

4.1

KEY CONCEPT

Mechanical and chemical forces break down rocks.

BEFORE, you learned

- Minerals make up most rocks
- Different minerals have different properties
- Rocks are broken down to form sediments

NOW, you will learn

- How mechanical weathering breaks down rocks
- How chemical weathering changes rocks
- What factors affect the rate at which weathering occurs

VOCABULARY

weathering p. 115
mechanical weathering p. 116
exfoliation p. 116
abrasion p. 116
chemical weathering p. 118

EXPLORE Mechanical Weathering

What causes rocks to break down?

PROCEDURE

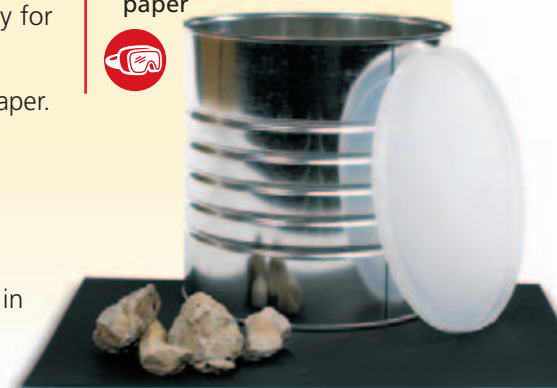
- 1 Place a handful of rocks on a piece of dark-colored construction paper. Observe the rocks and take notes on their appearance.
- 2 Place the rocks in a coffee can. Put the lid on the can and shake the can forcefully for 2 minutes, holding the lid tightly shut.
- 3 Pour the rocks onto the construction paper. Observe them and take notes on any changes in their appearance.

WHAT DO YOU THINK?

- What happened to the rocks and why?
- What forces in nature might affect rocks in similar ways?

MATERIALS

- coffee can with lid
- rocks
- dark-colored construction paper



Weathering breaks rocks into smaller pieces.

Think about the tiniest rock you have ever found. How did it get so small? It didn't start out that way! Over time, natural forces break rocks into smaller and smaller pieces. If you have ever seen a concrete sidewalk or driveway that has been cracked by tree roots, you have seen this process. The same thing can happen to rocks.

Weathering is the process by which natural forces break down rocks. In this section you will read about two kinds of weathering. One kind occurs when a rock is physically broken apart—like the cracked sidewalk. Another kind occurs when a chemical reaction changes the makeup of a rock.

VOCABULARY

Remember to add *weathering* to your notebook, using the vocabulary strategy of your choice.

Mechanical weathering produces physical changes in rocks.



Learn more about weathering.

READING TIP

The word *expand* means “to increase in size or volume.”

If you smash a walnut with a hammer, you will break it into a lot of small pieces, but you will not change what it is. Even though the pieces of the walnut are no longer connected together, they are still composed of the same materials. **Mechanical weathering**—the breaking up of rocks by physical forces—works in much the same way. In this natural process, physical forces split rocks apart but do not change their composition—what they are made of. Ice wedging, pressure release, plant root growth, and abrasion can all cause mechanical weathering.

- 1 Ice Wedging** When water freezes, it expands. When water freezes in the cracks and pores of rocks, the force of its expansion is strong enough to split the rocks apart. This process, which is called ice wedging, can break up huge boulders. Ice wedging is common in places where temperatures rise above and fall below the freezing point for water, which is 0°C (32°F).
- 2 Pressure Release** Rock deep within Earth is under great pressure from surrounding rocks. Over time, Earth’s forces can push the rock up to the surface, or the overlying rocks and sediment can wear away. In either case, the pressure inside the rock is still high, but the pressure on the surface of the rock is released. This release of pressure causes the rock to expand. As the rock expands, cracks form in it, leading to exfoliation. **Exfoliation** (ehks-FOH-lee-AY-shuhn) is a process in which layers or sheets of rock gradually break off. This process is sometimes called onion-skin weathering, because the rock surface breaks off in thin layers similar to the layers of an onion.
- 3 Plant Root Growth** Trees, bushes, and other plants may take root in cracks in rocks. As the roots of these plants grow, they wedge open the cracks. The rock—even if it is large—can be split completely apart.
- 4 Abrasion** Water can wear down rocks on riverbeds and along shorelines by abrasion. **Abrasion** (uh-BRAY-zhuhn) is the process of wearing down by friction, the rubbing of one object or surface against another. The force of moving water alone can wear away particles of rock. Water also causes rocks to tumble downstream. The tumbling rocks wear down as they grind against the riverbed and against each other. Ocean waves beating against a rocky shore also wear down rocks by abrasion.

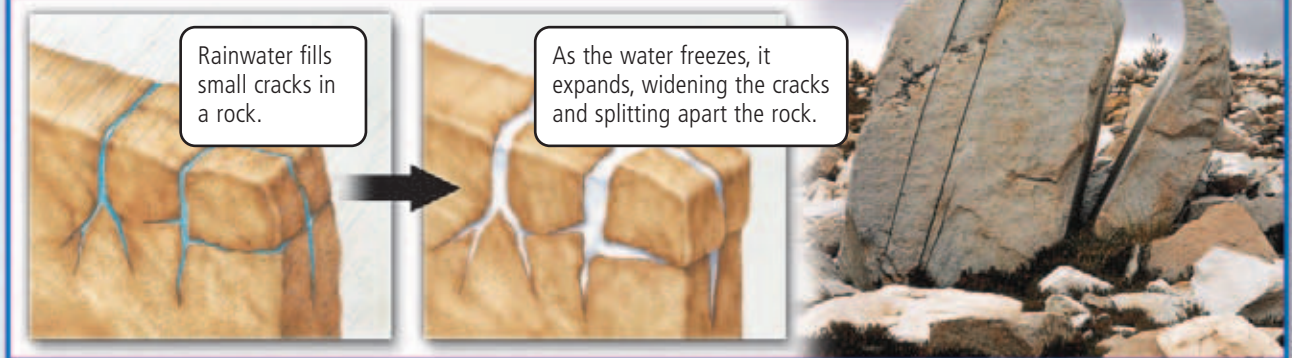


How does moving water weather rocks?

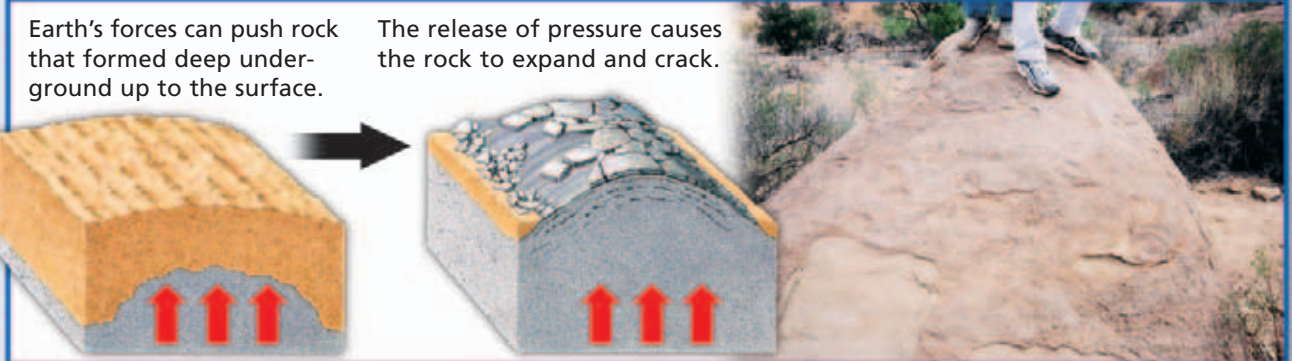
Mechanical Weathering

Ice wedging, pressure release, plant root growth, and abrasion can all break apart rocks.

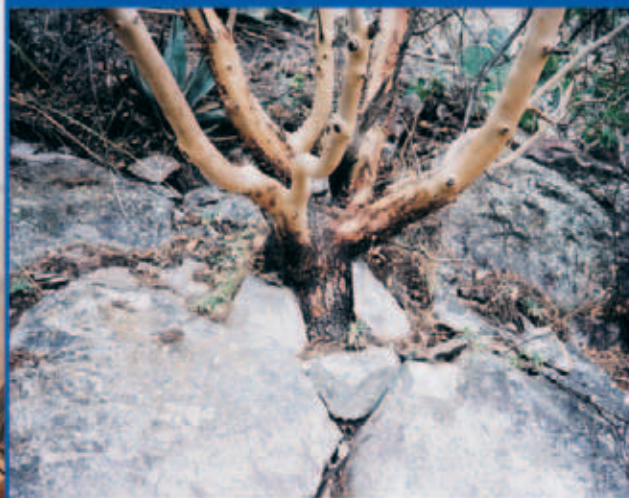
1 Ice Wedging



2 Pressure Release



3 Plant Root Growth



When plants grow in cracks in a rock, their roots can widen the cracks and force the rock apart.

4 Abrasion



Flowing water can move rocks, causing them to rub together and wear down into rounded shapes.

READING VISUALS What evidence of mechanical weathering can you see in each photograph above?

Chemical weathering changes the mineral composition of rocks.



Watch chemical weathering in action.

If you have seen an old rusty nail, you have witnessed the result of a chemical reaction and a chemical change. The steel in the nail contains iron. Oxygen in air and water react with the iron to form rust.

Minerals in rocks also undergo chemical changes when they react with water and air. **Chemical weathering** is the breakdown of rocks by chemical reactions that change the rocks' makeup, or composition. When minerals in rocks come into contact with air and water, some dissolve and others react and are changed into different minerals.

Dissolving

Water is the main cause of chemical weathering. Some minerals completely dissolve in ordinary water. The mineral halite, which is the same compound as table salt, dissolves in ordinary water. Many more minerals dissolve in water that is slightly acidic—like lemonade. In the atmosphere, small amounts of carbon dioxide dissolve in rainwater. The water and carbon dioxide react to form a weak acid. After falling to Earth, the rainwater moves through the soil, picking up additional

INVESTIGATE Chemical Weathering

What is necessary for rust to form?

PROCEDURE

- 1 Place a piece of steel wool in a cup filled to the top with water. Place a second piece of steel wool in a cup with a small amount of water. The water should touch but not cover the steel wool. Place a third piece in a cup with no water.
- 2 Allow the three cups to sit overnight. Observe the appearance of the steel wool in each container the next day.

WHAT DO YOU THINK?

- What happened to the steel wool in each cup?
- Judging by the appearance of the pieces of steel wool, what do you think is necessary for rusting to occur?

CHALLENGE Tear the steel wool that rusted most apart and compare the appearances of the inside and the outside. Why might the inside and the outside look different?

SKILL FOCUS

Identifying variables

MATERIALS

- steel wool
- 3 cups
- water

TIME
15 minutes



About 100 Years Ago



Today



READING
VISUALS

INFER This ancient stone monument was moved from a desert in Egypt to New York City in 1881. How and why has it changed?

carbon dioxide from decaying plants. The slightly acidic water breaks down minerals in rocks. In the process, the rocks may also break apart into smaller pieces.

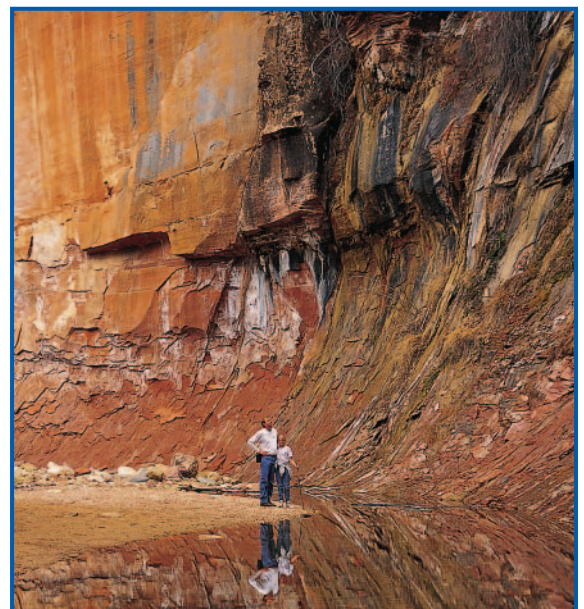
Air pollution can make rainwater even more acidic than it is naturally. Power plants and automobiles produce gases such as sulfur dioxide and nitric oxide, which react with water vapor in the atmosphere to form acid rain. Acid rain causes rocks to weather much faster than they would naturally. The photographs above show how acid rain can damage a granite column in just a hundred years.

Rusting

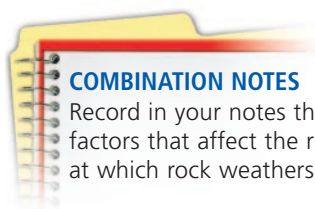
The oxygen in the air is also involved in chemical weathering. Many common minerals contain iron. When these minerals dissolve in water, oxygen in the air and the water combines with the iron to produce iron oxides, or rust. The iron oxides form a coating that colors the weathered rocks like those you see in the photograph of Oak Creek Canyon in Arizona.

CHECK YOUR
READING

How is air involved in chemical weathering?



The rocks in Oak Creek Canyon are reddish because iron in the rocks reacted with water and air to produce iron oxides.



COMBINATION NOTES

Record in your notes three factors that affect the rate at which rock weathers.

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Weathering occurs at different rates.

Most weathering occurs over long periods of time—hundreds, thousands, or even millions of years. It can take hundreds or thousands of years for a very hard rock to wear down only a few millimeters—a few times the thickness of your fingernail. But the rate of weathering is not the same for all rocks. Factors such as surface area, rock composition, and location influence the rate of weathering.

Surface Area The more of a rock's surface that is exposed to air and water, the faster the rock will break down. A greater surface area allows chemical weathering to affect more of a rock.



Over time, mechanical weathering breaks a rock into smaller pieces.



As a result, more of the rock's surface is exposed to chemical weathering.

Rock Composition Different kinds of rock break down at different rates. Granite, for example, breaks down much more slowly than limestone. Both of these rocks are often used for tombstones and statues.

Climate Water is needed for chemical weathering to occur, and heat speeds up chemical weathering. As a result, chemical weathering occurs faster in hot, wet regions than it does in cold, dry regions. However, mechanical weathering caused by freezing and thawing occurs more in cold regions than in hot regions.

4.1 Review

KEY CONCEPTS

1. What is weathering?
2. What are four causes of mechanical weathering?
3. How do water and air help cause chemical weathering?
4. Describe three factors that affect the rate at which weathering occurs.

CRITICAL THINKING

5. **Infer** How does mechanical weathering affect the rate of chemical weathering?
6. **Predict** Would weathering affect a marble sculpture inside a museum? Explain your answer.

CHALLENGE

7. **Infer** The word *weather* is most commonly used to refer to the state of the atmosphere at a certain time. Why do you think the same word is used to refer to the breakdown of rocks?