National Park Service
U.S. Department of the Interior

Arches National Park

Field Trip in a Box
Geologic Changes

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Geologic Changes

National Park Service
Utah

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Contents

Fossils in limestone

Introduction

THEME
Geologic processes cause continuous changes in the earth's physical features.

FOCUS
Rock Layers, Weathering, and Arch Formation

LOCATION SUGGESTIONS
- Windows Primitive Loop – behind North Window
- Park Avenue – Down the wash past the Northern Parking Lot
- Balanced Rock – Picnic area
- Garden of Eden

LEARNING STATIONS

Optional Prep Activity (to be used if students are unfamiliar with basic rock types):

A Journey from Rock to Rock - Decide if your rock is igneous, metamorphic or sedimentary, and contemplate the forces that could change it.

Field Trip Learning Stations
Each station is designed for up to 10 students and requires 1/2 hour and one instructor (for larger groups we recommend dividing your group and teaching stations simultaneously, then having students switch stations.)

1. Weathering or Not – Investigate the causes of physical and chemical weathering of rock.

2. Falling Arches – Explore how arches form and what types of arches are found in and around Arches National Park.

3. Picture This – Observe exposed rock layers, and discover their names and histories.

Extension Back to School (assessment activity): *Tell Me About It* - Students work together to create brochures to educate others on the geological processes that created Arches National Park.

Core Connections

This lesson has been designed specifically to connect with the Utah State Science Core Curriculum for 8th grade. The lesson also meets standards for 5th grade and high school physical science with some minor adjustments in teaching style and depth of content.

UTAH STATE SCIENCE CORE CURRICULUM TOPIC – EIGHTH GRADE

Standard 3: Students will understand the processes of rock and fossil formation.

Objective 2: Describe the nature of the changes that rocks undergo over long periods of time.

Objective 3: Describe how rock and fossil evidence is used to infer Earth's history.

Objective 4: Compare rapid and gradual changes to Earth's surface.

Science language students should use: volcano, earthquake, weathering, minerals, fossils, sedimentary, magma, metamorphic, rock cycle, igneous, sedimentation, deposition, geology, paleontology

UTAH STATE SCIENCE CORE CURRICULUM TOPIC - SECONDARY EARTH SYSTEMS

Standard 2: Students will understand that the features of Earth's evolving environment affect living systems, and that life on Earth is unique in our solar system.

Objective 2: Analyze how ecosystems differ from each other due to abiotic and biotic factors.

Objective 3: Examine Earth's diversity of life as it changes over time.

Science language students should use: abiotic, atmosphere, biodiversity, biome, biotic, ecosystem, extinction, system, aesthetic, ethical, social, economic, stellar, photosynthesis, biomass, species.

UTAH STATE SCIENCE CORE CURRICULUM TOPIC – FIFTH GRADE

Standard Two: Students will understand that volcanoes, earthquakes, uplift, weathering, and erosion reshape Earth's surface.

Mud patterns in sandstone

Objective One: Describe how weathering and erosion change Earth's surface.

Objective Three: Relate the building up and breaking down of Earth's surface over time to the various physical land features.

Science language students should use: earthquakes, erode, erosion, faults, uplift, volcanoes, weathering, buttes, arches, glaciers, geological, deposition biodiversity, taxonomy, kingdom, virus, protist, fungi, plant, animal, dichotomy.

Background

MORE INFORMATION

http://www.nps.gov/arch/naturescience/geologicformations.htm

http://www.nps.gov/cany/naturescience/rockstrata.htm

http://www.nps.gov/cany/planyourvisit/upload/geology.pdf

http://en.wikipedia.org/wiki/Natural_arch

http://en.wikipedia.org/wiki/Rock_types

http://en.wikipedia.org/wiki/Weathering

The rock layers and fault exposed at the entrance to Arches National Park are of textbook quality. The layers are easy to see; they have different colors as well as different compositions.

By looking at the rocks close-up, we learn about the ancient environments in which the sediments of the rock layers were deposited. Most mudstones and siltstones formed in low-gradient streams or tidal-flat environments. Some sandstones were deposited in steeper streams or on beaches. Sandstones made up of very rounded sand grains that are all the same size (well-rounded and well-sorted, in geological terms) indicate aeolian or windblown deposition in a relatively dry environment. Limestones usually indicate a marine environment, and many contain fossils. (A few thin limestone layers in the Moab area were deposited in freshwater lakes.)

Arches National Park's erosional landscape of valleys, towers, fins, canyons, pinnacles, and arches began to form about 10 million years ago. That's relatively young in geologic terms: the rock layers in the park were deposited roughly 300 million to 150 million years ago. Many natural features are named for things explorers imagine they look like. For example, piano leg arch looks like the leg of a piano. Sheep rock looks like the head of a bighorn sheep.

Based on the definition of an arch, an opening at least three feet in one direction, there are over 2,000 named arches in Arches National Park, most within the Entrada Formation. Water is the main culprit in arch formation. Rainwater is usually slightly acidic, which weakens the cement between grains in the sandstone. The process of frost wedging involves water freezing (expanding) and thawing (contracting) in pores and cracks. This process is key in breaking apart sandstone, especially because of the large temperature fluctuations of the high desert climate. In addition to water, wind and gravity aid in the process of erosion by removing the weathered parts of rocks. Arches can be classified by their shapes: categories include free-standing arches, cliff-wall arches, and jug-handle arches. Natural bridges, unlike arches, are formed by flowing streams.

Weathering is the physical breakup of rocks, and is often confused with erosion which is the removal of rock by gravity, wind and water once it has weathered. This confusion is understandable because they are often intertwined. There are two types of weathering, physical and chemical. Physical weathering breaks the rock into smaller pieces. An example might be ice expanding a crack on the side of an arch. Each time the water freezes, the crack gets bigger. Eventually the piece falls out of the arch, which is erosion. Throughout the processes of physical weathering and erosion, the sandtone remains sandstone; it is merely smaller pieces.

Chemical weathering involves breaking down of the minerals that hold the individual grains of sand together. On the Colorado Plateau this is often caused by rainwater, picking up CO2 in the atmosphere and becoming slightly acidic. This weak carbonic acid reacts with the calcium carbonate in the stone, slowly eating away at the rock. Chemical weathering dissolves approximately a depth of one sand grain per year from the rock. These tiny grains are then removed by wind and rain. Standing water on stone speeds up this process, causing depressions to slowly deepen. Thus, desert potholes grow deeper over time.

PREP ACTIVITY

A Journey from Rock to Rock

Objectives

Students will be able to:

a. name the three main types of rocks.

b. describe the rock cycle and the changes it represents.

Materials

Samples of the three rock types; hand lenses; Igneous, Metamorphic, and Sedimentary posters; **What Type of Rock Do You Have?**

PROCEDURE

1) Inform students that geologists study the earth by looking at rocks, particularly those rocks found very near the earth's surface. There are many kinds of rocks; geologists group them into three types, based on how they formed. Tell students that they will be looking at and classifying a rock in a few minutes.

2) Ask students to name the three major types of rocks: igneous, metamorphic and sedimentary. Use the three posters illustrating the types to discuss each. The names give clues about how they form: Sediments make up sedimentary rocks, metamorphosis means changing form (as in insect life cycles), and they can think of ignite for igneous.

3) Pair students. Pass out a rock to each pair for them to look at. After half a minute, have them pass their rocks. Do this at least two or three times. Then pass out the "What type of rock do you have?" sheets, and go over them. Remind students that rocks will not have all the characteristics listed in each category. Have each student pair classify the rock they currently hold. After a couple minutes, have the students who think their rock is igneous stand in one area, metamorphic another and sedentary another. Tell students to examine rocks from the other pairs and make sure their entire group is one type. Finally have each group pick two rocks that best illustrate their rock type. Have a student describe their reasoning and show the rock. Once all three groups have presented, collect the rocks.

4) Have students look at the rocks in the area around them and discuss what kind of rocks they are. At Arches most of the rocks they will find are sandstone, a sedimentary rock.

Studying rocks with a hand lens

What Type of Rock Do You Have?

Sediments deposited, buried and cemented together make:

SEDIMENTARY ROCKS

Look for:

- visible rounded grains
- obvious layers
- fossils in limestone
- usually chips apart easily

Liquid magma crystallizes into:

IGNEOUS ROCKS

Look for:

- interlocking angular crystals that are not layered
- light and dark speckles
- large crystals if slow cooled
- small or no crystals if quick cooling – often looks glasslike
- small gas holes
- very hard to smash (but don't try it)

Sedimentary, igneous or already metamorphic rocks + heat and pressure form:

METAMORPHIC ROCKS

Look for:

- usually extra hard
- flattened minerals in bands or wavy lines
- sheet-like texture, sometimes
- Has an all over shininess (rather than speckles)

TEACHING STATION #1

Weathering or Not?

Objectives

Students will be able to:

a. Students will be able to define physical and chemical weathering of rocks.
b. Students will be able to name one agent of physical weathering.
c. Students will be able to describe a sign of chemical weathering.

Materials

Small pieces of chalk; bottle of water; pencils; clipboards; weathering investigation worksheets; weathering chart; coke; lemon juice; vinegar; pothole photo; limestone; acidity level chart; 3 measuring scoops.

PROCEDURE

1) Tell the students that they will be discussing rocks. Point out a particularly picturesque view, and ask the students what geologic processes created the landscape they see today. Tell students that both weathering and erosion created the landscape. Ask if any of the students can remember the difference between weathering and erosion. Clarify with students that weathering is the physical breaking up of rock into smaller pieces. To demonstrate take a small piece of chalk and have a student smash it. Talk about the fact that the chalk is still chalk; it is just in smaller pieces. This works best if you pick a student wearing heavy boots. Next, tell students that erosion is the removal of the rock. To demonstrate; have a student pour water on the chalk so that it washes away.

2) Discuss the two types of weathering. Physical weathering results from a physical change in the rock; chemical weathering refers to a chemical change in the rock. They are going to first investigate types of physical changes that can occur in rocks. Divide students into pairs and give each a clipboard, pencil and investigation sheet, turned to the physical weathering side. Have each pair think of a way that rocks could be physically weathered and ask each pair to write a hypothesis about one way a rock can be physically weathered. Ideas include: smashing, prying, abrading, and throwing. Give students boundaries and let students test their hypothesis, using a palm sized rock, to find out if their action indeed breaks rocks apart. They should then write a sentence under results describing what happened. Have each pair describe their hypothesis and their results to the group. Discuss the results and compare with the physical weathering chart.

3) Discuss with the students that physical weathering tends to lead to dramatic changes in the landscape. Mention a few examples: boulder falling out of Skyline arch in 1940, chunks falling out of Landscape Arch in 1991, Wall Arch collapsing in 2008.

4) Tell students that they now get to investigate chemical weathering. Ask students if anyone can tell you the difference between physical and chemical changes in matter. Have the students recall the signs of a chemical change, such as gas production, temperature change, or color change. Tell students that chemical weathering takes place on sandstone as water reacts with the calcium carbonate that holds the sand grains together, loosening their bonds and allowing them to get blown or washed away. It is a slow process: rock weathers at a rate of about a depth of one sand grain a year. It happens more quickly in places where water stands such as depressions or potholes. Ask students if they have ever seen a pothole filled with water with bubbles on the bottom. Ask students what they think is creating these bubbles.

5) In the atmosphere, water reacts with gasses like carbon dioxide to make it slightly acidic. Show students the acidity level chart and discuss the acidity level of various substances, including normal rain water. To demonstrate, have a student pour a tablespoon of a weak acid such as coke, lemon juice or vinegar onto a piece of chalk. Ask students if a chemical reaction took place, and discuss how they can tell. On limestone it is also easy to see chemical weathering take place. Have a student pour a tablespoon of coke on a piece of limestone and observe what happens.

6) Ask students to turn their worksheets over to the chemical weathering side. Tell students that they are going to investigate a weak acid will allow them to speed up the hands of time and erode sandstone at a rate faster than one sand grain a year. Each pair should choose a type of acid that might create chemical weathering. Show them their choices: lemon juice, coke and vinegar. Have students write under "hypothesis" what they think will happen if they pour the acid on sandstone. Let them test their hypothesis by putting a dime sized piece of sandstone in a tablespoon of their chosen weak acid. Have them write about the result, including how they decided that chemical weathering took place.

7) Ask students what they learned about weathering and erosion. Have them extrapolate by having several students pick a nearby landform and discussing what caused it to look the way it does today.

SCIENCE INVESTIGATION FORM

Physical Weathering

Scientist names:

Question: What is a cause of the physical weathering (break up) of sandstone?

Hypothesis:

Procedure:

1. Find a palm size rock

2. Test your hypothesis

Result: (Did the rock break apart? Describe)

SCIENCE INVESTIGATION FORM

Chemical Weathering

Scientist names:

Question: Do mild acids cause chemical weathering in sandstone?

Hypothesis:

Procedure:

1. Choose an acid

2. Place a dime sized piece of sandstone in a tablespoon of your chosen acid

3. Record your observations

Result: (Did chemical weathering take place? How do you know?)

TEACHING STATION #2

Falling Arches

Objectives

Students will be able to:

a. Name three types of arches.

b. Describe two weathering processes involved in arch formation.

Materials

5 *types of arches* charts with sets of photographs of specific arches with velcro; paper, pencils and clipboards; arch formation foam model; pictures of arches with names on the back.

PROCEDURE

1) Introduce arches as the subject of this station. Ask the students to guess how many arches they think are located within Arches National Park. Have the students name and discuss some arches they have heard of or seen during their trip. Use the foam model to discuss the typical processes of arch formation. Briefly describe weathering by rainwater, frost wedging, and gravity, emphasizing that water is the main factor in arch formation. Inform students that there are over 2,000 named arches in the park. Review that an arch must have an opening of at least three feet in one direction to be considered an arch.

2) Introduce different types of arches showing pictures of each: jug handle, free standing, pothole, and cliff wall. Divide students into 5 groups, give each group a type of arch chart and a set of pictures and ask each group to sort them. When they think they are finished have each group present their completed chart and discuss the results.

3) Explain that arches are often named for something they look like. Discuss some examples and show pictures. Show some more examples and ask students what they would name the arch, prompt with the wildest names you can think of to encourage creativity. After the group has decided on a name for each picture tell the students the real name.

4) Hand out paper, pencil, and clipboard to each student. Have each student draw an imaginary arch, name it, write what type of arch it is, and present it to the group.

5) Examine an arch in the vicinity. If you are within walking distance and you have time, walk right up to it. Have students think about how it was formed, asking them what the rock might have looked like 1000 years ago. Discuss what type of arch it is, what it might be named as well as its actual name. Finally talk about what this arch might look like in a 1000 years, 5,000 years or 50,000 years.

One student's imaginary arch

TEACHING STATION #3

Picture This

Objectives

Students will be able to:

a. List three of the rock layers in Arches National Park.
b. Describe three environments in which the rock layers were deposited.

Materials

Rock layers and environments cards with pictures; rock samples; hand lenses

PROCEDURE

1) Show students a poster of the rock layers visible from the visitor center at Arches National Park. Point out the distinct, relatively flat layers, telling the students that the soil sediments in each layer were deposited at a time when the environment here at Arches was much different than it is today.

2) Have students line up from oldest to youngest. Discuss the concept that each of the rock layers began as sediments deposited in different environments. Hand each student a layer card giving Hermosa to the oldest student and Entrada to the youngest. If you have more than eight students, two students can work with one rock layer. Tell students they need to read the information on their layer card and be prepared to answer questions. Once everyone has had a chance to read their card; ask each student, oldest to youngest, to answer the following questions.

1. How old is your layer?
2. Describe the climate at Arches when your layer was created. Is there a place on earth today that has a similar climate?
3. What kind of creatures lived at Arches during the time your layer was created?
4. Describe what your layer looks like today.
5. Is there something your layer is famous for today? If so, what?

3) As each student answers his/her questions reward them with a rock sample from their layer. Give students hand lenses and let them examine their rocks. Ask students to think of three scientific observations about their rocks. If needed discuss that scientific observations allow others to visualize the object in their minds; feelings such as "it's neat" are not scientific observations. Give students several minutes to make observations and then have each student show their rock, remind us of the layer and present their observations. Older students may be able to hypothesize about how climatic factors affected the way the rock looks today.

4) Reinforce the understanding of superposition by having students attempt to stack their rocks, with the oldest formation on the bottom and the youngest on the top. Have students see how high they can stack their rocks before they fall, without touching any of the ones underneath. To review, as each student sets down their rock on the pile they should name the type of environment that existed when his/her layer was deposited.

5) Have students examine the rocks upon which they are sitting. Using the information just discussed have them guess what rock layer it is (most likely Navajo or Entrada, depending on where you are in the park.)

Stacking rocks from oldest to youngest

ASSESSMENT ACTIVITY

Tell Me About It

PROCEDURE

Divide students into groups. Tell each group that their assignment will be to create an 8½ x 11 brochure about geological processes at Arches. Each brochure should include:

- A description of the process that forms arches including the weathering of rock.
- A picture showing several of the rock layers at Arches. Describe the climate that created each layer and what it is known for today. The layer where most arches are found must be discussed.
- Several arches: each with a picture, its name and its type of arch.

Students can gather more information for their brochures on the internet or from brochures available at the Arches Visitor Center.

Arches would like to have quality examples of student work. Please send copies to:

Canyon Country Outdoor Education
Arches National Park
P.O. Box 907
Moab, Utah 84532

GRADING RUBRIC

Arches Brochure

4 Points	**3 Points**	**2 Points**	**1 Point**
Brochure correctly describes the process of arch formation listing at least 5 steps, and discusses different types of weathering of rock.	Brochure correctly describes the process of arch formation, listing at least 5 steps.	Brochure correctly describes the process of arch formation listing at least 3 steps.	Brochure does not correctly describe the process of arch formation.
Brochure discusses 5 of 7 rock layers using a picture to describe how they are layered. Labels for each layer discuss the climate when the layer was deposited and a fact about the current rock. Brochure cites Entrada as the arch forming layer.	Brochure discusses 5 of 7 rock layers using a picture to describe how they are layered. Labels for each layer discuss the climate when the layer was deposited and a fact about the current rock.	Brochure discusses 3 of 7 rock layers using a picture to describe how they are layered. Labels for each layer discuss the climate when the layer was deposited or a fact about the current rock.	Brochure discusses 3 of 7 rock layers using a picture to describe how they are layered.
Lists 3 arches, each has: a picture and is labeled with its name and its type of arch.	Lists 3 arches, has a picture of each, and is labeled with its name or its type of arch.	Lists 3 arches, has either a picture of each, or a label with its name or its type of arch.	Lists less than 3 arches

References and Resources

Baars, D. L. (1993). *Canyonlands country: Geology of Canyonlands and Arches National Parks*. Salt Lake City, UT: University of Utah Press.

Brady, I. (1998). *The redrock canyon explorer*. Talent, OR: Nature Works.

Chesterman, C.W. (1978). *The Audubon Society field guide to North American rocks and minerals*. New York, NY: Alfred Knopf.

Cuff, K. (1995). *Stories in stone: Teacher's guide, grades 4-9*. GEMS Series. Berkeley, CA: Lawrence Hall of Science, University of California.

Doelling, H. H. (1985). *Geology of Arches National Park*. Utah Geological and Mineral Survey Map 74, and accompanying booklet, 15 p.

Fluegelman, A., (ed.). (1976). *The new games book*. Garden City, NY: Headlands Press, Doubleday.

Geology: The active earth. (1988). Ranger Rick's NatureScope Washington, DC: National Wildlife Federation.

Stevens, D. J., & McCarrick, J. E. (1988). *The arches of Arches National Park, A comprehensive study.* Orem, Utah: Mainstay Publishing.

Williams, D. (1997). *Geology: Arches National Park*. Moab, UT: Canyonlands Natural History Association. Brochure.

Williams, D. (2000). *A naturalist's guide to canyon country*. Helena, MT: Falcon Publishing.

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