

Museum of the
WHITE MOUNTAINS

PLYMOUTH STATE UNIVERSITY

BEYOND GRANITE

The geology of adventure

An elementary school geology unit

INTRODUCTION

“Our favorite hikes, climbs, and ski runs are tied to rich geologic histories... there are stories beneath our feet.... We often view the mountains as an inert landscape—an environment that we explore and inhabit, a setting for our adventures. But the mountains have their own stories—how the different rock formations came to be, how the mountains have been sculpted through time, sometimes slowly, sometimes very fast, and how they continue to change today. This exhibit allows us to explore the connections between our mountain adventures and the stories of the mountains themselves. It gives you a sense of being connected to a much bigger picture, a much longer tale.”

Sarah Garlick, exhibit curator

New Hampshire’s White Mountains are home to some of the world’s best outdoor recreational opportunities; ice fishing, snowmobiling, snowboarding, skiing, hiking, and rock and ice climbing draw visitors every year to the lakes, rivers and mountains that were formed through a series of geologic events starting more than 400 million years ago. *Beyond Granite: The Geology of Adventure* explores connections between recreation in and the geological history of the White Mountains.

The essential questions and lessons in this unit have been designed to meet a range of ages and abilities, and are based on the NH Science Frameworks, Next Generation Science Standards, and Common Core State Standards. These questions are foundations that may be modified and changed to meet the needs of educators in their classroom and communities.

The following website contains information and resources for this activity:

<https://www.plymouth.edu/museum-of-the-white-mountains/exhibitions/beyond-granite-the-geology-of-adventure/>

Essential Questions

- What is the connection between the geologic processes that shaped the White Mountains and the adventures people have in them?
- What are the three main types of rock, how is each formed, and which of these are found in the White Mountains?
- How are mountains formed, and what shapes them?

Learning Objectives from NH Science Frameworks:

Students will be able to:

- Distinguish between the 3 categories of rock and describe the processes that create them.
- Recognize that some changes are too slow or fast to be easily observed.
- Identify and describe processes that affect features of the Earth's surface, including plate tectonics, weathering and erosion.
- Explain how wind, water or ice shape and reshape the Earth's surface.
- Connect geologic processes with active experiences people have in the outdoors.

Description of the Unit

The online exhibit focuses on three main areas: *Climbers and Bedrock* (the history of rock climbing in the White Mountains and the influence of different rock types on climbing styles), *Hiking Ancient Mountains* (the story of the 2,180-mile Appalachian Trail that passes through the heart of the White Mountains), and *Adventures Shaped by Climate* (how climate has shaped the winter landscape of the White Mountains and how it will likely dictate our experiences in the future). A special feature of this online exhibit includes three ultra-high resolution panoramic images created through gigapixel photographic technology: Cannon Cliff, Franconia Ridge, and Mt. Washington's Tuckerman and Huntington ravines. These "gigapans" allow viewers to interact with the images through a deep zooming interface so that geologic features- and even climbers- can be seen up close.

This unit combines the exploration of the online exhibit with appropriate grade-level content and hands-on activities to investigate the geologic processes that created the White Mountains, and to connect these events to the activities we enjoy here. Students will investigate which of the three basic rock types are found in the White Mountains and visually understand how the differences between these rock types provide for varied rock climbing experiences. They will also explore mountain building (through plate convergence and volcanic activity) and erosion (through glaciation and other events). Throughout the unit, they will connect these processes to skiing, snowboarding, hiking, climbing and other recreational activities.

Anticipated Length of the Unit

Estimated class length: 45 minutes

Estimated length of unit: 7 days

- Class time may vary from school to school. The sequence may be modified to fit to a school's instructional schedule.

Sequence of Daily Lessons

The following is an outline of the possible sequence of procedure for the unit. This foundation may be modified as needed by the instructor.

Days 1 and 2: Introduction, and three rock categories

Objectives- Students will be able to:

- Use observable properties, such as color and texture, to classify and organize rocks and minerals.
- Distinguish between the 3 categories of rock and describe the processes that create them.

- Show students the first 1:45 minutes of the *Beyond Granite* [video](#). Afterward,
 - o Ask for definitions of geology (not just study of rocks, but processes and history of Earth's formation).
 - o Ask which activities were people doing in video? What do these activities have to do with the geology of the area?
- Spend a few minute viewing images in exhibit as a whole class, with images projected on screen.
 - o Ask students to select two images that contain cliffs. Look at the rock in each cliff up close, and compare and contrast the two cliffs. Does it look like the cliffs are made up of the same kind of rock? Different? Explain.
 - Teacher may wish to select Images 7 (Rumney) and 8 (Whitehorse Ledge) in [Section 1](#) to highlight differences between the two cliffs, which are made up of two different kinds of rock.
 - o Ask students if they think different types of rock provide different types of climbing experiences for rock climbers. Use these same images and quotes for Climbers and Bedrock (in [section 1](#)) to describe differences for students.
- Teach basic vocabulary and concepts about the three types of rock (sedimentary, igneous and metamorphic) and how each is formed. Have students examine specimens of all 3 types of rock.
 - o How are the samples similar?
 - o How are they different?
 - o Does each type of rock contain observable clues about the way it was formed? (Can students see individual grains of minerals in igneous rock? What does this indicate about how quickly it cooled? Can students see signs of pressure- folding- in metamorphic rock? Can they see layers of sediments in sedimentary rock?)
 - o Students should draw and label in science notebooks. Depending on grade, students might include observations of similarities and differences, and/or observable clues about how each is formed.

Days 3 and 4: Mountain Building (constructive forces)

Objectives- Students will be able to:

- **Recognize that some changes are too slow or fast to be easily observed.**
- **Identify and describe processes that affect features of the Earth's surface, including weathering and erosion.**

- Revisit vocabulary and concepts from Days 1 and 2. Explain to students that sedimentary rock is not found in the White Mountains, but igneous and metamorphic rocks are found here in abundance. Use the *Presidential gigapan* in [Section 2](#) to illustrate a mountain range that is composed of metamorphic rock, formed by the folding of layers of Earth through the convergence of plates. Compare and contrast with mountains shown in the *Franconia gigapan* ([Section 3](#)), a mountain range that is composed of igneous rock, formed from volcanic activity. It is suggested that teacher do this for whole class, projecting image, and zoom in to find observable difference in the rock. Briefly discuss the processes that led to the creation of each type of rock.
- In addition, teachers may wish to show two images from the [Digital Library for Earth System Education](#), which show great examples of folding in metamorphic rock.
- Explain to students that today they will simulate one of the processes that create mountains. They will use playdough to simulate the folding of bedrock that occurs when continental plates come together. Students should understand that this activity only models folding; however, but in reality, both folding and faulting occur when plates converge.
[Folded mountains activity](#) (adapted from the [Digital Library for Earth System Education](#) Teaching Boxes)

Materials- Each group of students will need:

- 2 oz. each of four different colors of play dough
- One butter knife

Procedures

1. Tell students that they will be building some mountains made up of layers.
 - a. Have students roll each color of play dough, forming a flattened pancake about 15 cm. (or 6 inches) in diameter and 1 cm (or 1/3 inch) thick. The greater the diameter and the thinner the layers, the more easily the model can be folded.
 - b. Have the students stack the layers on top of each other. It doesn't matter in which order the colors are stacked.
 - c. Ask students to observe the layers from the side; the layers should look flat.

- d. Have students draw and label a side view of this model of unfolded layers in their science notebooks.
2. Now students will simulate compression: Have them place their hands, one on either end of the play dough layers so that they can squeeze it along its longer axis. Tell them to gently push their hands together causing the play dough layers to fold and buckle. Try to make at least one upward fold (anticline) and one downward fold (syncline). Ask students to draw and label the folded model in their science notebooks.
3. Either as a class or in students' science notebooks, discuss:
 - What actually might cause similar compression to occur to the earth's crust? (Answer: plates moving toward one another)
 - Where might this occur: (Answer: at convergent plate boundaries)
 - Do you think a person can observe mountains being formed (plates moving)?

Depending on the age of students, teacher may want to go into greater depth with plate tectonics. A plate boundary map can be found at [Plate Boundary Map](#)].

Teacher should highlight [Section 3](#) text to help explain plate movement: “When continents collide it is analogous to a head-on collision of automobiles....”

Continue to answer questions:

- How does the model you made illustrate the processes at work in the Earth's crust?
- How is this model different from the actual process?
- Look at the image of Jeremy Johnson on *Man Overboard* at Rumney ([section 1](#), image 7). Can students see the folded layers in the rock of the cliff?
- Look at the geologic cross section showing the “anatomy of the Presidential Range” in [section 3](#). (Teacher should explain how to view a cross-section: similar to the side view of layers of play dough.) Can you see evidence for the folding of metamorphic rock in the illustration?

Optional questions for class discussion:

Ask students what they think would happen if they had rocks that were less squishy and more brittle than play dough? When the rocks got squeezed, they might actually break instead of just bend. Tell them that natural mountains do both. Sometimes they bend and sometimes they break. The breaks are called faults, and faults that move because of compression are called "thrust faults." We therefore call this type of mountains "fold-thrust mountains" – the mountains both fold and have breaks called thrust faults.

Relate the formation of mountains to hikers and their love for hiking. Have any students hiked in the White Mountains? Where? Did you know you were hiking upon land that had been uplifted when two plates came together? Investigate image 7 ([section 3](#)) of the Herr family: Sage (age 6), has hiked all forty-eight 4,000 foot mountains in New Hampshire, and Alex, (age 9) has hiked all of them in winter along with their mom, Patricia.

Days 5 and 6: Glacial Erosion (destructive forces)

Objectives- Students will be able to:

- **Recognize that some changes are too slow or fast to be easily observed.**
 - **Identify and describe processes that affect features of the Earth's surface, including weathering and erosion.**
 - **Explain how wind, water or ice shape and reshape the Earth's surface**
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- On days 3 and 4, students explored mountain building. Ask: have the White Mountains remained exactly the same since they were formed, whether from volcanic activity or collision of plates? What else has shaped them? Students will intuitively know that the mountains have not stayed the same, and some will likely mention erosion, glaciers, or the Ice Age as something that shaped the White Mountains. Basically, erosion (of various types) and weathering are destructive forces that shape terrain. Introduce vocabulary words such as glacier, erosion and weathering.
 - Students will investigate one such force today: glacial activity, and how it shapes mountains.
 - First, show image of reconstruction of the ice sheet covering North America ([section 2](#), image 12). Identify NH on this map. Did glaciers once cover NH?
 - How do glaciers shape land? There are several activities teachers might choose from to communicate this process. Two recommendations are:
 - o For grades K-5: [You're as Cold as Ice](#) (PBS' Nature Series), [glacial erosion activity](#) Students use mini glaciers (water and sand frozen in ice cube trays) to shape terrain (play dough).
 - o For grades 4-5: [Explaining Glaciers, Accurately](#) (free NSTA *Science and Children* journal article, April/May 2009). Describes two activities that help students develop correct understanding of how glaciers change the earth's surface: water, ice cubes, small rocks and dirt are used to demonstrate plucking; and pieces of wood, sandpaper, ice, and various types of rocks are used to demonstrate abrasion.
 - After completing one of the above activities, have student look at the Mount Washington panoramic in [section 2](#). Ideally, students should do this independently or in pairs. Teacher should help students understand navigation so they can zoom in on Tuckerman Ravine. Can they spot the areas that were channeled, or rounded out by glaciers? The two deepest "bowls" just to the left and right of the center are Tuckerman and Huntington Ravines. Tuckerman Ravine is famous for spring skiing. What is it about the shape of a ravine that makes it a better place to ski than other parts of the mountain? (Answer: ravines collect more snow.)

- What other images show evidence that glaciers once moved over the White Mountains? Select an image from the exhibit, and through discussion or in science notebooks, describe the shapes of the mountains seen in the photograph and how you can tell that glaciers shaped them.
- Can students find evidence for other types of erosion in the images? (They should be able to spot landslides, eroded dykes, etc.) Teacher may ask students to select an image and describe to partner or to entire class.
- Can we see glaciers moving? Can we see rocks eroding? Which types of erosion might people actually witness? (Any images with talus or gullies are examples of erosion, which is largely a very slow process. Any images with landslides, such as Hillman's Highway, image 8 ([section 2](#)), are examples of fast processes.)

Day 7: Stories of mountains, stories of adventure

Objectives- Students will be able to:

- Connect geologic processes with active experiences people have in the outdoors.

Many people snowshoe, ice fish, snowmobile, snowboard, ski, hike, rock and ice climb in the White Mountains each year. The White Mountain Visitors' Center and the Museum of the White Mountains want more people to come here to do these activities! Pick one activity and create a travel poster that advertises doing this in the White Mountains.

1. Find an image from the exhibit of a person performing your chosen activity.
2. On a large piece of paper or poster board, either sketch the exhibit image or draw one of your own that shows that same type of geologic feature (mountain, cliff, etc.) as the exhibit image (or students can print image and paste into notebook). Be sure to include the person doing their activity!
3. On your poster,
 - Write a sentence that describes what the person is doing.
 - Write a sentence that explains how the feature (mountain, cliff, etc.) was formed.
 - Write a sentence that explains how the feature (mountain, cliff, etc.) was shaped.
 - Write a sentence that explains the connection between the activity and the characteristics of the feature (mountain, cliff, etc.) that make this activity possible.

Instructional resources

An [Abecedy of Rocks and Ice: An alphabetical introduction to the geology of the White Mountains](#)

Roadside Geology of Vermont and New Hampshire (Roadside Geology Series) by Bradford B. Van Diver

[NH Department of Environmental Services: Hot Topics](#)

- 2013 Highway Geology Symposium Field Trip Guide:
 - [Introduction](#)
 - [History](#)
 - [Field Trip Overview](#)
 - [Stop Descriptions](#)
- [Madison Boulder Natural Area brochure](#)

PhysicalGeography.net

- [Intro to the Lithosphere](#)
- [Composition of Rocks](#)
- [Plate tectonics](#)
- [Mountain Building](#)

Digital Library for Earth System Education

- [Evidence for Plate Tectonics](#)
- [Mountain Building](#)

Glaciers, Climate and Society

- Compendium of excellent [glacier education resources](#) for all grade levels

NeoK-12

- Collection of online educational [videos](#) about glaciers

Assessment

Teachers may use diagrams in students' science notebooks and activity discussion questions as formative assessment. The final question on Day 5 may be used as a summative assessment. Additional assessments, tailored to specific student needs and learning styles, may be designed by the teacher. Assessments by should be guided by the essential questions. Did students explore, engage with, address and interpret the essential questions during the unit?

NH Science Curriculum Frameworks

S:ESS1:2:2.2 Use observable properties, such as color and texture, to classify and organize rocks and minerals.

S:ESS1:4:6.2 Distinguish between the 3 categories of rock and describe the processes that create them.

S:ESS1:2:5.1 Recognize that some changes are too slow or fast to be easily observed.

S:ESS1:4:5.1 Identify and describe processes that affect features of the Earth's surface, including plate tectonics, weathering and erosion.

S:ESS1:4:5.2 Explain how wind, water or ice shape and reshape the Earth's surface.

Common Core State Standards

ELA-Literacy.RI.2.3 Describe the connection between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text.

ELA-Literacy.W.2.7 Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report; record science observations).

Next Generation Science Standards

Disciplinary Core Ideas

- ESS1c. The History of Planet Earth
Some events on Earth occur very quickly; others can occur very slowly.
- ESS2a. Earth materials and systems
Wind and water change the shape of the land.
- ESS2.B Plate tectonics and large-scale system interactions
Earth's physical features occur in patterns, as do earthquakes and volcanoes.
Maps can be used to locate features and determine patterns in those events

Cross Cutting Concepts

- Patterns
- Cause and effect
- Scale, Proportion and Quantity
- Stability and Change

Science and Engineering Practices

- Developing and using models
- Constructing explanations
- Engaging in argument from evidence