

Earth's Weathered Crust

OBJECTIVES

Students examine the makeup of Earth's crust and explore the role of weathering in the formation of soil.

The students

- ▶ examine the composition of Earth's crust
- ▶ simulate the chemical and mechanical weathering of rocks
- ▶ examine the composition of different types of soil

SCHEDULE

Session I About 40 minutes

Session II About 40 minutes, 1 day after Session I

VOCABULARY

chemical weathering
mechanical weathering
soil
weathering

MATERIALS

For each student

- 1 Activity Sheet 3, Parts A and B

For each team of four

- Earth model, from Activity 2*
- 1 magnifier
- 1 pipette
- 4 tubes, plastic, with caps

For the class

- 1 clock, with sweeping second hand*
- 1 container, 1-L*
- 2 bags gravel†
- 1 roll paper towels*
- 2 bags rocks, marble†
- 1 bag soil, clay†
- 1 bag soil, sandy†
- 2 spoons, plastic
- 1 roll tape, masking
- 1 btl vinegar
- water, tap*

*provided by the teacher

†in Sand and Soil Box

PREPARATION

- 1 Make a copy of Activity Sheet 3, Parts A and B, for each student.
- 2 One day before the activity, rinse and air-dry the gravel to remove excess dust.
- 3 For Session I, set up a distribution station with the vinegar, a 1-L container of tap water, two spoons, the two types of soil, and the gravel.
- 4 Prepare an area where students can leave their tubes of gravel and soil undisturbed overnight.
- 5 Each team of four will need one piece of marble, one magnifier, one pipette, four plastic tubes with caps, a paper towel, several pieces of masking tape, and access to the distribution station and to a clock with a sweeping second hand. Each team will also need its Earth model from Activity 2.

BACKGROUND INFORMATION

The rock that makes up Earth's crust is exposed to the elements and gradually breaks down in a process called **weathering**.

Mechanical weathering is the physical breakdown of rocks into smaller pieces, gradually reducing them to the tiny particles that make up **soil**. Wind, water, plants, and temperature and pressure changes all cause mechanical weathering. **Chemical weathering** is the breakdown of rocks caused by chemical reactions with other substances. Chemical weathering results in a change in the chemical composition of rocks. Lichens, a combination alga/fungus often found growing on rocks, are particularly effective agents of chemical weathering because of the acid they release. In recent years, acid rain has become a significant factor too.

Examples of mechanical weathering vary considerably. The Grand Canyon is a dramatic example of the ability of moving water to wear away rock. At Half Dome in Yosemite National Park, weathering and erosion of the overlying rock caused a release of pressure on the granite. Cracks formed and the outer layers of rock peeled off like layers of an onion.

Wind erosion caused the natural sculptures at Arches National Monument in Utah. At Mount Rushmore National Memorial in South Dakota, the sculpted heads of Washington, Jefferson, Theodore Roosevelt, and Lincoln must be patched every year because of the effects of weathering. Weeds that grow on Jefferson's cheeks are mowed to prevent chemical weathering by the acids released from the plants' roots.

The type of soil that is produced by weathering depends on the type of rock that is broken down. Sandstone and quartz break down into sand, feldspar produces clay, and so on. Different soils contain different proportions of sand, clay, and other mineral particles.

▼ Activity Sheet 3, Part A

Earth's Weathered Crust

Chemical Weathering

1. To demonstrate chemical weathering, place a piece of marble rock on a paper towel. Position it so that the flattest surface is facing up. Bring your pipette to the distribution station and fill it with a small amount of vinegar. Back at your workstation, place several drops of the vinegar, a weak acid, onto the flat surface of the rock. Allow it to sit undisturbed for several minutes. Observe the rock and vinegar closely. Describe what you see.

The vinegar dissolved tiny particles of the rock.

Allow the vinegar to sit for several more minutes. Then rub your finger over the affected area. Describe what you feel.

The rock may feel rough and gritty.

What do you think caused this?

The vinegar dissolved tiny particles of the rock.

How does this demonstrate chemical weathering?

The acid in the vinegar broke down the rock by changing its chemical composition.

Mechanical Weathering

2. Bring one plastic tube to the distribution station and fill it to a height of 8 cm with gravel. Then add water until the tube is three-quarters full. Bring the tube back to your workstation.
3. Your teacher will assign your team a number. This number represents the number of minutes you are to shake your team's tube. When the teacher gives the signal, begin shaking the tube. Watch the clock and stop shaking when your team's time is up.
4. After you have stopped shaking the tube, swirl the water in your tube several times, then pour it off into the second tube. Using masking tape, label the second tube with your team name and the number of minutes the tube was shaken. Allow the sediment to settle out overnight.

▼ Activity Sheet 3, Part B

Earth's Weathered Crust

Separating Soil

5. Use masking tape to label one tube Sandy Soil and the other Clay Soil. Bring the tubes to the distribution station and place 4 rounded teaspoons of each type of soil into the appropriate tube. Fill the tubes with water to within 3 cm of the top. Place the caps securely on the tubes. Return with the tubes to your workstation. Shake each tube thoroughly. Tip each tube upside-down for a few seconds and then place it upright on your table. Leave the tubes undisturbed overnight. What do you predict will happen?

The soil particles will settle in layers on the bottom of the tube.

6. The next day, observe the soil in the two tubes. Record your observations below.

Sandy Soil:

The soil has settled in several layers. The bottom layer is light brown and looks like sand. The layers above are increasingly dark and fine.

Clay Soil:

The soil has settled in several layers. The bottom layer appears to contain some tiny stones. The layers above are increasingly dark (reddish brown in color) and fine.

What makes up soil?

small particles of broken-down rock and organic material, such as decaying plant matter

Where do the particles in soil come from?

the weathering of various kinds of rocks and other materials

Are all soils the same? If not, how do they differ?

No. They are made up of particles of different sizes, textures, and colors. They contain different minerals.

Guiding the Activity

Additional Information

Session I

- 1 Have each team retrieve its Earth model from Activity 2. To review, ask, **Where is Earth's crust located?**

Ask, **What part of the Earth is underneath the oceans?**

Ask, **What is Earth's crust made of?**

If students do not mention soil, point out that the surface of the crust in most areas is covered by a layer of soil.

- 2 Instruct students to recall places where they have seen outcroppings of rock. Ask, **In which of Earth's layers were the outcroppings located?**

Ask, **What did the rock formations look like?**

Ask, **Have you ever traveled along a highway that has had sections of road cut through solid rock?**

Ask, **What did you see on the ground at the base of the rock walls?**

Ask, **Where else have you observed pieces of broken rock?**

Show the class samples of the gravel and the two types of soil. Ask, **Which layer of the Earth do each of these samples come from?**

- 3 Write the word *weathering* on the board. Tell students that **weathering** is the process by which rocks in Earth's crust are broken down into smaller pieces. These pieces can vary in size from boulders to pebbles to the tiny particles that make up soil.

The crust is the outermost layer of Earth, or Earth's surface layer.

The crust. Make sure students understand that the crust covers the entire surface of Earth, not just those areas covered by land masses.

solid rock and soil

again, the crust

Students' answers will vary.

Most students will say they have.

Smaller pieces of broken rock. Students may also mention seeing signs that read: "Danger—Falling Rock Zone."

Students' answers will vary.

the crust

Guiding the Activity

Write the terms *mechanical weathering* and *chemical weathering* on the board. Ask, **What do you think is the difference between these two types of weathering?**

Explain to students that **mechanical weathering** is the physical breakdown of rocks into smaller pieces. No matter how small the rock particles become, however, they still have the same chemical composition as the original rock. Distinguish mechanical weathering from **chemical weathering**, which is the breakdown of rocks caused by a chemical reaction with another substance. Chemical weathering results in a change in the chemical composition of the rocks.

4

Tell students that mechanical weathering occurs in a variety of ways (Figure 3-1). Ask, **What is one example of mechanical weathering?**

Ask, **What do you think causes the pieces of rock to break off the rock walls?**

Write the words *wind*, *water*, *pressure*, *temperature*, and *plants* on the board. Tell students that each of these factors can cause mechanical weathering. Encourage students to suggest how.

Explain that when a strong wind blows, it picks up sand and blows it against rocks. The result is abrasion similar to that caused by sandpaper on wood, and the rock is gradually worn down.

Rocks at the surface of the Earth may expand and contract due to rapid changes in temperature or pressure. At some point they will crack into pieces or break apart in layers. Ask, **Where else besides in rocks can you see cracks caused by temperature changes?**

Additional Information

Accept reasonable answers.

Students should say that the pieces of rock that fall from rock walls along the highway are the result of mechanical weathering.

Some pieces may have been loosened initially during blasting, then broke off completely after continued exposure to the weather. Gravity also plays a role. Allow students to suggest various possibilities.

in sidewalks and roads

Guiding the Activity

Explain that plants may grow in these cracks and cause them to expand more rapidly, sometimes splitting the rock into pieces. On steep terrain, these pieces may be pulled downward by the force of gravity and break up even more as they tumble to the base of the slope.

Tell students that water is another powerful agent of mechanical weathering. When water enters cracks in rocks and freezes, it expands and may break off pieces of rock. Weathering also takes place underwater. Rushing water in a stream or river, or the pounding surf along the seashore, bangs the rocks against one another and chips off corners and rough spots, gradually making the rocks smoother, more rounded—and smaller.

5

To reiterate, ask students, **How does chemical weathering differ from mechanical weathering?**

Write the terms *rainwater*, *oxygen*, and *acid rain* on the board. Tell students that all of these factors can cause chemical weathering (Figure 3-2). Ask, **Where does the oxygen that causes chemical weathering come from?**

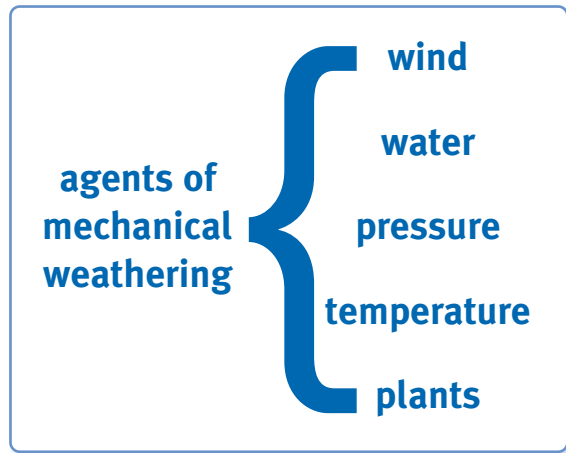
Explain to students that many of the acids that cause weathering are released from dead plants and from the roots of growing plants. Pollutants in the air create acid rain, which also causes chemical weathering.

Ask, **Where have you seen examples of chemical weathering?**

Explain that rocks that have been pitted by chemical weathering are then attacked by freezing water, and mechanical weathering continues the breakdown of the rocks.

Additional Information

Students may also have seen weeds growing in the cracks in sidewalks.

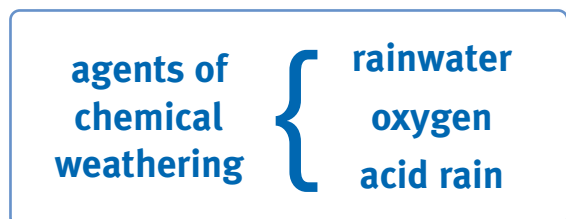


▲ *Figure 3-1. Mechanical weathering breaks down rocks into smaller and smaller pieces.*

Chemical weathering actually changes the chemical composition of the rock, not just the size or shape of the rock.

Oxygen is in the air and dissolved in water.

Students may have seen old gravestones whose lettering has been worn away by lichens or statues that are pockmarked from continued exposure to acid rain.



▲ *Figure 3-2. Chemical weathering changes the chemical composition of rocks.*

Guiding the Activity

Additional Information

6 Tell students that they will now demonstrate both chemical and mechanical weathering. Divide the class into teams of four. Give each student a copy of **Activity Sheet 3, Part A**. Distribute to each team one piece of marble, one pipette, two plastic tubes with caps, a magnifier, a paper towel, and a piece of masking tape. Point out the materials at the distribution station. Tell students to follow the directions in Step 1 on Part A of the activity sheet and to answer the questions in that section.

Discuss students' answers to the questions in Step 1.

7 Have students follow the directions in Step 2 on Part A of the activity sheet.

When students have completed Step 2, assign each team a number, which represents the number of minutes the team is to shake its tube. Assign two teams to each of the following numbers: 5, 10, 15, and 20. Have students begin shaking their tubes, as described in Step 3.

Ask, **Why is it important for all of the teams to shake their tubes at the same rate?**

When students have stopped shaking the tubes, have them complete Step 4 and then line up their sediment tubes according to the amount of time they shook the gravel. In other words, the two tubes containing water from the gravel that was shaken for 5 minutes will be next to each other at one end of the line, and the two tubes containing water from the gravel that was shaken for 20 minutes will be next to each other at the other end of the line. Leave the tubes overnight to allow the sediment to settle to the bottom.

The bubbles that form on the marble are very tiny; students will need to look closely to see them.

You may wish to have a volunteer stand in front of the room to set the beat. Also, tell students to take turns, so that everyone has a chance to shake his or her team's tube and no one gets tired.

This ensures that the gravel in each tube is exposed to approximately the same amount of agitation (abrasion) per minute, so that the results can be compared.

Note: For best results, students should shake their tubes side to side horizontally, not up and down vertically.

Guiding the Activity

- 8 Write the word *soil* on the board. Ask students, **What is soil?**

Inform students that **soil** is the loose weathered material on the surface of Earth's crust in which plants can grow. Again, show students the two soil samples. Ask, **Are these the same?**

Ask, **How are they different?**

Tell students that they will separate each type of soil into its component parts to better see how the soil samples are different from one another. Distribute a copy of **Activity Sheet 3, Part B**, to each student. Give each team two more plastic tubes with caps and two pieces of masking tape. Instruct students to follow the directions in Step 5 on Part B of the activity sheet.

Have students rinse off the pieces of marble, blot them dry with a paper towel, and return them to the bag. Then have them dispose of the gravel in their tubes either outdoors or in a plastic-lined container. Finally, rinse and air-dry the pipettes and the tubes that contained gravel. Return these and all other materials not in use to the kit.

Session II

- 9 Distribute one magnifier to each team. Tell students to observe the tubes that contain the gravel sediment from Session I. Ask, **What do you notice about the amount of sediment deposited in the various tubes?**

Additional Information

Accept all answers.

no

Students will probably point out the difference in color and possibly texture.

The longer the tube of gravel was shaken, the more sediment was deposited.

Guiding the Activity

Ask, **How can you explain this observation?**

Tell students that particles removed from rocks by mechanical weathering end up as one of the components of soil.

Additional Information

Shaking the tube caused the pieces of gravel to bang against one another and tiny chips and particles to break loose. The sloshing water inside the tube removed these tiny particles from the gravel. The longer the pieces of gravel were banged around inside the tube, and the longer the water acted on the gravel, the greater the number of particles removed, and the greater the amount of sediment deposited. This experiment demonstrated the process of mechanical weathering.

- 10** Have students retrieve their tubes of soil and water and follow the directions in Step 6 on Part B of the activity sheet. Then have them answer the rest of the questions.

Discuss students' answers to the questions on the activity sheet. Ask, **What could you tell about the soil samples after conducting the experiment that you could not tell before by simply observing them?**

Ask, **To what do you attribute the different colors of the two soils?**

They were made up of particles of different sizes and colors that settled out of water at different rates.

They are made up of different earth materials.

- 11** To wrap up, ask, **What is the connection between Earth's crust, rocks, weathering, and soil?**

Earth's crust is made up of rocks. When these rocks are weathered, small particles break off. Some of these particles mix with particles from other rocks and organic matter to form soil.

REINFORCEMENT

Have students use a piece of paper to model mechanical weathering: Tell them to tear it, cut it, fold it, crumple it, stomp on it, poke holes in it, and so on. Point out that although the paper no longer looks the way it did before it was mutilated, it is still paper. To model chemical weathering, burn a corner of a piece of paper. Explain that the ashes have a different chemical composition than the paper.

SCIENCE NOTEBOOKS

Have students place their completed activity sheets in their science notebooks.

CLEANUP

Have students discard the soil from their tubes into a plastic-lined trash container. Wash and dry the tubes and caps and return them, along with the magnifiers, to the kit.

Connections

Science Challenge

Ask students to find out what the term *soil profile* means. (A soil profile is a cross-section of soil layers above the bedrock.) Have student teams research the names and characteristics of the layers, or horizons, in a typical soil profile and then draw a picture or construct a model of a profile. Encourage students to use a variety of materials to make their pictures and models as realistic as possible. For example, they could use painted sandpaper with pebbles and bits of organic materials glued to it to represent the upper layer. Suggest that they make their pictures and models as complete as they can, showing plant roots growing and earthworms, insects, and other small organisms living in the top layer.

Science Extension

► Ask several volunteers to collect and bring in samples of soil from various locations. In class, give each team one soil sample. Tell students to spread the soil out on sheets of plain newsprint paper and examine it closely with a magnifier, noting the different shapes, sizes, colors, and textures of the particles. Have students identify any living organisms or organic materials they find in the soil. (Living organisms should be removed from the soil and returned to their original location.) Next, tell students to fill a clear glass or plastic jar about halfway with the soil sample, add water to almost fill the jar, shake the jar to mix the soil and water thoroughly, then let the jar stand undisturbed overnight. The next day, have each team examine and describe the different layers of particles that have formed. Ask students to explain the layering process. (Particles settled out according to their weight, with the heaviest forming the bottom layer and the lightest forming the top layer.)

► Ask interested students to create a mural showing how the Grand Canyon was formed. Students can find descriptions and diagrams in science textbooks, library books, encyclopedias, and on the Internet. Divide the group into as many teams as there are stages to be shown. Each team should research its stage, draw it on the mural in its correct chronological order, and label the drawing with the time period and a concise description of the processes that occurred in that stage.

Science and the Arts

Suggest that students find and photograph examples of water erosion in their community. You could provide one or two inexpensive cameras for students to share. Students who have access to a video camera could tape erosion as it occurs—runoff cutting channels in an embankment after a heavy rain, for example. Tell students to look for examples of all sizes, from a tiny rivulet eroding soil at the edge of a road, to a rain-swollen river cutting away its banks. Let students display their photographs in the classroom or in an area of the school where other students will be able to view them.

Science and Math

As a variation of the first Science Extension above, have students separate each soil sample using two sifters—one with a coarse-mesh screen and the other with a fine-mesh screen. Pebbles and large particles that do not pass through the coarse-mesh screen should be considered coarse soil. Soil that passes through the coarse-mesh screen but not through the fine-mesh screen is medium soil. Soil that passes through the fine-mesh screen is fine soil. Tell students to weigh each type of soil and then construct a bar graph to show the proportion of each type by weight in the total sample.