melts, it deposits the sediment it eroded from the land, creating various landforms.** These landforms remain for thousands of years after the glacier has melted. The mixture of sediments that a glacier deposits directly on the surface is called **till.** Till is made up of particles of many different sizes. Clay, silt, sand, gravel, and boulders can all be found in till.

The till deposited at the edges of a glacier forms a ridge called a **moraine.** A terminal moraine is the ridge of till at the farthest point reached by a glacier. Long Island in New York is a terminal moraine from the continental glaciers of the last ice age.

Retreating glaciers also create features called kettles. A **kettle** is a small depression that forms when a chunk of ice is left in glacial till. When the ice melts, the kettle remains. The continental glacier of the last ice age left behind many kettles. Kettles often fill with water, forming small ponds or lakes called kettle lakes. Such lakes are common in areas, such as Minnesota, that were covered with ice.

Reading Checkpoint **What is a terminal moraine?**

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