How do rocks break down into smaller pieces?

Teaching and Learning Focus

Before completing this investigation, students should examine some of the physical properties of different types of rocks. In this investigation, students think about how rocks change through time. They consider the breakdown of rock into smaller and smaller pieces through processes that collectively are known as weathering. The specific process that students examine in this investigation is abrasion, the action of rocks and sediment grinding against each other and wearing away exposed surfaces. In nature, abrasion occurs as wind and water rush over rocks, causing them to bump against one another and changing their shapes. Rocks become smoother as rough and jagged edges break off. Students run a model of this process by shaking sugar cubes and gravel together in a plastic container. The sugar cubes become smoother as their edges break off when they collide in the container.

Materials Needed

For each student:

- 2-3 sugar cubes
- 2-3 pieces of gravel
- small plastic container with a lid
- observation sheet
- magnifying glass
- paper (e. g. newsprint) to cover desktops

For instructional purposes:

- Images of Weathering, either as a printed sheet or on presentation slides

Safety

This investigation is generally considered safe to do with students. Do not provide glass containers to students because the shaking of the gravel could cause them to break. Students should be reminded not to eat the sugar cubes. Also, review the investigation for your specific setting, materials, students, and conventional safety precautions.

Setting the Scene

Most probably, students recognize that in nature rocks exist in different sizes, from exposed mountain sides and plateaus to boulders to gravel to grains of sand. The processes by which rocks break down into smaller and smaller pieces, however, may be new to students. Begin the investigation by asking students about the various sizes of rocks they may have experienced or seen.

1. Describe the different sizes of rocks you have seen.
2. How big can rocks in nature get? What are some examples of big rocks? Where can they be found?
3. How small can rocks in nature get? Where are small rocks found?

Have your students discuss these questions, first in pairs, then groups and then as a whole class. Record their answers on a flipchart that you can refer to throughout the investigation.

Presenting the Investigation Question

After the scene is set, introduce your students to the investigation question: "*How do rocks break down into smaller pieces?*" Have your students discuss the question in pairs, then in groups, and then as a whole class. Record their answers on the flipchart.

Have your students brainstorm ideas about how to investigate this question:

1. What materials would be needed?
2. What would you have to do?
3. What would be measured?
4. How long would the experiment take?

Tell your students that they will be investigating this question and at the end of their study they will be able to provide reliable answers.

Assessing What Your Students Already Know

Students will probably have had some personal experiences of breaking rocks apart, such as by hitting a rock with a hammer or throwing a rock onto a hard surface. Some may be able to transfer this knowledge to a natural setting, such as rocks grinding against each other in a rockfall or landslide. Here are some initial questions that your students can discuss, in pairs, in groups, and as a whole class:

1. What happens when rocks smash into each other?

2. What might cause rocks to smash or grind against each other?
3. Do all rocks break apart in the same way?
4. Some rocks can have rough edges while others are quite smooth. What might create a smooth rock?

Have your students share their ideas with the class and record them as a list on the flipchart.

Have students think about what they would like to learn about the breakdown of rock into smaller and smaller pieces. Record their ideas on the flipchart as a list called "Questions we have about how rocks breakdown." This list will provide further insights into what your students know, and also what they would like to know. By the end of the investigation, some of these questions will probably be answered.

Exploring the Concept

1. Provide the materials to the students.
2. Instruct students to cover their desktops with paper.
3. Have students examine the sugar cubes with magnifying glasses. Students should record their observations on the observation sheet provided. They can either draw or describe the sugar cubes.
4. Ask students to place their sugar cubes in the small plastic container and to close the container with the lid.
5. Ask students to predict how the sugar cubes will change after they have been shaken inside the container for 1 minute. Students should record their predictions on the observation sheet.
6. Students shake the container with the sugar cubes inside for one minute.
7. Instruct students to open their containers and to pour the materials inside onto their desktops.
8. Students use their magnifying glasses to re-examine the sugar cubes. They should record their observations on the observation sheet.
9. Ask students to put the sugar cubes back into the container along with the gravel provided. Ask them to close the containers with the lids.
10. Ask students to predict how the sugar cubes will change after they have been shaken inside the container with the gravel for 1 minute. Students should record their predictions on the observation sheet.

11. Students shake the container a second time for 1 minute with the sugar cubes and gravel inside.
12. Students use their magnifying glasses to re-examine the sugar cubes. They should record their observations on the observation sheet.
13. Ask students to develop a conclusion about why the cubes changed as they did after each shaking.
14. Hold a class discussion about what the students observed. Ask students the following questions. Record their answers on the flipchart.
    a. How did the sugar cubes change after the first shaking? What may have caused these changes?
    b. Did the second shaking with the gravel cause the sugar cubes to look more worn? Why?
    c. Which shaking had more or less “crumbs”? Why?
    d. How did your predictions compare to your results.
15. Introduce to students the term weathering. Ask them the following questions:
    a. What might cause rocks in nature to be shaken together much like how you shook the sugar cubes together with the gravel?
    b. How long do you think this type of weathering takes? Why? [In nature, the abrasion of rocks is a process that takes place over a longer period of time. This activity is meant to simulate the abrasion process; therefore, it is important for students to realize this difference.]

Applying Students' Understanding

Show the Images of Weathering pictures to your students. Have your students answer the following questions as related to the pictures:

1. Describe the surface of the rocks in each picture. Are the rocks smooth or rough?
2. What evidence would suggest that these rocks are weathering as a result of other rocks bouncing and grinding against them?

You could also have students conduct another model of abrasion. But, instead of using sugar cubes, they use small pieces of broken limestone, all about the same size. They put the pieces into a plastic container filled with water. They shake the container for a total of 700 shakes. After each 100 shakes, they observe how the shapes of the rocks change. Have students predict how the rocks will change before they begin the activity to see if they are able to apply what they learned in the sugar cube activity to this new situation.

Revisiting the Investigation Question

Complete this investigation by asking your students to reflect on this question and how their answers may have changed as a result of the investigation. For example, they should note that rocks breakdown into smaller and smaller pieces as they bounce, collide, and grind against each other. They also change shape, becoming rounder and smoother.

Digging Deeper

The following passage provides more detailed information related to this investigation that you may choose to explain to your students.

Physical Weathering

Physical weathering (mechanical weathering) includes processes which break rocks apart without changing their chemical composition. Examples include:

Rock Abrasion

Rock abrasion occurs when rocks collide with one another or rub against one another. Collisions, if they are strong enough, can cause pieces of rock to break into two or more pieces, or cause small chips to be broken off a large piece. When two pieces of rock are rubbed together, the mineral grains in the rocks can be broken away from the rock surface. Rock abrasion occurs commonly in landslides where pieces of rock slide past one another as the mass moves downhill. It also occurs at the base of a glacier where pieces of rock that are frozen into the ice are dragged along beneath the glacier. In fast-moving streams and rivers, pieces of rock that are being moved by the flow rub against one another and against other pieces resting on the riverbed.

Ice wedging

Ice wedging refers to the repeated freezing and melting of water within small cracks in rocks near the surface. The water in the cracks freezes as the temperature drops below freezing. As the water freezes, it expands. This expansion exerts tremendous pressure on the surrounding rock and acts like a wedge, making cracks wider. After repeated freezing and thawing of water, the rock breaks apart.

Plant roots

Plant roots can grow in cracks. As the plant grows, the root becomes larger. The pressure of a confined growing root can be substantial. These pressures make cracks in the rocks larger, and, as roots grow, they can break rocks apart.

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Observation Sheet

Name ____

Number of sugar cubes used _________

Number of gravel pieces used _____________

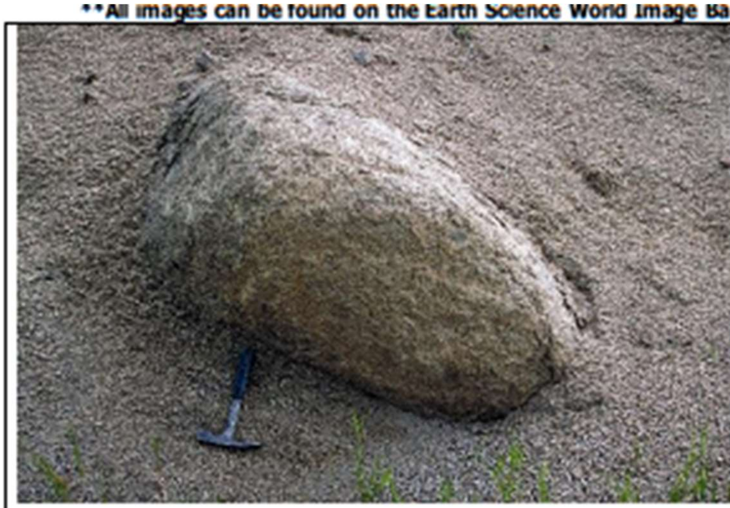
Observations:

Sugar cubes before shaking	Predict how the sugar cubes will change after they have been shaken for 1 minute	Sugar cubes after 1 minute of shaking	Predict how the sugar cubes will change after they have been shaken with gravel for 1 minute	Sugar cubes after 1 minute of shaking with gravel

Conclusions:

Images of Weathering

**All images can be found on the Earth Science World Image Bank (www.earthscienceworld.org/images/)



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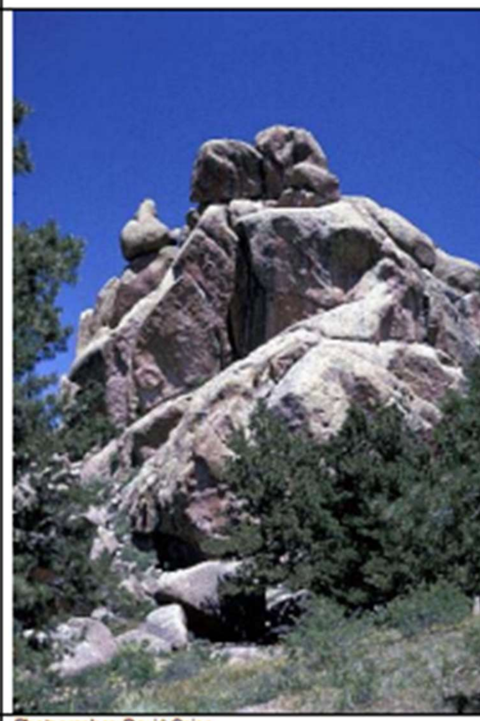

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Do rocks dissolve?

Teaching and Learning Focus

In the last investigation, students began thinking about how rocks change through time. Students were introduced to the concept of weathering and looked at abrasion as one of several physical weathering processes. In this investigation, students explore how rocks weather chemically. Chemical weathering is the process that breaks down rock through chemical changes. The most common agents of chemical weathering include water, oxygen, carbon dioxide, and living organisms. Chemical weathering creates holes or soft spots in rock, so the rock breaks apart more easily. Chemical and mechanical weathering often go hand in hand; mechanical weathering breaks rock into pieces, exposing more surface area to chemical weathering. In this investigation, students examine the effects of naturally formed acids on the breakdown of rock. When water (e.g. rainwater) mixes with carbon dioxide gas in the air or in air pockets in soil, a weak acid solution, called carbonic acid, is produced. When carbonic acid flows through the cracks of some rocks, it chemically reacts with the rock causing some of it to dissolve. Carbonic acid is especially reactive with calcite, which is the main mineral that makes up limestone. Over many thousands of years, the dissolving action of carbonic acid on limestone sometimes produces underground caves.

In this investigation, students will simulate the effect of carbonic acid on limestone. Pieces of chalk represent limestone and vinegar represents carbonic acid. Students place the chalk into the acid and observe how it changes over time.

Materials Needed

For each student group:

- 2 clear plastic cups
- vinegar
- water
- 2 small pieces of chalk
- masking tape
- marker or pen
- magnifying glass
- paper towels
- student-designed data table
- paper (e.g. newsprint) to cover desktops
- safety goggles and apron

For instructional purposes:

- images of Chemical Weathering
- overhead projector and blank transparency sheet, flip chart or white board for recording student responses

Safety

This investigation is generally considered safe to do with students. Students should be reminded not to drink the water or vinegar. Also, review the investigation for your specific setting, materials, students, and conventional safety precautions.

Setting the Scene

Begin the investigation by reminding students of the abrasion activity they did in the last investigation. Continue with the following questions:

1. What caused the rocks to break apart?
2. What other processes are responsible for breaking up rocks? How do they work?

Have your students discuss these questions, first in pairs, then groups and then as a whole class. Record their answers on a flipchart that you can refer to throughout the investigation.

Presenting the Investigation Question

After the scene is set, introduce your students to the investigation question: "Do rocks dissolve?" Have your students discuss the question in pairs, then in groups, and then as a whole class. Record their answers on a flipchart.

Have your students brainstorm ideas about how to investigate this question:

1. What materials would be needed?
2. What would you have to do?
3. What would be measured?
4. How long would the experiment take?

Tell your students that they will be investigating this question and at the end of their study they will be able to provide reliable answers.

Assessing What Your Students Already Know

Students will have had some experiences with solids dissolving in liquid, e.g. mixing salt, sugar, or a drink mix in water. Students will probably not recognize that rocks can dissolve in water. They will also not know that rainwater is naturally slightly acidic.

Here are some initial questions that your students can discuss, in pairs, then in groups:

1. What happens when you mix salt, sugar, or a drink mix in water?

2. If you mixed rock in water, could the same thing happen? Why or why not?
3. What causes solids to dissolve in water?

Have your students share their ideas with the class and record them as a list on a flipchart.

Have students think about what they would like to learn about how rocks dissolve. Record their ideas on the flipchart as a list called “Questions we have about how rocks dissolve.” This list will provide further insights into what your students know, and also what they would like to know. By the end of the investigation, some of these questions will probably be answered.

Exploring the Concept

1. Explain to students that rainwater is not the same as the water they drink. Rainwater is a weak acid. Tell them that they will be looking at the effects of rainwater on the weathering (breakdown) of rocks. They will be putting chalk, which is similar in composition to limestone, into vinegar, which is a weak acid, much like rainwater. They will observe the chalk over time to see whether or not the acid has any effect on the chalk. They will also be putting chalk in water for comparison.
2. Break students into groups of 3 or 4. Provide materials to the groups.
3. Instruct groups to cover their desktops with paper.
4. Provide the following instructions to groups and work with students to design a data table (similar to the previous investigation):
    a. Use the magnifying glass to examine each piece of chalk. Draw or describe what each piece of chalk looks like on the observation sheet.
    b. Pour vinegar into one clear plastic cup until it is about 2/3 of the way full. Use the masking tape to write “acid” and put the label on the cup.
    c. Pour water into one clear plastic cup until it is about 2/3 of the way full. Use the masking tape to write “water” and put the label on the cup.
    d. Predict what will happen to the chalk after it sits in the vinegar for one hour. Record your prediction on the observation sheet.
    e. Place one piece of chalk in each plastic cup.
    f. Store the cups in a safe place.
    g. After 1 hour, examine the chalk with the magnifying glass. Draw or describe on the observation sheet what each piece of chalk looks like.
    h. Predict what will happen to the chalk after it sits in the vinegar for a total of 24 hours. Record your prediction on the observation sheet.

i. After 24 hours, examine the chalk with the magnifying glass. Draw or describe on the observation sheet what each piece of chalk looks like.
j. On the observation sheet, write a conclusion that explains your observations.

6. Discuss students' findings as a class. Prompt them with the following questions:
    a. Which piece of chalk changed the most, the one soaking in water or the one soaking in vinegar? Why?
    b. How did the chalk change after soaking in vinegar for 1 hour? After 24 hours? What may have caused these changes?
    c. Was there more of a change after 24 hours? Why?
    d. How did your predictions compare with your results?
    e. How does what you observed compare to what happens when rainwater falls on rocks?
    f. How long does it take to dissolve rocks in nature?
7. Help students to understand that when rainwater mixes with carbon dioxide in the air or carbon dioxide in air pockets in soil, a weak acid called carbonic acid is produced. When carbonic acid flows through the cracks of some rocks, it chemically reacts with the rock causing some of the rock to be dissolved. Over many thousands of years, much rock can be dissolved.

Applying Students' Understanding

Show students the *Images of Chemical Weathering* pictures. Have students answer the following questions related to the pictures:

1. Describe the rocks in each picture.
2. What evidence would suggest that these rocks are undergoing chemical weathering?

Revisiting the Investigation Question 4

Complete this investigation by asking your students the following: "Do rocks dissolve?"

As a result of this investigation, students should be able to state that certain rocks can dissolve when exposed to rainwater, which is slightly acidic. This exposure increases the breakdown of rocks into smaller and smaller pieces.

Digging Deeper

The following passage provides more detailed information related to this investigation that you may choose to explain to your students.

Chemical Weathering Processes

Chemical weathering is the decomposition of rocks due to chemical reactions occurring between the minerals in rocks and the environment. Examples include:

Water

Water, and many chemical compounds found in water, is the main agent of chemical weathering. Feldspar, one of the most abundant rock-forming minerals, chemically reacts with water and water-soluble compounds to form clay.

Acids

Water contains many weak acids, such as carbonic acid. This weak, but abundant, acid is formed when carbon dioxide gas from the atmosphere mixes with rainwater. Sulfur dioxide and nitrogen gases create other types of acids that act as chemical weathering agents. Some sources of sulfur dioxide are power plants that burn coal; as well as volcanoes and coastal marshes. Sulfur gases react with oxygen and rainwater to form sulfuric acid. Although relatively weak, this acid's abundance and long term effects produce noticeable damage to vegetation, fabrics, paints and rocks.

Oxidation

Oxidation is another kind of chemical weathering that occurs when oxygen combines with another substance and creates compounds called oxides. Rust, for example, is iron oxide. When rocks, particularly those with iron in them, are exposed to air and water, the iron undergoes oxidation, which can weaken the rocks and make them crumble.

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Images of Chemical Weathering

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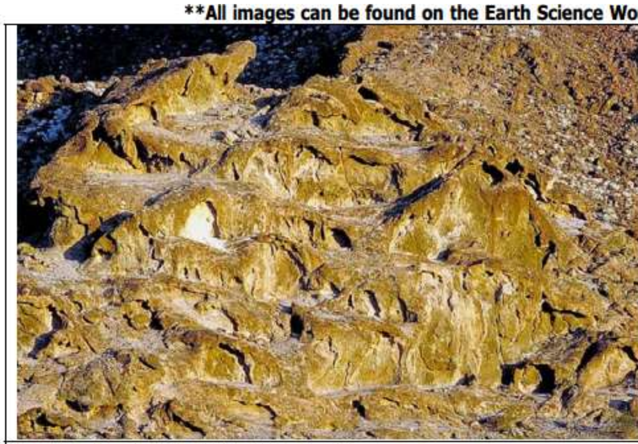

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