Disappearing Rocks

SUBJECT: Science

GRADES: 4-8

ACTIVITY SUMMARY: Students will drip vinegar onto rocks to demonstrate the weathering effect of a weak acid on limestone.

DURATION: approximately 20 minutes

OBJECTIVES:
Students will be able to:

1. Explain that rocks have physical and chemical properties that can undergo change.
2. Describe how passageways and caverns form in limestone rock.

TEKS ADDRESSED:

4th grade
1A-demonstrate safe practices and the use of safety equipment as described in the Texas Safety Standards during classroom and outdoor investigations.
2B-collect and record data by observing and measuring, using the metric system, and using descriptive words and numerals such as labeled drawings, writing, and concept maps.
2D-analyze data and interpret patterns to construct reasonable explanations from data that can be observed and measured.
2F-communicate valid, oral, and written results supported by data.
7B-observe and identify slow changes to Earth's surface caused by weathering, erosion, and deposition from water, wind, and ice.

5th grade
1A-demonstrate safe practices and the use of safety equipment as described in the Texas Safety Standards during classroom and outdoor investigations.
2C-collect information by detailed observations and accurate measuring.
2D-analyze and interpret information to construct reasonable explanations from direct (observable) and indirect (inferred) evidence.
2F-communicate valid conclusions in both written and verbal forms.

6th grade
1A-demonstrate safe practices during laboratory and field investigations as outlined in the Texas Safety Standards.
2C-collect and record data using the International System of Units (SI) and qualitative means such as labeled drawings, writing, and graphic organizers.
2E-analyze data to formulate reasonable explanations, communicate valid conclusions supported by the data, and predict trends.
5D-identify the formation of a new substance by using the evidence of a possible chemical change such as production of a gas, change in temperature, production of a precipitate, or color change.
10B-classify rocks as metamorphic, igneous, or sedimentary by the processes of their formation.

7th grade
1A-demonstrate safe practices during laboratory and field investigations as outlined in the Texas Safety Standards.
2C-collect and record data using the International System of Units (SI) and qualitative means such as labeled drawings, writing, and graphic organizers.
2E-analyze data to formulate reasonable explanations, communicate valid conclusions supported by the data, and predict trends.
8B-analyze the effects of weathering, erosion, and deposition on the environment in ecoregions of Texas.

8th grade
1A-demonstrate safe practices during laboratory and field investigations as outlined in the Texas Safety Standards.
2C-collect and record data using the International System of Units (SI) and qualitative means such as labeled drawings, writing, and graphic organizers.
2E-analyze data to formulate reasonable explanations, communicate valid conclusions supported by the data, and predict trends.

NATIONAL SCIENCE STANDARDS:

Grades 5-8
Structure of the Earth System

- Land forms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and deposition of sediment, while destructive forces include weathering and erosion.

VOCABULARY: limestone, carbonic acid, bedrock, weathering

MATERIALS REQUIRED:

- Safety goggles
- White table vinegar
- Squeeze droppers or straws
- Samples of rocks, one being limestone
- Dishes or shallow containers

Note: You may obtain rock samples by contacting your states minerals agency or a local aggregate organization, or by purchasing them at a nature store.

Natural Bridge Caverns, Inc.
26495 Natural Bridge Caverns Rd
San Antonio, TX 78266
210-651-6101
www.naturalbridgecaverns.com

Lesson plan adapted from *Project Underground.*

2.

BACKGROUND:

Most karst is formed where carbonate rocks such as dolostone and limestone are exposed at the earth's surface. The largest and greatest number of caves are found in areas of extensive deposits of limestone. Limestone is composed mainly of the mineral calcite ($CaCO_3$), with minor amounts of insoluble minerals (clays, quartz, feldspar). Limestone is rather soluble as rocks go, but only in acidic water. Raindrops reaching the earth's surface are generally not acidic (except in rare cases of acid rain caused by industrial emissions or volcanoes). In the underlying soil, however, aerobic bacteria break down dead organisms, producing carbon dioxide concentrations of ten to twenty times that of the outside atmosphere. As precipitation percolates though the soil, some of this CO_2 dissolves to form a carbonic acid solution. This slightly acidic water (essentially very flat seltzer water) seeps through cracks in the ground and slowly dissolves calcite out of the limestone and carries it away in the solution of water. People who live in karst areas and depend on well water can see evidence of the dissolved rock first-hand, including mineral deposits formed in their teakettles and hot water heaters. These minerals were originally part of the underlying bedrock.

The most active dissolution of bedrock occurs just below the water table, where fresh, acidic water from the surface comes in contact with submerged limestone. The water table is the elevation below which fractures and voids in the bedrock are completely filled with water. Over thousands of years the water continues to dissolve along underground fractures and rock layers, and it hollows out spaces within the rock. These spaces are called passageways and caverns, or caves.

Rock which has not been significantly eroded and is still connected to the underlying strata is called bedrock. The decomposition of bedrock by the forces of weathering produces a zone of weathered rocks and soil. This layer has been most affected by the forces of weathering (breaking up of rocks, both chemically and physically) and erosion (removal of the weathered materials). Wind, water, and freezing and thawing are constant contributors to the weathering and erosion processes and explain the varying sizes and shapes of sediments found within this top layer. This fairly porous layer has a relatively fast rate of water permeability when compared to the underlying bedrock.

Chemical weathering changes the minerals within the rock, typically softening and weakening them. Rainwater dissolves carbon dioxide in the air and in the soil, where it is produced by organisms and during the decay of organic material. This forms a weak acidic solution of carbonic acid that moves through the ground towards the water table. Some minerals react with the acid to make new minerals and release chemicals into solution. The best examples of this are the feldspars, a group of minerals commonly found in granites and some sandstones. Other minerals are soluble—they dissolve completely into the acidic water but at varying rates. These soluble materials [including halite (table salt), gypsum, calcite, and dolomite] dissolve more slowly, and produce a characteristic landscape, called karst when exposed at the earth's surface. Because limestone (dominantly calcite) and dolostone (dominantly dolomite) is much more common than rock gypsum, most of the world's karst topography forms where these rocks are exposed at the earth's surface. A notable exception is the Guadalupe Mountains of New Mexico, which have karst topography developed dominantly in gypsum.

PROCEDURE:

1. Explain to students that one can often tell what kinds of minerals are found in rocks by the physical properties of the rock (appearance and characteristics such as their grain sizes, hardness, color, texture, and whether they can be dissolved). Explain solubility by discussing (or demonstrating) how sugar added to iced tea or jello mix added to hot water "disappears" into solution.
2. Explain to students that most caves form in limestone areas. Limestone (and dolostone) is somewhat unique because its mineral grains can be dissolved in nature by a very mild carbonic acid. The weak acid forms from a mixture of water (from rain) and carbon dioxide (from air and soil). Remind students they breathe in oxygen and breathe out carbon dioxide. When the carbonic acid comes in contact with calcite, it dissolves small amounts of the calcite and carries it away (in solution) through cracks and pores in the rock, leaving behind a slightly larger opening. Over a very long time, these holes can become large, interconnected cave passages.
3. Tell students that one of the samples of rock is limestone, and ask if they can suggest a way to determine which one it is. The rock samples can be tested for calcite by checking to see which ones dissolve. Explain that they will participate in a Bubble Test. The samples with calcite will bubble and those without calcite will not. Have students test each sample first with water to serve as a comparison. None of the samples should see the formation of bubbles. Next, have students apply drops of the vinegar on the samples. Because this is such a vivid demonstration, be prepared to allow extra time for each student to try it and comment.
4. Ask the students to identify the bubbles (carbon dioxide). (For older students: ask if this is evidence of a physical or chemical change. Carbon dioxide and a salt--calcium acetate--are the new products formed.)
5. Ask students to determine which rock sample is the limestone. Identify the other samples.
6. Ask students what might happen if a limestone layer of rock is sandwiched between harder rock layers, or rock layers which would not dissolve. Guide students to an understanding that the water will seep or flow through available cracks

and crevices to the lowest point possible and pool, or run down slope along any non-permeable low angle planes. Over thousands of years, the chemical weathering by the weak acidic water solution will further erode and hollow out areas of the limestone creating passageways and caverns, or caves.

EVALUATION:

How does chemical weathering break down rock?
How does a cave form in limestone?

VARIATION FOR THE BUBBLE TEST:

Note: appropriate laboratory safety procedures should be followed when using hydrochloric acid. (You may substitute vinegar, which is safer but gives a less dramatic effect.)
Partially fill two breakers with a 5% solution of hydrochloric acid (HCl). Select two samples of rock, one limestone and one non-carbonate rock, and weigh or measure them before placing them in the solution. The limestone will readily fizz when placed in the acid; the non-carbonate will not react. Check the level of activity every ten to fifteen minutes. (The dissolving action will stop if either the acid or the calcite is no longer available to react. If this happens, the solution from the breaker can be tested on a separate, dry sample of limestone. As determination of the cause requires, you can add more acid or break the rock (exposing more accessible calcite). In approximately one hour, the limestone sample will be noticeably smaller in size. After drying, the samples can be reweighed to determine the changes due to dissolution.

EXTENSIONS:

1. To provide a visual opportunity to discuss variation in rates of geologic processes, a third beaker of hydrochloric acid (do not substitute vinegar) can be used to demonstrate dissolution of a sample of dolostone. (The dolostone contains the mineral dolomite, which is similar to calcite.) Ask the students which rock will form caves more quickly: limestone or dolostone. (The dolomite will react to the acid but much more slowly than the calcite. Caves will form more quickly in limestone because of its higher solubility.)
2. Place the limestone and dolostone samples in seltzer water and let the samples sit for a month, changing the water daily. Use another sample of distilled water as a control. This emphasizes the relative slowness of geologic time.
3. Have students write the formula for carbonic acid ($H_2O + CO_2 = H_2CO_3$). Given the compounds, where does the “H” come from in carbonic acid?

Name: _____

Disappearing Rocks

The types of minerals that are found in rocks can often be determined by the physical properties of the rock (appearance and characteristics such as their grain sizes, hardness, color, texture, and whether they can be dissolved).

Most caves form in limestone areas. Limestone (and dolostone) is somewhat unique because its mineral grains can be dissolved in nature by a very mild carbonic acid. The weak acid forms from a mixture of water (from rain) and carbon dioxide (from air and soil—remember, you breathe in oxygen and breathe out carbon dioxide). When the carbonic acid comes in contact with calcite, it dissolves small amounts of the calcite and carries it away (in solution) through cracks and pores in the rock, leaving behind a slightly larger opening. Over a very long time, these holes can become large, interconnected cave passages.

Today you will do a test to determine which one of your rock samples is limestone. You will do the Bubble Test to see which sample dissolves when a weak acid (vinegar) comes in contact with it. The calcite in the rocks will react with the vinegar to produce gas bubbles.

Procedure:

1. Put on safety goggles.
2. Put a couple of drops of water on your first sample and record your observations in the data table. Repeat for all rock samples.
3. Repeat step 2, this time using vinegar.
4. Answer the Analysis Questions.

Data Table

Sample	Water	Vinegar

Analysis Questions

1. When vinegar was dropped onto the limestone, what did you observe?

2. What are the bubbles you saw?

3. Is this a physical or a chemical change?

4. Thinking about what you have just observed and the background information, what could happen if a layer of limestone rock is sandwiched between harder rock layers?