WEATHERING AND EROSION

Background Information

The earth's crust is constantly changing, and, with the exception of new volcanoes and the mid-oceanic ridges such as the Mid-Atlantic Ridge, the crust is wearing down. These changes are the result of two continuing processes:

- weathering, the breakdown of rock into smaller pieces through exposure to wind, water, heat, and cold
- erosion, the movement of that weathered material by gravity, wind, and water

These two processes affect so much of physical geography that they merit a separate section. The combination of weathering and erosion is often referred to as erosion, but they are, in fact, two separate processes and are treated as such in this section, which expands on the basic information about weathering and erosion presented in other sections of this manual. The information and activities in this section are designed for Year 5 and 6 students who have the vocabulary and basic knowledge of physical geography concepts to explore the fascinating topics of weathering and erosion in more detail.

Weathering

There are two types of weathering. The first is **mechanical weathering**, the gradual breakdown of rock to sand, and then to **silt**, or powdered rock, and finally to clay through physical means.

Mechanical weathering occurs in a variety of ways. Heat and cold may cause minerals within a rock to expand and shrink at different rates, creating cracks. Water may seep into those cracks and freeze, expanding and splitting the rock. A raging river or ocean waves can smash rocks against each other, wearing the outsides smooth and turning rocks into sand. Or sand carried by the wind can act like sandpaper, slowly wearing rock away. A glacier can rub debris against the rock beneath it, also acting like sandpaper. Even plants can force rocks to split as roots creep into cracks and grow.

The second type of weathering is **chemical weathering**, the breakup of rock caused by a change in its chemical makeup. Rain is the most common producer of chemicals that can weather rock. Rain absorbs carbon dioxide and sulfur dioxide from the atmosphere, forming **carbonic acid** and **sulfuric acid**, two liquids capable of dissolving other materials. The levels of carbonic and sulfuric acids in rain, while generally weak, can over time dissolve rock such as limestone, freeing other types of rock. Over very long periods, rain can even dissolve enough limestone to create caves and unusual rock formations.

Many scientists today believe that rain is becoming more acidic as a result of the pollution caused by increasing burning of oil and gas in the world, for such purposes as heating buildings, cooking food, and operating vehicles. **Acid rain**, as it is called, has the potential to change the acidity of lakes and rivers and make it impossible for some types of animals and plants to flourish. Acid rain has also been named as

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the cause of increased rates of wear on buildings and statues.

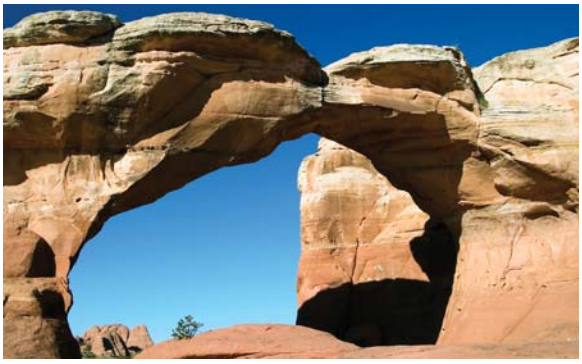
Plants and plant-like organisms also play a role in chemical weathering. For example, **lichens**, which are plant-like organisms, often appear on rock as green, gray, or yellow patches. Lichens secrete a weak acid that helps roughen the surface of the rock, allowing moss and other plants to take root there.

Note to the teacher

Formerly, lichens were classified by botanists as plants, but are now classified as plant-like organisms. For more information, please refer to the NAMC upper elementary manual on botany.

Note to the teacher

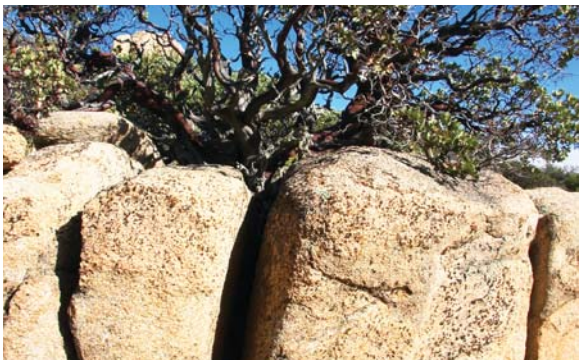
Thinking about weathering will inspire some students to explore science, especially concepts that illustrate the forces exerted by heat and cold. For ideas to suggest to students, teachers can refer to several NAMC upper elementary science manuals, such as Matter and Energy, Scientific Method and Technology, and Astronomy and Ecology. Teachers may also wish to refer to the NAMC lower elementary manual of science experiments.



Mechanical weathering

Freezing water

River weathering



Plant weathering

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Surface Chemical weathering

Underground Chemical weathering

Acid rain

Lichen

Erosion

The term “erosion” comes from “erodere,” a Latin verb meaning “to gnaw.” Erosion is what usually happens to the material loosened by weathering. Six main processes have an eroding effect, each in its own way (these processes are also listed on a summary sheet shown elsewhere in this section):

- gravity
- wind
- rain
- rivers
- oceans
- glaciers

The first main eroding process, gravity, is a passive force that moves what has already been loosened by weathering. Though not an active eroding force like wind or rain, the constant pull of gravity toward the centre of the earth is what makes rocks fall from mountains and sand settle to the bottom of oceans. Gravity is a factor in all patterns of deposition of weathered material. For example, mountains are often surrounded by **scree**, loose rock debris fallen from exposed rock.

The second eroding process is the wind. When carrying dust and sand, the wind is a tremendous sculptor of the earth. Not only does wind erode rock, wind also carries away the sand and dust it creates in the process. Anything in the way of sand- and dust-carrying wind will be slowly weathered and eroded away. The sand breaks up

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whatever surface it encounters, just like sandpaper, and then the wind blows the freed material to another location. Examples are found wherever persistent winds occur. Such winds not only shape rock, but also can scour paint off barns and houses and lift valuable **topsoil**, the upper layer of soil that nourishes plant roots, from one place and deposit it in another.

Rain is the third erosion process. Precipitation works to erode the land on which it falls through **rainsplash erosion**, rain splashing down on the land and dislodging weathered material such as pebbles or soil. Heavy rainfall, or large amounts of melting snow or ice, can also carry away the sediment into streams and rivers. The rivers continue the process, carving watersheds where the land is steep and enriching floodplains where the land is flat.

Rivers make up the fourth erosion process. Though rivers and streams weather and erode the earth, they also build it up by depositing the material they erode downstream. The way in which it is deposited creates the typical shape of a meandering river. A river slowly winding its way through flat land flows a little bit faster on the outside riverbank than on the inside riverbank. This gives the water on the outside curve more power to weather the ground on that riverbank, extending and deepening the river in that direction. The slower water on the inside curve tends to deposit material carried by the river from the previous curves, adding material to the inside riverbank. In this way, a meander is expanded sideways, producing a deeper curve in the river.

At the end of its course, a river deposits much of the remaining sediment at its mouth. If the sediment is not carried away into the ocean by the river current or by ocean tides, it remains and builds up, eventually expanding the mouth of the river by creating islands and **sandbars**, large underwater deposits of sand, to make a river delta. The river is then forced to branch out into smaller streams to flow across the delta and into the ocean.

Even after water enters the ocean, its ability to erode does not disappear — oceans erode in several powerful ways. When it blows across the ocean, the wind creates waves that erode the loose sand on beaches. The repeated motion, often many times a minute, washes the beach sand back into the ocean. The rising and falling tides allow the waves to work on higher and lower elevations of the shore, removing material from different levels.

Efforts by humans to protect shorelines from erosion by building rock walls often fail, as the energy of the ocean is transferred to more vulnerable areas, increasing erosion there. The actions of waves are heightened during a **storm surge**, a dome of water that accumulates under a major storm and is then driven onto the land by high winds. The high water level created allows the waves to reach further inland than usual, and the wind causes bigger than normal waves. The combination can be devastating to the shoreline, especially at high tide when the waves can be pushed even further inland.

Oceans also erode the land with currents. As an ocean current moves past the shore, it picks up sand washed off the beach by

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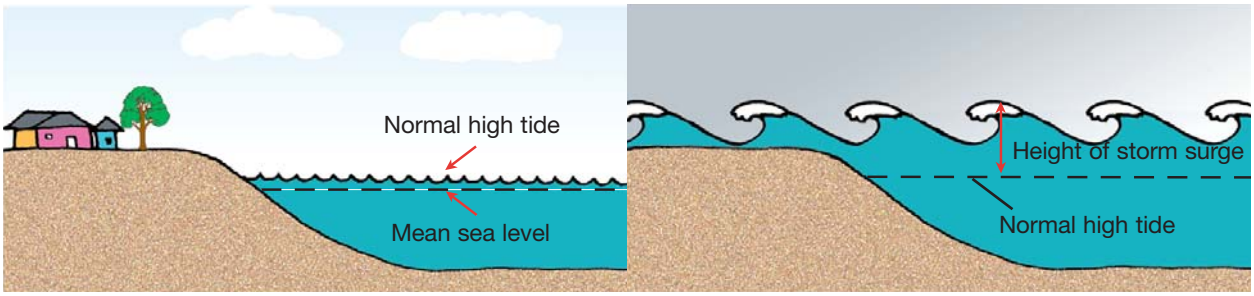

A storm surge

Glacial erosion

the waves and sweeps it downstream, depositing it wherever the current slows down. The area with its beach washed away is left more vulnerable to wave action. On the other hand, downstream areas that receive the sand from the currents are bolstered and protected from wave action. In this way, the shoreline evolves naturally.

Glaciers are the sixth erosion process to be discussed here. Given their enormous size and weight, it is no surprise that continental glaciers weather and erode significant portions of continents, and alpine glaciers weather and erode entire valleys. The enormous weight of the glacial ice and the embedded debris causes a glacier to weather the rocks beneath it as it flows, picking up still more debris along the way. As many glaciers in the world illustrate, the rock, sand, and clay debris is then deposited at the tip of the glacier as the glacier breaks off or retreats.

Beach erosion

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Summary sheet: Six main erosion processes

Erosion Process	Description
gravity	Gravity is a passive force that moves what has already been loosened by weathering. Though not an active eroding force like wind or rain, the constant pull of gravity toward the center of the earth is what makes rocks fall from mountains and sand settle to the bottom of oceans. Gravity is a factor in all patterns of deposition of weathered material. For example, mountains are often surrounded by scree, loose rock debris fallen from exposed rock.
wind	When carrying dust and sand, the wind is a tremendous sculptor of the earth. Not only does wind erode rock, wind also carries away the sand and dust it creates in the process. Anything in the way of sand- and dust-carrying wind will be slowly weathered and eroded away. The sand breaks up whatever surface it encounters, just like sandpaper, and then the wind blows the freed material to another location. Examples are found wherever persistent winds occur. Such winds not only shape rock, but also can scour paint off barns and houses and lift valuable topsoilfrom one place and deposit it in another.
rain	Precipitation works to erode the land on which it falls through rainsplash erosion, rain splashing down on the land and dislodging weathered material such as pebbles or soil. Heavy rainfall, or large amounts of melting snow or ice, can also carry away the sediment into streams and rivers. The rivers continue the process, carving watersheds where the land is steep and enriching floodplains where the land is flat.
rivers	Though rivers and streams weather and erode the earth, they also build it up by depositing the material they erode downstream. The way in which it is deposited creates the typical shape of a meandering river. A river slowly winding its way through flat land flows a little bit faster on the outside riverbank than on the inside riverbank. This gives the water on the outside curve more power to weather the ground on that riverbank, extending and deepening the river in that direction. The slower water on the inside curve tends to deposit material carried by the river from the previous curves, adding material to the inside riverbank. In this way, a meander is expanded sideways, producing a deeper curve in the river. At the end of its course, a river deposits much of the remaining sediment at its mouth. If the sediment is not carried away into the ocean by the river current or by ocean tides, it remains and builds up, eventually expanding the mouth of the river by creating islands and sandbars, to make a river delta. The river is then forced to branch out into smaller streams to flow across the delta and into the ocean.
oceans	When it blows across the ocean, the wind creates waves that erode the loose sand on beaches. The repeated motion, often many times a minute, washes the beach sand back into the ocean. The rising and falling tides allow the waves to work on higher and lower elevations of the shore, removing material from different levels.

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	Efforts by humans to protect shorelines from erosion by building rock walls often fail, as the energy of the ocean is transferred to more vulnerable areas, increasing erosion there. The actions of waves are heightened during a storm surge, a dome of water that accumulates under a major storm and is then driven onto the land by high winds. The high water level created allows the waves to reach further inland than usual, and the wind causes bigger than normal waves. The combination can be devastating to the shoreline, especially at high tide when the waves can be pushed even further inland. Oceans also erode the land with currents. As an ocean current moves past the shore, it picks up sand washed off the beach by the waves and sweeps it downstream, depositing it wherever the current slows down. The area with its beach washed away is left more vulnerable to wave action. On the other hand, downstream areas that receive the sand from the currents are bolstered and protected from wave action. In this way, the shoreline evolves naturally.
glaciers	With their enormous size and weight, continental glaciers weather and erode significant portions of continents, and alpine glaciers can weather and erode entire valleys. The enormous weight of the glacial ice and the embedded debris causes a glacier to weather the rocks beneath it as it flows, picking up still more debris along the way. As many glaciers in the world illustrate, the rock, sand, and clay debris is then deposited at the tip of the glacier as the glacier breaks off or retreats.

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Did you know?

- Historically, seasonal rains in the African highlands that feed the Nile caused it to overflow its riverbanks every year, depositing a rich, black soil on the fields. The fertility of the Nile floodplain allowed Egyptian civilization to thrive, providing enough sustenance for the farmers to feed themselves and have the energy to build the pyramids.
- The Amazon River deposits an average of 3.0 million tons (2.7 million metric tons) of sediment in the ocean every day.
- With rising sea levels, which scientists increasingly attribute to global warming, numerous islands that are close to sea level need to be evacuated. For example, the Pacific island country of Tuvalu has already begun to evacuate its 11,000 citizens because of rising sea levels. Scientists predict that the Maldives, with 311,000 people, will have to be evacuated in the next 50 years.

Scree

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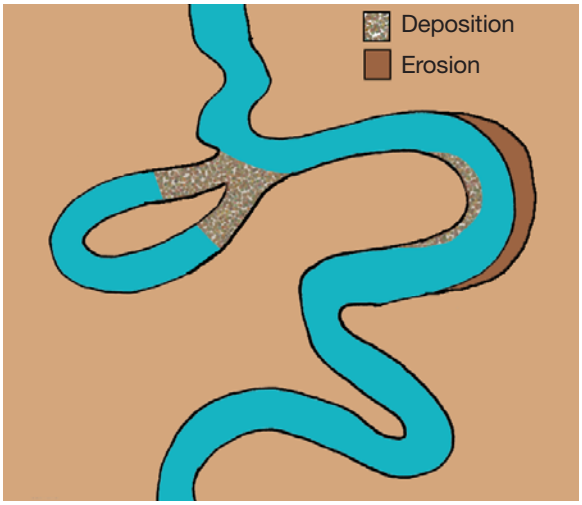
Dunes sculpted by the wind



Erosion and deposition on a meander

A river delta

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Resources

There are many excellent books, websites, and videos about weathering and erosion. Here are some examples:

- Downs, Sandra. *Shaping the Earth: Erosion.* Brighton, MA: Fitzhenry & Whiteside, 2004.

- Spilsbury, Louise, and Richard Spilsbury. T*he Disappearing Mountain and Other Earth Mysteries: Erosion and Weathering.* Chicago, IL: Heinemann-Raintree, 2006.

- Stille, Darlene R. *Erosion.* Minneapolis, MN: Compass Point Books, 2005.

- Juan, Thomas, and Dak Helentjaris. Glaciers and Glacial Geology. Montana State University. "Erosional Processes: A Simple Approach." <http://www.homepage.montana.edu/~geol445/hyperglac/eroproc1/#Introduction>

- The Why Files. The University of Wisconsin. "Beach Erosion." <http://whyfiles.org/091beach/>

- Earth Science in Action. *Weathering and Erosion*. Earth Science in Action DVD Series, producer. Wynnewood, PA: Schlessinger Science Library for Children. 2005. 23 min. Videocassette, DVD.

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ACTIVITY 1

Exploring Types of Weathering

Purpose

To learn more about the types of weathering and how they break down the earth's crust.

Material

Illustrations of various types of mechanical and chemical weathering.

Sample of mechanically weathered object (e.g., piece of glass worn smooth by sand).

Physical Geography journals and pencils.

Presentation

- Most Montessori teachers present these concepts in Years 5 and 6. This activity can be done in two parts, the first focusing on mechanical weathering and the second on chemical.

- Announce that the students will have an opportunity to explore types of weathering.

MECHANICAL WEATHERING

- Review what weathering is. Emphasize that the earth's crust is constantly breaking down into smaller bits, with rock turning into sand, sand into silt, and silt into clay.

- Explain that there are two types of weathering: mechanical and chemical.

- Explain that mechanical weathering occurs because rocks get broken into smaller pieces by something exerting force. Add that this force can break a rock in half or just wear it away slowly so that it gets smaller.

- With the students, name what kinds of forces might cause a rock to split (heat, cold, water, wind, sand, ice, plant roots), and then discuss and clarify each.

- Demonstrate the illustrations on mechanical weathering, and use them to describe each type. As each type of mechanical weathering is discussed,

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invite the students to describe examples of mechanical weathering they have seen or heard about. For example, students may have seen rocks around a campfire split from exposure to repeated heat, or picked up a smooth stone on a beach, or noticed a blade of grass pushing its way up through pavement.

- Demonstrate the sample and invite the students to examine it closely and consider questions like these: What might this sample have looked like when it fell into the ocean? How long might it have taken for the sand to smooth any rough edges on the sample?

CHEMICAL WEATHERING

- Explain that chemical weathering occurs when a liquid melts or dissolves rock. Point out that the acids in rain are the most common cause of chemical weathering, but that some plants and plant-like organisms, such as lichens, also have an acidic effect on rock. Add that as a result of pollution, rain is becoming more acidic. With the students, discuss some of the possible consequences of this change.

- Demonstrate the illustrations on chemical weathering and Lichen. Discuss with the students.

- Invite the students to describe any examples of chemical weathering they have seen or heard about. For example, students may have read about a famous statue being placed indoors to protect it from acid rain.

- Ask the students to use their journals to define mechanical and chemical weathering and give two examples of each, with illustrations.

Extensions

- To observe a process similar to how sand smoothes rock and other hard items, invite a local jeweler to come to the classroom and demonstrate how to use a stone polisher.

- Conduct a short study of the weathering force of repetitive cooling and warming on rock. Find several small rocks that have cracks, but have not yet split into pieces. Soak the rocks in water for an hour, and then put them in a freezer overnight. Take them out the next day and let them warm to room temperature. Even better, put them in the sun to get hot or place them on a source of heat, such as a radiator. Repeat this process for five days. Write a report about what happens and why.

- Research and write an illustrated report about an example of weathering that has been written about in newspapers in the past 5 years. Identify the types of weathering involved, describe their effect, and explain how people dealt with the weathering.

- Research and write an illustrated report about the effect of acid rain on a famous building or statue. Describe the effect, and explain how people dealt with it.

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- Sandblasting is an industrial technique for cleaning buildings. Find out how sandblasting works and write a report about it, including what kind of weathering sandblasting resembles.
- Take a walk through the neighborhood around the school and record examples of mechanical and chemical weathering. Include as wide a range of examples as possible, from heat and cold to ice and plant roots, and identify which type of weathering each example represents.

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ACTIVITY 2

Exploring Erosion

Purpose

To learn more about the types of erosion and their effects.

Material

Illustration, Scree.

Illustration, Dunes sculpted by the wind.

Illustration, Erosion and deposition on a meander.

Illustration, A river delta.

Illustration, A storm surge.

Illustration, Beach erosion.

Illustration, Glacial erosion.

Summary sheet, Six main erosion processes.

Physical Geography journals and pencils.

Presentation

- Most Montessori teachers present these concepts in Years 5 and 6.
- Announce that the students will have an opportunity to explore erosion.
- Review what is meant by erosion. Clarify that there are six main processes involved in erosion (gravity, wind, rain, rivers, oceans, glaciers) and that each has a different effect.
- One by one, demonstrate and discuss the illustrations, Scree, Dunes sculpted by the wind, Erosion and deposition on a meander, A river delta, A storm surge, Beach erosion, and Glacial erosion. As each illustration is demonstrated, ask the students to describe the process shown. The students will be familiar with most of the terms, but as needed, review such terms as gravity, dunes, river delta, and meander, and introduce such terms as scree, topsoil, rainsplash erosion, sandbars, and storm surge.
- Demonstrate the summary sheet, Six main erosion processes, and review it with the students. Invite the students to describe examples of each type of erosion they have seen or heard about (e.g. a local river that meanders, an article about a house that fell into the ocean because the cliff on which the house was built eroded). Encourage the

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students to refer to the summary sheet as they carry out projects.

- Ask the students to use their journals to describe and draw pictures of three main types of erosion discussed in this activity.

Extensions

- Conduct a study of how erosion happens at different levels for different objects. Watch the weather forecast to see when it is going to rain. Place a few hard, flat objects such as coins or jar lids on a sandy area outside just before it rains. Or, if there is no rain in the forecast, allow a garden sprinkler to spray over the objects for about an hour. Draw a picture of the pattern of erosion made by the rain falling on the hard objects and the surrounding soft sand. Leave the objects in place, and then allow them to be rained on (or sprinkled on) three more times over several days. Draw another picture of the pattern of erosion after several days of rain. Write a short report describing the findings.

- Research and write an illustrated report about river erosion and deposition on one of the world's great rivers (e.g., Nile, Amazon, Mississippi).

- Visit a local meandering river. Get as close as possible to one of the major curves in the river, and record where the river erodes and where it deposits the soil. Back at the classroom, locate the river on a map, identify the source and the mouth, and research its name and history. Then write an illustrated report describing the river.

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