

4-ESS2 Earth's Systems

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Students who demonstrate understanding can:

- 4-ESS2-a. Design and conduct fair tests on the effects of water, ice, wind, and vegetation on the relative rate of weathering and erosion.** [Clarification Statement: Examples of variables to test are angle of slope in the downhill movement of water, amount of vegetation, speed of wind, rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, or volume of water flow.] [Assessment Boundary: Variables must be tested individually.]
- 4-ESS2-b. Design solutions to mitigate the effect of the processes of erosion and weathering on local landscapes by brainstorming, testing, refining, and communicating solutions with peers.*** [Clarification Statement: Processes of weathering refers to mechanical (physical or biological) weathering.]
- 4-ESS2-c. Analyze maps showing a variety of Earth's features and the occurrence of geologic hazards to determine the geographic patterns that emerge.** [Clarification Statement: Earth's features include mountain ranges, deep ocean trenches, and ocean floor structures. Examples of geologic hazards include volcanoes and earthquakes often found at the boundaries of continents.] [Assessment Boundary: Results of analysis and evaluation are qualitative.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p>Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.</p> <ul style="list-style-type: none"> Design and conduct investigations collaboratively, using fair tests in which variables are controlled and the number of trials considered. (4-ESS2-a) <p>Analyzing and Interpreting Data Analyzing data in 3–5 builds on K–2 and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations.</p> <ul style="list-style-type: none"> Display data in tables and graphs, using digital tools when feasible, to reveal patterns that indicate relationships. (4-ESS2-c) Use data to evaluate claims about cause and effect. (4-ESS2-c) Compare data collected by different groups in order to discuss similarities and differences in their findings. (4-ESS2-c) <p>Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3–5 builds on prior experiences in K–2 and progresses to the use of evidence in constructing multiple explanations and designing multiple solutions.</p> <ul style="list-style-type: none"> Use evidence (e.g., measurements, observations, patterns) to construct a scientific explanation or design a solution to a problem. (4-ESS2-b) 	<p>ESS1.C: The History of Planet Earth</p> <ul style="list-style-type: none"> Earth has changed over time. Understanding how landforms develop, are weathered (broken down into smaller pieces), and erode (get transported elsewhere) can help to infer the history of the current landscape. (secondary to 4-ESS2-a), (secondary to 4-ESS2-b) <p>ESS2.A: Earth Materials and Systems</p> <ul style="list-style-type: none"> Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. (4-ESS2-a), (4-ESS2-b), (secondary to 4-ESS1-a) <p>ESS2.B: Plate Tectonics and Large-Scale System Interactions</p> <ul style="list-style-type: none"> The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features where people live and in other areas of Earth. (4-ESS2-c) <p>ESS2.C: The Roles of Water in Earth's Surface Processes</p> <ul style="list-style-type: none"> The downhill movement of water as it flows to the ocean shapes the appearance of the land. (4-ESS2-a) <p>ESS2.E: Biogeology</p> <ul style="list-style-type: none"> Living things affect the physical characteristics of their regions (e.g., plants' roots hold soil in place, beaver shelters and human-built dams alter the flow of water, plants' respiration affects the air). Many types of rocks and minerals are formed from the remains of organisms or are altered by their activities. (4-ESS2-a), (secondary to 4-ESS1-a) 	<p>Patterns</p> <ul style="list-style-type: none"> Similarities and differences in patterns can be used to sort, classify, and analyze simple rates of change for natural phenomena and designed products. (4-ESS2-c) <p>Cause and Effect</p> <ul style="list-style-type: none"> Cause and effect relationships are routinely identified, tested, and used to explain change. (4-ESS2-a) <p>Connections to Engineering, Technology, and Applications of Science</p> <p>Influence of Engineering, Technology, and Science on Society and the Natural World</p> <ul style="list-style-type: none"> Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands. (4-ESS2-b)

Connections to other DCIs in this grade-level: will be added in future version.

Articulation of DCIs across grade-levels: will be added in future version.

Common Core State Standards Connections:

ELA/Literacy –

RI.4.7 Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears. (4-ESS2-c)

Mathematics –

MP.1 Make sense of problems and persevere in solving them. (4-ESS2-b)

MP.7 Look for and make use of structure. (4-ESS2-c)

4.MD.1 Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. (4-ESS2-a), (4-ESS2-c)

4.MD.2 Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale. (4-ESS2-a), (4-ESS2-b), (4-ESS2-c)

4.MD.4 Make a line plot to display a data set of measurements in fractions of a unit ($\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$). Solve problems involving addition and subtraction of fractions by using information presented in line plots. (4-ESS2-a), (4-ESS2-b), (4-ESS2-c)

4.MD.5 Measure angles in whole-number degrees using a protractor. Sketch angles of specified measure. (4-ESS2-a)

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice, Disciplinary Core Idea, or Crosscutting Concept.

Cracked Marbles

4th Grade

Jeremy White, Brent Greene, & Kathleen Waugaman

References:

- Lesson plan from CPS 4th grade Earth Science curriculum guide

Benchmarks:

(Benchmark B): Summarize the processes that shape the Earth's surface and describe evidence of those processes. ES-9: Identify and describe how freezing, thawing, and plant growth reshape the land surface by causing the weathering of rock.

Objectives:

Students should be able to describe how weather events such as ice, snow, and freezing water cause weathering of the Earth's surface and rocks. Students should be able to distinguish between erosion and weathering, and understand that freezing water expands to create cracks and broken rocks over time.

Materials:

- Marbles
- Hand lens
- Ice cubes
- Safety goggles
- Potholder
- Water
- Paper towels
- Tin cans
- Small pan
- Bunsen burner or heat source
- Lab journal/paper
- Large pictures and handout about Mt. Rushmore

Initial Demonstration:

Each student should receive a handout about Mt. Rushmore. The students should be aware that Mt. Rushmore is made of granite rock, which is some of the hardest rock available on Earth. The formation of this rock is a result of volcanic magma cooling under the Earth's surface over millions of years. The pictures of the presidents' faces should be close up to demonstrate the cracks in the faces of the presidents. Use these pictures to show how heating and cooling have led to large cracks in the largest sculpture ever built. Discuss with the students that water can get into these cracks and cause them

to get larger between cooling and heating of the rock. Also point out that if nothing is done to prevent these cracks, the faces of the presidents could begin to fall off and ruin the sculpture. Also talk about ways that people can prevent any further damage to this landmark, such as using special sealants and caulking to fill the cracks, thus preventing water getting into those cracks.

Target Observations:

- Weathering causes rocks to break up, even some of the hardest rock on Earth.
- The faces of the presidents have large cracks as a result of expanding and contracting rock from changes in temperature.
- Further damage can be prevented by blocking off the cracks from water.

Target Model:

- Freezing water causes weathering of rocks, as demonstrated with the marbles.
- Water expanding and contracting as a result of temperature changes over several years will eventually cause large pieces of mountains to break off and break into smaller pieces, which eventually turns into dirt and sand.

Procedure:

Have each group get a set of materials they will need. Have the students examine the marbles with their hand lens. Do they see any cracks? Have them describe in their journals the way the marbles look and feel. Have students put ice cubes into a small tin can and cover the ice cubes with water. Place this to the side for later use. The students are then to place several marbles into a small pan and then bring them to you to heat over the burner for several minutes (3 should work). Have another student from the same group bring the tin of ice water over to where you are and very carefully tip their marbles into the cold water and ice. Have them sit for three minutes. During this time you can heat the other group's marbles. Keep trading off groups of cooling and heating for at least three more turns.

After the last turn of being heated, have the students take their ice water and marbles back over to their area. Have them remove the marbles from the water and dry them off with the paper towels. Students need to observe their marbles with their hand lenses and record their new observations in their journals. Have students write and complete the following questions in their journals: A. What happened to the marbles with the heating and cooling? B. How are our Earth's landforms heated and cooled? C. How does repeated heated and cooling change those landforms? D. What landforms near us might be affected by heating and cooling? Discuss student's answers after the lab has been cleaned up.

Target Observations:

- The marbles are smooth, round and contain no cracks in the first examination.
- The marbles expand and contract between the heating and cooling processes.

- After the final cooling stage, the marbles are still round, but they contain small cracks in them. Some marbles may have cracked in half upon observations.
- This heating and cooling causes rocks to expand and contract, thus cracking and breaking them into pieces. This is the definition of physical weathering.

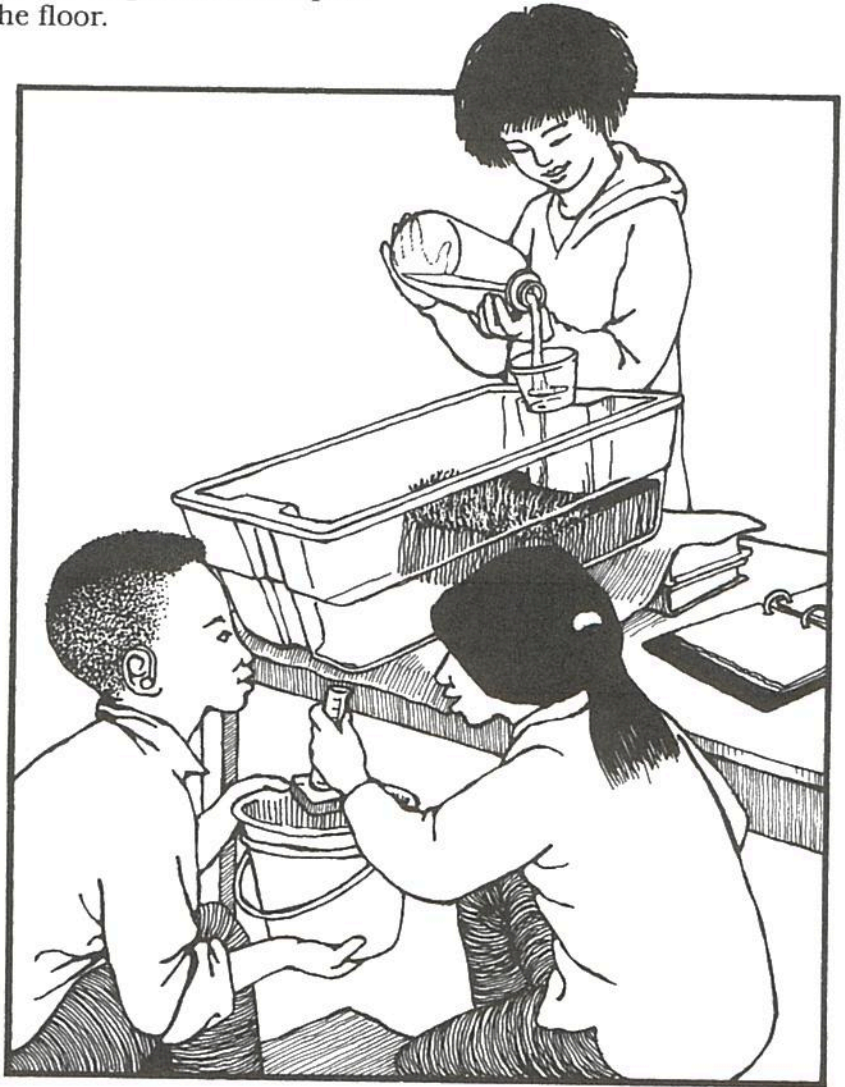
Summary:

Landforms and especially rocks are worn down by wind and rain. Plants and freezing water help split them apart. Heating and cooling also play a major role in the erosion and weathering of the land. This lesson helps students see the effect of heat and cold on rocks.

Student Instructions for Investigating the Effects of Plants on Erosion

Part A: Investigation with Plants

1. Label one of your cylinders "14A" for this part of the investigation.
2. Stack your books about 18 cm (7 in) high on your work space. Cover the books with the large absorbent pad. Place the smaller pad on the floor.
3. Raise the end of the stream table and set it on the covered books as you did in Lesson 13. Use the illustration to help you. The drain hole should be near the edge of your work space.
4. Remove the rubber stopper from the drain hole.
5. Attach the plastic cup with the large hole (red dot) to the stream table.
6. Hold the catch bucket under the drain hole.
7. When you are ready, run only 1 liter of water (one-half of the bottle) through the cup. You may need to hold the cup steady with your hand.
8. When you are almost at the 1-liter mark on your bottle, collect a sample of runoff in the cylinder marked "14A." Fill the cylinder to the 50-ml mark if possible.



Part B: Investigation with Some Plants Removed from the Soil

1. Label the second cylinder "14B" for this part of the investigation.
2. Remove a section of plants from the *middle* of the stream table. Use the illustration to help you. You should be able to see soil where the plants used to be. Place the plants you removed on the paper towel.



3. Pour the water from your bottle into the stream table. Try to keep the water at the line on the cup at all times.
4. When your bottle of water is almost empty, collect another cylinder of runoff in the cylinder marked "14B." Fill it to the 50-ml mark.
5. Now complete **Record Sheet 14-A: Investigating the Effects of Plants on Erosion.**

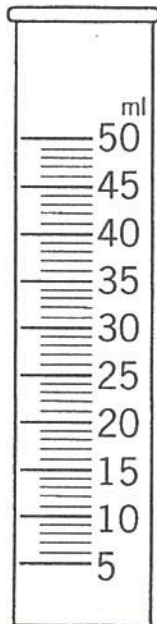
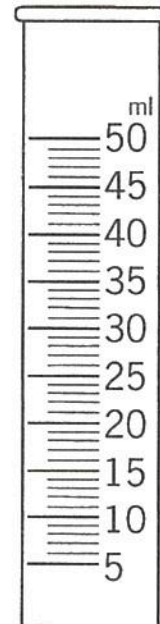
Record Sheet 14-A

Name(s): _____

Group: _____ Date: _____

Investigating the Effects of Plants on Erosion**Observing the Cylinders of Runoff**

1. Place your two cylinders of runoff (14A and 14B) side by side. Let them sit for a few minutes. Then draw what you see.

Cylinder 14A: With Plants**Cylinder 14B: Some Plants Removed**

2. Compare the two cylinders. How are they alike? How are they different?

3. Look at the soil in each cylinder. In which cylinder do you see more soil? _____

What happens when you remove plants from soil?

Record Sheet 14-A

Name(s): _____

Investigating the Effects of Plants on Erosion, *continued***Thinking about Plants on Earth**

1. Why do people plant grass or other vegetation? List as many reasons as you can.

2. Think of some situations in which people remove trees and other plants from the soil. List as many as you can.

3. How does removing plants affect the land?

4. Do you think people should remove plants? Explain.
