

## Introduction

**Glaciers**, water, wind, and **gravity**—all are forces responsible for **weathering** and **erosion**. Changes resulting from these forces determine the shape of Earth's surface. They create our mountains, valleys, sand **dunes**, and deserts. They determine the type of **soil** that is formed in a particular area. Learning about weathering and erosion gives us clues to understanding our Earth.

## Weathering

*Weathering* is a slow process that breaks down substances and materials exposed to the atmosphere. Some examples of weathering are peeling paint, rust, and rock fragments. Rocks on Earth's surface are broken down by two types of weathering—mechanical and chemical.

### Mechanical Weathering

In **mechanical weathering**, rocks are broken down into smaller fragments. As weathering progresses, the rock fragments become smoother and more rounded. The agents of mechanical weathering are temperature, water, plants, and wind.

Changes in temperature can cause rocks to expand and contract. This can cause particles of rock on the surface to flake off.



*the effects of weathering*



*weathering caused by water*

Water expands as it freezes. If water seeps into cracks in a rock and the temperature falls below freezing, the resulting ice expands in the crack. Eventually this expansion will break the rock into smaller pieces. Plants can also enlarge cracks in rocks as their roots expand and grow into the rock. Small rock particles can be carried by the wind. These windblown particles create a *sand blasting* effect on soft rocks, abrading

or wearing away rocks. Many rock formations in desert regions are the result of this abrasion. Landslides are often caused by mechanical weathering.

### Chemical Weathering

**Chemical weathering** causes changes in the mineral composition or chemical makeup of the rock.

Chemical weathering is sometimes called *decomposition*. The agents of this type of weathering are water, oxygen, and acids. For instance, water can dissolve rocks. These dissolved rocks can form other deposits, such as **clay**, or formations such as stalactites and stalagmites. Another form of chemical weathering involves oxygen. Oxygen in the atmosphere can chemically combine with other compounds. The resulting *rust* is darker and chemically different than the original material.

Acids and other chemicals can also cause changes in rocks. Carbon dioxide can dissolve in water, making it carbonated. This carbonated water can dissolve limestone and feldspar. In addition, acid rain can corrode the surface of rocks. Some plants are capable of growing on rocks. They produce weak acids to *soften* the rock's surface so their roots can attach. Lichens are examples of plants that produce acids and cover rock surfaces.



*weathering caused by wind*



*effects of erosion*

### Erosion

The surface of Earth is continually being built up and worn down. The breaking down of rocks and other materials by chemical or physical means is called *weathering*. *Erosion* is the movement of these weathered rocks and soil from one place to another. The four main types of erosion are water, wind, ice, and gravity.

## Water Erosion

Of all the forces that cause erosion, water is the most important. Water is responsible for changing much of Earth's surface. Below are several ways in which water can erode the surface of Earth:

### How Liquid Water Erodes Earth's Surface

1. Rivers are important because they affect large areas. Heavy rains and large amounts of melting snow cause **runoff** water to carry away sediment. The sediment goes into rivers where more material eroded from other areas is carried. Rivers then empty into other rivers, lakes, or oceans. Water carries materials as it moves. Rivers slow down where they empty into large bodies of water. The slowing of the current at the river's mouth causes moving **sand** and other particles to stop moving and fall to the bottom of the stream. The sediment builds up and forms a delta—a wedge-shaped area of sand at the mouth of a river. As more sediment is added to the delta, the path of the river will change.
2. Fast-moving water in rivers also wears away the banks, creating canyons and carrying rocks and soil downstream to new locations. The Grand Canyon, formed by the Colorado River, is an example of erosion caused by a fast-moving stream.
3. **Caverns** are caves formed by underground running water dissolving limestone and carrying it away. The Carlsbad Caverns in New Mexico and the Linville Caverns in North Carolina were formed by this type of erosion.
4. When the roof of an underground cave formed by erosion sinks or collapses, a *sinkhole* is formed. Central Florida has many sinkholes.

The amount of erosion is determined by several factors. The type of minerals that make up rocks and soil determines how quickly it will erode. Rocks with holes in them or with large spaces between them will soak up the running water, whereas rocks with no openings cause rapid *runoff*. The slope of a surface also determines the amount of erosion. A steep hill will cause more erosion than a gently sloping hill. The amount and type of plants grown in an area also affect the rate of erosion. An area

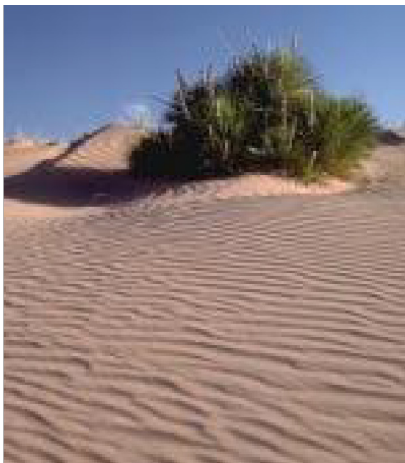
with many plants will erode less quickly than an area with few or no plants. This is why picking sea grasses along sand dunes is often prohibited.

## Wind Erosion

Wind erosion occurs mainly in areas where there is very little moisture. Because of this, there are few plants to hold the soil in place. Wind picks up and carries small bits of sand and dust. Wind erosion occurs in deserts, along the beach, and by rivers in dry regions.



Loose particles carried by the wind act like sandpaper, wearing down rocks into flat, sharp forms. Wind erosion depends on the speed of the wind, the length of time that it blows, and the size of the particles being carried. Sand is the heaviest type of particle carried by the wind. It is carried close to the ground and is the first to be deposited by the wind. **Silt** is finer than sand and is carried farther before it is deposited. Dust is the lightest material carried by the wind. It gets into the high air currents and can be carried for hundreds of miles.



When the wind dies down, the materials it has been carrying are deposited. Hills of sand called *sand dunes* are the most common type of wind deposit. They are formed near rocks and bushes and where the wind slows down in desert areas and along shorelines. **Loess** is another type of wind deposit formed of angular pieces of silt and clay that tend to pack together into a dense mass. Loess deposits are usually light in color and may be several meters thick. They form fertile soil. The hilltops and valleys of the Mississippi River are formed from deposits of loess. The presence

of grass and shrubs helps to control wind erosion. Roots hold soil and other particles in place.

## Ice Erosion

Ice erosion is caused by large sheets of moving ice known as *glaciers*. Glaciers form in areas where winter snowfall is greater than summer melting. The snow piles up, putting pressure on the snow at the bottom. The snow at the bottom of the pile eventually packs tightly and turns into ice. As the ice continues to build up, the pressure causes it to move. As the glacier moves, it tears rocks and soil from the ground similar to the effect of dragging a heavy rake across an unpaved driveway. The glacier also acts like a bulldozer. The front of the glacier piles up material called *till*. When the glacier melts and retreats, it leaves behind the material it was carrying.

Mountain shapes can be changed by glaciers. Glaciers have eroded mountain tops into peaks, such as the Matterhorn in Switzerland, and formed hanging valleys with beautiful waterfalls like those in Yosemite National Park in California. Glaciers can also form lakes. The Great Lakes were formed by glaciers deepening river valleys and damming them to form lakes.

## Gravitational Erosion

The gravitational pull of Earth also causes erosion. Sometimes the movement of rocks and soil down a hillside, due to the pull of *gravity*, is very slow. Soil and rock particles may be pulled down a hillside so slowly that it is hardly noticeable. This slow movement which may not even be noticeable is called *slump*. Eventually, this material comes to rest at the bottom of the slope. At other times the combined forces of gravity, water, and steep slopes cause rapid movements. *Landslides* are rapid movements of large amounts of rock caused by excessive rains or earthquake activity. *Mudflows* are also rapid movements that occur after heavy rains. *Avalanches* happen when rapid melting of snow or earthquake activity occurs in heavy layers of snow. Gravitational erosion can cause major structural damage wiping out roads, houses, and sometimes entire towns.

## Soil

*Soil* is a combination of weathered rock and **organic** material with air and water filling the spaces between the soil particles. The type of minerals and organic matter that are contained in the soil determine the type of soil. The organic material in soil, called **humus**, comes from the decaying or breaking down of dead plants and animals. Humus is dark-colored and found in the upper layer of soil called **topsoil**. The humus in the soil makes it fertile and good for growing plants.

Particles of soil vary in size. Large particles of rock and mineral found in the soil are called **gravel**. Weathering causes gravel to break down into smaller pieces called *sand*. Sand is further weathered to produce smaller particles called *silt*. *Clay* is the smallest particle in the soil. It is so small that it must be magnified to see. It packs very tightly to form large clumps so it may be impossible to see the individual particles. **Loam** is a type of soil that is a mixture of sand, silt, and clay. It holds a large amount of water which makes it very good for farming.

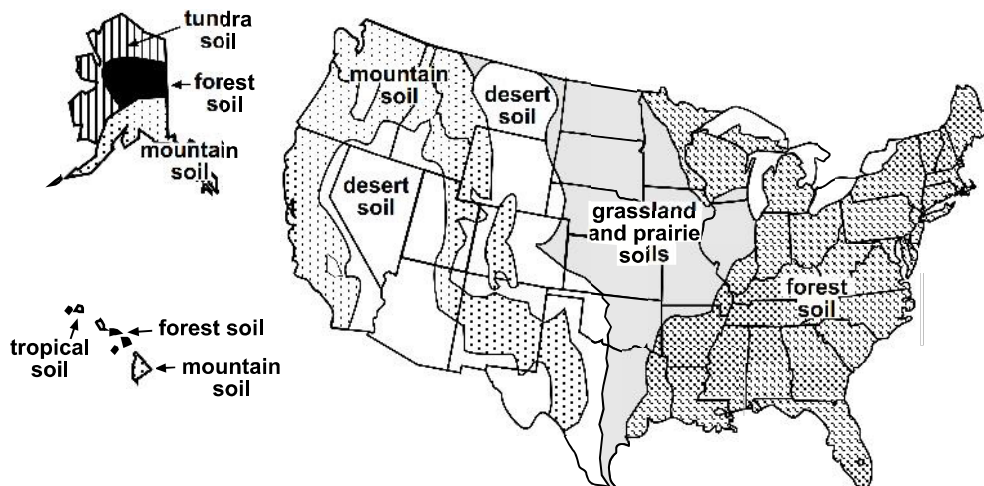
### Soil Types and Regions

Soil is classified by its makeup and the region in which it forms. The chart below lists several factors that determine soil types.

Factors Which Determine Soil Types	
time	the amount of time the soil has had to form
climate	the average weather for that region
rocks	the type of rocks present in the area
Earth's surface	the shape of Earth's surface in the area

**Forest Soil.** The soil in the eastern part of the United States ranges from brownish-gray in the Northeast to a reddish color in the Southeast. Forest soil forms under tree cover, contains very little humus, and requires frequent fertilization because heavy rainfall causes the minerals in the soil to be washed away. The southeastern forest soil is slightly more fertile than northeastern forest soil due to the warmer southern climate, which causes organic matter to decay more quickly.

### Soil Regions of the United States



**Grasslands and Prairie Soils.** The part of the United States from the eastern forest region to the Rocky Mountains has grasslands and prairies. The soil there is rich in humus and receives large amounts of rainfall, which makes it fertile and good for farming.

**Desert Soil.** The lack of rainfall in the desert regions of the western United States results in soil that is rich in minerals. However, the soil lacks humus due to the limited number of plants.

**Mountain Soil.** The soil found in the mountain ranges of the western United States, although rich in mineral ores, is dry and made up of pieces of rock. Therefore, it is not a good soil for growing crops.

**Tundra Soil.** The tundra region of the United States has thin soil. This, combined with the severely cold climate, allows only the growth of mosses and lichens. Alaska is the only region in the United States that has tundra soil.

**Tropical Soil.** Tropical soil is found in only one part of the United States, the very warm, humid climates of the Hawaiian rain forests. The tropical soil region has excessive rain and heat which causes organic matter to rapidly decay. A thick layer of humus does not form because heavy rain washes it away. However, the plentiful organic matter in this region quickly replaces the humus and minerals needed to keep the rain forests growing.

Soils contain different minerals and nutrients depending on their formation. Sometimes fertilizers are added to soil to enrich it for growing crops. Phosphate, nitrate, and other chemicals may be used in fertilizers. These substances, however, can act as pollutants when applied incorrectly. Organic fertilizers such as manure or compost may be used to increase organic material content. The risk of misuse with these appears to be less than with other fertilizers.

## Summary

Mechanical and chemical weathering breaks down rocks and other materials exposed to the atmosphere. Temperature, water, plants, and wind are mechanical weathering agents. The agents of chemical weathering are water, oxygen, and acids. The process of erosion moves weathered materials from one place to another. The four main types of erosion are water, wind, ice, and gravity. Weathered rock becomes part of our soil. Soil types vary depending on the composition and other factors such as age and climate.