Weathering of Limestone

Strand Geology

Topic Investigating Earth's Surfaces

Primary SOL

ES.7 The student will investigate and understand geologic processes, including plate tectonics. Key concepts include
a) geologic processes and their resulting features.

ES.8 The student will investigate and understand how freshwater resources are influenced by geologic processes and the activities of humans. Key concepts include
b) development of karst topography.

Related SOL

ES.1 The student will plan and conduct investigations in which
a) volume, area, mass, elapsed time, direction, temperature, pressure, distance, density, and changes in elevation/depth are calculated utilizing the most appropriate tools;
e) variables are manipulated with repeated trials; and
f) current applications are used to reinforce Earth science concepts.

ES.2 The student will demonstrate an understanding of the nature of science and scientific reasoning and logic. Key concepts include
a) science explains and predicts the interactions and dynamics of complex Earth systems;
b) evidence is required to evaluate hypotheses and explanations;
c) observation and logic are essential for reaching a conclusion.

Background Information

Limestone is a chemical sedimentary rock that is created from the remains of calcium bearing organisms and chemical precipitants. The calcium can come from the shells and/or the skeletal fragments of deceased organisms. Over millions of years, the calcium normally contained within the shells of marine and land organisms is broken down and put into solution. Calcium rich solutions are left to settle while the water evaporates. Through deposition and heating from Earth, this calcium rich location will become a limestone deposit. Due to the nature of limestone to slowly dissolve when in the presence of a light acid as well as allow water to pass through the matrix of the limestone, many cave formations are as a result of large limestone deposits. Another geologic landform in which limestone plays a key factor in its generation is a sinkhole. Areas in which there are numerous sinkholes are also known as karst topography.

Students will identify examples of both mechanical and chemical weathering (the processes by which rocks are broken down by the actions of water, air, chemicals, and organisms) and its by-products, including sediments and soil and its products. Students will observe the effects of temperature on chemical weathering rates and observe the effects of physical weathering on chemical weathering rates by increasing surface area for chemical reactions.

Materials

For each small group:

- Goggles and other safety equipment
- 500-ml plastic beaker or plastic cup
- Chalk, or calcium carbonate tablets
- Stopwatch
- Weathering of Limestone handout (attached)
- Hot water
- Room-temperature water
- Ice water
- Various concentrations of hydrochloric acid
- Four mortars and pestles

Vocabulary

acidity, calcite, chemical weathering, hydrolysis, limestone, physical weathering (mechanical weathering)

Student/Teacher Actions (what students and teachers should be doing to facilitate learning)

Prepare for the lesson by doing the following:

- Fill a large chest cooler with ice and water.
- Fill another large container with water, and allow it to stand long enough to become room temperature.
- Set up a large 40-cup coffee maker to supply very warm water.
- *Caution! Be sure to follow appropriate safety procedures.*

Introduction

1. Introduce the concept that *physical weathering* (the disintegration of rock material into smaller particles) and *chemical weathering* (the decomposition of rock material by chemical reactions) work together to transform rocks and minerals into soil and to dissolve minerals in solution. Tell students that the following activity will demonstrate that physical and chemical weathering can occur separately or in tandem and will reveal that physical weathering can accelerate chemical weathering.
2. Ask students, “Why do we chew our food?” They may say, “To break it up” “To make it smaller.” “To make it easier to digest.” Then ask, “Why do we have acid in our stomachs?” They may have difficulty coming up with any reasons besides “to digest the food,” but with some prompting, they should realize the acids react with the food to decompose or dissolve the food.
3. Have the students complete the prelesson inquiry activity. This is an activity in which the students will draw a short four segment comic strip and answer some questions.

Procedure

1. Ask students to provide some examples of how rocks can be broken into smaller pieces. Rocks falling or tumbling down cliffs and mountains are obvious examples. Students may have more difficulty providing examples of rocks being chemically dissolved because the process is slow and goes largely unnoticed. Photographs of very old and more recent

gravestones and their engravings can provide clear examples of the effects of chemical weathering on the stones.

2. Introduce students to available materials, including various temperatures of water and various concentrations of hydrochloric acid. Instruct students to write a procedure to determine how physical weathering could alter the rate of chemical weathering. *(by increasing surface area for chemical reactions)* Approve students' procedures before allowing them to proceed to the experimentation phase.
3. Have students carry out approved experiments to observe the effects of physical weathering on the rate of chemical weathering.
4. After experimentation is complete, have students discuss results with partners and collaboratively write a conclusion based on their findings. Have partners share their results with the class.

Observations and Conclusion

1. Discuss the effect of reducing particle size by physical weathering on the chemical weathering rate. Questions to ask might include the following:
   Which piece of chalk (or $CaCO_3$ tablet) took the most time to dissolve?
   Which tablet dissolved in the least amount of time?
   What does breaking up the tablet into smaller pieces affect? *(the rate of chemical weathering)* Why?
2. Discuss the effect of varying amounts and concentrations of acid on chemical weathering rates. Questions to ask might include the following:
   Which solution dissolved the tablet in the least amount of time?
   Which solution dissolved the tablet in the greatest amount of time?
   Why does acidity affect the chemical reaction rate?

Assessment

- **Questions**
  - You visit a car junkyard and notice that every car there is rusting away. What type of weathering is most responsible for transforming shiny new cars into rusty old ones in a junkyard?
  - On a field trip to Shenandoah National Park, you observe a tree growing out of a crack in a large boulder. How does the growth of the tree affect this boulder? What kind of weathering does the tree cause?
  - On the same boulder, you observe lichen growing on the rock surface. Lichen obtains nutrients from the rock. How does the weathering caused by the growth of the lichen differ from the weathering caused by the growth of the tree?
  - If limestone is easily weathered, what does this mean for structures that utilize limestone as a building material?
  - If a home is built with limestone bricks and nonlimestone bearing mortar to hold the home together, what does this mean for the weathering rates of the two materials?
  - Looking specifically at our nation's capitol, why would so many of the monuments and buildings be constructed of limestone if it will eventually weather away?

- **Other**
  - As a demonstration, prepare a beaker containing room-temperature water. Drop a sugar cube into the beaker, and stir until the cube completely dissolves. Record on the board the time this takes. Repeat the procedure with another beaker of water and a tablespoon of granulated sugar. Ask students to write an explanation of their observations and the data.

Extensions and Connections (for all students)

- Have students use a spreadsheet program to tabulate data, compute trial averages using the Function Wizard, and create bar graphs for export into formal lab reports.
- Have students investigate street potholes on their school bus route throughout a school year and explain the physical and chemical weathering involved.
- Have students investigate the long-term chemical weathering effects of acid (e.g., vinegar) on the mass of various limestone samples. Have them use an electronic balance to find each sample's mass and record these data in their notebook. Then, have them place the samples in a beaker containing an acid solution. Once per week, have them remove the samples from the acid bath and use the electronic balance to determine any changes in each sample's mass.
- Discuss how the observations made during the lab relate to the weathering of rocks in different climates and environments.
- Desert climates are often rocky (boulders to gravel-sized) and sandy. Which type of weathering is dominant in such an environment? (A picture may help students formulate a correct response.)
- Excluding the Blue Ridge and the Valley and Ridge provinces, Virginia landscapes are relatively free of rocky outcroppings. In fact, a certain amount of digging through soil is usually required to uncover solid rock. Which type of weathering appears to be dominant throughout most of the state?

Strategies for Differentiation

- Take students outside for a "Nature Walk" in which pairs of students work together to identify real-world samples of physical and chemical weathering in nature. Provide a template or series of sentence frames to assist each student in writing a descriptive paragraph describing examples of weathering viewed during the walk. Have partners share, revise, and edit their descriptive paragraphs before you collect them.
- Group students in pairs. Have partner A create a semantic map with words, concepts, processes, and examples related to physical weathering. Have partner B make a similar semantic map for chemical weathering. Then, have partners exchange their maps and add to each other's work. Have each pair share their maps with the class, as you record correct information from each pair on a class T-chart.

Weathering of Limestone

Name: _____ **Date:** _____

Pre-Lesson Inquiry activity:
All over the world fossils are found in various sedimentary rock formations. Since limestone is a type of sedimentary rock, there are certainly a large number of fossils that can be found in a limestone formation. Think back on how limestone is formed and draw a short 4 segment cartoon strip, depicting the correct type of fossil found in limestone and how you think it arrived there. (Hint: What kinds of living things have large amounts of calcium and live in or near the water.) After you have finished the comic strip, answer the questions below the comic strip.

The steps to fossilization in limestone.

Questions:

1. With what you know about the creation of limestone, list some characteristics of limestone that would allow it to break down easily by chemical and mechanical means.

2. List 3 items that are made of calcium carbonate (aka limestone) be sure to list why limestone is a good fit for the building of the items that you listed.

3. What is a major disadvantage to using limestone to build something?

4. Knowing that many limestone formations are created by the calcium rich remains of marine organisms, what can you conclude about limestone formations being created in an inland location such as Richmond and even further west as the central boarder of West Virginia?

Physical Weathering											
Substance	**Dissolving Time (in seconds) Group Trials**										**Average Dissolving Time (sec.)**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Whole Chalk (or Tablet)											
Broken Chalk											
Powdered Chalk											

Chemical Weathering											
Solutions	**Dissolving Time (in seconds) Group Trials**										**Average Dissolving Time (sec.)**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Tap Water											
Concentration 1 (acid)											
Concentration 2 (acid)											