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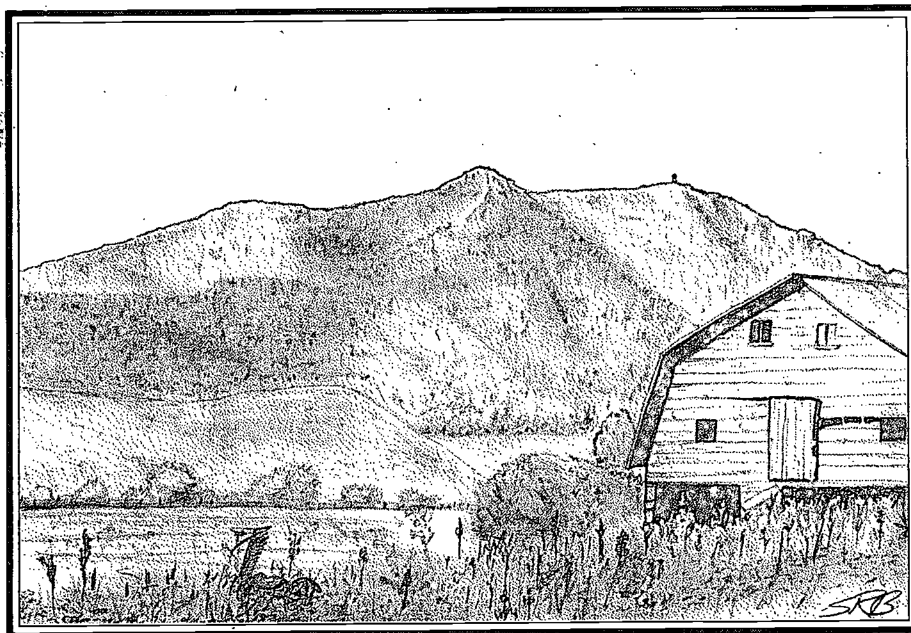
ABSTRACT

Mount Jefferson State Natural Area is located in the southern Blue Ridge highlands of North Carolina and covers 489 acres, which includes peaks and upper slopes to the Mount Jefferson mountain. This document introduces students to the geology of Mount Jefferson State Park and focuses on the geologic processes and rocks and minerals of Mount Jefferson. Major concepts covered include the rock types and their uses, rock cycle, weathering and erosion, rock and mineral identification, geologic history, and resource use. Three types of activities are featured: (1) pre-visit activities; (2) on-site activities; and (3) post-visit activities. The pre-visit activities will introduce students to the different rock types, how rocks are formed, how to identify them, and how they weather. Students will also learn about geologic time scale and identify the geologic belts of North Carolina. The on-site activities will familiarize the students with actual rock types of Mount Jefferson State National Area, their characteristics and where they are found. In addition, students will learn how the geology of the Mt. Jefferson area affected the cultural history. The post-visit activities are designed for review and will broaden students' understanding of minerals. The post-visit activity focuses on concepts such as mining, environmental issues and conservation of natural resources. These activities may be performed independently or in a series to build upon students' newly gained knowledge and experiences. A vocabulary list and definitions are listed in the back of the activity packet, along with a list of reference materials used in developing activities. (CCM)

# METAMORPHIC



# MOUNTAIN

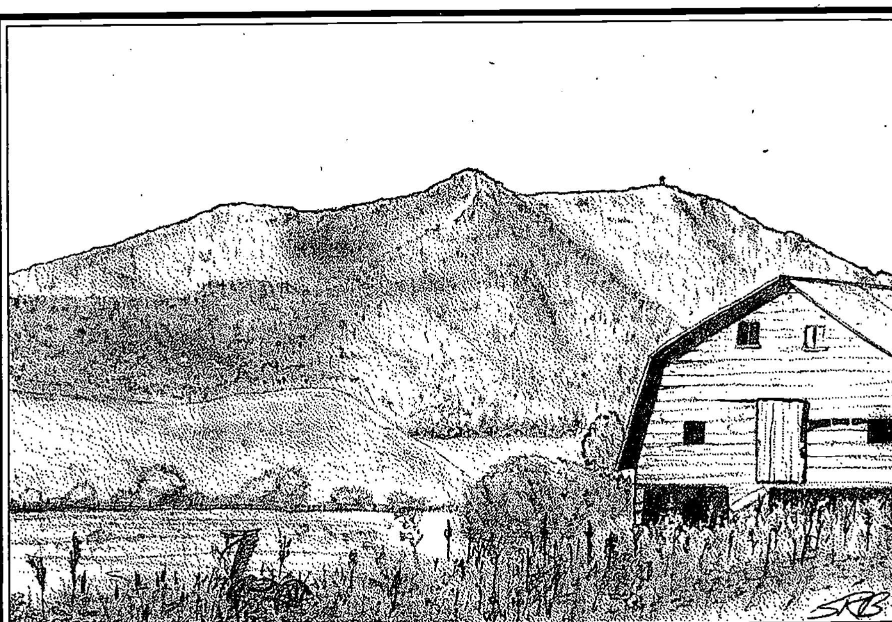


**Mount Jefferson State Park**

**An Environmental Education Learning Experience**

Designed for Grades 5-7

# METAMORPHIC



# MOUNTAIN

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**Mount Jefferson State Park**

**An Environmental Education Learning Experience**

Designed for Grades 5-7

*"Geology is something most of us do not think about as we go about our daily activities. Yet all of us are affected by the powerful geologic processes that formed our continent."*

- A Geologic Guide To North Carolina's State Parks

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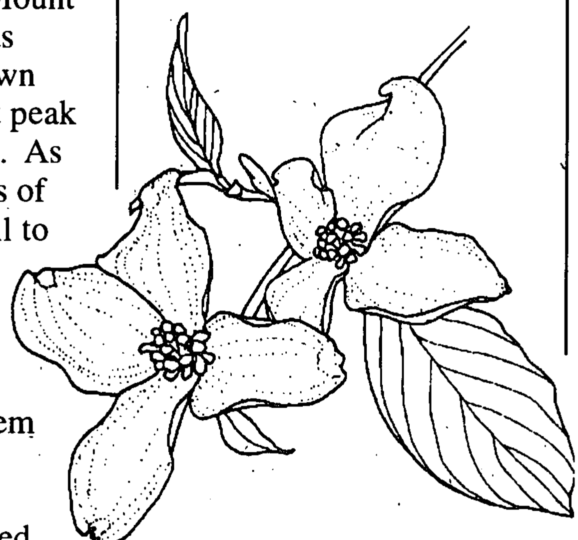
# Table of Contents

# Introduction to the North Carolina State Parks System

Preserving and protecting North Carolina's natural resources is actually a relatively new idea. The seeds of the conservation movement were planted early in the 20th century when citizens were alerted to the devastation of Mount Mitchell. Logging was destroying a well-known landmark - the highest peak east of the Mississippi. As the magnificent forests of this mile-high peak fell to the lumbermen's axe, alarmed citizens began to voice their objections. Governor Locke Craig joined them in their efforts to save Mount Mitchell. Together they convinced the legislature to pass a bill establishing Mount Mitchell as the first state park of North Carolina. That was in 1915.

The North Carolina State Parks System has now been established for more than three quarters of a century. What started out as one small plot of public land has grown into 59 properties across the state, including parks,



recreation areas, trails, rivers, lakes and natural areas. This vast network of land boasts some of the most beautiful scenery in the world and offers endless recreation opportunities. But our state parks system offers much more than scenery and recreation. Our lands and waters contain unique and valuable archaeological, geological and biological resources that are important parts of our natural heritage.

As one of North Carolina's principal conservation agencies, the Division of Parks and Recreation is responsible for the more than 150,000 acres that make up our state parks system. The Division manages these resources for the safe enjoyment of the public and protects and preserves them as a part of the heritage we will pass on to generations to come.

An important component of our stewardship of these lands is education. Through our interpretation and environmental education services, the Division of Parks and Recreation strives to offer enlightening programs which lead to an understanding and appreciation of our natural resources. The goal of our environmental education program is to generate an awareness in all individuals that cultivates responsible stewardship of the earth.

**For more information contact:**

**N.C. Division of Parks and Recreation**
**P.O. Box 27687**
**Raleigh, NC 27611-7687**
**919/ 733-4181**
**www.ncsparks.net**

# Introduction to Mount Jefferson State Natural Area

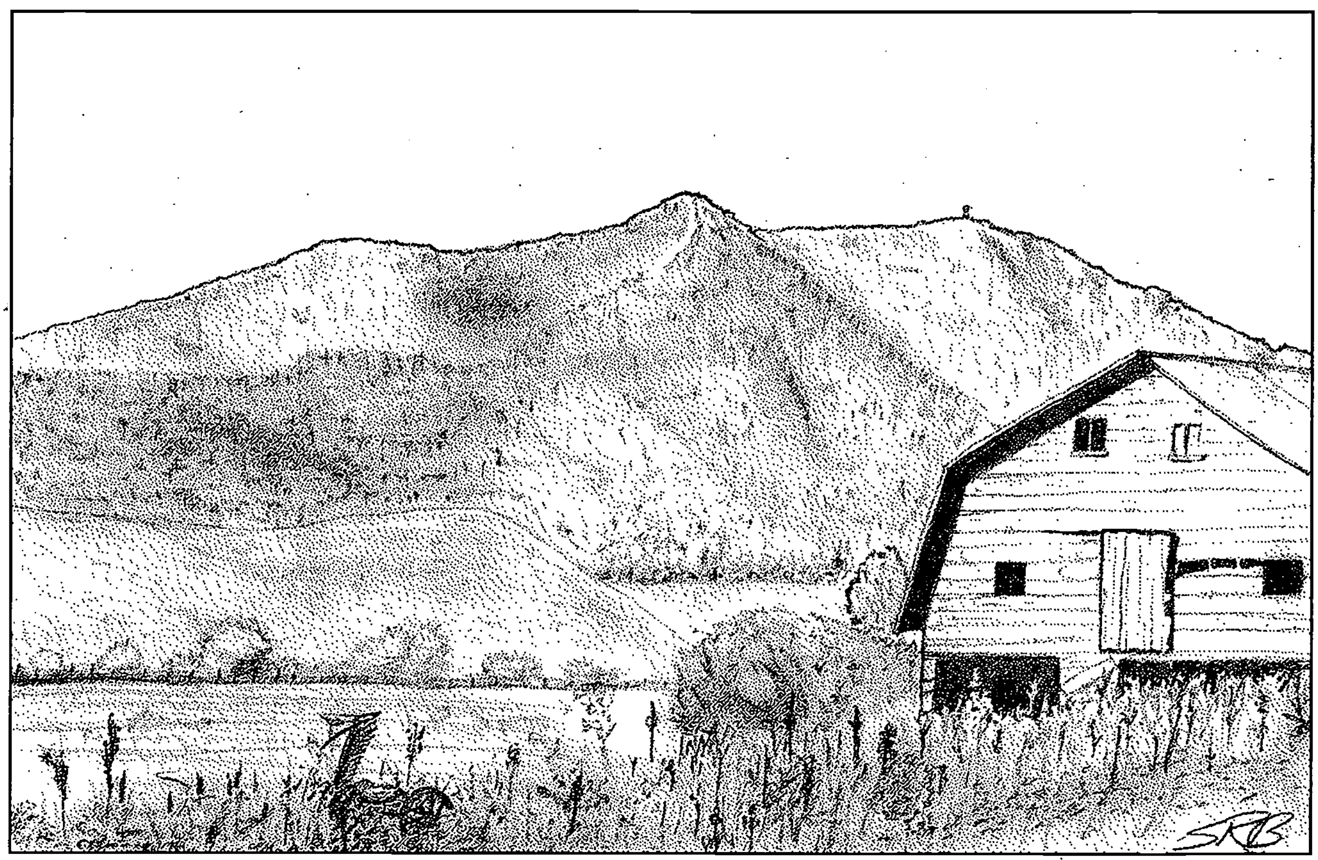
Mount Jefferson State Natural Area, located in the southern Blue Ridge highlands, covers 489 acres, which includes the peak and upper slopes of the mountain. On clear days, Mount Rogers and Whitetop Mountain in Virginia, Grandfather Mountain in North Carolina, and Snake Mountain in Tennessee can be seen from the natural area's overlooks. Nestled at the foot of Mount Jefferson are the towns of Jefferson and West Jefferson.

Mount Jefferson is a northwest trending mountain that reaches a maximum elevation of 4,683 feet, approximately 1,600 feet above the nearby New River Valley. The mountain is located between the north and south forks of the New River, which have played a tremendous role in eroding Mount Jefferson to its present-day height and shape.

Mount Jefferson and the other high mountains in the area are the remnants of a high, broad plateau that once existed there. Weathering and erosion have removed much of the original material of the plateau, creating broad mountain valleys, and leaving the more resistant underlying rock.

The rocks that would one day become Mount Jefferson were originally formed from depositions in a trough or basin on the floor of an ancient sea, 600 to 800 million years ago. Some sand and clay materials were washed into the basin from the surrounding land areas, eventually forming sedimentary rocks, which later changed into the metamorphic rocks gneiss and schist. Other materials were deposited as volcanic debris from now extinct volcanoes. The black rock amphibolite, seen in the park today, is an example of an igneous, volcanic rock that has been changed into a metamorphic rock by heat and pressure.

It is difficult to explain



Mount Jefferson's height. Amphibolite is normally not very resistant to erosion and is usually found at lower elevations. The gneiss and schists found in the valley below Mount Jefferson, normally have a higher quartz content and are more resistant to erosion. It has been suggested that the gneiss and schists in this area are more thinly layered than in the rest of the southern Blue Ridge Highlands, thereby making them mechanically weaker and causing them to erode more easily. The topography at Mount Jefferson is controlled by joint and fracture patterns in the area.

# The Natural Area's Natural Resources:

### Plant Communities:

Mount Jefferson State Natural Area has a wide variety of trees, shrubs and flowers. Sugar maple, red maple, black locust, ash, hickory, birch, white oak and red oak form the canopy in most of the natural area's forests. The understory, flowering shrubs of purple rhododendron, mountain laurel and wild azalea, is a visual treasure to be enjoyed during the summer months. Native wildflowers such as trillium, jack-in-the-pulpit and Dutchman's breeches add variety to your visit.

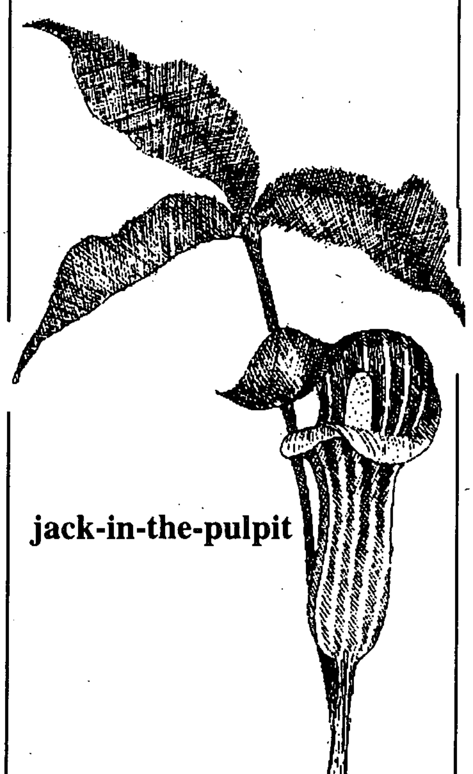
### Wildlife:

Wildlife you might encounter on the mountain include chipmunks, deer, groundhogs, red and gray squirrels, ruffed grouse and numerous song birds and raptors.

### Hiking Trails:

The natural area's two hiking trails are accessed from the picnic area. They begin as one trail, but divide into two at the ridge line after passing the restrooms. The left fork, the Summit Trail, is a 50-yard trail to a North Carolina Forest Service fire tower on top of Mount Jefferson.

The right fork is the Rhododendron Trail, a self-guided nature trail. It is a one mile loop which leads to Luther's Rock overlook, meanders through rhododendron thickets and then returns to the picnic area.



**jack-in-the-pulpit**

Trail booklets are available at the summit area parking lot. School groups can borrow trail booklets at the park office. Please return them to the office when you are finished.

### Facilities:

Restrooms: Restrooms are located above the picnic area. They are open from May 15 to November 1.

Picnic Area: Nineteen tables and six grills are located in a wooded area above the parking lot. No reservations are required as the area is used on a first-come basis. A six-table picnic shelter with a fireplace and large grill may be reserved for a nominal fee by contacting the office.

Overlooks: There are two overlooks located along the road leading up to the summit of Mount Jefferson.

**NOTE:** The road to the top of Mount Jefferson is very steep and many vehicles overheat as a result. Please take appropriate measures to ensure that you have a safe and productive trip.

### Scheduling a Trip:

**1.** To make a reservation, contact the natural area at least two weeks in advance.

**2.** Complete the Scheduling Worksheet, located on page 8.1, and return it to the natural area as soon as possible.

### Before the Trip:

**1.** Complete the pre-visit activities in this Environmental Education Learning Experience.

**2.** The group leader should visit the natural area without the participants prior to the group trip. This will enable you to become familiar with the facilities and natural area staff, to identify themes and to work out any potential problems.

**3.** The group leader should discuss park rules and behavior expectations with adult leaders and participants. Safety should be stressed.

**4.** *The group leader is responsible for obtaining a parental consent form for each participant.* Be sure that health conditions and medical needs are noted. A sample consent form is located on page 8.2.

**5.** Research Activity Permits may be required for activities in which samples are to be taken from the park. Contact the natural area to determine if research activity permits are needed.

**6.** *If you will be late or need to cancel your trip, please notify the natural area immediately.*

## While at the Natural Area:

Whether your class is working on an Environmental Education Experience or taking a nature hike, please obey the following rules:

**1.** Be safety conscious. Some sections of the natural area's trails are strenuous. It is recommended that proper footwear be worn and that water be carried. Also, hazards such as bees and extreme weather conditions may exist. These hazards can cause problems if you are not prepared. Students with any medical conditions should be monitored closely by the adult leaders.

**2.** Be as quiet as possible while in the natural area. This will help you get the most out of the experience, while increasing your chance of observing wildlife.

**3.** On hikes, walk behind the leader at all times. Running is not permitted. Please stay on the trails!

**4.** All plants and animals are protected within the park. Injuring or removing plants or animals is prohibited in all North Carolina State Parks and Natural Areas. Removal of rocks is also prohibited. This allows others to enjoy our natural resources.

**5.** Picnic only in the designated picnic area. Help keep the park clean and natural by not littering and by picking up any trash left behind by others.

**6.** *In case of accidents or emergencies, contact the Mt. Jefferson staff immediately.*

## Following the Trip:

**1.** Complete the post-visit activities in this Environmental Education Learning Experience.

**2.** Build upon the field experience and encourage participants to seek answers to questions and problems encountered while at the natural area.

**3.** Relate the experience to classroom activities through reports, projects, demonstrations, displays and presentations.

**4.** Give tests or evaluations, if appropriate, to determine if students have gained the desired information from the experience.

**5.** Please complete the program evaluation sheet on page 8.3 and send it to the natural area.

## Natural Area Information:

### Address:

Mount Jefferson State Natural Area
P. O. Box 48
Jefferson, NC 28640
Tel: (336) 246-9653
Fax: (336) 246-3386
e-mail: moje@skybest.com

### Office Hours:

Year-round
Mon - Fri. 8:00 a.m. - 12:00 p.m.

### Hours of Operation:

| | |
|---|---|
| Nov. - Feb. | 9:00 a.m. - 5:00 p.m. |
| March, Oct. | 9:00 a.m. - 6:00 p.m. |
| April, May, Sept. | 9:00 a.m. - 7:00 p.m. |
| June - Aug. | 9:00 a.m. - 8:00 p.m. |

# Introduction to the Activity Packet for Mount Jefferson State Natural Area

The Environmental Education Learning Experience (EELE), *Metamorphic Mountain,* is designed to introduce the student to the geology of the Blue Ridge Mountains through hands-on environmental education activities for the classroom and the outdoor setting of Mount Jefferson State Natural Area. It is targeted for the 5th through 8th grades and meets established curriculum objectives of the North Carolina Department of Public Instruction. Three types of activities are included:

1) pre-visit activities
2) on-site activities
3) post-visit activities

The on-site activities will be conducted at the natural area, while pre-visit and post-visit activities are designed for the classroom. The pre-visit activities should be conducted prior to the visit to Mt. Jefferson so students will have the necessary background and vocabulary for the on-site activities.

The pre-visit activities will introduce the students to the different rock types: sedimentary, igneous and metamorphic. The students will learn how rocks are formed, how to identify them, and how they weather. In addition, students will learn about the geologic time scale and identify the geologic belts of North Carolina. By creating models of crystals, they will also learn that all minerals have characteristic crystal shapes.

The on-site activities will familiarize the students with the actual rock types of Mount Jefferson State Natural Area, their characteristics and where they are found in the park. In addition, students will learn how the geology of the Mt. Jefferson area affected the cultural history, and take a hike to see first-hand examples of folds and faults, dipping rock strata, weathering, erosion and foliation.

The post-visit activites are designed for review and will broaden the students' understanding of how we use rocks and minerals.

These activities may be performed independently or in a series to build upon the students' newly gained knowledge and experiences.

The Environmental Education Learning Experience, *Metamorphic Mountain,* will expose students to the following major concepts:

- **Geology**
- **Rock types and their uses**
- **Rock cycle**
- **Weathering and erosion**
- **Geologic belts**
- **Geologic time and history**
- **Mineral properties**
- **Rock formation**
- **Strata orientation**
- **Mining**
- **Conservation of natural resources**

The first occurrence of a vocabulary word used in these activities is indicated in **bold type**. Their definitions are listed in the back of the activity packet. A list of the reference materials used in developing the activities follows the vocabulary list.

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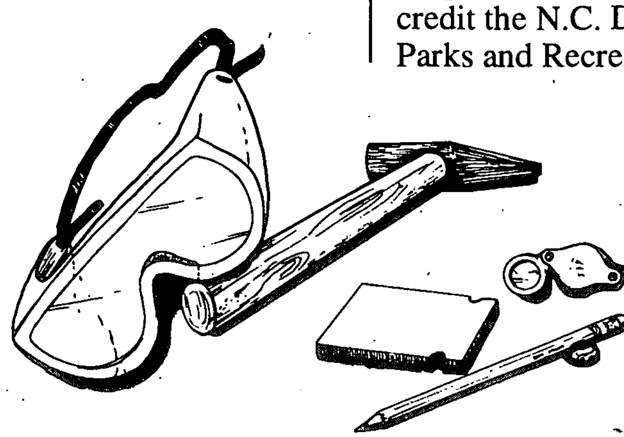


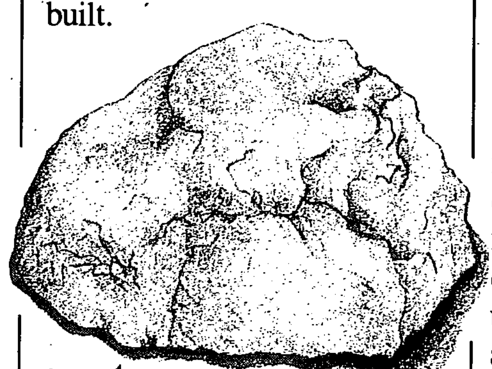
# Introduction to the Geology of Mount Jefferson State Natural Area

**Geology** – it is something most of us seldom think about, yet it affects all of us... where and how we live, the resources available to us and the landscape that surrounds us. The powerful geologic processes that formed our continent were as sudden and catastrophic as a volcanic eruption or as slow as a stream eroding and sculpting the landscape. These processes also created varied **minerals** and **rocks**. Locally they concentrated minerals into deposits that could be mined, and produced the soil which would become either forests or farmlands. The eventual result is the beautiful state we enjoy today.

Geology influences the world and our lives in many different ways. For example, the resistance and structure of the rocks profoundly influence the landscape of North Carolina. When rocks weather, they produce soil and, thus, significantly influence the type of vegetation we see. Mineral deposits provide us with raw materials needed to construct cities, supply our heat and energy needs, and fabricate the commodities of our modern civilization. The Blue Ridge region is well known for its deposits of feldspar, mica and **quartz** – essential minerals used in the ceramics, glass, paint, plastics, electronics and computer industries. Significant deposits of copper were once mined in the Blue Ridge; in fact a major deposit, now depleted, is nearby at Ore Knob, less than eight miles east of Mount Jefferson.

The rocks now found at Mount Jefferson State Natural Area were originally igneous or sedimentary. However, when the rocks were buried in the **Earth's crust** intense heat and deforming pressure converted all the older strata to **metamorphic rocks**. We can easily see that the rocks are tilted, folded and fractured. These observations, along with unmistakable signs of metamorphism, are evidence that the area has had a long, complicated geologic history.

The oldest rocks of the Blue Ridge, some of which are exposed in a 10-mile wide belt passing several miles northwest of Mount Jefferson, make up the region's geological basement, the foundation upon which all the region's geologic structure is built.


**quartz**

Locally, these very ancient rocks were mostly derived from molten rock materials, called **magma**, that gradually hardened or crystallized far down in the Earth's crust. With the passage of time, these deep-seated, generally granitic rocks underwent deformation and metamorphism and were altered to various types of granitic gneiss. Geologists who study these rocks have concluded that throughout much of eastern North America very similar deformation and metamorphism occurred at this same time, approximately 1- 1.25 billion years ago.

An integral part of the deformation process must have involved widespread uplift of the land. Of course, whenever uplift occurs, the elevated region becomes exposed to the forces of **erosion**. If uplift proceeds faster than erosion, then a highland or mountain landscape may evolve. In our area, however, subsequent geologic events have virtually obliterated evidence needed to determine how high the land became during this ancient time. It seems likely that a major mountain chain developed. As the uplifting forces gradually died away, erosion continued and, ultimately, the land's elevation and features must have been greatly worn down.

The next chapter in the story of the Mount Jefferson State Natural Area region is recorded in rocks that formed in an ocean environment. At first, along a fracture in the sea floor, vast outpourings of fiery hot **lava** dominated the scene. Most of the material was probably very similar to the flows and shallow intrusions of very fluid lava such as those in and around the Hawaiian Islands today. As each sheet of lava cooled, it solidified into a dark-colored, rock called basalt. Between some of the lava eruptions, thin layers of sand and mud were deposited. Eventually, as the eruptions became less frequent, the sandy and muddy deposits began to dominate in this part of the ocean basin. All this activity is estimated by some geologists to have occurred between 550 to 900 million years ago.

Considering the great expanse of geologic time, the Earth's crust is seldom quiet for long. About 475 million years ago the rocky material filling this distant ocean basin began to get squeezed together. The basin's large thickness of accumulated lava flows and interlayered **sediments** began crumpling, or **folding**, and moving westward by sliding along major thrust faults at great depth. As the layers were squeezed, crumpled and moved, the deeply buried original minerals in the rocks recrystallized into new and different minerals and shapes. The old lava flows, or basalts, were altered by intense heat and pressure to rocks containing abundant, dark-colored hornblende and variable proportions of light-colored feldspar, along with some other lesser minerals. In the sediments, the original clay making up the muddy component recrystallized mostly to biotite and muscovite-mica. The original quartz and feldspar grains of sand and silt became reorganized and recrystallized into larger, intergrown and interlocking crystals.

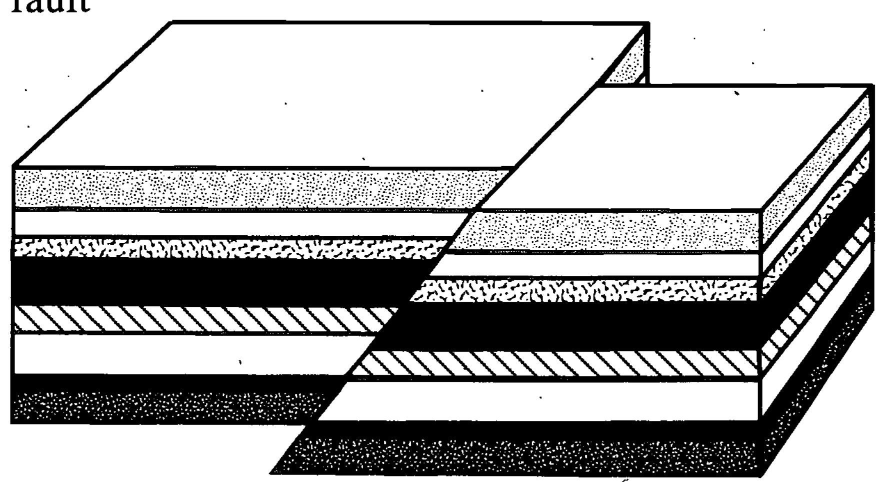
Thus were formed the metamorphic rocks that underlie Mount Jefferson State Natural Area:

- *amphibolite,* which dominates, is mostly made up of hornblende (one specific mineral in a large group of minerals collectively called amphiboles) and feldspar;
- *schist,* which contains abundant biotite and muscovite; and
- *metagraywacke* (sometimes referred to as metamorphosed "dirty **sandstone**"), which contains abundant quartz and feldspar, with lesser biotite and mica.

This major episode of folding, **faulting** and metamorphism, very vigorous at first but then gradually declining, also resulted in uplift and subsequent erosion and the continued sculpting of the land. Critical evidence that would enable us to estimate the height of the mountains that undoubtedly developed has been greatly complicated and obscured by subsequent geologic events. Finally, about 375 million years ago, roughly 100 million years after the start of this major metamorphic episode, the Earth in the region was temporarily tranquil.

But it wasn't long until the Earth, a dynamic, ever-changing body, once again began to deform eastern North America about 300 million years ago. This event was the last of the collision-like interactions of the continental

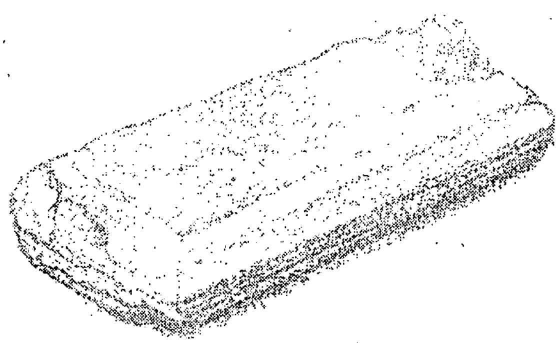
fault

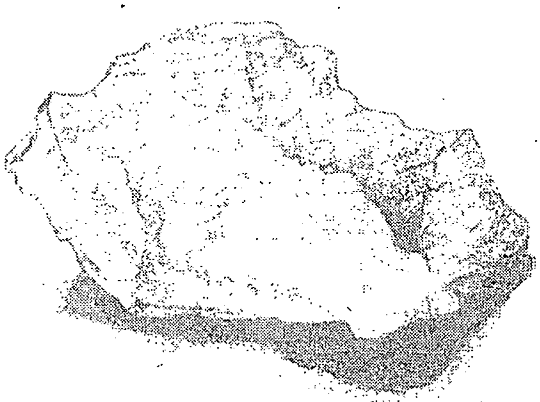


plates of North America and Africa. As before, great masses of the Earth's crust were carried west or northwestward along another series of major thrust faults. In the region of Mount Jefferson State Natural Area, it appears that some of the quartz veins that formed in cracks or fractures may have developed during this episode. The sum of the previous westward movements, including the most recent one, is certainly many tens of miles; some geologists estimate the total lateral displacement may well exceed 200 miles!

From the minerals contained in the rocks now exposed in and around Mount Jefferson State Natural Area, geologists conclude that the rocks were once probably buried some 10 miles or so beneath the surface of the Earth. Because these rocks are now at the Earth's surface, the total uplift could have been on the order of 50,000 to 55,000 feet! However, because erosion was occurring at the same time the rocks were being pushed up, it is quite unlikely the mountains were ever as high as 50,000 feet. Although their actual height long ago is difficult to estimate, it seems reasonable to infer that the peaks may have been on the order of 15,000 to 20,000 feet. What remains today, some 250 million years later, are the erosion-scarred, nearly worn-down roots of high mountain ranges. Typically **resistant rocks** underlie the hills and peaks we see now; less resistant rocks underlie the valleys and lowlands.

As we look carefully at the Earth, we can see that it changes constantly. New rocks form, they are cooled, folded and faulted, perhaps even metamorphosed during the processes of deep burial and then uplift and exposure at the earth's surface. Once exposed at the surface, they weather and erode, producing sediment that washes into nearby streams and rivers and moves to the ocean. These processes and their results continue today and are visible all around us. As you walk the trails at Mount Jefferson, it is interesting to think about the many changes these rocks and the landscape have undergone to reach their present form.





# Activity Summary

The following outline provides a brief summary of each activity, the major concepts introduced and the objectives met by completion of the activity.

## I. Pre-Visit Activity

### #1 Rainbow Rock (page 3.1.1)

Through this activity, students will learn how sedimentary, metamorphic and igneous rocks are formed and about the rock cycle.

**Major Concepts:**

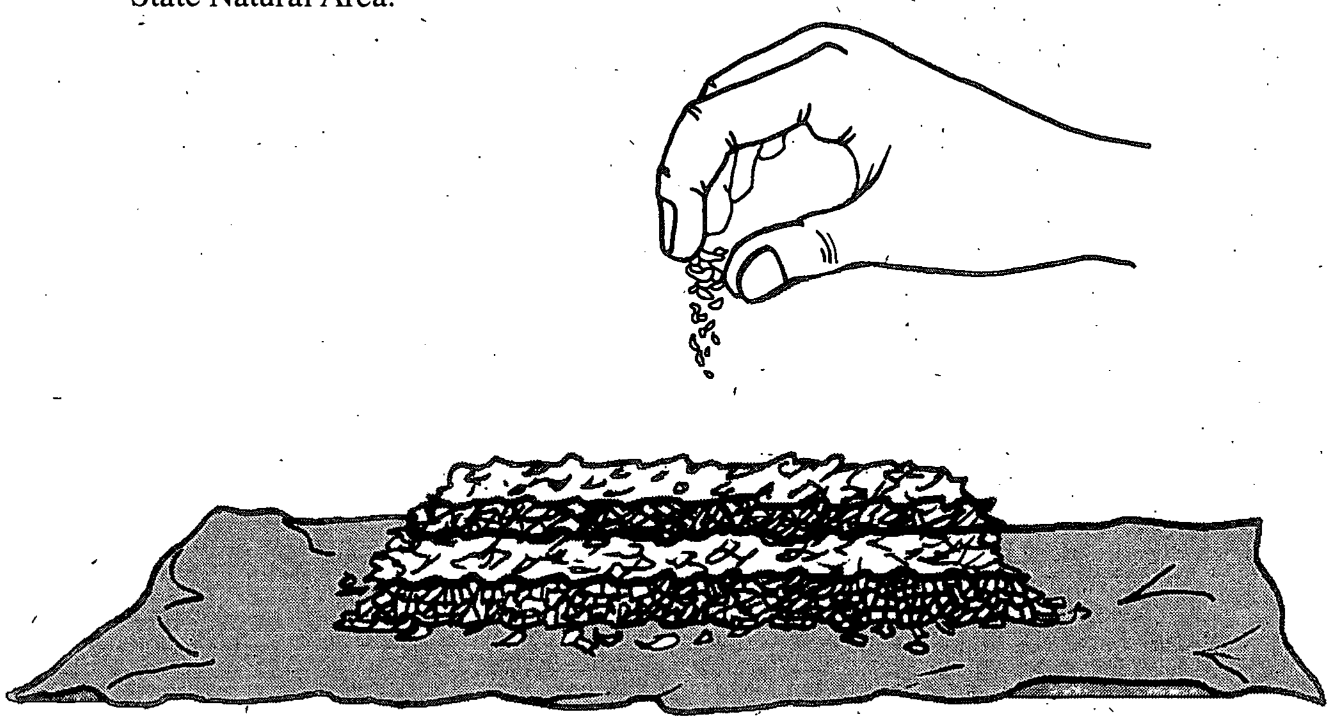
- Rock cycle
- Mechanical weathering
- Sedimentary rock formation
- Metamorphic rock formation
- Igneous rock formation

**Learning Skills:**

- Observing, classifying, inferring and making models
- Following directions to create a product
- Measuring

**Objectives:**

- List the three main rock classifications.
- Describe how the three rock classifications are formed.
- Explain the rock cycle.
- Name the predominant metamorphic rock, and its minerals, found at Mount Jefferson State Natural Area.



## #2 Belting It Out (page 3.2.1)

During this activity, students will locate the geologic belts of North Carolina, pinpoint the locations of specific types of sedimentary, metamorphic and igneous rocks, identify some of the rocks and minerals mined in the state, locate the origins of some North Carolina rocks and minerals and answer questions about the specific ages of various rocks and minerals.

**Major Concepts:**
- Physiography
- Geologic belt
- Geologic time

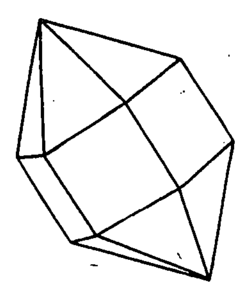
**Learning Skills:**
- Observing, communicating and inferring
- Reading and interpreting maps.
- Estimating distances
- Reading tables

**Objectives:**
- Locate three physiographic provinces and 10 geologic belts on a geologic map of North Carolina.
- Compare and contrast the three physiographic provinces in North Carolina.
- Use a geologic map to determine rock types and approximate age or formation for given locations in North Carolina.
- List at least seven rocks and minerals that are mined in North Carolina and locate major sources on a geologic map.
- Using a map scale and ruler, estimate distances on a state geologic map.

## #3 Mt. Jefferson's Crystals (page 3.3.1)

In this activity, students will learn that many minerals display characteristic shapes. They will then learn about the crystal shapes of some minerals found at Mt. Jefferson and cut out, color, and make mobiles and three-dimensional models of the crystal shapes.

**Major Concepts:**
- Mineral properties
- Crystal shape



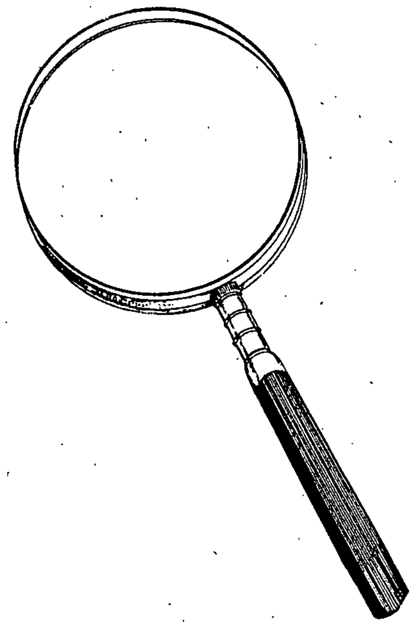
**Learning Skills:**
- Observing and classifying
- Making models of 3-D geometric shapes
- Following directions to make a product

**Objectives:**
- Participate in a group demonstration to grow large crystals of salt (halite) and describe the crystal shape and growth pattern.
- Define mineral and list at least five characteristics that geologists use to identify minerals.
- Observe and describe the crystal shapes of five minerals found in the rocks at Mt. Jefferson State Natural Area.
- Create three-dimensional models of quartz and feldspar crystals.

# II. On-Site Activities

## #1 Geo-Trek (page 4.1.1)

This activity is designed to familiarize the student with the specific rock types of the southern Blue Ridge highlands, their characteristics and where they are found in the park. In Part I, students will learn the names and characteristics of three different rocks and five minerals found at Mount Jefferson State Natural Area. In Part II, students take a short walk to observe firsthand the effects of geologic processes on the landscape.



**Major Concepts:**

**Part I: Rock ID**
- Rock formation
- Rock characteristics
- Sedimentary, metamorphic and igneous rocks

**Part II: Talking Rocks**
- Weathering
- Erosion
- Rock cycle

**Learning Skills:**
- Observing, classifying, inferring
- Comparing; writing notes

**Objectives:**

**Part I:**
- Identify three major rocks and five major minerals found at the park by listing their distinguishing characteristics.
- List five characteristics that geologists use to help identify rocks and minerals.

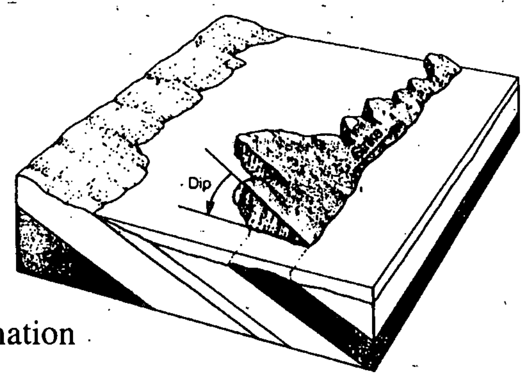
**Part II:**
- Describe three factors that cause rocks to weather.
- Describe how metamorphic rock is formed and name one common to this area.
- Describe how sedimentary rocks are formed and how they are layered.
- Explain why rocks found in this area are no longer in a horizontal plane.

## #2 Exploring Metamorphic Mountain (page 4.2.1)

In this activity, the students will see firsthand examples of folds and faults, dipping rock strata, weathering, erosion, and foliation during a hike atop Mount Jefferson.

**Major Concepts:**

- Metamorphic rock
- Geologic formations
- Mountain-building processes
- Weathering and erosion




**Learning Skills:**

- Observing, classifying, communicating, inferring
- Collecting, analyzing and evaluating information
- Measuring angles

**Objectives:**

- Describe how metamorphic rocks are formed and name two common to Mount Jefferson.
- Explain the presence of vein quartz on the surface and in the soil throughout the park.
- Explain how horizontal beds or sheets of rock are folded and tilted.
- Identify rocks and minerals along the trail.
- Describe three factors that cause rocks to weather and erode.

## #3 Geology and Cultural History (page 4.3.1)

From the second overlook at the natural area, students will listen to a talk presented by the ranger describing the geologic and cultural history of the Mt. Jefferson area. The students will locate landmarks and mountain peaks.

When the students return to their school they will be given a Mt. Jefferson Quiz which will assess how much information the students retained from the visit.

**Major Concepts:**

- Mt. Jefferson's geologic history
- The cultural history of the Mt. Jefferson area

**Learning Skills:**

- Observing and communicating
- Listening for details
- Acquiring information

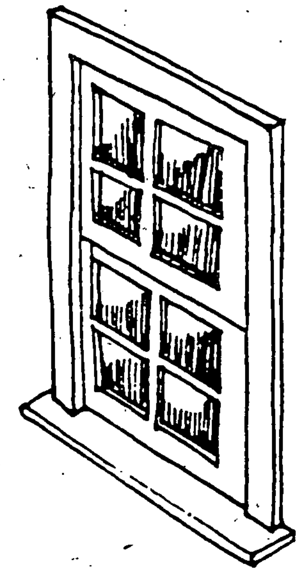
**Objectives:**

- Identify and observe seven peaks and two towns seen from Mt. Jefferson's second overlook.
- Describe the difficulty explorers had traveling through the Mt. Jefferson area.
- Identify the first explorers and the first permanent settlers in the Mt. Jefferson area.
- Identify the rock for which Mt. Jefferson was originally named.
- Write a story about life as a boy or girl in the Mt. Jefferson area in the 1800s.

# III. Post-Visit Activities

## #1 Geo-Scavenge (page 5.1.1)

In this activity, the student will gain an understanding of how many of the things we use in our daily lives are derived from rocks and minerals. They will learn the origins of many common objects then match up different objects with the rocks and minerals they are made from.



**Major Concepts:**
- Mining
- Raw materials
- Uses of rocks and minerals

**Learning Skills:**
- Observing, classifying, inferring
- Noting important details and drawing conclusions
- Gathering and organizing information

**Objectives:**
- Use reference materials to match household objects, or pictures of these objects, to the mineral(s) used to make them.
- Explain the importance of Earth resources in our daily lives.

## #2 It's About Time (page 5.2.1)

The vast scale of geologic time is difficult to envision for most people. This activity presents geologic time in a 24-hour cycle and provides a quick review of various events that have occurred since the Earth formed.

**Major Concepts:**
- Geologic time
- Geologic history

**Learning Skills:**
- Gathering, organizing and analyzing information
- Calculating numbers and solving mathematical problems
- Interpreting data

**Objectives:**
- Convert geological and biological events, occurring millions of years ago, to a 24-hour time clock by following a sample calculation.
- Identify and describe three important events in the geologic history of Mt. Jefferson.
- Use reference materials to identify the period or epoch for a given event in geologic time.

## #3 Ironing It Out (page 5.3.1)

In this activity, students will debate and decide if the area inside and adjoining Mt. Jefferson State Natural Area should be mined for iron ore.

**Major Concepts:**

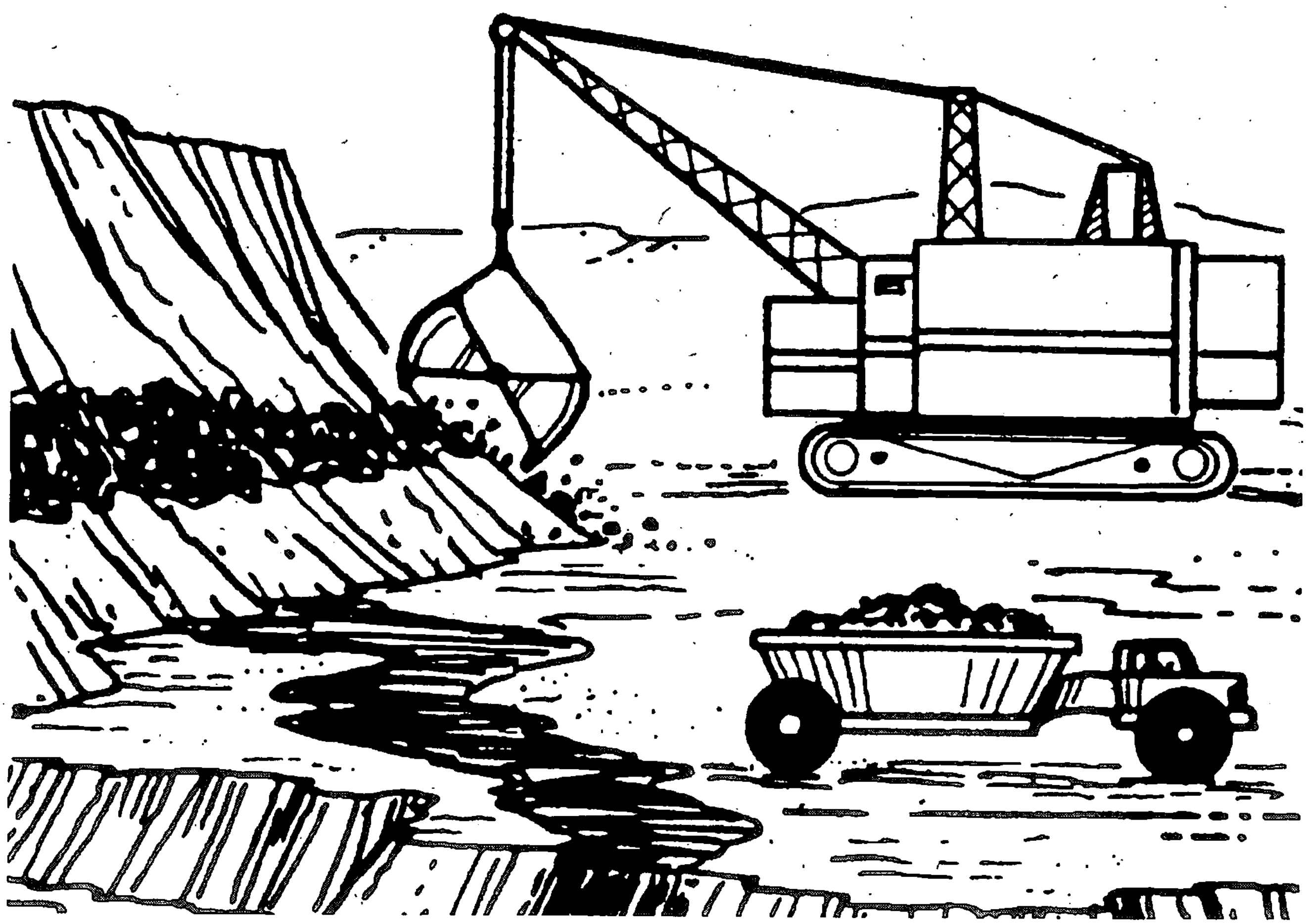
- Mining
- Environmental issues
- Conservation of natural resources

**Learning Skills:**

- Predicting, communicating, inferring
- Participating effectively in groups, problem-solving
- Using language for personal response
- Evaluating the accuracy and value of information and ideas

**Objectives:**

- Write an essay supporting or opposing a proposed mining operation near a state park. Provide at least three logical reasons to support the position.
- Listen critically to oral presentations and write notes of key points.
- Demonstrate a willingness to acknowledge other points of view and work toward a group solution to a natural resources issue.



# Correlation Chart

**Note to classroom teachers:** The following Correlation Chart shows how each activity in this Environmental Education Learning Experience (EELE) correlates with the North Carolina Department of Public Instruction (DPI) objectives in science, mathematics, social studies and English language arts. The activities are listed in the order in which they appear in this EELE. The recommended grade levels are listed along the side of the chart. Notice that only the objective numbers are listed. Use your DPI Teacher Handbook for each subject area to get a complete description of the objectives in that subject area.

**Pre-Visit Activity #1: Rainbow Rock,** p. 3.1.1

| Grade | Science | English Lang. Arts | Soc. Studies | Mathematics |
|---|---|---|---|---|
| 5 | 3.01 Strands: Nature of Science, Science Inquiry, Personal & Social Perspectives | 1.1, 2.1, 2.2, 2.3 | | |
| 6 | 4.02 Strands: Nature of Science, Science Inquiry | 1.1, 1.2, 1.3 2.1, 2.2 | | 4.1 |
| 7 | 4.01, 4.04 Strands: Nature of Science, Science Inquiry | 1.1, 1.2, 1.3 2.1, 2.2 | | 4.1 |
| 8 | 3.01, 3.04 Strands: Nature of Science, Science Inquiry | 1.1, 1.2, 1.3 2.1, 2.2 | | |
| Earth/ Envtl. Science | 1.02 Strands: Science as Human Endeavor, Science Inquiry | | | |

**Pre-Visit Activity #2: Belting It Out,** p. 4.2.1

| Grade | Science | English Lang. Arts | Soc. Studies | Mathematics |
|---|---|---|---|---|
| 5 | 3.03 Strands: Nature of Science, Personal & Social Perspectives | 1.1, 1.2, 1.3, 2.1, 2.2 | 3.1, 9.2 Skill Goal I | 4.6 |
| 6 | Strands: Nature of Science, Personal & Social Perspectives | 1.1, 1.2, 1.3 2.1, 2.2 | | 4.1 |
| 7 | Strands: Nature of Science, Personal & Social Perspectives | 1.1, 1.2, 1.3, 2.1, 2.2 | | 4.1 |
| 8 | 2.02, 3.01, 3.03 Strands: Nature of Science, Personal & Social Persp. | 1.1, 1.2, 1.3 2.1, 2.2 | 1.1, 1.2 Skill Goal I | |
| Earth/ Envtl. Science | 1.03, 1.06, 3.03 Strands: Nature of Science, Science as Human Endeavor | | | |

# Correlation Chart

| Pre-Visit Activity #3: Mt. Jefferson's Crystals, p. 3.3.1 | | | | |
|---|---|---|---|---|
| **Grade** | **Science** | **English Lang. Arts** | **Soc. Studies** | **Mathematics** |
| 5 | Strands: Nature of Science, Science Inquiry | 1.1, 1.2, 1.3, 2.1, 2.2, 2.3 | | 2.1, 2.2 |
| 6 | Strands: Nature of Science, Science Inquiry | 1.1, 1.2, 1.3, 2.1, 2.2, 2.3 | | 2.1. 2.4, 2.7 |
| 7 | 4.01, 4.04 Strands: Nature of Science, Science Inquiry | 1.1, 1.2, 1.3, 2.1, 2.2, 2.3 | | 2.4, 2.5 |
| 8 | 3.01 Strands: Nature of Science, Science Inquiry | 1.1, 1.2, 1.3, 2.1, 2.2, 2.3 | | 2.3 |
| Earth/ Envtl. Science | 1.01 Strands: Nature of Science, Science as Human Endeavor | | | |

| On-Site Activity #1: Geo-Trek, Part I, Rock ID, p. 4.1.1 | | | | |
|---|---|---|---|---|
| **Grade** | **Science** | **English Lang. Arts** | **Soc. Studies** | **Mathematics** |
| 5 | 3.03 Strands: Nature of Science, Science Inquiry | 1.1, 1.2. 1.3, 2.1, 2.2, 2.3 | 9.1 Skill Goal I | |
| 6 | Strands: Nature of Science, Science Inquiry | 1.1, 1.2, 1.3, 2.1, 2.2. 2.3 | | |
| 7 | 4.01, 4.04 Strands: Nature of Science, Science Inquiry | 1.1, 1.2, 1.3, 2.1, 2.2, 2.3 | | |
| 8 | 3.01 Strands: Nature of Science, Science Inquiry | 1.1, 1.2, 1.3, 2.1, 2.2. 2.3 | | |
| Earth/ Envtl. Science | 1.01, 1.02 Strands: Nature of Science, Science Inquiry | | | |

# Correlation Chart

**On-Site Activity #1: Geo-Trek, Part II,** p. 4.1.11

| Grade | Science | English Lang. Arts | Soc. Studies | Mathematics |
|---|---|---|---|---|
| 5 | 3.01 Strands: Nature of Science, Science Inquiry | 1.1, 1.2, 1.3, 2.1, 2.2 | | |
| 6 | Strands: Nature of Science, Science Inquiry | 1.1, 1.2, 1.3, 2.1, 2.2 | | |
| 7 | Strands: Nature of Science, Science Inquiry | 1.1, 1.2, 1.3, 2.1, 2.2 | | |
| 8 | 3.01, 3.04 Strands: Nature of Science, Science Inquiry | 1.1, 1.2, 1.3, 2.1, 2.2 | | |
| Earth/ Envtl. Science | 1.02, 1.05 Strands: Science as Human Endeavor. Science Inquiry | | | |

**On-Site Activity #2: Exploring Metamorphic Mountain,** p. 4.2.1

| Grade | Science | English Lang. Arts | Soc. Studies | Mathematics |
|---|---|---|---|---|
| 5 | 3.01, 3.02, 3.03 Strands: Nature of Science, Science Inquiry, Personal & Social Perspectives | 1.1, 1.2, 1.3, 2.1, 2.2. 2.3 | | 2.6 |
| 6 | 1.01 Strands: Nature of Science, Science Inquiry | 1.1, 1.2, 1.3, 2.1, 2.2, 2.3 | | 2.2, 2.3, 2.7 |
| 7 | 4.01, 4.04 Strands: Nature of Science, Science Inquiry | 1.1, 1.2, 1.3, 2.1, 2.2, 2.3 | | 2.1, 2.4 |
| 8 | 3.01, 3.02, 3.03, 3.04 Strands: Nature of Science, Science Inquiry | 1.1, 1.2, 1.3, 2.1, 2.2, 2.3 | | 2.7 |
| Earth/ Envtl. Science | 1.02, 1.05, 2.01, 3.03 Strands: Science as Human Endeavor, Nature of Scientific Knowledge, Science Inquiry | | | |

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# Correlation Chart

| On-Site Activity #3: Cultural History & Geologic History -- The Connection, p. 4.3.1 | | | | |
|---|---|---|---|---|
| **Grade** | **Science** | **English Lang. Arts** | **Soc. Studies** | **Mathematics** |
| 5 | 3.03 Strands: Personal & Social Perspectives | 1.1, 1.2, 1.3, 2.1, 2.2, 4.1, 4.2 | 1.1, 5.2, 6.2, 11.3 Skill Goals I & II | |
| 6 | 1.03 Strands: Nature of Science, Personal & Social Perspectives | 1.1, 1.2, 1.3, 2.1, 2.2, 4.1, 4.2 | | |
| 7 | Strands: Nature of Science, Personal & Social Persp. | 1.1, 1.2, 1.3, 2.1, 2.2, 4.1, 4.2 | | |
| 8 | 2.01 Strands: Nature of Science, Personal & Social Perspectives | 1.1, 1.2, 1.3, 2.1, 2.2, 4.1, 4.2 | 1.3, 1.4, 1.5, 3.2 Skill Goals I & II | |
| Earth/ Envtl. Science | 7.02 Strands: Historical Perspectives, Personal & Social Perspectives | | | |

| Post-Visit Activity #1: Geo-Scavenge, p. 5.1.1 | | | | |
|---|---|---|---|---|
| **Grade** | **Science** | **English Lang. Arts** | **Soc. Studies** | **Mathematics** |
| 5 | Strands: Personal & Social Perspectives | 1.1, 1.2, 1.3, 2.1, 2.2, 2.3 | 5.2, 9.1 Skill Goals I & II | |
| 6 | Strands: Science & Technology, Personal & Social Perspectives | 1.1, 1.2, 1.3, 2.1, 2.2, 2.3 | | |
| 7 | 4.03 Strands: Science & Technology, Personal & Social Perspectives | 1.1, 1.2, 1.3, 2.1, 2.2, 2.3 | 1.3, 11.2 Skill Goals I & II | |
| 8 | 2.02 Strands: Science & Technology, Personal & Social Perspectives | 1.1, 1.2, 1.3, 2.1, 2.2, 2.3 | | |
| Earth/ Envtl. Science | 1.03, 7.02 Strands: Science & Technology, Personal & Social Perspectives | | | |

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# Correlation Chart

**Post-Visit Activity #2: It's About Time,** p. 5.2.1

| Grade | Science | English Lang. Arts | Soc. Studies | Mathematics |
|---|---|---|---|---|
| 5 | 3.01 Strands: Nature of Science, Personal & Social Perspectives | 1.1, 1.2, 1.3, 2.1, 2.2, 2.3 | | 5.1, 5.5, 7.14 |
| 6 | Strands: Nature of Science | 1.1, 1.2, 1.3, 2.1, 2.2, 2.3 | | 5.1, 5.4, 7.3, 7.4 |
| 7 | Strands: Nature of Science | 1.1, 1.2, 1.3, 2.1, 2.2, 2.3 | | 5.1, 5.2. 5.4, 7.3 |
| 8 | 3.01, 3.02, 3.03, Strands: Nature of Science | 1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 4.3 | | 5.1, 5.2, 5.5 |
| Earth/ Envtl. Science | 3.01, 3.02 Strands: Nature of Scientific Knowledge | | | |

**Post-Visit Activity #3: Ironing It Out,** p. 5.3.1

| Grade | Science | English Lang. Arts | Soc. Studies | Mathematics |
|---|---|---|---|---|
| 5 | 1.01, 1.06, 3.03 Strands: Nature of Science, Science & Technology, Personal & Social Perspectives | 1.1, 1.2, 1.3,2.1, 2.2, 2.3, 3.1, 3.2, 4.1, 4.2, 4.3 | 2.3, 5.2, 5.3 Skill Goals I, II, III, & IV | |
| 6 | 1.03, 2.03 Strands: Nature of Science, Science & Technology, Personal & Social Persp. | 1.1, 1.2, 1.3,2.1, 2.2, 2.3, 3.1,3.2, 4.1, 4.2, 4.3 | | |
| 7 | Strands: Nature of Science, Science & Technology, Personal & Social Perspectives | 1.1, 1.2, 1.3,2.1, 2.2, 2.3, 3.1, 3.2, 4.1, 4.2, 4.3 | | |
| 8 | 1.04, 2.01, 2.02, 2.03, 2.04 Strands: Nature of Science, Science & Technology, Personal & Social Perspectives | 1.1, 1.2, 1.3,2.1, 2.2, 2.3, 3.1, 3.2, 4.1, 4.2, 4.3 | 1.3, 1.5, 11.2 Skill Goals I, II, III, & IV | |
| Earth/ Envtl. Science | 1.03, 1.06, 7.01, 7.02, 7.03 Strands: Science as Human Endeavor, Science & Technology, Personal & Social Persp. | | | |

# Pre-Visit Activity #1 — Rainbow Rock

**Curriculum Objectives:**
**Grade 5**
- Communication Skills: listening, reading, vocabulary and viewing comprehension, writing
- Guidance: competency for interacting with others
- Healthful Living: safe school environment
- Science: Earth science
- Social Science: gather, organize and analyze information, draw conclusions, participate effectively in groups

**Grade 6**
- Communication Skills: listening, reading, vocabulary and viewing comprehension, writing
- Guidance: competency and skill for interacting with others
- Social Studies: gather, organize and analyze information, draw conclusions

**Grade 7**
- Communication Skills: listening, reading, vocabulary and viewing comprehension
- Guidance: being responsible in a group
- Healthful Living: school safety
- Science: Earth science, natural phenomena
- Social Studies: know the importance of natural resources, gather, organize and analyze information, draw conclusions

**Location:**
Classroom/science lab

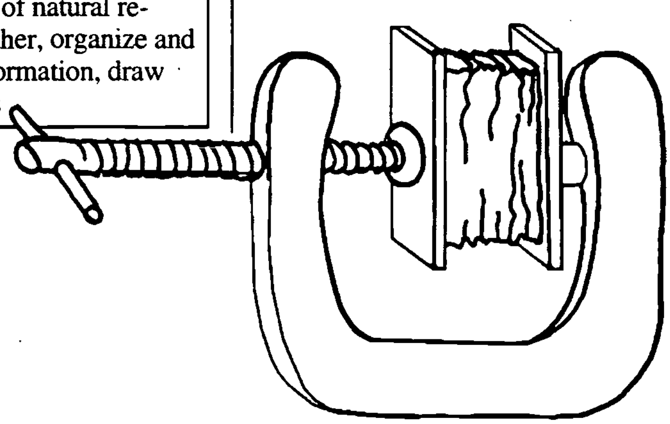
**Group Size:**
30 students or less, class size

**Estimated Time:** 2 to 4 hours

**Appropriate Season:** Any

**Materials:**
Provided by the educator:
Per student: safety goggles, large pocket pencil sharpener, four wax crayons of the same color, (either red, green, blue, or yellow), envelope, wax paper, "Rock Cycle" worksheet, "Rainbow Rock" worksheet
Per group: hot plate, two oven mittens, petri dish, aluminum foil, three disposable aluminum foil pie pans, trivet, newspaper (enough to cover lab surfaces– have lots of newspaper handy)
Per class: samples of real sedimentary, metamorphic and igneous rocks (contact the park if you need to borrow a rock set), crushed ice, water
Provided by the park:
Per group: one 8 inch C-clamp, two boards

**Special Considerations:**
Take proper safety precautions. The hot plate and hot crayon wax can cause burns. C-clamps can pinch/crush fingers.



## Major Concepts:
- Rock cycle
- Mechanical weathering
- Sedimentary rock formation
- Metamorphic rock formation
- Igneous rock formation

## Objectives:
- List the three main rock classifications.
- Describe how the three rock classifications are formed.
- Explain the rock cycle.
- Name the predominant metamorphic rock, and its minerals, found at Mount Jefferson State Park.

## Educator's Information:

Students often have a difficult time understanding the abstract concept of the **rock cycle**. The students can see rock examples in the classroom; the difficulty lies in their inability to visualize just how these **rock** samples were formed. The following activity is extremely effective in giving students the opportunity to "see" the rock cycle through a series of simulation activities; **mechanical weathering** and erosional processes, and formation of **sedimentary**, **metamorphic** and **igneous rock**. The activity can be done as one continuous process or can be separated into five parts.

**Instructions:**

Set the stage by asking students to describe local rocks and rock formations, or ones that they have seen during walks along a lake or river's edge, near or on a mountain, or during drives along highways that were built through road cuts. Be sure to have several rock samples distributed around the room.

Ask the students questions such as, "Have you ever wondered just how these rocks form?" and "Are new rocks forming at this moment?" You might ask each student to write down one rock-related question they would like to have answered in class. Discuss with the students the three classifications of rock: sedimentary, metamorphic and igneous.

## Part A: Weathering

Each student should complete a "Rainbow Rock" worksheet as they do the activity. Cover all desk tops with newspaper. Give each student a sheet of wax paper, a pocket pencil sharpener and four crayons of the same color. The crayons represent rock material, and the pencil sharpeners represent **weathering** agents. Students should remove and discard the paper from the outside of their crayons. Next, they should carefully shave the crayons with the pencil sharpener, keeping all of the fragments (which represent rock **sediments**) in a small pile. As the students are "weathering" their crayons on the wax paper, call their attention to the size and shape of the fragments. Discuss with them the following questions:

"Are the weathered fragments all the same?" (Answer: No.)

"Why or why not?" (Answer: The process of weathering can be either mechanical (breaking up a rock into smaller fragments), or chemical (rearranging the elements into new **minerals**). Many factors are involved within each of the two types of weathering. As a result, a rock will show a characteristic size and/or shape, depending on which kind of weathering is taking place.)

"What are some of nature's weathering forces?" (Answer: Mechanical weathering forces can include water, ice, wind, growing roots, worms and burrowing animals, lightning, expansion and contraction caused by heating and cooling, human activity, and expansion of rock caused when **erosion** removes weight on top and produces cracks under the surface of the rock. **Chemical weathering** forces include oxygen, carbon dioxide, water, etc., reacting with a rock or mineral, resulting in change.)

"Where do rock fragments tend to collect?" (Answer: On the downhill side of the rock.)

"Why?" (Answer: Gravity.)

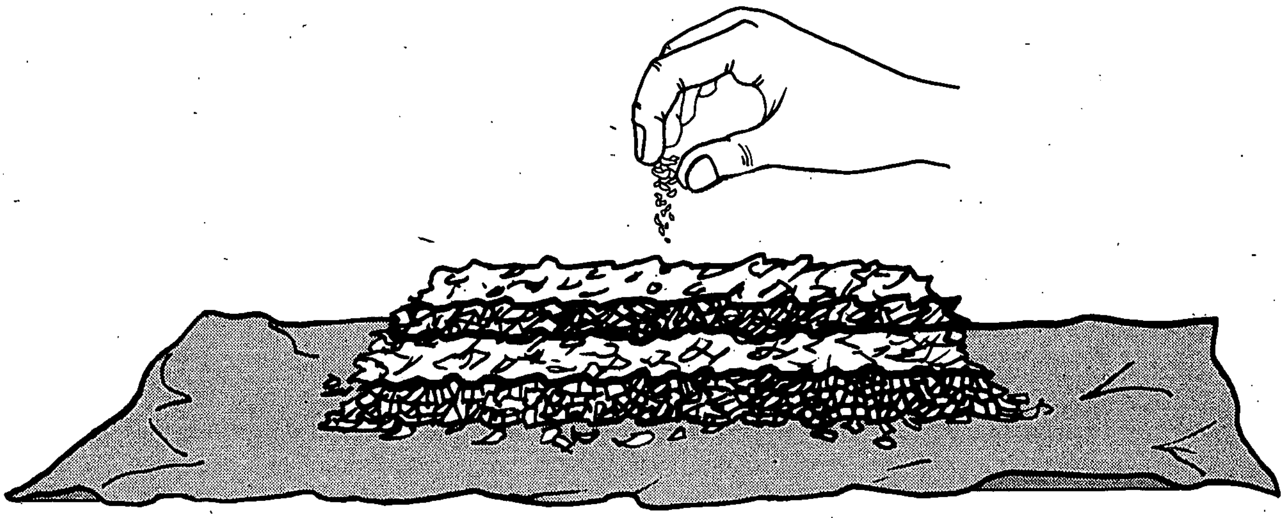
"Why do similarly sized fragments seem to be found together?" (Answer: Because similar weathering processes will usually take place in one particular area. Smaller, lighter rock fragments will be carried farther away, in a winnowing effect.)

When the "weathering" is complete, the students should wrap their fragments in their wax paper and place each wax paper packet in an envelope, unless you plan to do part B immediately. Label each envelope as to its contents, "red," "yellow," etc., for proper distribution when the activity is resumed.

## Part B: Erosion and Sedimentation

Once rock fragments have been created, they are usually moved by some force of nature. Here, the students act as the erosive force as they move the envelopes containing the fragments within the room. Ask the students what this force of movement is called, and to name some of its causes. (Answer: Erosion, caused by wind and water such as streams, rivers, and waves.)

Place all the weathered "rock" fragments in four separate piles, one color to a pile. Divide the class into groups of four and give each group a sheet of aluminum foil (31 cm x 45 cm). A student from each group should carefully transfer some "weathered" fragments to the center of their aluminum foil. Spread the fragments into a 1 cm thick layer. Repeat with the remaining colors, layering the colors one on top

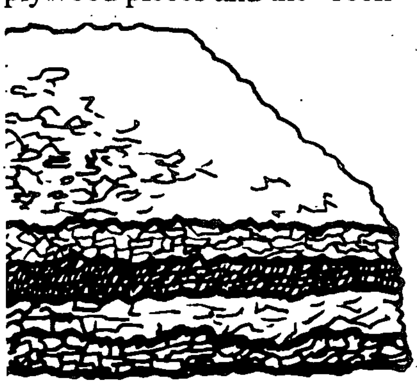


of another (see illustration).

Students should record their observations of their "weathered" fragments on their "Rainbow Rock" worksheet. Fold the foil over the fragment layers, allowing for a 1 cm space all around the fragments, and then carefully fold the edges to seal the packages. If you are breaking the activity into sections, stop here and label each package for proper distribution when the activity is resumed.

### Part C: Sediments/ Sedimentary Rock Simulation

Instruct the groups to place their folded foil package between two pieces of plywood. Apply very light pressure with the C-clamp to compress the plywood pieces and the "rock" fragments that are between them. Once the "rock sandwich" has been lightly compressed, remove it from the C-clamps. Students should then carefully open their packages and observe the new product. Call their attention to the central region which is more tightly compressed; they should lift this portion from the non-compressed fragments and carefully break it into two parts. Look at the broken edges and describe the layers. How do they compare with the original layers? What happened to the spaces between the fragments? (Answer: The layers are thinner and the spaces between the crayon fragments are now smaller.)



Each group should transfer a few of their loose fragments and the smaller piece of the "sedimentary rock" into one of their pie pans. Place the rest of the fragments in an envelope (for part E). The pieces in the pie pan will be used for comparison with the other "rocks" the students will produce during this activity. Return the larger piece of "sedimentary rock" to the aluminum foil and wrap it up again.

Compare real sedimentary rock with the sedimentary "crayon rocks." Explain to the students that, in this area, sediments were laid down in a shallow basin or sea around 540 million years ago. These sediments were buried within the **Earth's crust**, forming sedimentary rock. Then, when the North American and African continental plates collided, the buried sedimentary rock was changed into metamorphic rock. These rocks were the **core**, or basement, of the Appalachian Mountain Range that resulted from the collision. Later, as the rock above was eroded away, the landscape that we see around us today was exposed.

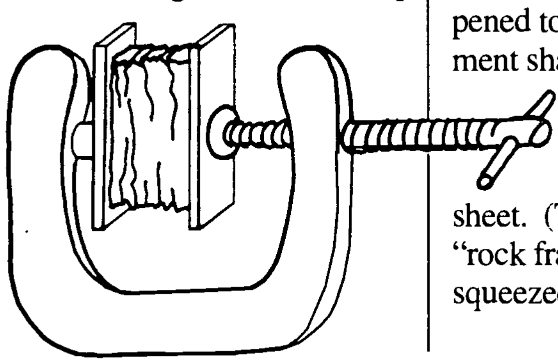
There is not much sedimentary rock left in its original layered form at Mount Jefferson when compared to the amount of metamorphic rock. This is due to the age of the rocks and the changes the rocks underwent as the fragments were buried, heated, folded and pressed together. As "Rainbow Rock" demonstrates, the original fragments are hardly recognizable after the pressure and heat processes.

Examine a sedimentary rock with fossils imbedded within it. Almost all fossils are found in sedimentary rock. Fossils are not found in igneous rock since the tremendous heat necessary to melt rock would obliterate any fossils. The same is true for metamorphic rock. Due to the heat, folding and pressure required to create metamorphic and igneous rock, any fossils that might have been present are usually destroyed. Since almost all the rocks at Mount Jefferson State Park are metamorphic, no fossils have been found here.

If you are breaking the activity into sections, stop here and label each package for proper distribution later.

### Part D: Metamorphic Rock Simulation

Each group should place their foil package with the "sedimentary rock" between the two plywood boards and the C-clamps again. Tell the students to tighten the C-clamp as much as they can this time. This part of the activity demonstrates the need for greater pressure to cause a rock to metamorphose. In reality, as the pressure deep within the Earth increases, the temperature increases as well. A temperature change is probably occurring in this activity, but we do not have the equipment to measure this change. The chemical activity associated with the formation of metamorphic rock is not a part of this activity. It is important for the students to understand that metamorphic rock may become contorted in appearance and actually flow like a plastic material in response to the pressure that is caused by the overriding rock load and continental plate movement.



Have the students release the compression on the C-clamp, remove the foil package and open it carefully to examine the newly formed "metamorphic rock." They should carefully break this "rock" into two parts and examine it, noting what happened to the thickness, fragment shape and surface. The students should write down their observations on their worksheet. (The different colored "rock fragments" will be squeezed together.)

Examine a real metamorphic rock and compare it to the metamorphic "crayon rock." Also compare the real metamorphic rock to the real sedimentary rock. Have the students examine the texture, the edges and overall appearance of these rocks. As the basin or sea opened and closed due to two continents colliding about 250 million years ago, the sedimentary rock was turned into metamorphic rock by heat and pressure.

Place the smaller piece of "metamorphic rock" into the pie pan with the fragments and the first "sedimentary rock" sample the students made. The larger piece of "metamorphic rock" will go in an envelope labeled "metamorphic." (You can reuse the envelopes used earlier to hold the crayon fragments.) If you are breaking the activity into sections, stop here and label each group's pie pan for proper distribution later.

### Part E: Igneous Rock Formation

> **Safety Note:** This portion of the activity requires that the students be especially safety conscious as they will be working with a hot plate and melted wax.

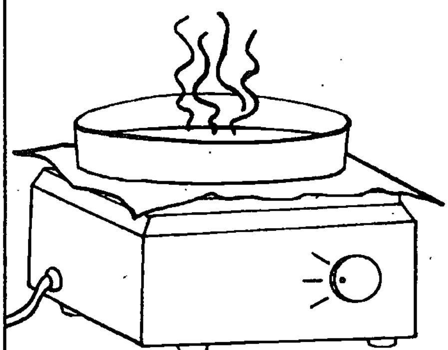
Each group should line their remaining two pie pans with aluminum foil and do the following:

Groups 1 and 2 should each fill one of their pie pans with crushed ice.

Group 3 should fill one of their pie pans halfway with warm water.

Group 4 should place the "weathered fragments" and the smaller pieces of "sedimentary and metamorphic rocks" they saved earlier into one of their foil-lined pie pans. (Groups 1, 2, and 3 will save their fragments and "rock" pieces for comparison with "igneous rocks" they will make during this part of the activity.)

For the igneous rock simulation, all groups should place the "weathered sediments" they set aside in envelopes, plus the larger piece of "metamorphic rock," into one of their foil-lined pie pans. ***Be Especially Careful Here!*** This part of the activity requires a hot plate as a heat source. ***Students Should Avoid Dropping Wax Fragments on the Hot Plate Surface or Themselves.*** The students or teachers doing this portion of the activity should wear protective oven mittens to avoid being burned. Cover each hot plate surface with a layer of foil before you turn it on. (This will diffuse the heat from the coils of the hot plate so the crayons will not burst into flames.) Each group should place their pie pan of "weathered sediments" and "metamorphic rock" on the hot plate and turn the hot plate temperature to medium. Melt the wax, being careful that the melting process does not occur so rapidly that the molten wax splatters or burns. When most of the "rock" and "weathered sediments" are in the molten state, turn the hot plate off and carefully remove the pie pan, using the oven mittens. There is enough heat energy in the molten wax to melt the remaining solid mass. Caution: ***Do not let the wax heat to the splattering point!***



While the wax is still in the molten state, representing **magma**, a student from each group, or the teacher, should CAREFULLY do the following:

Group 1 - Form a trench in the ice which has been placed in their second pie pan. Using the oven mittens, pour the melted wax into the ice trench, then cover the "magma" with more crushed ice. This simulates **intrusive igneous rock**, which is formed by magma flowing into rock cracks deep inside the Earth.

Group 2 - Using the oven mittens, pour the melted wax (lava) directly over the surface of the crushed ice. This will simulate the formation of **extrusive igneous rock.**

Group 3 - Using the oven mittens, pour the melted wax into the warm water. This will simulate the formation of extrusive igneous rock in a warm water region, i.e. a **volcano** that forms under the ocean.

Group 4 - Using the oven mittens, pour the melted wax over the "weathered sediments" and the small pieces of "sedimentary and metamorphic rock" from sections B and C. This simulates **lava** flowing over sediments, sedimentary and/or metamorphic rock, as would happen in a volcanic eruption. Some of the fragments will melt quickly, while the "sedimentary and metamorphic rocks" will at least partially maintain their integrity. During a volcanic eruption, lava will flow over and around rocks in its path, causing some to melt, while others remain as they were originally. These rocks that are surrounded by lava are called **xenoliths**.

Allow the pie pans and wax to cool thoroughly (about 5 to 10 minutes). After the "lava" wax has cooled, the students should carefully remove their "igneous rock" from the pie pans. Students should make comparisons between the igneous rock in each group's pie pans, then draw and write their

observations on their worksheet. For instance, comparisons should be made between the crystal sizes and shapes formed by each of the group's cooled magma. Comparisons should also be made between these "igneous rocks" and the "sediments" and the "sedimentary and metamorphic rocks" students created in the previous sections of this activity.

As a class be sure to discuss the following:

Using Group 1's pie pan, discuss the effect of the "magma" on the sedimentary or metamorphic "rock" which the ice represents.

Using Group 2's pie pan, discuss the effect of "lava" on the surface "sediments" and "rocks" which the ice represents.

Using Group 3's pie pan, discuss the effect of the warm water on the "lava."

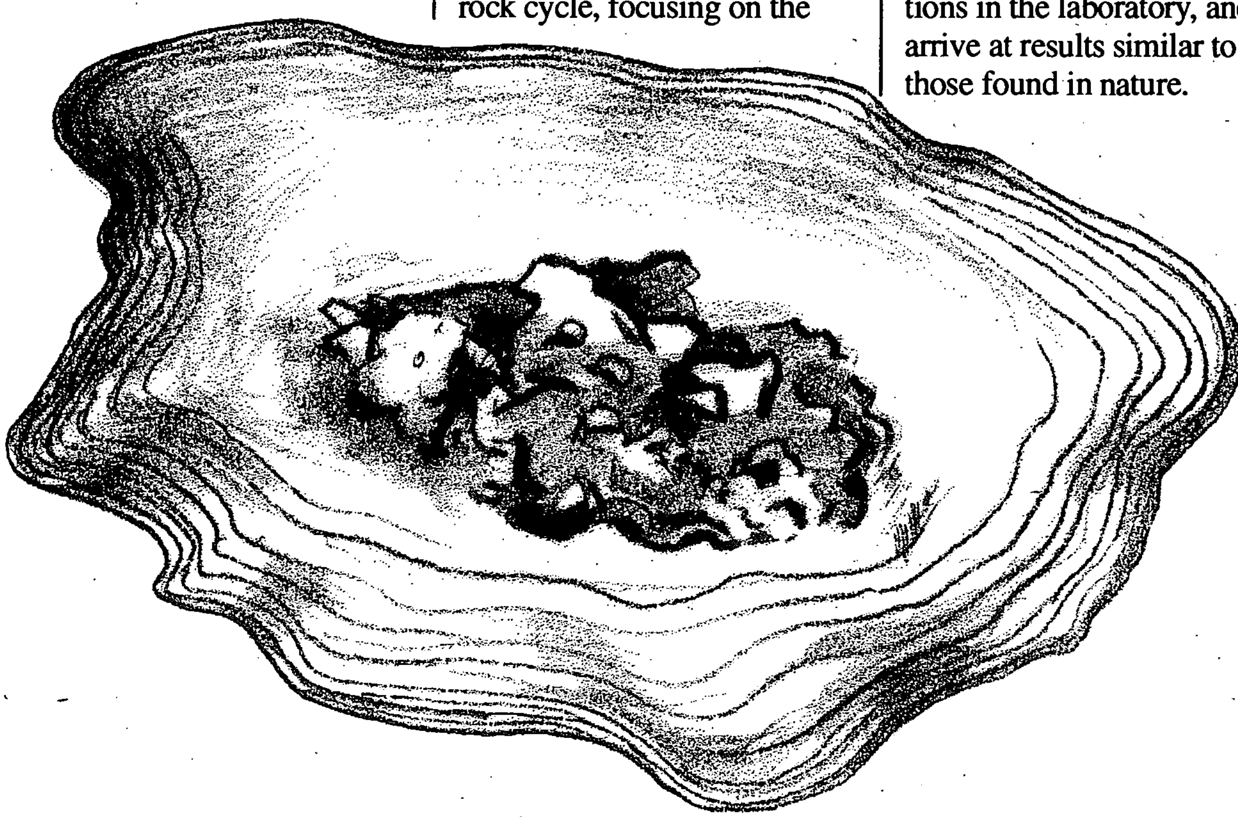
Using Group 4's pie pan, discuss the effect of the "lava" flowing directly onto the sedimentary and metamorphic "rock" and "sediments."

If possible, show the students various examples of real **volcanic rocks** and compare the real rocks with their igneous "crayon rocks." Remind the students that most of the rock visible at Mount Jefferson State Park were first volcanic, eroded to sediments then compressed into sedimentary and finally, with the collision of North America and Africa, were pressed into metamorphic rock. These rocks have formed deep within the Earth. The processes of weathering and erosion have exposed them to our view and shaped the landscape into what we see today.

While the students are looking at the three types of rocks, lead a discussion on the rock cycle, focusing on the processes they observed in action to transform one rock into the next. Have the students discuss the differences and similarities between their "crayon rocks" and the real rock samples. Talk about the questions your students had when the activity first started.

Reiterate the concept of the rock cycle by reminding the students of the "rocks" (crayons) that were weathered down into "sediments", compressed into "sedimentary rock" and then "metamorphic rock" and then melted into "igneous rocks."

It is important for everyone to understand that not all conditions for rock formations can be simulated. In fact, geologists have never "seen" intrusive rocks form. However, they are able to look at all of the available evidence, simulate some of the conditions in the laboratory, and arrive at results similar to those found in nature.



# Student's Information

**Rocks** forming the **Earth's crust** are classified according to their origin. There are three basic rock classifications. Of these three, two (**igneous** and **metamorphic**) are formed by geologic processes occurring deep within the Earth. The other, **sedimentary**, is formed closer to the Earth's surface. The relationship between these three rock classifications is what is generally considered the **rock cycle**. (The rock cycle is discussed below.)

1. **Sedimentary rock** - rock that is composed of tiny particles of sand, clay or other **sediments** that are deposited in layers on land or on the bottom of lakes, rivers and oceans. Over time, the extreme pressure from the weight of the layers above presses the deposition into rock, or the sedimentary particles are cemented together. Examples are limestone, **sandstone** and shale.

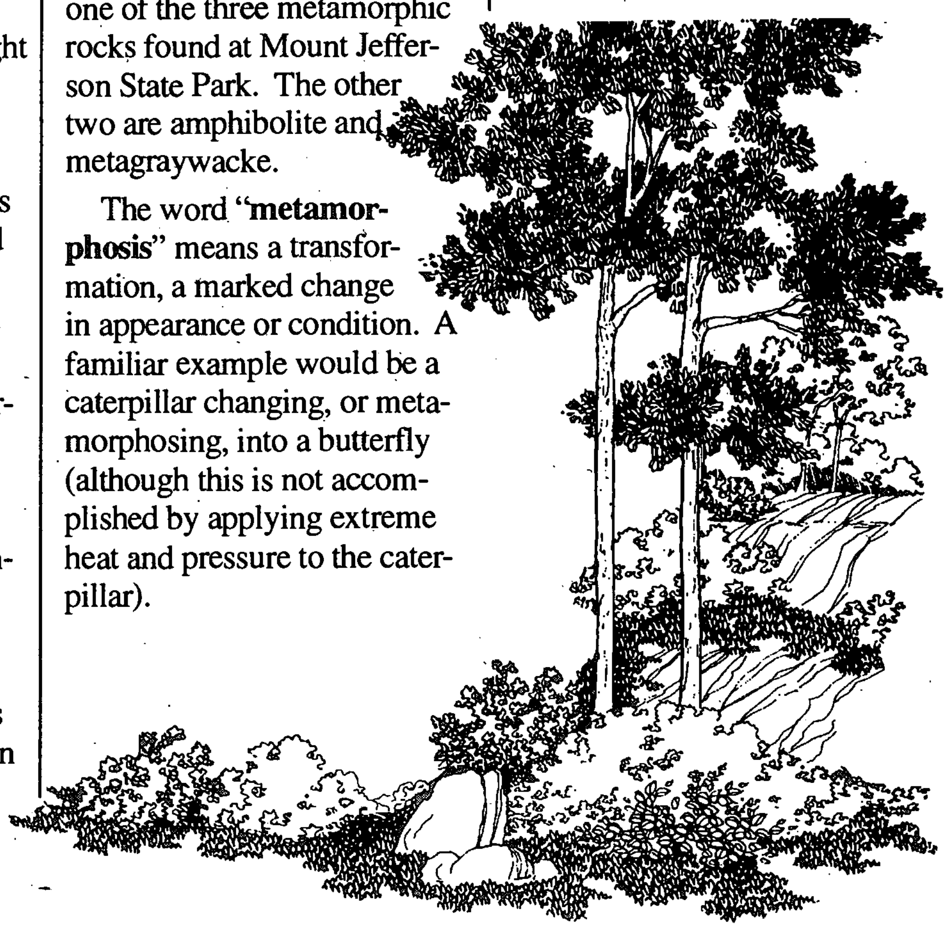
Sedimentary rocks are important when discussing the rock cycle and are also important in the understanding of how metamorphic rock is formed. The metamorphic rock of the Blue Ridge Mountains was formed when sedimentary rock layers were subjected to extremely high temperatures and tremendous pressure. The chemical action of solutions and gases during the last 540 million years of the Earth's dynamic activity played a part as well.

There is no sedimentary rock at Mount Jefferson. There is sedimentary rock in the eastern part of the state. A good example of sedimentary rock can be seen at Cliffs of the Neuse State Park in Seven Springs, North Carolina.

2. **Metamorphic rock** - sedimentary or igneous rock that has been changed deep inside the Earth by extreme heat and pressure over a long period of time into a harder rock with different qualities. An example of sedimentary rock which was changed to a metamorphic rock is Schist, which is made from mudstone. Schist is a major rock type found throughout the Blue Ridge Mountains and is one of the three metamorphic rocks found at Mount Jefferson State Park. The other two are amphibolite and metagraywacke.

The word "**metamorphosis**" means a transformation, a marked change in appearance or condition. A familiar example would be a caterpillar changing, or metamorphosing, into a butterfly (although this is not accomplished by applying extreme heat and pressure to the caterpillar).

3. **Igneous rock** - rock formed from **magma**, solidified from a molten state. It can be extrusive or intrusive. **Extrusive igneous rock** is formed when magma spews out onto the Earth's surface from cracks or **vents** in the Earth's crust. This type of magma is called **lava**. **Intrusive igneous rock** is formed when magma finds its way into cracks in the rock and solidifies within the Earth. There are no intrusive igneous rocks at Mount Jefferson. A good example of intrusive igneous rock can be seen at Stone Mountain State Park, located in Wilkes County at Traphill, North Carolina.



## The Rock Cycle

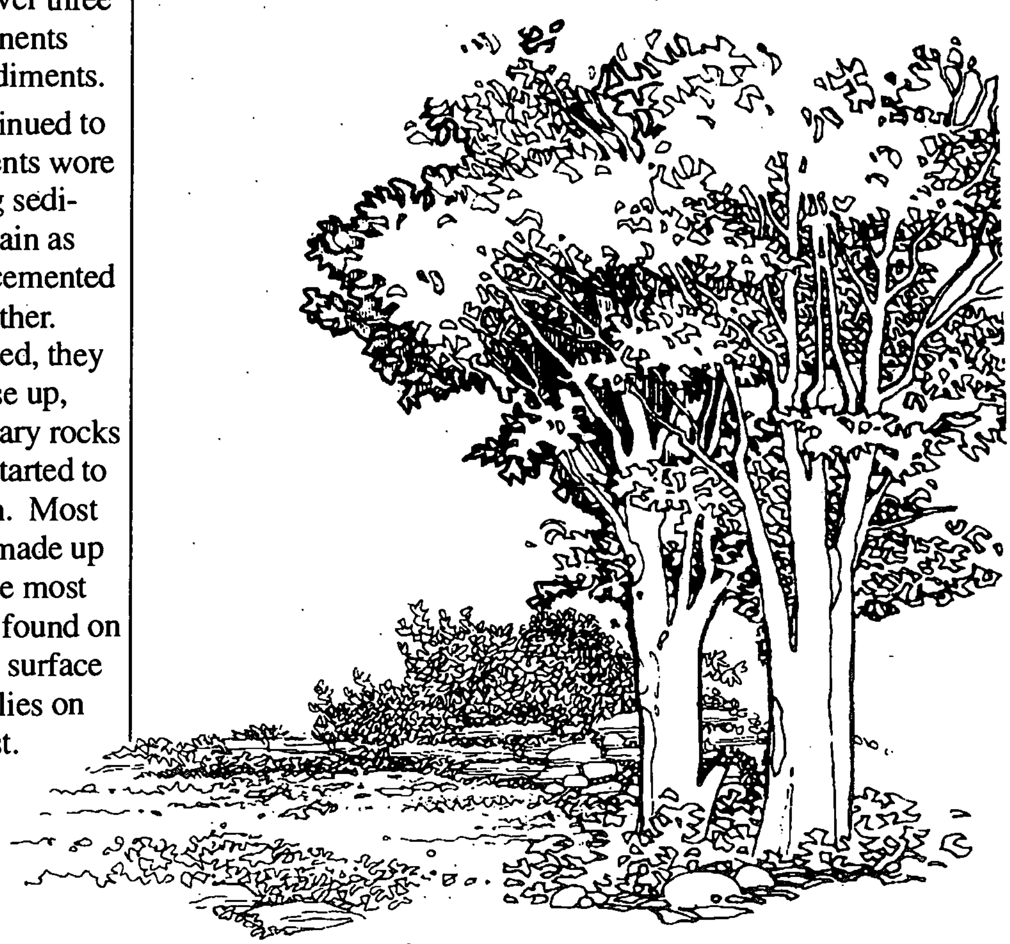
Geologists believe that at one time the Earth was a ball of molten magma and gases. As the Earth cooled, the outermost layer of magma solidified into a crust of igneous rock. Today, the Earth's crust is 30 miles thick in some places, yet in others it is so thin that lava can spew up through cracks.

Even as the first rocks cooled, **weathering** began breaking them down into sediments which were **eroded** away by wind and water. Those first sediments were deposited at the edges of the continents in the first oceans. The eroded rock particles traveled more quickly than they do today, as there were no plants to stabilize these first soils. For over three billion years, the continents were bare rock and sediments.

The sediments continued to build up as the continents wore down. The underlying sediments became rock again as the pressure and heat cemented the particles back together. As the continents eroded, they became lighter and rose up, exposing the sedimentary rocks to the air, where they started to erode away once again. Most of the Earth's crust is made up of igneous rock, but the most common class of rock found on the Earth's continental surface is sedimentary, which lies on top of the igneous crust.

The continents are not stationary but drift about on top of the molten **mantle** which is beneath the crust. The North American continental plate is moving westward, causing the crust at the leading edge of the Pacific plate to slide underneath the continental plate. This pushes the crust down far enough that it melts, turning into magma. (The collision of the Pacific and continental plates is what pushed up the Rocky Mountains.) This type of collision causes sedimentary and igneous rocks caught in it to be under tremendous heat and pressure, enough so that a third class of rock is formed: metamorphic. Eventually the metamorphic rock will reach the Earth's surface where it will be subjected to weathering.

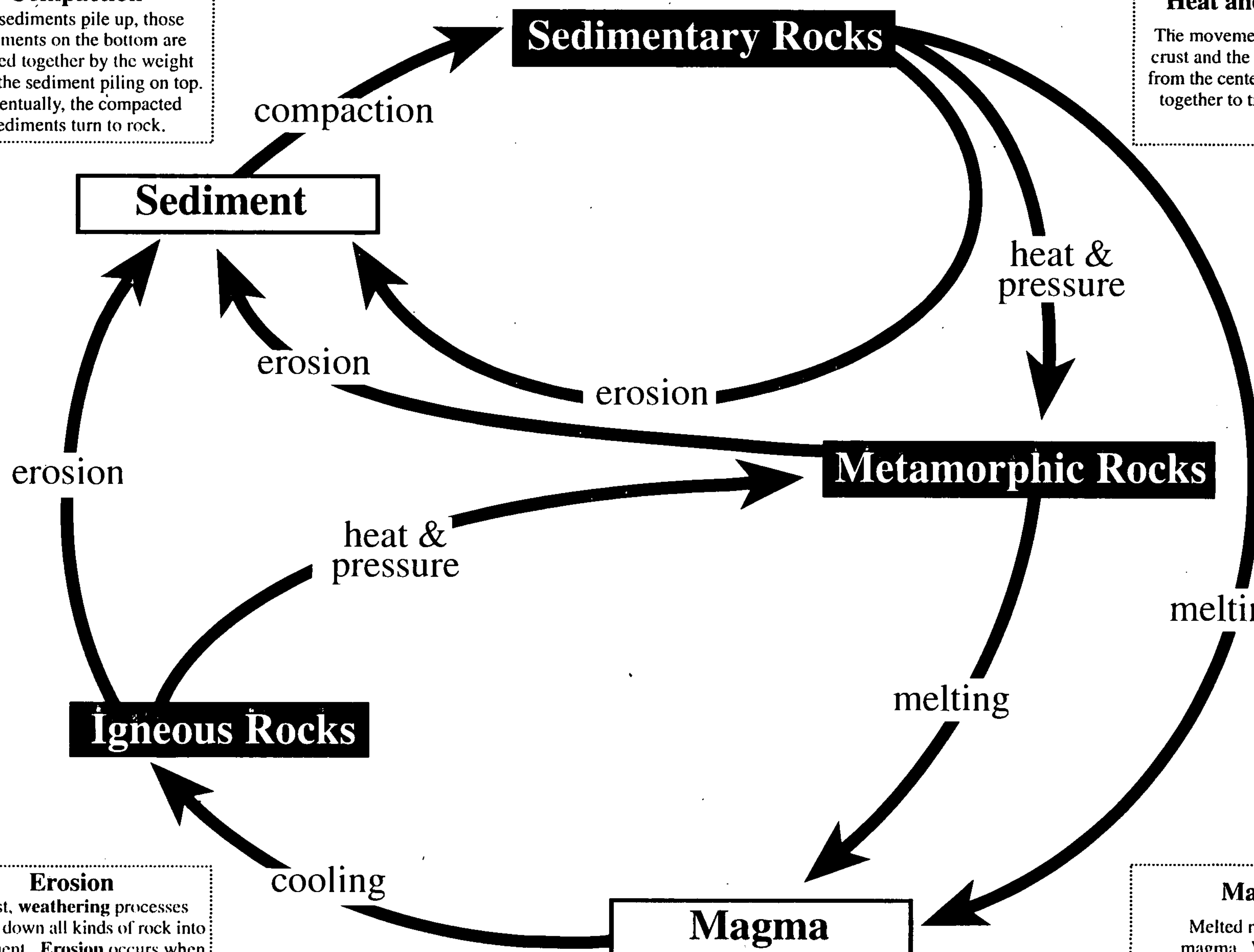
The continuing cycle of rocks melting down and then cooling into rocks again, or breaking down and then being pressed into rocks again has happened many times. It is hard to imagine, but all the rocks you see around you were once sediments at the bottom of the sea, and one day the particles in these rocks will be washed there again. It is also difficult to imagine something as hard as a rock breaking down, or the time it takes for this to happen. It has been estimated that the particles in the rocks that make up Mt. Everest, the highest mountain in the world, have eroded to the sea at least three times.



# Rock Cycle Worksheet

**Compaction**
As sediments pile up, those sediments on the bottom are packed together by the weight of all the sediment piling on top. Eventually, the compacted sediments turn to rock.

**Heat and Pressure**
The movement of the Earth's crust and the tremendous heat from the center of the Earth act together to transform rocks.




**Erosion**
First, **weathering** processes break down all kinds of rock into sediment. **Erosion** occurs when wind, water, ice and snow carry these sediments away.

**Magma**
Melted rock is called magma. When magma comes out of a volcano, it is called lava.

# "Rainbow Rock" Worksheet

1. Describe and draw the "weathered sediments" that you made. Note the sizes and shapes of the "sediments."

2. Do a colored drawing of the "rock fragments" after light pressure has compacted these "sediments" into "sedimentary rock." Describe the broken edge and the layers that are formed.

3. Do a colored drawing of the "sedimentary rock" after heavy pressure has compacted it into "metamorphic rock." Describe the broken edge and the layers that are formed. How have they changed with the addition of heavy pressure?

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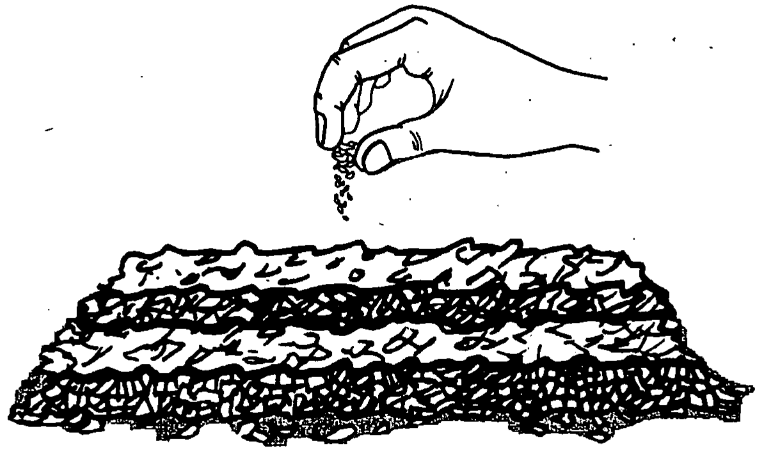
4. Do a colored drawing of each of the four "igneous rocks" created. Compare and contrast the formation of the extrusive with the intrusive igneous rocks.

| Group One's "Igneous Rock" | Group Two's "Igneous Rock" |
|---|---|
| | |
| **Group Three's "Igneous Rock"** | **Group Four's "Igneous Rock"** |
| | |

5. Write a comparison between the "weathered rock fragments," "sedimentary rocks," "metamorphic rocks," and "igneous rocks" formed in this activity. Describe their similarities and differences as to color, texture, etc.

# "Rainbow Rock" Answer Sheet

1. Describe and draw the "weathered sediments" that you made. Note the sizes and shapes of the "sediments."



2. Do a colored drawing of the "rock fragments" after light pressure has compacted these "sediments" into "sedimentary rock." Describe the broken edge and the layers that are formed.


3. Do a colored drawing of the "sedimentary rock" after heavy pressure has compacted it into "metamorphic rock." Describe the broken edge and the layers that are formed. How have they changed with the addition of heavy pressure?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4. Do a colored drawing of each of the four "igneous rocks" created. Compare and contrast the formation of the extrusive with the intrusive igneous rocks.

| Group One's "Igneous Rock" | Group Two's "Igneous Rock" |
|---|---|
| | |
| **Group Three's "Igneous Rock"** | **Group Four's "Igneous Rock"** |
| | |

5. Write a comparison between the "weathered rock fragments," "sedimentary rocks," "metamorphic rocks," and "igneous rocks" formed in this activity. Describe their similarities and differences as to color, texture, etc.

*The "weathered rock fragments" will vary in size and shape, depending on the implement used and how it is used. The "rock fragments" can be oriented (up/down or right/left) in any direction. In the "metamorphic rocks" the space between the fragments is very small and the orientation of "fragments" is now flattened (right/left). The thickness is much thinner, but each layer of rock (color) can still be seen. The "igneous rock" is grayish-black due to the melting and mixing of different "rock fragments" and has a variety of forms, depending on how the separate groups' rocks were cooled.*

***Note: The different methods of cooling are not intended to simulate real rock formations: they do, however, give the students the understanding that different cooling conditions will create different rocks.***

# Pre-Visit Activity #2. Belting It Out

**Major Concepts:**
- Physiography
- Geologic belt
- Geologic time

**Learning Skills:**
- Observing, communicating and inferring
- Reading and interpreting maps
- Estimating distances
- Reading tables

**Subject Areas:**
- Science
- Social Studies
- English Language Arts
- Math
- * See **Activity Summary** for a Correlation with DPI objectives in these subject areas.

**Location:** Classroom

**Group Size:** 20 - 30 students in groups of 5 or less

**Estimated Time:** One to two class periods

**Materials:**
Provided by the educator
Per Group: NC Rock Kit,* or other samples of common North Carolina rocks and minerals, "Generalized Geologic Map of North Carolina,"* ruler, calculator
Per Student: one copy of Student's Information and worksheet, pencil

* For information on the NC Rock Kit, call Mary Watson at (919) 733-2423. Purchase copies of the "Generalized Geologic Map of North Carolina" at approximately $0.25 each by calling the NC Geological Survey Sales Office at (919) 715-9718. The rock kit and map are available for loan from the park upon request.

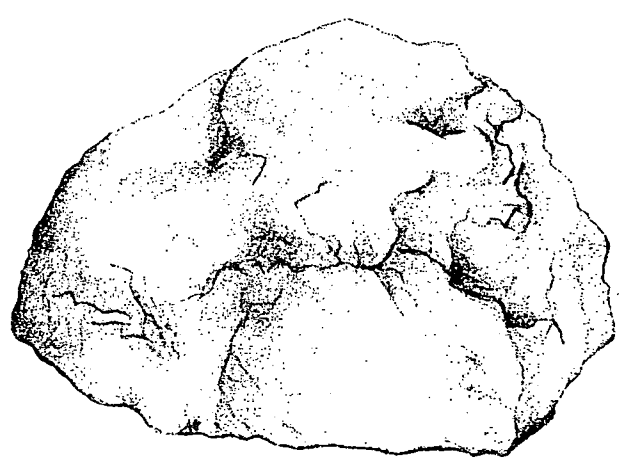
**Credits:** Adapted from the "Using the Geologic Map" activity found in the North Carolina Geological Survey's *Mineral and Rock Kit Guide.*

## Objectives:

- Locate three physiographic provinces and 10 geologic belts on a geologic map of North Carolina.
- Compare and contrast the three physiographic provinces in North Carolina.
- Use a geologic map to determine rock types and approximate age or formation for given locations in North Carolina.
- List at least seven rocks and minerals that are mined in North Carolina and locate major sources on a geologic map.
- Using a map scale and ruler, estimate distances on a state geologic map.

## Educator's Information:

The purpose of this activity is to introduce students to the "Generalized Geologic Map of North Carolina." They will use this map to answer questions about rock types across the state, geologic age of various formations, and the location of economically valuable **rocks** and **minerals.** Students will also compare the general **geology** of Mt. Jefferson State Natural Area with the school. For more information about **geologic time** and how **geologists** determine the age of rock formations, see Post-Visit Activity #2.



## Instructions:

**1.** Purchase and laminate copies of the "Generalized Map of North Carolina." For a class size of 28, you will need at least seven maps. Teachers living near Mt. Jefferson State Natural Area can borrow maps from the staff. Call for availability.

**2.** Create small learning teams of two to four students per group. Give each group the "Generalized Geologic Map of North Carolina," a ruler and a calculator. Give each student a copy of the Student's Information. Read and discuss the Student's Information, making sure the students understand the terms **physiographic province** and **geologic belt**. The Student's Information is designed to help you provide guided practice in using the map to find the types and ages of rocks, locate economically valuable rocks and minerals, and calculate distances. Can students locate their school and Mt. Jefferson State Natural Area on the geologic map? Hint: Mt. Jefferson lies in southern Ashe County.

**3.** Give each student the Belting It Out — Worksheet. Encourage students to work together to find the answers, but each student should fill out his/her own worksheet.

**4.** Discuss the correct answers to the worksheet. Compare the geology of Mt. Jefferson with your school. Are the rock types similar or different? What about the ages of the rock formations? Is your school located in the same physiographic province and geologic belt as Mt. Jefferson? If not, how are they different? Are there economically valuable rocks and minerals near your school?

**5.** If you are planning to take your students to Mt. Jefferson for a field trip, ask them to draw a sketch or write a paragraph describing the **physiography** and geology of Mt. Jefferson based on the "Generalized Geologic Map of North Carolina." After the field trip, you can return these descriptions to the students and ask them if the real Mt. Jefferson was anything like their descriptions. Why or why not?

## Assessment:

Ask each student to develop a Jeopardy-style Answer and Question based on the "Generalized Geologic Map." Use these questions to quiz the whole class, or divide the class into teams and have a contest. For a pencil and paper quiz, ask students to compare the three physiographic provinces in North Carolina in terms of their topography, rock types and ages of formation, and economically valuable rocks and minerals.

## Extensions:

**1.** After the students have finished the worksheet, pass out (one per group) the following specimens from the NC Rock Kit: limestone, dunite, spodumene pegmatite, gneiss, granite, diabase and pyrophyllite. The specimens should be passed out, one at a time, to avoid misidentification problems. (Individual specimens are not labeled in the kit.) Ask students to use the "Origins of Some North Carolina Rocks and Minerals" in the Student's Information to discover the geologic belt where each specimen is located. Place each specimen on the "Generalized Geologic Map of North Carolina" in its approximate location. Note: You can substitute the large wall map, "Geologic Map of North Carolina," and do this as a whole class activity. Make sure the map is laminated and place it on a table or counter in the classroom. Give each group one of the samples from the rock kit. Each group should place their specimen in the proper location on the map. This could be used as a classroom display during the geology unit.

**2.** Display specimens of the common rocks in the Ashe Metamorphic Suite in your classroom: metagraywacke, mica schist, amphibolite and gneiss. Ask students to observe the specimens carefully; provide a hand lens. To help students really observe, require that they make a sketch of each specimen. Will students be able to recognize these rocks when they come to Mt. Jefferson? Can they find similar rocks in their backyard or on the school grounds?

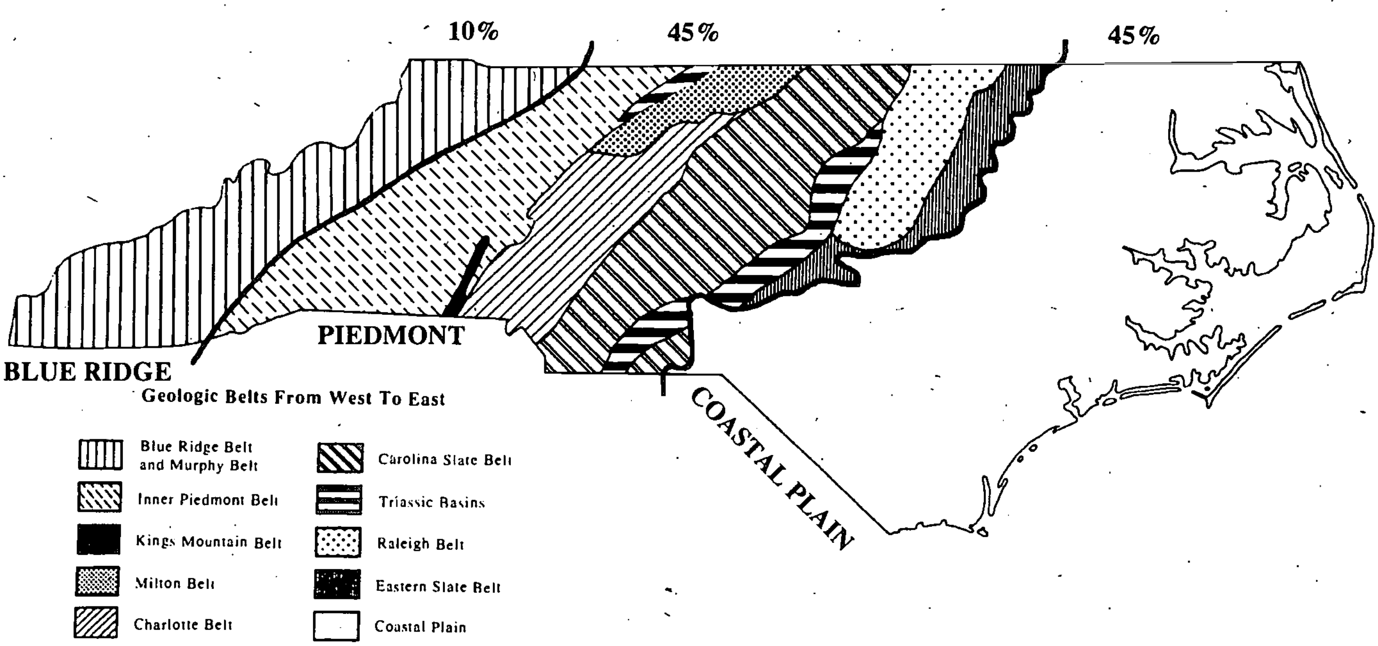
# Student's Information

In this activity, you will be using the "Generalized Map of North Carolina" to help you learn about rock types at Mt. Jefferson State Natural Area and many other locations in the state. North Carolina can be divided into three **physiographic provinces**: Coastal Plain, Piedmont and Blue Ridge. (**Physiography** is the study of the physical features of the Earth's surface, how they formed and how they have changed over time.) Each province has particular types of landforms and contains one or more **geologic belts**. A geologic belt is an area with similar rock types and geologic history. The **rocks** in each belt formed at approximately the same time and in the same manner.

Examine the map on this page while you read about each of the three provinces. (This map is basically the same map shown on the back of the "Generalized Geologic Map" in the lower left section.) Covering about 45 percent of the state, the Coastal Plain Province has flat land to gently rolling hills and valleys. It includes only one geologic belt, made mostly of marine **sedimentary rocks** that are partially covered by sand and clay **sediments**.

The Piedmont Province has gently rolling, well-rounded hills and long low ridges. The elevation difference between the hills and valleys is, on average, only a few hundred feet. However, the Sauratown Mountains in Stokes and Surry counties are notable exceptions, rising from 1,700 to 2,500 feet above the surrounding countryside. This province is geologically diverse with eight different geologic belts. Can you find all eight belts? Notice that the Kings Mountain belt in southwestern North Carolina is very small; it looks like a black finger wedged between the Inner Piedmont and the Charlotte belts. Most of the rocks in the Piedmont are **metamorphic rocks**. However, the Triassic basins contain sedimentary rocks and other Piedmont areas have granite, an **intrusive igneous rock.**

The Blue Ridge Province covers only 10 percent of the state and has steep, rugged mountains. In fact, it has the highest elevations and most rugged topography of the entire Appalachian Mountain system. With an elevation of 6,684 feet, Mt. Mitchell in

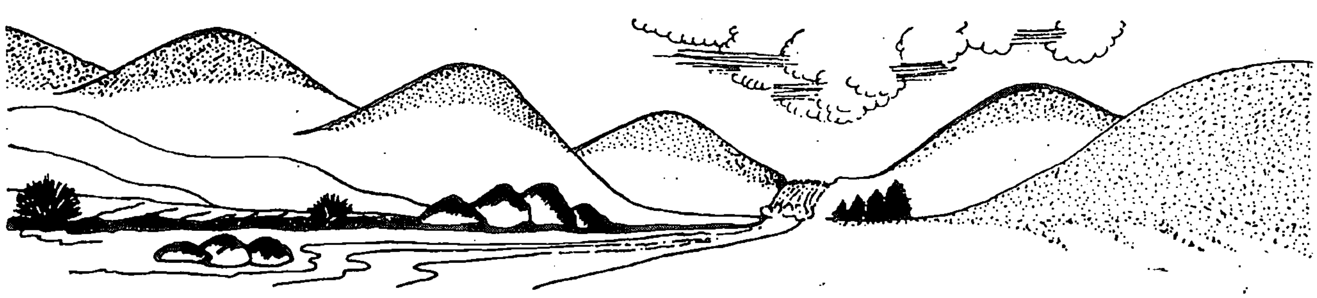


Yancey County is the highest mountain in the eastern United States. The Blue Ridge has only one geologic belt composed of metamorphic rocks over one billion years old. Mt. Jefferson State Natural Area is located in the Blue Ridge Province. In which province is your school located?

Now find your group's copy of the "Generalized Geologic Map of North Carolina." This map uses colors and symbols to illustrate the major rock types found at the surface. The legend below the map has colored blocks with rock names listed to the right of each block, and rock ages listed to the left of each block. For example, use the map to find Randolph County in the center of the state. You will see three different colors, indicating three rock types, within this county. Locate the light-blue box in the legend below the map. The text to the right of this box tells you that the light-blue area on the map contains **metavolcanic rocks** of the Carolina Slate belt. To the left of the box, you can see the age of these rocks — from late Proterozoic to early Paleozoic. If you are not familiar with geologic ages, turn the map over and read the "Geologic Time Scale for North Carolina." In this chart, late Proterozoic was 900 million years ago, while early Paleozoic (also called Cambrian) was 570 million years ago. Thus, the ages of the metavolcanic rocks in the Carolina Slate belt are from 570 to 900 million years old! Can you discover the name and age of the rocks near your school? Near Mt. Jefferson State Natural Area in Ashe County?

You can calculate distances on the "Generalized Geologic Map of North Carolina" by using the map scale. A map scale shows the relationship between linear distance on a map and the corresponding distance on the actual land surface. Find the map scale in the lower right section of the map. On this map, 1.5 inches equals 50 miles of actual land surface. How many miles is it from Asheville to Raleigh, in a straight line? Use a ruler to measure the distance between Raleigh and Asheville on the map. (Answer: 6.5 inches) If 1.5 inches = 50 miles, how many miles does 6.5 inches represent? (Answer: 6.5" ÷ 1.5" = 4.33; 4.33 x 50 miles = 217 miles)

You can learn more about economically important rocks and **minerals** in our state by using the "Principal Mineral-Producing Areas" map and legend. Find it on the back of the "Generalized Geologic Map of North Carolina" in the lower right section. This small map will help you locate rocks and minerals mined in North Carolina. Deposits of metals or minerals that are concentrated enough to be economically valuable are called **ores**. Because an ore contains larger amounts of the desired mineral than an average rock, the ore can be mined for profit. The following chart, "Origins of Some North Carolina Rocks and Minerals," will assist you in placing the economically valuable rocks and minerals within their correct geologic belts.



# Origins of Some North Carolina Rocks and Minerals

| Specimen | Mineral or Rock Type | Origin |
|---|---|---|
| limestone | sedimentary | Coastal Plain |
| dunite | igneous | Blue Ridge Belt |
| spodumene pegmatite | igneous | Kings Mountain Belt |
| gneiss | metamorphic | Inner Piedmont Belt |
| granite | igneous | Raleigh Belt |
| diabase | igneous | Triassic Basins |
| pyrophylite | mineral | Carolina Slate Belt |
| conglomerate | sedimentary | Coastal Plain |

# Belting It Out — Worksheet

Student Name: ______________________________

**(Use Geologic Belts From West to East for questions 1 through 6.)**

**1.** North Carolina is divided into 10 geologic belts that trend northeast-southwest. List their names.

**2.** Which geologic belt is the largest? ______________________________

**3.** The eastern half of the Piedmont is divided into four geologic belts. List their names. ____________________ ____________________ ____________________ ____________________

**4.** List the remaining four geologic belts in the western Piedmont, in any order:

________________ ________________ ________________ ________________

**5.** Mount Jefferson State Natural Area (Ashe County) is located in which geologic belt? ________________

**6.** In which geologic belt is your school located? ________________________

**(Use the Principal Mineral-Producing Areas map for questions 7 - 9)**

**7.** Name two economic materials mined in the Coastal Plain: ______________ and ______________

**8.** What materials are mined in the Charlotte Belt in Mecklenburg County? ________________________________________

**9.** Gemstones are mined in which two counties? ____________ and ____________

**10.** Mica and kaolin are mined in what two geologic belts? ____________ and ________________________

**(Use the Generalized Geologic Map of North Carolina for questions 11 - 16)**

**11.** What four rock formations occurred during the Cretaceous Period, 66 - 138 million years ago? ____________________ ____________________

____________________ ____________________

**12.** Mt. Jefferson State Natural Area (southern Ashe County) has metasedimentary and metavolcanic rocks of the _____ ___________ Suite, which includes rocks such as gneiss, ______, metagraywacke, ___________, and calc-silicate granofels.

**13.** How many counties, other than Ashe County, have rocks that are similar in age and composition to the rocks at Mt. Jefferson? Hint: Look for the "green zone."

______________ List the counties below.

**14.** The dark burgundy (deep red) color on the map indicates what type of rock?

____________________________

**15.** The lavender (light purple) color on the map indicates what type of rock?

____________________________

**16.** Using the map scale and a ruler, determine the distance between Charlotte and Cape Lookout, in a straight line. Hint: 1.5 inches = 50 miles

________________

Now find the straight-line distance between Winston-Salem and Asheville.

________________

**(Use the Generalized Geologic Map of North Carolina and Geologic Time Scale for North Carolina to answer questions 17 - 21)**

**17.** How old are the rocks in Ashe County? Express your answer as a range in millions of years. ____________________

**18.** What rocks in Ashe County are older — the felsic gneiss found in northern Ashe

County **OR** the metasedimentary and metavolcanic rocks found in southern Ashe County? ____________________

**19.** The Geologic Time Scale for North Carolina gives the age of the oldest dated rock in North Carolina. What is it in millions of years? Hint: Look toward the bottom of the chart. ____________________

**20.** During which geologic PERIOD did the Atlantic Ocean form and erosion of the Piedmont and Appalachian Mountains occur? ____________________

How many millions of years ago did this happen? ____________________

**21.** What is the approximate age of the Earth in millions of years? ____________________

# Belting It Out — Answer Sheet

Student Name: ____________________

**(Use Geologic Belts From West to East for questions 1 through 5)**

**1.** North Carolina is divided into 10 geologic belts that trend northeast-southwest. List their names.

Blue Ridge Belt
Inner Piedmont Belt
Kings Mountain Belt
Milton Belt
Charlotte Belt
Carolina Slate Belt
Triassic Basins
Raleigh Belt
Eastern Slate Belt
Coastal Plain

**2.** Which geologic belt is the largest? Coastal Plain

**3.** The eastern half of the Piedmont is divided into four geologic belts. List their names.

Eastern Slate Belt, Raleigh Belt, Triassic Basins, Carolina Slate Belt

**4.** List the remaining four geologic belts in the western Piedmont, in any order:

Inner Piedmont, Kings Mountain, Milton, Charlotte

**5.** Mount Jefferson State Natural Area (Ashe County) is located in which geologic belt? Blue Ridge

**6.** In which geologic belt is your school located? answers will vary

**(Use the Principal Mineral-Producing Areas map for questions 7 - 9)**

**7.** Name two economic materials mined in the Coastal Plain: phosphate and peat

**8.** What materials are mined in the Charlotte Belt in Mecklenburg County? crushed stone, sand & gravel

**9.** Gemstones are mined in which two counties? Macon and Alexander

**10.** Mica and kaolin are mined in what two geologic belts? Blue Ridge and Inner Piedmont

**(Use the Generalized Geologic Map of North Carolina for questions 10 - 15)**

**11.** What four rock formations occurred during the Cretaceous Period, 66 - 138 million years ago? Peedee Formation, Black Creek Formation, Middendorf Formation, Cape Fear Formation

**12.** Mt. Jefferson State Natural Area (southern Ashe County) has metasedimentary and metavolcanic rocks of the Ashe Metamorphic Suite, which includes rocks such as gneiss, schist, metagraywacke, amphibolite, and calc-silicate granofels.

**13.** How many counties, other than Ashe County, have rocks that are similar in age and composition to the rocks at Mt. Jefferson? Hint: Look for the "green zone."

17 List the counties below:

(Surry, Alleghany, Wilkes, Watauga, Caldwell-a tiny strip, Avery, Burke, McDowell, Mitchell, Yancey, Buncombe, Henderson, Haywood, Transylvania, Jackson, Macon, Madison- a tiny strip)

**14.** The dark burgundy (deep red) color on the map indicates what type of rock? Metamorphosed granitic rock

**15.** The lavender (light purple) color on the map indicates what type of rock? Metasedimentary and metavolcanic rocks of the Kings Mountain Belt

**16.** Using the map scale and a ruler, determine the distance between Charlotte and Cape Lookout, in a straight line. Hint: 1.5 inches = 50 miles

242 miles (7.25 inches ÷ 1.5 inches = 4.83; 4.83 x 50 miles = 242 miles)

Now find the straight-line distance between Winston-Salem and Asheville.

134 miles (4 inches ÷ 1.5 inches = 2.67; 2.67 x 50 miles = 133.5 miles)

**(Use the Generalized Geologic Map of North Carolina and Geologic Time Scale for North Carolina for questions 17 - 21)**

**17.** How old are the rocks in Ashe County? Express your answer as a range in millions of years.

570 to 1600 million years old

**18.** What rocks in Ashe County are older -- the felsic gneiss found in northern Ashe County **OR** the metasedimentary and metavolcanic rocks found in southern Ashe County? the felsic gneiss found in northern Ashe is older

**19.** The Geologic Time Scale for North Carolina gives the age of the oldest dated rock in North Carolina. What is it in millions of years? Hint: Look toward the bottom of the chart. 1,800 million years old

**20.** During which geologic PERIOD did the Atlantic Ocean form and erosion of the Piedmont and Appalachian Mountains occur? Triassic Period

How many millions of years ago did this happen? 220 - 240 million years ago (estimated)

**21.** What is the approximate age of the Earth in millions of years? About 4,500 millions years old

# Pre-Visit Activity #3 Mt. Jefferson's Crystals

**Major Concepts:**
- Mineral properties
- Crystal shape

**Learning Skills:**
- Observing and classifying
- Making models of 3-D geometric shapes
- Following directions to create a product

**Subject Areas:**
- Science
- Mathematics (Geometry)
- English Language Arts
- * See **Activity Summary** for a Correlation with DPI objectives in these subject areas.

**Location:** Classroom

**Group Size:** 20 - 30 students

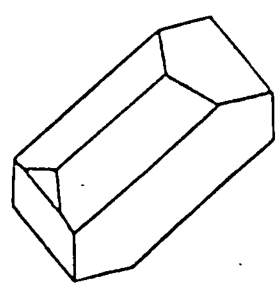
**Estimated Time:** One class period

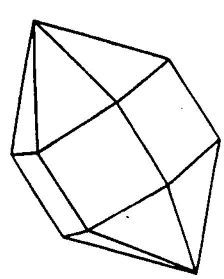
**Materials:**
FIRST DAY —
Provided by the educator:
Per Group: 3 tablespoons of soil, 2 tablespoons of table salt, 1/2 cup of water, saucer, glass, tablespoon, magnifying glass
SECOND DAY —
Per Class: large crystals (or photographs of crystals) of quartz, mica, feldspar, hornblende or other crystals of the teacher's choice; rock specimens with obvious mineral grains; several dissecting scopes
Per Student: one copy of Student's Information, Two-Dimensional Cutouts and Three-Dimensional Cutouts sheets, coat hanger, five pieces of yarn or string, crayons or colored markers, scissors, glue or tape, hand lens

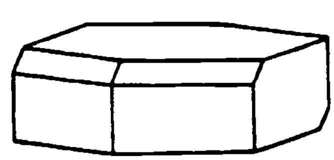
**Credits:** Adapted from the "More About Crystal Shape" activity found in the North Carolina Geological Survey's *Mineral and Rock Kit.*

## Objectives:

- Participate in a group demonstration to grow large crystals of salt (halite) and describe the crystal shape and growth pattern.
- Define mineral and list at least five characteristics that geologists use to identify minerals.
- Observe and describe the crystal shapes of five minerals found in the rocks at Mt. Jefferson State Natural Area.
- Create three-dimensional models of quartz and feldspar crystals.



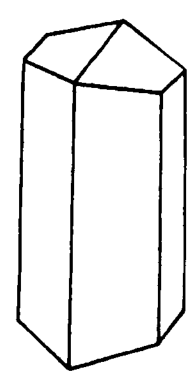




## Educator's Information:

In this activity, students will grow and observe **crystals** of halite (salt). They will learn that **minerals** have unique crystal shapes that can be used for identification. The students will observe the crystal shapes of rock-forming minerals found at Mt. Jefferson: biotite, muscovite, hornblende, feldspar and **quartz**. They will make mobiles of the five shapes and build three-dimensional models of the two most common minerals, quartz and feldspar.

In conjunction with this activity, teachers may wish to use the Student's Information and Rock and Mineral Classification Fact Sheet provided in On-Site Activity #1. These materials address the difference between **rocks** and minerals and detail the characteristics that **geologists** use when classifying rocks and minerals.



**Instructions:**

**FIRST DAY**

**1.** Divide the class into groups of three to five. Distribute the materials to each group.

**2.** Ask each group to spread about three tablespoons of **soil** out in their saucer.

**3.** Ask them to fill their glass about half full with warm water, add two tablespoons of salt, and stir for several minutes until most of the salt has dissolved.

**4.** Tell the groups to set their saucers in a warm place. Then, a member of each group should pour the salt water over the soil very slowly. Once this is done do not disturb the soil for at least one day.

**SECOND DAY**

**1.** When the water in all the saucers has evaporated and the soil is dry, ask the groups to retrieve their saucer and examine the soil under a magnifying glass. Explain to them that the soil has been topped by large crystals of salt called rock salt. Rock salt is formed when minerals are dissolved in water. The salt water is drawn up through small openings in the soil and rocks by **capillary action**. The water then evaporates into the air leaving the salt behind. As the water evaporates, the **molecules** in the salt start to cling together and grow into larger crystals. The slower the evaporation, the larger the crystals.

Ask students to describe or sketch the salt crystals. (The crystals should be cube-shaped. The minerals pyrite and galena also have cubic crystal shapes.)

**THIRD DAY**

**1.** Obtain samples of the following crystals: mica, quartz, feldspar and hornblende. Teachers living near Mt. Jefferson State Natural Area are invited to borrow specimens from the park office. Call for availability. Note that quartz and mica crystals can be found in the NC Rocks Kit given to each school by the NC Geological Survey. Other sources of crystals are scientific supply catalogs or your local gem and mineral club.

**2.** Photocopy the Student's Information, Two-Dimensional Cutouts, and Three-Dimensional Cutouts for each student. Note: You may want to enlarge the cutouts to 129 percent on 11 x 17 paper for larger crystal shapes. Make samples of the crystals on the Three-Dimensional Cutouts.

**3.** Read and/or discuss the Student's Information with the class. Make sure that students can define mineral and list at least five identifying characteristics of minerals. Distribute the Two-Dimensional Cutouts page.

**4.** Show the students a quartz crystal and ask them to count the number of sides on the crystal. (There will be six sides.) What kind of geometric shape is this? (Hexagonal) It may remind them of the six-sided shape that many pencils have. Reinforce that this crystal formed naturally; it was not cut or broken into this shape. Have students locate the quartz crystal shape on the Two-Dimensional Cutout sheet.

**5.** Show the students the other four minerals, one at a time, asking them to find each crystal shape on the Two-Dimensional Cutout sheet. Use dissecting scopes to view the smaller crystals. Discuss:

• Why do crystals of muscovite and biotite look identical?

(They are both in the mica group and have similar chemical formulas; i.e., are composed of nearly the same **elements**.)

• How can you tell them apart in the field?

(By the color – biotite is black.)

• If you are examining small crystals of feldspar and hornblende that make up a **metamorphic rock**, it may be difficult to see a good crystal shape. Why is that? (The crystals formed in a very tightly-packed, restrictive environment. Compare these crystals with crystals that grow inside a pocket or cavity in a rock and so had lots of space to grow. A geode would be a good example of a situation where crystals can grow in an unrestricted space.)

• Both hornblende and feldspar crystals are prismatic, columnar or tabular crystals. How can you tell them apart? (Hornblende crystals are generally stubby, and are longer than feldspar cystals; hornblende is black or dark green in color while feldspar is white or gray.)

**6.** Distribute scissors, crayons, glue, yarn or string, and coat hanger to each student. Ask students to color the minerals the appropriate color. (Note that most of these minerals come in a variety of colors. Use resource materials or page 4.1.10 of this EELE to help decide on possible colors for each mineral.) Next have the students cut out the crystal shapes and make mobiles with them.

**7.** Distribute the Three-Dimensional Cutouts pages. Ask students to color, cut, fold, and then tape the sides of each model together. Display the models that you have prepared so that students will have a visual picture of how the crystals should look when finished.

## Assessment:

Ask the students to write the answers to the following questions:

**1.** What is a mineral?

**2.** List at least five characteristics of minerals that are used in identification.

**3.** Name a mineral that has a hexagonal crystal shape.

**4.** Name a mineral that has a flat crystal resembling a sheet of paper.

**5.** Name two dark-colored minerals that can be found in the rocks at Mt. Jefferson State Natural Area.

## Extension:

Use the dissecting scopes or hand lenses to study rocks found in the NC Rocks Kit. Can students recognize any of the minerals? Use the Mineral and Rock Kit Guide or other resource materials to find out what minerals are contained in each rock specimen. Note that some rocks, such as slate, are so fine-grained that you may not be able to see any minerals at all.

# Student's Information

You have just grown and observed **crystals** of the mineral halite (salt). Now let's learn about crystal shape as an identifying property of **rocks** and **minerals** and identify the crystal shapes found in some of the rocks of Mt. Jefferson.

A mineral is a naturally-occurring, **inorganic** substance that is found in the Earth's crust. Each mineral has its own special **chemical make-up**, crystal shape, **luster**, hardness and **cleavage**. **Geologists** use these characteristics to help them identify minerals. For example, the mineral **quartz** always has a chemical formula of $SiO_2$, silicon dioxide. It has a hexagonal crystal shape, a glassy luster, a hardness of 7 on the Mohs Scale, and no cleavage (it fractures like glass when hit with a hammer). Quartz specimens found all around the world, or even on the Moon, have these same characteristics. No mineral except quartz has this same set of characteristics.

Sometimes color is an aid to identifying minerals. For example, the mineral biotite is always black — unless it has been chemically changed by weathering to a golden yellow color. Quartz, however, comes in many different colors, depending on the **impurities** present in a particular sample.

In this activity, you will focus on one identifying characteristic of mineralss; crystal shape. You will observe models of the crystal shapes of five rock-forming minerals found at Mt. Jefferson State Natural Area. Of course, the actual mineral crystals in the rocks at Mt. Jefferson are really very tiny. You may not be able to see the crystal shapes very well. Remember that the metamorphic rocks in the park formed under great temperatures and pressures. There wasn't a lot of room for large crystals to form.

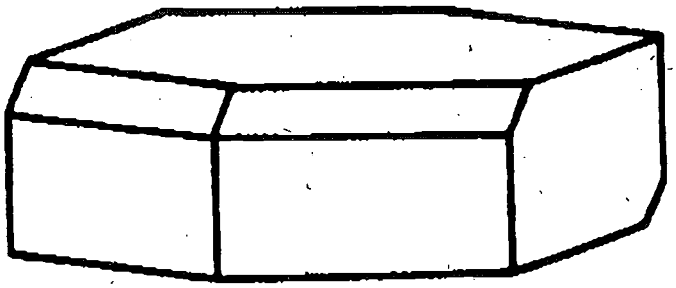
You have already learned that each mineral has its own **chemical formula**. Because of this formula, the **atoms** (tiny building blocks of matter) within a mineral are joined together in orderly, repeating patterns. These repeating patterns result in a beautiful **geometric** shape that we call a crystal. Sometimes the crystal has enough space and the right conditions to grow very large. But more often, the crystal is small and we will need a hand lens or dissecting scope to view it. In some cases, the crystals are so tiny that geologists must use a special instrument called a **petrographic microscope** to study them.

Individual mineral crystals are bounded by smooth, flat surfaces called **faces**. The faces meet at characteristic angles. For example the faces on a salt crystal always meet at a 90 degree angle. In the six-sided quartz crystal, the angle between the faces is 120 degrees. The faces in a quartz crystal also meet at the top forming a characteristic **pyramidal** point.

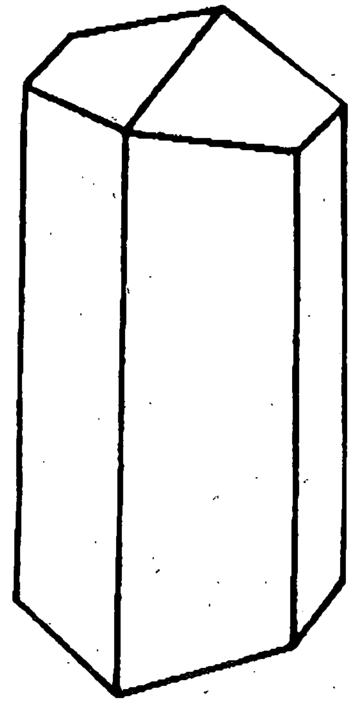
Other minerals also found in the rocks at Mt. Jefferson include feldspar, hornblende, muscovite and biotite. Both feldspar and hornblende form **prism**-shaped columnar or tabular crystals. However, hornblende crystals are typically stubby, longer, and much darker (blackish green) than feldspar crystals (white to gray). Both muscovite and biotite are in the mica group. They have similar chemical formulas and therefore similar crystal shapes. The crystals are **tabular** (look like sheets of paper stacked on top of one another) and often have a six-sided outline. You can tell the two micas apart primarily by color —biotite is black,while muscovite is clear to greenish in color.

Studying Mt. Jefferson's crystals is only the beginning of a fascinating look into the world of minerals. There are six basic crystal systems. When you make the crystal models in this activity, you will have explored only a few examples of two of the crystal systems.

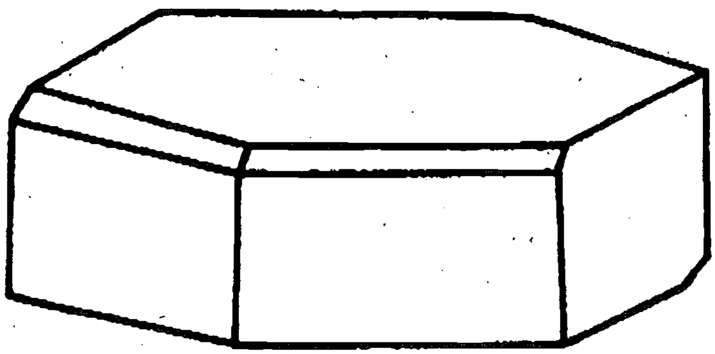
# Two-Dimensional Cutouts



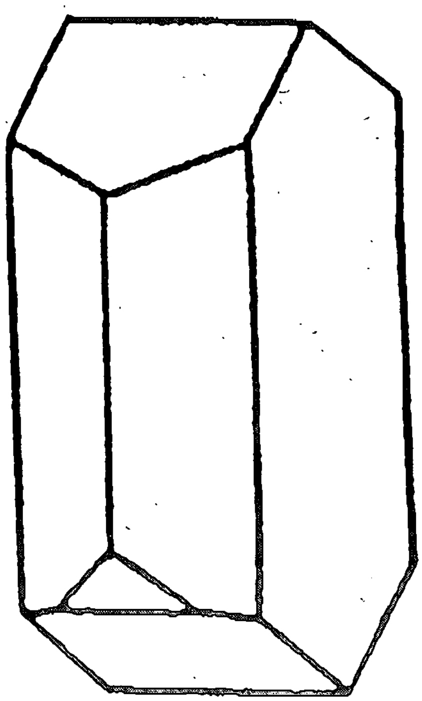
**Biotite**



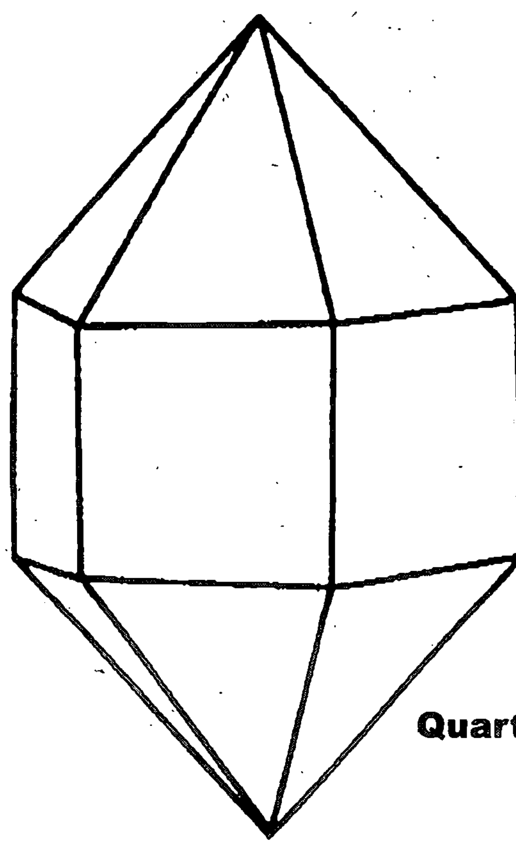
**Hornblende**



**Muscovite**

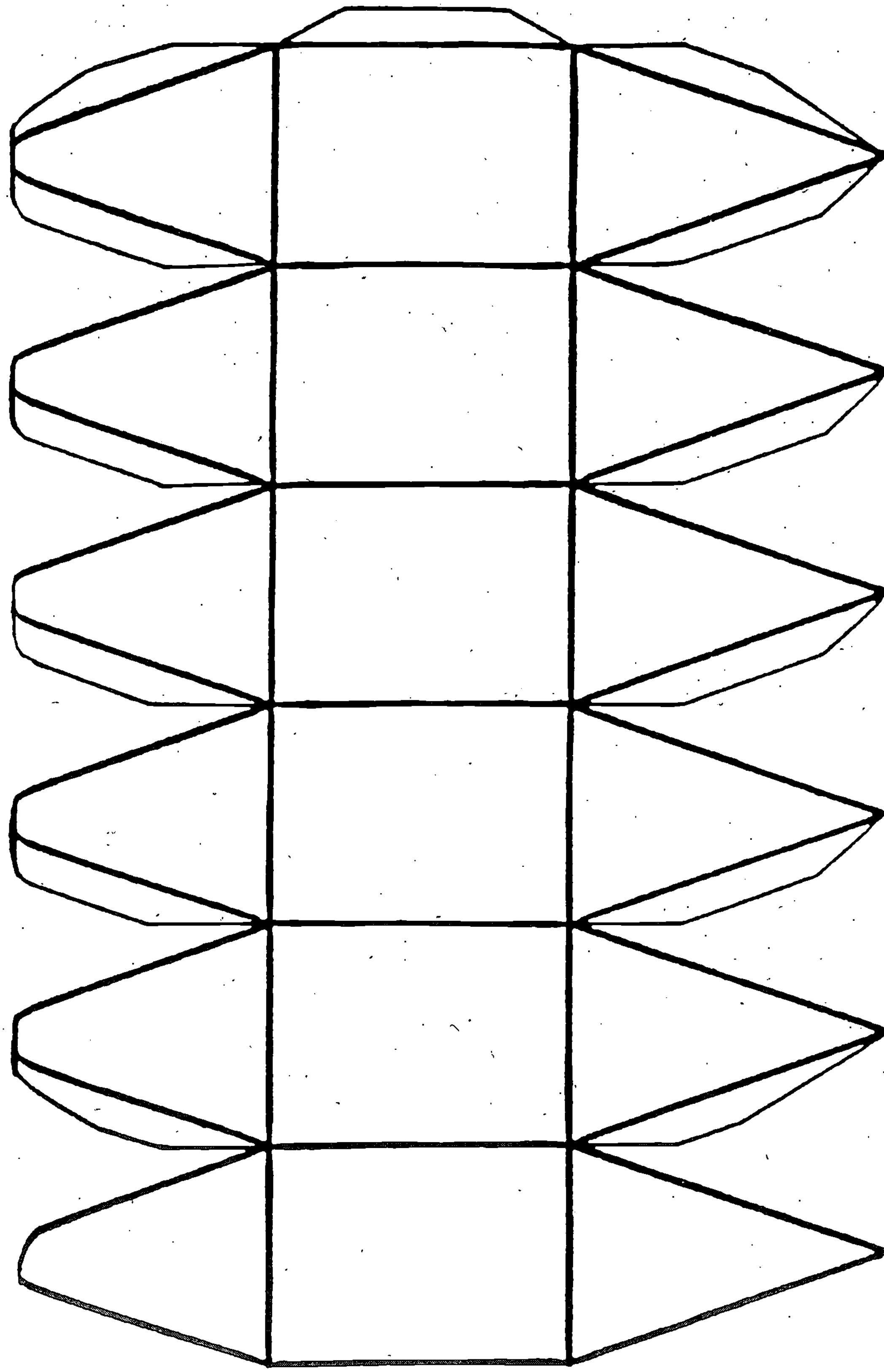


**Feldspar**



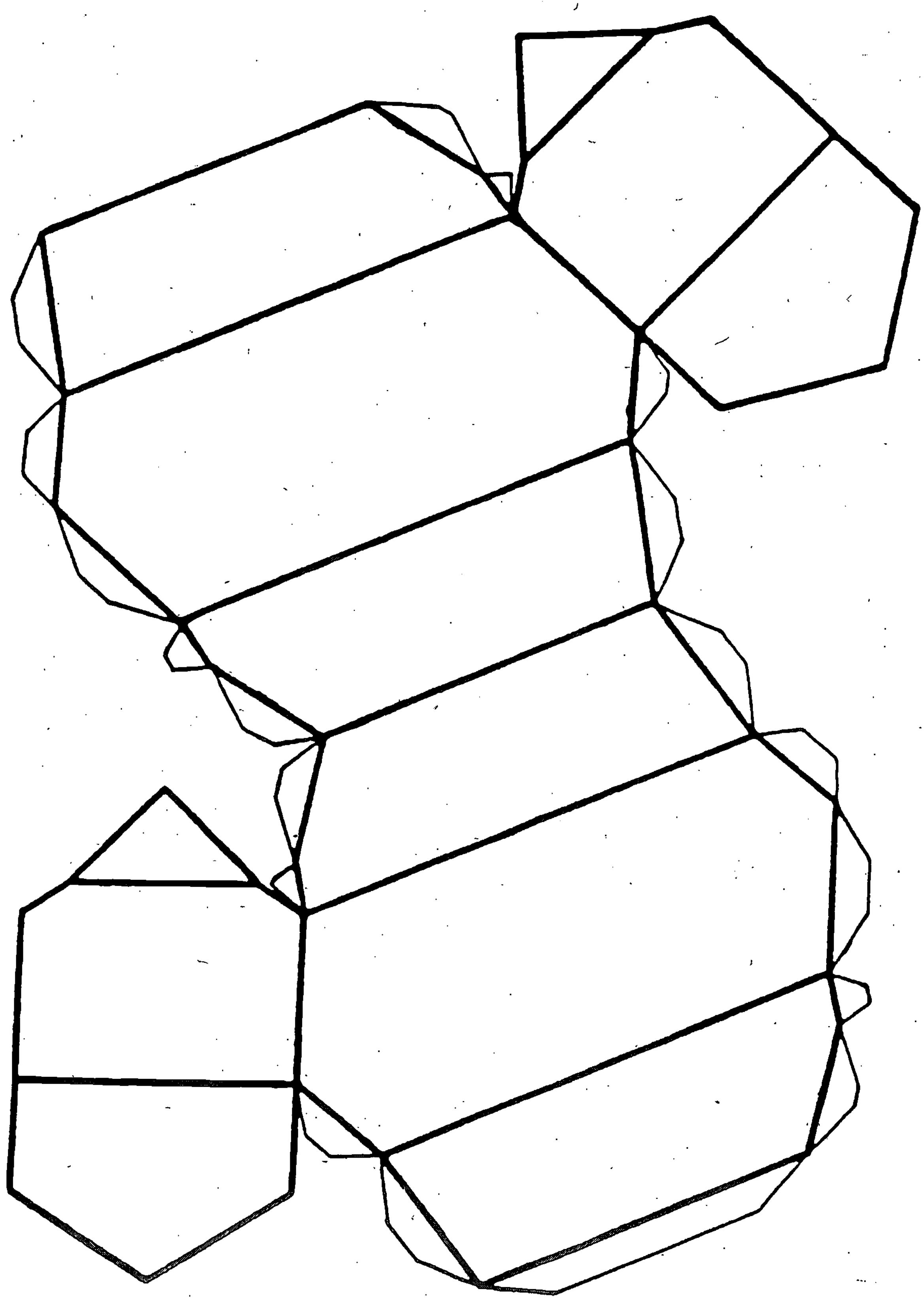
**Quartz**

# Three-Dimensional Cutouts



**Quartz Crystal**

# Three-Dimensional Cutouts continued



**Feldspar Crystal**

**Curriculum Objectives:**

**Grade 5**
- Communication Skills: listening, reading, vocabulary and, viewing comprehension
- Guidance: competency and skill for interacting with others
- Healthful Living: recreational safety
- Science: Earth science, environment
- Social Science: organize and analyze information, draw conclusions, participate effectively in groups

**Grade 6**
- Communication Skills: listening, reading, vocabulary and, viewing comprehension
- Guidance: competency and skill for interacting with others
- Healthful Living: recreational safety
- Science: Earth science environment
- Social Studies: organize and analyze information, draw conclusions, locate and gather needed information

**Grade 7**
- Communication Skills: listening, reading, vocabulary and, viewing comprehension
- Guidance: being responsible in a group
- Science: soils, scope of Earth science, Earth forms and natural phenomena
- Social Studies: organize and analyze information, draw conclusions, locate and gather needed information

**Location:**
**Part I:**
Summit picnic area
**Part II:**
Starting point for the hike will be the second overlook parking area. The hike will end at the outlook tower located at Mount Jefferson's summit.

**Group Size:**
30 or less; for Part I, divided into seven groups of about four students each

**Estimated Time:**
Part I: 50 minutes
Part II: 1 to 2 hours

**Appropriate Season:**
Spring and summer months are recommended, weather permitting

**Materials:**
**Part I:**
Provided by the park: 1 large rock identification work sheet
Per group: pencil, index card, rock hammer, safety goggles, streak plate, penny, steel file, hand lens, Field Guide to Rocks and Minerals, rock and mineral set to include the following rocks: schist, amphibolite, metagraywacke; and the following minerals: feldspar, hornblende, muscovite, biotite, quartz
Provided by the educator:
Per student: "Rock and Mineral Identification" Fact Sheet

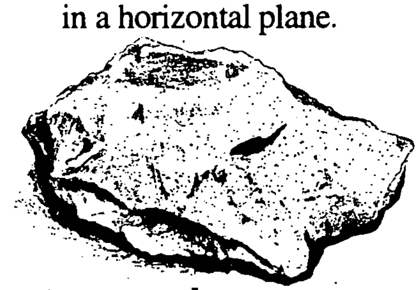
**Part II:**
Provided by the students: pencil and paper for drawing geological features

## Major Concepts:
### Part I
- Rock formation
- Rock characteristics
- Sedimentary, metamorphic and igneous rocks

### Part II
- Weathering
- Erosion
- Rock cycle

## Objectives:
### Part I
- Identify three major rocks and five major minerals found at Mount Jefferson State Park by listing their distinguishing characteristics.
- List five characteristics that geologists use to help identify rocks and minerals.

### Part II
- Describe three factors that cause rocks to weather.
- Describe how metamorphic rock is formed and name one common to this area.
- Describe how sedimentary rocks are formed and how they are layered.
- Explain why rocks found in this area are no longer in a horizontal plane.



**metagraywacke**

60

## Educator's Information:

This activity is divided into two parts:

In Part I, "Rock ID," the students will identify five different types of **minerals** and three different types of **rocks**. Each one is a common mineral or rock found at Mount Jefferson State Park and some can probably be found around the students' homes and school.

Students will be required to fill-in a rock and mineral identification worksheet in which, for a mineral, they will determine color, streak color, luster, cleavage, hardness and name. For the rock identification, the students will determine color, major and minor minerals, texture, foliation, what it was formed from and name.

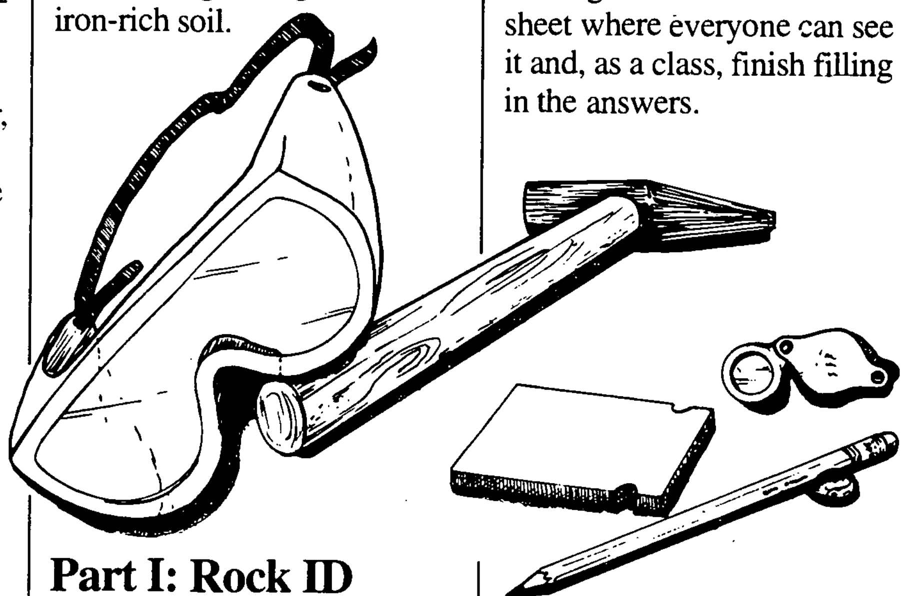
In Part II, "Talking Rocks," the students will hike through the park and observe the effects of geologic processes on the landscape.

**NOTE:** Before arriving at the park for the on-site activities, teachers and students should read through this "Rock ID" activity and the "Introduction to the Geology of Mount Jefferson State Park," found in the Introductions.

## Suggested Extensions:

**1.** Have the students bring rocks to class and try to identify them using the "Rock and Mineral Identification" fact sheet and worksheet.

**2.** If time allows, take the group on the Rhododendron Trail to examine amphibolite and metagraywacke outcrops more closely. A self-guided trail brochure is available to help you identify the mountain vegetation growing in this iron-rich soil.



# Part I: Rock ID

## Instructions:

**1.** Divide the students into seven groups, one group placed at each station. Have the students put on their goggles for this activity.

**2.** Using the mineral **quartz** (M1), lead the groups through the tests on the "Rock and Mineral Identification" worksheet. Make sure each group understands how to do each test and describe their results before moving on to the next test. When all the groups have finished a test, write the answers on the large identification worksheet. To help in this process, encourage the students to use the "Rock and Mineral Identification" fact sheet and "Rock and Mineral Classification" fact sheet.

3. Have the students repeat the identification steps for each of the other four minerals and three rocks at their station.

4. After each group has completed their worksheet, place the large identification worksheet where everyone can see it and, as a class, finish filling in the answers.

5. Have the groups discuss how they came to their conclusions. Also, lead them in a discussion on how geologists key out minerals and rocks.

**Special Considerations:**

During part of this activity, students will break rocks apart to determine the rock's color. Rock fragments can be very sharp and may fly off and hit the student who is breaking the rocks or other students. It is important for all students to wear safety goggles during this activity.

# Student's Information

## Rocks

There are three basic **rock** classifications: **igneous**, **sedimentary** and **metamorphic**.

Igneous rocks are formed when molten **magma** cools under the Earth's surface or when the magma flows out on the Earth's surface as **lava** and cools. Ninety-five percent of the **Earth's crust**, to a depth of ten miles, is made up of igneous rock.

Sedimentary rock is formed when loose **mineral** particles, or **sediments**, are deposited on land or in the water. With enough pressure from the weight of the sediments and water above, the lower sediment particles get pressed into sedimentary rock. For example, if large amounts of volcanic ash built up on the bottom of a lake or ocean, the ash would eventually be pressed into a type of rock called shale. Sedimentary rock is always formed in layers, which is the easiest way to identify this type of rock. About 75% of the exposed surface rocks of the Earth are sedimentary. However, these sedimentary rocks are only a relatively thin covering over the underlying igneous rocks. Shale, **sandstone** and limestone make up almost 99% of the sedimentary rocks, with shale being more common than sandstone and sandstone being more common than limestone.

Metamorphic rock is formed when either igneous or sedimentary rocks are put under enough heat and pressure over a long period of time to change the rock both physically and chemically. The tremendous amount of pressure brought about with the collision of continental tectonic plates is one of the major forces that creates metamorphic rock. This type of metamorphic process changes shale to schist (sometimes referred to as mica schist or muscovite/biotite schist), limestone to marble, and sandstone to quartzite.

Geologists have identified about 2,000 rocks, each with their own characteristics. To identify rocks, geologists look at fresh color, texture, foliation, composition and many other characteristics.

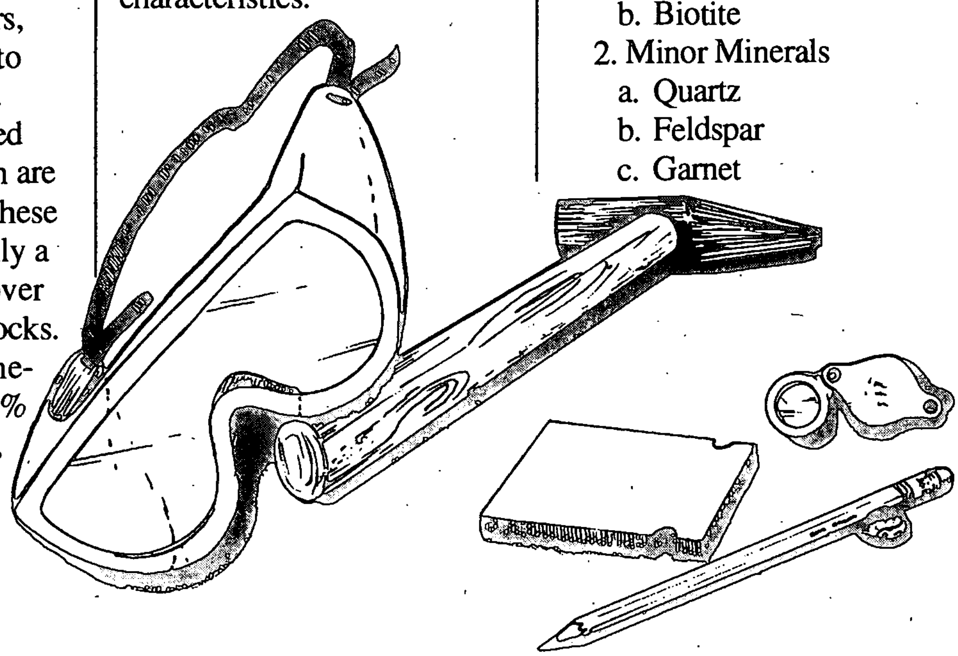
### Metamorphic Rock Types at Mount Jefferson State Park

All the major rock types at Mount Jefferson State Park are metamorphic. These rocks and their component minerals are:

I. Amphibolite:
   1. Major Minerals
      a. Hornblende
      b. Feldspar
   2. Minor Minerals
      a. Epidote
      b. Biotite
      c. Garnet

II. Metagraywacke:
   1. Major Minerals
      a. Quartz
      b. Feldspar
   2. Minor Minerals
      a. Biotite
      b. Muscovite
      c. Garnet

III. Schist:
   (Mica-schist, Muscovite/biotite schist)
   1. Major Minerals
      a. Muscovite
      b. Biotite
   2. Minor Minerals
      a. Quartz
      b. Feldspar
      c. Garnet



## Minerals

A rock is made up of one or more minerals, so one characteristic geologists look for is the type of minerals found in a rock, and the ratio of minerals to one another. Each mineral always has the same chemical **composition** and its own particular crystalline structure. A mineral is a combination of one or more elements. **Quartz**, for example, is a combination of two elements, silicon and oxygen, and has a chemical formula of $SiO_2$. Quartz is a common mineral in the park and in North Carolina. Gold is a mineral of just one element with the chemical formula (and symbol) of Au. Gold has been found in several locations in Avery, Watauga and Ashe counties, as well as in the Ore Knob Mine, but not in quantities sufficient for mining.

Most minerals are made up of a combination of only eight elements. Below is a list of these elements with a percentage figure indicating their abundance in the Earth's crust, and hence their approximate abundance in the rocks and soil around us.

The relationship between a rock and its minerals can be compared to a fruitcake's relationship to its ingredients. If the rock were the fruitcake, the minerals would be the raisins, nuts, cherries, candied fruit, sugar, flour, eggs, etc.

| Element | Symbol | Percentage by Weight |
|---|---|---|
| **Oxygen** | **O** | **46.7%** |
| **Silicon** | **Si** | **27.7%** |
| **Aluminum** | **Al** | **8.1%** |
| **Iron** | **Fe** | **5.1%** |
| **Calcium** | **Ca** | **3.7%** |
| **Sodium** | **Na** | **2.8%** |
| **Potassium** | **K** | **2.6%** |
| **Magnesium** | **Mg** | **2.1%** |
| | **TOTAL** | **98.8%** |

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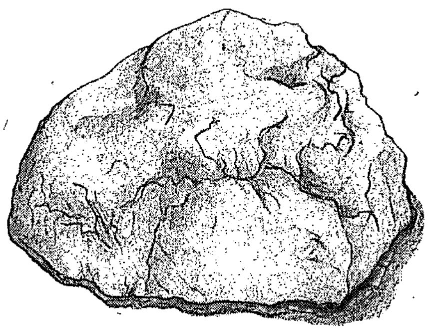
# Rock and Mineral Identification Fact Sheet

Rocks are identified by their component minerals.

## Minerals:



### Quartz:

Quartz is a common mineral, found in many different types of rocks. In its pure form, quartz will be clear, but it usually contains impurities which give it a variety of colors, including white, red, pink, smoky black, black, yellow, green and gray. Its chemical formula is $SiO_2$, silicon dioxide.

Quartz has a hardness of 7.0 and can NOT be scratched by a file. (A good steel file has a hardness of nearly 6.5. In contrast, feldspar has a hardness of 6.0 - 6.5 and can, just barely, be scratched by a file.)

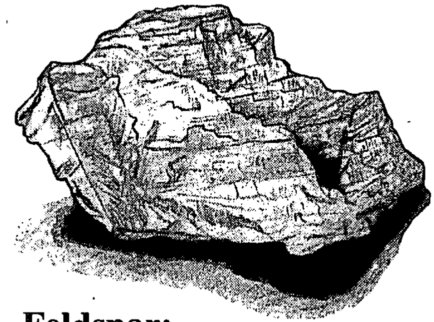
Quartz has the same hardness as the traditional streak plate (unglazed porcelain tile). Thus, if you see any white powder after rubbing quartz on the plate, this is probably due to the quartz scratching the plate. Its **luster** is greasy to glassy.

Quartz has no **cleavage**, but does have conchoidal fracture. This means when quartz breaks, you can observe round, shell-like fracture lines (Ex: Nearly everyone has seen the conchoidal fractures in broken glass.)

The common quartz of Mount Jefferson State Natural Area formed most likely during metamorphism. Water is driven out of super-heated rocks. Quartz, a mineral with a relatively low melting temperature, dissolves in this water and moves into and through cracks and other openings where it is later deposited in ribbons (veins) and pods. During **weathering**, quartz is both chemically and physically resistant. Therefore, much of a quartz vein is left behind while less resistant, surrounding rocks are eroded away.

In an outcrop, a natural exposure of rock, quartz is usually elevated slightly above other minerals. This phenomena is referred to as **differential weathering**. Quartz veins can be seen in the amphibolite outcrop located at the second overlook on Mount Jefferson.

Early European settlers in this area used quartz-based rock to build walls and fences. Some of these structures still exist and can be seen from the park's second overlook.



### Feldspar:

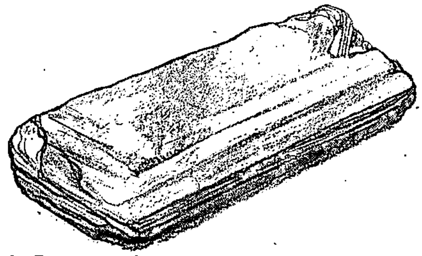
Feldspars form the most abundant group of minerals in the Earth's crust. If this group were considered a single mineral it would be the most common mineral by far — five times as common as quartz. Feldspars are found in nearly all igneous rocks and rocks formed from them. Feldspars usually show two good cleavage faces, which are at right angles or nearly so. The hardness of feldspar is 6; you should be able to scratch it with a good steel file. This mineral group will usually have a smooth, glassy or pearly luster. Some feldspars (orthoclase) produce a white streak, but not all of them. Depending on the hardness of the streak plate used, feldspar may produce a white powder. Feldspar is the secondmost abundant mineral found in an amphibolite at Mount Jefferson. When closely examined, amphibolite has small white specks embedded in it; these specks are small feldspar grains..

Feldspar is mined almost entirely from bodies of pegmatite, a special kind of rock containing large crystals of feldspar, as well as quartz. Three large feldspar mining operations are located at Spruce Pine, in Mitchell County.

## Hornblende: (See Amphibolite)

Hornblende is a lustrous green, brown or black mineral. It is a **silicate** and contains aluminum and other elements. Hornblende can occur in crystals or in other forms, such as fibers and granules. Hornblende has a glassy luster and a hardness of 5-6. It has two cleavage planes meeting at oblique angles of approximately 60 degrees. (This is sometimes called prismatic cleavage.) It usually occurs in metamorphosed igneous rock, such as amphibolite.

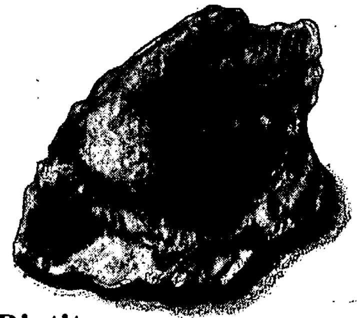
Its name is of Germanic origin. *Horn* refers to its dark color, which reminded people of an animal's horn, and *blende* in German refers to being false. This is because the mineral looks like it could be melted down into a metal, which it can not. Hornblende can be found in and around amphibolite outcrops located on Mount Jefferson.



## Muscovite:

Muscovite is a type of mica which contains aluminum, oxygen, potassium, silicon and water. It is a light colored mica that may be colorless, yellow, light brown or light green. Its luster varies from glassy to pearly. It has a hardness of 2 to 2.5 and its cleavage is strong in one direction. All micas will cleave in one direction into very thin sheets. One sheet can be as thin as 1/10,000 of an inch.

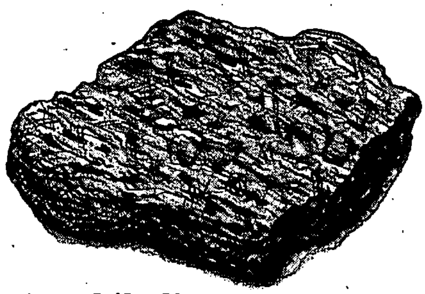
Most muscovite is very clear and leaves a colorless streak when rubbed on a streak plate. It is so named because in Russia, the poorer Muscovites used it instead of glass. Muscovite is found in highly metamorphosed, shaley sediments, which can be seen scattered through the park.



## Biotite:

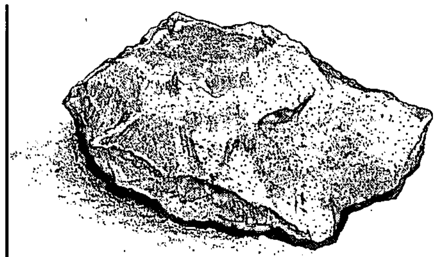
Biotite is one of the dark-colored micas, consisting of aluminum, hydrogen, iron magnesium, oxygen, potassium and silicon. It has a hardness of 2.5 to 3 and a pearly luster. Biotite cleaves strongly in one direction and leaves a colorless streak when rubbed on a streak plate. It is abundant in some granites and is also common in schists and gneisses. Biotite may occur with muscovite in metamorphic rocks. Thin sheets often show light spots and rings. Biotite and muscovite can be seen together throughout the park.

## Rocks:



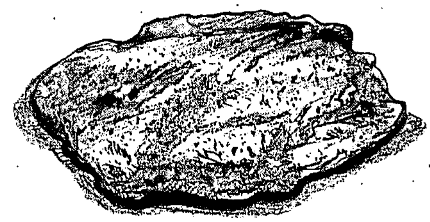
### Amphibolite:

Amphibolite is a metamorphic rock consisting mainly of an amphibole mineral (hornblende) and feldspar (plagioclase). It is weakly foliated, meaning it will split into layers, but with difficulty. The amphibolite was originally a mafic (dark) volcanic rock either from lava flows or materials ejected by a volcano and deposited in layers. Amphibolite's fresh color is black. It is commonly medium-grained in texture.



### Metagraywacke:

Metagraywacke is a metamorphic rock which formed from gray, coarse-grained impure sandstone. It consists of poorly sorted, angular to sub-angular grains of quartz with variable amounts of feldspar, muscovite, biotite and rare rock fragments. This rock can be non-foliated to very coarsely foliated. Foliated or **foliation** refers to the parallel arrangement of mineral grains, giving a layered appearance to a metamorphic rock. Layers are usually not as obvious in metagraywacke. During metamorphism, the quartz grains in the rock enlarged and interlocked, giving it a more uniform appearance.



### Schist:

Schist is a thinly foliated metamorphic rock that can be readily split into thin flakes or slabs. Schist is a less abundant rock type at Mt. Jefferson that is found interlayered primarily with metagraywackes. It originated as a sedimentary rock, most likely a shale layer composed principally of clay minerals. Its fresh color is medium to dark gray. It is made up of the minerals muscovite, biotite, quartz and garnet. The texture of this rock is fine to medium-grained.

# Rock and Mineral Classification Fact Sheet

## Characteristics Used to Identify Minerals:

**Luster** - Luster is the way a mineral reflects light. Classify the luster as pearly, glassy, dull or metallic.

**Hardness** - Hardness is based on what material is able to scratch a mineral's surface. The Mohs hardness scale ranges from one to ten, with one being the softest mineral and ten being the hardest. You can use ordinary objects to help you estimate a mineral's hardness. For example, a fingernail can scratch minerals with a hardness of 2.5 or less. Try to scratch the unknown mineral with these objects to help establish its hardness. Use the hand lens to see if any of these things made a scratch on the mineral's surface.

**<u>Hardness of Ordinary Objects:</u>**

| | | |
|---|---|---|
| 2.5 | (very soft) | fingernail |
| 3.5 | (soft) | penny |
| 5.5 | (hard) | steel nail |
| 6.5 | (very hard) | steel file |

**Cleavage** - Cleavage is the tendency of a mineral to break or split along a defined plane surface. Observe whether the mineral has cleavage or not, and describe it.

**Streak** - Streak is the color a mineral leaves behind when it is scratched across a streak plate or unglazed porcelain. Write down the streak's color. (Note: A streak plate will NOT be helpful in separating quartz, feldspar, mica and hornblende. Use hardness, color and cleavage as the main clues to identification.)

## Characteristics Used to Identify Rocks:

**Texture** - Texture is the size and shape of the mineral crystals present in the rock and their spatial relationships with each other.

**<u>Texture Classifications:</u>**

**fine-grained:** individual minerals in the rock can only be seen if using a hand lens.

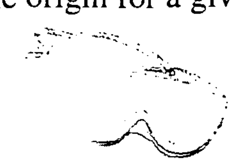
**medium-grained:** individual minerals can be seen with the naked eye, but are about the size of sand grains (less than 2 mm in size).

**coarse-grained:** individual minerals in the rock are greater than 2 mm in size.

**Foliation** - The development of wavy or contorted layers under intense metamorphism is called foliation. Does the rock split easily into layers? If so, it is well-foliated. If difficult to split into layers, it is weakly foliated. If the rock does <u>not</u> break or split into layers, it is nonfoliated.

**Major/Minor Minerals** - The minerals that combine to make up a rock.

**Formed From** - Every rock is formed from a previous stage in the rock cycle. Use the information on page 4.1.7 to try to determine a rock's origin only AFTER you have identified the rock. You are not expected to determine the parent rock by simply observing the rock out of its environmental context. In fact, geologists do not always agree on the parent rock, or there may be more than one possible origin for a given rock type.



**Color** - Color is the identifiable color of the rock or mineral when it is freshly broken. To determine the rock or mineral's overall color, use the rock hammer to break it so you can see the color inside. This is important, as the outside color may have been altered due to weathering factors. (Quartz may be colorless; white, if it has water vapor trapped inside; pink; smoky; black; yellow; or purple if it has impurities within it, depending on the impurities.)

# Rock and Mineral Identification Worksheet

| Minerals | | | | | | |
|---|---|---|---|---|---|---|
| Mineral Sample | Color | Luster | Hardness | Cleavage | Streak | Name |
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |

| Rocks | | | | | | |
|---|---|---|---|---|---|---|
| Rock Sample | Color | Texture | Foliation | Major/Minor Minerals | Formed From | Name |
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |

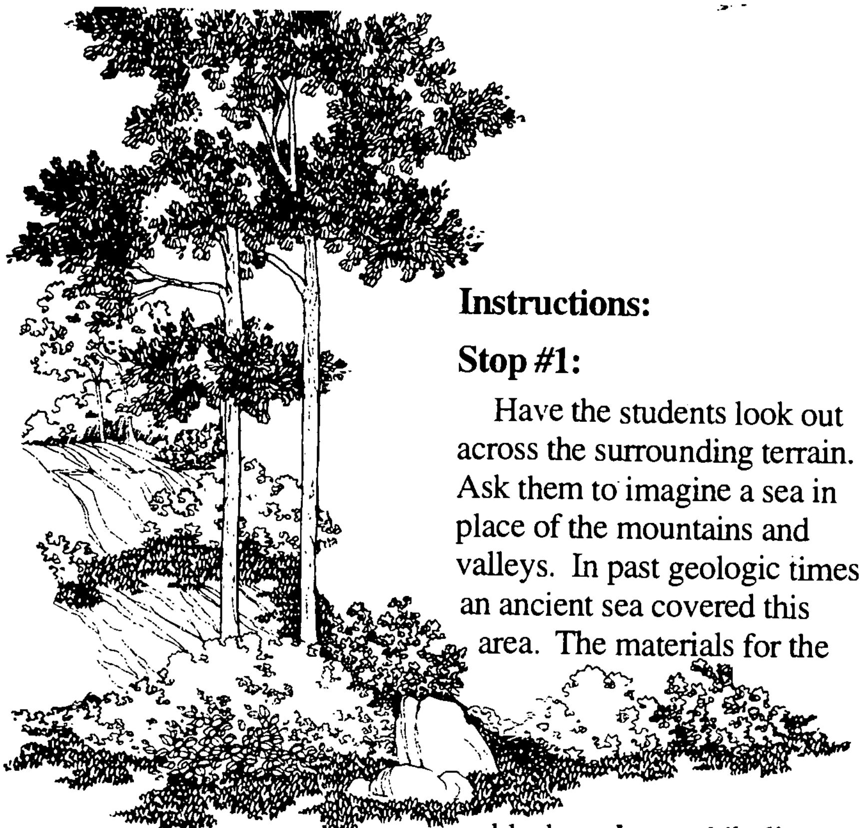
# Rock and Mineral Identification Worksheet

| Minerals | | | | | | |
|---|---|---|---|---|---|---|
| **Mineral Sample** | **Color** | **Luster** | **Hardness** | **Cleavage** | **Streak** | **Name** |
| 1 | colorless to colored varieties | glassy to greasy | 7 | none | colorless* | quartz |
| 2 | white, pink or gray | glassy | 6+ | two directions nearly always at right angles | colorless* | feldspar |
| 3 | black to greenish | glassy | 5 - 6 | two varying directions | colorless | hornblende |
| 4 | colorless | glassy to pearly | 2 - 2.5 | strong in one direction | colorless | muscovite |
| 5 | black | pearly | 2.5 - 3 | strong in one direction | colorless | biotite |

* The white streaks left by quartz and feldspar are due to scratching the streak plate, not due to the mineral.

| Rock | | | | | | |
|---|---|---|---|---|---|---|
| **Rock Sample** | **Color** | **Texture** | **Foliation** | **Major/Minor Minerals** | **Formed From** | **Name** |
| 1 | black | medium | weakly foliated | hornblende, feldspar | mafic volcanic (igneous) | amphibolite |
| 2 | silvery gray | medium to coarse-grained | foliated or well-foliated | muscovite, biotite, quartz, garnet | shale (sedimentary) | schist |
| 3 | medium to dark gray | medium to coarse-grained | non-foliated | muscovite, feldspar, quartz , biotite | dirty sandstone (sedimentary) | metagraywacke |

# Part II: Talking Rocks



**Instructions:**

**Stop #1:**

Have the students look out across the surrounding terrain. Ask them to imagine a sea in place of the mountains and valleys. In past geologic times an ancient sea covered this area. The materials for the black **rock**, amphibolite, were deposited in a basin on the floor of the ancient sea some 600 to 800 million years ago. Some of the materials in the basin were washed in from surrounding land areas, but other materials were deposited as volcanic debris from now extinct **volcanoes**.

At this stop there is a large **outcrop** of black rock. This black rock, amphibolite, is the most common rock found in the park. Amphibolite is made up of an **aggregate** or combination of **minerals**. Hornblende and feldspar are the two primary minerals that make up the amphibolitic on Mount Jefferson. Epidote, a yellowish-green, pistachio-green, or blackish-green mineral and biotite, a black-colored mica, are also present in the amphibolite. Amphibolite is an example of a **metamorphic rock**.

The amphibolite here at the second overlook was at one time actually molten, **igneous rock** from volcanoes. After the eruptions, the volcanoes eroded away, their debris and **sediments** washing into the sea for thousands of years. The weight of the layers began to place great heat and pressure on the lower layers, producing **sedimentary rock**. This sedimentary rock was put under such intense heat and pressure from the collision of the North American and African continental plates that the sedimentary rocks were metamorphosed, eventually changing to the black amphibolite found in the park today. The newly formed metamorphic rocks were put under continuing pressure from the collisions when the rocks were still very hot and pliable, resulting in the amphibolite being **folded** and curved. When the rocks cooled, they retained their folded and bent shapes.

Have the students note the physical characteristics of the soil around the amphibolite outcrop. This soil is being produced by the rock's **weathering**. Some characteristics the students should notice include fine particles, reddish-orange particles, small greenish particles and small shiny

**Special Considerations:**

This is a one mile hike of moderate difficulty. Sturdy footwear is recommended.

Mount Jefferson State Park contains many high rock outcrops. Students will visit some of these outcrops during the geology hike. Teachers, please make sure the students understand that horseplay will not be tolerated and that serious injury or death could result from a fall.

Part of this hike will be along the park road. Please be alert for vehicular traffic along this road.

flakes. Have the students try to find examples of hornblende, epidote, feldspar, **quartz**, garnet, biotite, muscovite and vermiculite. Have them refer to their "Rock and Mineral Identification" fact sheet to help identify the minerals.

What do these soil characteristics tell us?

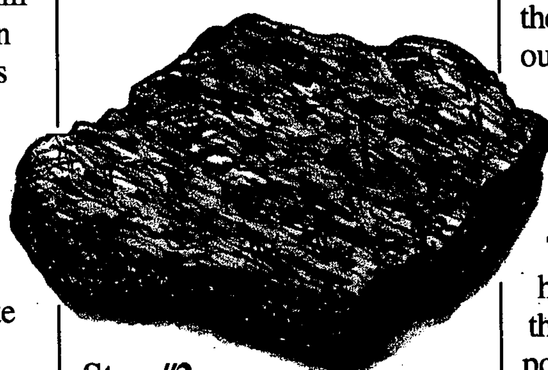
**1.** Fine particles settled here because there is no steep slope at the base of the outcrop. Water running downhill from the top of the mountain during storms or snow melts slowed here, allowing the fine particles to settle.

**2.** Reddish-orange colored particles are nothing more than weathered pieces of amphibolite. Amphibolite commonly breaks down to clay-rich, reddish-orange soil.

**3.** The small greenish particles are small pieces of the mineral epidote which is sometimes present in amphibolite.

**4.** The small, shiny flakes are mica. These particles would indicate the breakdown of another primary rock type of the park, schist, commonly called mica schist because of the high proportion of mica in the rock. Black mica flakes are called biotite. White-clear mica flakes are called muscovite. Gold-colored flakes are called vermiculite. Vermiculite is chemically weathered biotite, and is commonly mistaken for flakes of gold.

Before going on to the next stop, have the students notice veins of white quartz running through the amphibolite. Quartz is much more **resistant** to weathering than amphibolite, which is why the white quartz veins are usually 1-2 inches above the less resistant amphibolite layers. This process of weathering is called differential weathering. Differential weathering has occurred where some minerals are visibly weathering faster than other minerals.



**Stop #2:**

This stop is just up the road from the second overlook parking area, approximately 50 yards on the left. This stop is located at the base of a large outcrop of amphibolite. Have the students describe the size of the rocks here and compare them to the size of the rocks at the last stop.

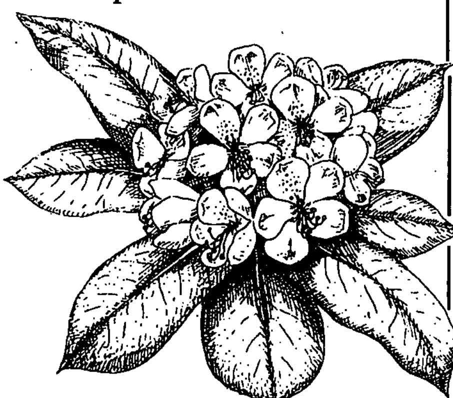
This outcrop of amphibolite is somewhat larger and more exposed than the section of outcrop just examined at the second overlook. Notice the many cracks and fractures all over this outcrop. These cracks and fractures are called joints. These joints allow more of the amphibolite outcrop to be exposed to erosive forces, thus causing much more breakdown of the amphibolite. When water seeps into these joints and freezes, it causes the rock to break apart in a process called ice wedging. When the pieces of rock break away from the main outcrop, gravity takes over, causing the rock to tumble and fall, crashing and bumping into other rocks along the way. This process is known as **mechanical weathering**.

Examine the ditch line at the base of the amphibolite outcrop. Small rocks at the base of the outcrop were deposited there as the result of the breakdown of the rocks forming the outcrop. These rocks were deposited here as the result of gravity; they were not water transported as were the small particles of rock located at the first stop.

Students might also notice pyrite, known as fool's gold, and garnets embedded in this outcrop of amphibolite.

**Stop #3:**

Located at the south end of the summit area parking lot, this rock outcrop contains some metagraywacke, but the primary rock type here is schist (mica schist). Schists are relatively soft and have many thin, flaky layers. Schists are considered metamorphic rock and are not usually seen as an outcrop in the park. Most often they are buried beneath valley floors. Here, the schist has been exposed by the erosive forces of weather and the road construction project to develop this parking lot. Schists probably surrounded the metagraywacke and amphibolite bodies which form Mount Jefferson before millions of years of **erosion** wore away the softer schists, exposing the metagraywacke and amphibolite we see in the park today. Note the single black vein of amphibolite to the left of the schist outcrop.

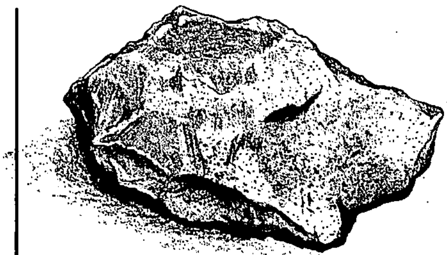


### Stop #4:

Walk up the service road, through the picnic area to the next stop. It is located at the Rhododendron Trail head. Just to the left of the trail head sign is what appears to be a cave. This is not a true cave, but is known as a fissure cave caused by a crack in the amphibolite. Notice the small trees growing out of the cracks and fractures on this outcrop. This is another form of mechanical weathering.

### Stop #5:

This stop is located at Mount Jefferson's summit. A rock outcrop is located beside the lookout tower.



This outcrop is an example of metamorphosed **sandstone** know as metagraywacke. Metagraywacke was once sedimentary rock before it was changed by intense heat and pressure. Ask students what this process is called (answer: metamorphism).

Metagraywacke is sometimes called "dirty sandstone" because of the abundance of clay in the original sediment. The main minerals found in metagraywacke include quartz, (which makes it more resistant than amphibolite), feldspar and mica flakes. The mica flakes are primarily biotite and muscovite. Since metagraywacke is the primary rock found at Mount Jefferson's summit, it is a good possibility that this quartz-rich rock is the reason why this area of the mountain has eroded more slowly than others. The elevation of this area is 4,683 feet. The rock outcrop where the elevation sign is posted is an excellent example of differential weathering.

This is the end of the hike.

### Summation:

Mount Jeffeson's height and soils are a result of the rocks that formed this region–amphibolite, schist and metagraywacke. The mountain was shaped by the north and south forks of the New River. As you look out over the mountains and valleys that surround Mount Jefferson today, try to imagine the valleys filled in, so you would be standing on a rolling plain several million years ago. With the passing of time, the rivers and streams have cut out the valleys, washing the material north into the Ohio River valley and later on down the Mississippi River. Sediments from the Appalachian Mountains filled in the shallow sea that once stretched into the middle of what we now call the North American continent.

The park was formed in 1958, as a result of local citizens petitioning the state legislature to make the mountains a state park. North Carolina State Parks are sanctuaries for wildlife. On Mount Jefferson, everything is protected by law. You cannot disturb the plants or animals. Even the rocks you see have to be left in the park. The role of state parks is to preserve and to protect the beauty, the rocks and significant features you see around you, as well as to educate our citizens about the significance of these resources, so people will use the park, and all the world's resources, wisely.

# On-Site Activity #2: Exploring Metamorphic Mountain

**Major Concepts:**
- Metamorphic rocks
- Geologic formations
- Mountain-building processes
- Weathering and erosion

**Learning Skills:**
- Observing, classifying, communicating, inferring
- Collecting, analyzing and evaluating information
- Measuring angles

**Subject Areas:**
- Science
- English Language Arts
- Mathematics
- * See **Activity Summary** for a Correlation with DPI objectives in these subject areas.

**Location:** Summit and Rhododendron trails

**Group Size:** 30 or less, preferably in groups of 10 or less with a minimum of one adult leader per group

**Time:** 1 hour

**Appropriate season:** spring, summer, fall

**Special Considerations:**
- It is strongly recommended that leaders scout the trail ahead of time to become familiar with recommended stops and to recognize potential hazards (i.e. slippery rocks, poison ivy, etc.)
- Leaders should carry a first aid kit and water.

**Materials:**

Provided by the school:

Per adult leader: one copy of *Exploring Metamorphic Mountain Geology Field Notebook*

Per class: one first aid kit and water bottle

Per student: one copy of *Exploring Metamorphic Mountain Geology Field Notebook*, pencil, clipboard

Provided by the park:

Per Group: compass, magnifying glass, clinometer, chalk, cardboard sheet, "hardness" tools - steel file, steel nail, penny

## Objectives:

- Describe how metamorphic rocks are formed and name two common to Mt. Jefferson.
- Explain the presence of vein quartz on the surface and in the soil throughout the park.
- Explain how horizontal beds or sheets of rock are folded and tilted.
- Identify rocks and minerals along the trail.
- Describe three factors that cause rocks to weather and erode.

## Educator's Information:

This activity is a hike which takes place on the Summit and Rhododendron trails. The moderately difficult hike originates in the picnic area and ascends to Luther Rock. It levels off once students reach the ridgeline of the mountain, and loops around, leading students back down to the picnic area. At 11 lettered stops, the students will study and answer corresponding questions in their *Exploring Metamorphic Mountain Geology Field Notebook*.

The purpose of this activity is to allow students to study first-hand examples of the **geology** of Mt. Jefferson. They will examine **folds** and **faults**, dipping rock **strata**, **weathering**, **erosion** and **foliation**. A brief overview of the hike follows:

- **Stop A** - Students observe a freshly-broken piece of amphibolite with a magnifying glass to identify at least two **minerals** in the rock. They also look for evidence of **chemical weathering**.
- **Stop B** - Students learn about **plate tectonics** as they study folded rocks.
- **Stop C** - Students observe a **quartz** vein and learn how quartz is deposited in ribbons (veins) and pods. They perform a hardness test on the quartz found along the trail.
- **Stop D** - Students look closely at a large, tilted outcrop of metagraywacke that is interlayered with mica schist and identify individual minerals present in the rock. They learn about the unique formation of rocks geologists call the Ashe Metamorphic Suite.
- **Stop E** - Students explore a large rock that contains a cave-like feature. They learn about **joints** and their role in weathering.

- **Stop F** - Students look for the point where the metagraywacke layer ends and the amphibolite layer begins again. They also observe the process of **mechanical weathering**.
- **Stop G** - The students learn that Mt. Jefferson could have been part of a mighty mountain range possibly as tall as the Himalayan Mountains over 250 million years ago.
- **Stop H** - Students again observe dipping strata and measure the **strike and dip** of the rock using a compass and a homemade **clinometer**.
- **Stop I** - Students observe **lichens** on the rocks. They learn the role lichens play in the **chemical weathering** of rocks and how to classify lichens by shape. They sketch an example of each type of lichen.
- **Stop J** - Students examine the steep bare rock surfaces of Luther Rock and observe the New River in the valley below.
- **Stop K** - Students observe the sharp points and ridges of the steeply dipping layers of amphibolite at Luther Rock caused by **differential weathering**. They study a small indentation in the rock, called a **weathering pit**, and discuss what may have formed the pit. They also observe and draw the **chevron folds** in the rock.

**Instructions:**

**1.** Before bringing students to Mt. Jefferson State Natural area, study the *Exploring Metamorphic Mountain Geology Field Notebook* in this EELE. Visit the natural area to scout the trail yourself. Ideally, this should be done at least one week prior to your class' visit and at the same time of day. This will help you become familiar with the exact locations of the stops described in the field notebook and potential trail hazards such as slippery or steep areas, etc.

**2.** Copy the *Exploring Metamorphic Mountain Geology Field Notebook* for each student and adult leader.

**3.** Take the students to the picnic area where the hike will begin. Divide the class into smaller groups of ten students or less. Provide one adult leader per small group.

**4.** Distribute an *Exploring Metamorphic Mountain Geology Field Notebook* to each adult leader and a field notebook, clipboard and pencil to each student. Each adult leader should also get the following items from park staff: compass, clinometer, chalk, cardboard sheet, steel file, steel nail, penny. You will need these items to do a hardness test at Stop C and measure strike and dip at Stop H.

**5.** During the hike, one of the group leaders should carry the first aid kit and water bottle. Make sure everyone knows which group has the first aid kit and water bottle in case of emergency. Each student should have a "buddy" in his/her group. Each leader will be given a small litter bag at the natural area to help with trail clean up.

**6.** Begin the hike with brief introduction during which you cover topic, trail distance, time, difficulty and special rules. Here are some special rules to teach your students:

a. Stay on the trail until told otherwise.

b. Watch for roots, stumps, sloped walking areas and other hazards. Running is not allowed on the trail.

c. Rock climbing is not permitted. No rocks are to be removed from the park.

d. All plants and animals within the park are protected. Injuring and removing plants or animals are prohibited in all state parks. This allows future visitors the same opportunity to enjoy our natural resources.

e. Being quiet will help you see more wildlife.

f. The adult leader should always be at the front of the group.

g. Do not litter. When picking up litter along the trail, do not touch broken glass or other sharp objects.

**7.** When conducting the hike, start each small group at 5-

minute intervals so the groups do not get too close to one another. Make sure all the leaders know the amount of time they have to conduct the hike and visit all the stops. All groups should have a designated meeting place to meet at the end of this activity.

Before the groups split up and hit the trail, the ranger or classroom teacher should demonstrate how to measure strike and dip. Or, if the classroom teacher, who knows how to take strike and dip, begins with her group, the ranger can then demonstrate to other groups while they are waiting their turn to begin the hike. The other groups can practice while they wait.

Remind leaders that when pausing for discussion or to view an interesting object along the trail, they should lead their group halfway beyond the object so all will have a good view.

## Assessment:

After you return to the classroom, ask the students to write the answers to the following questions:

**1.** In addition to amphibolite, what other two rock types make up the Ashe Metamorphic Suite?

(Mica schist and metagraywacke)

**2.** Name at least two minerals found in amphibolite.

(Hornblende, feldspar, quartz and epidote)

**3.** How old is the amphibolite at Mt. Jefferson and how did it form?

(The amphibolite is 600-800 million years old. It originated from volcanic activity in an ancient ocean. Later, the lava rock, basalt, was metamorphosed to create the amphibolite.)

**4.** What evidence did you find that the rocks at Mt. Jefferson have been placed under great stress and pressure in the past?

(Dipping rock strata, displaced rock units, **crenulations** or folds in the rocks)

**5.** What is differential weathering?

(Some minerals in a rock weather faster than others. Layers of more resistant minerals stand a few inches above the less resistant layers.)

**6.** Give an example of chemical weathering occurring at Mt. Jefferson.

(**Oxidation** of amphibolite; lichens "eating" rock surfaces)

**7.** Give an example of mechanical weathering at Mt. Jefferson.

(Water freezing in joints in the rocks, tree roots pushing rocks apart)

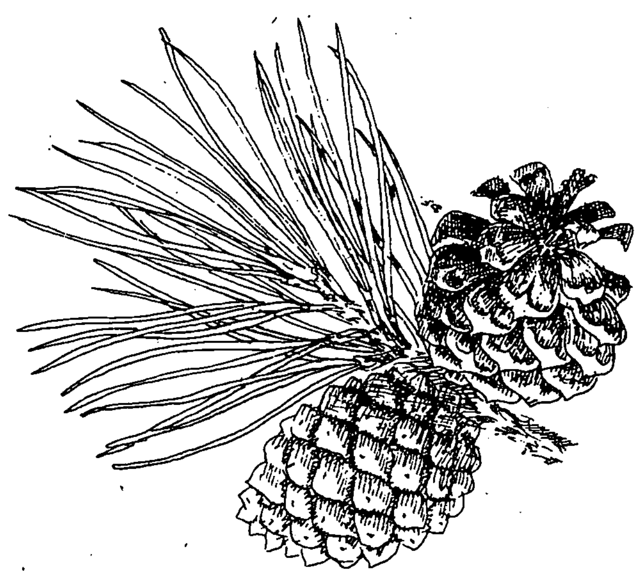
**8.** Describe in two or three sentences your favorite geologic feature at Mt. Jefferson. Or, which was your favorite trail stop and why?

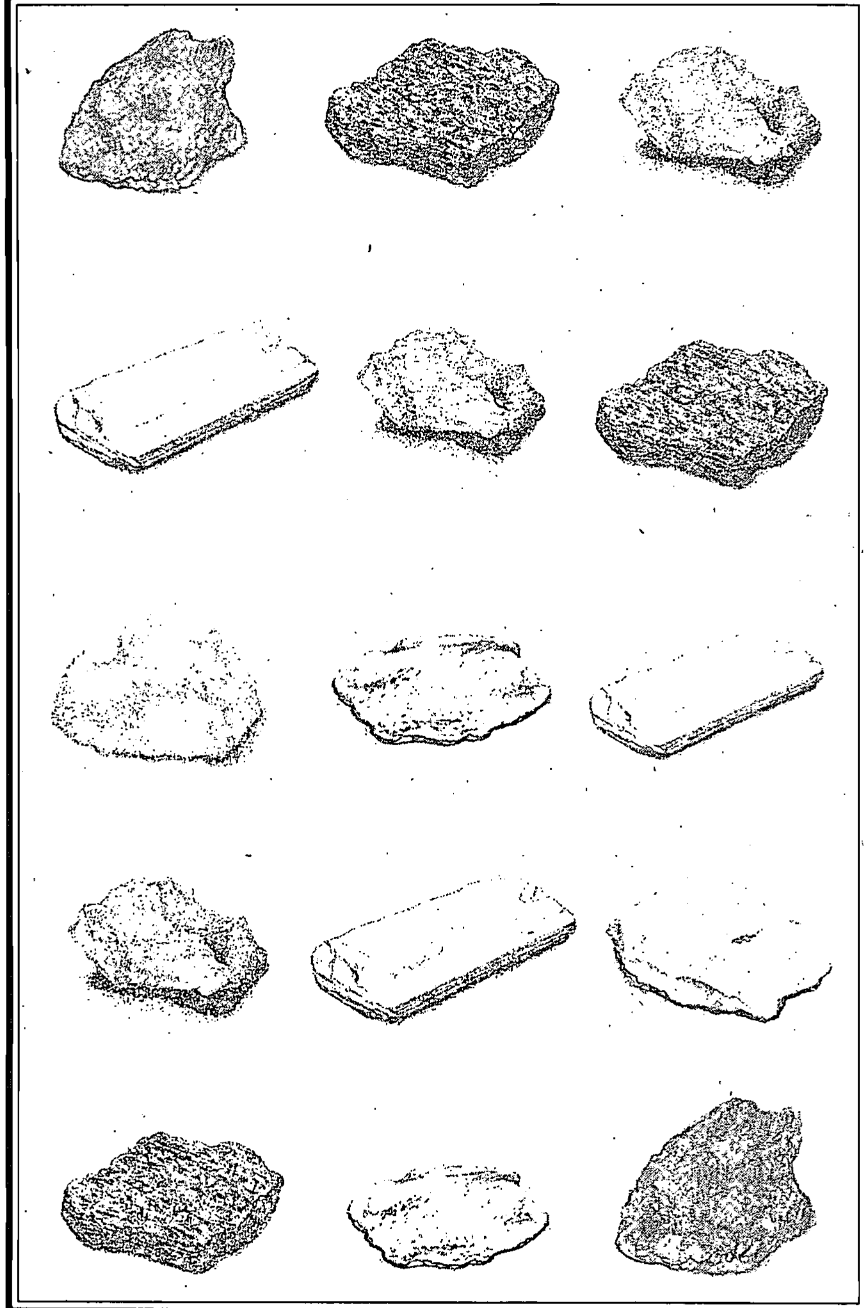
(Answers will vary.)

## Extensions:

**1.** Complete the other two on-site activities in this EELE to learn more about rock identification and the cultural history of the area.

**2.** Create your own geology trail at your school.





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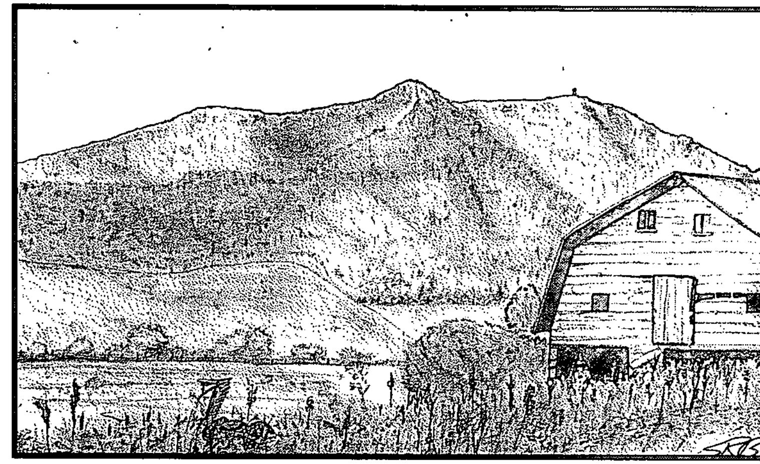
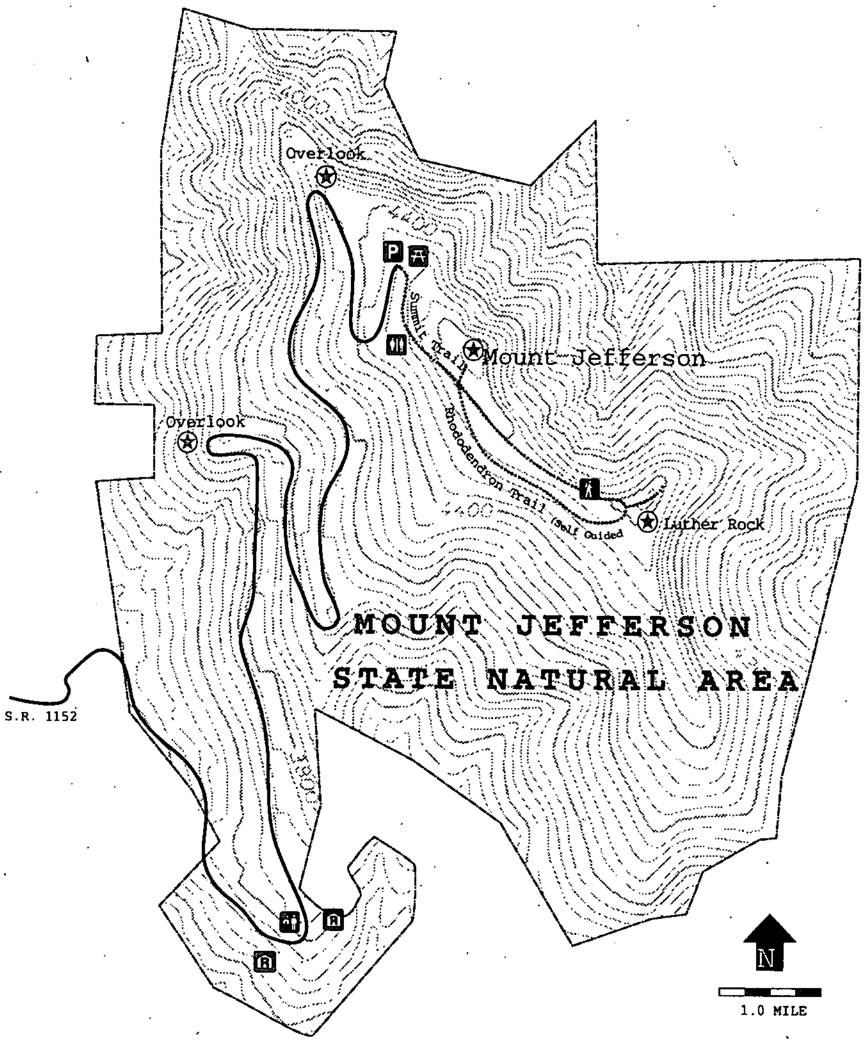
# Exploring Metamorphic Mountain



# GEOLOGY
## Field Notebook

**MT. JEFFERSON STATE NATURAL AREA**

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As you hike back to the picnic area, think about the clues in the rocks that help us to learn about past geologic history. The mineral composition of the rocks, along with the orientation of rock layers, provide evidence of powerful earth forces that have shaped this metamorphic mountain over time.

Answers to questions at Stop H: Compass direction - N 57 degrees W; Dip - 41 degrees SW

79

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## Stop K - Differential Weathering

**LOOK FOR: Amphibolite outcrop near marker #11.**

It is hard not to notice the sharp points and ridges of the steeply dipping layers of amphibolite here at Luther Rock. This is due to **differential weathering**, where some minerals are weathering faster than others. Layers of minerals resistant to weathering (containing epidote and quartz) stand a few inches above the less resistant layers (containing amphibole and feldspar).

Notice a small depression or indentation in the rock. This indentation, called a **weathering pit**, is the result of mechanical and/or chemical weathering. Frost action, a type of mechanical weathering, probably plays the greatest role in disintegrating rocks here at Mt. Jefferson. When water freezes in small cracks in the rocks, it expands and breaks off small pieces. An example of chemical weathering is the **oxidation** (rusting) of iron minerals in amphibolite, which commonly breaks down to a clay-rich, reddish-orange soil. What else could have caused this weathering pit?

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Also notice the excellent **chevron folds** (upside down V-shaped folds) exposed behind this post. These small folds demonstrate the powerful forces of nature which have bent this rock.

<u>Draw these folds on the next page</u>:

80





Welcome to Mt. Jefferson State Natural Area, an outdoor museum covering 800 million years of **geologic** history. Today, you will be hiking up to and along the Rhododendron Trail to see if you can unlock some of the mysteries of Mt. Jefferson.

The **rocks** of Mt. Jefferson State Natural Area consist mostly of amphibolite interlayered with other **metamorphic rocks** – metagraywacke and mica schist. Geologists think that all these rocks originated in an ocean **basin** 600-800 million years ago. **Lava** from ancient volcanoes as well as **sediments** such as mud, sand and gravel formed the parent rocks. Later, during several mountain-building periods (300 to 500 million years ago), these deeply-buried parent rocks were changed by heat and pressure (**metamorphosed**) as they were compressed and folded. Uplift and **erosion** of overlying rocks gradually exposed the rocks you see in the park today.

As you look around the mountainous environment of Mt. Jefferson State Natural Area, realize that this area did not always look this way. **Geologists** are really detectives who study rocks for clues to the past. The old saying, "A picture is worth a thousand words," is certainly true in geology. By making sketches in your field notebook, you will be able to piece together the story of Mt. Jefferson by the time you finish your hike.

Good luck in unlocking the secrets of Mt. Jefferson.

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## Stop A - Amphibolite

**LOOK FOR: Dark-colored rocks in the picnic area.**

Amphibolite, the dark-colored **metamorphic rock** seen at this location, is rich in iron and magnesium and has a grainy, layered appearance. It originated from lava flows on an ancient sea floor. The lava cooled to form basalt, a dark-colored igneous rock, which was later deeply buried in the Earth's crust. Here, high temperatures and pressures recrystallized the basalt, resulting in a new rock called amphibolite. Uplift and the erosion of overlying rocks gradually exposed the amphibolite to surface conditions.

Find a freshly-broken piece of amphibolite and examine it with a magnifying glass. If you look closely, it has a "salt and pepper" appearance. Put a check mark by the **minerals** you can see:

**Essential Minerals:**

_____ shiny black to dark green needles or grains = hornblende

_____ white grains = feldspar

**Accessory Minerals:**

_____ light green grains = epidote

_____ clear or glassy grains = **quartz**

Also look for rust stains on the rocks. This is evidence of a type of **chemical weathering** called **oxidation**. When minerals containing iron (ex: hornblende) are exposed to the air, they become oxidized. The iron chemically reacts with oxygen in the air, forming iron oxide or rust.



## Stop J - Water Erosion and the New River

**LOOK FOR: Bare rock surfaces at Luther Rock and, on a clear day, the New River in the distant valley below. (Look directly behind marker #9.)**

Notice the steep bare rock surfaces here which extend down slope. These steep slopes allow only a thin layer of **soil** to accumulate — almost as soon as soil forms, it is washed away by heavy rains.

If you look closely into the distant valley below, you may see the New River. Its meandering course is typical of a river on relatively flat land. While the area was being uplifted during the formation of the Appalachian Mountains, the river had enough force to cut down into the Earth, staying in its original river valley. Some of the rocks in the river bed to the northeast before Mouth of Wilson are over one billion years old.

**WARNING:** *Use extreme caution when walking along Luther Rock to reach trail marker #11, your next stop!*

## Stop I - Lichens & Chemical Weathering

**LOOK FOR: More dipping rocks that are covered with a green, moss-like growth; located before marker #7 and in view of last stop.**

Observe the **lichens** on the rocks in this area of the trail. Lichens aren't one, but two separate organisms — a **fungus** and an **alga**. (The fungus provides a home and absorbs water for the alga. The alga manufactures food for both using **photosynthesis** as long as the environment is moist, sheltered and receives some sunlight.) Lichens secrete an acid that slowly dissolves away the rock. This is another example of chemical weathering of rocks.

Lichens are classified according to shape. The following classifications are used for identification:

**Crustose:** looks like a crust on the rock

**Foliose:** has a flat, leaflike shape with free borders

**Fruticose:** grows upright and is shaped like a shrub

Sketch an example of each type of lichen below:

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## Stop B - Folded Rocks

**LOOK FOR: Wavy surface in large rock on trail near restrooms.**

Global-scale crustal movements, known as **plate tectonics**, caused the deep burial and resulting metamorphism that created this rock, amphibolite. About 500 million years ago, geologists think that the **crustal plate** carrying the African continent began moving towards the North American Plate. As the plates collided, the tremendous forces bent the rock as if it were soft plastic. Can you see the evidence here? Notice the folded appearance of other rocks as you walk along the trail.

Make a quick sketch of this folded rock:

85

## Stop C - Quartz

**LOOK FOR: White "rocks" near the junction of the Summit Trail with the lower loop of the Rhododendron Trail.**

In this vicinity and elsewhere along the trail, you may notice white "rocks" scattered across the ground. These "rocks" are actually pieces of quartz, a mineral composed of silicon and oxygen ($SiO_2$). How did the quartz get here?____________

________________________________________

During metamorphism, water is driven out of super-heated rocks. Quartz, a mineral with a low melting temperature, dissolves in this water and moves into cracks and other openings where it is deposited in ribbons (veins) and pods. Since quartz is both chemically and physically resistant to **weathering**, much of a quartz vein is left behind while less resistant, surrounding rocks and minerals are eroded away.

Quartz is used as a commercial material or ingredient in making glass, semi-conductors, clock timing devices, high intensity lights, computer chips, and fiber optics.

Perform a hardness test on the quartz that you find along the trail.

Result of Test: ____________________________

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## Stop H - Strike & Dip

**LOOK FOR: Dipping rock strata sticking out of the trail between markers #6 and #7.**

Once again we see here a textbook example of dipping strata. The surrounding rock was eroded away, leaving a pointed structure that dips into the mountain.

Measure the **strike** — the intersection of the imaginary horizontal plane to the Earth's surface and the inclined rock surface — by doing the following:

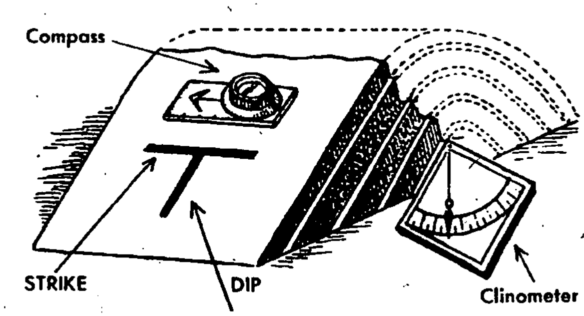
- Hold a cardboard sheet horizontal to the Earth's surface. Mark a line with chalk along the edge of the book at the intersection with the rock outcrop. This line is the strike line.

- Place the compass parallel to the line of strike. Record the compass direction: ________________

Measure the **dip** — the angle in degrees at which the outcrop rises from the ground — by doing the following:

- Place the bottom edge of the **clinometer** on the dip perpendicular to the strike line. The needle or arrow will point to the degrees of dip. Record the dip:

________________



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## *Stop G - Erosion of Large Masses of Rock*

**LOOK FOR: A rock outcrop on left side of trail (northeast). This outcrop is at marker #6.**

This amphibolite outcrop again demonstrates the dip of the rocks to the right (southwest) into the mountain. Notice the very small folds or ripples in this rock. These are called **crenulations**. (Refer to Stop B for information on what causes crenulations.)

Today geologists consider Mt. Jefferson and the surrounding area to be a high, broad plateau. About 250 million years ago, Mt. Jefferson was part of a range of mighty peaks that possibly rivaled today's Himalayan Mountains, which are about five miles above sea level. The highest mountain in the Himalayas, Mt. Everest is 29,028 feet in elevation. That's about 24,468 feet higher than where you are standing right now.

As these mountains eroded slowly over time, the New River and other rivers in the Mississippi drainage carried the eroded sediments to the Gulf of Mexico where new rocks and rock formations are forming today.



## *Stop D - Metagraywacke & Mica Schist*

**LOOK FOR: Large, tilted outcrop on left side of trail; flakes of mica may be seen if you look closely.**

How does this rock compare with amphibolite, the darker rock you have seen at other stops on the trail? Use your magnifying glass to examine the minerals present in the rock. This rock is called metagraywacke (pronounced meta-GRAY-wack). It resulted from the metamorphism of a dirty or muddy sandstone, a **sedimentary rock** that contained quartz along with variable amounts of feldspar and clay particles.

You should be able to see flakes of muscovite (silvery-white to dark brown mica) and biotite (black mica) at certain places in this rock outcrop. This indicates that mica schist, another metamorphic rock, is *interlayered* with the metagraywacke. Mica schist also originated as a sedimentary rock, most likely a shale layer composed of clay.

On a small scale, you can see interlayering of mica schist within the metagraywacke. On a larger scale, you can observe the interlayering of metagraywacke with amphibolite as you hike along this trail. As you hike, try to find the location where the metagraywacke layer ends and the amphibolite begins again.

**Note:** The amphibolite, along with the metagraywacke and mica schist, make up a unique formation (group) of rocks that geologists call the Ashe Metamorphic Suite. With an average thickness of 7.5 to 9.5 miles (12 to 15 kilometers), this formation runs along the eastern flank of the Blue Ridge from southwestern Virginia to northwestern North Carolina.

## Stop E - Strata Orientation

**LOOK FOR: A large rock unit that is tilted. It is located behind the brochure box where the Rhododendron Trail begins.**

Notice that this large outcrop of metagraywacke is tilted about 60 degrees from the horizontal. (90 degrees is vertical.) However, the "parent" rock to this metagraywacke formed from sand and clay sediments that were deposited in horizontal layers. Can you picture how a horizontal rock unit could be folded and displaced to this new orientation?

Explore the cave-like feature in this outcrop where two **joints**, or cracks in the rock, intersect. Joints play a role in weathering rocks. When water enters the crack, then freezes and expands, the force can push the rock apart, more and more each year. Sketch this outcrop below - be sure to include the quartz veins.



## Stop F - Root Destruction

**LOOK FOR: Tree roots in rock next to marker #4 on trail.**

As you were hiking, did you notice where the metagraywacke layer ended and the amphibolite layer began again? The location is between this stop and your last stop. Hint: Look for the excellent folds in the amphibolite on the trail floor.

Now examine the yellow birch tree from below the trail. The roots are growing in cracks in the amphibolite and can put enough pressure on the rock to break off small pieces. This is a type of **mechanical weathering**.

Write your observations or make a sketch here:

# On-Site Activity #3 Geology and Cultural History

**Major Concepts:**
- Mt. Jefferson's geologic history
- The cultural history of the Mt. Jefferson area

**Learning Skills:**
- Observing and communicating
- Listening for details
- Acquiring information

**Subject Areas:**
- Science
- English Language Arts
- Social Studies
- * See **Activity Summary** for a Correlation with DPI objectives in these subject areas.

**Location:** Overlook #2

**Group Size:** 30 or less

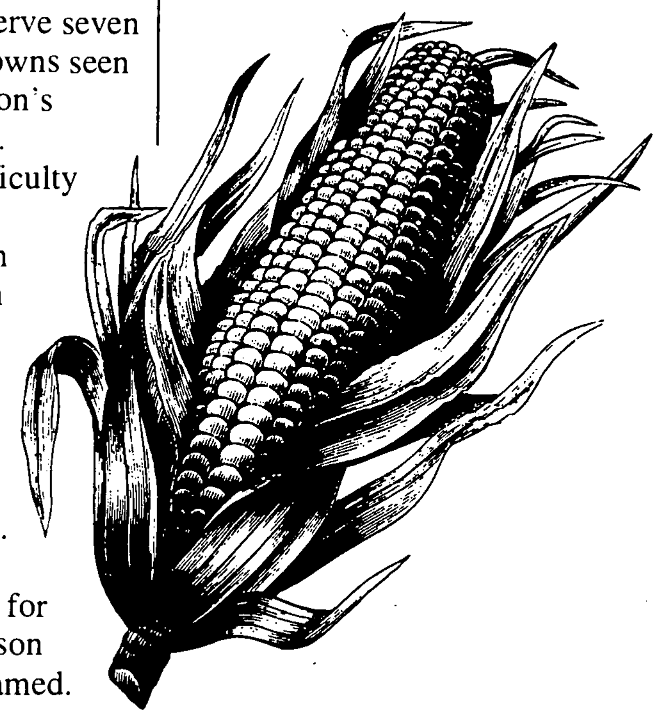
**Time:** park visit — 45 minutes; quiz — 30 minutes

**Appropriate season:** spring, summer, fall

**Special Considerations:** For safety reasons, it is critical that teachers make sure students do not lean on the rail at the overlook area and that they do not walk out onto the rocky area where no rail exists.

**Materials:**
Provided by the park:
Geology and Natural History Presentation Text in this EELE
Provided by the educator:
Per student: one copy of Introduction to the Geology of Mount Jefferson State Natural Area found on pages 1.6 - 1.8 of this EELE, one copy of Mt. Jefferson Quiz

**Objectives:**
- Identify and observe seven peaks and two towns seen from Mt. Jefferson's second overlook.
- Describe the difficulty explorers had traveling through the Mt. Jefferson area.
- Identify the first explorers and the first permanent settlers in the Mt. Jefferson area.
- Identify the rock for which Mt. Jefferson was originally named.
- Write a story about life as a boy or girl in the Mt. Jefferson area in the 1800s.



## Educator's Information:

Prior to their visit to the natural area, students should read the Introduction to the Geology of Mount Jefferson State Natural Area in this EELE. (This could be done in the context of one of the pre-visit activities in this EELE.) The educator should become familiar with the Geology and Cultural History Presentation Text found in this activity, and prepare students for listening and observing.

From the second overlook at the natural area, students will listen to a talk presented by the ranger describing the **geologic** and cultural history of the Mt. Jefferson area. The students will locate landmarks and mountain peaks.

When the students return to their school they will be given a Mt. Jefferson Quiz which will assess how much information the students retained from the visit.

**Instructions:**

Before visiting Mt. Jefferson State Natural Area for the ranger's presentation, review the following rules with the students:

**1.** Students must stay with the group.

**2.** Students must remain quiet and listen carefully during the ranger's presentation. They will be quizzed on what they learned following the trip.

**3.** Students must not lean on the railing at the overlook and they will not be permitted to go out on the rocky area where no rail exists.

**Assessment:**

Following the visit to Mt. Jefferson, distribute the "Mt. Jefferson Quiz" to each student. When they have completed the quiz, review the answers with the class. **Answers to quiz:** 1)c; 2)a; 3)d; 4)b; 5)a; 6)c; 7)b; 8)a; 9)a; 10)a; 11)a.

**Extension:**

**1.** Ask the students to write a story about a boy or girl who might have lived in the Mt. Jefferson area in the 1800s and the experiences he or she had in a time of few modern conveniences. How would his/her lifestyle be different from the lifestyle of a teenager living in this area today?

**2.** Use a transportation map or other maps to locate the towns and places mentioned in the ranger talk: Blowing Rock, Ashe County, Wautaga County, Alleghany County, Yadkin River, Catawba River, Brushy Mountains, Winston-Salem, etc.

# Geology and Cultural History Presentation Text

Mt. Jefferson was named after our third U.S. President, Thomas Jefferson, and was established as a state park in 1956. In 1994 the official name of the park was changed to Mt. Jefferson State Natural Area.

The peak of Mt. Jefferson reaches 4,683 feet above sea level in elevation and rises more than 1,600 feet above the surrounding valleys. Mt. Jefferson contains a number of rare plant species as well as a **heath bald** — a treeless or nearly treeless area unique to the southern Appalachian Mountains.

Prior to 1956 the mountain was known as "Negro Mountain," a name local legend attributes to a cave or caves on the mountain that were REPORTEDLY used to hide runaway slaves enroute north during the pre-Civil War years. In actuality, the more likely reason for the original name of the mountain is a rock known as amphibolite. This rock is very dark in appearance and covers the slopes of the mountain. Particularly during the winter months, when there are no leaves on the trees, the mountain appears to be almost black.

The rocks underlying Mt. Jefferson originated from **volcanic** debris and other **sediments** deposited in an ancient sea approximately 600-800 million years ago. Therefore, this mountain is much, much older than any known human habitation of the area. In fact, aside from Native Americans, there was little or no human presence here prior to the beginning of the American Revolutionary War in the mid-1770s, merely 200+ years ago.

The first persons to explore this area and to leave a written record of it were a small party of **Moravians** led by Bishop Augustus Gottlieb Spangenberg. Bishop Spangenberg and his men were looking for a large tract of land suitable to establish a Moravian settlement. In late November 1752, they were in camp near the Catawba River where the Bishop's diary related:

"We are in a region that has perhaps been seldom visited since the creation of the world. We are some 70 to 80 miles from the last settlement in North Carolina and have come over terrible mountains and through dangerous ways."

At this point they encountered a lone hunter who volunteered to guide them across the Brushy Mountains to the Yadkin River. It developed that he did not know the way and instead of leading them

across the smaller Brushy Mountains to the Yadkin, he led them in a frontal assault on the Blue Ridge at one of its most inaccessible places. They reached the top in what was to be Ashe County through Blowing Rock or thereabouts.

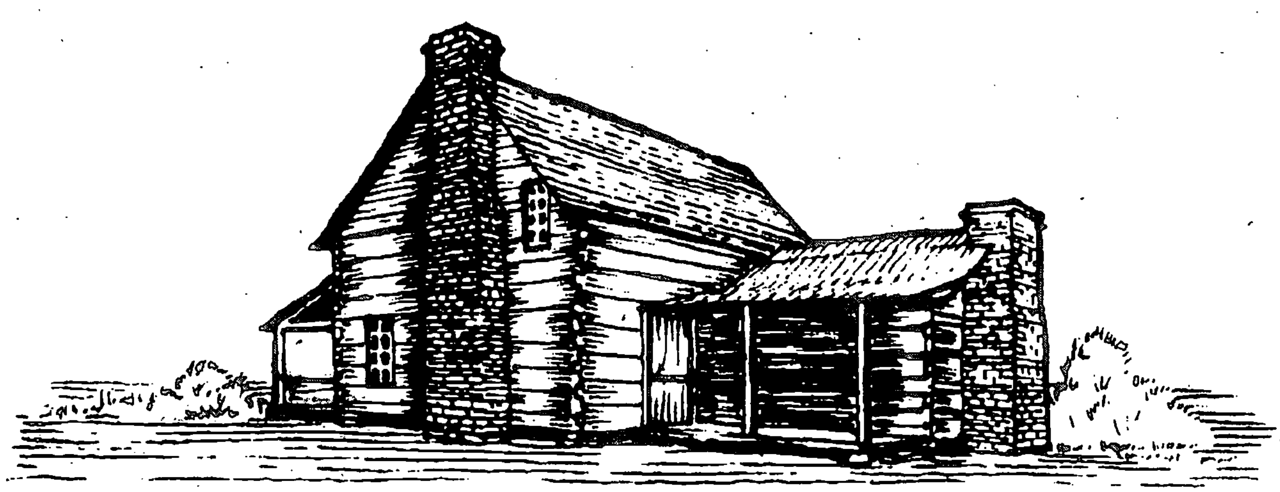
On December 5, 1752 the Bishop wrote in his diary:

"We have reached here after a hard journey over very high, terrible mountains and cliffs. A hunter whom we had taken to show us the way and who once knew the path to the [Y]atkin, missed the trail and led us into a place where there was no way out except by climbing an indescribably steep mountain. Part of the way we climbed on hands and knees, dragging after us the loads we had taken from the backs of the horses, for had we not unsaddled them they would have fallen backward down the mountain — indeed this did happen once; part of the way we led the horses which were trembling like a leaf. When we reached the top we saw mountains to the right, to the left, before and behind us, rising like great waves in a storm. We put up our tent but had barely finished when there came such a windstorm that we could hardly stand against it. I think I have never felt a winter wind so strong and so cold. The ground was covered with snow; water froze by the fire. Then our men lost heart! What should we do? Our horses would die and we with them. For the hunters had about concluded that we were across the Blue [Ridge] Mountains and on the Mississippi **watershed**." Indeed the hunters were correct — they had crossed the Eastern Continental Divide. The New River near Mt. Jefferson eventually empties into the great Mississippi which flows to the Gulf of Mexico.

Unable to locate a suitable tract of land for settlement, and determining that they were on lands claimed by the country of France, the Bishop's party left the mountains. In January, 1753 they located and began establishment of a Moravian settlement on a 100,000 acre tract of land near present-day Winston-Salem, North Carolina.

The first permanent settlers of the Mt. Jefferson area were Virginians who came in the early 1770s and were mostly English, German and Scottish descendants. By the year 1799, when Ashe County was created, there were less than 3,000 inhabitants in the entire county which then included all of present-day Alleghany and Watauga counties.

Because of the area's remoteness and inaccessibility to and from the rest of the state of North Carolina, the later counties of Ashe, Alleghany and Watauga became known as the Lost Provinces. (**Ranger:** Use raised relief topographical map to illustrate natural migration routes from Virginia and the "wall" to



migration created by the Blue Ridge escarpment.)

The population of Ashe County slowly grew to 20,000+ people by 1950 when an out-migration during the 1950s and 1960s actually reduced the population back to 19,000, the same as it had been in the year 1900. This out-migration occurred as people turned away from the farming work their families had traditionally done to seek the more lucrative jobs big industry offered elsewhere. Today the county population is 23,000. The local Chamber of Commerce predicts that as native-born Ashe County residents continue to move away and retirees continue to move into the county, the population will level out at about 24,000 within the next five years.

The first two reliable "roads" into Ashe County were a railroad and a highway. In 1914 the Norfolk and Western Railroad extended its Virginia-Carolina line from Abingdon, Virginia through Ashe County, including West Jefferson, to Todd, North Carolina near Watauga County.

Primarily a timber-harvesting railroad, it also provided passenger service. However, when the timber supply was exhausted the railroad company began closing its operations. Passenger service ceased in the early 1960s and today there is little sign of the original railroad except for the remaining portions of the roadbed itself. In the 1920s an "all-weather" road (Highway 16) was finally completed from North Wilkesboro to Jefferson. This was the beginning of numerous road building projects in the county. No longer was Ashe County a "lost province."

(**Ranger:** Point out the locations of the various landmarks and peaks at this point.) The landmarks visible from this location are:

**1.** Jefferson (county seat established in 1803)

**2.** West Jefferson (established in 1915 - timber town)

**3.** Grandfather Mountain (elevation 5,964 ft. - profile resembles an old man)

**4.** Beech Mountain (elevation 5,506 ft.)

**5.** Snake Mountain, NC & TN (elevation 5,574 ft.)

**6.** Bluff Mountain (elevation 5,100 ft. - protected by the Nature Conservancy and contains more than 30 rare or endangered plant/animal species)

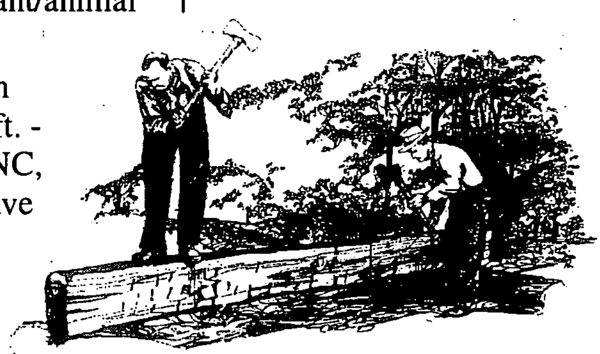
**7.** Pond Mountain (elevation 4,982 ft. - nearby is where NC, VA and TN all have a common boundary point)

**8.** Whitetop Mountain, VA (elevation 5,344 ft. - a unique grassy bald and spruce/fir forest community exists here)

**9.** Big Phoenix Mountain (elevation 4,690 ft.)

**10.** Mount Rogers, VA (elevation 5,729 ft. - highest peak in VA - spruce/fir forest community)

Mt. Jefferson and all of the mountain peaks you see today were here a long, long time before the arrival of humans. Since our arrival a few thousand years ago, or in the case of Europeans a mere 200+ years ago, we have made a number of visible changes to the landscape which we can see in almost any direction we look. Our challenge in the management of state parks is to provide for the appropriate use of parks and, at the same time, protect them for the use and enjoyment of future generations. We believe that the same principle extends to the preservation and use of all lands and waters throughout these unique mountains we call the Appalachians.



# Mt. Jefferson Quiz

**Circle the letter next to the correct answer for each question.**

1. The elevation at the summit of Mt. Jefferson is what?

a. 6,645 ft.

b. 1,600 ft.

c. 4,683 ft.

d. 5,000 ft.

2. The prominent rock type at Mt. Jefferson that is very dark in appearance and covers the slopes of the mountain is known as:

a. amphibolite

b. granite

c. quartz

d. gneiss

3. The rocks underlying Mt. Jefferson originated from deposits in an ancient sea approximately how many million years ago?

a. 300 - 400

b. 500 - 600

c. 800 - 900

d. 600 - 800

4. Who were the first persons to explore this area and to leave a written record of it?

a. A group of explorers led by Christopher Columbus

b. A small party of Moravians led by Bishop Augustus Gottlieb Spangenberg

c. A group of explorers led by Captain John Smith

5. True or False. In his diary entry on December 5, 1752, Bishop Spangenberg said that part of the way up the steep mountain they climbed on hands and knees, dragging the loads they had taken off their horses.

a. True

b. False

**6.** The original group of explorers led by the bishop left the mountains and established a settlement on a tract of land near present-day:

a. Charlotte

b. Asheville

c. Winston-Salem

d. Wilkesboro

**7.** Because of the Mt. Jefferson area's remoteness and steep terrain, the later counties of Ashe, Alleghany and Watauga became known as:

a. The Forbidden Land

b. The Lost Provinces

c. The Highlands

**8.** The unique grassy bald area you saw from the overlook area is known as:

a. Whitetop Mountain

b. Pond Mountain

c. Grandfather Mountain

**9.** The mountain you saw from the overlook area that has a profile that resembles an old man is called:

a. Grandfather Mountain

b. Snake Mountain

c. Bluff Mountain

**10.** The town you saw from the overlook that was established in 1915 as a timber town is:

a. West Jefferson

b. Jefferson

c. Boone

11. True or False. The first permanent settlers of the Mt. Jefferson area were Virginians and were mostly English, German, and Scottish descendents.

a. True

b. False

**Major Concepts:**
- Mining
- Raw materials
- Uses of rocks and minerals

**Learning Skills:**
- Observing,classifying, inferring
- Noting important details and drawing conclusions
- Gathering and organizing information

**Subject Areas:**
- Science
- English Language Arts
- Social Studies

* See **Activity Summary** for a Correlation with DPI objectives in these subject areas.

**Location:** Classroom and home

**Group Size:** 30 or less

**Estimated Time:** Part I — 30 to 45 minutes; Part II — 45 minutes

**Appropriate Season:** Any

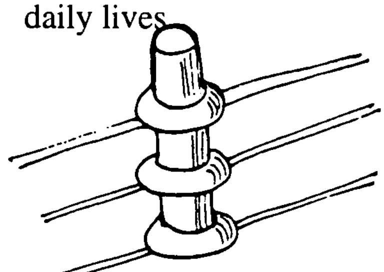
**Materials:**
Provided by the park upon request:
Per class: quartz, feldspar and mica specimens
Provided by educator:
Per student: Geo-Scavenger Hunt sheet
Per class:*quartz watch, amethyst ring or necklace, pressure gauge, camera, eyeglasses, sandpaper, polishing compound (car wax), computer chip (or picture of computer), calculator, sand, fertilizer, drinking glass, ceramic dish, soap, abrasive cleanser or scouring powder, roofing shingle, piece of fabric, sheet of paper, paint can, Christmas-tree "snow," plastic bottle, rubber band, lipstick, cold cream, vitamins.

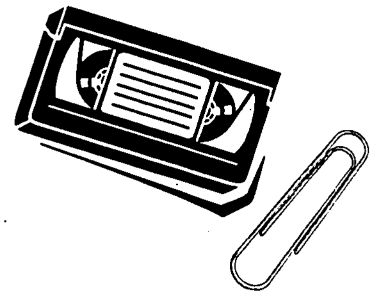
* You do not have to have every object in this list for the activity to work effectively. Use the objects you can conveniently locate.

**Credits:** Adapted from the "Uses of Minerals and Rocks Mined In North Carolina" and "Your House Comes From a Mine!" activities found in the North Carolina Geological Survey's *Mineral and Rock Kit Guide*. Facts and statistics in Student's Information provided by NCGS.

**Optional:** Teachers can contact the North Carolina Geological Survery (NCGS) at P.O. Box 27687, Raleigh, NC 27611-7687, (919) 733-2423 to get a free rock kit containing the minerals listed in the materials list.

## Objectives:
- Use reference materials to match household objects, or pictures of these objects, to the mineral(s) used to make them.
- Explain the importance of Earth resources in our daily lives.





## Educator's Information:

In this activity, the students will learn that many of the things we use in our daily lives come from **rocks** and **minerals**. First the students will examine various household items, or other common items provided by the teacher. They will group items by the primary mineral used to create each item. Note that three common minerals, found in Mt. Jefferson's rocks, are used in this introductory activity. Later, students will take a Geo-Scavenger Hunt list home. They will try to locate as many items as possible from the list and identify the rocks or minerals used to create them. The Student's Information should provide students with most of the background information they need to complete the worksheet and scavenger hunt, but some additional research may be required. Note that mining issues are addressed in Post-Visit Activity #3.

**Instructions:**

**1.** Place pieces of quartz, feldspar, and mica (muscovite would be preferable) in three different locations in the classroom. Samples of these minerals are available in the NC Rocks Kit from NC Geological Survey. Place the items listed in the Materials section in a large box in the front of the room. Photocopy the Student's Information and Geo-Scavenger Hunt worksheet for each student.

**2.** Ask students to read the Student's Information, carefully underlining or noting important ideas. Then have students come, one at a time, to take an item from the box and physically place it next to the main mineral used to create it. Students should do this quickly without talking to others.

**3.** When all the items are placed, ask if everyone agrees with the placement. Move items to another mineral's location if good arguments can be made for doing so. Note that some items are made from more than one mineral – there could be more than one correct answer. Use the Student's Information to check for accuracy and to discuss how each of the three minerals is used to produce specific items.

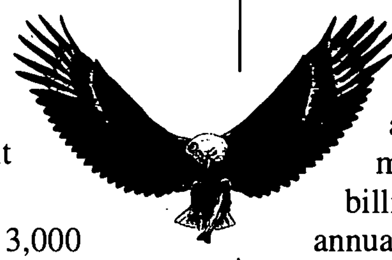
**4.** Give each student a copy of the Geo-Scavenger Hunt worksheet. For homework, they should check off each of the items they are able to locate in their homes. Then referring to the Student's Information, they should choose ten items that have been checked and list the rocks or minerals used to make each item.

**Assessment:**

Create your own matching quiz by listing 10 products mentioned in the Student's Information on one side of the page, and the rocks or minerals used to create each one on the other side of the page. Can students correctly match at least 8 items? Or, use the worksheet found on page 16 of the North Carolina Geological Survey's *Mineral and Rock Kit Guide.*

# Student's Information:

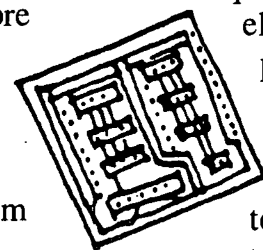
Life has always depended on **minerals**. The first life, primitive **microbes**, depended on minerals for **nutrients** to live and grow. Today, plants, animals and people still get essential nutrients from minerals and their building blocks, the **elements**. For example, all animals living on land need salt to maintain the right balance of fluid in their bodies. Animals that have backbones or shells could not exist without calcium or the minerals that provide it in their diets.



More than 3,000 different minerals exist on our planet. About 2,000 of them are so useful that we mine and process them to create cars, buildings, appliances and many other essential items. An **ore** is a concentrated deposit of minerals, including metallic minerals such as iron, copper and gold, that can be mined for profit. Many ores come from underground mines, but some are extracted from open pit or surface mines. In North Carolina, companies must apply for permits to mine. They must go through a public review process before mining can begin. Then, government officials ensure that mine operators follow procedures to reduce environmental problems that could result from mining, such as runoff into nearby streams. Once the ore or **rocks** have been removed from the earth, mining companies are required to reclaim the land. A large percentage of land once mined has already been restored as wildlife habitats, public parks and housing developments.

Our nation consumes large amounts of Earth materials, about 2.3 billion metric tons annually. Each year, miners produce 10 metric tons — that's about a dump truck load – of rocks and minerals for each person in the United States! Even though you are surrounded by mineral products in your home and school, you may not recognize the **raw material** from which they came. For example, did you know that refined **quartz** and feldspar components are used in television picture tubes? Feldspar is also used in bath tiles, abrasives in cleaners, and roofing tiles. Let's learn more about the three common minerals you found in Mt. Jefferson's rocks.

**QUARTZ**

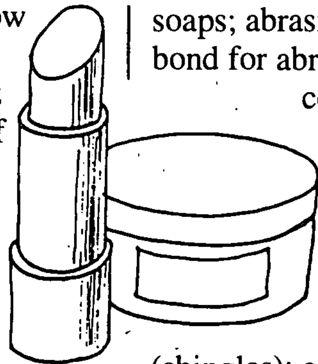


Quartz displays **piezo-electricity**. Pressure on a quartz **crystal** causes electrical charges to be produced across the crystal. An electrical charge placed on the crystal will cause it to vibrate. This property makes quartz the main component in watches, computer chips, transistors for radios and calculators, solar cells, and other precision instruments including pressure gauges, **oscillators**, **resonators** and **wave stabilizers**.

Because of its transparency and ability to affect the transmission of light rays, quartz is used to make the glass in many optical instruments. Examples are camera lenses, telescope mirrors, eyeglasses and heat-ray lamps. High-quality, North Carolina quartz was used to make the mirror in the famous telescope at the Mt. Palomar Observatory in California.

Silica sand and quartz mined in North Carolina are used in the manufacture of glass. Refined silica sand is also used in the glass screens of televisions and computers and in electronic chips.

Quartz is a semi-precious stone. Amethyst jewelry is made from purple quartz. Many other fine gem specimens of quartz found in North Carolina include citrine or yellow quartz, smoky or gray quartz, rutilated quartz (needle-like crystals of rutile are imbedded in the quartz), and adventurine or green quartz.



Ground-up quartz is used in industry to create ceramics, hydraulic cements, water filtration units, sandpaper, polishing compounds and scouring powder. It is also used as a filler in cosmetics (lipstick and cold cream), pharmaceuticals (vitamins and minerals), and rubber (rubber bands).

## FELDSPAR

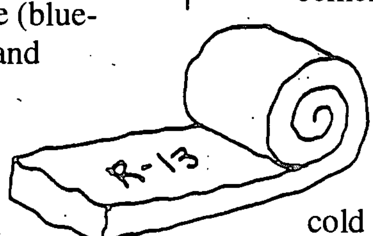
Feldspar is mined from pegmatite and other **intrusive igneous rocks** at Spruce Pine, North Carolina in Mitchell County. North Carolina provides about 70 percent of the world's feldspar.

Many of the more than 70 varieties of feldspar can be cut into gems or rounded into beads. Varieties found in North Carolina are moonstone with a pearly **luster**, amazonite (blue-green feldspar), and sunstone which displays flashes of color.

Feldspar is an important industrial mineral used in many products: glass and ceramics; pottery and enamel ware; soaps; abrasive cleaners; bond for abrasive wheels; cements and concretes; insulation; fertilizer; poultry grit; roofing materials (shingles); and filler in textiles and papers. Fiberglass insulation is made from fused quartz and feldspar.

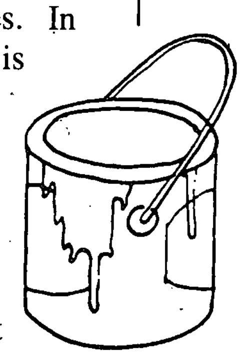
## MICA

Large, thin translucent sheets of muscovite were once used to make heat-resistant windows in ovens, toasters, and furnaces. In our state, muscovite is mined from pegmatites and alaskite in Avery, Mitchell and Cleveland counties. North Carolina mines produce about 65,000 metric tons of scrap mica (ground-up mica) per year valued at over $3.5 million. The mica is used in many products including paints, plastics, plasterboard, wallboard joint cement, well-drilling muds, roofing, welding rods, rubber, cosmetics (lipstick and cold cream) and cement.



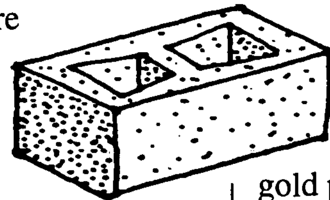

Here are more examples of products that come from mines in North Carolina:

- Kaolin clay is used in the manufacture of dinnerware, fine porcelain and as a paper coating.
- Furnaces used to bake bricks are lined with olivine. Olivine is used as a heat-resistant liner in kilns and heating furnaces. Olivine is mined in Yancey County.
- Peat is mixed with soil around plants and flowers. Peat is also used as an insulation for packing fruits and vegetables and as a protein additive in cattle food.
- Phosphate is used in plant food, fertilizers, animal feed, pesticides, ceramics and photographic chemicals.

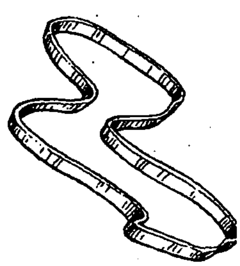


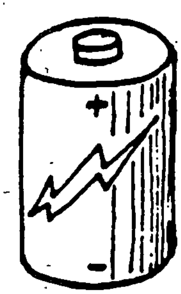
- Lithium is produced from spodumene. Lithium is used in supersonic aircraft, spacecraft, paints, batteries, grease, lubricants and medicine.
- Talc is used in paints, insecticides, rubber products, ceramics, paper coatings and dinner ware.
- Pyrophyllite is used in soap bleaching powders and electric insulators. The most familiar use for both talc and pyrophyllite minerals is in talcum powder.
- Brick manufacturing is the third largest income producing mining industry in North Carolina. Clay is mined and made into bricks

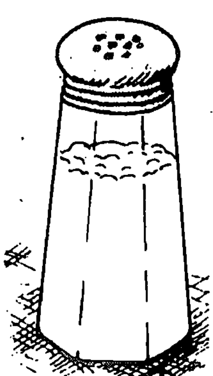
of all shapes, colors and sizes. Bricks are also used for large buildings and in the paving of walkways. Some clays are made into drain and floor tiles.

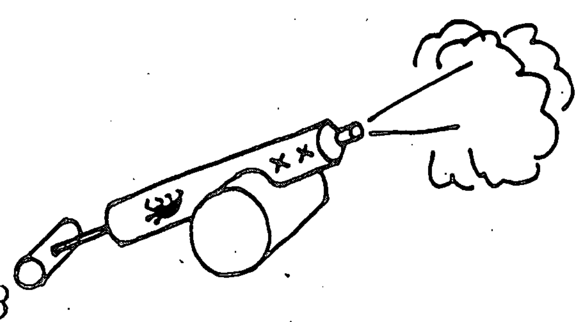


- Many buildings, including the State Capitol, are covered by North Carolina dimension stone. One of the most popular is the Mt. Airy Granite. Dimension stone is also used to build monuments.
- Building stone is used to face or veneer buildings, walls and fireplaces.
- Emeralds, rubies, garnets and more than 300 other varieties of gemstones can be found in North Carolina. Thousands of tourists and rockhounds search for gemstones in North Carolina each year.
- North Carolina was once a major gold producing state. In 1799, a 17-pound nugget was discovered in Cabarras County. That discovery touched off the first true gold rush in the United States. During the mid 1800s, gold coins were minted at the privately owned Bechtler Mint in Rutherford County and a branch of the United States Mint in Charlotte. Although large-scale gold production ended in the 1800s, gold production continued until 1942. New mining technology has renewed interest in commercial gold production.
- The crushed rock, sand and gravel used to build roads comes from North Carolina's largest income-producing mining industry. Without it, we could not build roads of concrete or asphalt or construct bridges. Large stones, called riprap, are often used on steep slopes, in stream channels or along shorelines to help hold the soil in place, preventing **erosion** and **sedimentation**.









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# Part II: Geo-Scavenger Hunt

**Put a check mark next to each of the objects you are able to locate in and around your home. Choose ten of the checked items and list the rocks or minerals used to make each.**

| **Used to Build the Home:** | **Rocks/Minerals Derived From:** |
|---|---|
| roofing shingles | |
| brick | |
| wallboard | |
| wall paper | |
| paint | |
| door knobs, locks and hinges | |
| windows | |
| sandpaper | |
| plumbing | |
| sinks and porcelain fixtures | |
| insulation | |
| ornamental flooring | |
| floor tile | |
| foundation | |
| gravel driveway | |
| fertilizers | |
| **Found in the Home:** | |
| light bulb | |
| antacid tablet | |
| table salt | |
| paper clip | |
| personal computer or calculator | |
| soft drink can | |
| pencil | |
| bug spray | |
| piece of glossy paper | |
| toothpaste | |
| baby powder | |
| piece of jewelry | |
| face powder (makeup) | |

# Part II: Geo-Scavenger Hunt — Answer Sheet

**Put a check mark next to each of the objects you are able to locate in and around your home. Choose ten of the checked items and list the rocks or minerals used to make each.**

| **Used to Build the Home:** | **Rocks/Minerals Derived From:** |
|---|---|
| roofing shingles | talc, mica, quartz, feldspar |
| brick | clays |
| wallboard | gypsum, mica |
| wall paper | clay |
| paint | pigments made from metal oxide minerals, also kaolin, limestone, talc and other fillers such as pyrophyllite |
| door knobs, locks and hinges | copper, zinc, iron (talconite) |
| windows | glass made from quartz, feldspar |
| sandpaper | ground minerals like quartz, garnet, aluminum oxide |
| plumbing | copper, zinc, steel (taconite), nickel, chrome |
| sinks and porcelain fixtures | clay, pyrophyllite |
| insulation | quartz and feldspar |
| ornamental flooring | marble or granite |
| floor tile | limestone, pyrophyllite, talc |
| foundation | concrete made from limestone, clay, gypsum iron, feldspar and crushed rock |
| gravel driveway | crushed rock |
| fertilizers | peat, phosphate,limestone, gypsum |
| **Found in the Home:** | |
| light bulb | tungston, quartz, copper |
| antacid tablet | calcium carbonate (calcite) from limestone, kaolin |
| table salt | mineral halite |
| paper clip | steel from iron ore (taconite) |
| personal computer or calculator | silicon in computer chips is made from quartz |
| soft drink can | aluminum from mineral bauxite; white paint on label from titanium dioxide |
| pencil | "lead" is mineral graphite mixed with clay |
| bug spray | pyrophyllite is used as inert "carrier" material |
| piece of glossy paper | kaolin is used to make glossy paper |
| toothpaste | calcium carbonate from limestone, sodium carbonate |
| baby powder | talc |
| piece of jewelry | metals, gemstones |
| face powder (makeup) | talc, mica, clays, iron oxide and titanium dioxide pigments |

# Post-Visit Activity #2: It's About Time

**Major Concepts:**
- Geologic time
- Geologic history

**Learning Skills:**
- Gathering, organizing and analyzing information
- Calculating numbers and solving mathematical problems
- Interpreting data

**Subject Areas:**
- Science
- English Language Arts
- Mathematics
- * See **Activity Summary** for a Correlation with DPI objectives in these subject areas.

**Location:** Classroom

**Group Size:** 20 - 30 students

**Estimated Time:** One class period

**Materials:**
Provided by the educator:
Per Class: Geologic Clock Illustration, Geologic Events Cards
Per Student: Student's Information, Geologic Time Illustration, Geologic Clock — Worksheet, pencil, calculator (optional)

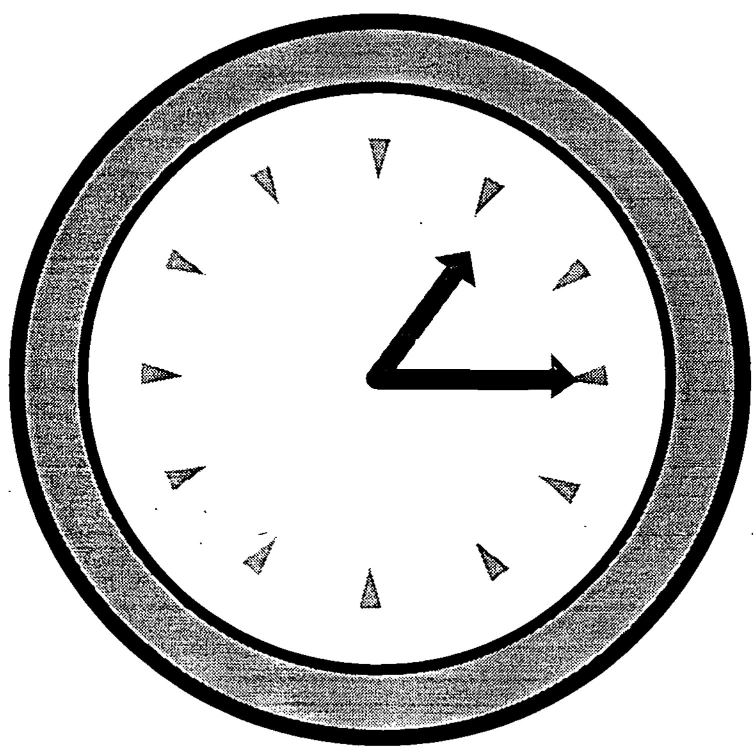
## Objectives:

- Convert geological and biological events, occurring millions of years ago, to a 24-hour time clock by following a sample calculation.
- Identify and describe three important events in the geologic history of Mt. Jefferson.
- Use reference materials to identify the period or epoch for a given event in geologic time.

## Educator's Information:

In this activity, student's will be introduced to **geologic time** (as scientists see it) and get a quick review of various events that have occurred since the Earth formed.

They will accomplish this by receiving a slip of paper with an event in geologic history described on it. They will calculate and record when their event occurred during a special 24-hour cycle using the formula provided in the Student's Information. As the instructor calls out each hour on the 24-Hour Geologic Clock, the student with an event occurring at that time will stand up and announce to the class what their event was and when it occurred in 'real' time. They will then post their event in the appropriate location on the geologic clock.



**Instructions:**

**1.** Using the 24-Hour Geologic Clock as your model, create a giant clock on a poster or as a bulletin board dispay.

**2.** Cut out and laminate each of the Geologic Events Cards.

**3.** Use the Student's Information to assist you in explaining how to convert an event in geologic time to the 24-hour geologic time clock. Provide further guided practice as needed.

**4a.** Younger students: Provide a geologic event card for each student, or each team of two students. The students should follow the sample calculation given in the Student's Information to convert their event to compressed time on the special geologic clock. They should write their time on the Geologic Clock Worksheet under the column labelled "Compressed Time" next to their assigned event. When you call out their time on the 24-hour geologic clock, each student or team should stand up and announce their event and tape the event card to the clock illustration on the board. Students should fill in the worksheet as their classmates stand up to announce each event.

**4b.** Older students: Provide older students with the worksheet; they will not need the Geologic Events Cards. Following the sample calculation in the Student's Information, they should be able to calculate the compressed time for each event.

**5.** For further study of geologic time with older students: Assign an event or geologic time period to each student. Ask the students to use the information provided in the Geologic Time — Reference Section, along with reference materials in the school library, to write a report on their event or time period. You might also use the 24-Hour Geologic Clock illustration as a worksheet that students can label with the geologic time periods. Note: Students should first find the beginning and ending times for each of the periods in the Geologic Time — Reference Section. Then they should convert these times to compressed time in order to mark the appropriate lengths of each period on the 24-Hour Geologic Clock.

## Modification:

If you want to avoid the calculations and focus merely on sequencing of geological events, use the Geologic Events Cards and the Geologic Clock — Modified Version of the worksheet. Students should find the "approximate real time" given on their geological event card, then write their event in the proper place on the chart. When the teacher calls out the time of their event, they should stand up and announce it. All the other students should enter this event on their charts.

## Assessment:

- Ask the students to identify three geologic events that are especially important for Mt. Jefferson.

**Answer:** 1) 800 million years old — the original rocks (sedimentary & igneous rocks) were laid down in the Iapetus Sea, an ancient ocean; 2) 500 million years ago — mountain building begins (Appalachian Mountains); the parent rocks are metamorphosed to create the rocks we see on Mt. Jefferson today; 3) After 220 million years ago — mountain building period is over and **erosion** and **weathering** dominate the geological scene at Mt. Jefferson.

- Ask the students to list three other geologic events that have occurred since the Earth formed.

## Extension:

Using reference books, encyclopedias, field guides, etc., search for other Earth history events not listed on the Geologic Events Cards and include them on the 24-Hour Geologic Clock.

# Student's Information

## Using Your Geologic Clock

Geologists think the Earth is about 4.5 billion years old. Or, another way to say that is 4,500 million years old. However you say it, that's old! In this activity you will compress or squeeze 4.5 billion years of geologic time into a 24-hour cycle. Pretend that the Earth formed at midnight (the beginning of the 24-hour cycle) and that the following midnight represents today, right now. On this scale, one second equals 52,083 years; one minute equals 3,125,000 years; and one hour equals 187,500,000 years, or 187.5 million years.

Your teacher will give you a card or slip of paper with an event in geologic history. **Example:** Cockroaches appeared (in the fossil record) approximately 320 million years ago — 320,000,000. ***Calculate when your event occurred during our special 24-hour cycle.***

**Sample calculation:**

**1.** Remember that one hour = 187.5 million years on our scale. Use a calculator to divide the actual years given on your Geologic Event card by 187.5 million years.

Example: 320 ÷ 187.5 = 1.71 hours

**2.** To find your time on the 24-hour Geologic Clock, subtract the number of hours in step #1 from 24 hours.

Example: 24.00 - 1.71 = 22.29 hours

**3.** Round the number from step #2 to the nearest tenth of an hour.

Example: 22.29 = 22.3

**4.** Look at the conversion chart on this page to convert the tenth of an hour to minutes.

Example: .3 of an hour = 18 minutes

**5.** Now round your time off to the <u>nearest</u> 5 minutes, be it forward or back

Example: 22 hours and 18 minutes becomes 22 hours and 20 minutes

**6.** Change from military time to regular time.

Example: 22 hours = 10 p.m., so 22 hours and 20 minutes = 10:20 p.m.

When the leader calls out your time, stand up and announce your event. Example: When the clock says 22:20 p.m., you stand up and say something like, "22:20 hours military time or 10:20 p.m. — Cockroaches appeared; in 'real' time that was 320 million years ago." Tape your slip of paper on the clock at 22:20 hours.

**Conversion Chart:**

| | |
|---|---|
| .1 of an hour = 6 minutes | .6 of an hour = 36 minutes |
| .2 of an hour = 12 minutes | .7 of an hour = 42 minutes |
| .3 of an hour = 18 minutes | .8 of an hour = 48 minutes |
| .4 of an hour = 24 minutes | .9 of an hour = 54 minutes |
| .5 of an hour = 30 minutes | .99 of an hour = 59 minutes |

# Geologic Events Cards

The earliest life forms (bacteria) appeared in the fossil record about 3,300 **million** years ago.

3,300,000,000

Hard-shelled sea creatures (such as the trilobites & horseshoe crabs) appeared in the fossil record about 550 **million** years ago.

550,000,000

Blue-green algae appeared in the fossil record around 2,600 **million** years ago. Photosynthesis began on planet Earth!

2,600,000,000

Mountain building begins in North Carolina about 500 **million** years ago when the crustal plate carrying Africa moved toward the plate carrying North America; dinoflagellates appear

500,000,000

Oldest known rock in North Carolina dates back to 1,800 **million** years ago.

1,800,000,000

Earliest known fossils of fish date back to about 450 **million** years ago.

450,000,000

Eucaryotic cells (cells with distinct nuclei) appeared in the fossil record about 1,600 **million** years ago. Up until this time, all the cells were procaryotic cells (bacteria and blue-green algae)

1,600,000,000

First land plants (mosses) and land animals (millipedes) appeared in the fossil record about 400 **million** years ago.

400,000,000

Earliest multi-cellular organisms appeared 800 **million** years ago (fossils of worm tracks). This is also the time when parent rocks of today's Mt. Jefferson rocks were deposited in an ancient ocean basin.

800,000,000

Amphibians appeared in the fossil record about 400 **million** years ago.

400,000,000

Soft-bodied sea creatures (jellyfish and corals) appeared in the fossil record about 700 **million** years ago.

700,000,000

Early reptiles and flying insects appeared in fossil record about 300 **million** years ago.

300,000,000

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# Geologic Events Cards continued

| | |
|---|---|
| Dinosaurs appeared on Earth about 250 **million** years ago.<br>250,000,000 | Early primates appeared in the fossil record about 65 **million** years ago.<br>65,000,000 |
| The Atlantic Ocean formed about 220 **million** years ago when the crustal plates carrying North America and Africa moved apart. Rippp! Weathering and erosion become the dominant forces acting on Mt. Jefferson rocks.<br>220,000,000 | The dinosaurs became extinct about 65 **million** years ago. (Boo hoo)<br>65,000,000 |
| Small, marsupial mammals (vertebrates with hair and pouches like opossums) appeared about 220 **million** years ago.<br>220,000,000 | The earliest known whales appeared in the fossil record about 38 **million** years ago.<br>38,000,000 |
| The earliest birds got the worms (ha, ha) and appeared 195 **million** years ago in the fossil record.<br>195,000,000 | Humans arrived about 1 **million** years ago or less.<br>1,000,000<br>Note: Please round this "time" off to the nearest minute rather than the nearest 5 minutes. *Hint: Use conversion chart provided BUT don't round off (skip Step 5 in steps in sample calculation.* |

# Geologic Clock — Worksheet

| Compressed Time | Event | Approximate Real Time |
| --- | --- | --- |
| 12:00 Midnight - "day" begins | The Earth is born | 4,500 million years ago |
| | Earliest life forms appear (bacteria) | 3,300 million years ago |
| | Blue-green algae appear & photosynthesis begins | 2,600 million years ago |
| 12:00 p.m. (noon) | Nothing big happening here | 2,250 million years ago |
| | Oldest known rock in North Carolina dates back to this time | 1,800 million years ago |
| | Eucaryotic cells appear (cells with distinct nuclei) | 1,600 million years ago |
| | Earliest multicellular organisms (fossils of worm tracks); Mt. Jefferson's parent rocks deposited in ancient sea | 800 million years ago |
| | Soft-bodied sea creatures appear | 700 million years ago |
| | Hard-shelled sea creatures appear | 550 million years ago |
| | Mountain building begins in NC when Africa moves toward N. America ; dinoflagellates appear | 500 million years ago |
| | Fishes appear | 450 million years ago |
| | First land plants and animals appear; earliest amphibians | 400 million years ago |
| 10:20 p.m. | Cockroaches Appear - gross! | 320 million years ago |
| | Early reptiles and flying insects appear | 300 million years ago |
| | Dinosaurs appear | 250 million years ago |
| | Atlantic Ocean forms; weathering and erosion occur; small, marsupial mammals appear | 220 million years ago |
| | Birds appear | 195 million years ago |
| | Early primates appear; dinosaurs become extinct | 65 million years ago |
| | Earliest known whales | 38 million years ago |
| * round to nearest minute | Humans arrive seconds before midnight | 1 million years ago or less |
| 12:00 Midnight - "day" ends | Today, like RIGHT NOW | 00:00:00 |

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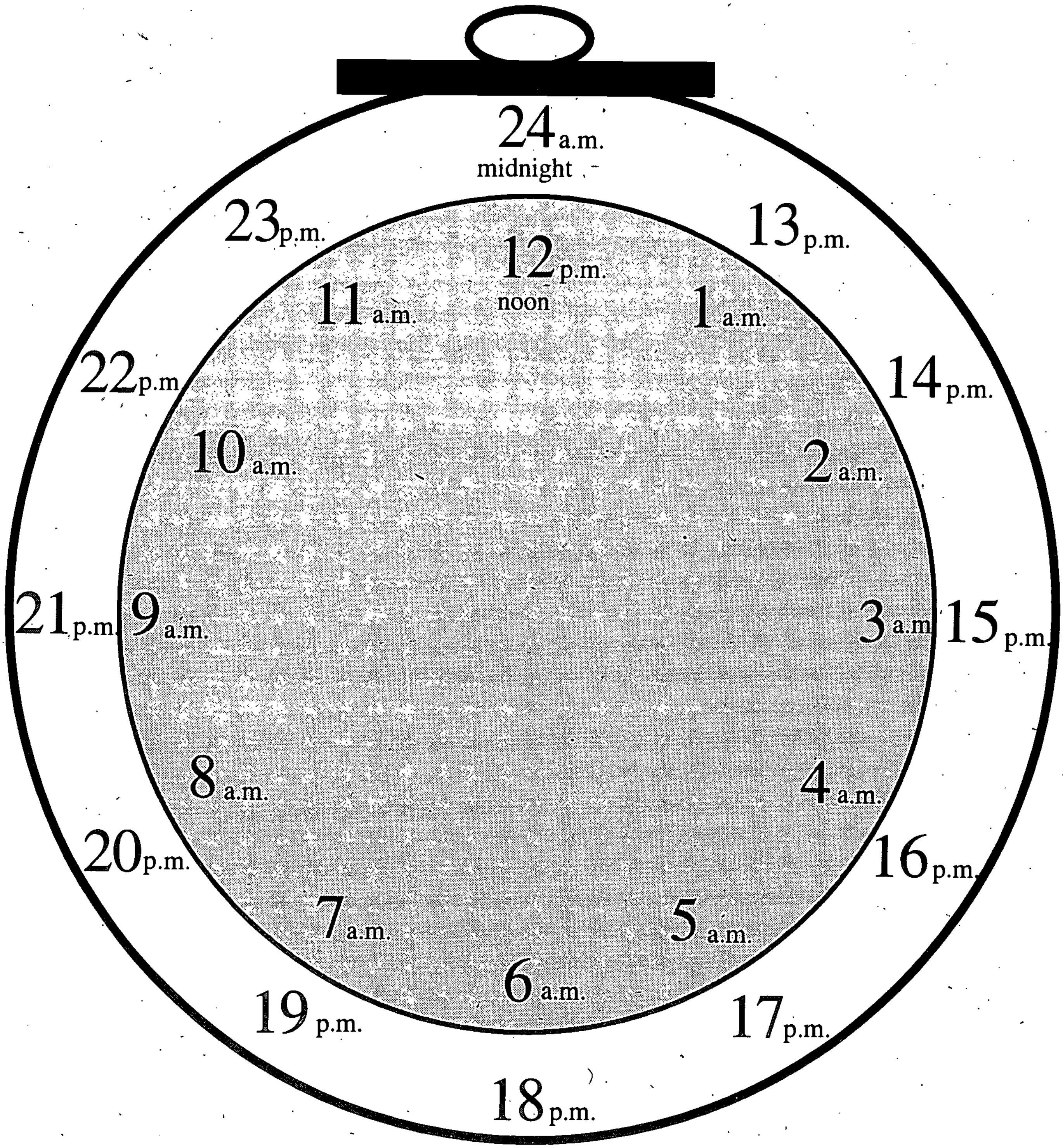
# Geologic Clock — Answer Sheet

| Compressed Time | Event | Approximate Real Time |
|---|---|---|
| 12:00 Midnight - "day" begins | The Earth is born | 4,500 million years ago |
| 6:25 a.m. | Earliest life forms appear (bacteria) | 3,300 million years ago |
| 10:05 a.m. | Blue-green algae appear & photosynthesis begins | 2,600 million years ago |
| 12:00 p.m. (noon) | Nothing big happening here | 2,250 million years ago |
| 2:25 p.m. | Oldest known rock in North Carolina dates back to this time | 1,800 million years ago |
| 3:30 p.m. | Eucaryotic cells appear (cells with distinct nuclei) | 1,600 million years ago |
| 7:40 p.m. | Earliest multicellular organisms (fossils of worm tracks); Mt. Jefferson's parent rocks deposited in ancient sea | 800 million years ago |
| 8:20 p.m. | Soft-bodied sea creatures appear | 700 million years ago |
| 9:05 p.m. | Hard-shelled sea creatures appear | 550 million years ago |
| 9:20 p.m. | Mountain building begins in NC when Africa moves toward North America; dinoflagellates appear | 500 million years ago |
| 9:35 p.m. | Fishes appear | 450 million years ago |
| 9:55 p.m. | First land plants and animals appear; earliest amphibians | 400 million years ago |
| 10:20 p.m. | Cockroaches Appear - gross! | 320 million years ago |
| 10:25 p.m. | Early reptiles and flying insects appear | 300 million years ago |
| 10:40 p.m. | Dinosaurs appear | 250 million years ago |
| 10:50 p.m. | Atlantic Ocean forms; weathering and erosion occur; small, marsupial mammals appear | 220 million years ago |
| 11:00 p.m. | Birds appear | 195 million years ago |
| 11:40 p.m. | Early primates appear; dinosaurs become extinct | 65 million years ago |
| 11:50 p.m. | Earliest known whales | 38 million years ago |
| 11:59 p.m.<br>* round to nearest minute | Humans arrive seconds before midnight | 1 million years ago or less |
| 12:00 Midnight - "day" ends | Today, like RIGHT NOW | 00:00:00 |

# 24-Hour Geologic Clock

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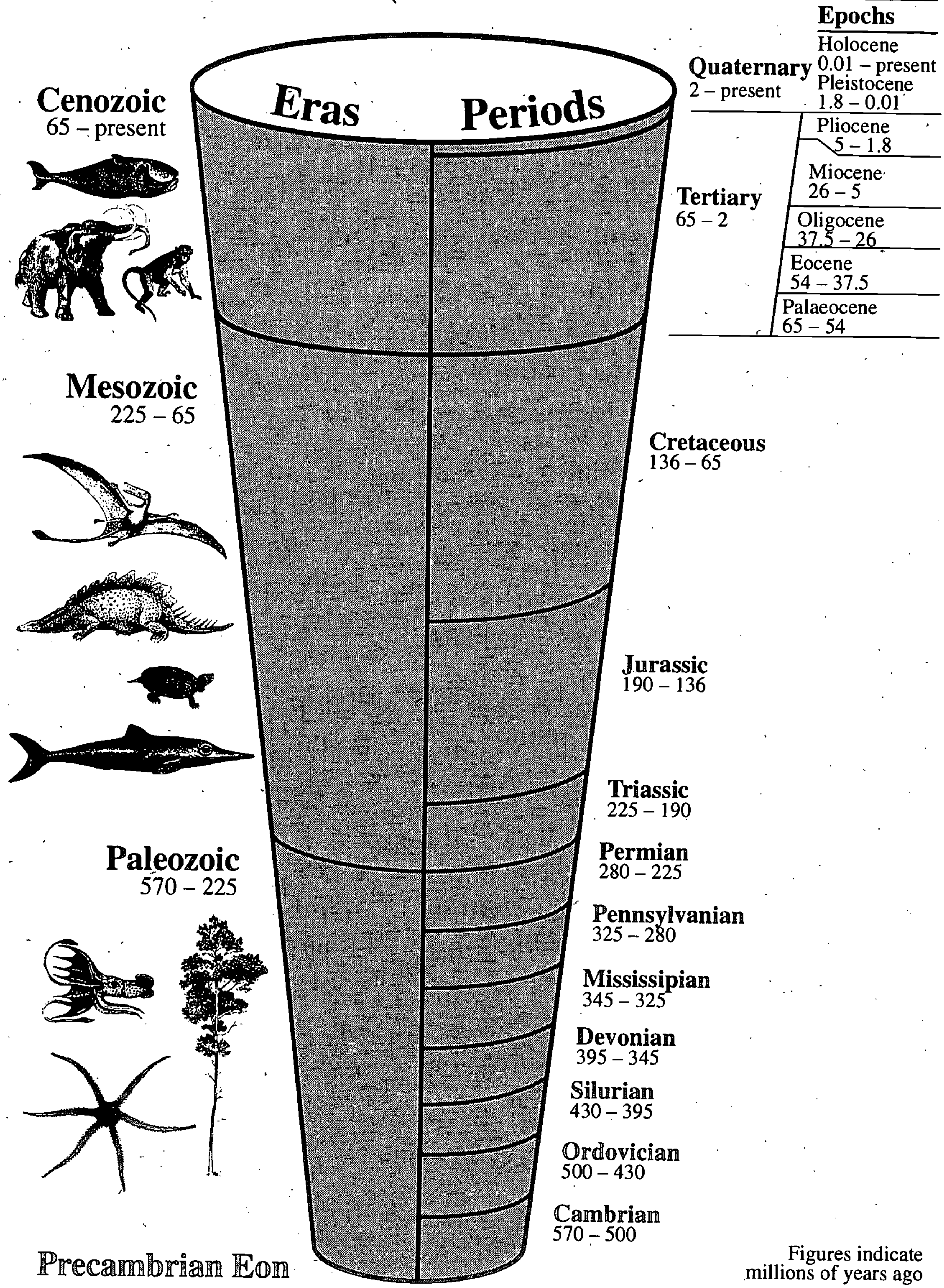
# Geologic Clock — Modified Version

| Compressed Time | Event | Approximate Real Time |
|---|---|---|
| 12:00 Midnight - "day" begins | The Earth is born | 4,500 million years ago |
| 6:25 a.m. | | 3,300 million years ago |
| 10:05 a.m. | | 2,600 million years ago |
| 12:00 p.m. (noon) | Nothing big happening here | 2,250 million years ago |
| 2:25 p.m. | | 1,800 million years ago |
| 3:30 p.m. | | 1,600 million years ago |
| 7:40 p.m. | | 800 million years ago |
| 8:20 p.m. | | 700 million years ago |
| 9:05 p.m. | | 550 million years ago |
| 9:20 p.m. | | 500 million years ago |
| 9:35 p.m. | | 450 million years ago |
| 9:55 p.m. | | 400 million years ago |
| 10:20 p.m. | Cockroaches Appear - gross! | 320 million years ago |
| 10:25 p.m. | | 300 million years ago |
| 10:40 p.m. | | 250 million years ago |
| 10:50 p.m. | | 220 million years ago |
| 11:00 p.m. | | 195 million years ago |
| 11:40 p.m. | | 65 million years ago |
| 11:50 p.m. | | 38 million years ago |
| 11:59 p.m. * round to nearest minute | | 1 million years ago or less |
| 12:00 Midnight - "day" ends | Today, like RIGHT NOW | 00:00:00 |

# Geologic Time — Reference Section



Time is an extremely important concept in geology. **Geologic time** includes all the time that has occurred since the formation of the Earth – an estimated 4.5 billion years ago. These 4.5 billion years have been broken down into different eons, eras, periods and epochs based on the life forms that were inhabiting the Earth at the time. All of time is divided into two eons: Precambrian and Phanerozoic. The Precambrian Eon lasted from the formation of the Earth until the time when fossils became abundant in the rocks. The Phanerozoic Eon has been divided into three eras. Each of the eras is further subdivided into periods. Each of the periods is further subdivided into epochs. Each of the units of geologic time is characterized by different environmental conditions and specific kinds of life that flourished. Often, the boundaries between the geologic time periods was marked by mass extinctions. Scientists are using records that are preserved in rocks to put together a history of our planet.

## Precambrian Eon

*4.5 billion years ago to 570 million years ago*

This is the longest division of Earth's history, representing about 87% of the 4.5 billion years that the Earth has existed. The rocks laid down during the Precambrian Eon form the cores of today's continents. The very first, extremely simple forms of life started to evolve about 3.4 billion years ago. Life on Earth began as simple, one-celled organisms, like blue-green algae. This algae used carbon dioxide and sunlight as energy sources. However, its waste product, oxygen, enabled the evolution of more complex life. Sponges, soft corals, jellyfish and annelid worms also evolved during the Precambrian Eon.

## Phanerozoic Eon

*570 million years ago to the present*

## Paleozoic Era

"Age of Ancient Life"

*570 million to 225 million years ago*

### Cambrian Period

*570 to 500 million years ago*

This period marks the first appearance of fossil shells. The most common shelled animal of this time was the trilobite. Trilobites were probably scavengers on the floor of the ocean. All life lived in the ocean during this period, because the Earth's atmosphere had not yet developed to protect the land from the ultraviolet radiation of the sun. Along with the trilobites, there were sponges, brachiopods and gastropods (one-shelled mollusks like whelks). At the end of the Cambrian Period, there was a mass extinction of 75% of all the trilobite families, 50% of the sponge families and many of the brachiopods and gastropods. No one knows what caused this extinction.

### Ordovician Period

*500 to 430 million years ago*

A few very primitive plants evolved to live on land during this period. However, most life forms were still evolving in the oceans. Bivalves, like clams and oysters, developed during the Ordovician Period, along with most of the other invertebrate (without a backbone) animals. Starfish, brittle stars, hard corals and crinoids were some of these invertebrates. Very primitive, jawless fishes also developed during this period. Fish are one kind of vertebrate, or animal with a backbone. There was a mass extinction at the end of this period. Many of the remaining trilobites and some of the sponges and early fish went extinct.

### Silurian Period

*430 to 395 million years ago*

This period is marked by the development of extensive coral reefs. No new major forms of life developed during this period. All of the life that had already evolved continued to flourish with the exception of the trilobite which continued to become rarer. There may have been millipedes and scorpions beginning to live on the land.

## Devonian Period

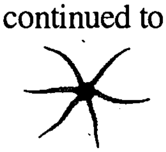
*395 to 345 million years ago*

This period is called the Age of Fishes because the early, primitive forms of fish really multiplied and diversified. Sharks, rays and bony fishes developed during this period. One was the giant, 30 foot long fish called the Dunkleosteus. It did not have any teeth, but the bones in its jaw were as sharp as knives. Other invertebrates began to live in fresh water during this period. The first amphibians, animals that live part of their life in water and part on land, evolved. The first forests, with giant horsetails and tree ferns, were formed during the Devonian Period. The first seed-bearing plants also evolved then. Mass extinction marked the end of this period. About 25% of all species went extinct.

## Mississippian Period:

*345 to 325 million years ago*

During this period almost all of North America was covered by oceans. Crinoids, feather stars and sea lilies flourished in the oceans during this period. The trilobites continued to decline.



## Pennsylvanian Period:

*325 to 280 million years ago*

The 45 million years of the Pennsylvanian period were a time of mountain building and the loss of many of the shallow seas. As a result, many of the marine species declined. However, the first insects and reptiles evolved. In fact, the largest insect that ever lived, a dragonfly with a wingspan of 29 inches lived during this time. Most of the land was covered with swampy forests. Conifers first developed during the Pennsylvanian Period.

## Permian Period:

*280 to 225 million years ago*

During the 55 million years of the Permian Period, the marine invertebrates specialized into many different forms. The ginkgo tree first appeared. Reptiles and amphibians continued to develop. One of the most important groups of reptiles from this period was the pelycosaurs. They had tall, sail-like projections from their backs that were supported by spines out of their backbone. The pelycosaur probably used its sail to help heat and cool its body. The pelycosaurs were the ancient forerunners of mammals. The Permian Period ended with the most severe of all mass extinctions – 96% of all species were lost.

# Mesozoic Era:

"Time of Middle Life"

*225 to 65 million years ago*

## Triassic Period:

*225 to 193 million years ago*

At the beginning of the Triassic Period, there was very little marine life left after the mass extinction that ended the Permian Period. The first modern corals developed. The entire Mesozoic Era is known as the Age of Reptiles because the reptiles developed to dominate the air, land and sea. The first dinosaurs appeared near the end of the Triassic. These dinosaurs were the saurichians which walked on two feet and had stabbing teeth. Crocodiles also appeared in the end of the Triassic Period. Lizards, turtles and marine reptiles, like the plesiosaurs, also evolved in the Triassic. Finally, the first mammal, a small mouse-like animal that ate insects, evolved. The Triassic ended with a mass extinction in which 25% of all species went extinct.

## Jurassic Period:

*190 to 136 million years ago*

Oysters, crabs, lobsters, sea urchins and shrimps developed in the oceans. The stegosaurous and the pterosaurs, flying reptiles, appeared during this time. The mammals were still quite small, but more diverse. The Jurassic Period marks the evolution of the first bird. Insects continued to become more diverse.

## Cretaceous Period:

*136 to 65 million years ago*

The Cretaceous Period was one of the longest periods, lasting 70 million years. Much of the land was covered by shallow seas. Pterosaurs, the flying reptiles, became more specialized. Some of the Cretaceous Period dinosaurs include tyrannosaurs, ankylosaurs and the duck-billed dinosaurs. Flowering plants, bees and butterflies also evolved during this time. The end of the Cretaceous Period was also the end of the Mesozoic Era and was marked by a mass extinction, second only to the extinction that marked the end of the Permian Period. All of the dinosaurs went extinct, along with marine reptiles, pterosaurs, many corals, sponges and other marine invertebrates.

# Cenozoic Era:

"Time of Recent Life"

*65 million years to present*

## Tertiary Period:

*65 to 2 million years ago*

### Paleocene Epoch:

*65 to 54 million years ago*

Much more dry land was exposed as the seas dried up during the Paleocene or "old recent life" epoch. The entire Tertiary Period is known as the Age of Mammals because of the development of many different kinds of mammals during the 63 million years of the period. Along with the development of hoofed mammals, rodents and squirrel-like primates on land, sharks were very abundant in the oceans.

### Eocene Epoch:

*54 to 38 million years ago*

Eocene means the dawn of recent life. Mammals continued to diversify giving rise to whales, sea cows, bats, early horses, tapirs and rhinoceroses.

### Oligocene Epoch:

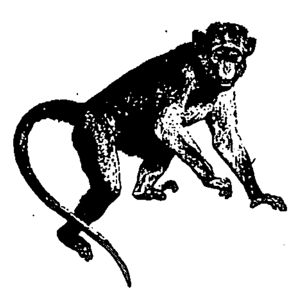
*38 to 26 million years ago*

Oligocene means "few recent (kinds of life)." Dogs, rats, camels, cats and pigs all multiplied during this time. Sloths, armadillos and guinea pigs also evolved.

### Miocene Epoch:

*26 to 5 million years ago*

The "less recent" epoch lasted for 19 million years. Saber-toothed cats, elephants, apes, monkeys, giraffes and cattle are some of the mammals that evolved and multiplied during this epoch.



### Pliocene Epoch:

*5 to 2 million years ago*

The vegetation of the Pliocene was much like today's. Australopithecines, the ancestors of humans, evolved during the Pliocene. The mammals that had evolved during the other epochs continued to multiply and spread throughout the Earth.

## Quaternary Period:

*2 million years ago to the present*

### Pleistocene Epoch:

*2 million to 10,000 years ago*

There were at least four glacial advances during the Pleistocene Epoch, or Ice Ages. Most notably during this epoch, Homo sapiens, or humans, evolved–probably in Africa. During the Ice Ages, wooly mammoths, mastodons and wooly rhinoceroses were common. During the warmer periods, giant ground sloths, saber-toothed cats, lions, wolves, bison, camels, cattle and horses were common. Many of the large mammals went extinct at the end of this epoch. Some scientists think that it may have been due to hunting by the early humans, but no one knows for sure.

### Holocene Epoch:

*10,000 years ago to the present*

The climate of the present epoch is much warmer than the climate of the Ice Ages. Humans are playing a greater role in causing extinctions, particularly in the rain forest regions of the world. Some scientists feel that another ice age will likely start within a few thousand years.

# Post-Visit Activity #3 — Ironing it Out

**Major Concepts:**
- Mining
- Environmental issues
- Conservation of natural resources

**Learning Skills:**
- Predicting, communicating, inferring
- Participating effectively in groups, problem-solving
- Using language for personal response
- Evaluating the accuracy and value of information and ideas

**Subject Areas:**
- Science
- English Language Arts
- Social Studies

* See **Activity Summary** for a Correlation with DPI objectives in these subject areas.

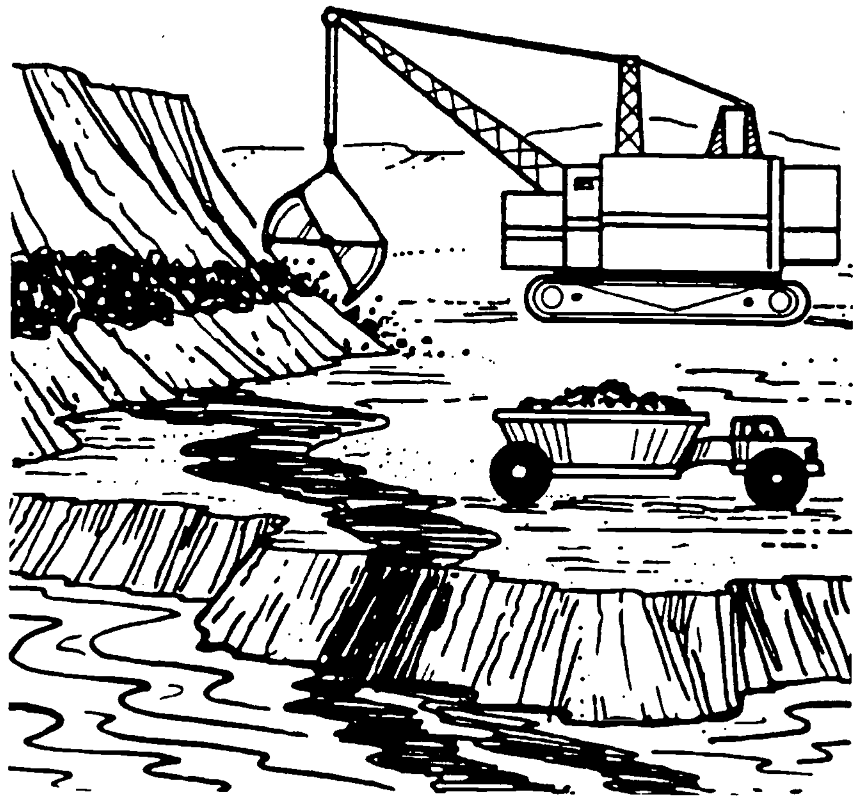
**Location:** Classroom

**Group Size:** 30 students, class size

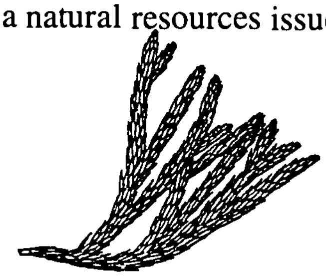
**Time:** 90 minutes (at least two 45-minute periods over a two or three day period would be preferable)

**Appropriate season:** Any

**Materials:**
Provided by educator:
Per student: one copy of the Student's Information, Map of Black Ridge State Natural Area, Unusual Plant & Animal Species of Black Ridge, Iron Ore Fact Sheet and a Possible Arguments page that either supports or opposes the mining project



## Objectives:
- Write an essay supporting or opposing a proposed mining operation near a state natural area. Provide at least three logical reasons to support the position.
- Listen critically to oral presentations and write notes of key points.
- Demonstrate a willingness to acknowledge other points of view and work toward a group solution to a natural resources issue.



## Educator's Information:
In this activity, students will explore many viewpoints surrounding a proposed mining operation near a state natural area. Each student will choose, or be assigned, a viewpoint to represent. The purpose of this activity is to help students become aware of **environmental issues** related to Earth resources, appreciate different points of view, and develop skills in problem solving.

A scenario is provided that centers on an imaginary state natural area in a fictitious state. Students are asked to pretend that geological engineers have determined an economical way to extract iron from amphibolite — the **metamorphic** rock which they studied during their field trip to Mt. Jefferson. This imaginary extraction technology makes the rocky outcrops surrounding the state natural area a very valuable commodity. A fictitious mining company is buying the land surrounding the state natural area in order to mine the amphibolite in the future.

The process for citizen participation in a mining issue presented in this activity roughly parallels the process followed in North Carolina. The North Carolina Department of Environment and Natural Resources (DENR) receives and reviews applications from individuals and companies that would like to conduct mining activities here. (The actual agency within DENR that is responsible for this review is the Land Quality Section of the Division of Land Resources.) The applicant must notify adjacent landowners, local government officials, and other interested parties that it has filed a mining permit application with DENR. All parties have 30 days to prepare written comments and request a public hearing in the application.

Depending on public interest in the proposed project and the potential environmental impacts, DENR may schedule and conduct a public hearing. At the hearing, private citizens and groups may present their views and learn more about the proposed mining project. DENR staff evaluates the technical issues concerning the project as well as the public comments provided, then makes a recommendation to the Director of DENR's Division of Land Resources. The Director ultimately makes the final decision on the application. If mining is allowed, the company is given a permit that details the procedures and precautions they must follow to minimize environmental impacts from the project.

## Instructions:

**1.** Give each student a copy of the Student's Information, Map of Black Ridge State Natural Area, Unusual Plant & Animal Species of Black Ridge, and Iron Ore Fact Sheet. Discuss the proposed mining project near Black Ridge State Natural Area. List pros and cons of the mining project on the chalk-board or overhead. Also, list all possible stakeholders in this issue.

**2.** Divide the class in half; give one half the opposing viewpoints and the other, the supporting viewpoints. Assign, or ask them to choose a viewpoint from their sheet and write an essay explaining this position. This could also be done in the form of a letter to the State Mining Board. Each student should have at least three key points to back up their argument. If desired give students time to research their viewpoint, their interest group, or more about mining operations in general.

**3.** Ask several students on each side of the debate to read their essays or letters to the class. The students should make notes of the key points presented. Then, as a class or in small groups, brainstorm solutions to the problem; the goal should be to list as many solutions as possible. Next, have students suggest criteria that could be used to evaluate the solutions. Finally, use the criteria to rank the solutions. If this is done in small groups, ask each group to report on its top-ranked solutions. Discuss ways that environmental issues are resolved in a democratic society.

Explain to the students how the process for citizen participation in a mining issue actually works in North Carolina. See the Educator's Information in this activity for a simple explanation. See also the Reference Section for more resources.

## Assessment:

Have each student write a second essay representing a different viewpoint. For example, if the student's first essay was opposed to the mining project, their second essay should be in support of the project.

## Modification:

Do this activity as a simulated public hearing where student teams are assigned interest groups to represent at the hearing. Each team should orally present its position to a group of students role playing the State Mining Board. After listening to all the interest groups, the State Mining Board should make a recommendation, explaining their reasons to the class.

## Extention:

Have students do research on a real environmental issue in their state or county. Identify all the interest groups and their positions. Who made the final decision on how the issue was to be resolved? What agency or group of people carried out the solution? What was the outcome?

# Student's Information

**Geologists** and the mining industry have known for years about the large outcrops of amphibolite that give Black Ridge its name. Amphibolite is a black **metamorphic rock** composed of hornblende (or another amphibole **mineral**) and plagioclase (a feldspar mineral). The hornblende is an iron-bearing **silicate** mineral that gives the amphibolite its dark color.

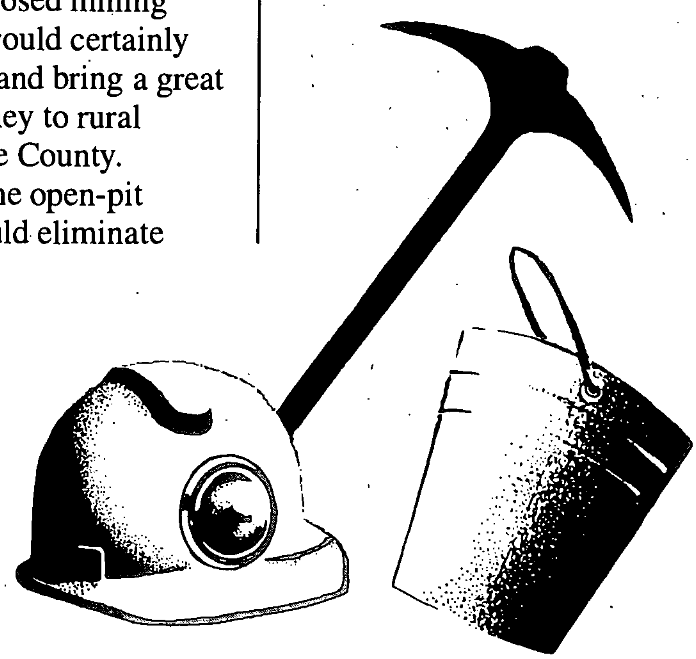
Although amphibolite is rich in iron, the mining companies believed that it was too difficult and too expensive to extract the iron from the rock. However, in this activity, we will pretend that geologists, chemists, and mineral processing engineers have developed a new, economical extraction process. This new process allows mining companies to mine the amphibolite and extract the iron at a profit. The large outcrops of amphibolite that underlie most of Black Ridge have now become a very valuable commodity!

In this simulation, Smith Mining Company, which pioneered the imaginary iron-extracting process, wants to mine the amphibolite. It has already purchased 250 acres of land adjacent to the park along the northern slopes of Black Ridge and has applied for a mining permit with the State Mining Board.

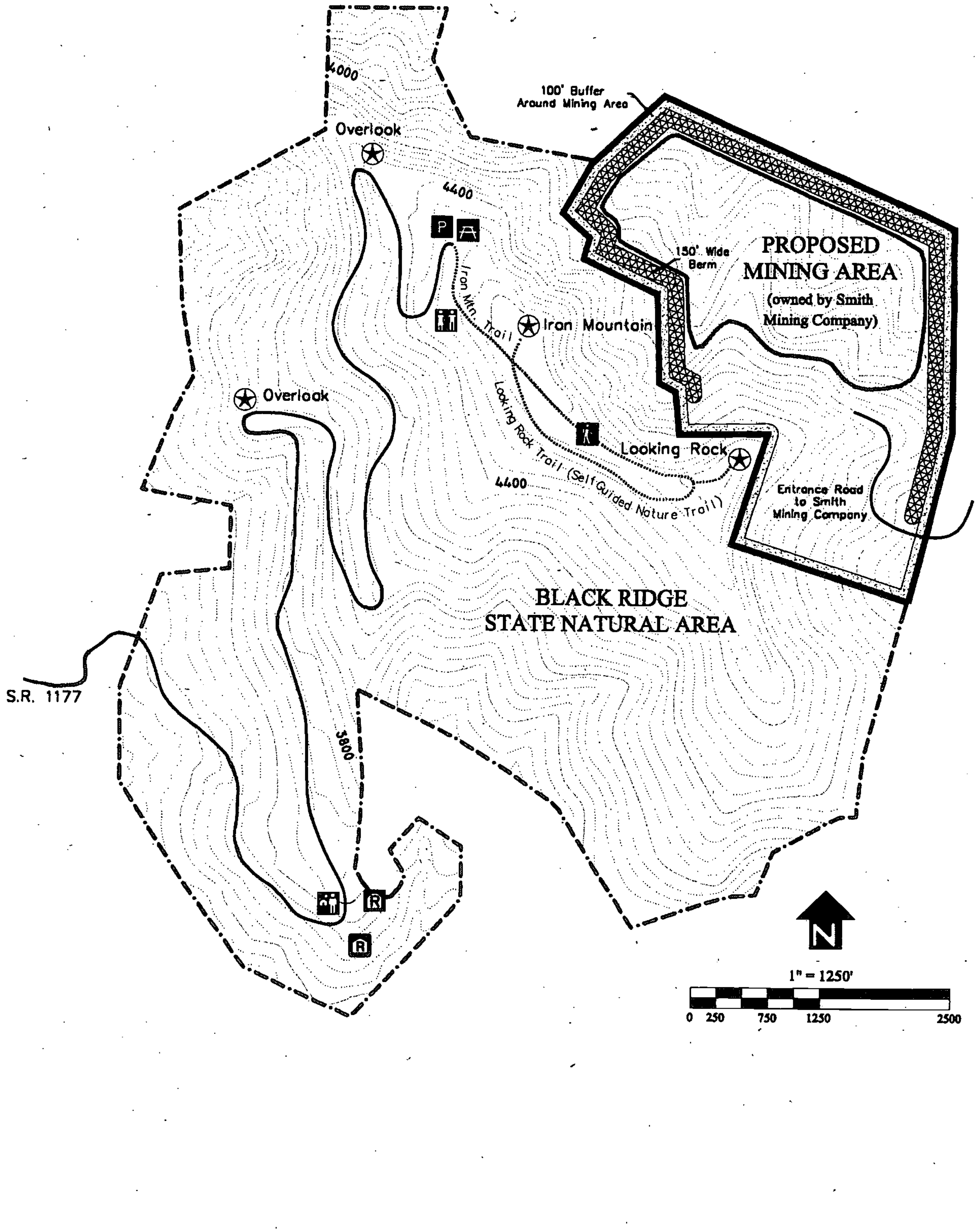
The land now owned by Smith Mining is the same land that the State Parks Department was hoping to buy to enlarge the Black Ridge State Natural Area. Currently, only the higher elevations of Black Ridge are within the state natural area. The State Parks Department wants to protect rare plant populations and valuable wildlife habitat that extend outside the current boundaries of the natural area. Their goal is to have the entire ridge set aside as a nature preserve.

The proposed mining operation would certainly create jobs and bring a great deal of money to rural Black Ridge County. However, the open-pit mining would eliminate many of the rocky cliffs on the north side of Black Ridge and disturb land where large populations of Bigtooth Aspen are currently growing near Looking Rock. (See map on following page.)

The State Mining Board has set up a **public hearing** to listen to all sides of the issue. They will decide whether the mining company should be allowed to mine so close to a state natural area. If they allow the mining activity, they will outline, in a permit, what types of mining activities are allowed or not allowed. If they decide against the mining activity, state geologists may help determine a fair price for the land — if the state legislature should agree to purchase the 250-acre tract.



# Black Ridge State Natural Area Map




Map provided by Martin Marietta Aggregates, Raleigh, NC

# Unusual Plant & Animal Species of Black Ridge

Land use in and around Black Ridge State Natural Area is very important because it affects the plants and animals living in the natural area. Listed below are some unusual or special species living within the natural area.

## Ruffed Grouse

*Bonasa umbellus*

The ruffed grouse, a chicken-like bird with a fan-shaped tail, lives in brushy woodlands. The male announces his territory and attracts a mate in an unusual way. Bracing his tail against a fallen log, he makes a series of strong wing beats to create a loud drumming noise.

During the winter, the ruffed grouse grows "snowshoes" — tiny, scaly projections grow out from the sides of each toe that help the grouse walk in deep snow.

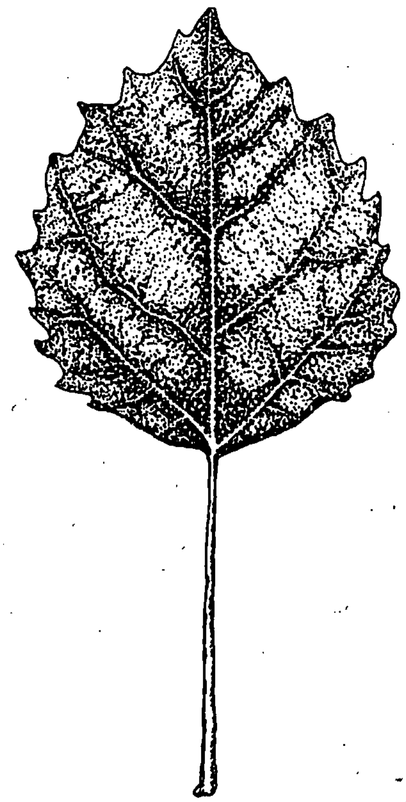
During the spring, the grouse nests on the ground, making it vulnerable to predators like cats and dogs. Black Ridge Natural Area provides a protected nesting habitat for this species, as well as plenty of food (nuts, berries and seeds).

## American Chestnut

*Castanea dentata*

The chestnut blight (caused by a fungus, *Endothia parasitica*) practically destroyed the American chestnut throughout its range. The blight was accidentally introduced in 1904 and within a few decades covered the entire range of the chestnut. The trees were fast-growing, long-lived and sprouted profusely from the stump when cut. During the past 70 years, many of the old stumps repeatedly have grown sprouts.

At Black Ridge and other areas within its native range, the sprouts grow to 15 or 20 feet and produce a few fruits, but the blight kills the sprouts repeatedly. It is hoped the species eventually may become immune to the blight. However, most pathologists believe the chestnut is doomed and that the only hope is to produce resistant hybrids.



## Bigtooth Aspen

*Populus grandidentata*

Bigtooth aspen, a tree species found primarily from West Virginia northward, exists on the northerly slopes of Black Ridge. This small to medium-sized tree has large leaves and flattened leafstalks. It is found in only one other location and is on the watch list of the state's Plant Conservation Program.

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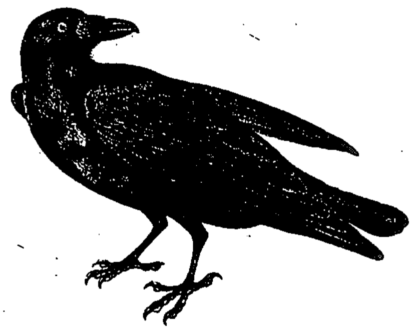
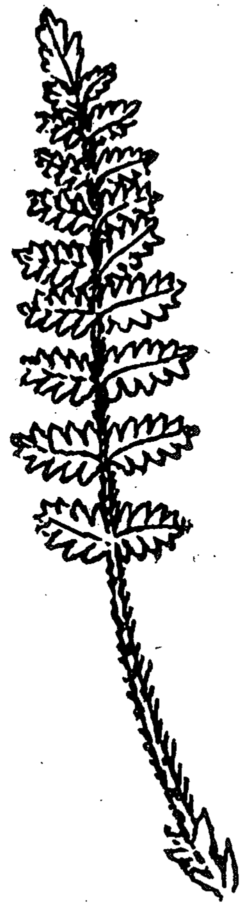


**Common Raven**

*Corvus corax*

This native bird is listed as significantly rare with the state's Natural Resources Program. Nesting sites are uncommon due to a lack of remoteness and privacy which the ravens seem to require, but ravens are frequently seen in Black Ridge State Natural Area. Potential breeding habitat exists on the rock cliffs on the north side of Black Ridge. However, nesting has not been confirmed in at least 10 years.

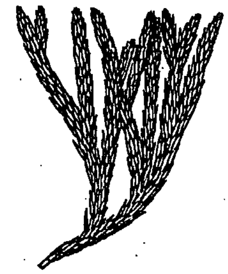
Because many of the other ridges in the area are becoming developed, biologists feel that Black Ridge State Natural Area is key to the raven's survival in the future.



**Rusty Cliff Fern**

*Woodsia ilvensis*

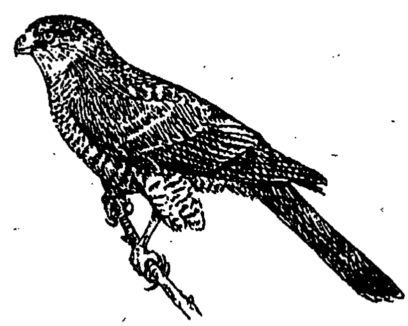
Rusty cliff fern is considered significantly rare with the state's Natural Resources Program. It is currently known in only two counties in the state. At Black Ridge, it lives in the crevices of amphibolite. This species is susceptible to visitor trampling at Black Ridge.



**Fir Clubmoss**

*Lycopodium Selago*

Fir clubmoss has a status of significantly rare with the state's Natural Resources Program. It was reported at Black Ridge State Natural Area in 1991 near the upper overlook. Currently, the fir clubmoss is known from only 10 mountain counties in the state.



**Cooper's Hawk**

*Accipiter cooperii*

This short-winged, long-tailed hawk is listed as Special Concern with the state's Natural Resources Program. Cooper's hawks are frequently observed at Black Ridge. There are no confirmed sightings of nests.

# Iron Ore Fact Sheet

Iron ore is a commodity essential to life as we know it in the United States. Why? Because iron is a metal used to make magnets, auto parts, cement, fireworks, paints, inks, plastics, cosmetics like eye shadow, artist colors and pigments, polishing compounds, inks and medicines. In addition, we need iron in our bodies to keep our blood healthy and red. The biggest reason it so essential, however, is because iron ore is used to make steel. Steel is necessary for our civilization to exist.

Ninety-nine percent of the iron ore mined in the United States is sold to the steel industry. Steel is an iron-base alloy containing up to about 2 percent carbon. Carbon is a chemical element common in coal and organic materials.

Factories that convert iron to steel are called steel mills. At the mills, workers mix coke, a fuel made by heating coal in large ovens, with iron ore in a large furnace. Then the workers add limestone to the mix. Very hot air is blasted into the bottom of the furnace. This hot air makes the coke burn. Inside the furnace, the temperature rises above 3,000 degrees Fahrenheit (1,600 degrees Celsius). The burning coke melts the iron ore. A pool of hot, liquid iron forms at the bottom of the furnace. Impurities within the ore melt and combine with the limestone. This mixture is called slag. The slag floats on top of the pool of iron and is drained off. Then the slag is poured into huge containers that are carried on railroad cars. Some of the slag is used as aggregate in making concrete and asphalt and in the manufacture of glass, mineral wool, and roofing materials. Other uses include using slag as a backfill, for soil conditioning, and sewage treatment. Of the estimated 10 to 15 million metric tons of slag generated yearly in the United States, about 12 million metric tons are used yearly in these various applications. The rest is discarded.

The hot, liquid iron that forms at the bottom of the furnace is rich in carbon. It then goes to a different furnace where it is kept hot. The heat in this furnace removes much of the carbon from the iron, and the iron turns into steel. Some steel is made in an electric furnace. Other steel is made in a furnace that is heated with oxygen.

The liquid steel is then poured into molds to cool. Blocks of molded steel are called ingots. Ingots are used to make steel slabs. First, the ingots must be heated again. Then special machines with rollers flatten the steel into slabs.

Liquid steel may also be shaped into long bars called blooms. Hot blooms and slabs are cut into pieces with torches. Steel is then rolled into thin sheets or shaped with powerful hammers. From there it can be used to make an endless array of steel products.

Try to imagine a world without iron and steel. There would be no steel railroad tracks or airplanes to transport goods and people, no steel appliances to make our lives easier, and no steel cans to keep our foods fresh. We wouldn't be able to build skyscrapers without the steel beams that support them, and our cars would be lack the strength and security provided by steel frames. Think of all the tools and machines that are made of steel. How would we manage without steel? There are no suitable substitutes for steel in today's world.

In 1997, the iron and steel industry and ferrous foundries in the United States produced $75 billion worth of goods. Ninety-two companies operating 126 steel mills across the country produced approximately 122 million tons of raw steel. At all of these operations, furnace gases are treated in order to meet air pollution standards.

World resources of iron ore are estimated to exceed 800 billion tons of crude ore containing more than 230 billion tons or iron. U.S. resources are estimated to be about 110 billion tons of ore containing about 27 billion tons of iron. If we don't produce the iron we need here in the United States,we will have to import it from other countries – an expensive proposition.

## Some Possible Arguments for Supporting the Mining Project

### Smith Mining Company

If you are allowed to mine the amphibolite, you could hire more employees and thus lower unemployment in the county. Also, the more money your company makes, the more taxes they pay. This would surely help the local economy. You will take every reasonable measure to protect the environment, as required by law. However, there would be some effects. You will have to blast the rock, cut it into smaller blocks, and transport it with heavy equipment to your nearby iron extraction plant. This plant will be located along the Rolling Ridge River and will require large volumes of water as part of the extraction process. You will have the latest technology to reduce air and water pollution that might result from this process.

You have read the master plan for the Black Ridge State Natural Area. You know that the state would like to add more land to eventually include the entire Black Ridge in the natural area. You might be willing to sell the land to the state very cheaply after you remove the amphibolite. An old quarry is not just a hole in the ground. It could be an interesting place for people to visit and it may even have recreational value as a swimming area. In your reclamation plan, you could also include replacement of rare plants like the fir clubmoss.

### Strong Steel Mill

You are eager to work with the Smith Mining Company to purchase the iron ore extracted from the amphibolite in the Black Ridge at a much lower cost than you have previously paid for iron. Your mill, located in a neighhboring state on the Rolling Ridge River, will convert the iron to steel. This steel will be used in making cars, appliances, buildings, cans, tools, farm and factory machinery, pipes, shovels, and more. Your company has always stayed below the air and water pollutant discharge limits outlined in your federal and state discharge permits.

### Chamber of Commerce

You support this project, with some reservations. Your mission is to bring business and industry to Black Ridge County to create new jobs and provide the county with extra tax money. This project sounds as if it could create lots of new jobs and help your rural economy to grow. You are also a little worried about the project's effect on the state natural area. Some of the income in the county comes from tourists visiting the park. If the view from Looking Rock is destroyed as a result of the mining this could discourage tourists, therefore, some local businesses may suffer.

### Real Estate Development Company

You are eager to begin construction of a new housing development in Black Ridge County so all of the new employees hired as a result of the local mining operation will have places to live. You think it is possible to minimize the impacts of mining and development. Besides, the loss of one or two unusual plants or animals is a small price to pay for progress. Millions of plant and animal species have become extinct throughout geologic time and life has continued to advance. Since you use the most advanced energy conservation techniques in the design of your houses, your development will help the environment in the long run. Finally, the taxes on the sale of your homes will bring enough money into the county to build a new library, modern schools, ball fields and other recreational areas which are very much needed in this rural setting.

# Some Possible Arguments for <u>Opposing</u> the Mining Project

## State Parks Department

Your mission is to protect and preserve the natural environment. Black Ridge State Natural Area and adjoining land are home to several rare and endangered plant species. A mining operation could destroy plant communities and valuable wildlife habitat. Trees would be removed, the ground would be bulldozed, and the resulting erosion and sedimentation might damage the water quality in the Rolling River watershed, if not properly controlled. (The Bureau of Natural Resources recognizes the Rolling River as one of the cleanest rivers in the state and you want to keep it that way.) You are also concerned about visitor safety in and around a mining operation. Park rangers are very busy with park duties. Ensuring that park visitors do not wander into the proposed mining area would add to their workload. Also, what happens when the mining operation ends? Old rock quarries fill up with water and are very dangerous places. This area would not be suitable for use by the typical park visitor.

## A Hiking or Wilderness Club

You are a large group of environmentalists including anglers, rock climbers, hikers, bird watchers and campers. You would like to see the land, now proposed for mining, become part of the state natural area. A mining operation would destroy the breathtaking scenic views as well as the beautiful and rare plant communities. The noise from the trucks and the blasting is offensive to those people who come to the area for peace and quiet. It will disrupt possible nesting activity of the ravens and Cooper's hawks. If not properly controlled, the erosion and sedimentation resulting from the mining operation could damage water quality, killing trout and other gamefish that need clean water. Also,what about the reduction in water flow that will result when the iron extraction factory needs lots of water? This would disrupt canoeing activities and surely hurt gamefish. Preserving the environment is much more important than increasing tax revenues.

## Local Residents

You are a group of local residents who live near the proposed mining operation. You do not want to hear blasting or to have heavy truck traffic in your neighborhood. When the mining operation is over, you are concerned that the abandoned quarry will become a dangerous place for your children. You want to know what kind of land reclamation the mining company plans to do. You moved here because of the beautiful scenery and abundant wildlife. An open-pit mine is an ugly eyesore and would certainly lower the value of your property. You'd much rather see the land become part of the state natural area.

## Local Ecotourism Businesses

You are a group of small businesses who cater to the tourists that come to the state natural area and the nearby Rolling River State Park to go fishing, hiking, swimming, camping, rock climbing, mountain biking, and horseback riding. Many of you own sporting goods stores and rent outdoor recreational equipment to the tourists. Some of you run concessions in Rolling River State Park. You are opposed to the mining operation as you feel it would negatively impact your business by scaring away the tourists and lowering the water flow in the Rolling River.

# VOCABULARY

**Aggregate** - Composed of a mixture of minerals separated by mechanical means.

**Alga** - Simple, one-celled or many-celled plant, capable of photosynthesis. It is usually aquatic and has no true root, stem or leaf.

**Atom** - The smallest unit of an element. Atoms are composed of protons, neutrons, and electrons.

**Basin** - A bowl-shaped depression in the surface of the land or ocean floor.

**Capillary action** - The rise of water along narrow passages, facilitated and caused by surface tension.

**Chemical formula** - A symbolic representation of the composition of a chemical compound.

**Chemical make-up** - See chemical formula.

**Chemical weathering** - Process that chemically changes the minerals in rocks, resulting in a weakening of the rocks. ex: oxidation.

**Chevron fold** - A V-shaped bend, or flexure, in a rock..

**Cleavage** - A tendency in rocks to split along definite, parallel, or crystal planes characteristic of the mineral.

**Clinometer** - An instrument for measuring the angle of an incline, as of a rock outcrop.

**Composition** - A putting together of parts or elements to form a whole; a combining.

**Core** - The innermost or most important part of anything; heart; center; essence.

**Crenulations** - Small folds or scalloped projections in a rock.

**Crustal plate** - A large rigid section of the Earth's lithosphere that floats upon the Earth's mantle according to the theory of plate tectonics.

**Crystal** - A regular polyhedral form, bounded by symmetrically-arranged plane surfaces, formed by solidification of a chemical element or compound under favorable conditions.

**Differential weathering** - Variation in the rate of erosion of different minerals in a rock.

**Dip** - The angle in degrees at which a rock outcrop rises from the ground.

**Earth's crust** - A rigid shell only about 30 miles thick, less than one hundredth of the distance to the center. Eight elements account for almost 99 % of the Earth's crust - oxygen (46.7%), silicone (27.7%), aluminum (8.1%), iron (5.1%), calcium (3.7%), sodium (2.8%), potassium (2.6%) and magnesium (2.1%).

**Element** - A substance, such as oxygen, silicon and carbon, that can not be split into smaller chemical substances.

**Environmental issue** - A matter of public concern over how something will affect our natural world. An environmental problem becomes an environmental issue when people do not agree on how to solve it.

**Erosion** - The movement of bits of weathered rock by wind, water, gravity and glacial action.

**Extrusive igneous rocks** - Rocks formed on the Earth's surface by the cooling of molten magma material originating from within the Earth's crust.

**Face** - The most significant or prominent surface of an object.

**Faulting** - In geology, a fracture on the Earth in which layers of rock slide up or down along the break.

**Folding** - To bend over or double-up so that one part lies on another part.

**Foliation** - The directional property of some metamorphic rocks caused by the layering of minerals. This parallel alignment of mineral grains is generally caused by crystallization under pressure. Foliation also refers to the flat arrangement of features in any rock type.

**Fungus** - Any of numerous plants lacking chlorophyll, ranging in form from a single cell to a body mass, that often produce specialized fruiting bodies and include the yeasts, molds, smuts, and mushrooms.

**Gem** - A rock, mineral or other substance that has economic value as jewelry, because it is beautiful.

**Geologic belts** - Areas with similar rock types and geologic history.

**Geologic time** - The period of time covering the Earth's geologic history.

**Geologist** - A person who studies the materials, structure and history of the Earth.

**Geology** - The study of the Earth, its origin, composition, structure, history and nature of processes resulting in its present state.

**Geometric** - Using simple geometric forms in design and shape.

**Heath bald** - An extensive tract of open, uncultivated land covered with herbage and low shrubs.

**Igneous rock** - Rock formed by the cooling of molten rock on or under the surface of the Earth. The crust of the Earth is approximately 95% igneous rock.

**Inorganic** - Involving neither organic life nor the products of organic life; not composed of organic matter.

**Impurities** - Contaminants that render something else inconsistent or impure.

**Intrusive igneous rock** - The type of igneous rock that forms when magna cools inside the Earth, usually resulting in course-grained mineral crystals.

**Joint** - A fracture in a rock along which no appreciable movement has occurred.

**Lava** - 1. Molten rock that issues from a volcano or a fissure in the Earth's surface. 2. The rock formed by the cooling and solidifying of this substance.

**Lichen** - Any of numerous plants consisting of a fungus in close combination with certain of the green or blue-green algae, characteristically forming a crustlike, scaly, or branching growth on rocks or tree trunks.

**Luster** - The way a mineral reflects light. Can be glassy, metallic, pearly or dull.

**Magma** - Molten rock deep within the Earth from which igneous rock is formed.

**Mantle** - In geology, the layer of the Earth between the crust and the core.

**Mechanical weathering** - Type of weathering which breaks rocks apart without changing their mineral composition. ex: freezing and thawing

**Metamorphic rock** - Rocks that have been altered chemically and/or physically by great heat and pressure. Amphibolite is an example.

**Metamorphosis** - Meta means "change," morphe means "form." A transformation, a marked change in appearance or condition.

**Microbe** - A very small (microscopic) life form; microorganism.

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**Minerals** - Chemical compounds found in the Earth's crust. They are inorganic and occur naturally. Each mineral has its same chemical make-up wherever found, as well as its characteristic crystal shape, color, specific gravity and hardness. Quartz is a common mineral found in the park.

**Molecule** - A stable configuration of atomic nuclei and electrons bound together by electrostatic and electromagnetic forces. It is the simplest structural unit that displays the characteristic physical and chemical properties of a compound.

**Monadnock** - A hill of more resistant rock, left as a residue of erosion, that stands above the surrounding area.

**Moravian** - A member of a Protestant denomination founded in Saxony in 1722 by Hussite emigrants from Moravia.

**Nutrient** - Something that provides food or nourishment.

**Ore** - A source of minerals that can be mined for a profit. Ore refers to either metallic or nonmetallic deposits.

**Oscillator** - A device that swings back and forth with a steady uninterrupted rhythm.

**Outcrop** - An exposure of rock or sediment at the Earth's surface as in road cuts, rock exposures on hillsides and stream bed exposures.

**Oxidation** - The combination of a substance with oxygen resulting in an oxide.

**Petrographic microsope** - An optical instrument that uses a combination of lenses to produce magnified images of the separate minerals in a rock.

**Photosynthesis** - The chemical process carried on by green plants in which the cells that contain chlorophyll use light energy to produce glucose (a plant food) from carbon dioxide and water; oxygen is released as a by-product.

**Physiographic province** - A land area characterized by particular types of landforms.

**Physiography** - The study of the physical features of the Earth's surface, how they formed and how they have changed over time.

**Piezoelectricity** - Ability of some materials, such as quartz, to generate a small amount of electricity when squeezed or put under pressure.

**Plate tectonics** - A model of global tectonics that suggests that the outer layer of the Earth known as the lithosphere is composed of several large plates that move relative to one another; continents and ocean basins are passive riders on these plates.

**Prism** - A crystalline solid having three or more similar faces parallel to a single axis; a polyhedron having parallel, congruent polygons as bases and parallelograms as sides.

**Pyramidal** - Having a rectangular base and four triangular faces culminating in a single apex.

**Quartz** - A hard, crystalline mineral of silicon dioxide, $SiO_2$. Quartz is among the hardest and most resistant of all minerals - so it is often left behind where wind and rain have worn away surrounding rock.

**Raw material** - Unprocessed natural products used in manufacture.

**Resistant rock** - Rock that weathers and erodes more slowly than other rock in the same area.

**Resonator** - A hollow chamber or cavity with dimensions chosen to permit internal resonant oscillation of electromagnetic or acoustical waves to specific frequencies.

**Rock** - Substances made up of one or more minerals. Rocks are an important part of the Earth's crust, mantle and core. They come in three forms: igneous, sedimentary and metamorphic.

**Rock cycle** - The set of processes that describe how rocks change from one type to another.

**Sandstone** - Sedimentary rock composed primarily of quartz sand grains, deposited over millions of years, that are cemented more or less firmly together.

**Sediment** - Material that settles to the bottom.

**Sedimentary rock** - Rock made by the compaction and/or cementing of sediments. Example: sandstone, shale.

**Sedimentation** - The build up of sediment in a body of water.

**Silicate** - Any mineral containing silicon and oxygen.

**Soil** - Earth material so modified by biological, chemical, and physical processes that the material will support rooted plants.

**Strata** - A formation containing a number of beds or layers of rock of the same kind of material.

**Strike** - The intersection of the imaginary horizontal plane to the Earth's surface and the inclined rock surface.

**Tabular** - Having a plane surface; flat.

**Topography** - The shape and form of the Earth's surface.

**Vent** - The exit hole for the lava flow from a volcano.

**Volcanic rock** - Rocks produced by or discharged from a volcano.

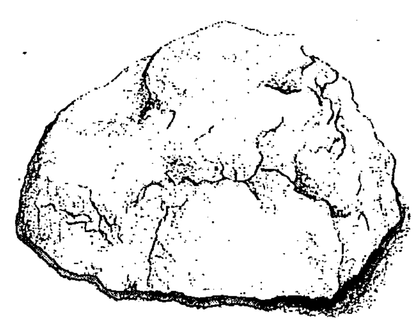
**Volcano** - 1. A vent in the Earth's crust through which molten lava and gases are ejected. 2. A mountain formed by the materials so ejected.

**Watershed** - All of the land area that drains directly or indirectly into a creek, river, lake or other body of water.

**Weathering** - Any of the chemical or mechanical processes by which rocks exposed to the weather decay to soil. In the broadest sense, any of the destructive elements that wear down rocks, causing them to fragment, crack or crumble. Examples include heat, chemicals, wind and water. (Erosion loosens and carries away debris caused by weathering.)

**Weathering pit** - An indentation in a rock that is the result of mechanical and/or chemical weathering.

**Xenolith** - Literally a "stranger" rock, which was surrounded during the movement of magma to form an unrelated inclusion within the surrounding igneous rock.



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# SCHEDULING WORKSHEET

For office use only:
Date request received_______________ Request received by_______________________

1) Name of group (school) ______________________________________________

2) Contact person ______________________ ______________________________
name phone (work) (home)

_____________________________________________________________________
address

3) Day/date/time of requested program ___________________________________

4) Program desired and program length ___________________________________

5) Meeting place _________________________________________________

6) Time of arrival at park ____________ Time of departure from park ____________

7) Number of students ______________ Age range (grade) ______________
(Note: A maximum of 30 participants is recommended.)

8) Number of chaperones ____________
(Note: One adult for every 10 students is recommended.)

9) Areas of special emphasis __________________________________________

10) Special considerations of group (e.g. allergies, health concerns, physical limitations)________
_____________________________________________________________________

11) Have you or your group participated in park programs before? If yes, please indicate previous programs attended: _____________________________________________
_____________________________________________________________________

12) Are parental permission forms required? ________ If yes, please use the Parental Permission form on page 8.2.

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

I, _______________________________, have read the entire Environmental Education Learning Experience and understand and agree to all the conditions within it.

Return to: Mount Jefferson State Park
P.O. Box 48
Jefferson, NC 28640

Fax: (910) 982-3943

# PARENTAL PERMISSION FORM

Dear Parent:

Your child will soon be involved in an exciting learning adventure - an environmental education experience at **Mount Jefferson State Park**. Studies have shown that such "hands-on" learning programs improve children's attitudes and performance in a broad range of school subjects.

In order to make your child's visit to "nature's classroom" as safe as possible we ask that you provide the following information and sign at the bottom. Please note that insects, poison ivy and other potential risks are a natural part of any outdoor setting. We advise that children bring appropriate clothing (long pants, rain gear, sturdy shoes) for their planned activities.

Child's name ________________________________

Does your child:

- Have an allergy to bee stings or insect bites? ______________________________
  If so, please have them bring their medication and stress that they, or the group leader, be able to administer it.

- Have other allergies? ______________________________

- Have any other health problems we should be aware of? ______________________________
  ______________________________

- In case of an emergency, I give permission for my child to be treated by the attending physician. I understand that I would be notified as soon as possible.

________________________________ Parent's signature

______________ date

Parent's name ________________________ (please print)

Home phone ______________

Work phone ______________

Family Physician's name ________________________ phone ______________

Alternate Emergency Contact

Name ________________________________ phone ______________

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# NORTH CAROLINA PARKS & RECREATION
# PROGRAM EVALUATION

Please take a few moments to evaluate the program(s) you received. This will help us improve our service to you in the future.

1. Program title(s) ______________________ Date __________

   Program leader(s) ______________________

2. What part of the program(s) did you find the most interesting and useful? ______________________

______________________

3. What part(s) did you find the least interesting and useful? ______________________

______________________

4. What can we do to improve the program(s)? ______________________

______________________

______________________

5. General comments ______________________

______________________

______________________

______________________

**LEADERS OF SCHOOL GROUPS AND OTHER ORGANIZED YOUTH GROUPS PLEASE ANSWER THESE ADDITIONAL QUESTIONS:**

6. Group (school) name ______________________

7. Did the program(s) meet the stated objectives or curriculum needs? ______________________

   If not, why? ______________________

______________________

**Please return the completed form to park staff. Thank you.**

Mount Jefferson State Park
P.O. Box 48
Jefferson, NC 28640
Fax: (919) 982-3943

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