

Chapter 14

Weathering and Erosion

You know from experience that rocks are hard objects. Sitting on a stone bench is not as comfortable as sitting on a sofa! And it takes a lot of work to break a rock into pieces. Over time though, rock *does* break down. This chapter describes how that happens and how rock is moved from place to place. *Weathering* is a term that describes how rock is broken down to form sediment. *Erosion* describes the transportation of sediment by water, wind, ice, or even gravity. In time, even the hardest rock will become small pieces and particles of sediment.



Key Questions

1. *How do rocks and minerals break down?*
2. *What is the difference between weathering and erosion?*
3. *How do rivers shape the land?*



14.1 Weathering

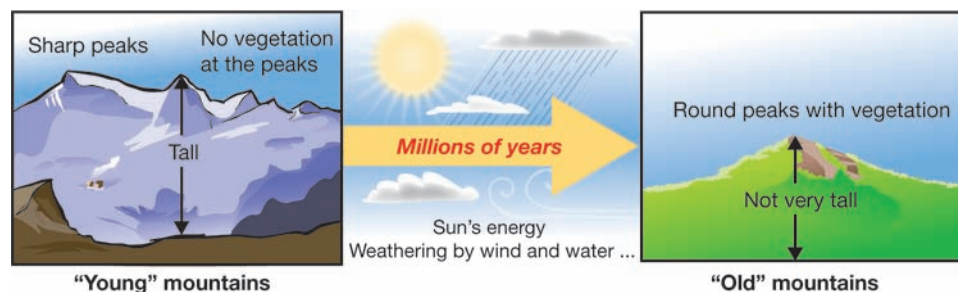
Weathering is the process of breaking down rock and minerals. Weathering is caused by many different factors, including the Sun's energy, wind, running water, moving ice, chemical reactions, and the actions of plants or animals.

Mountains and weathering

Mountains Mountains—because they are so big and impressive—seem to be unchanging features in a landscape. However, mountains wear down over time due to weathering. What does a weathered mountain look like?

Old versus young mountains A good example of old, weathered mountains are the Great Smoky Mountains, which are part of the Appalachian mountain range. In contrast, the Rocky Mountains in the western United States and Canada are younger mountains (Figure 14.1).

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



VOCABULARY

weathering - the process of breaking down rock and minerals. Weathering is caused by the Sun's energy, wind, running water, ice, chemical reactions, and the actions of organisms.



Photos courtesy of Jim Sammons, Sammons' INK.

Figure 14.1: The sharp peaks of the Canadian Rocky Mountains, and the rounded peaks of the Great Smoky Mountains.



Ways that weathering occurs

Energy sources for weathering	The two main sources of energy that cause weathering are the Sun and Earth's internal energy. The Sun drives our weather and the water cycle. Earth's internal energy results in the movement of lithospheric plates on Earth's surface. Earth's internal energy also plays a role in the rock cycle. A rock may be changed by mechanical weathering, chemical weathering, or both (Figure 14.2).
Mechanical weathering	Mechanical weathering occurs when forces break or chip rocks and minerals into smaller pieces without changing their composition. Mechanical weathering may break large blocks loose or chip away tiny grains, one at a time.
Chemical weathering	Chemical weathering is the process of breaking down rocks and minerals by chemical reactions between water and the rock or mineral particles. Other agents of chemical weathering include oxygen and acids (from plants or acid rain). Rock material is chemically changed by this kind of weathering. Some kinds of rock are more easily chemically weathered than others. For example, marble is chemically weathered faster than granite. Chemical weathering has worn away the surfaces of many old marble statues (Figure 14.2).
Gravity and surface area	The force of gravity is important in the weathering process because gravity causes water and pieces of rock to move downhill. In this way, rock and mineral pieces from a mountain top move to low areas like beaches. As a rock breaks down, more and more surface area is exposed. The more surface area that is exposed, the faster weathering occurs.

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mechanical weathering - the process of breaking down rocks and minerals into smaller pieces by physical force. Also called physical weathering.

chemical weathering - the process of breaking down rocks and minerals by chemical reactions.



Figure 14.2: *Mechanical and chemical weathering.*

Agents of mechanical weathering

Running water Weathering often involves water. Changing conditions of wetness and dryness cause rocks and minerals to break down. Also, weathering occurs quickly when running water knocks rocks against each other. Sediment carried by running water also wears away rock by abrasion, making it smooth and round. You can see this by looking at the rocks in any river or at the base of a waterfall.



Frost wedging **Frost wedging** is a form of mechanical weathering that occurs when a small amount of water enters a tiny crack in a rock. When the water freezes, it expands, making the crack a little wider. More water enters the crack, freezes, and widens the crack even more. Eventually frost wedging splits the rock into separate pieces (Figure 14.3).

Where frost wedging occurs Frost wedging tends to occur in areas with available water and temperatures that fluctuate around the freezing point. Rocks that have many pores or cracks are susceptible to frost wedging. The photo in Figure 14.3 shows an example of frost wedging near the crest of Mount Hoffman in the Sierra Nevada Mountains. Many hand-sized rocks have been split away by frost wedging.

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frost wedging - mechanical weathering that results from freezing water.

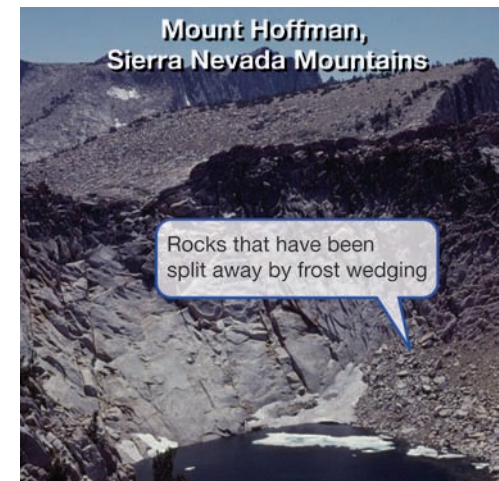


Photo courtesy of Jim Sammons, Sammons' INK.

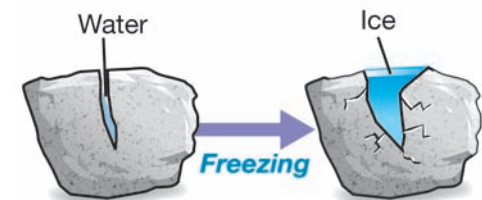


Figure 14.3: An example of frost wedging.



Biological weathering by plants Weathering by plants or animals is called *biological weathering*. Mechanical weathering by plants occurs when roots grow into cracks in a rock. In this process called *root wedging*, roots exert force on the rock as they grow and may cause the rock to split (Figure 14.6). Chemical weathering occurs when plants release chemicals that break down the rock on which they are growing.

Biological weathering by animals Animals cause mechanical weathering when they dig into soil or burrow underground. When they do this, they create pockets for water to move deeper underground. Ultimately, this means that the weathering process of rocks that are underground speeds up.



Exfoliation Exfoliation is a weathering process that results in rock layers peeling away. Weathering causes an outer layer to peel away first. The layers of rock underneath experience a decrease in pressure and expand. As they expand, they crack and more weathering occurs. Eventually, the resulting rock structure can look rounded with cracked layers.

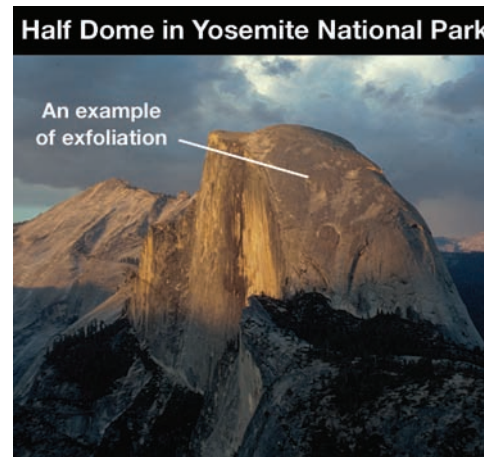


Photo courtesy of U.S. Geological Survey

Wind Wind is also a mechanical weathering agent. Wind-blown sand chips away tiny bits of rock from the surface of exposed rock. During this process, the remaining rock can take on unusual shapes and the removed bits eventually become sand (Figure 14.5).

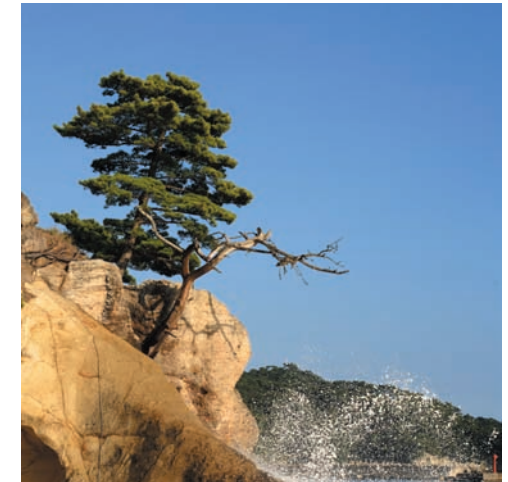


Figure 14.4: Over time, the tree's roots will split the rocks on this cliff by root wedging.



Photo courtesy of Jim Sammons, Sammons' INK.

Figure 14.5: Wind-blown sand has mechanically weathered this sandstone into tall pillars called hoodoos.

Chemical weathering

Water and minerals When water washes over a rock, it can react with minerals in that rock and cause chemical changes. A result is that the mineral dissolves or a new mineral is made. For example, the mineral feldspar reacts with water to make clay.

Acid rain Chemical reactions can occur on the surface of a rock or mineral when water is present. For example, acid rain occurs when pollutants or volcanic ash in the atmosphere mixes with water (rain) and form an acidic solution. Acid rain can weather rocks, including statues. If the statues are made of marble, they will weather more quickly (see the statue in Figure 14.2). Marble is made of calcite (calcium carbonate) which dissolves in acidic water. Granite statues do not dissolve when exposed to acid rain.

Oxygen in the atmosphere Oxygen in the atmosphere also participates in weathering. Oxygen combines with metals in minerals and changes them. This process is called *oxidation*. For example, oxygen combines with iron in the minerals biotite and hornblende to make rust.

Weathering by plants Moss, lichens, and other plants can cause chemical weathering. Chemicals released by the plants eventually cause the rock on which they are growing to break down (Figure 14.6).

Chemical and mechanical weathering Both chemical and mechanical weathering can affect rock at the same time. Look at Figure 14.7. Originally there were a few tiny cracks in the rock. Frost wedging probably opened up these cracks. Now chemical weathering is changing the rock so that the sides of the crack are filled with loose grains. You can see the tufts of plants growing in the loose grains of rock.

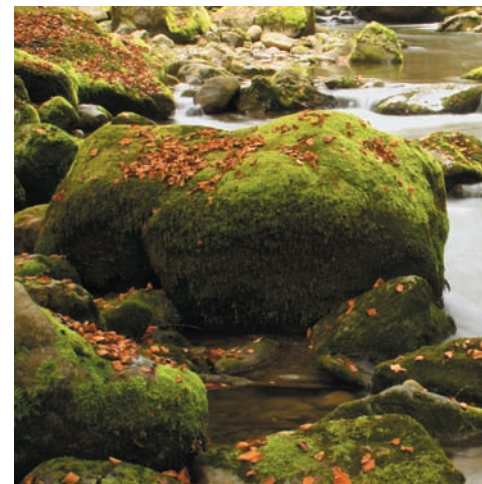


Figure 14.6: Moss growing on rocks causes chemical weathering.

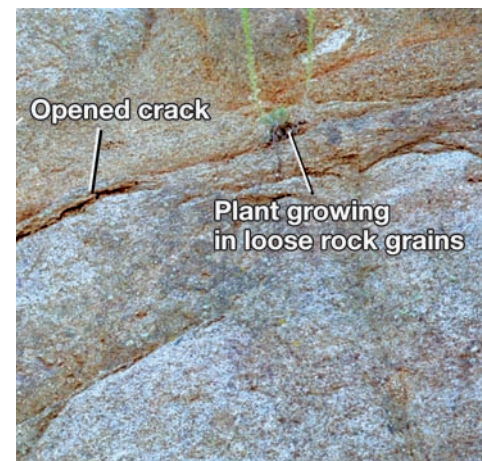


Photo courtesy of Jim Sammons, Sammons' INK.

Figure 14.7: Both mechanical and chemical weathering often occur at the same time.



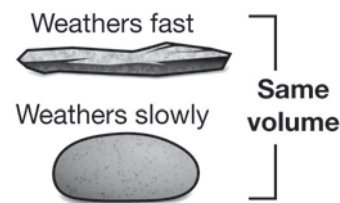
Factors that affect the rate of weathering

Water and climate If an area has a humid, warm climate, then rocks and minerals will tend to weather faster. Chemical weathering is more likely to happen in humid conditions. Weathering is slowest in dry, cold climates. Frost wedging will occur more often in an area with abundant water and freezing temperatures. Running water—like the water from a river or a waterfall—speeds up mechanical weathering by wearing down and breaking up rocks. This water can also cause chemical weathering to occur.

Plants and animals Weathering is also faster when there are plants and animals in the area. Plants growing on or near rocks can speed up weathering. Animals can dig or burrow and alter how much exposure a rock has to weathering.

Minerals The kind of minerals found in a rock also affects how fast it is weathered. Marble, which has calcite, weathers faster than granite. Calcite dissolves in acidic solutions (like acid rain). The minerals in granite are more resistant to weathering.

Surface area The greater the surface area of a rock or mineral compared to its volume, the faster it will weather. For example, a flat, jagged rock will weather more quickly than a rounded rock of the same volume.



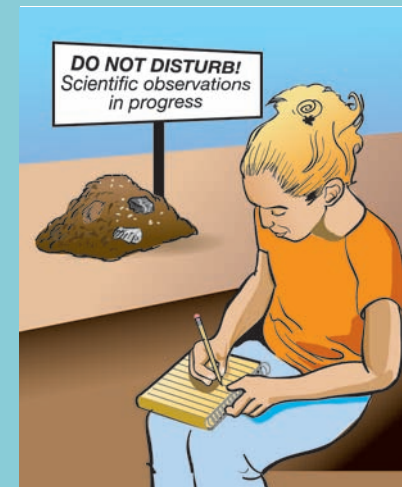
Sediments are the products of weathering The result of the weathering of rocks and minerals is *sediment* which is small pieces and particles of rock. Eventually, sediment becomes part of soil, which you will learn about in the next chapter.

MY JOURNAL

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

Make a prediction about what you think will happen to the pile over the next two weeks. Keep in mind that weathering events usually take longer than two weeks to happen. However, what events might occur that would affect the pile during this time period?

Make regular observations in a journal. Then, write up your finding in a short report.



14.1 Section Review

- Are mountains permanent structures? Justify your answer.
- Name two differences between old and young mountains.
- How long does it take for a mountain's sharp peaks to wear down? Choose an answer below and explain your reasoning.
 - millions of years
 - hundreds of years
 - about ten years
 - one year
- How does the Sun play a role in weathering?
- Compare and contrast mechanical and chemical weathering.
- Why is gravity important in weathering?
- How is frost wedging similar to root wedging?
- How can animals speed up the process of weathering?
- For the following examples, state whether mechanical or chemical weathering is occurring:
 - a bicycle left in the rain becomes rusty
 - a chunk of rock breaks off of a mountain.
- Over time, how might the grass growing up through a crack in a sidewalk affect the sidewalk? Use the terms "mechanical weathering" and "chemical weathering" in your answer.
- List three factors that affect how fast a rock might weather.



CHALLENGE

Limestone (calcium carbonate) weathers when it is exposed to acidic water or acid rain. A number of famous caves have been formed by chemical weathering of underground limestone. Research Mammoth Cave in Kentucky to find out more about how this cave formed.



SOLVE IT!

In which situation will weathering happen faster?

- a tropical rainforest or a dry desert
- a rock with lots of jagged edges or a smooth, round rock
- a warm environment or a really cold environment
- a rock with a lot of surface area compared to its volume or a rock with a small amount of surface area compared to its volume