

Section 2

Rates of Weathering

Key Concept The rate at which rock weathers depends on climate, elevation, and the size and makeup of the rock.

What You Will Learn

- Differential weathering is the process by which softer rocks weather more rapidly than harder rocks do.
- Surface area, climate, and elevation are factors that affect the rate at which rock weathers.

Why It Matters

Understanding rates of weathering will help you understand the formation of soil and landforms where you live.

Have you ever seen a cartoon in which a character falls off a cliff and lands on a ledge? Natural ledges exist because the rock that makes up the ledges weathered more slowly than the surrounding rock. Weathering generally takes a long time. However, the rate at which a rock weathers depends on climate, elevation, and the chemical makeup of the rock.

Differential Weathering

Hard rocks, such as granite, weather more slowly than softer rocks, such as limestone. [Differential weathering](#) is the process by which softer, less weather resistant rocks wear away and leave harder, more weather resistant rocks behind. For example, Devils Tower in Wyoming, shown in **Figure 1**, is a result of this process. About 50 million years ago, a mass of molten rock cooled and hardened underground to form igneous rock. The surrounding rock was softer than the igneous rock. As the rocks were weathered for millions of years, the softer rock was completely worn away. The harder, more resistant rock of the tower is all that remains.



Figure 1 Devils Tower in Wyoming appears as it does today because of differential weathering. As surrounding rock was worn away, the hard rock of the tower was exposed.

Standards Check How does the composition of a rock relate to differential weathering?

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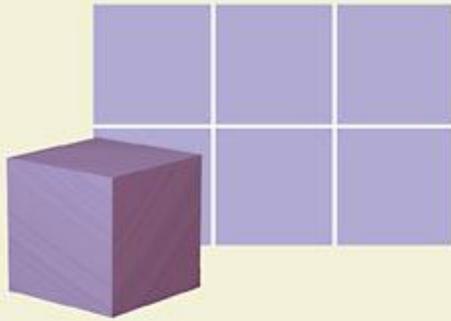
The Surface Area of Rocks

The greater the proportion of a rock that is exposed to weathering, the faster the rock

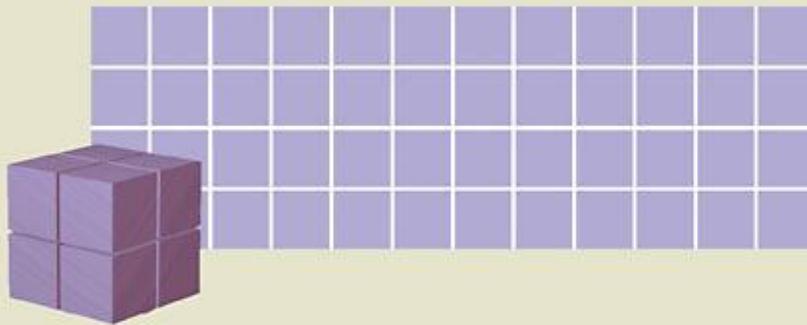
will wear down. However, most weathering takes place only on the outer surface of rock. A large rock has a large surface area that is exposed to weathering. But a large rock also has a large volume. Most of this volume is in the middle of the rock, away from the surface. Therefore, most of the large rock is not exposed to weathering. Because of its volume, the large rock will take a long time to wear down.

If a large rock is broken into smaller pieces, weathering happens much more quickly. The rate of weathering increases because the surface area-to-volume ratio of the small rocks is greater than that of the large rock. So, a greater proportion of a smaller rock is exposed to weathering processes. **Figure 2** shows this concept in detail.

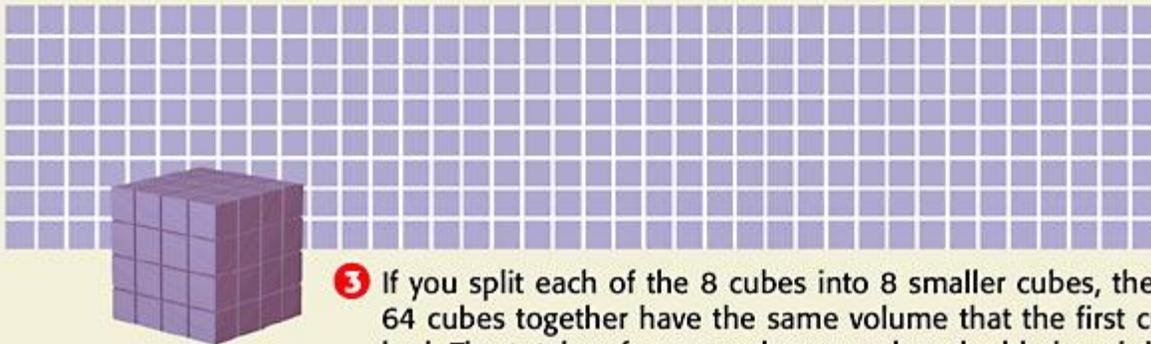
Figure 2 Total Surface Area to Volume



1 All cubes have both volume and surface area. Surface area is the sum of the area of the six sides. Area is length \times width. Volume is the amount of space occupied by the cube. Volume equals length \times width \times height.



2 If you split the cube into 8 smaller cubes, the combined volume is the same but the surface area doubles.



3 If you split each of the 8 cubes into 8 smaller cubes, the 64 cubes together have the same volume that the first cube had. The total surface area, however, has doubled again!

Weathering and Climate

The rate of weathering in an area is greatly affected by the climate of that area. *Climate* is the average weather conditions of an area over a long period of time. For example, the mailboxes shown in **Figure 3** are in areas that have different climates. The mailbox on the left is in an area that has a hot, dry climate. The mailbox on the right is in an area that has a warm, wet climate. As you can see, the mailbox in the area that has a warm, wet climate is rusty.

Figure 3 Water and Rates of Weathering



This mailbox is in an area that has a dry climate, so the rate of chemical weathering is low.



This mailbox is in an area that has a wet climate. The rate of chemical weathering is high.

Temperature

Temperature is a major factor in both chemical and mechanical weathering. Many chemical reactions happen more rapidly at higher temperatures. Cycles of freezing and thawing also increase the chance that ice wedging will take place. Thus, climatic regions that experience many freezes and thaws have a greater rate of mechanical weathering than other regions do.

Moisture

Water can interact with rock as precipitation, as running water, or as water vapor in the air. The rate of chemical reactions may increase when water is present. For example, oxidation, like some other chemical reactions, happens at a faster rate when temperatures are higher and when water is present. The rusty mailbox in **Figure 3** has experienced oxidation.

Water also increases the rate of some methods of mechanical weathering. For example, ice wedging cannot happen without water. Abrasion is also more rapid when water is present.

Other Factors That Affect Weathering

Several other factors affect the rate of weathering. These factors include the following:

- **Elevation** Rocks can be exposed to different weathering environments at different elevations. Rocks at high elevations are exposed to high winds and temperature extremes. They may also be exposed to large amounts of precipitation, which may cause these rocks to weather rapidly. Rocks at sea level can be weathered by the action of ocean waves.
- **Slope** The steep sides of mountains and hills increase the speed of water running downhill. Water that flows rapidly has more energy to break down rock than slow-moving water does. Rainwater that runs down the sides of mountains and hills breaks down and carries away rock.
- **Biological Factors** Organisms in the soil can produce acids that can speed chemical weathering. The activities of burrowing animals and plant roots also speed mechanical weathering.

Section Summary

- Hard rocks weather more slowly than soft rocks.
- The larger the surface area-to-volume ratio of a rock is, the faster the rock will wear down.
- Chemical weathering occurs faster in warm, wet climates than in hot, dry climates.
- Rates of weathering are affected by elevation, by the slope of the ground, and by living things.

