# Weathering and Erosion

## Overview

In this lesson students are provided with hands on experiments that teach about the different types of erosion. Students rotate through four stations, with each station providing an experiment regarding one type of erosion. Students fill out a science journal along the way. Teachers then lead a discussion on which types of erosion were most powerful and ways in which we can slow or stop erosion from happening in areas that would impact human activity.

## Standards Covered

4-ESS1-1. Use evidence from a given landscape that includes simple landforms and rock layers to support a claim about the role of erosion or deposition in the formation of the landscape over long periods of time.

4-ESS2-1. Make observations and collect data to provide evidence that rocks, soils, and sediments are broken into smaller pieces through mechanical weathering and moved around through erosion.

5-ESS3-1. Obtain and combine information about ways communities reduce human impact on the Earth's resources and environment by changing an agricultural, industrial, or community practice or process.

## Learning Outcomes

1. Students will be able to define weathering and erosion.
2. Students should be able to list and describe the four main types of erosion.
3. Students can discuss ways in which we can reduce erosion in some locations.

## Materials Included

- Materials to complete each experiment
- Laminated photos
- Suggested lesson plan
- Copy of student science journal
- Laminated student instructions for each experiment

# Teacher Background

## What are weathering and erosion?

Weathering and erosion can occur almost anywhere on Earth's surface. They are responsible for shaping landforms that we see on the surface - from the highest mountains to the rugged canyons to the flat plains. Most landforms get their shapes, in large part, due to weathering and erosion.

## Types of weathering

Weathering is the breaking apart of rocks that are exposed at Earth's surface. Rocks cannot be weathered unless they are at Earth's surface and exposed to the hydrosphere, biosphere, and atmosphere. Weathering can break down rocks into fragments of varying sizes. Weathering is also responsible for the formation of sedimentary rocks. The process of weathering creates the sediments needed to form these rocks.

Weathering can take place in a variety of ways, which are classified into two main groups: **physical and chemical weathering. Physical Weathering** is the physical or mechanical break up of rocks into smaller pieces without changing their chemical makeup. The main types of physical weathering are:

**Biological:** Would you believe that some plants are stronger than rocks?! It's true! When a tree's roots grow down into the cracks of rocks, as the tree and its roots grow, they break apart the rock.

**Freeze/Thaw:** When water seeps into cracks and then freezes, it expands. This expansion of the ice is strong enough to break apart rocks!

**Abrasion:** Abrasion occurs when rock fragments (sand, gravel, silt) are carried by wind, water, or ice and wear away other rock outcrops.

**Chemical weathering** is the chemical breakdown of rocks, which means the chemical makeup of the rocks is changing through forming new minerals or the breaking apart of chemical bonds. The main types of chemical weathering are:

**Dissolution:** This is when water or acidic water (acid rain) interacts with the minerals in a rock. Sometimes the minerals dissolve into the solution or new minerals are formed. An example of dissolution is the interaction of limestone with carbonic acid (acid rain). This breaks down and dissolves the limestone.

**Oxidation:** This is the interaction of minerals with oxygen, which forms new minerals that become more susceptible to physical weathering. Think of rust on iron rich metal. A mineral example would be the transformation of the mineral Olivine into the mineral Limonite due to the iron present in this mineral.

## Types of Erosion

Erosion is the removal of rock fragments from their original location. This occurs after a rock has been weathered. Erosion and transportation of rock fragments can occur by water, ice, wind, and gravity.

## Water

Water is responsible for the majority of weathering, erosion, and transportation of sediments on Earth. Erosion from liquid water occurs from moving water on Earth's surface - such as streams, rain, ocean, lakes, floods, etc. As water moves across Earth's surface, it takes soil and sediments along with it. Some erosion can occur from ground water, such as dissolution of limestone creating caves and sinkholes.

Run-off from rainstorms causes topsoil to erode. Sometimes small channels can form, causing more erosion. If enough rain occurs, those small channels can turn into gulleys, in which a large amount of soil is removed during that rain event.

Rivers are responsible for the creation of much larger valleys and canyons. For example, the Grand Canyon, which is the largest canyon in North America, was created due to the Colorado River that flows at the bottom. For millions of years the Colorado River has been flowing through this area slowly eroding away the rock beneath it. Today we see the exposed layers of much older sedimentary rocks and the very old basement rock due to this erosion that has sliced through these rocks; like a knife through a layered cake!

Coastal (ocean) erosion is constantly reshaping our coastline. We have first-hand knowledge of what coastal erosion can do, especially to man-made structures built too close to the water! But coastal erosion can also impact ecosystems as well. Beaches and dunes can be eroded due to the action of waves and storm surges. Rocky coasts also experience coastal erosion as well. The battering of waves against the rocks will erode the rock and create sea caves. If the erosion breaks all the way through a section of rock an arch will form. Examples of this can be found along the coast of Maine as well as coastline in California, Oregon, and Washington.

## Ice

Ice erosion is mostly caused by the movement of glaciers and ice sheets across a landscape. Glaciers can freeze and fracture the bedrock beneath it. This causes fragments (boulders or larger) to be picked up by the glacier and carried for some distance inside the ice. Evidence of this can be seen all over New England. Ever stumble across a large boulder in the middle of the woods or a field and wondered how it got there. If there are no obvious outcrops of rock nearby, these rocks are most likely a glacial erratic. Meaning during the last ice age, the ice sheet plucked up this boulder and carried it to that location. The rock was dropped once the ice melted. The largest one in North America (possibly the world) can be found in Madison, NH! Madison Boulder Natural Area can be visited any time of year. It is believed this boulder travelled between 4 -24 miles by the last ice sheet before being deposited in its current location.

Small fragments (sand and cobbles) also get plucked up by glaciers. These smaller fragments can sometimes scrape along the bedrock below, causing further erosion of the rock. Evidence of this can be seen by the scratch marks, called glacial striations, that are left behind on the bedrock.

## Wind

Under certain conditions, strong winds are also responsible for moving a substantial amount of sediments. Wind can erode in two main ways. First, when wind is strong enough, it will pick up and carry very fine particles (fine sands – silt). This material is then moved for some distance before being dropped. Sand dunes are the result of continual movement and deposition of this wind-blown material. Dunes get their unique shape due to the direction in which the material is being moved, where one side is more steeply sloped than the other side. The wind is generally blowing from the gentle side towards the steep side.

The second way in which wind will erode material occurs when fine sediment that is being carried by the wind hits and abrades another rock or surface. The particles collide with a rock or surface and will eventually break apart that surface. This process essentially sand blasts the rock or surface and slowly breaks it apart.

## Gravity

Gravity is responsible for moving sediment down a slope. Erosion due to gravity is also called mass wasting. The downhill movement of material can occur on various scales. A large, fast movement of material down a slope is called a **landslide** (when it occurs on unconsolidated sediments) or an **avalanche** (if it is from bedrock). Sediment can also move on a much slower timescale. This process is called **creep** or **slump**. Creeping of sediment is not always noticeable. However, you may notice small cracks or scrapes in the ground as well as movement of man-made structures - like a fence that is no longer straight. The highest angle a material can achieve while maintaining its stability is called the angle of repose. Different sediments will have a different angle of repose. For example, large angular gravel has a much higher angle of repose than sand-sized sediments. This is why you may see slopes along the edges of man-made structures covered in gravel or rock debris. Angular gravel has an angle of repose of around $45^{o}$; whereas dry, fine sand has an angle of repose of around $30^{o}$. Erosion of a slope (i.e., undercutting) can cause the slope to reach an angle that exceeds the material's angle of repose, which will lead to slope failure and mass wasting.

# Human Impacts

For the most part, humans cannot stop erosion from occurring, but we do have some control over where and how fast it occurs in regards to protecting structures. Humans can also damage ecosystems which may then lead to an increase in erosion. An example of damage would be humans walking across a sand dune at the beach and damaging the delicate sea grasses that grow. The roots of the grass add more structure to the sand and help hold the dune together. When grass is damaged and dies, these roots no longer hold the sediment, causing an increase in the amount of erosion that takes place. Displacing vegetation from deforestation, construction or farming is a large contributor to increasing erosion. Studies have shown that erosion rates in some areas have increased by a factor of 100 due to human activity.

There are several ways in which we can slow down this increase in erosion caused by human activity. You may notice barriers, sometimes fencing or logs, along dunes at the beach. These structures diverts material (snow, water, etc.) away from the slope and prevents or slows erosion. Along

larger/steeper slopes you can notice rocks (called riprap) along the slope. Rocks are also used to stabilize the soil and slow or divert water as it flows down as well as increase the angle of repose of that slope (preventing any mass wasting). Plants and grasses are the best way to slow erosion, as the roots hold together and stabilize the soil.

# Lesson Set Up

****Night Before:**** In one ice cube tray, place only water and set in freezer overnight. In a second ice cube tray, place a little bit of sand in each well and then fill with water and set in the freezer overnight.

**Day of Lesson:** Set up the four stations around the room with each of the materials needed for that station and the correlating signage and information sheets. Divide the students into four groups and give them each a copy of an 'Erosion Science Journal'.

## Lesson Instructions:

1. If you have already covered the rock cycle, it would be beneficial to quickly review the rock cycle. You can ask students what sedimentary rocks are made of. They may recall sedimentary rocks are made of sediments.
2. Ask the students (or review) how are sediments made.
3. Define what a sediment is and discuss with the class that sediments are fragments of other rocks.
4. Discuss with the class how sediments form from weathering and erosion. Define and go over weathering and erosion and show them the included photos. (Review the 'Teacher background' for information on weathering and erosion.)
5. Have the students break out into their groups and each go to one station.
6. The students should spend a few minutes reading the experiment instructions for the station they are at. Give the students about 10 minutes to each get a turn to do the experiments at their stations and fill out their journals.
7. Once they have completed their experiments the students can all switch to a different station.
8. After all four groups have had a turn at every station, you can discuss their results as a class.
9. You can ask the students what they think is the biggest (moves the most stuff) agent of erosion. Lead them to the answer of water if needed.
10. Ask them when weathering and erosion is a good or bad (for humans) natural phenomenon. Discuss instances where we might want to minimize erosion. Ask the students to come up with ideas on things they can do to help minimize erosion in those places.

# Extension/Homework:

## Weathering in your neighborhood?

Ask the students to walk around their neighborhood and search for evidence of weathering or erosion. Some clues may be cracks in the sidewalk or driveway, movement of soil from run-off or roots breaking/cracking the road.

# Erosion Experiments: Teacher Instructions

***Note: each station has enough materials for two groups/station***

## Station 1: Water – Pour water over water bottles of soil

**Materials:**

1. 4 aluminum loaf pans
2. Plastic forks (made to look like trees)
3. Watering cans x 2
4. Aluminum sheet pan
5. Soil

**Procedure:**

1. Have each group of students take two aluminum loaf pans, one sheet pan, a handful of forks, and one watering can.
2. Using the provided soil, have the students put soil inside each loaf pan filled to the top and lightly packed down.
3. Students should stick several forks (8-10) in the soil of one loaf pan (tines down all the way into the soil). Teacher Note: These forks represent trees and they are planting a forest. The tines of the fork represent the roots of the trees.
4. Fill the watering can with water.
5. Place the two loaf pans side-by-side inside the sheet pan, with one side of the loaf pan elevated (either on the edge of the sheet pan, on books, or held with their hands).
6. Have the students slowly pour water over the loaf pan with the forks. Let the students observe how much dirt is washed down into the sheet pan. Teacher Note: Students should observe some soil get washed away but that the trees block a lot of the soil from moving.
7. Now have the students slowly pour water over the loaf pan without the forks. Have the students observe how much dirt is washed down into the sheet pan. Teacher Note: The students should see a dramatic increase in the amount of soil that gets washed away without the forks.
8. Have the student fill out their erosion journal. They should discuss with themselves ways in which we can prevent erosion using vegetation.

# Station 2: Wind

**Materials:**

1. Aluminum roasting pans (one side missing)
2. Sand, silt, and pebbles mixture
3. Hair Dryer
4. Cup

**Procedure:**

1. Read the information card(s) about wind erosion.

2. Have students take one roasting pan and a hairdryer.

3. Take one cup of the sand mixture and pour it in a straight line across the pan, about 1 inch from the open side. Take another cup of the mixture and pour another line across the pan directly behind the first one. Repeat again with one more cup of the sand mixture.

4. Hold the hair dryer near the open end of the gravel pan pointing towards the other end. Turn the hair dryer on low, blowing towards the sand mixture. Once about half of the sand/silt has eroded turn the dryer on high.

5. Write your observations in your erosion journal.

   Teacher Note: Students should observe the smallest particles blow across the pan and form dunes. They should also note that the larger particles do not move and are left behind.

# Station 3: Ice Erosion

****Night Before:**** In one ice cube tray, place only water and set in freezer overnight. In a second ice cube tray, place a little bit of sand in each well and then fill with water and set in the freezer overnight.

**Materials:**

1. Ice Cube tray with ice cubes pre-frozen.
2. Modelling clay
3. Rolling pin
4. Placemat

**Procedure:**

1. Have the students take a fist full of modelling clay and kneed it to make rolling easier.
2. On the placemat the student should roll out their clay about ¼ in thick.
3. Have the student take an ice cube from the tray with no sediment.
4. The student can then pretend the ice cube is a glacier and rub the ice cube back and forth on the modelling clay. Teacher Note: Students should see not much change in the clay, it may get smooth as the ice melts and wets the clay. Students should stop before the clay gets excessively wet.
5. They should write their observations in their journal.
6. Next the students can take an ice cube that contains sediment.
7. Again, have them pretend the ice cube is a glacier and rub the ice cube across the modelling clay. Teacher Note: Students should see that the ice with sand embedded in it will dig into and leave scratch marks across the clay.
8. The students should compare their clay to provided pictures of glacial striations.
9. Have the student write their observations in their journal.
10. Students can then compare their model to pictures and examples of glacial striations. They can write about their observations in their journal.

# Station 4: Mass Wasting/Gravity

**Materials:**

1. Play sand - one container of dry sand and one container of damp sand
2. Two aluminum pie plates
3. Protractors
4. Shovel
5. Cup of water

**Procedure:**

1. Have the students take one pie plate and a protractor.
2. The students should read the information card about mass wasting and answer the questions in their journal.
3. The students can then slowly scoop sand into their pie plate, until sand is filled to the brim in a conical shape. See the provided picture for what this should look like.
4. Holding the straight edge on the brim of the pie plate, students should carefully, as to not disturb the sand too much, push the protractor into the sand until the edge of the sand pile meets the 0 degree point.
5. Students can then measure the angle of the sand pile. Teacher Note: Loose unconsolidated sand should have an angle of repose of roughly $30^0$.
6. They can take several measurements to be sure.
7. Students can then repeat steps 3-6 using the damp sand. They should notice that they can manipulate the steepness of the sand when it is damp. Teacher Note: Damp sand can obtain a much higher angle of repose ( $> 30^o$) due to the surface tension of water increasing stability.
8. Have the students take the cup of water and slowly pour it down one side of the damp sand. Teacher Note: They should observe that too much water (saturation) causes the sediment to become very unstable causing mass wasting at very low angles.
9. They should write their observations. Teacher Note: Students should conclude that light amounts of water will not impact a natural slope, but that a large amount of water (saturation) will cause the slope to be unstable. This is why many landslides occur after periods of very heavy rainfall.