



Weathering Instructional Case: A series of student-centered science lessons

Lesson 5

Suggested Timeline

Two 45-minute periods with one 24-hour period in between for soaking overnight.

Materials

- Plastic, wide mouth screw top 12-16 oz. bottles - 1 per group of 4 students
- 4 Scales with 0.1g accuracy -
- Marble chip (or other carbonate rock that is soluble in vinegar) about 1-2 inches across- 1 Per group of 4 students
- Plastic spoon – 1 Per group of 4 students
- Timer - 1 Per group of 4 students
- Plastic or paper bowl - 1 Per group of 4 students
- Paper Towels
- Safety Goggles
- Vinegar
- Seltzer Water
- Small gravel (fish tank gravel or other)
- -Salt
- -Sand
- -Plastic portion cups (3 oz)
- -Plastic cups (8 oz)
- -Large waste container

Weathering Competition

Summary

This is a culminating activity that is used at the end of the weathering unit after students have learned about physical and chemical weathering. This activity is set up as a competition where groups of students are given a small piece of marble and different weathering agents to see who can reduce the mass of the rock the most in a 24 hour period. Students may choose one liquid (vinegar, seltzer or tap water) and one material (gravel, sand or salt) to accelerate the weathering of the rock sample.

Objective

- Identify factors that affect rates of chemical and physical weathering
- Predict which factors will affect the rate of weathering in a real rock sample and explain how each selected factor will affect rock
- Create a class bar graph to display group data
- Analyze class graph
- Use the C-E-R format to explain their thinking behind their hypothesis and results

Teacher Background Knowledge

There are two types of weathering processes: chemical and physical weathering. *Chemical weathering* involves the chemical transformation of minerals and commonly results in the dissolution of minerals in a rock. *Physical weathering* (also known as *mechanical weathering*) is the result of physical forces that break rock into smaller and smaller pieces without changing the rock's mineral composition. Although we commonly consider weathering and erosion as separate processes, they occur simultaneously on the Earth's surface and may aid one another. In this activity, students will "weather" their rock sample using a choice of agents. The rock chosen for this activity is composed of the mineral calcite. Calcite is soluble in weak acids and will readily dissolve in a vinegar solution. This portion of the activity is analogous to chemical weathering and the vinegar will have a greater effect than water or seltzer. Students also will have a choice of materials (salt, sand or gravel) to put into the bottle with the sample and liquid. Gravel is the most effective choice since it will abrade the sample during shaking of the bottle. The shaking of the bottle and the inclusion of another material is analogous to physical weathering such as the transport (erosion) of sediment in a river. The results of the activity should indicate that the most effective agents for weathering are acid (vinegar), gravel, and vigorous shaking.

Lesson 5

Weathering Competition

Prep

Day 1

1. Label plastic jars with period and group number
2. Make trays of materials for each group that include the following for each group: 1 plastic, wide mouth, screw top jar, Electronic scale with 0.1g accuracy, and timer.
3. Identify an easily accessible location to set up a variable station with premeasured plastic portion cups of each of the solid variables (sand, gravel, salt), and 8 oz cups of each of the liquid variables (tap water, seltzer water, vinegar).
4. Create and label trays by period for students to set their bottles on after the experiment.

Day 2

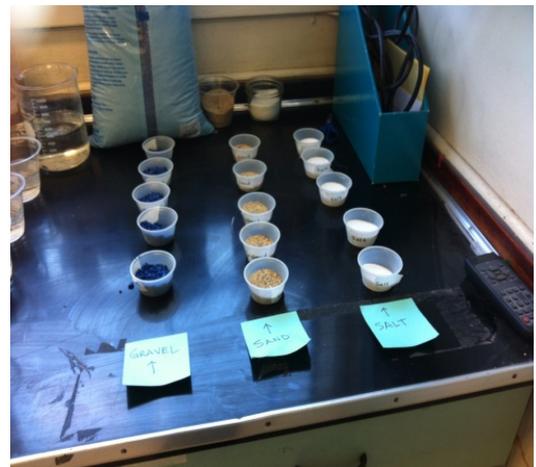
5. Prepare trays of materials for each group including: Jars (with rocks and variables), funnel, plastic bowl, plastic spoon, scale, calculator, and paper towels
6. Designate a central location for the large waste container for students to pour their liquid/solid mixtures (so they do not go in the sink)
7. Technology (if possible): Document camera or PowerPoint slide to project worksheet instructions and graph of class results.



Setup of liquids (seltzer water, water and vinegar)



Funnel, electronic scale, Timer, empty bottles



Setup of solids (gravel, sand and salt)

Lesson 5 Weathering Competition

Preparation of Materials

The bottles used in the weathering competition should be sturdy plastic bottles with a wide opening and screw top lid that are 12-16 oz. in size. Sport drink and juice bottles work well for this activity. Avoid glass bottles since they may break during vigorous shaking.

The rock sample used in the Weathering Competition should be a carbonate rock (composed of the mineral calcite) that will react to a weak acid such as vinegar. White landscape rock composed of marble works well for this activity; this material is readily available in hardware stores and plant nurseries in 20 pound bags. Since some marbles may be composed of the mineral dolomite (that is less soluble in vinegar) rather than calcite, it is important to test the solubility of the sample in vinegar by pre-running the activity. Alternatively, limestone samples may also be used in this activity if they are composed of calcite and are mildly soluble in vinegar. It is also important to use samples that are small enough to fit through the opening of the bottle.



Sport drink bottle with wide opening and screw top lid



White marble landscape rock

Ordinary white vinegar may be used for the experiment. Typically, white vinegar has an acidity of ~5%. In order to prevent the complete dissolution of the sample, it is advisable to dilute the vinegar by about one-half with tap water. This can be done ahead of time so that the students do not need to be concerned about an

Lesson 5 Weathering Competition

Standards ¹²

NGSS Performance Expectations:		
<i>This lesson supports students in progressing toward the NGSS Performance Expectation.</i>		
MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. [Clarification Statement: Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials.]		
MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. [Clarification Statement: Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.]		
Assessment Boundaries: <i>Assessment is limited to the interactions of two systems at a time.</i>		
In this lesson...		
Science and Engineering Practices	Disciplinary Core Ideas	Cross Cutting Concepts
<p>Analyzing and Interpreting Data Students use graphical displays of the multi-variable charts to identify the correlational relationships in the data (between the solid variables and liquid variables). Students analyze and determine similarities and differences in the findings as they tabulate class data.</p> <p>Using Mathematics and Computational Thinking Apply mathematical concepts and/or processes of percent and ratio to calculate the percent change in mass from before and after the 'shaking'.</p>	<p>ESS2.A: Earth's Materials and Systems The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.</p> <p>ESS2.C: The Roles of Water in Earth's Surface Processes Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.</p>	<p>Energy and Matter Students learn that within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. In this case, it was the energy of motion (shaking the water bottles) that modeled an expedited agent of weathering the marble rocks.</p> <p>Stability and Change Students' models of the different chemical and mechanical weathering agents demonstrate changes in mass over a 24-hour period.</p>
In this lesson...		
CCSS Mathematics	CCSS English-Language Arts	
<u>CCSS.MATH.CONTENT.6.RP.A.3.C</u> Find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means 30/100 times the quantity); solve problems involving finding the whole, given a part and the percent.	<u>CCSS.ELA-LITERACY.RST.6-8.7</u> Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).	

¹ NGSS Lead States. 2013. Next Generation Science Standards: For States, By States. Washington, D.C.: The National Academies Press.

² National Governors Association Center for Best Practices, Council of Chief State School Officers Title: Common Core State Standards (insert specific content area if you are using only one) Publisher: National Governors Association Center for Best Practices, Council of Chief State School Officers, Washington D.C. Copyright Date: 2010

Lesson 5 Weathering Competition

Prior Knowledge

In grades 3-5, students learned that water, ice, wind, organisms, and gravity break rocks, soils, and sediments into smaller pieces and move them around. Students have also learned that most of Earth's water is in the ocean and much of the Earth's fresh water is in glaciers or underground.

In previous lessons, students have learned about mechanical and chemical weathering. They have received inquiry-based instruction and direct instruction. Students have also conducted their own experiments and used models as tools to demonstrate observable and unobservable phenomena.

Lesson

Prelab

1. Divide students into teams of four and pass out worksheets for Prelab
2. Introduce the main question: What affects the rate of the weathering of a rock?
3. Explain the general overview of the activity and the rules. Overview: "Each group of students will be given a marble rock and a bottle and will have 24 hours to try to reduce the mass of the rock the most. Each group selects different variables that may increase the rate of weathering.

Rules (listed on student sheets):

- a. You must use your safety glasses.
 - b. You will have 24 hours, and bottles cannot leave the classroom.
 - c. The rock must stay inside the bottle at all times.
 - d. As a group, choose one variable from each list (liquid and solid).
 - e. After you have closed the container, you cannot open it up until instructed on Day 2.
 - f. On Day 2 you may not shake your container.
 - g. Only the Materials Manager may get out of their seat.
4. Instruct the groups to read through the list of solid and liquid variables and choose one liquid and one solid variable and write it in the table. Explain that seltzer water is carbonated, and therefore has carbon dioxide in it. (To make sure there are a range of choices, you can limit the number of groups that choose the same variable. For example, in a class with 9 students, only 3 groups could have the same liquid and only 2 groups could have the same liquid and solid. It's also important for results to make sure that at least two groups choose vinegar, and that these groups choose different solid variables. However, do not let students know that the vinegar is an important variable to represent. If necessary, the teacher can set up an extra experimental bottle.)
 5. Once students select variables, groups decide on the agent of weathering they are modeling (they may select more than one agent for each variable), and indicate this on the worksheet.
 6. Instruct students to choose and rewrite their hypothesis.

Lab Day 1

7. Assign student roles in the groups: Materials Manager, Timer, Scale Expert, Pourer
8. Read procedure aloud while modeling and pointing out location of shared materials.
9. Instruct groups to check off steps as they complete them.
10. Ask materials managers to get trays of materials
11. Float around room while students are working and check to make sure they make accurate measurements and follow procedure correctly.
12. After groups have finished, materials managers bring bottles and materials trays to designated areas.
13. Restock trays and variable station before each class.

Lesson 5 Weathering Competition

Lab Day 2

14. Read procedure aloud and model and point out location of shared materials.
15. Explain how to calculate percent change and how use the calculator.
16. Rotate between groups to check and record each group's percent change and variables used, and add y-axis units on the graph template.
17. Create class graph. Project the class results graph on the board, and color in bars on the graph template to add the percent change for each group, and check off the variables used for each group.
18. Instruct students to analyze the graph and fill out the class results section.
19. Have students clean up materials and pass out exit ticket for students to complete individually.
20. Lead class discussion of student conclusions about the data, to connect results to previous learning about chemical and mechanical weathering.

Potential Pitfalls

Students may be confused by the numerous variables involved in this activity. It is best to front-load the students with the two main points: each group had a liquid variable and a solid variable to focus on. Considering the data from the entire class, students will see that (for this experiment) the agent that is most effective at decreasing the mass of the rock sample is vinegar. However, all groups will have some mass loss due to physical weathering during the shaking of the bottle.

As with the previous lessons on weathering, students may conclude that weathering is a rapid process since they may get dramatic results from their experiment overnight.

Although many minerals are soluble in acid solutions, most geologic environments are not as acidic (low pH) as vinegar. Thus, dissolution in the natural environment is generally much slower. It is important to understand that this activity is a model of chemical and physical weathering and has some limitations. Make sure that students understand the relative timeframes for geologic change as they relate to weathering of rock.

Another possible misconception is that students may reveal that they conceptualize different shaped and sized rocks as just being that way, and haven't made connections to the key concept that rocks are part of the Earth's crust, and have changed over time, chemically and/or mechanically.



Source: Gary Halvorson, Oregon State Archives