This photo shows Horseshoe Bend on the Colorado River as it flows through the Grand Canyon. Notice the trees growing along the river’s edge. They look tiny from the top of the canyon. They show how deep the canyon is. The Colorado River carved this spectacular canyon down through layer upon layer of rock. How can water cut through rock? How did the horseshoe shape form? In this chapter, you’ll find answers to questions like these. You’ll learn how moving water and other natural forces shape Earth’s surface, sometimes in spectacular ways.

PaxsonWoelber:www.flickr.com/photos/paxson_woelber/8077922348/.CCBY2.0
Lesson Objectives

- Explain how flowing water causes erosion and deposition.
- Describe how runoff, streams, and rivers change Earth’s surface.
- Identify features caused by groundwater erosion and deposition.

Vocabulary

- alluvial fan
- cave
- delta
- deposition
- erosion
- floodplain
- levee
- meander
- oxbow lake
- saltation
- sinkhole
- suspension
- traction

Introduction

Erosion and deposition are responsible for many landforms. Erosion is the transport of sediments. Agents of erosion include flowing water, waves, wind, ice, or gravity. Eroded material is eventually dropped somewhere else. This is called deposition.

How Flowing Water Causes Erosion and Deposition

Flowing water is a very important agent of erosion. Flowing water can erode rocks and soil. Water dissolves minerals from rocks and carries the ions. This process happens really slowly. But over millions of years, flowing water dissolves massive amounts of rock.

Moving water also picks up and carries particles of soil and rock. The ability to erode is affected by the velocity, or speed, of the water. The size of the eroded particles depends on the velocity of the water. Eventually, the water deposits the materials. As water slows, larger particles are deposited. As the water slows even more, smaller particles
are deposited. The graph in Figure 10.1 shows how water velocity and particle size influence erosion and deposition.

**Water Speed and Erosion**

Faster-moving water has more energy. Therefore, it can carry larger particles. It can carry more particles. What causes water to move faster? The slope of the land over which the water flows is one factor. The steeper the slope, the faster the water flows. Another factor is the amount of water that’s in the stream. Streams with a lot of water flow faster than streams that are nearly dry.

**Particle Size and Erosion**

The size of particles determines how they are carried by flowing water. This is illustrated in Figure 10.2.

- Minerals that dissolve in water form salts. The salts are carried in solution. They are mixed thoroughly with the water.
- Small particles, such as clay and silt, are carried in suspension. They are mixed throughout the water. These particles are not dissolved in the water.
- Somewhat bigger particles, such as sand, are moved by saltation. The particles move in little jumps near the stream bottom. They are nudged along by water and other particles.
- The biggest particles, including gravel and pebbles, are moved by traction. In this process, the particles roll or drag along the bottom of the water.
Deposition by Water

Flowing water slows down when it reaches flatter land or flows into a body of still water. What do you think happens then? The water starts dropping the particles it was carrying. As the water slows, it drops the largest particles first. The smallest particles settle out last.

Erosion and Deposition by Surface Water

Water that flows over Earth’s surface includes runoff, streams, and rivers. All these types of flowing water can cause erosion and deposition.

Erosion by Runoff

When a lot of rain falls in a short period of time, much of the water is unable to soak into the ground. Instead, it runs over the land. Gravity causes the water to flow from higher to lower ground. As the runoff flows, it may pick up loose material on the surface, such as bits of soil and sand.

Runoff is likely to cause more erosion if the land is bare. Plants help hold the soil in place. The runoff water in Figure 10.3 is brown because it eroded soil from a bare, sloping field. Can you find evidence of erosion by runoff where you live? What should you look for?

Much of the material eroded by runoff is carried into bodies of water, such as streams, rivers, ponds, lakes, or oceans. Runoff is an important cause of erosion. That’s because it occurs over so much of Earth’s surface.
10.1. Erosion and Deposition by Flowing Water

Erosion by Mountain Streams

Streams often start in mountains, where the land is very steep. You can see an example in Figure 10.4. A mountain stream flows very quickly because of the steep slope. This causes a lot of erosion and very little deposition. The rapidly falling water digs down into the stream bed and makes it deeper. It carves a narrow, V-shaped channel.

How a Waterfall Forms

Mountain streams may erode waterfalls. As shown in Figure 10.5, a waterfall forms where a stream flows from an area of harder to softer rock. The water erodes the softer rock faster than the harder rock. This causes the stream bed to drop down, like a step, creating a waterfall. As erosion continues, the waterfall gradually moves upstream.

Erosion by Slow-Flowing Rivers

Rivers flowing over gentle slopes erode the sides of their channels more than the bottom. Large curves, called meanders, form because of erosion and deposition by the moving water. The curves are called meanders because they slowly “wander” over the land. You can see how this happens in Figure 10.6.

As meanders erode from side to side, they create a floodplain. This is a broad, flat area on both sides of a river. Eventually, a meander may become cut off from the rest of the river. This forms an oxbow lake, like the one in Figure 10.6.

Deposition by Streams and Rivers

When a stream or river slows down, it starts dropping its sediments. Larger sediments are dropped in steep areas, but smaller sediments can still be carried. Smaller sediments are dropped as the slope becomes less steep.

Alluvial Fans

In arid regions, a mountain stream may flow onto flatter land. The stream comes to a stop rapidly. The deposits form an alluvial fan, like the one in Figure 10.7.
FIGURE 10.5
How a Waterfall Forms and Moves. Why does a waterfall keep moving upstream?

FIGURE 10.6
Meanders form because water erodes the outside of curves and deposits eroded material on the inside. Over time, the curves shift position.
Deltas
Deposition also occurs when a stream or river empties into a large body of still water. In this case, a delta forms. A delta is shaped like a triangle. It spreads out into the body of water. An example is shown in Figure 10.7.

Deposition by Flood Waters
A flood occurs when a river overflows its banks. This might happen because of heavy rains.

Floodplains
As the water spreads out over the land, it slows down and drops its sediment. If a river floods often, the floodplain develops a thick layer of rich soil because of all the deposits. That’s why floodplains are usually good places for growing plants. For example, the Nile River in Egypt provides both water and thick sediments for raising crops in the middle of a sandy desert.

Natural Levees
A flooding river often forms natural levees along its banks. A levee is a raised strip of sediments deposited close to the water’s edge. You can see how levees form in Figure 10.8. Levees occur because floodwaters deposit their biggest sediments first when they overflow the river’s banks.

Erosion and Deposition by Groundwater
Some water soaks into the ground. It travels down through tiny holes in soil. It seeps through cracks in rock. The water moves slowly, pulled deeper and deeper by gravity. Underground water can also erode and deposit material.

Caves
As groundwater moves through rock, it dissolves minerals. Some rocks dissolve more easily than others. Over time, the water may dissolve large underground holes, or caves. Groundwater drips from the ceiling to the floor of a cave. This water is rich in dissolved minerals. When the minerals come out of solution, they are deposited. They build up on the ceiling of the cave to create formations called stalactites. A stalactite is a pointed, icicle-like mineral deposit that forms on the ceiling of a cave. They drip to the floor of the cave and harden to form stalagmites. A stalagmite is a more rounded mineral deposit that forms on the floor of a cave (Figure 10.9). Both types of formations grow in size as water keeps dripping and more minerals are deposited.
A stream within its banks.

A stream at flood stage deposits large particles along its banks.

After many floods, natural levees have been built up along stream banks.

FIGURE 10.9
This cave has both stalactites and stalagmites.
Sinkholes

As erosion by groundwater continues, the ceiling of a cave may collapse. The rock and soil above it sink into the ground. This forms a **sinkhole** on the surface. You can see an example of a sinkhole in Figure 10.10. Some sinkholes are big enough to swallow vehicles and buildings.

![A sinkhole.](image)

Lesson Summary

- Water flowing over Earth’s surface or underground causes erosion and deposition.
- Water flowing over a steeper slope moves faster and causes more erosion.
- How water transports particles depends on their size. When water slows down, it starts depositing sediment, starting with the largest particles first.
- Runoff erodes the land after a heavy rain. It picks up sediment and carries most of it to bodies of water. Mountain streams erode narrow, V-shaped valleys and waterfalls.
- Erosion and deposition by slow-flowing rivers creates broad floodplains and meanders.
- Deposition by streams and rivers may form alluvial fans and deltas. Floodwaters may deposit natural levees.
- Erosion and deposition by groundwater can form caves and sinkholes. Stalactites and stalagmites are mineral deposits that build up in caves as water continues to drip.

Lesson Review Questions

**Recall**

1. Define erosion.
2. What is deposition?
3. When does flowing water deposit the sediment it is carrying?
4. What happens to the sediment eroded by runoff?
5. Describe how a waterfall forms?
6. What are meanders?

**Apply Concepts**

7. Make a table that relates particle size to the way particles are transported by flowing water.
8. Create a sketch that shows effects of groundwater erosion and deposition.

**Think Critically**

9. Explain why mountain streams erode V-shaped valleys.
10. What might be pros and cons of living on the floodplain of a river?

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**Points to Consider**

Ocean waves are another form of moving water. They also cause erosion and deposition.

- How do waves erode shorelines?
- What landforms are deposited by waves?
Lesson Objectives

• Explain how waves cause erosion of shorelines.
• Describe features formed by wave deposition.
• Identify ways to protect shorelines from wave erosion.

Vocabulary

• barrier island
• breakwater
• groin
• longshore drift
• sandbar
• sea arch
• sea stack
• spit

Introduction

Have you ever stood on a sandy ocean beach and let the waves wash over your feet? If you have, then you probably felt the sand being washed out from under your feet by the outgoing waves. This is an example of wave erosion. What are waves? Why do they cause erosion? And what happens to the sand that waves wash away from the beach?

What Are Waves?

All waves are the way energy travels through matter. Ocean waves are energy traveling through water. They form when wind blows over the surface of the ocean. Wind energy is transferred to the sea surface. Then, the energy is carried through the water by the waves. Figure 10.11 shows ocean waves crashing against rocks on a shore. They pound away at the rocks and anything else they strike.

Three factors determine the size of ocean waves:

1. The speed of the wind.
2. The length of time the wind blows.
3. The distance the wind blows.

The faster, longer, and farther the wind blows, the bigger the waves are. Bigger waves have more energy.
Wave Erosion

Runoff, streams, and rivers carry sediment to the oceans. The sediment in ocean water acts like sandpaper. Over time, they erode the shore. The bigger the waves are and the more sediment they carry, the more erosion they cause.

Landforms From Wave Erosion

Erosion by waves can create unique landforms (Figure 10.12).

- Wave-cut cliffs form when waves erode a rocky shoreline. They create a vertical wall of exposed rock layers.
- Sea arches form when waves erode both sides of a cliff. They create a hole in the cliff.
- Sea stacks form when waves erode the top of a sea arch. This leaves behind pillars of rock.

Wave Deposition

Eventually, the sediment in ocean water is deposited. Deposition occurs where waves and other ocean motions slow. The smallest particles, such as silt and clay, are deposited away from shore. This is where water is calmer. Larger particles are deposited on the beach. This is where waves and other motions are strongest.
10.2. Erosion and Deposition by Waves

Beaches

In relatively quiet areas along a shore, waves may deposit sand. Sand forms a beach, like the one in Figure 10.13. Many beaches include bits of rock and shell. You can see a close-up photo of beach deposits in Figure 10.14.

![Figure 10.13](image)

Sand deposited along a shoreline creates a beach.

![Figure 10.14](image)

Beach deposits usually consist of small pieces of rock and shell in addition to sand.

Longshore Drift

Most waves strike the shore at an angle. This causes longshore drift. Longshore drift moves sediment along the shore. Sediment is moved up the beach by an incoming wave. The wave approaches at an angle to the shore. Water then moves straight offshore. The sediment moves straight down the beach with it. The sediment is again picked up by a wave that is coming in at an angle. This motion is show in Figure 10.15 and at the link below.

http://oceanica.cofc.edu/an%20educator's%20guide%20to%20folly%20beach/guide/driftanimation.htm

Landforms Deposited by Waves

Deposits from longshore drift may form a spit. A spit is a ridge of sand that extends away from the shore. The end of the spit may hook around toward the quieter waters close to shore. You can see a spit in Figure 10.16.

Waves may also deposit sediments to form sandbars and barrier islands. You can see examples of these landforms in Figure 10.17.
FIGURE 10.15
Longshore drift carries particles of sand and rock down a coastline.

FIGURE 10.16
Spit from Space. Farewell Spit in New Zealand is clearly visible from space. This photo was taken by an astronaut orbiting Earth.

FIGURE 10.17
Wave-Deposited Landforms. These landforms were deposited by waves. (A) Sandbars connect the small islands on this beach on Thailand. (B) A barrier island is a long, narrow island. It forms when sand is deposited by waves parallel to a coast. It develops from a sandbar that has built up enough to break through the water's surface. A barrier island helps protect the coast from wave erosion.

Protecting Shorelines

Shores are attractive places to live and vacation. But development at the shore is at risk of damage from waves. Wave erosion threatens many homes and beaches on the ocean. This is especially true during storms, when waves
10.2. Erosion and Deposition by Waves

may be much larger than normal.

**Breakwaters**

Barrier islands provide natural protection to shorelines. Storm waves strike the barrier island before they reach the shore. People also build artificial barriers, called breakwaters. Breakwaters also protect the shoreline from incoming waves. You can see an example of a breakwater in Figure 10.18. It runs parallel to the coast like a barrier island.

![Figure 10.18](https://www.ck12.org/coverimage/10.2-Erosion-and-Deposition-by-Waves.png)

**Groins**

Longshore drift can erode the sediment from a beach. To keep this from happening, people may build a series of groins. A groin is a wall of rocks or concrete that juts out into the ocean perpendicular to the shore. It stops waves from moving right along the beach. This stops the sand on the upcurrent side and reduces beach erosion. You can see how groins work in Figure 10.19.

![Figure 10.19](https://www.ck12.org/coverimage/10.2-Erosion-and-Deposition-by-Waves.png)

**Lesson Summary**

- Ocean waves are energy traveling through water. They are caused mainly by wind blowing over the water.
- Sediment in ocean water acts like sandpaper. Over time, it erodes the shore. It can create unique landforms, such as wave-cut cliffs, sea arches, and sea stacks.
- Deposits by waves include beaches. They may shift along the shoreline due to longshore drift. Other wave deposits are spits, sand bars, and barrier islands.
- Breakwaters are structures that protect the coast like barrier islands. Groins are structures that help prevent longshore drift from eroding a beach.
Lesson Review Questions

Recall

1. What are waves?
2. How do ocean waves cause erosion?
3. Identify three types of landforms created by wave erosion.
4. What is a spit? How does it form?

Apply Concepts

5. Create a diagram to illustrate the concept of longshore drift.
Think Critically

6. Why are the smallest particles on a beach usually sand?
7. Explain how a barrier island helps protect the coast from wave erosion.
8. Compare and contrast how breakwaters and groins protect shorelines.

Points to Consider

Moving air, like moving water, causes erosion. Moving air is called wind.

- How does wind cause erosion? Does the wind carry particles in the same ways that moving water does?
- What landforms are deposited by the wind?
Lesson Objectives

- Explain how wind causes erosion.
- Describe sediments deposited by wind.
- Identify ways to prevent wind erosion.

Vocabulary

- loess
- sand dune

Introduction

Wind is only air moving over Earth’s surface, but it can cause a lot of erosion. Look at Figure 10.20. It will give you an idea of just how much erosion wind can cause. The dust storm in the photo occurred in Arizona. All that dust in the air was picked up and carried by the wind. The wind may carry the dust for hundreds of kilometers before depositing it.

FIGURE 10.20
Dust storm over Arizona desert. Have you ever experienced a dust storm like this one?
10.3. Erosion and Deposition by Wind

Wind Erosion

Dust storms like the one in Figure 10.20 are more common in dry climates. The soil is dried out and dusty. Plants may be few and far between. Dry, bare soil is more easily blown away by the wind than wetter soil or soil held in place by plant roots.

How the Wind Moves Particles

Like flowing water, wind picks up and transports particles. Wind carries particles of different sizes in the same ways that water carries them. You can see this in Figure 10.21.

- Tiny particles, such as clay and silt, move by suspension. They hang in the air, sometimes for days. They may be carried great distances and rise high above the ground.
- Larger particles, such as sand, move by saltation. The wind blows them in short hops. They stay close to the ground.
- Particles larger than sand move by traction. The wind rolls or pushes them over the surface. They stay on the ground.

![Figure 10.21](image)

Wind transports particles in different ways depending on their size (left). A dust storm in the Middle East (right).

Abrasion

Did you ever see workers sandblasting a building to clean it? Sand is blown onto the surface to scour away dirt and debris. Wind-blown sand has the same effect. It scours and polishes rocks and other surfaces. Wind-blown sand may carve rocks into interesting shapes. You can see an example in Figure 10.22. This form of erosion is called abrasion. It occurs any time rough sediments are blown or dragged over surfaces. Can you think of other ways abrasion might occur?

Wind Deposition

Like water, when wind slows down it drops the sediment it’s carrying. This often happens when the wind has to move over or around an obstacle. A rock or tree may cause wind to slow down. As the wind slows, it deposits the largest particles first. Different types of deposits form depending on the size of the particles deposited.

Deposition of Sand

When the wind deposits sand, it forms small hills of sand. These hills are called sand dunes. For sand dunes to form, there must be plenty of sand and wind. Sand dunes are found mainly in deserts and on beaches. You can see
examples of sand dunes in Figure 10.23.

How Sand Dunes Form

What causes a sand dune to form? It starts with an obstacle, such as a rock. The obstacle causes the wind to slow down. The wind then drops some of its sand. As more sand is deposited, the dune gets bigger. The dune becomes the obstacle that slows the wind and causes it to drop its sand. The hill takes on the typical shape of a sand dune, shown in Figure 10.24.
Migration of Sand Dunes

Once a sand dune forms, it may slowly migrate over the land. The wind moves grains of sand up the gently sloping side of the dune. This is done by saltation. When the sand grains reach the top of the dune, they slip down the steeper side. The grains are pulled by gravity. The constant movement of sand up and over the dune causes the dune to move along the ground. It always moves in the same direction that the wind usually blows. Can you explain why?

Loess

When the wind drops fine particles of silt and clay, it forms deposits called loess. Loess deposits form vertical cliffs. Loess can become a thick, rich soil. That’s why loess deposits are used for farming in many parts of the world. You can see an example of loess in Figure 10.25.

Preventing Wind Erosion

It’s very important to control wind erosion of soil. Good soil is a precious resource that takes a long time to form. Covering soil with plants is one way to reduce wind erosion. Plants and their roots help hold the soil in place. They also help the soil retain water so it is less likely to blow away.

Planting rows of trees around fields is another way to reduce wind erosion. The trees slow down the wind, so it doesn’t cause as much erosion. Fences like the one in Figure 10.26 serve the same purpose. The fence in the figure is preventing erosion and migration of sand dunes on a beach.

Lesson Summary

- Dry, bare soil is more likely to be eroded by the wind than moist soil or soil covered with plants. How wind carries particles depends on their size. The sediment in wind causes erosion by abrasion.
- Sand dunes form when the wind deposits sand. Loess form when the wind deposits clay and silt.
- Wind erosion can be prevented by keeping the ground covered with plants. They help hold the soil in place. Rows of trees and fences can help by slowing the wind.
FIGURE 10.26
Protecting Sand Dunes from Wind Erosion. Many beaches uses fences like this one to reduce wind erosion of sand. If plants start growing on the dunes, they help hold the sand in place.

Lesson Review Questions

Recall

1. How does the wind carry particles of sand?
2. What is abrasion?
3. What are sand dunes? Where are they found?
4. Describe loess.
5. Identify two ways to reduce wind erosion.

Apply Concepts

6. Wind-blown snow forms drifts that are similar to sand dunes. Apply lesson concepts to infer how you could reduce snowdrifts in a driveway.

Think Critically

7. Compare and contrast how the wind transports clay, sand, and pebbles.
8. Explain why a sand dune migrates.

Points to Consider

Abrasion is the main way that wind causes erosion. The next lesson explains how glaciers cause erosion.

• How do you think glaciers cause erosion?
• Do you think glaciers might erode by abrasion, like the wind?
Lesson Objectives

- Describe how continental and valley glaciers form.
- Explain how glaciers cause erosion.
- Identify landforms deposited by glaciers.

Vocabulary

- continental glacier
- glacial till
- glacier
- moraine
- plucking
- valley glacier

Introduction

Glaciers are masses of flowing ice. Today, they cover only about 10 percent of Earth’s surface. They are getting smaller and smaller as Earth’s temperature rises. But just 12,000 years ago, glaciers dipped as far south as Chicago and New York City. Much of Europe was also covered with glaciers at that time.

Glaciers erode and leave behind telltale landforms. These landforms are like clues. They show the direction a glacier flowed and how far it advanced. Did glaciers leave clues where you live? Would you know what to look for?

How Glaciers Form

Glaciers form when more snow falls than melts each year. Over many years, layer upon layer of snow compacts and turns to ice. There are two different types of glaciers: continental glaciers and valley glaciers. Each type forms some unique features through erosion and deposition. An example of each type is pictured in Figure 10.27.

- A continental glacier is spread out over a huge area. It may cover most of a continent. Today, continental glaciers cover most of Greenland and Antarctica. In the past, they were much more extensive.
- A valley glacier is long and narrow. Valley glaciers form in mountains and flow downhill through mountain river valleys.
Erosion by Glaciers

Like flowing water, flowing ice erodes the land and deposits the material elsewhere. Glaciers cause erosion in two main ways: plucking and abrasion.

- **Plucking** is the process by which rocks and other sediments are picked up by a glacier. They freeze to the bottom of the glacier and are carried away by the flowing ice.
- **Abrasion** is the process in which a glacier scrapes underlying rock. The sediments and rocks frozen in the ice at the bottom and sides of a glacier act like sandpaper. They wear away rock. They may also leave scratches and grooves that show the direction the glacier moved.

Erosion by Valley Glaciers

Valley glaciers form several unique features through erosion. You can see some of them in Figure 10.28.

- As a valley glacier flows through a V-shaped river valley, it scrapes away the sides of the valley. It carves a U-shaped valley with nearly vertical walls. A line called the trimline shows the highest level the glacier reached.
- A cirque is a rounded hollow carved in the side of a mountain by a glacier. The highest cliff of a cirque is called the headwall.
- An arête is a jagged ridge that remains when cirques form on opposite sides of a mountain. A low spot in an arête is called a col.
- A horn is a sharp peak that is left behind when glacial cirques are on at least three sides of a mountain.
Figure 10.28

Features Eroded by Valley Glaciers. Erosion by valley glaciers forms the unique features shown here.

10.4. Erosion and Deposition by Glaciers

Deposition by Glaciers

Glaciers deposit their sediment when they melt. They drop and leave behind whatever was once frozen in their ice. It’s usually a mixture of particles and rocks of all sizes, called glacial till. Water from the melting ice may form lakes or other water features. Figure 10.29 shows some of the landforms glaciers deposit when they melt.

- **Moraine** is sediment deposited by a glacier. A ground moraine is a thick layer of sediments left behind by a retreating glacier. An end moraine is a low ridge of sediments deposited at the end of the glacier. It marks the greatest distance the glacier advanced.
- A drumlin is a long, low hill of sediments deposited by a glacier. Drumlins often occur in groups called drumlin fields. The narrow end of each drumlin points in the direction the glacier was moving when it dropped the sediments.
- An esker is a winding ridge of sand deposited by a stream of meltwater. Such streams flow underneath a retreating glacier.
- A kettle lake occurs where a chunk of ice was left behind in the sediments of a retreating glacier. When the ice melted, it left a depression. The meltwater filled it to form a lake.

Lesson Summary

- Glaciers are masses of flowing ice. Continental glaciers are huge. They may spread out over much of a continent. Valley glaciers are long and narrow. They form in mountains and flow through mountain river valleys.
Glaciers cause erosion by plucking and abrasion. Valley glaciers form several unique features through erosion, including cirques, arêtes, and horns.

- Glaciers deposit their sediment when they melt. Landforms deposited by glaciers include drumlins, kettle lakes, and eskers.

Lesson Review Questions

Recall

1. What is a glacier?
2. Describe how glaciers form.
3. Identify the two main ways glaciers cause erosion.
4. Name and describe three unique features eroded by valley glaciers.
5. What is glacial till?

Apply Concepts

6. Create a lesson to teach younger students how a kettle lake forms. Outline your lesson.

Think Critically

7. Compare and contrast valley and continental glaciers and how they change Earth’s surface.
8. Areas once covered by glaciers may have large boulders called erratics, like the one in the photo below. Infer why erratics typically consist of a different type of rock than the bedrock where they are found.
Points to Consider

So far in this chapter, you’ve read how moving water, air, and ice shape Earth’s surface. Water and ice move because of gravity.

- Do you think gravity can erode and deposit sediment without the help of water or ice?
- How might gravity alone shape Earth’s surface?
Lesson Objectives

- Identify causes and effects of landslides and mudslides.
- Explain how slump and creep occur.

Vocabulary

- creep
- landslide
- mass movement
- mudslide
- slump

Introduction

Gravity is responsible for erosion by flowing water and glaciers. That’s because gravity pulls water and ice downhill. These are ways gravity causes erosion indirectly. But gravity also causes erosion directly. Gravity can pull soil, mud, and rocks down cliffs and hillsides. This type of erosion and deposition is called mass movement. It may happen suddenly. Or it may occur very slowly, over many years.

Landslides and Mudslides

The most destructive types of mass movement are landslides and mudslides. Both occur suddenly.

Landslides

A landslide happens when a large amount of soil and rock suddenly falls down a slope because of gravity. You can see an example in Figure 10.30. A landslide can be very destructive. It may bury or carry away entire villages.

A landslide is more likely if the soil has become wet from heavy rains. The wet soil becomes slippery and heavy. Earthquakes often trigger landslides. The shaking ground causes soil and rocks to break loose and start sliding. If a landslide flows into a body of water, it may cause a huge wave called a tsunami.
10.5. Erosion and Deposition by Gravity

Mudslides

A mudslide is the sudden flow of mud down a slope because of gravity. Mudslides occur where the soil is mostly clay. Like landslides, mudslides usually occur when the soil is wet. Wet clay forms very slippery mud that slides easily. You can see an example of a mudslide in Figure 10.31.

Other Types of Mass Movement

Two other types of mass movement are slump and creep. Both may move a lot of soil and rock. However, they usually aren’t as destructive as landslides and mudslides.
**Slump**

*Slump* is the sudden movement of large blocks of rock and soil down a slope. You can see how it happens in **Figure 10.32**. All the material moves together in big chunks. Slump may be caused by a layer of slippery, wet clay underneath the rock and soil on a hillside. Or it may occur when a river undercuts a slope. Slump leaves behind crescent-shaped scars on the hillside.

![Figure 10.32](image)

**FIGURE 10.32**

Slump takes place suddenly, like a landslide. How does slump differ from a landslide?

**Creep**

*Creep* is the very slow movement of rock and soil down a hillside. Creep occurs so slowly you can’t see it happening. You can only see the effects of creep after years of movement. This is illustrated in **Figure 10.33**. The slowly moving ground causes trees, fence posts, and other structures on the surface to tilt downhill.

![Figure 10.33](image)

**FIGURE 10.33**

Creep is seen on a hillside. What evidence shows creep has occurred?

Creep usually takes place where the ground freezes and thaws frequently. Soil and rock particles are lifted up when the ground freezes. When the ground thaws, the particles settle down again. Each time they settle down, they move a tiny bit farther down the slope because of gravity.

**Lesson Summary**

- Gravity can pull soil, mud, and rocks down cliffs and hillsides. This is called mass movement. The most destructive types of mass movement are landslides and mudslides. They occur suddenly and without warming. They engulf everything in their path.
• Two other types of mass movement are slump and creep. They usually aren’t as destructive as landslides and mudslides. Slump is the sudden movement of large blocks of rock and soil down a slope. Creep is the very slow movement of rock and soil down a slope. It causes trees, fence posts, and other structures to tilt downhill.

Lesson Review Questions

Recall

1. Define mass movement.
2. List four types of mass movement.
3. What is a landslide?
4. What factors increase the chances of landslides occurring?
5. What type of soil forms mudslides?

Apply Concepts

6. Assume you are riding in a car down a road or street. Suddenly, you see evidence of creep. Describe it.

Think Critically

7. Relate earthquakes to mass movement.
8. Compare and contrast slump and creep.

Points to Consider

Erosion and deposition are always changing Earth’s surface.

• Do you think that the same forces that cause erosion today — moving water, wind, ice, and gravity — were also at work in the past?
• How might observations of erosion and deposition today help us understand Earth’s history?

10.6 References

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