DOCUMENT RESUME

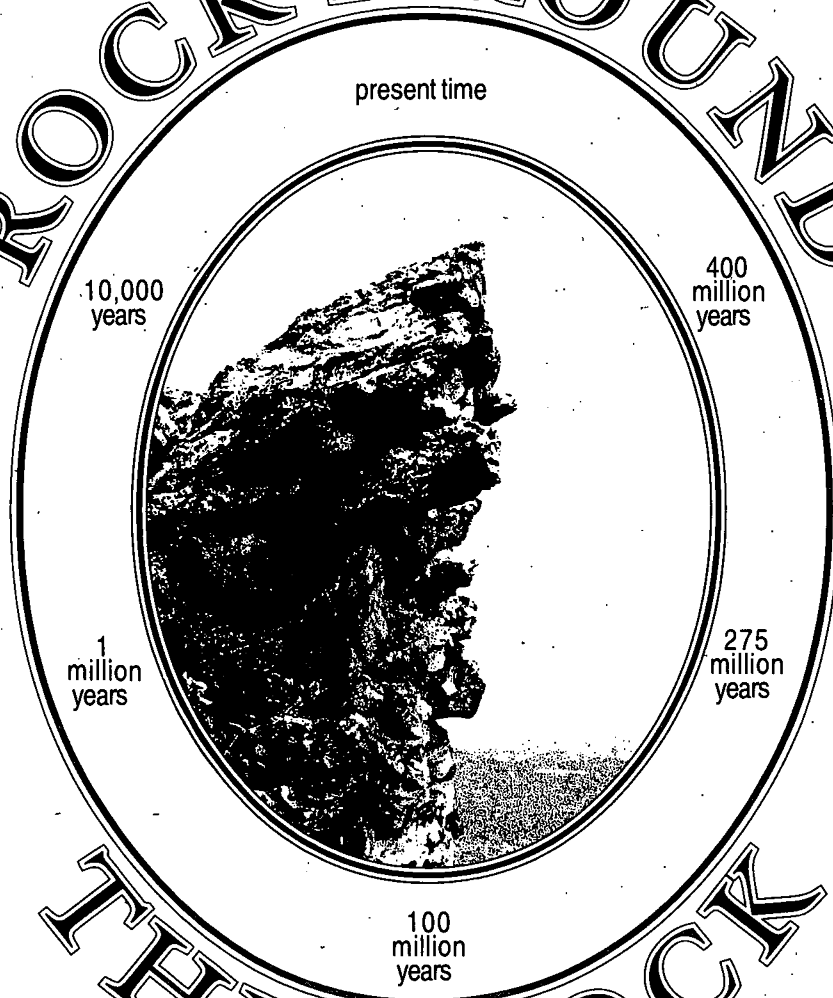
ED 448 996 SE 063 837

AUTHOR	Dow, Jaye
TITLE	Rock around the Clock: Hanging Rock State Park. An Environmental Education Learning Experience. Designed for Grade 5.
INSTITUTION	North Carolina State Dept. of Environment, Health, and Natural Resources, Raleigh. Div. of Parks and Recreation.
PUB DATE	2000-04-00
NOTE	98p.; Revised edition of ED 376 027.
AVAILABLE FROM	North Carolina Div. of Parks and Recreation, 12700 Bayleaf Church Road, Raleigh, NC 27614.
PUB TYPE	Guides - Classroom - Teacher (052)
EDRS PRICE	MF01/PC04 Plus Postage.
DESCRIPTORS	Elementary Education; *Environmental Education; Experiential Learning; Field Trips; *Geology; Grade 5; Intermediate Grades; *Outdoor Activities; *Parks; *Petrology; Science Education
IDENTIFIERS	Erosion; *North Carolina; *State Parks

ABSTRACT

This learning packet was developed for grade 5 to teach about the geology of a park. Sections include: (1) Introduction, which introduces the North Carolina State Park System, Hanging Rock State Park, the park's activity packet, and the geology of the park; (2) Summary, a brief summary of the activity outlines including major concepts and objectives covered; (3) Pre-visit activities, which introduce students to rock types and the rock cycle and explains how they change over time due to weathering and erosion; (4) On-site activities, including observations on the landforms and geological formations of the parks; (5) Post-visit activity, which reinforces the vocabulary and concepts learned in the previous activities; (6) Vocabulary, which provides a list of 51 related vocabulary words; (7) References; and (8) related forms including worksheets, a parental permission form, and a North Carolina Parks & Recreation Program Evaluation. (Contains 17 references.) (YDS)

ROCK AROUND THE CLOCK

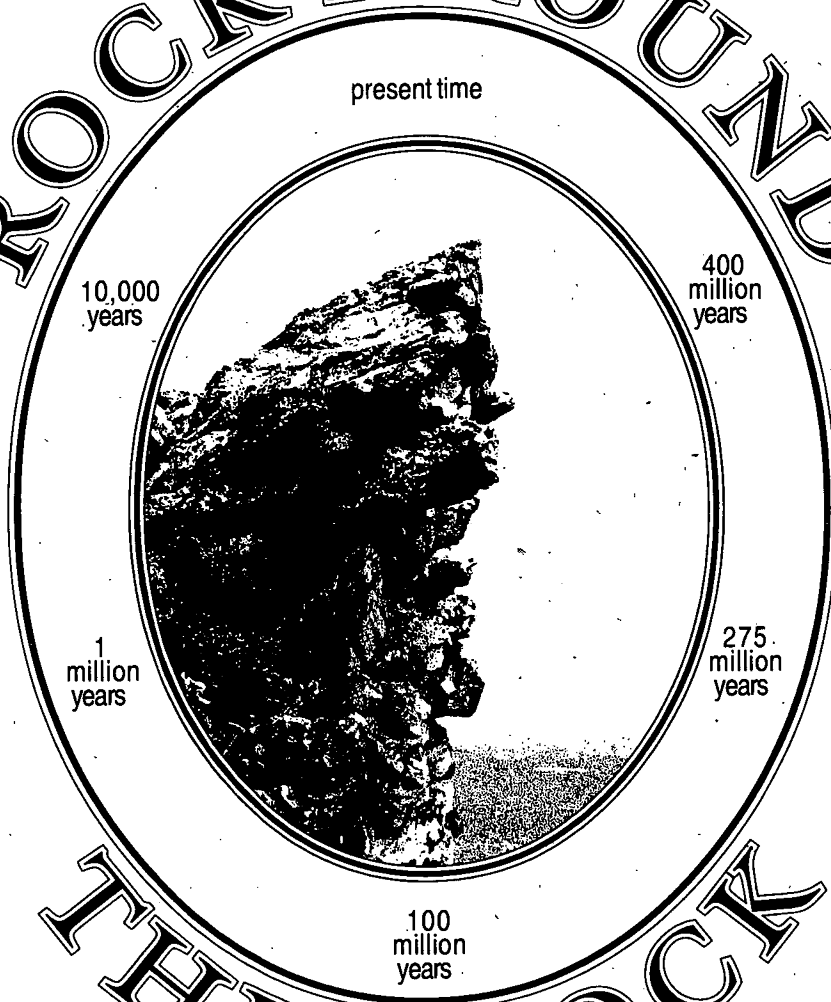


Hanging Rock State Park

An Environmental Education Learning Experience

Designed for Grade 5

ROCK AROUND THE CLOCK



Hanging Rock State Park

An Environmental Education Learning Experience

Designed for Grade 5

"Today's understanding of the earth's history bears little resemblance to earlier ideas. Many old theories have been revised and new theories developed. As research continues, the story of the earth's history as we presently understand it will continue to change. Every day discoveries raise new questions and result in the elimination or revision of old ideas. Much of the earth's history has yet to be deciphered and the farther back one goes in time, the less clear the evidence becomes."

Fred Beyer,
North Carolina–The Years Before Man

Funding for the original printing of
this Environmental Education Learning Experience
was generously contributed by

CP&L

This Environmental Education Learning Experience
was developed by

Jaye Dow
Park Ranger III
Hanging Rock State Park

N.C. Division of Parks and Recreation
Department of Environment and Natural Resources

NCDENR

James B. Hunt Jr.
Governor

Bill Holman
Secretary

Other Contributors . . .

Park volunteers;

David Howells, former Ranger, Hanging Rock State Park;

Luann Bridle, Hanging Rock State Park Advisory Committee;

Fred Beyer, Science Educator, Fayetteville, NC;

The N.C. Department of Public Instruction;

The N.C. Department of Environment and Natural Resources;

and the many individuals and agencies who assisted in the review of this publication:

Phyllis Baker Smith, Hanging Rock Advisory Committee
Marjory Roth, Principal, Greenhill School
Nancy Parks, former Secretary, Greenhill School
Carl Merschat, N.C. Geological Survey
Mark Carter, N.C. Geological Survey
Tyler Clark, N.C. Geological Survey
Tracy Davis, N.C. Division of Land Resources

500 copies of this public document
were printed at a cost of $3,272
$6.54 per copy

Printed on recycled paper.
4-00

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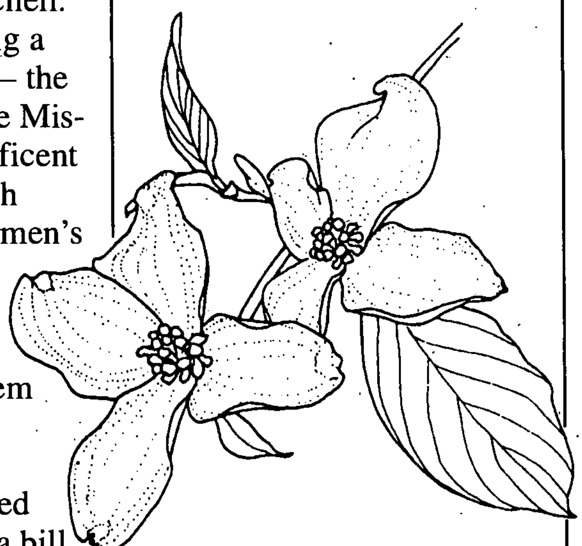
Introduction to the North Carolina State Parks System

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 opinions. 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.

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 58 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 160,000 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 that 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 which cultivates responsible stewardship of the earth.

For more information contact:

NC Division of Parks and Recreation
1615 Mail Service Center
Raleigh, NC 27699-1615
919/ 733-4181
Website – www.ncsparks.net

Introduction to Hanging Rock State Park

Hanging Rock State Park covers 6,554 acres in the Sauratown Mountains. One of the most easterly mountain ranges in the state, the Sauratown Mountains are often called "the mountains away from the mountains," because they are separated from the nearby Blue Ridge Mountains. Prominent peaks in the Sauratown range rise from 1,700 feet to over 2,500 feet in elevation and stand in bold contrast to the surrounding countryside, which averages only 800 feet in elevation.

The Sauratown Mountains are the remnants of a once mighty range of peaks. Over millions of years, wind, water and other forces wore down the lofty peaks. What remains of these ancient mountains is due to erosion-resistant quartzite, which now supports the scenic ridges of Moore's Knob, Cook's Wall and Hanging Rock.

The park is named for one of its prominent topographical features, Hanging Rock, which offers a view across the valley of the Dan River to the Blue Ridge Mountains of North Carolina and Virginia. In addition to beautiful scenery, numerous facilities and activities make Hanging Rock one of the most popular parks in the state parks system.

The History of Hanging Rock

Two Native American tribes inhabited this area during the same period – the Saura in Stokes County and the Cherokee in Surry County. The Saura people, after whom the Sauratown Mountains were named, were a peaceful tribe. They had a number of village sites along the Dan River; evidence indicates habitation as far back as AD 1000. Around 1710, the Sauras moved south to eventually join the Catawbas near the Pee Dee River in South Carolina. By the time of the American Revolution, the Saura population had been greatly reduced by smallpox epidemics. There are a few individuals in Stokes County who claim ancestry today.

The first European settlers to enter what is presently Stokes County traveled from Pennsylvania and Virginia along the "Great Wagon Road" and settled in the rich bottomland of the Town Fork Creek area. These settlements were well established prior to 1752 when Moravians entered the area and established dwellings along Town Fork Creek from the Dan River to an area west of present-day Germantown.

British troops did not appear in the Stokes County area until late in the Revolutionary War, but there were conflicts with Tories, as a popular legend indicates. Reportedly, a section of the park called Tory's Den was so named when a group of Tories captured the daughter of a local member of the Whig party and held her captive in a cave to gain aid for their cause.

In the mid-1930's considerable enthusiasm existed for the creation of a state park at Hanging Rock. The Stokes County Committee for Hanging Rock State Park, a citizen group, joined forces with the Winston-Salem Foundation. On April 20, 1936, the Stokes County Committee for Hanging Rock State Park deeded a gift of more than 3,000 acres in the Sauratown Mountains to the state of North Carolina.

In 1933, Franklin Roosevelt began the first relief agency, the Civilian Conservation Corps (CCC), to provide jobs through the development of public property. The CCC began work at what was to become Hanging Rock State Park in 1935. CCC activity continued in the park during the early 1940's. During this period a number of projects were completed. In 1942, during the early days of the second World War, the CCC was abolished and work at the park slowed dramatically. Nonetheless, most of the park's goals had been attained and the park was formally opened on July 21, 1944.

Program Options:

Rich in natural history and cultural resources, Hanging Rock State Park is an excellent place to teach ecology, environmental issues, biology, conservation, earth science and Sauratown Mountain geology, as well as to enjoy recreation.

Groups are encouraged to visit the park during all seasons of the year for hikes, exploration, nature study and other activities. The new visitor center includes an auditorium, classroom and exhibit hall. Leaders may choose to design and conduct their own activities or use this Environmental Education Activity Packet.

Park staff will be happy to assist you with your programming needs. Please contact the park office at least two weeks in advance.

Scheduling a Trip:

1. To make a reservation, contact the park at least two weeks in advance. Please provide the following information:

- Name of group (school)
- Name, address, work and home telephone numbers of the group contact
- Requested date, time of arrival and meeting place at the park
- Departure time from the park
- Number of participants and adult leaders

  A maximum of 30 participants is recommended. Please have at least one adult leader per 10 students. Adult leaders are responsible for maintaining control of the group.
- Age range and/or special needs of participants
- Desired activities; types of park facilities needed; other assistance needed from park staff

2. Research activity permits may be required for sampling activities. If your group plans to collect any plant, animal, or mineral within the park, please contact the park office at least 30 days in advance to obtain a permit application.

3. The usual fees for activities, such as boat rental, camping, and swimming will apply.

Before You Make the Trip:

1. Visit the park without the participants prior to the group trip. This will allow you to become familiar with facilities and park staff and to identify any potential problems.

2. Group coordinators should discuss park rules and behavioral expectations with adult leaders and participants. Safety should be stressed.

3. Inform the group about poison ivy, ticks, snakes and insects. Discuss the need to use sun screen and insect repellent from late spring through early fall.

4. Everyone should wear a name tag. Please color-code tags (for groups) and establish a buddy system.

5. Encourage everyone to wear appropriate, comfortable clothing and walking shoes.

While at the Park:

Please obey the following rules:

1. Be as quiet as possible while in the park. This will help you get the most out of the experience, while increasing the chance of observing wildlife.

2. On hikes, walk behind the leader at all times. Trails lead to areas of cliffs and high rock ledges. Running, climbing or horseplay are not permitted. Please stay on the trails!

3. All rocks, plants and animals in the park are protected. Injuring or removing plants, animals or rocks is prohibited in all state parks. This allows future visitors to enjoy our natural resources.

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

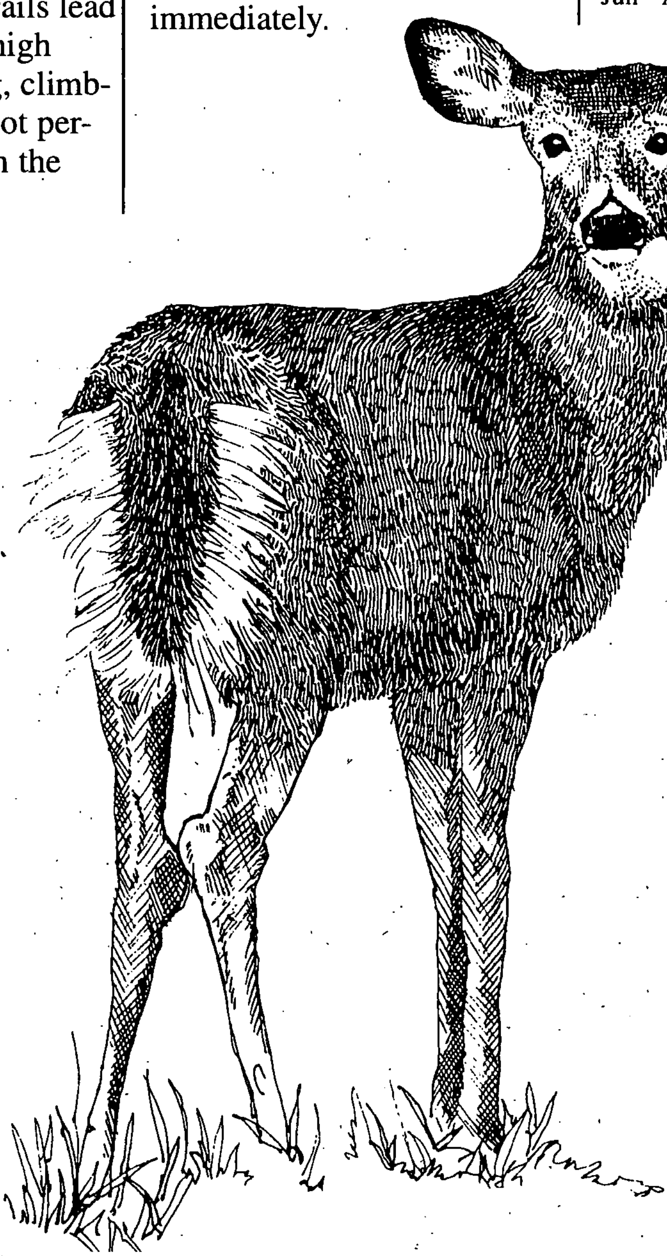
5. In case of an accident or emergency, contact park staff immediately.

Park Information:

Address:
Hanging Rock State Park
Post Office Box 278
Danbury, NC 27016
Tel: (336) 593-8480
Mon - Fri
8:00 AM - 5:00 PM
Fax: (336) 593-9166
Email: ncs1220@interpath.com

Hours of Operation:

Nov - Feb	8:00 AM - 6:00 PM
Mar, Oct	8:00 AM - 7:00 PM
Apr, May, Sep	8:00 AM - 8:00 PM
Jun - Aug	8:00 AM - 9:00 PM



Introduction to the Activity Packet for Hanging Rock State Park

The environmental education learning experience, *Rock Around the Clock*, was developed to provide hands-on environmental education activities for the classroom and the outdoor setting of Hanging Rock State Park. This activity packet will acquaint your students with the basic geological processes that influenced the formation of the Sauratown Mountains, of which Hanging Rock is a part. It is designed to be implemented in grade 5, but also meets established curriculum objectives of the North Carolina Department of Public Instruction in other grades. (See Correlation Chart in Activity Summary.)

Three types of activities are included:

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

The on-site activities will be conducted at the park, while the pre-visit and post-visit activities are designed for the school environment. The pre-visit activities should be introduced prior to the park visit so that students will have the necessary background and vocabulary for the on-site activities. We encourage you to use the post-visit activities to reinforce concepts, skills and vocabulary learned in the pre-visit and on-site activities.

The environmental education learning experience, *Rock Around the Clock*, will expose the students to the following major concepts:

- **Rock Cycle**
- **Rock Formation**
- **Weathering & Erosion**
- **Geologic Time**
- **Geologic Processes**
- **Sauratown Mountain Geology**
- **Conservation of Natural Resources**

Vocabulary words used throughout this EELE appear in **bold type** the first time they are used in each activity. These words and 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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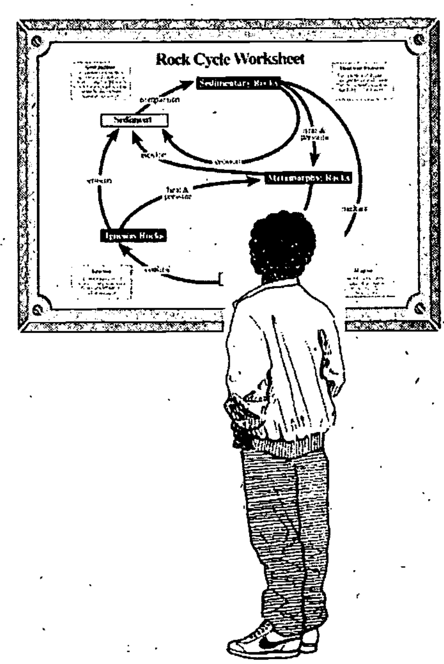
NOTE: While in the park, please remember that the purpose of the state parks system is to preserve and protect our natural resources. Explain to students that they should not pick, injure, or destroy any plants or animals. Rocks should not be removed from the park, but should be returned to their original positions in the areas from which they were collected. Please stay on the trails!

The educator will assist in seeing that all safety precautions are followed. It is also the responsibility of the educator to become aware of special considerations, medical needs, etc. of participants and be prepared to take appropriate precautionary measures. Park staff should be informed of any special considerations prior to the group's arrival at the park.



Introduction to the Geology of Hanging Rock State Park

By carefully observing the **rocks** at Hanging Rock State Park, geologists have pieced together their geologic history. Remember that as research continues, geologists will modify or revise this version of the earth's history.

Over 800 million years ago during the Proterozoic **eon**, the **Iapetus Sea** was located off the east coast of what was then the North American continent. **Sandstones** and other **sedimentary rocks** formed slowly here as layer upon layer of **sand**, silt and mud was deposited.

We can see evidence of the ancient sea preserved in the rocks at the park. Some rocks preserve the original bedding (layering), as well as **cross-bedding** where the **sediment** layers are aligned at an angle to one another. Cross-bedding usually occurs in a nearshore environment. Here, sand-carrying currents of water and wind frequently change direction.

The next series of geological events that contributed to the formation of the **Sauratown Mountains** can be traced to movements in the earth's crust. About 500 million years ago, the **crustal plates** carrying the continents of North America and Africa began to move toward each other. As the Iapetus Sea closed, the sandstones and other sedimentary rocks were folded and metamorphosed. The **quartzite** found in the park today is this metamorphosed sandstone. In other parts of the Sauratowns, you can find **schist** and **gneiss**; these rocks probably resulted from the metamorphism of shale and mudstones.

Between 250 and 500 million years ago, the entire region was gradually pushed up to heights that would rival today's Rocky Mountains. Originally the layers of rock were lying horizontally like a stack of papers; however, as the earth's surface moved, the layers were gradually folded and bent. Older layers of rock were thrust up and over younger layers. Today, the Sauratown Mountains represent the axis of a giant fold in the crust that geologists call the Sauratown Mountain **anticlinorium**. (An anticlinorium is an area where the rocks were arched upwards.)

During crustal movement, the rocks behaved like taffy candy. Today these rock layers are sloping or dipping gently to the southeast on one side of the anticlinorium and to the northwest on the other side. **Fractures** show up clearly in the cliffs of the upper ridges, the Upper Cascades, and especially well at Hidden Falls. Along these fractures, smooth-sided blocks of quartzite break out of the cliffs like building blocks.

Other products of the mountain-building period are the **quartz** veins found throughout the quartzite rock. During metamorphism, solutions of hot water were squeezed between the beds or layers in the quartzite. As the water cooled, silica precipitated out and solidified to create the quartz veins.

About 220 million years ago, the continents of North America and Africa began to pull apart. The Atlantic Ocean formed, as well as many rift valleys and Triassic basins, including the Dan River basin. At this time, **weathering** and **erosion** became the dominant forces acting on the Sauratown Mountains.

Over millions of years, erosion has removed the softer rocks and exposed the more resistant quartzite, which forms the ridge line of the Sauratown Mountains. Each time it rains or the wind blows, a little more of the mountains are carried away. Some of these sediments travel down the Dan River on their way to the Atlantic Ocean. Eventually, these mountains will disappear sometime in the distant future of geologic time.

Activity Summary

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

I. Pre-Visit Activities

#1 A Rock Solid Foundation (page 3.1.1)

Students are introduced to the three basic rock types and the rock cycle. The concept of geologic time is also introduced by an involving, visual activity.

Major Concepts:
- Rock cycle
- Weathering
- Erosion
- Geologic time

Learning Skills:
- Observing, inferring, using models
- Organizing and expanding information; creating a product
- Measuring

Objectives:
- Name the three basic rock classes and explain how they are formed.
- Name the rock class found in the Sauratown Mountains.
- Describe the forces of weathering and erosion, and explain how these shape the land.
- Explain the rock cycle.
- Give three reasons why understanding the rock cycle is important.
- Define geologic time.
- Name the epoch, period and era in which we live.

#2 Layer on Layer (page 3.2.1)

Sedimentary rock formation is the focus of this activity. Students simulate the formation of sedimentary rocks either in an aquarium using different colors and types of sediments, or in the edible version, using various flavors of gelatin in a clear container.

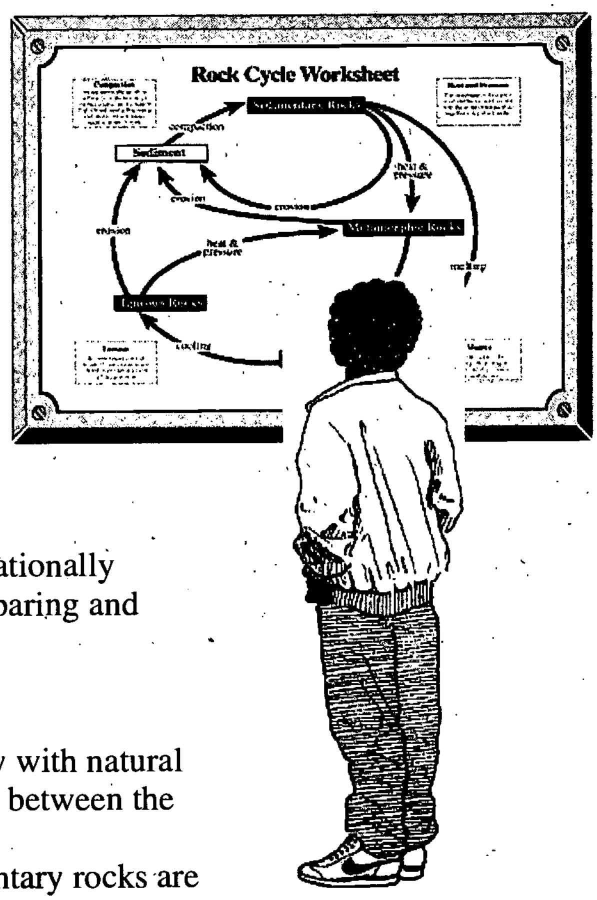
Major Concepts:
- Sedimentary rock formation
- Faulting, folding and thrusting

Learning Skills:
- Observing, inferring, predicting
- Drawing conclusions from models

Objectives:
- Define sedimentary rock and explain how sedimentary rock forms.
- Using a simple model, demonstrate and describe what can happen to rock layers when the earth's crust is compressed.
- Give examples of the evidence that geologists use to reconstruct the geological history of the Sauratown Mountains.

#3 A Rock Called Sandstone (page 3.3.1)

Once again, students focus on the formation of sedimentary rock. In this activity, they simulate the creation of an actual sedimentary rock using canary grit and Epsom salts. After the "rock" is created, they have the opportunity to compare and contrast their creation with rocks created through natural processes that take millions of years.



Major Concepts:
- Lithification
- Sedimentary rock characteristics
- Sedimentary rock formation

Learning Skills:
- Observing, communicating, defining operationally
- Writing observations and inferences; comparing and contrasting

Objectives:
- Compare sandstone made in the laboratory with natural sandstone; list similarities and differences between the two samples.
- Write a paragraph explaining how sedimentary rocks are formed.

#4 For A Change (page 3.4.1)

By firing greenware in a kiln to make bisque, students will simulate the formation of metamorphic rocks. Careful observations are an integral part of this activity.

Major Concepts:
- Metamorphic rocks
- Sedimentary rocks

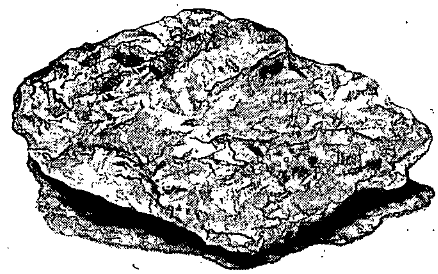
Learning Skills:
- Observing, communicating, using models
- Writing observations; comparing and contrasting

Objectives:
- Compare greenware (dried clay) with bisque (fired clay) by listing two similarities and two differences.
- Write a short paragraph explaining how firing clay in a kiln is similar to the process by which sandstone metamorphoses to quartzite.

#5 Shake It, Baby, Shake It (page 3.5.1)

Weathering and erosion have shaped the current landscape of Hanging Rock State Park. In this activity, students will act as forces of weathering and erosion and measure their effects on two types of rock–quartzite and weathered quartzite.

Major Concepts:
- Weathering and erosion
- Mechanical and chemical weathering


Quartzite

Learning Skills:
- Observing, inferring, predicting
- Summarizing new facts and comparing information

Objectives:
- Define weathering and erosion.
- Give examples to show how water can be an agent of both weathering and erosion.
- Compare the effects of abrasion on weathered quartzite and quartzite in a simulated stream environment by listing observations for each rock and then writing a conclusion.

II. On-Site Activities

#1 Erosion of a Mountain (page 4.1.1)

Students will gain a sense of how landforms change over time by constructing a model representing the Sauratown Mountains approximately 300 to 400 million years ago. Then they will act as agents of erosion to witness the effects on the model landscape.

Major Concepts:
- Erosion
- Change over geologic time

Learning Skills:
- Observing, communicating, formulating models
- Recording and comparing information; drawing conclusions; expressing opinions and ideas
- Measuring heights

Objectives:
- Participate in a group to create a model representing the Sauratown Mountains 300 to

400 million years ago, then simulate the effects of erosion by pouring water on the model.
- Record significant changes in the model by measuring, writing notes or sketching.
- Based on the experiences with the model, write a paragraph describing the geologic history of the Sauratown Mountains beginning 400 million years ago and continuing 150 million years into the future.

#2 A Geo-hike (page 4.2.1)

The Geo-hike will expose the students to the effects of geologic processes in the park and give them the opportunity to identify some rocks and minerals common to the area.

Major Concepts:
- Sauratown Mountain geology
- Erosion
- Weathering

Learning Skills:
- Observing, classifying, inferring, communicating
- Taking notes and developing conclusions

Objectives:
- Identify one mineral and one rock found in the park.
- Gain an appreciation for the geologic formations in Hanging Rock State Park.
- Present at least one theory that explains how the geologic formations found in the park may have formed.

III. Post-Visit Activities

#1 A Sauratown Mountain Bulletin Board (page 5.1.1)

This post-visit activity will give students an opportunity to share their new geological knowledge with others.

Major Concepts:
- Geologic processes
- Sauratown Mountains

Learning Skills:
- Observing, communicating
- Creating a group product of the field trip

Objectives:
- Describe at least one part of the rock cycle.
- Explain how weathering and erosion affect geologic formations.
- Describe one or more geological concepts, using text and art materials.

#2 Geo Talk (page 5.2.1)

In this activity, students will review the vocabulary they have learned through their exploration of the Hanging Rock EELE. Additionally, they will research the importance of earth resources in our daily lives.

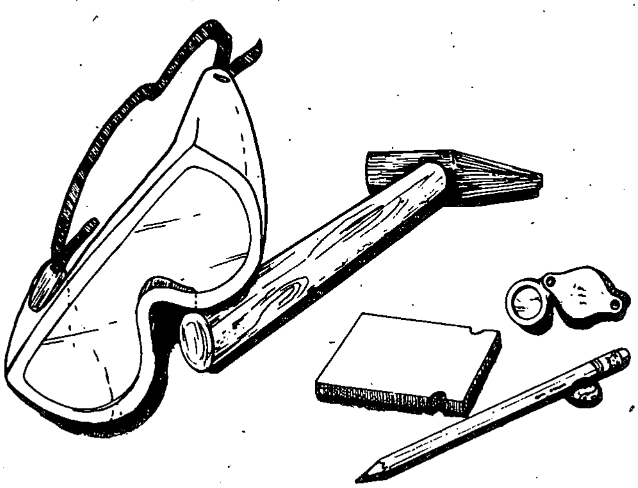
Major Concepts:
- Geology
- Earth resources

Learning Skills:
- Observing and communicating
- Identifying key words; collecting and organizing new information
- Acquiring information from primary and secondary sources

Objectives:
- Match geology words with their correct definitions.
- Collect and organize information on a specific rock or mineral. Include information on location of major sources, how it is mined, how people use it, its economic importance, and environmental issues related to its extraction and use.

#3 Do You Mine? (page 5.3.1)

Students will explore different viewpoints surrounding a proposed mining operation near a fictitious state park. Each student will write an essay representing a particular interest group, then work toward a group solution to this issue.



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

Learning Skills:
- Predicting, communicating
- 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 resource issue.

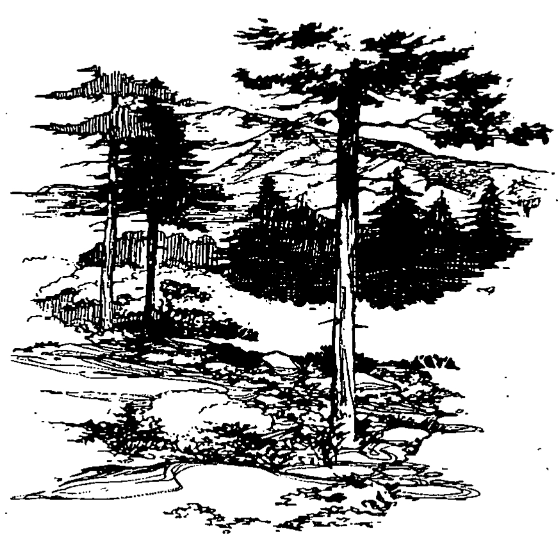
CORRELATION CHART - Hanging Rock

Hanging Rock State Park's EELE: *Rock around the Clock*

Note to classroom teachers: The following Correlation Charts show 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: Rock Solid Foundation, p. 3.1.1

Grade	Science	English Lang. Arts	Soc. Studies	Mathematics
5	3.01 Nature of Science Science & Tech.	1.1, 2.1, 2.3, 2.4, 3.1, 3.6, 3.10, 3.12, 5.1		1.1
6		1.1, 1.2, 1.3, 2.2, 2.3, 3.2, 3.9, 5.1		1.1
7		1.1, 2.3, 3.2, 5.1		1.1, 4.3
8	3.01, 3.02, 3.03, 3.04 Nature of Science	2.1, 2.3, 3.2, 3.6, 3.7, 3.12, 4.1, 4.2, 5.6, 6.3		1.5, 2.12
Earth Science	1.02, 3.01, 3.02 3.03 Nature of Science			



Pre-Visit Activity #2: Layer on Layer, p. 3.2.1

Grade	Science	English Lang. Arts	Soc. Studies	Mathematics
5	3.01, 3.03 Nature of Science Science as Inquiry	1.1, 2.2, 2.4, 2.5, 3.1, 3.6, 3.10, 5.1		
6		1.2, 1.3, 2.3, 3.2, 3.9, 4.1, 6.2		
7		1.2, 3.2, 5.6		
8	3.01, 3.03, 3.04 Nature of Science Science as Inquiry	2.1, 3.2, 4.1, 4.3, 6.3		
Earth Science	1.02, 2.04, 4.01 Nature of Science Science as Inquiry			

Pre-Visit Activity #3: A Rock Called Sandstone, p. 3.3.1

Grade	Science	English Lang. Arts	Soc. Studies	Mathematics
5	3.01 Nature of Science Science as Inquiry	1.1, 2.2, 2.4, 3.1, 3.6, 4.1, 5.1, 5.5, 6.2, 6.5		
6		1.2, 3.2, 3.9, 4.1, 5.4, 5.8, 5.10, 6.2		
7	4.01, 4.04 Nature of Science Science as Inquiry	3.2, 5.3, 6.7, 6.8		
8	3.01, 3.04 Nature of Science Science as Inquiry	1.2, 2.1, 3.2, 4.1, 4.3, 5.1, 5.5, 6.3		
Earth Science	1.02, 4.01 Nature of Science Science as Inquiry			

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Pre-Visit Activity #4: For a Change, p. 3.4.1

Grade	Science	English Lang. Arts	Soc. Studies	Mathematics
5	3.01 Nature of Science Science as Inquiry	1.1, 2.2, 2.4, 3.1, 3.6, 5.1, 6.2, 6.6		
6		1.2, 3.2, 3.9, 4.1, 5.4, 5.7, 6.2		
7	4.05 Nature of Science Science as Inquiry	3.2, 5.3		
8	3.01, 3.04 Nature of Science Science as Inquiry	2.1, 3.2, 4.1, 6.3		
Earth Science	1.02 Nature of Science Science as Inquiry			

Pre-Visit Activity #5: Shake It, Baby, Shake It, p. 3.5.1

Grade	Science	English Lang. Arts	Soc. Studies	Mathematics
5	3.01 Nature of Science Science as Inquiry	1.1, 2.4, 3.1, 3.6, 5.1, 6.6		1.15, 4.3, 4.5
6	1.01 Nature of Science Science as Inquiry	1.2, 3.2, 3.9, 4.1, 6.2		4.4, 4.6
7	4.05 Nature of Science Science as Inquiry	3.2, 5.3		4.5, 4.10
8	3.01, 3.04 Nature of Science Science as Inquiry	2.1, 3.2, 4.1, 6.3		2.12, 4.3, 4.6
Earth Science	1.02, 1.05, 4.01 Nature of Science Science as Inquiry			

On-Site Activity #1: Erosion of a Mountain, p. 4.1.1

Grade	Science	English Lang. Arts	Soc. Studies	Mathematics
5	3.01, 3.02, 3.03 Nature of Science Science as Inquiry Science & Tech.	1.1, 2.4, 3.1, 4.1, 5.1, 6.2		
6	1.01 Nature of Science Science as Inquiry	1.2, 3.2, 4.1, 5.4, 6.2		
7		3.2, 5.3, 5.6, 6.7		
8	1.05, 2.02, 3.01, 3.04 Nature of Science Science as Inquiry	2.1, 3.2, 4.1, 4.2, 5.5, 6.3	1.1, 1.2 Skill Goal I	
Earth Science	1.02, 1.05, 1.06 3.03, 4.01 Nature of Science Science as Inquiry			

On-Site Activity #2: A Geo-hike, p. 4.2.1

Grade	Science	English Lang. Arts	Soc. Studies	Mathematics
5	3.01, 3.02, 3.03 Nature of Science Science as Inquiry	1.1, 2.2, 2.4, 3.1, 3.6, 5.1, 6.6	3.1 Skill Goal I	
6	1.01 Nature of Science Science as Iinquiry	3.2, 3.9, 4.1, 5.4, 6.2, 6.7		
7		3.2, 5.3, 6.7		
8	1.05, 2.02, 3.01 3.04 Nature of Science Science as Inquiry	2.1, 3.2, 3.6, 4.1, 5.1, 6.3	1.1, 1.2 Skill Goal I	
Earth Science	1.02, 1.05, 1.06 3.03, 4.01 Nature of Science Science as Inquiry			

Post-Visit Activity #1: Sauratown Mountain Bulletin Board, p. 5.1.1

Grade	Science	English Lang. Arts	Soc. Studies	Mathematics
5	3.01, 3.02, 3.03 Nature of Science	5.1, 5.4, 6.2		
6	1.01 Nature of Science	5.7, 6.2		
7		5.1, 6.5, 6.7		
8	3.01, 3.02, 3.03 3.04 Nature of Science	5.2, 5.3, 5.6, 5.7		
Earth Science	1.02, 3.03, 4.01 Nature of Science			

Post-Visit Activity #2: Geo Talk, p. 5.2.1

Grade	Science	English Lang. Arts	Soc. Studies	Mathematics
5	2.02, 3.01, 3.03 Science & Tech., Personal & Social Perspectives	1.1, 2.2, 2.4, 3.1, 3.6, 3.10, 3.12, 5.1, 6.2, 6.6	2.3, 5.2, 5.3 Skill Goals I & II	
6	1.03 Science & Tech., Personal & Social Perspectives	2.2, 3.2, 3.9, 4.1, 5.4, 5.7, 6.2	3.1, 5.2, 9.2 Skill Goals I & II	
7	1.04 Science & Tech., Personal & Social Perspectives	2.3, 3.2, 5.6, 6.7	3.1, 5.2, 9.2 Skill Goals I & II	
8	1.04, 2.02, 3.01 3.04 Science & Tech., Personal & Social Perspectives	2.1, 2.7, 3.2, 3.6, 3.7, 4.1, 5.5, 6.3	1.2, 1.3 Skill Goals I & II	
Earth Science	1.02, 1.03, 1.06, 7.01, 7.02 Science & Tech., Personal & Social Perspectives			

Post-Visit Activity #3: Do You Mine? p. 5.3.1

Grade	Science	English Lang. Arts	Soc. Studies	Mathematics
5	1.03, 1.06, 2.02, 3.01 Science & Tech., Personal & Social Perspectives	1.1, 2.1, 2.4, 3.1, 3.6, 3.10, 3.11, 3.12, 3.15, 5.1, 6.2, 6.6, 6.7	2.3, 5.2, 5.3 Skill Goals I, II, III, & IV	
6	1.01, 1.03 Science & Tech., Personal & Social Perspectives	1.2, 1.3, 1.4, 1.5, 2.2, 3.2, 3.9, 3.13, 4.1, 5.2, 5.4, 5.7, 5.11, 6.2, 6.6, 6.7		
7	1.04 Science & Tech., Personal & Social Perspectives	1.2, 1.3, 2.3, 3.2, 3.4, 3.5, 3.11, 3.12, 4.1, 4.2, 5.3, 5.5, 5.6, 6.1, 6.2, 6.3, 6.8		
8	1.04, 1.05, 2.01, 2.02, 2.03, 2.04, 2.05, 3.04 Science & Tech., Personal & Social Perspectives	1.1, 1.2, 2.1, 2.3, 3.2, 3.3, 3.4, 3.5, 3.7, 3.9, 3.10, 4.3, 5.1, 5.5, 5.7, 5.8, 6.1, 6.2, 6.3	1.3, 1.5 Skill Goals I, II, III & IV	
Earth Science	1.03, 1.05, 1.06, 4.01, 7.01, 7.02, 7.03 Science & Tech., Personal & Social Perspectives			

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Pre-Visit Activity #1 "A Rock Solid Foundation"

Major Concepts:
- Rock cycle
- Weathering
- Erosion
- Geologic time

Learning Skills:
- Observing, inferring, using models
- Organizing and expanding information; creating a product
- Measuring

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

Location: Classroom

Group Size:
30 students, class size

Estimated Time:
Part A: 30 minutes
Part B: 2 - 3 class periods

Appropriate Season: Any

Materials:
Part A:
Provided by the educator:
Per student: Student's Information, Rock Cycle Diagram

Part B:
Provided by the educator:
A 65' long continuous strip of 24" wide paper, measuring stick, markers or crayons, tape, reference books on fossils and life during the various geologic time periods
Per student: Geologic Time Fact Sheet and the Events in Geological History chart

Objectives:
- Name the three basic rock classes and explain how they are formed.
- Name the rock class found in the Sauratown Mountains.
- Describe the forces of weathering and erosion, and explain how these shape the land.
- Explain the rock cycle.
- Give three reasons why understanding the rock cycle is important.
- Define geologic time.
- Name the epoch, period and era in which we live.

Educator's Information

This activity is divided into two parts:

Part A, "Let's Get the Basics," is designed to introduce the students to the **rock cycle** and the three classes of **rocks**.

Part B, "Time After Time," is designed to help students understand that **geologic time** is much more than minutes, hours and days. By visually comparing our existence with the formation of the **Sauratown Mountains**, the large expanse of time becomes more understandable.

Note: The term *Precambrian* is sometimes used to describe rocks older than 544 millon years. Precambrian is a time term without specific rank. In this EELE, we use the more specific term, *Proterozoic eon,* to refer to earth's history prior to 544 million years ago.

Part A: Let's Get the Basics

Instructions:

1. Use the background information on the **geology** of Hanging Rock State Park (page 1.6) to acquaint students with the Sauratown Mountains and with the concepts of **weathering** and **erosion**.

2. Distribute the Student's Information and the Rock Cycle Diagram. Have students read this background information.

3. Discuss how the rock cycle works. Emphasize the formation of **sedimentary**, **igneous** and **metamorphic rocks**. Explain that all the rocks in the Sauratown Mountains today are metamorphic rocks. They originated from sedimentary and igneous rocks that were deeply buried and folded in the earth's crust. Millions of years of erosion have exposed these rocks at the earth's surface.

Student's Information:

Minerals combine to form rocks. There are a few **rocks** that consist of only one **mineral**. But, most rocks are made of a few major, or essential minerals, along with a number of minor, or accessory minerals. All rocks fall into one of three classes, which are named according to their origin. These classes are sedimentary, igneous and metamorphic.

Sedimentary rocks are formed as loose **sediments** wash into streams and rivers, then settle along the river's course or at the river's delta. As this **deposition** piles up over time, pressure on the bottom layers increases, compacting and cementing the layers together to eventually form sedimentary rock. An example of this type of rock is **sandstone**.

Fossils of plants and animals are sometimes found in sedimentary rocks and, rarely, in slightly metamorphosed sedimentary rocks. Fossils form when plants and animals are buried quickly in sediment and remain undisturbed for a long time. The organic material usually decays, leaving behind only the hard parts, such as bone, shell or wood.

Sedimentary rocks usually have a layered or bedded appearance. They may even show ripple marks or mud cracks, revealing the environment where they formed.

Igneous rocks come from **magma**. Magma is molten material found deep below the earth's surface. Some igneous rocks, such as granite, are formed when magma cools slowly within the earth's crust. Other igneous rocks are formed when molten magma flows or spews out of a volcano or crack onto the earth's surface. Magma that comes to the surface of the earth is called **lava**. Lava on the earth's surface cools much faster than magma trapped beneath the surface, causing different types of rocks to form. Igneous rocks never contain fossils. Temperatures high enough to melt rock are also high enough to burn up any organic matter, plant or animal, as well as fossils.

Metamorphic rocks are formed when heat and pressure change exisiting rocks without actually melting them. "Meta" means changed and "morphic" means form, so a metamorphic rock is one that has changed form. An example found in the park is **quartzite**, which is the harder, more dense form of sandstone that has been metamorphosed.

Sedimentary, igneous and metamorphic rocks are all related to one another. The Rock Cycle Diagram shows how. Follow the arrows in the diagram to find out how one kind of rock changes to another. For example, what happens if any of the three rock classes undergoes melting? Follow the melting arrow to magma –the rock melts to become magma. Now follow the cooling arrow to igneous rocks. (After magma cools, it becomes a new igneous rock.) You can also follow the arrows backward to learn the origin of a particular class of rock.

The rock cycle is really a series of geologic processes that make and destroy rocks. It explains how rocks are formed and how they change into other rocks through earth movement, pressure and heat. It also explains how rocks and mountains are worn away through **weathering** by wind and water. This makes a complete cycle of building up and tearing down.

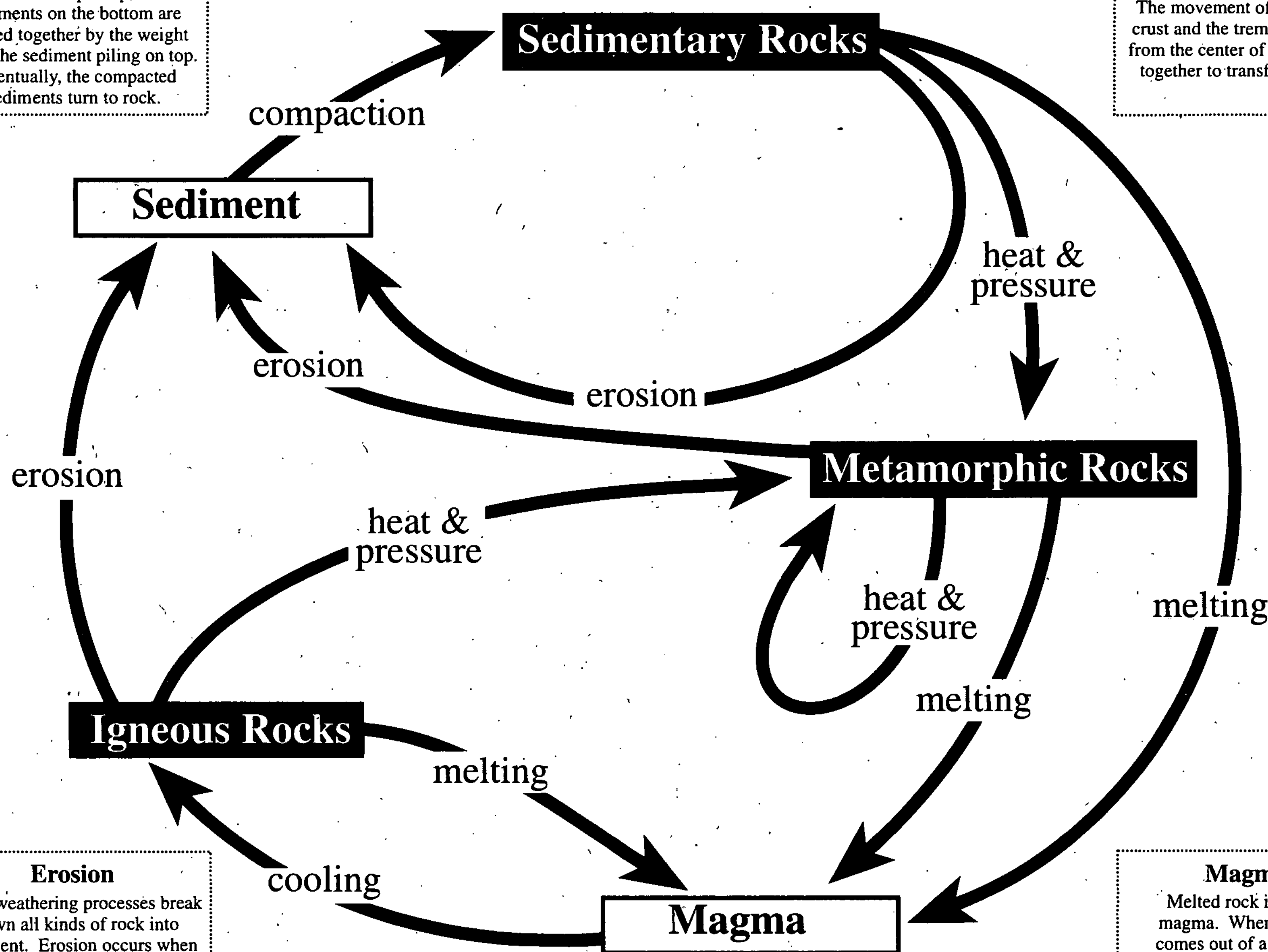
The rock cycle is an important geologic concept. Geologists have been able to put together a record of the earth's history by learning about the processes through which rocks change. They are also able to predict ongoing large-scale formation processes, such as earthquakes and volcanic eruptions.

Once you are able to identify the rocks you see and understand how they are formed, you can make educated guesses about the rocks you can not see. These inferences may help you determine the stability of a site as a building location, determine where water would likely be found (hence, where to dig a well), and determine the location of ecomonically important rocks and minerals.

Rock Cycle Diagram

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.

Part B: Time After Time

Educator's Information:

Geology is the science of the earth and its history. When we study geological history, we find that water invaded the land, layers of **sediment** were deposited, the land was pushed up into mountains and eventually wind, rain and ice leveled the land again. This sequence has been repeated many times over the history of the earth.

It is quite difficult for most of us to understand the concept of geologic time. Because we tend to regard events on our planet using a time scale of hours, days, months and years, it is easy to underestimate the vast amount of time covered during an **eon** like the Proterozoic.

By creating a visual model, the students should begin to more clearly understand the broad scope of geologic time.

Instructions:

1. Starting near the classroom door, run a continuous strip of paper around the room. If the circumference of the classroom is less than 65 ft (19.8 cm), the paper can be spiraled around the room. The recommended width of the paper strip is 24 inches (61 cm).

2. Using a yardstick and a black marker or crayon, have the students draw a continuous line, three inches (7.6 cm) up from the bottom of the paper, along the entire length of the paper. If a marker is used, make sure it will not "bleed through" onto the classroom wall.

3. Have the students draw another continuous line with the marker or crayon 16 inches (40.6 cm) above the first line.

4. Have the students make another continuous line three inches (7.6 cm) above the line drawn in step 3. After steps 1 - 4, the paper should look similar to Figure A.

5. Using the magic marker or crayon, have the students place and label 390 equally spaced marks on the paper below the bottom line. The distance between the marks should be two inches (5.1 cm). Each mark stands for 10 million years, giving a total representation of 3,900 million years, or 3.9 billion years. Note: This works out well as the oldest rock on earth is 3,800 million years old.

Calculation: 65 feet = 780 inches, divided by 2 inches gives you 390 marks, each of which represents 10 million years, for a total of 3,900 million years. (3,900 million = 3.9 billion.)

You may also want to divide the last 10 million years into 1 million year segments (approximately 5 mm apart). The term *millions of years* can be abbreviated to "mya." After step 5, the paper should look like Figure B.

Figure A

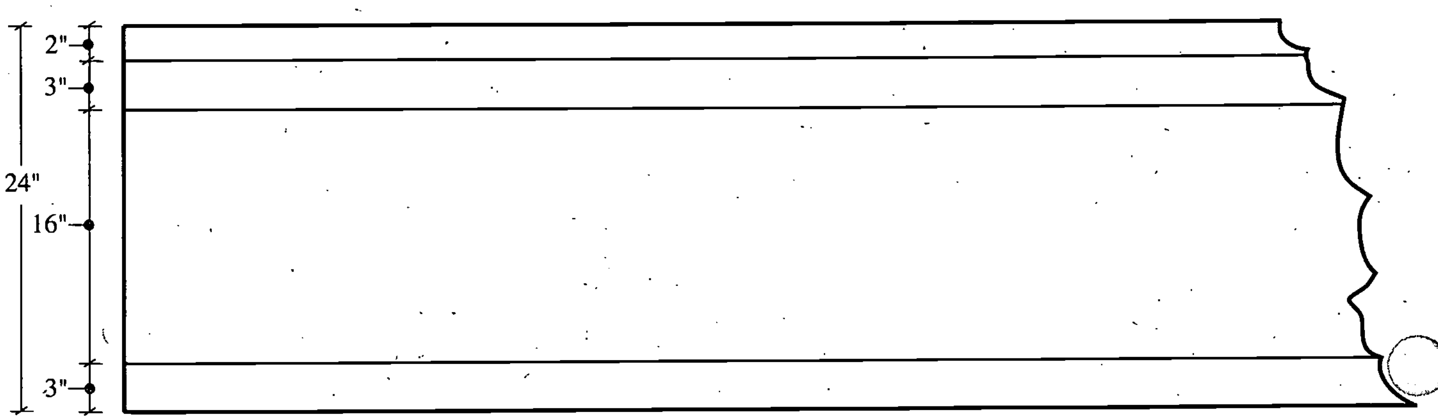


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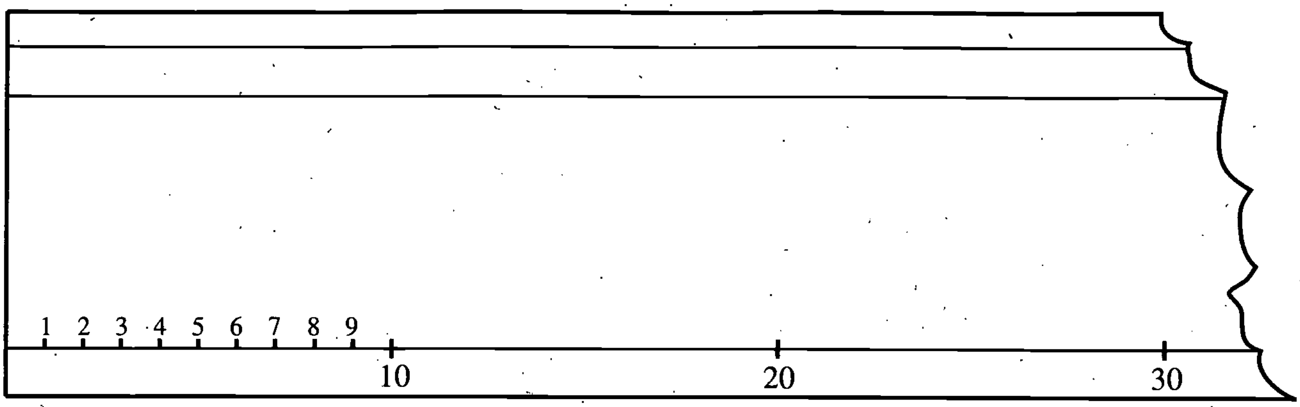
Figure B



millions of years ago

6. This geologic time activity provides information on 12 **periods**. Divide the class into 12 teams. (Some "teams" may consist of just one student.) The whole class will be responsible for depicting the Proterozoic eon after the periods in the Phanerozoic eon have been portrayed.

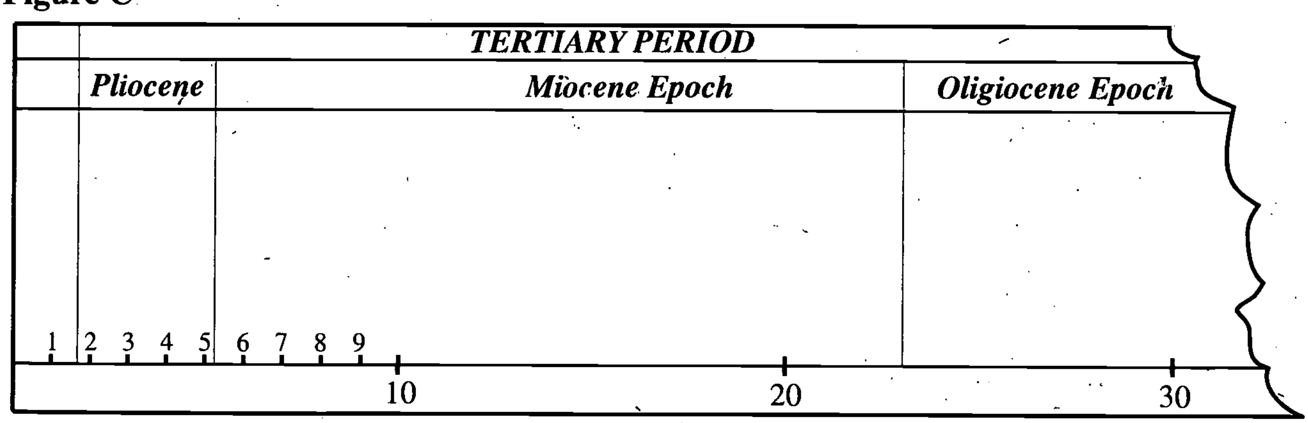
Each team should be assigned a period from the Geologic Time Fact Sheet. The team is responsible for finding their period on the time scale mural and marking it off with vertical lines, being sure to label the time periods (Figure C). Note that different references do not always agree on the exact beginning and ending for each period. The geologic time scale in this EELE includes the latest information from the North Carolina Geological Survey.

The students will also illustrate what animals and plants lived during their period. Students working within the 0 to 10 mya scale (Quaternary period) will not have room within these two inches to place the illustrations. They can use arrows to indicate where their illustrations fit into the main scale on the paper. The students can do some independent research if they are not familiar with the animals and plants found in their time period. After step 6 the mural should resemble Figure D.

7. In the space remaining on the mural, students can illustrate geologic events over the appropriate years. Use the Events in Geological History (pages 3.1.11-13) and library references as a guide.

8. After the students have completed the timeline mural, remind them that when studying geology, it is often difficult to determine absolute ages. Therefore, geologists use geological **eras** and periods when discussing the earth's history rather than

Figure C



millions of years ago

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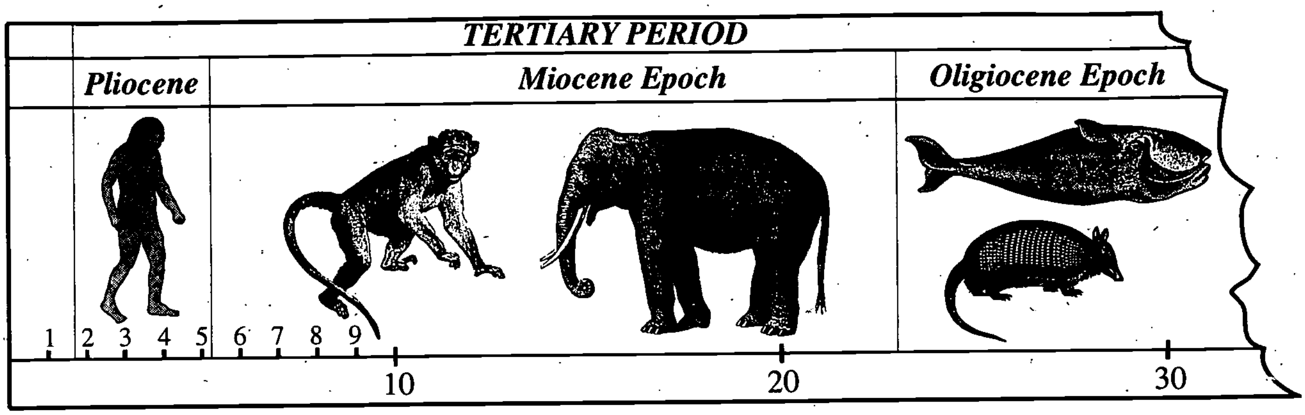
Figure D



millions of years ago

calendar dates. This mural illustrates the vast number of years our earth's history covers.

9. Compare the student's life history (years of age) with the history and age of the earth, and with rocks and formations of the Sauratown Mountains. Be sure to note what era, period and **epoch** we live in.

10. The Abbreviated Events in Geological History (page 3.1.13) is a simplified overview of the geological history of the earth. Geologic events in the Sauratowns are highlighted. Use this page with younger students, or to quickly give the "big picture."

Assessment:

1. Remove the words written in the arrows on the Rock Cycle Diagram, then copy for each student. List the following five terms on the chalkboard or overhead: compaction; melting; cooling; erosion; heat & pressure. Ask students to label the arrows on the Rock Cycle Diagram.

2. Scramble the events on the Abbreviated Events in Geological History chart. Can students place them in the correct sequence?

Extension:

Using reference books, encyclopedias, field guides, etc., search for other earth history events not listed in the Events in Geological History in this EELE and include them in the mural. High school students could assess the evidence for major geologic events and paleoclimatic changes.

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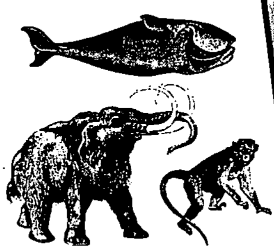
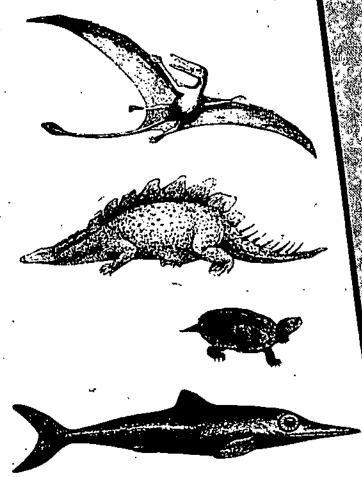
Geologic Time Fact Sheet

Phanerozoic Eon

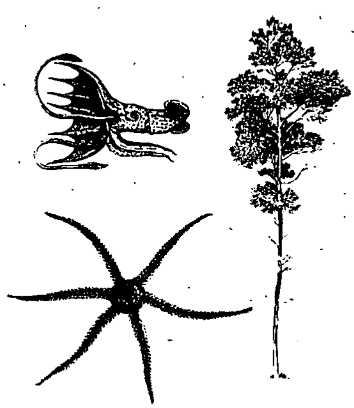
Cenozoic
65 – present



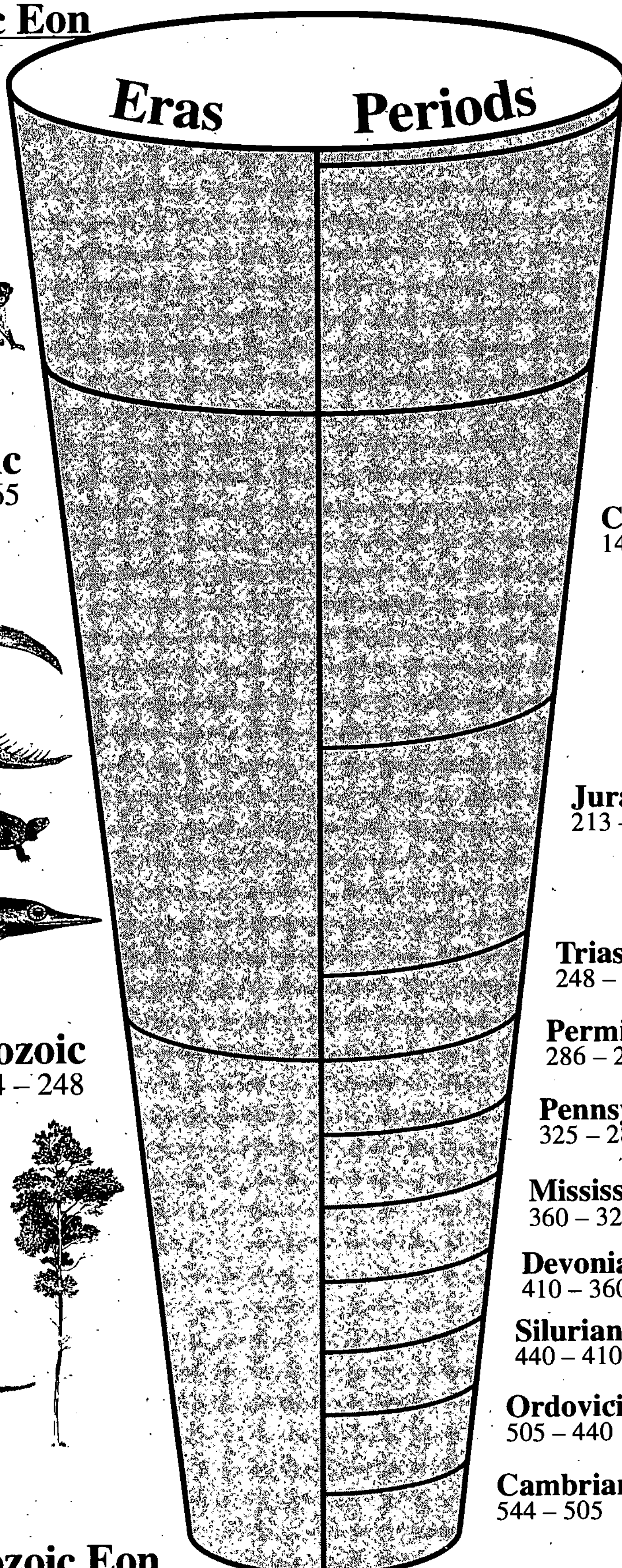
Mesozoic
248 – 65



Paleozoic
544 – 248



Proterozoic Eon



Quaternary
1.8 – present

Epochs
Holocene
0.008–present
Pleistocene
1.8 – 0.008

Tertiary
65 – 1.8

Pliocene
5.3 – 1.8
Miocene
23.8 – 5.3
Oligocene
33.7 – 23.8
Eocene
55.5 – 33.7
Paleocene
65 – 55.5

Cretaceous
145 – 65

Figures indicate millions of years ago

Jurassic
213 – 145

Triassic
248 – 213

Permian
286 – 248

Pennsylvanian
325 – 286

Mississipian
360 – 325

Devonian
410 – 360

Silurian
440 – 410

Ordovician
505 – 440

Cambrian
544 – 505

Information courtesy of N.C. Geological Survey

Geologic Time Fact Sheet

Time is an 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**. Eons are subdivided into eras; eras are subdivided into periods; and periods are 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 were marked by mass extinctions. Geologists continue to study rock formations today to put together a more accurate history of our planet.

Note: The earth's history is divided into four eons: Phanerozoic, Proterozoic, Archean and Hadean. Because there are no ancient rocks from the Archean or Hadean in North Carolina, we will concentrate on the two more recent eons– Phanerozoic and Proterozoic.

PROTEROZOIC EON...

2.5 billion years ago to 544 million years ago

The Proterozoic eon is divided into three eras: early, middle and late. The oldest known rock in North Carolina (Roan Mountain) dates to the early Proterozoic (1.8 billion years old). By the beginning of the Proterozoic, blue-green algae had evolved and photosynthesis had begun. The oxygen produced during photosynthesis changed the earth's atmosphere, enabling the evolution of more complex life. Sponges, soft corals, jellyfish and annelid worms also evolved during this eon.

PHANEROZOIC EON...

544 million years ago to the present

PALEOZOIC ERA

"Age of Ancient Life"

544 million to 248 million years ago

Cambrian Period

544 to 505 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 ocean floor. 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, 75% of all the trilobite families, 50% of the sponge families and many of the brachiopods and gastropods disappeared. No one knows what caused this mass extinction.

Ordovician Period

505 to 440 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 invertebrates (animals without a backbone). 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. A mass extinction ended this period, when many of the remaining trilobites and some of the early fish and sponges died out.

Silurian Period

440 to 410 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. Millipedes and scorpions may have begun to live on the land.

Devonian Period

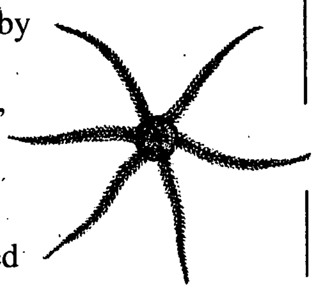
410 to 360 million years ago

This period is called the Age of Fishes because the early, primitive forms of fish multiplied and diversified. Sharks, rays and bony fishes developed during this period. A giant, 30 foot long fish called the Dunkleosteus did not have any teeth, but the bones in its jaw were as sharp as knives. Other invertebrates began to live in freshwater 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 found during the Devonian period. The first seed-bearing plants also evolved then. Mass extinction marked the end of this period–25% of all species disappeared.

Mississippian Period

360 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. The trilobites continued to decline.



Pennsylvanian Period

325 to 286 million years ago

The 39 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", lived during this time. Most of the land was covered with swampy forests. Conifers first developed during the Pennsylvanian period.

Permian Period

286 to 248 million years ago

During the 38 million years of the Permian period, the marine invertebrates specialized into many different forms. The ginko tree first appeared. Reptiles and amphibians continued to develop. One of the most important groups of reptiles from this period was the pelycosaurs, ancient forerunners of the mammals. 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. This period ended with the most severe of all mass extinctions–96% of all species were lost.

MESOZOIC ERA

"Time of Middle Life"

248 to 65 million years ago

Triassic Period

248 to 213 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 at the end of the Triassic. 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 became extinct.

Jurassic Period

213 to 145 million years ago

Oysters, crabs, lobsters, sea urchins and shrimps developed in the oceans. The stegosaurus 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

145 to 65 million years ago

The Cretaceous period was one of the longest periods, lasting 80 million years. Much of the land was covered by shallow seas. Pterosaurs, the flying reptiles, became more specialized. Some of the Cretaceous dinosaurs include tyrannosaurs, ankylosaurs and the duck-billed dinosaurs. Flowering plants, bees and butterflies also evolved during this time. The end of the Cretaceous 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. 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 1.8 million years ago

Paleocene Epoch

65 to 55.5 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 is known as the Age of Mammals because many different kinds of mammals developed during the 63 million years of this period. Along with the development of hoofed mammals, rodents, and squirrel-like primates on land, sharks were abundant in the oceans.

Eocene Epoch

55.5 to 33.7 million years ago

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

Oligocene Epoch

33.7 to 23.8 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 all evolved separately in South America.

Miocene Epoch

23.8 to 5.3 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

5.3 to 1.8 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

1.8 million years ago to the present

Pleistocene Epoch

1.8 million to 8,000 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

8,000 years ago to 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. Humans may also be playing a role in global warming.

Events In Geological History

Millions of Years Ago

4500 +++	Planet formed. **Hadean eon** begins.
4000	By now, earth has a relatively stable crust with oceans and primitive atmosphere.
3800	Age of some of oldest rocks on earth's surface today. Hadean eon ends; **Archean eon** begins.
3400	Primitive single cell life appears.
2500	Archean eon ends; **Proterozoic eon** begins. Algae have evolved – photosynthesis begins.
1800	Oldest known rock in North Carolina.
1600	Sediments deposited in a very ancient ocean off the North American continent. (Later, they were metamorphosed and formed the Blue Ridge Mountains.)
800	Layers of sediment accumulate in the Iapetus Sea. (Sandstones and other sedimentary rocks formed here are the "parent rocks" to those found in the Sauratown Mountains today.)
544	Proterozoic eon ends; **Phanerozoic eon** begins. **Cambrian period** begins – First animals with shells appear in oceans.
505	**Ordovician period** begins – Continental collision of North America and Africa. This is the beginning of the mountain-building process. Layers of sandstone are folded and metamorphosed.
440	**Silurian period** begins – Uplift continues along with some erosion.
410	**Devonian period** begins – Plants are thriving on land above the sea; first land animals appear; insects are common.
408	Due to movement of the earth's crust as North America and Africa move together, the Iapetus Sea closes and disappears.
360	**Mississippian period** – Time of uplift and erosion.
325	**Pennsylvanian period** – Time of uplift and erosion.
300	Reptiles appear.
286	**Permian period** begins – Final collision of North America and Africa. Thrust faulting occurs in western North Carolina along with deformation of rocks in the Piedmont.
248	**Triassic period** begins – Formation of Atlantic Ocean, as North America and Africa drift apart. Weathering and erosion of Piedmont and mountains.

Millions of Years Ago

225	Faulting and rifting creates the Dan River Basin and other Triassic basins in North Carolina.
213	**Jurassic period** begins – Dinosaurs rule! First mammals appear. Erosion continues.
145	**Cretaceous period** begins.
78	Modern fish appear.
70	Dinosaurs become extinct; Rocky Mountains pushed up. Weathering and erosion continue in the Piedmont and mountains of North Carolina.
65	**Tertiary period** begins with **Paleocene epoch** – Limestone deposited in Coastal Plain; weathering and erosion continue in Piedmont and mountains.
60	Beginning of the Age of Mammals; first hoofed mammals and primates appear.
55.5	**Eocene epoch** begins.
33.7	**Oligocene epoch** begins.
23.8	**Miocene epoch** begins – Phosphate is deposited in eastern North Carolina.
5.3	**Pliocene epoch** begins – Erosion of Piedmont and Appalachian Mountains to their present rugged features.
1.8	**Quaternary period** begins with the **Pleistocene epoch.**
1	Time of Ice Ages.

Thousands of Years Ago

100	Neanderthal man walks the earth.
40	Modern humans (*Homo sapiens*) appear.
30	People first cross over to North America.
20	Physical evolution of humans as we know them today is complete.
15	Ice sheets still cover most of North America.
10	Groups of people in North America begin to settle down in villages.
8	**Holocene epoch** begins – glaciers retreat.
1	The Saura people have a number of villages along the Dan River.
0	Present time.

Geologic Time Information Courtesy of the North Carolina Geological Survey

Abbreviated Events in Geological History

Most geologists think that the earth is about 4.5 billion years old. Let's squeeze this vast amount of time into one day, a 24-hour cycle. On this scale, one second represents 52,000 years! Here are some benchmarks in this special 24-hour day. Notice that most of the events occurred just a few hours before midnight!

Compressed Time	Event	Approximate Real Time
12:00 Midnight	The Earth is born.	4.5 billion years ago
6:30 AM	Earliest life forms appear (bacteria).	3.3 billion years ago
10:00 AM	Blue-green algae appear & photosynthesis begins.	2.6 billion years ago
2:30 PM	Oldest known rock in North Carolina forms.	1.8 billion years ago
7:45 PM	Sandstone ("parent rock" to quartzite found in park) forms in Iapetus Sea, an ancient ocean.	800 million years ago
8:15 PM	Soft-bodied sea creatures appear.	700 million years ago
9:00 PM	Hard-shelled sea creatures appear.	550 million years ago
9:15 PM	Sandstone in park metamorphoses to quartzite when crustal plates carrying North America and Africa collide.	500 million years ago
10:00 PM	First land plants and animals appear; amphibians follow soon after.	400 million years ago
10:25 PM	Early reptiles and flying insects appear.	300 million years ago
10:40 PM	Dinosaurs appear. Weathering & erosion of Piedmont and Sauratown Mountains.	250 million years ago
10:50 PM	Dan River basin develops; Atlantic Ocean forms as Africa and North America move apart; small mammals appear.	220 million years ago
11:00 PM	Birds appear.	195 million years ago
11:40 PM	Early primates appear; dinosaurs become extinct. Erosion in Piedmont continues.	65 million years ago
11:59 PM	Humans arrive seconds before midnight.	1 million years ago or less

Major Concepts:
- Sedimentary rock formation
- Faulting, folding, thrusting

Learning Skills:
- Observing, inferring, predicting
- Drawing conclusions from models

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

Location: Indoors

Group Size: 30 or less

Estimated Time:
Option A: 60 minutes
Option B: 60 minutes over several days

Appropriate Season: Any season

Materials:
Provided by the educator:
Option A
Per group: Small aquarium or 3-liter clear plastic soda bottle with the top cut off, water, sand, clay soil, and other "sediments." Note: Any type of fine material that will settle in water can be used, preferably of several different colors so the layering effect can be seen. Make sure none of the materials can float before using them with students!
Option B
Per class: Several packages of gelatin in assorted colors, hot water, two-quart bowl, package of licorice strings, plastic wrap to cover gelatin, glass cake pan, spatula
Per student: Clear plastic 8 oz. cup, spoon, pen to mark cup

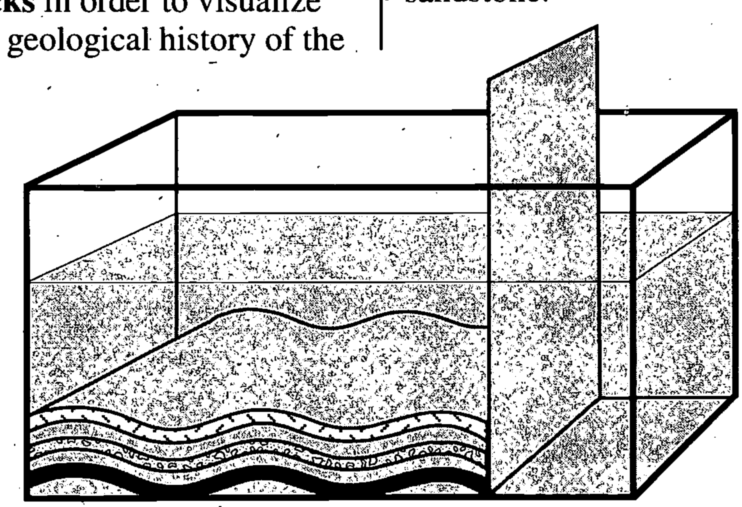
Credits: Museum Institute for Teaching Science, Oct/Nov 1988. (See References section.)

Objectives:
- Define sedimentary rock and explain how sedimentary rock forms.
- Using a simple model, demonstrate and describe what can happen to rock layers when the earth's crust is compressed.
- Give examples of evidence that geologists use to reconstruct the geological history of the Sauratown Mountains.

Educator's Information:

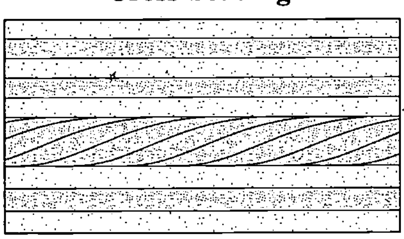
In this activity, students will manipulate simple models of **sedimentary rocks** in order to visualize the geological history of the **Sauratown Mountains**. Two options are provided: Option A focuses on **sediment deposition** and how movements in the earth's crust can later fold or deform the original layers. Option B reinforces the concept of **geologic time** and demonstrates **cross-bedding**.

Although most of the exposed rock in the park today is **metamorphic**, the parent rock was sedimentary. Geologists think that the sedimentary rock (primarily **quartz sandstone**) was laid down in a shallow sea about 800 million years ago. Much later this deeply-buried sedimentary rock was metamorphosed and became **quartzite**. Although the quartzite was folded, metamorphosed and thrust up and over younger rocks, it still exhibits the sediments and layers in the original sandstone.

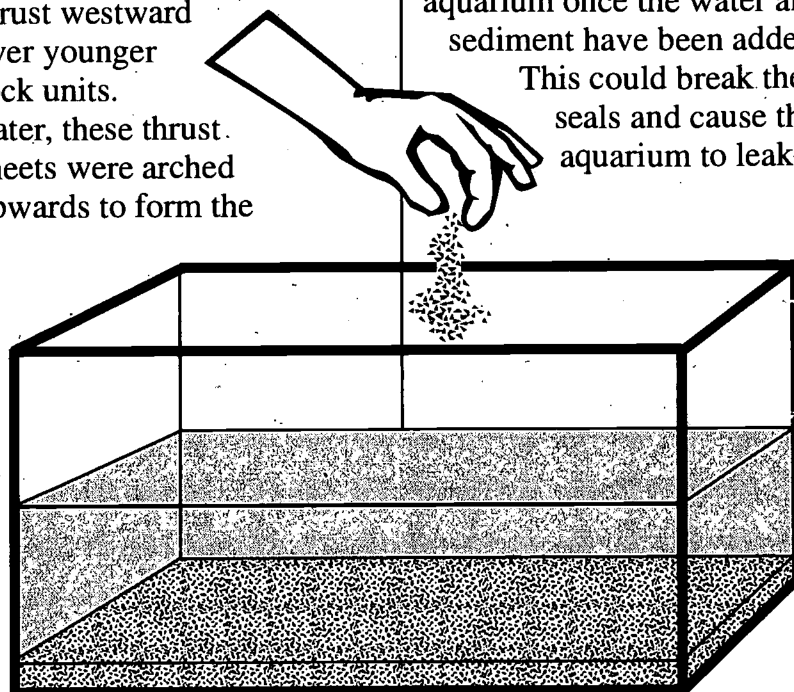


When your students visit Hanging Rock State Park, they may observe that some rock layers, although parallel, have internal layers aligned at an angle, one to another. This feature is called cross-bedding and occurs when the currents or winds that carry sand change direction over time. Cross-bedding within the quartzite layers provides evidence that the rocks of the park were formed in a nearshore or beach environment. Note: This original sedimentary feature is best displayed beneath Hanging Rock in the more weathered rock layers. (Cross-bedding can also be observed on the upwind side of large sand dunes such as those at Jockey's Ridge State Park.)

Cross-bedding



At the park, students will observe that some of the quartzite layers are tilted. This indicates that deformation of the earth's crust occurred after the deposition of the sediments. Geologists think that beginning about 500 million years ago, large folds and **faults** developed in the crust as the **tectonic plates** carrying North America and Africa started to come together to form the supercontinent, **Pangaea**. In the Sauratown Mountain area, older rock units were thrust westward over younger rock units. Later, these thrust sheets were arched upwards to form the Sauratown Mountain **anticlinorium**. Some geologists describe this anticlinorium as a large fold in the crust that has flopped over on its side.



Instructions:

Review the Student's Information and determine if you wish to use this as an introduction to the activity options below. Make copies as needed.

OPTION A:

1. Divide the students into groups of four. Provide each group with a container, water, and portions of clay soil, sand, or other sediments. At least one group should use an aquarium, or the teacher can complete the activity in the aquarium as a demonstration.

Note: DO NOT move the aquarium once the water and sediment have been added. This could break the seals and cause the aquarium to leak.

2. Each group should fill their container about halfway with water.

3. Have the students very slowly sprinkle some clay soil (or whatever material they are using) into the container of water.

4. Allow all the deposited material to settle to the bottom of the container. (Time will vary depending on the material used; generally it will take about one minute.)

5. After the first layer has settled, add a second layer of sand. Continue making layers, alternating clay soil, sand, and other sediments until there is a minimum of eight layers. Remember to let the materials settle for about a minute before adding the next layer. If desired, students can place leaves, shells or other natural objects against the glass in several layers to simulate **fossils**.

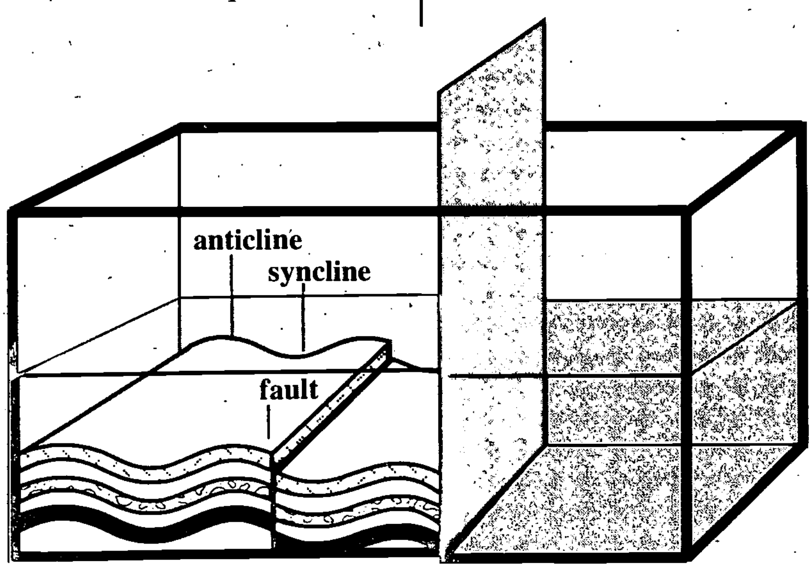
6. After the final layer has settled, have the students observe the results in their container and make a sketch showing the different layers. Explain that this represents the original rock at Hanging Rock State Park that formed in an ancient ocean about 800 million years ago. Draw their attention to the parallel layers and ask them why they think the layers are parallel and not tilted. (Answer: gravity and the even distribution of sediments in still water)

7. Using the aquarium as a demonstration, take a thin piece of plywood or similar material and place it through the layers to the bottom at one end of the aquarium.

8. Ask the students to predict what will happen to the horizontally-layered sediments as you push the plywood towards the other end. Have them write down their predictions. Explain that this will represent the compression of the earth's crust that occurred about 500 million years ago when the continental plates carrying North America and Africa collided.

9. Now slowly move the plywood, pushing and compressing the layers of sand and clay. By doing this you are changing the position of the layered soil that was deposited in the still water of the aquarium. This change in position of the sediments can be used to represent the rocks in the earth that are folded, faulted and changed by movement in the crust.

10. Have the students draw a sketch and write about the results of this compression. If desired, they can use the diagrams in the Student's Information to help them label and interpret the new geological formations.



11. Discuss the accuracy of their predictions. Review major events in the park's geological history. Discuss: During our up-coming visit to the park, what clues will we look for that will tell us more about these events? (Sediments in rock, layers in rock, cross-bedding, tilting or folding of rock layers)

Assessment:

Discuss the following questions, or ask your students to write/sketch their answers on paper.

- How do sedimentary rocks form in nature? (Here's one possibility: Sediments, soils or rock fragments are carried by wind or water and deposited in layers. As the layers accumulate, the pressure caused by the weight of the upper layers compresses the lower layers into rock.)

- Which layer is the oldest? (the bottom layer)

- Which layer is the youngest? (the top layer)

- Describe what can happen if the earth's crust is compressed after the sediments are deposited.

(Layers will be folded, tilted or faulted. See diagrams in Student's Information.)

OPTION B:

1. Have each student label a cup with their name.

2. Prepare one color of gelatin, following directions on the package. Allow mixture to cool slightly and spoon some into each student's cup. The teacher should also pour a thin layer into a glass cake pan for class demonstration use.

3. Have the students date the layer (today's date) on the cup. Tell the students that today, the winds or water currents are moving from east to west. Each student should place licorice strings (or similar item) on top of the gelatin in an east-west orientation. The licorice strings represent the orientation of the various sediments in the rock. **Note: Do not include licorice strings in the class demonstration model.**

4. Refrigerate the first layer overnight. Note: If the gelatin layers are kept fresh by covering cups with plastic wrap each time, students may enjoy eating the end results!

5. Repeat the procedure of preparing another package of gelatin—this time with a different color. Spoon some into each student's cup, on top of the first layer. Pour a thin layer on top of the first layer in the class demonstration model also.

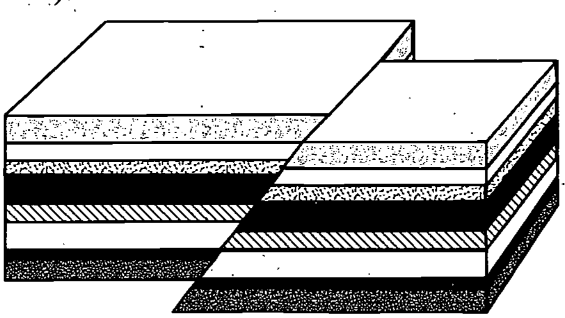
6. Have the students date the new layer as well (with appropriate date). Tell the students that today the winds or water currents are moving from the north to the south. Therefore, they should place their licorice strings on the gelatin in a north-south orientation. **Note: Omit the licorice strings in the class demonstration model.**

7. Repeat steps 5 & 6 for several days.

8. After 4 to 5 days, the students will have several layers in place and should be able to understand that layering requires a great deal of time. They should also be able to observe that different layers are oriented in different directions to one another, depending on the direction of the wind or water currents during their formation.

9. Have the students draw and explain their results in writing (comparing class time with geological time). Discuss how this model of sedimentary rock formation is similar to what geologists think actually happens in nature. Remind students that geologists think the original rocks at Hanging Rock State Park were formed under an ancient sea between 500 and 800 million years ago.

10. Ask students to predict: What would happen if the layers are compressed or tilted <u>after</u> they set up? The teacher can now use the class demonstration model to show the results of crustal movements. One suggestion is to use a spatula to cut a large block of the layered gelatin and place it on poster paper or other heavy paper. Push on both ends of the paper to illustrate what happens to rock layers when they are arched upwards. Geologists think something like this may have occurred to form the Sauratown Mountains. (Geologists call this large arch of rock the Sauratown Mountain Anticlinorium.) Faulting and thrusting can also be demonstrated by cutting the layered gelatin into two blocks and placing one block on top of the other so that older layers from the top block cover younger layers in the bottom block.



Fault - rock layers slide along a break

See the diagrams on the Student's Information page for other ideas.

Assessment:

Discuss the following questions, or ask your students to write/sketch their answers on paper.

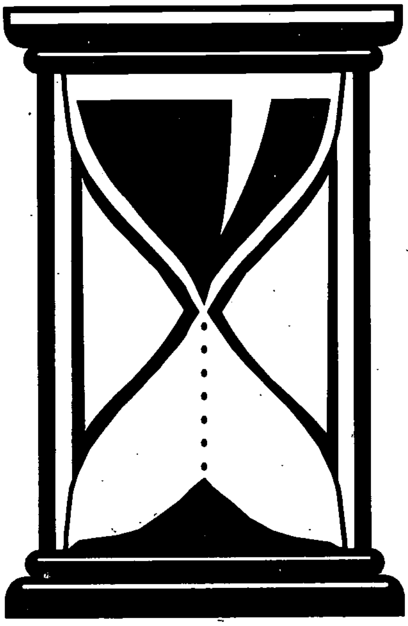
• How does the time required for the gelatin layering compare to the geological time required for the layering of sedimentary rock? (One day could represent 50 to 100 million years.)

• Which layer is the oldest? (The bottom layer)

• Which is the youngest? (The top layer)

• Why can an older layer of rock sometimes be found on top of a younger layer? (During faulting and thrusting, one rock unit may be pushed up and over another.)

• What causes cross-bedding? (Wind or water currents deposit the sediment in layers. If the wind or water shifts direction, the sediments in one layer may be oriented differently than the sediments in another layer. This happens in sand dunes and also near the shore of an ocean or large lake.)



Student's Information

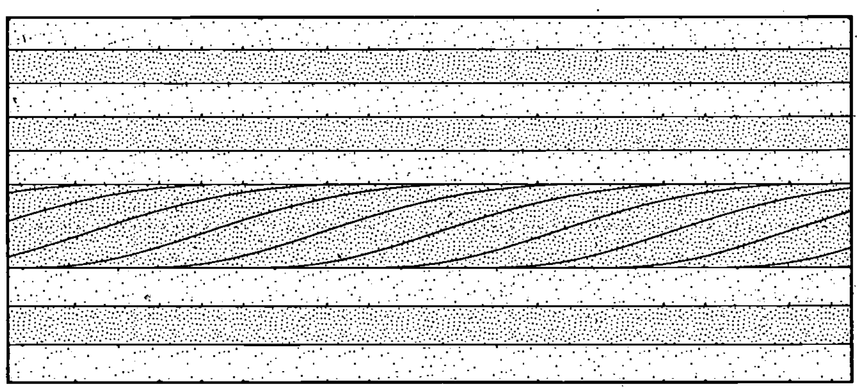
Geologists think that the rocks of the **Sauratown Mountain** area, including Hanging Rock State Park, originated in an ancient sea about 800 million years ago. What evidence would lead them to this conclusion? The most common rock in the park is called **quartzite**, a type of metamorphosed **sandstone**. Sandstone typically forms underwater, usually near the shore in a beach environment. By observing the **sediments** and layers in the rocks at the park, geologists have evidence for an ancient sea that existed before the time of the dinosaurs!

You can make a model of a **sedimentary rock** like sandstone by depositing layers of sediment, one at a time, into a container filled with water. Of course, your sediments will not actually make a rock. In nature, as more and more layers are deposited, the bottom layers are crushed by the weight of the top layers. This pressure compacts and cements the sediments together and turns them into a rock. The sediments that formed the rock in the park were mostly made of **quartz sand**. Sediments in other sedimentary rocks may be clay, silt, pebbles or even volcanic ash.

If you were outdoors observing a large section of sedimentary rock, which layer would be the oldest? The one on the bottom would usually be the oldest. If you chose one layer within the rock, it would be older than the layer above it, but younger than the layer below it. Sometimes large units of rock are thrust up and over other rocks. When this happens, older layers can be pushed on top of younger layers. Geologists look for evidence of thrusting before deciding on the age of a rock layer.

Some sedimentary rocks contain the **fossils** of animals and plants that were trapped in the sediments. Geologists can use these fossils to estimate the age of the rock. Rarely, fossils can be seen in sedimentary rocks that have been slightly metamorphosed. Unfortunately, no fossils have been found in the **metamorphic rocks** at the park.

Sometimes, the sediments or particles in one layer may be oriented differently than those in the layer above or below it. This is called **cross-bedding.** It happens when wind or water currents change direction as sediments are being laid down. Demonstrate this by holding your right hand in front of you with fingers together and palm down. Your fingers should be pointing straight ahead of you, indicating the direction of the water currents that deposited the sediments in this right-hand "layer." Now place your left hand across your right hand to form a cross.



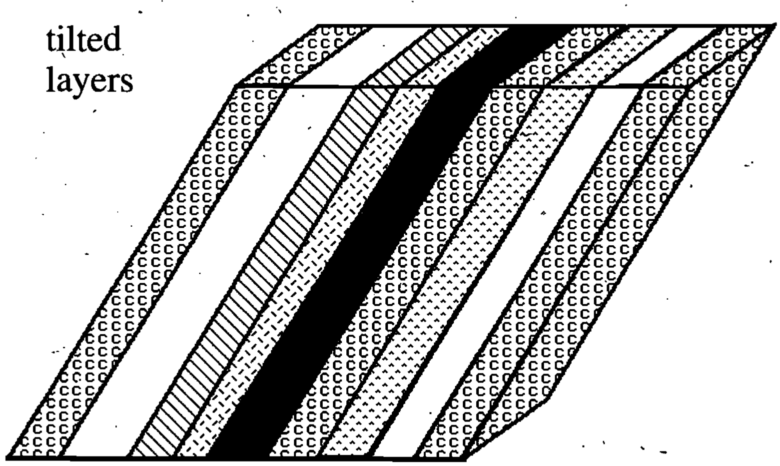
Cross-bedding in weathered quartzite located off the trail below the Hanging Rock

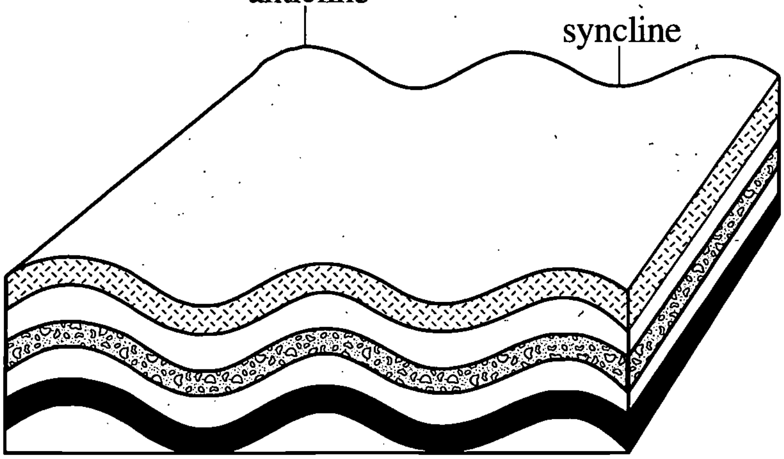
The fingers in your left hand will be pointing to the right, indicating a different current direction than in the "layer" below. The make-believe sediments in your left-hand "layer" are lined up at right angles to the sediments in your right-hand "layer."

If you deposit sediments in a container, you will notice that the layers are parallel to each other and to the bottom surface. However, if you visit Hanging Rock State Park, you will see rock layers that are folded or tilted at different angles. What could this mean?

Tilted or folded layers indicate that the earth's crust moved <u>after</u> the layers were deposited. Geologists think this movement could have occurred during several mountain-building periods beginning nearly 500 million years ago. Study the diagrams on this page to discover how rock layers moved as the Sauratowns Mountains were formed.

The heat and pressure during mountain building caused the original sandstone rocks to recrystallize into a hard metamorphic rock called quartzite. During metamorphosis, the layers and cross-bedding in the original sandstone were preserved. When you visit the park, you will see the quartzite and you can learn about the park's geological story by observing the rock layers. Sorry, you won't actually see the ancient ocean. You're about 500 million years too late!





folded layers

Pre-Visit Activity #3 "A Rock Called Sandstone"

Major Concept:
- Lithification
- Sedimentary rock characteristics
- Sedimentary rock formation

Learning Skills:
- Observing, communicating, defining operationally
- Writing observations and inferences; comparing and contrasting

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

Location: Classroom

Group Size: 30 students

Estimated Time:
Initial procedure 20-30 minutes. Drying time - minimum of one week.

Appropriate Season: Any

Materials:
Provided by the educator:
Per student: One copy of Student's Information and worksheet; magnifying glass (optional)
Per group: Canary grit. Epsom salt, 2 paper cups, water, popsicle sticks (for stirring), large chunks of gravel. *sandstone sample, pie plate or heavy sheet of paper

*Note: The North Carolina Rock Kit, given to each public school by NC Geological Survey, contains several specimens of sandstone.

Credits:
Elementary Science Discovery Lessons – The Earth Sciences, 1973 (See Reference section.)

Objectives:
- Compare sandstone made in the laboratory with natural sandstone; list similarities and differences between the two samples.
- Write a paragraph explaining how sedimentary rocks are formed.

Educator's Information:

When you visit Hanging Rock State Park, you will notice the mountainous terrain. Geologists speculate that the rocks composing the **Sauratown Mountains** were actually formed near the shore in an ancient ocean (called the **Iapetus Sea**) between 800 and 500 million years ago. Since the **sediment** that formed the rocks was primarily quartz **sand**, the resulting **sedimentary rock** is called **sandstone**. The transformation of loose sediments into a hard rock is called **lithification**. This occurs when the weight of many sediment layers compacts the lower layers into a rock. Or, in some cases, soluble materials such as silica (**quartz**), calcite, or iron oxides precipitate out of the water, filling the spaces between sediment grains and cementing these grains together.

About 500 million years ago, crustal movements caused the original sandstones to become deeply buried, folded and faulted. The resulting heat and pressure recrystallized the rock so that the sandstone metamorphosed to **quartzite**, which you can see in the park today. Later, the quartzite was thrust upwards during the final episode of mountain building.

In the previous pre-visit activity, the process of rock formation was emphasized. In this activity, the components of rock formation are the focus. Your students will simulate the formation of sandstone using a mixture of canary grit, Epsom salts and water. The canary grit represents sand and other sediments deposited in the ocean. The Epsom salts and water represent salt water, complete with its mineral components. Your students will compare and contrast real sandstone with the material they create.

Instructions:
Review the Student's Information and worksheet

with your students before beginning this activity. Following steps 1-9 below, the students should work in small groups of two or three in order to create the sandstone. Each student should complete his or her own worksheet.

1. Place one inch of canary grit into a paper cup.

2. Add about 1/2 inch of Epsom salt.

3. Add enough water to rise 1/4" to 1/2" above the grit/salt surface. Adding too much water will increase drying time significantly. (You want the consistency of thick soup.)

4. Take turns and stir the mixture well! (The object is to dissolve as much Epsom salt as possible.)

5. Fill the second cup with gravel and put this cup on top of the salt/grit/water mixture to add pressure.

6. Place the cups where they will be undisturbed for one week allowing the mixture time to set up and begin drying out. Hint: Put the cups close to a heat source or on a sunny window sill to speed up drying time.

7. Remove the top cup with the gravel so that additional air can reach the sand mixture. Again leave it undisturbed for one week to continue drying out. Hint: If an oven is available, you can try to dry the homemade sandstone by placing it in an oven at 250° for 2-3 hours. Use caution – place the paper cups on a cookie sheet and monitor carefully!

8. Carefully tear the paper cup away from the sand mixture and place the "chunk" gently (without breaking it apart) on a pie plate or heavy sheet of paper. Again, place the "chunk" where it will be undisturbed and allow it to dry out completely. (It takes time for evaporation of salt water to occur.)

9. Compare the homemade sandstone with sand and also with real sandstone. Complete the worksheet.

Assessment:

Check student worksheets for completeness and accuracy of observations. Then discuss the following, or ask students to write their answers on paper:

Observe the homemade sandstone with a magnifying glass. Observe sand (canary grit) with a magnifying glass. How are they different? Alike? Where is the salt? What holds the "rock" together? (The homemade rock is composed of sand held together by an Epsom salt "cement" that crystallized around the particles.)

How is the process that you used to make sandstone similar to the process that occurs in nature? How is it different? (In nature and in the classroom, sand is deposited in water and settles to the bottom. Then minerals in the sea water and the silica in the sand work to "glue" the particles together to make a rock. In nature, the process takes millions of years while your homemade rock was made in only a week or two. The pressure on the sediments is much greater in nature than in the classroom.)

Which is harder, the homemade sandstone or the natural sandstone? Why is it harder? (Pressure helps make natural sandstone stronger by pressing the sand grains closer together.)

Modification:

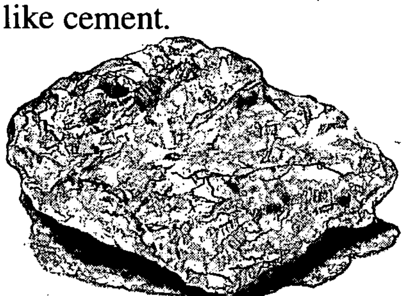
If your school has the *Mineral and Rock Kit Guide* by Mary Watson of the NC Geological Survey, refer to pages 51 and 52 for similar activities on making sandstone in the classroom. (A copy of this guide should be located in the North Carolina Rock Kit.)

Quartz

Student's Information

By studying the **rocks** at Hanging Rock State Park, geologists find clues to their origins. The rocks may have formed under a shallow sea, called the **Iapetus Sea**, about 800 million years ago. Note: The Iapetus Sea started to close about 500 million years ago as the **crustal plates** carrying Africa and North America moved closer together. About 200 million years ago, when Africa and North American began to drift apart again, the Atlantic Ocean formed.

Quartzite (metamorphosed sandstone) is the major kind of rock found in the park today. The "parent" rock to the quartzite was **sandstone**, a **sedimentary rock** formed when layers of sand were deposited under the ancient Iapetus Sea. The weight of water and sediments above squeezed the sand grains close together. Minerals, which were dissolved in the trapped sea water, precipitated out and crystallized around the sand grains, gluing them together like cement.



Quartzite

The area around Hanging Rock State Park is one of the few places in the world where you can find "flexible sandstone" or **itacolumite**. (Actually, itacolumite is not a true sandstone, but a special form of weathered quartzite.) Pieces of this rock can actually bend a little bit! As the itacolumite weathers, the interlocking grains of mica and quartz in the rock are loosened. The grains can then slide over each other like the pages in a large phone book. The flexible mica grains allow the rock to bend a little without breaking.

In this activity, you are going to make homemade sandstone using canary grit, Epsom salts and water. After you mix up the grit, salts and water, you will put the mixture in a paper cup and compress it with a cup filled with rocks. In about three weeks, you will have a piece of homemade sandstone. The canary grit represents the sandy sediments that were deposited in the Iapetus Sea. The mixture of water and Epsom salts is similar to the saltwater that filled the Iapetus Sea. The cup filled with rocks that compresses the grit mixture represents the weight of water and sediments that compressed the layers below them. The three weeks that it will take for all the water to evaporate represents the millions of years that it took for the layers to become cemented together to finally form a rock under the Iapetus Sea.

After you make your homemade sandstone, you will observe it very carefully and compare it to real sandstone. The chart on the worksheet will help you organize your observations. When you have completed the worksheet, it is time to use your imagination. Write a paragraph answering the questions below on the back of this paper. If you have time, draw a picture of yourself as a piece of sand in a chunk of sandstone.

- Imagine that you are a grain of sand in a piece of sandstone. Where did you come from?
- What is your name?
- How did you get here from where you started?
- What forces made you into a piece of sand?
- What forces helped you become part of the piece of sandstone?
- How old are you?
- Where do you think you might go next?

A Rock Called Sandstone - Worksheet

Student's Name: ______________________________ Date:__________

My drawing of homemade sandstone: **My drawing of natural sandstone:**

How are natural and homemade sandstone alike? different?

<u>Similarities</u>:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

<u>Differences</u>:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

In a short paragraph, compare real sandstone with your homemade sandstone.

A Rock Called Sandstone - Answer Sheet

Student's name: ______________________________ Date:__________

My drawing of homemade sandstone:

Sketches will vary depending on materials used.

My drawing of natural sandstone:

Sketches will vary depending on specimens used.

How are natural and homemade sandstone alike? different?

Similarities:

1. Both are light in color.
2. Both are brittle.
3. Both result in sand when crumbled.
4. Both were created with pressure.

Differences:

1. Natural sandstone displays layers.
2. Natural sandstone is not as brittle as homemade sandstone.
3. Natural sandstone seems to break off in layers. Homemade does not.
4. Particles in homemade sandstone will probably be larger.

In a short paragraph, compare real sandstone with your homemade sandstone.

Sandstone is a rock made up of sand grains cemented together. The sand is deposited in layers over time by water. As the layers increase, pressure from their weight pushes the sand grains together. As the water evaporates over time, minerals crystallize and cement the layers together. The homemade sandstone is also made up of sand. Like real sandstone, the grains of the homemade sandstone were deposited in water, which eventually evaporated leaving only the minerals behind. However, the time and pressure required to make real sandstone are incredible. The short time and little pressure resulted in a product that is much softer and more brittle. Also, the homemade sandstone did not form in layers like real sandstone.

Major Concepts:
- Metamorphic Rocks
- Sedimentary Rocks

Learning Skills:
- Observing, communicating, using models
- Writing observations; comparing and contrasting

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

Location: Classroom

Group Size: Approximately 30 students with teacher

Estimated Time: 30 minutes (plus firing time in a kiln)

Appropriate Season: Any

Materials:
Per class: Ceramic greenware (dry clay), access to a kiln, 3 samples of sandstone, 3 samples of quartzite*
Per student: One copy of Student's Information and worksheet

*Note: The North Carolina Rock Kit, given to each public school by the NC Geological Survey, contains several specimens of sandstone. The park can loan you specimens of quartzite.

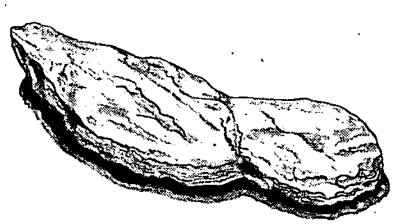
Credits:
Elementary Science Discovery Lessons - The Earth Sciences (See References section.)

Objectives:

- Compare greenware (dried clay) with bisque (fired clay) by listing at least two differences and two similarities.
- Write a short paragraph explaining how firing clay in a kiln is similar to the process by which sandstone metamorphoses to quartzite.

Educator's Information:

By firing greenware in a kiln to make bisque, your students will gain a greater appreciation of how some **metamorphic rocks** are formed. The process of greenware changing to bisque in a kiln is analogous to the process by which **sandstone** changes to **quartzite** deep in the earth's crust. The time, heat and pressure required to naturally produce metamorphic rocks are almost incomprehensible on a human scale. However, using the greenware analogy, your students should understand that rocks are recrystallized, not melted, during metamorphism.



mica schist

Here's how sandstone may have been changed to the quartzite that you can see in the park today. Geologists think that about 500 million years ago, the **tectonic plates** carrying North America and Africa began to move towards each other. As the **Iapetus Sea** closed, the resulting heat and pressure caused the sandstones created under deep burial beneath this sea to **recrystallize** – the quartz crystals in the sandstone enlarged and grew together to create a new rock, called quartzite. Recrystallization is not the same as melting. (If a rock completely liquifies and then solidifies, it would be classified as an **igneous rock**, not a metamorphic rock.) Recrystallization could be as simple as a change in texture or as complex as a rearrangement of ions resulting in new **minerals**.

Metamorphic rocks often have complicated geologic histories. The rocks in the **Sauratown Mountains** have undergone several periods of metamorphism. A rock that originally formed under medium or high temperatures and pressures could have been subject to lower temperatures and pressures at a later time. Although the basic elements in this rock did not change, the minerals in the rock resulting from these two metamorphic events could be quite different. Geologists study metamorphic rocks under the microscope and use other lab tests to try to unravel the complex histories of these rocks.

Instructions:

1. Students should observe the greenware and record observations on their worksheets.

2. Using a pen, each student should carefully carve his/her name in his/her piece of greenware.

3. Fire the greenware samples in a kiln.

4. Have the students observe the samples (now called bisque) and record observations on their worksheets.

5. Ask the students to share the samples of sandstone and quartzite. Students should record their observations on the worksheets.

6. Ask students to write a paragraph explaining how the firing of greenware to make bisque is similar to the metamorphic process that transforms sandstone into quartzite.

Assessment:

Check the students' worksheets for accuracy of observations and thoroughness of comparisons. Then discuss:

What did heat do to the greenware? (Heat changed greenware to bisque.)

How are greenware and bisque similar? (Both were originally mud.) Different? (Greenware is soft, brittle, grayish white. Bisque is harder, more resistant to scratching, and white.)

How are sandstone and greenware similar? (Greenware and sandstone are both soft and brittle.)

How are bisque and quartzite similar? (Bisque and quartzite are both hard and resistant to scratching. Quartzite formed from sandstone as the bisque formed from greenware.)

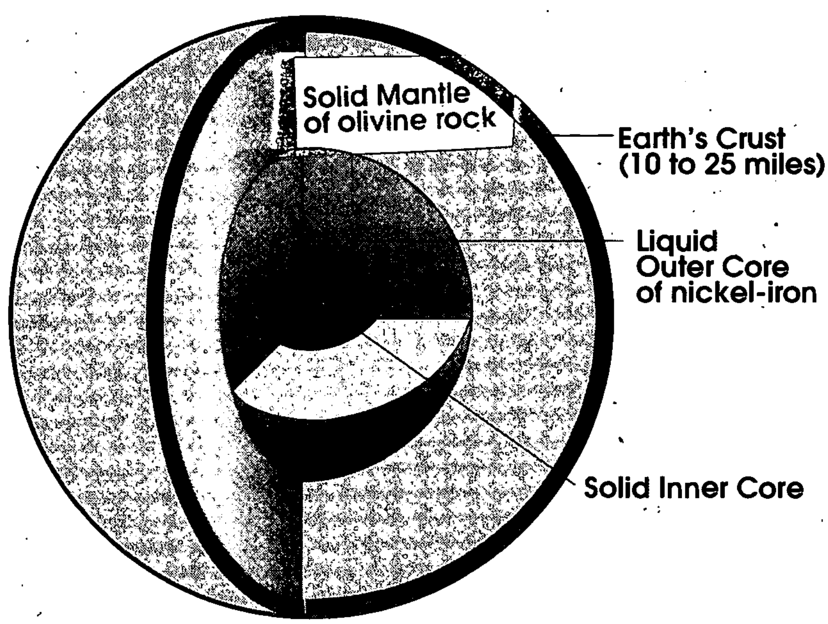
What is the relationship between sandstone and quartzite? (Sandstone is a sedimentary rock; quartzite is metamorphic. Quartzite is formed from sandstone by heat and pressure.)

What is metamorphic rock? (Metamorphic rock occurs when one rock changes into another due to heat and/or pressure.)

Extension:

1. Measure mass and/or volume of the greenware before and after firing in the kiln.

2. If samples of other metamorphic rocks, such as schist and gneiss are available, ask the students to compare quartzite with these rocks. (Some of these rocks can be seen in the exhibit hall at the park's visitor center.) Discuss the parent rocks and metamorphic conditions that were necessary to create these different metamorphic rocks. By studying the minerals in the



rocks, geologists have evidence that the rocks in the Sauratowns were metamorphosed under low to medium temperatures and pressures. In the following chart, *foliated* refers to a rock in which the mineral grains are aligned in a particular direction. Note that gneiss, metagraywacke and schist can be found throughout the Sauratown Mountains, while marble is rare, but present.

Metamorphic Rocks Found in the Sauratown Mountains

Metamorphic Rock Name	Description	Possible Protolith or Parent Rock
Quartzite	Nonfoliated to foliated	Sandstone (sedimentary rock with large amounts of quartz)
Metagraywacke	Weakly foliated	Graywacke - "dirty" sandstone (contains some clay, but still has lots of quartz)
Marble	Nonfoliated; fizzes with acid	Limestone (sedimentary rock)
Schist	Foliated; can often see abundant flakes of mica in the rock	Shale or similar sedimentary rocks with large amounts of clay
Gneiss	Foliated; rock has a banded appearance and is usually more coarse-grained than schist; more quartz and feldspar than mica	Granitic gneiss comes from granite, an igneous rock. (Other types of gneiss come from other igneous rocks, sedimentary rocks, and even metamorphic rocks.)

Student's Information

Metamorphosis means a transformation, a marked change in appearance or condition. Think of a caterpillar changing, or metamorphosing into a butterfly. Or, think of a snowball. To make a snowball you scoop up some fresh, soft, fluffy snow. Then the heat and pressure from your hands changes it into a hard, icy snowball.

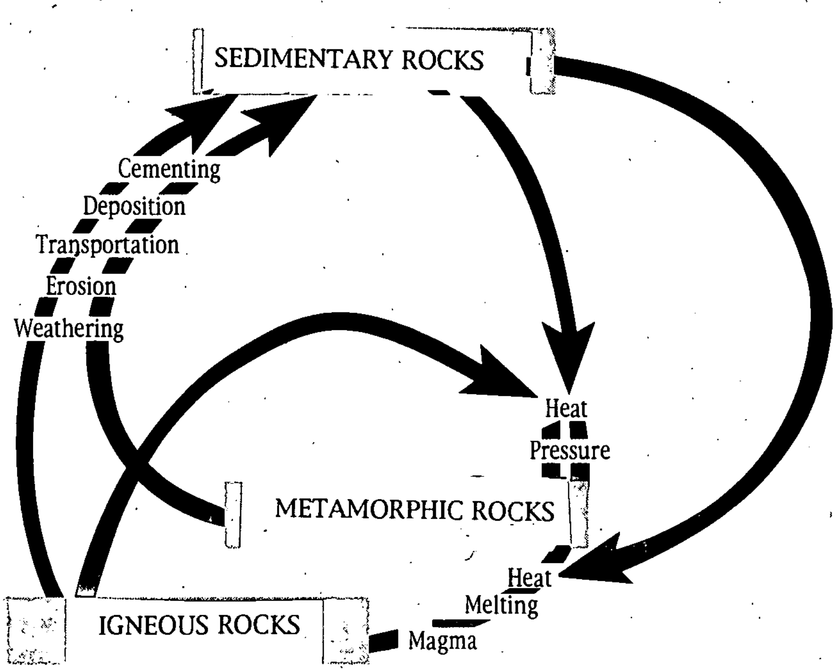
Metamorphic rock is rock which has been changed by heat and/or pressure, often over a long period of time. The original rock, sometimes called the parent rock, may have been an **igneous rock**, a **sedimentary rock** or even another metamorphic rock. The same rock will look different, depending on the amount of heat and pressure that it experiences. For example, the sedimentary rock called shale will become slate if it is exposed to low temperatures and pressures. However if the shale is exposed to higher temperatures and pressures, it will become another kind of metamorphic rock called **schist**.

The metamorphic rock found at Hanging Rock State Park is **quartzite**. Quartzite is a type of rock which formed from **sandstone**, a sedimentary rock. Sandstone is made of **quartz sand** and is relatively brittle. Over millions of years, the sandstone became deeply buried. The heat and pressure from within the earth's crust caused the sandstone to change, or metamorphose, into quartzite. Most of the outcrops and large rock formations that you will see at Hanging Rock are quartzite.

But what actually happened to the sandstone to change it into quartzite? The sandstone did not melt. At higher temperatures, the sandstone **recrystallized** – the quartz crystals in the rock enlarged and grew together. This resulted in a whole new texture and also made the quartzite much stronger than the original sandstone.

In this activity, you will use a kind of clay called ceramic greenware. Clay is basically mud, just like the sediments that make up many sedimentary rocks. The clay will be heated in a special oven called a kiln. After it is heated for a while, it will recrystallize into bisque, a kind of pottery. The bisque will have a different texture and appearance than the original greenware. This process is similar to sandstone changing into quartzite.

Rock Cycle



For A Change - Worksheet

Student's name: ______________________________ Date: ____________

Greenware characteristics:

Is it brittle? _____

Does it break easily in your hands? ______

Can you scratch it with a fingernail? _____

Color: _______________

Other characteristics: _________________

____

Bisque characteristics:

Is it brittle? _____

Does it break easily in your hands? ______

Can you scratch it with a fingernail? _____

Color: _______________

Other characteristics:_________________

____

Sandstone characteristics:

Is it brittle? _____

Does it break easily in your hands? ______

Can you scratch it with a fingernail? _____

Color: _______________

Texture: _____________________

Other characteristics: _________________

____

Quartzite characteristics:

Is it brittle? _____

Does it break easily in your hands? ______

Can you scratch it with a fingernail? _____

Color: _______________

Texture: _____________________

Other characteristics:_________________

____

In a short paragraph, describe how firing clay in a kiln is similar to the process by which sandstone becomes quartzite, a metamorphic rock.

For A Change - Answer Sheet

Student's name: ______________________________________ Date:____________

greenware characteristics:

Is it brittle? yes
Does it break easily in your hands? yes
Can you scratch it with a fingernail? yes
Color: gray

bisque characteristics:

Is it brittle? no
Does it break easily in your hands? no
Can you scratch it with a fingernail? no
Color: white

sandstone characteristics:

Is it brittle? yes
Does it break easily in your hands? yes
Can you scratch it with a fingernail? yes
Color: depends on your sample
Texture: coarse, gritty
Other characteristics? Layers; dull luster

quartzite characteristics:

Is it brittle? no
Does it break easily in your hands? no
Can you scratch it with a fingernail? no
Color: depends on your sample
Texture: smooth, fine-grained
Other characteristics? Layers; sugary luster

In a short paragraph, describe how firing clay in a kiln is similar to the process by which sandstone becomes quartzite, a metamorphic rock.

Dried clay and sandstone are both examples of sedimentary rock; they formed from sediments under water. When clay is baked in a kiln, it recrystallizes and becomes much harder. When sandstone is placed under heat and/or intense pressure, the quartz crystals in the rock swell and interlock to create a much harder rock, called quartzite.

Pre-Visit Activity #5 "Shake It, Baby, Shake It"

Major Concepts:
- Weathering and erosion
- Mechanical and chemical weathering

Learning Skills:
- Observing, inferring, predicting
- Summarizing new facts, comparing information

Subject Areas:
- Science
- English Language Arts
- Mathematics (See Modification.)

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

Location: Classroom

Group Size: Class size of 30; divide into six groups of five students per group

Estimated Time: 45 minutes

Appropriate Season: Any

Materials:
Provided by the educator:
Per student: One copy of Student's Information (optional), worksheet, and pencil
Per group: Four small pieces of weathered quartzite, 4 small pieces of quartzite, quart-sized plastic jar with screw-type lid, water, paper, marker, worksheet

For the modification, you will also need a graduated cylinder for each group or another instrument to measure changes in mass.

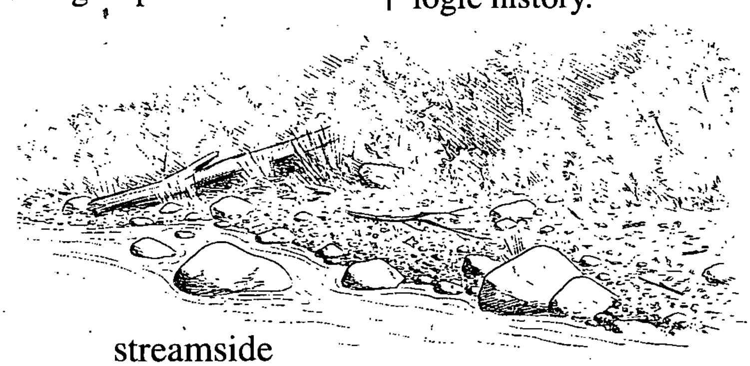
Note: For pieces of quartzite and weathered quartzite, call the park staff. As an option, purchase small rock specimens of various types from school supply catalogs.

Credits: *Elementary Science Discovery Lessons - The Earth Sciences*, and *Science is Elementary*, Museum Institute for Teaching Science. (See References section.)

Objectives:
- Define weathering and erosion.
- Give examples to show how water can be an agent of both weathering and erosion.
- Compare the effects of abrasion on weathered quartzite and quartzite in a simulated stream environment by listing observations for each rock and then writing a conclusion.

Educator's Information:
The previous activities in the Hanging Rock Environmental Education Learning Experience have focused on the early geologic history of the park. This activity will emphasize how **weathering** and **erosion** have created the landscape we find in the park today. This activity would be especially helpful as an introduction to the Geo-hike to the Upper Cascades (On-site Activity #2). In this on-site activity, students will explore firsthand, how water in Cascade Creek erodes the quartzite formations in the park.

In this simple experiment, your students will simulate how **rocks** are weathered and eroded by water. By comparing the effects of **abrasion** on both weathered quartzite and **quartzite**, they will find that quartzite is far more resistant to erosion than weathered quartzite. They will discover that quartzite must undergo a great deal of weathering before it can be eroded by water. See the Student's Information for a review of geologic history.


streamside

Important Note: In the Sauratowns, all the rocks are **metamorphic**. **Schist, gneiss** and **metagraywacke** are examples of metamorphic rocks that are more susceptible to weathering and erosion than quartzite. After millions of years of weathering and erosion, the quartzite was left behind to form the ridge line of the **Sauratown Mountains**. As an option, the teacher could purchase small samples of various types of rocks for this activity. Alter the Instructions to reflect the actual rocks used.

Read the Modification in this activity and, if you decide to use it, add the appropriate cues to the Instructions below.

Instructions:

Assemble the needed materials. Discuss the Student's Information with your students and assign them to work groups. Ask each student to fill out a worksheet to record his/her observations. Guide the groups through the exercise:

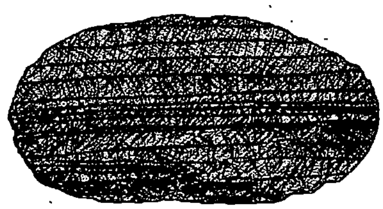
1. Examine both weathered quartzite and quartzite. (The weathered quartzite has been exposed to both water and air at the earth's surface for a very long time. It has a grainy texture similar to that of sandstone.) Predict which rock will be more resistant to erosion. What observations helped you make your predictions?

2. Place one piece of weathered quartzite on a sheet of paper labelled "0." This will serve as the control. Put the three remaining pieces of weathered quartzite in the plastic jar. Fill the jar half full of water, tighten the lid, and shake the container vigorously 300 times.

3. Remove one piece of weathered quartzite and place it on a sheet of paper labelled "300."

4. Ask a different group member to shake the container vigorously another 300 times. Remove a piece of weathered quartzite and place it on a sheet of paper labelled "600."

5. A third group member should repeat the procedure, shaking another 300 times, removing the last piece and putting it on a sheet of paper labelled "900."



stream rock

6. Compare the rocks on the four sheets of paper. Observe what is left in the jar of water.

7. Repeat steps 2-6 with pieces of quartzite (and other kinds of rocks if desired).

8. Each student should compare the results for weathered quartzite and quartzite by sketching rock fragments on his or her worksheet.

Assessment:

Discuss the following questions with your students, or ask them to write their answers on paper.

After completing the worksheet comparing the changes in weathered quartzite and quartzite, which is more resistant to weathering and erosion? Why? (Quartzite showed the least amount of change; it is a very hard rock; mineral grains interlock. During weathering, the boundaries between the quartz grains and other mineral grains in the quartzite were gradually loosened. This process weakened the rock, making it more susceptible to erosion by water.)

Predict what will happen to the weathered quartzite and quartzite after several thousand shakes. (Weathered quartzite will break down into smaller sand grains. Quartzite will not change very much.)

How do rocks shaken in a jar compare to rocks from a stream? (Rocks carried in a stream bang against each other like those shaken in a jar.)

What is erosion? (Carrying away of rock fragments and soil)

Can rain cause erosion? Can streams? (Yes to both. Rain carries away debris as it runs down hill. This activity simulates what is happening in the Dan River and its tributaries, such as Cascade Creek.)

What is weathering? (Breaking up of rocks)

How can water cause weathering? (Water can weather rocks mechanically or chemically. Mechanically: Water can wear away rocks, or it can break rocks into pieces during freezing and thawing. Chemically: Water can react with minerals in the rock to form new compounds. Over time, chemical changes can dissolve the rock.)

What is left in the jar of water after shaking the weathered quartzite? (Quartz sand. Quartz is more resistant to weathering than other minerals that may be present in the rock.)

How does this activity help explain why the Sauratown Mountains look like they do today? (Erosion has removed the softer rocks to expose the more resistant quartzite. Quartzite must be exposed to water and air at the earth's surface for a long time before it can be eroded away. This erosion-resistant quartzite forms the peaks and ridges of Hanging Rock, Cook's Wall, Moore's Knob, and Pilot Mountain.)

Modification:

You can add math and measurement practice to this activity by asking students to find the volume of each rock piece. The volume of each piece should be measured at the beginning of the experiment, after 300 shakes, after 600 shakes, and finally at the end of the experiment. Volume can be measured by using the water displacement method with a graduated cylinder. Fill the cylinder part way with water and take a reading. (This is the "volume of water only.") Drop in the rock piece and take another reading. (This is the "volume of water plus rock.") Subtract the "volume of water only" from the "volume of water plus rock" to find the volume of the rock. You can ask the students to graph their results or do further calculations, such as finding the percent change in volume after 900 shakes, or determining the mean, median and mode of class data.

rock overhang

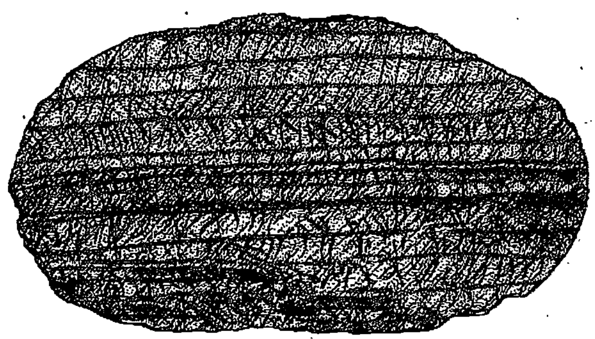
Student's Information

You have already learned how geologists think the rocks of Hanging Rock State Park were formed. Remember that over 800 million years ago, the original rocks (**sandstone**) were deposited under water. Later, most of these **sedimentary rocks** were deeply buried and transformed by heat and pressure into **quartzite**, a **metamorphic rock**. Next, uplift and movement of the earth's crust created mountains, which may have been as high as the Rocky Mountains are today. Finally, millions of years of **weathering** and **erosion** wore down the mountains to their current heights.

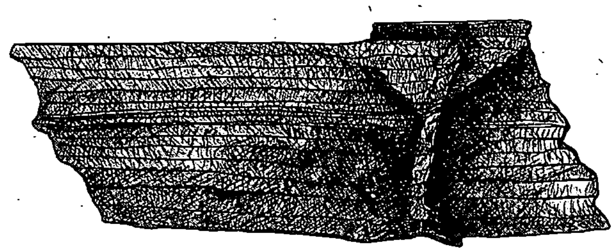
The forces of weathering and erosion are still at work in the **Sauratown Mountains** today. In the warm, humid climate of North Carolina, water is the most powerful agent of weathering and erosion. Water can weather rocks in two different ways: mechanically and chemically. First, weathering processes break down all kinds of rock into smaller pieces. In **chemical weathering**, minerals in the rock react with water or air to form new compounds. Over time, this process can dissolve rocks. In **mechanical weathering**, the rock simply breaks into smaller pieces, but is not chemically changed. One way that water can mechanically break a rock is through the freezing and thawing cycle. When water invades cracks or pores in a rock and later freezes and expands, the pressure may break off pieces of rock. This is called **ice wedging**.

Quartzite is very resistant to weathering. However, over long periods of exposure to water and air at the earth's surface, the boundaries between the interlocking mineral grains become loosened. The rock begins to soften and crumble. (At this point, the weathered quartzite resembles its "parent rock," sandstone.) Then, erosion occurs when wind, water, ice and snow carry these **sediments** away.

In this activity, you will simulate mechanical weathering and erosion by placing rocks into a jar of water and shaking it. This activity will help you determine what kinds of rocks are more resistant to weathering and erosion. You will discover how the weathering process continues as rocks are moved around by streams and rivers. Get ready to "shake it, baby, shake it"!



stream rock with rounded edges due to abrasion



freshly-broken rock showing sharp edges

Shake It, Baby, Shake It - Worksheet

Name: ______________________________ Date ____________

Weathered Quartzite results: (Draw results and write a short description for each rock.)

0

300

600

900

Quartzite results: (Draw results and write a short description for each rock.)

0

300

600

900

Which rock is more resistant to weathering and erosion? Why? ____________________

____

Shake It, Baby, Shake it - Answer Sheet

Weathered Quartzite results: (Draw results and write a short description for each rock.)

Note: The function of sketching is to get students to observe each specimen more carefully.

0	coarse feeling edges are fine layers
300	rock appears smaller than the one at "0"
600	rock is smaller and edges are beginning to round off
900	rounded edges; layers still obvious; much smaller

Quartzite results: (Draw results and write a short description for each rock.)

0	smooth - not grainy; layers; appears broken at right angles
300	no change from piece at "0"
600	no change
900	no change

Which rock is more resistant to weathering and erosion? Why? Quartzite; it was not changed by this activity, while the pieces of weathered quartzite became smaller as the activity progressed.

On-Site Activity #1 "Erosion of a Mountain"

Major Concepts:
- Erosion
- Change over geologic time

Learning Skills:
- Observing, communicating, formulating models
- Recording and comparing information, drawing conclusions, expressing opinions & ideas
- Measuring heights

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

Location: Park Lake - Beach

Group Size:
Approximately 30 students, divided into three groups with an adult supervising each group.

Estimated Time: 45 minutes

Appropriate Season: Any

Materials:
Provided by the educator:
Per class: (Optional) camera or camcorder
Per student: Worksheet and pencil
Provided by the park:
Per group: Quartzite rocks (large & medium sizes), sand (on location–beach), water, watering can (or hose), shovel, meter stick

Credits:
Elementary Science Discovery Lessons - The Earth Sciences. (See References.)

Special Considerations:
Students should stay with their group leaders – away from the water! Remind students that the lake is open for swimming only from June 1 - Labor Day.

Objectives:
- Participate in a group to create a model representing the Sauratown Mountains 300 to 400 million years ago, then simulate the effects of erosion by pouring water on the model.
- Record significant changes in the model by measuring, writing notes or sketching. (Also measure, in centimeters, the highest point on the model after each erosion event.)
- Based on the experiences with the model, write a paragraph describing the geologic history of the Sauratown Mountains, beginning 350 million years ago and continuing 150 million years into the future.

Educator's Information:

In this activity, your students will gain a sense of how landforms change over **geologic time** by constructing a model representing the **Sauratown Mountains** approximately 300 to 400 million years ago. At that time, geologists think the range was as least as high as the Rocky Mountains are today. In general, softer, more recent **rocks** were closer to the surface, while older, metamorphosed rocks were at the core. Using a watering can or hose, your students will simulate hundreds of millions of years of **erosion** in only a few minutes. Throughout the demonstration, the students will stop at designated times to sketch the changes in the appearance of the model and measure heights. They will use their experiences with the model to explain the geologic history of the Sauratowns.

Note: No answer sheet has been prepared for the worksheet, as student models and simulated erosion techniques will vary considerably. Focus on the students' abilities to participate in the model-making process as well as their abilities to make careful observations and arrive at logical conclusions based on observations.

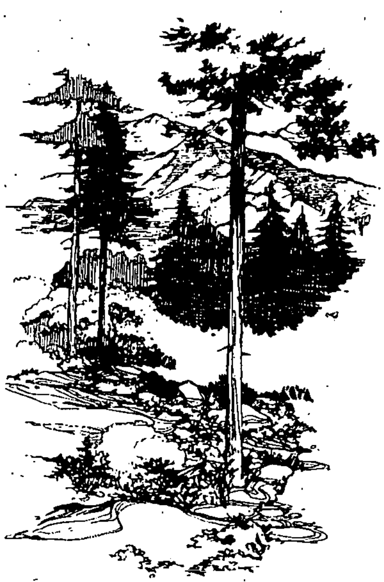
Instructions:
Before coming to the park, the teacher may wish to use the Student's Information from Pre-visit Activity #5 to familiarize the students with the terms,

weathering and erosion.

1. Divide the class into three groups and ask them to sit along the stone divider or on the timbers at Park Lake.

2. Prepare the students for this activity by describing the process of making a geologic model of the Sauratowns. Here's a sample script:

Sometimes, geologists use models to help them understand the **geologic processes** that shape the landscape over long periods of time. You will be working in your groups to construct a model representing the Sauratown Mountains 300 to 400 million years ago. At that time, geologists think the mountains were much



higher – perhaps higher than the Rocky Mountains are today. In general, the rocks closer to the surface of these mountains were softer, more recent rocks. The rocks in the core of the mountains were harder, highly metamorphosed rocks.

Keeping this in mind, build your model of the Sauratowns by using the quartzite rock pieces to form the core of your mountain range. Don't forget about layering; you want your model to be as realistic as possible. Then cover the quartzite with lots of sand to represent the softer rocks near the surface. Hint: If you have ever seen the Rocky Mountains, or other recently formed mountains, you know they have sharp peaks and do not look as rounded as older mountains. Remember to work together as a group to make your model; be sure to ask everyone for ideas.

Once you have completed your model, group members should take turns simulating water erosion by pouring water on the model with a watering can or hose. Your adult leader will ask you to stop at various times in the demonstration to take notes on your worksheet. You will also be asked to measure the height, in centimeters, of the highest peak in your mountain range. Take turns so that everyone in the group gets to do something. Later, you will use your experiences with the model to try to explain why the Sauratown Mountains look as they do today. You will also predict how they might look millions of years in the future.

3. Pass out the worksheets and pencils. Students should work on their models in the areas designated by the park staff. If group materials are not already in place at the designated sites, have students carry the equipment for their group to their site.

4. Once each group has finished its model, the students should individually make a sketch in the space marked "Beginning" on their worksheets. One or two group members should use the meter stick to measure, in centimeters, the highest point on their model. Students should record this on the worksheets under "Beginning."

5. Have one or two students in each group create "rain" on the mountain by using the watering can or hose. The adult leader should stop them when they have exposed less than 20% of the quartzite rock pieces in their model. Students will now sketch the result under Stop 1 on their worksheets. They will also measure the highest point on their model and record it under Stop 1.

6. Different group member(s) should continue the erosion process by pouring more water on the

model. The adult leader should stop them when about 50-75% of the quartzite has been exposed. Students should draw the result under Stop 2 on their worksheets. They should compare the model at this stage with Moore's Knob, which is located just across the lake from this activity location. Finally they should measure the highest point on their model and record it under Stop 2.

7. Again, have different group member(s) pour water on their group's model. Stop them when they have eroded away most of the sand and exposed most of the quartzite. They will make their final sketch under Stop 3 and take a final height measurement.

8. The teacher may wish to collect the student worksheets at this point. When students return to the classroom, they can write their paragraphs on the geologic history of the Sauratowns. Students should assist the teacher and park staff to clean up the activity site before leaving the park.

Assessment:

Review student worksheets for completeness and accuracy of observations. Then, ask your students the questions below. This may be done as a class discussion, or students can write their answers on paper.

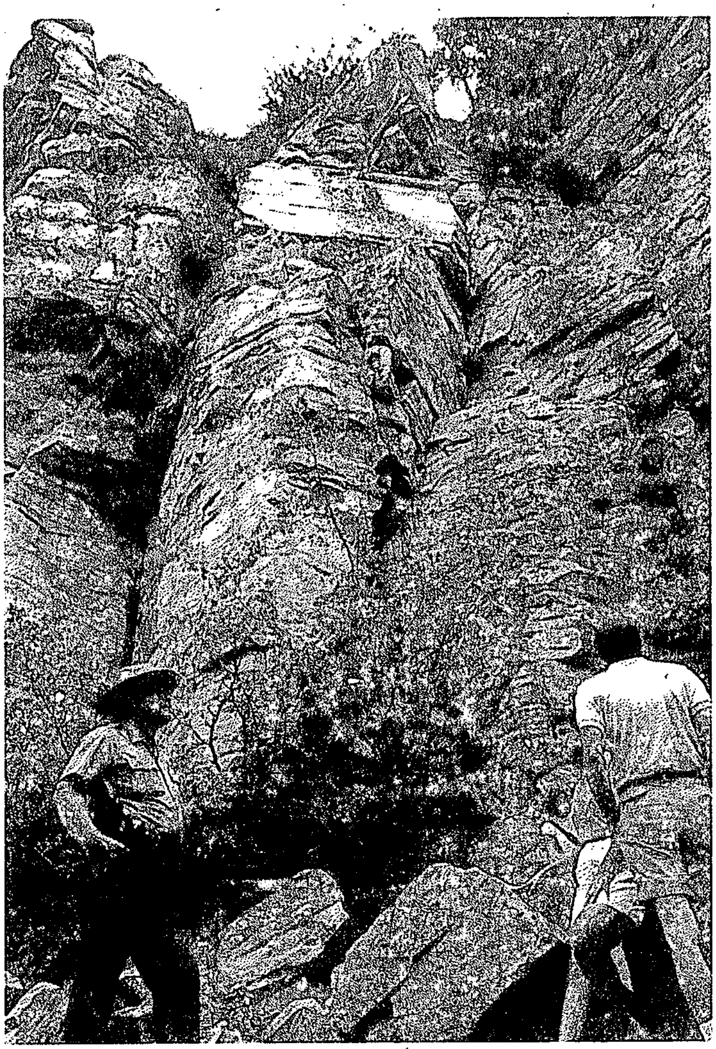
- What does moving water do to mountains? (Erodes softer rocks)

- How did the peaks and ledges at Hanging Rock State Park form over time? (Water eroded away the softer rocks, leaving the more resistant quartzite behind.)

- What do you think happened to the softer rocks that were here over 300 million years ago? Where did they go? (You can see sand and small rock particles in the soil at various locations within the park. Most of the rock pieces and sediments have long ago washed away into the Dan River and its tributaries. Some sediments may have travelled to the Atlantic Ocean by now!)

- What happened to the quartzite in your model? (No change)

- In nature, quartzite is very slowly worn away by weathering and erosion. Since running water doesn't seem to affect quartzite very much, what other agents of

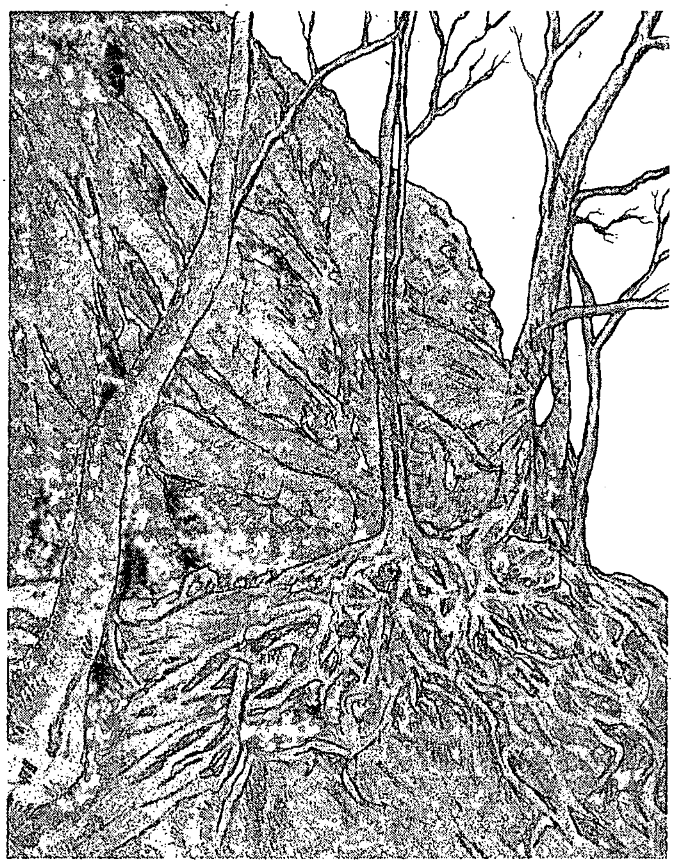


weathering might be able to break down this rock? (Water freezing in cracks in the rocks and expanding, tree roots, people, wind-blown sand)

• Today, the highest point in the Sauratown Range is Moore's Knob at approximately 2,570 feet above sea level. If erosion has made it this size today, how tall might it have been when it was first uplifted? Hint: Some geologists speculate it may have been five times its present size about 350 million years ago. (Answer: 12,850 feet)

• Compare your model to the "real thing." What was the height of your model at the beginning and at Stop 2, present time? Does this represent a five-fold decrease in height? Do you think your model of the Sauratowns is accurate? (Answers will vary depending on group models. Most likely, the models are not very accurate, but only crudely represent erosional events. You can discuss how scientists develop models that are more accurate in order to predict events with a fair amount of accuracy.)

• Predict what will eventually happen to these mountains. (Accept a variety of answers. Erosion will continue and the mountains will become smaller. However, at some point in the future, **tectonic plate** activity may cause mountain building to begin again. Refer to the



Rock Cycle Diagram on page 3.1.3 of this EELE.)

Modification:

If time does not allow students to sketch and measure group models, one class model can be made quickly. The teacher can narrate the geologic story while students act as "rainmakers." If the teacher has access to a camera or camcorder, a photographic or video record can be made and used when the class returns to school.

Extension:

Have students correlate their geologic stories with the information on geologic **eras** and **periods** they learned in Pre-visit Activity #1 in this EELE. For example, they could write the era and period names on their worksheet for Beginning, Stop 1, and Stop 2. (Answers: Beginning = Paleozoic era and Devonian or Mississipian period; Stop 1 = Mesozoic era and Jurassic period; Stop 2 = Cenozoic era and Quaternary period) Then, they could rewrite their paragraphs on page two of the worksheet to include information about the plants and animals of these periods. If your class created the timeline suggested in Pre-visit Activity #1, they could add sketches of how the Sauratowns may have looked during the Devonian and Jurassic periods and include a recent photograph of the Sauratowns for the Quaternary period.

Mountain Erosion - Worksheet

Name: ______________________________ Date: ______________

Draw changes observed during the activity. Label (or shade in) the rocks and use arrows to show directions in which sand was carried away. Also, measure the highest point on your model and record in the appropriate spaces on the worksheet.

Beginning - Represents how the Sauratown Mountains looked 350 million years ago.

Height in cm __________

Sketch:

Stop 1 - About 150 to 200 million years ago, erosion became the dominant force and began to reshape the land. (Mountain-building period is over.)

Height in cm ________

Sketch:

Stop 2 - Represents present time. Height in cm _______. Draw sketch below:

Mountain Erosion - Worksheet Page 2

Compare your model at Stop 2 to Moore's Knob, the peak you can see across the lake.

Similar:____

Different: ____

<u>Stop 3</u> - Represents how the mountains may look another 150 million years in the future.

Height in cm: _____

Sketch:

In a short paragraph, write the geologic story of the Sauratown Mountains beginning 350 million years ago and continuing about 150 million years into the future.

Major Concepts:
- Sauratown geology
- Erosion
- Weathering

Learning Skills:
- Observing, classifying, inferring, communicating
- Taking notes and developing conclusions

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

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

Location:
Option A - Upper Cascade Trail
Option B - Hanging Rock Trail

Group Size:
Approximately 30 students with a teacher, plus at least three adult assistants.

Estimated Time:
Option A - 30 minutes to 1 hour
Option B - 2-3 hours

Appropriate Season: Any, except winter months

Materials:
Provided by the educator:
Per student: Student's Information, park map (pg. 4.2.4), note paper and pencil

Special Considerations:
Please read the information in the Introduction to Hanging Rock State Park on "Before You Make the Trip" and "While at the Park."

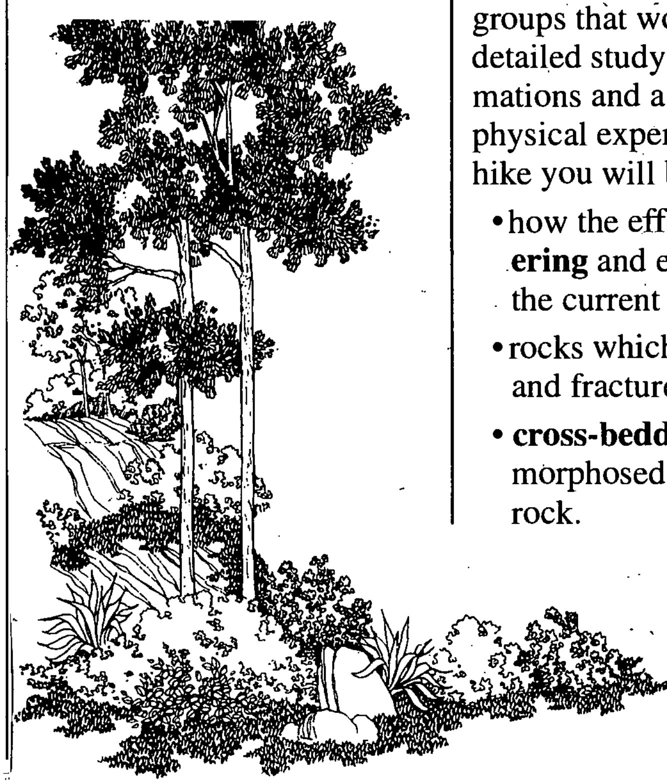
Objectives:

- Identify one mineral and one rock found in the park.
- Gain an appreciation for the geologic formations in Hanging Rock State Park.
- Present at least one theory that explains how the geologic formations found in the park may have formed.

Educator's Information:

This activity is a hike to observe some of the park's geologic features.

On-site Activity #1 and Pre-visit Activities #2 and #5 in this EELE are recommended prerequisites to your hike.



Option A is an easy hike to the Upper Cascades (0.6 mile round trip) on an accessible trail. This option is the better one for school groups. On this hike you will be able to observe:

- water **erosion**
- **fractures** or **joints** in the **quartzite**
- tilted rock layers
- metamorphic layering (**foliation**) in rocks.

Option B is a challenging hike to the base of Hanging Rock (two miles round trip) over steep, uneven terrain. This hike is NOT recommended for persons who have difficulty walking. Option B might be used by groups that would like more detailed study of rock formations and a more rigorous physical experience. On this hike you will be able to see:

- how the effects of **weathering** and erosion shaped the current landscape
- rocks which were folded and fractured
- **cross-bedding** in metamorphosed **sedimentary** rock.

Student's Information:

Option A:

The gorge at the Upper Cascades was created by millions of years of **erosion**. Here, water has eroded the rock along major **fractures** or **joints**. When the **quartzite** breaks off, it breaks along these fractures into smooth-sided blocks.

Originally, the layers of **rock** were lying horizontally like a stack of papers. However, as the earth's crust slowly moved, the layers were gradually folded and bent. At the time of the crustal movement, the layers were under about 8 1/2 miles of rock, and therefore under considerable pressure! At the increased temperatures and pressures deep in the earth, the rocks behaved plastically, something like taffy candy.

When put under intense pressure, some minerals in rocks will line up in bands or layers. This is called **foliation**. You can see this metamorphic layering, or foliation, in the quartzite at the Upper Cascades. Geologists think these layers may be parallel to the original bedding of the parent rock, **sandstone**. Today these layers of quartzite are sloping or dipping gently to the southeast.

Another item of interest at the Upper Cascades is the presence of **quartz** veins and pods between the layers in the quartzite. Quartz (silica) is a **mineral**, not a rock. Superheated water containing silica was pushed into the cracks in the quartzite during mountain building. As the water cooled, the silica precipitated out and solidified, filling the cracks.

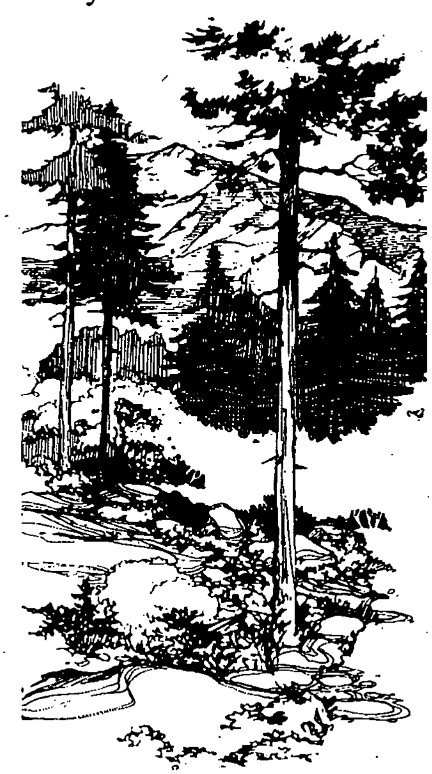
Option B:

During the geologic time period that witnessed the movement and collision of the land masses, this entire region was pushed up. Rock layers were folded, bent and fractured, and large slices of rock were shoved over one another. In many places, this process resulted in older rocks being pushed up and over younger rocks. Hanging Rock has a complex and fascinating geologic history, which geologists are still trying to unravel!

The knife-edge ridge you walk along to get to Hanging Rock is an interesting geologic feature. In the past, this ridge was a continuation of the Hanging Rock ridge and was capped with the same durable quartzite that forms Hanging Rock itself. This ridge is a preview of what the Hanging Rock ridge will look like in the distant future as erosion takes its toll.

Although quartzite is more resistant to **weathering** and erosion than other types of rock, it is not immune. A type of weathering called **ice wedging** can be very effective at breaking even this hard rock. When water gets into cracks and joints, then freezes and expands, it creates enough force to push rocks apart. The daily freeze-thaw cycle that occurs in winter and early spring slowly but surely weathers these rocks.

At the base of Hanging Rock, you can see the original layering of the now metamorphosed sandstone (quartzite). Look carefully to observe **cross-bedding**, where minor layers lie at an angle to the main layers. This is evidence that the parent rock formed in an ocean near the shore, where changing wind or water currents rearranged the original sandy sediments.



Instructions:

Option A:

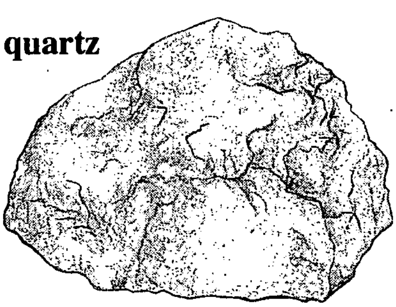
1. Discuss with the students basic trail safety information. (See page 1.4.) Remind the students that the purpose of the state parks system is to preserve and protect our natural resources. Explain to the students that they should not pick, injure or destroy any plants or animals. Rocks should not be removed from the park, but should be returned to the area from which they are collected.

2. Before you leave on the hike give an overview of the background information and review the **rock cycle** (Pre-Visit Activity #1). Encourage the students to use their observation skills to determine how the gorge was formed and note any layering, fractures or tilt in the rock formations. Students should record their observations by making simple notes or sketches.

3. Lead the hike to the Upper Cascades. (You may want to stop at the "rock garden" along the way.)

4. Once there, be sure to discuss how the cascades were formed. Emphasize how the rocks were laid down, the uplifting process, and then the erosive force of water and its effects on the rocks.

quartz



5. Have the students search for **quartz** veins in the quartzite and look for any layering or foliation. See if they can find fractures perpendicular to these layers and observe how straight and smooth the fractures are. Have the students also look at fallen rocks. Encourage them to speculate on why the rocks fell and why the rocks are shaped as they are.

Option B:

1. Discuss with the students basic trail safety information. (See page 1.4.) Remind the students that the purpose of the state parks system is to preserve and protect our natural resources. Explain to the students that they should not pick, injure or destroy any plants or animals. Rocks should not be removed from the park, but should be returned to the area from which they are collected.

2. Before you leave on the hike, give an overview of the background information and review the rock cycle (Pre-Visit Activity #1). Encourage the students to use their observation skills to note the erosion which has occurred along the ridge, giving it a distinctive shape, and to note any layering, fractures or tilt in the rock formations. Students should make simples notes or sketches to record their observations.

3. Before you reach the base of Hanging Rock, you will walk along a knife-edge ridge. Have the students compare the differences in height between the top of Hanging Rock and the ridge you are standing on. Continue the hike to the base of Hanging Rock, stopping for brief discussions where evidence of weathering and erosion of rock formations are noticed by the students.

4. Once at the base, ask students to observe fallen rocks for evidence of layering. Remind the students that quartzite is metamorphosed **sandstone**, but still shows the layering of the quartz-rich **sediments** as they were laid down by water. With careful observation, you may be able to see cross-bedding at this location.

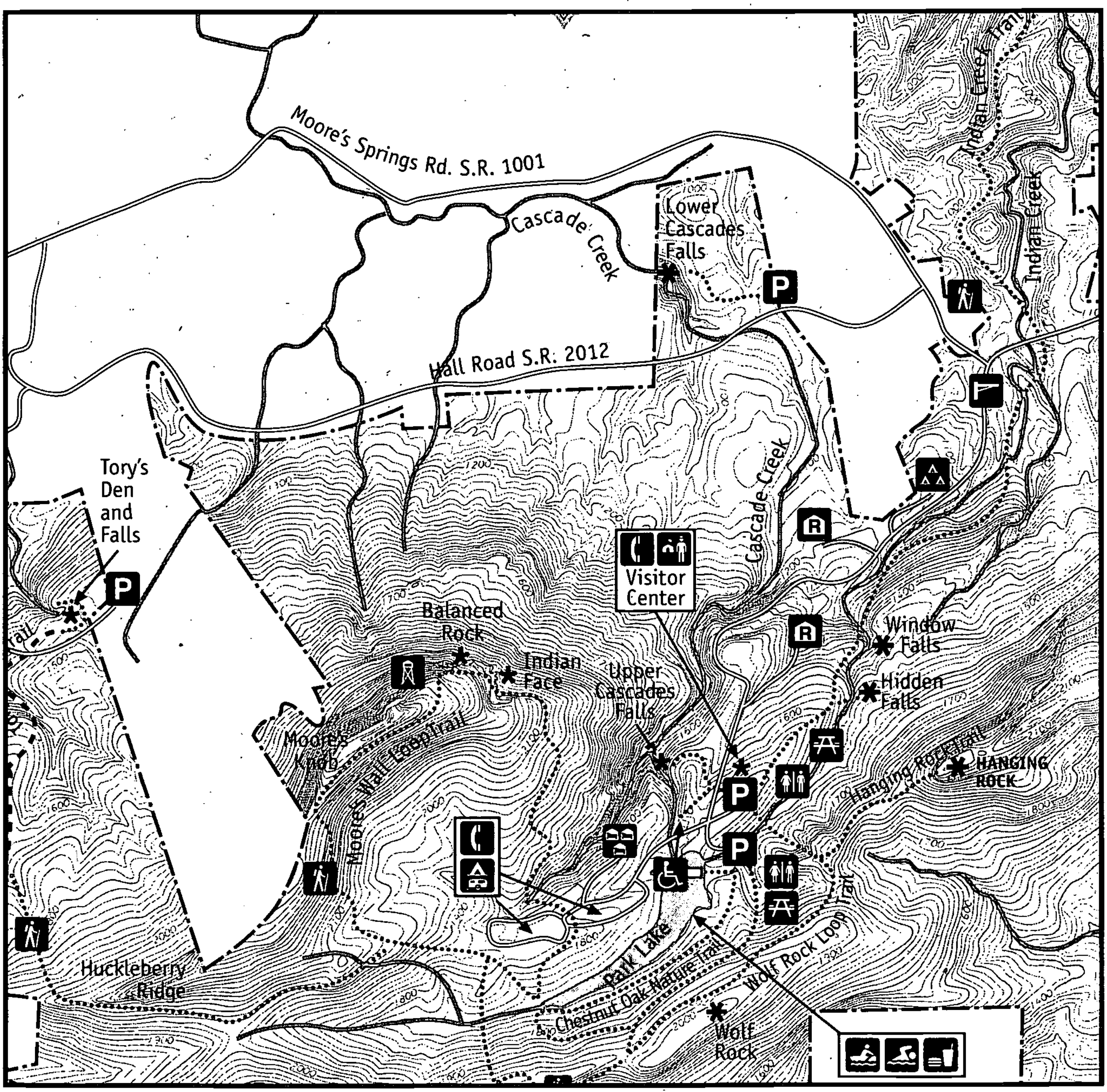
5. As you continue the hike to the top of Hanging Rock, remind the students that when this region was uplifted, the older quartzite rock was pushed up and over softer, younger rocks. In this **geologic process,** the quartzite was tilted, folded and later, fractured. Have the students search for evidence of these folds and fractures, and see if any of the rocks appear to have broken along these fractures, showing a straight and smooth surface. Discuss with them that fractures are weak spots, and with the processes of weathering and erosion constantly working on them, the quartzite will eventually break along these weak lines. Ask students to look for any evidence that weathering and erosion have occurred. Emphasize the importance of **ice wedging** (freeze-thaw cycle) in the weathering of quartzite.

Assessment:

1. Back in the classroom, ask students to work in groups to present a theory that explains how the geological formations they observed in the park may have formed. Their theories should be based on observations, but they do not have to agree with the ideas presented in the Student's Information. Each group should create at least one audiovisual to illustrate their theory.

2. Ask students to define or explain the following terms: quartz, quartzite, fracture or joint, foliation, erosion, cross-bedding, and ice wedging.

trail map (section of park map)



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Post-Visit Activity #1 "Sauratown Mountain Bulletin Board"

Major Concepts:
- Geologic processes
- Sauratown Mountains

Learning Skills:
- Observing, communicating
- Creating a group product of the field trip

Subject Areas:
- Science
- English Language Arts

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

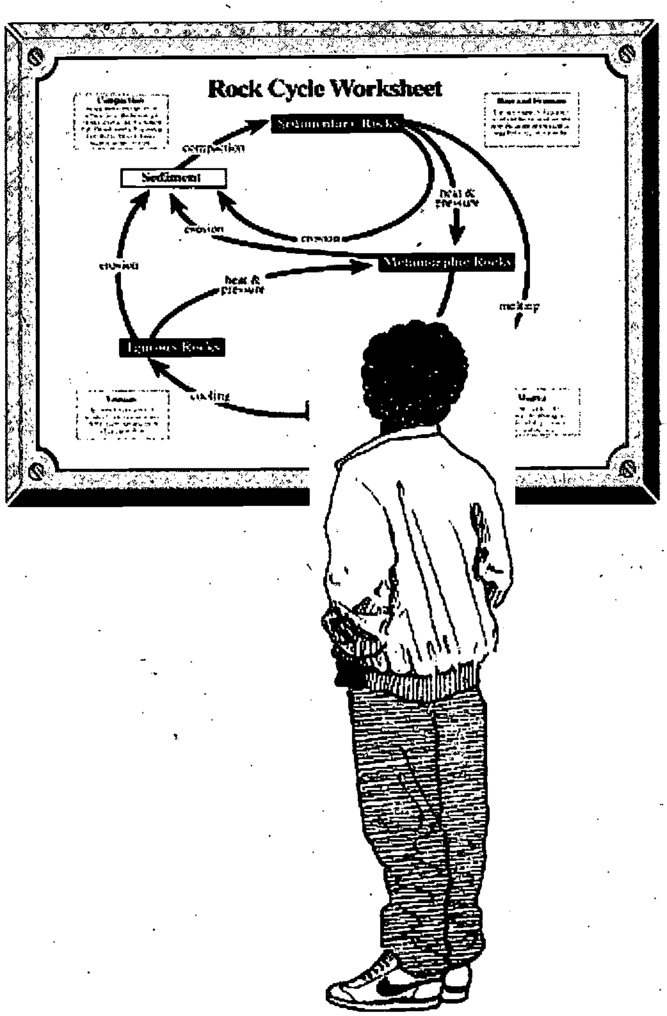
Location: School

Group size:
30 students – may want to work in small groups

Estimated Time: Variable

Appropriate Season: Any

Materials:
Provided by the educator:
Construction paper, markers or crayons of various colors, stapler and staples, glue, tape, scissors, bulletin board, any other art material that the students choose to use (perhaps clay, or paper mache?)



Objectives:
- Describe at least one part of the rock cycle.
- Explain how weathering and erosion affect geologic formations.
- Describe one or more geologic concepts, using text and art materials.

Educator's Information:

This activity reinforces the vocabulary and concepts learned in the previous activities.

Instructions:

1. As a class, plan the bulletin board. Be sure to cover one or more of the following concepts: rock cycle, rock formation, weathering, erosion and geologic time. Also be sure to relate this to the park and to the students' experiences. Sketch it.

2. Construct. (Students may want to work in small groups and do different parts of the display.)

3. Label various points, i.e., rocks, layers, ages, etc. Arrows could be used to point out "this formed from this" to demonstrate a rock cycle.

4. Display the bulletin board where other students can see it and learn from it.

Post-Visit Activity #2 "Geo Talk"

Major Concepts:
- Geology
- Earth resources

Learning Skills:
- Observing, communicating
- Identifying key words; collecting and organizing new information
- Acquiring information from primary and secondary sources

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

Location: Classroom

Group Size: Approximately 30 students plus teacher

Estimated Time: 30 minutes for part 1; 45 minutes or longer for part 2

Appropriate Season: Any

Materials:
Provided by the educator:
Per student: Word Search and/ or Word Puzzle, pencil
Per class: (Optional) map of country or world, library resources to assist with reports

Objectives:
- Match geology vocabulary words with their correct definitions.
- Collect and organize information on a specific rock or mineral. Include information on location of major sources, how it is mined, how people use it, its economic importance, and environmental issues related to its extraction and use.

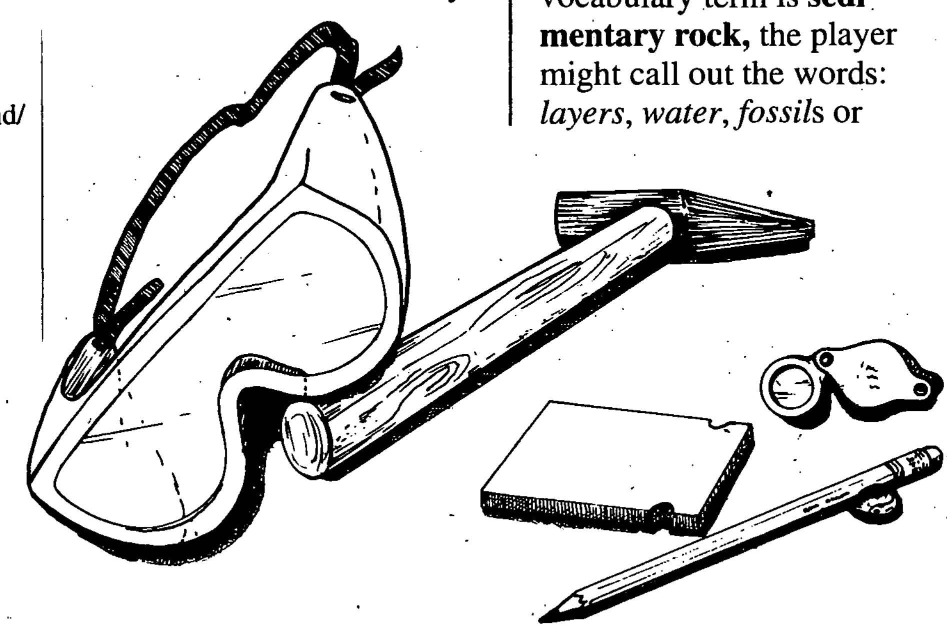
Educator's Information:

In this activity, students will review some of the new vocabulary they learned as a result of completing the other activities in the Hanging Rock Environmental Education Learning Experience. They will also do research to learn more about the importance of earth resources in our daily lives, and environmental issues that may be associated with them.

Instructions:
Part 1 - Vocabulary Review

1. Give each student a copy of the Word Search and instruct them to fill in the blanks with the appropriate word suggested by each definition or example. You can list the words on the chalkboard, or use the Word Search in combination with the Word Puzzle.

2. Create cards of vocabulary terms for a game of "Password." A student calls out words related to a given term in order to get his/her team members to say the correct term within 30 seconds. For example, if the vocabulary term is **sedimentary rock,** the player might call out the words: *layers*, *water*, *fossils* or



sandstone. He could not use a word that is contained within the vocabulary term, such as *sediment* or *rock*.

Assessment:

Use the Word Search as a quiz after playing the vocabulary games, or create your own matching test based on the Word Search.

Instructions:
Part 2 -
Rocks and Minerals in Your Daily Life

1. In this activity, students will do research on a specific rock or mineral. The teacher may wish to assign a different rock or mineral to each student or have students work together in teams. If desired, this could be correlated with the Social Studies unit in each grade level. For example, students could be assigned rocks and minerals from North America, Europe, or Africa.

2. Instruct students to collect information on their rock or mineral. They can do a web search, use printed resources from the media center, or contact a geologist or mining company. As a minimum requirement, they should collect the following:

- Location of major sources of their earth resource (use map, if possible)
- How people extract this resource from the earth
- How people use this resource
- Environmental issues surrounding their resource (mining issues, limited quantities, transportation issues, pollution that may result from processing the material, etc.)
- Any information on the economic importance of their earth resource (for example, is it a major export for the countries they are studying in Social Studies?)

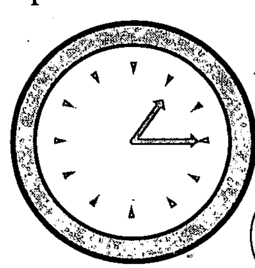
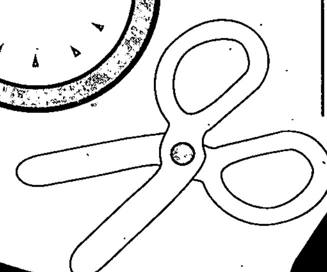
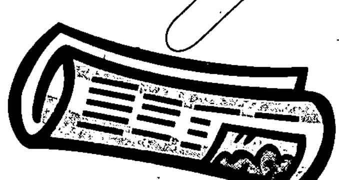
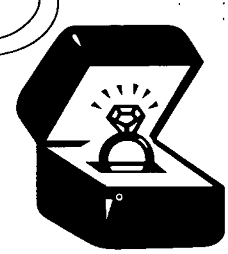
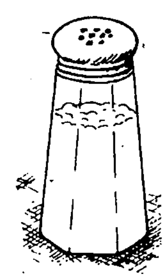
3. Students should organize their information so that it can be shared with others. Pictures, sketches or photographs would add to their reports.

Assessment:

- Check student reports for completeness. If time permits, ask students or teams to give brief reports to the class about their resource.
- Bulletin board activity: Ask students to use pieces of yarn to connect an illustration of their resource to a map of North Carolina, a country, a region, or the world (depending on your geographical focus for this activity). They should try to pinpoint the specific location of a major source of their rock or mineral.
- Make a class list of the environmental issues surrounding the earth resources. Discuss how individuals or countries can be better stewards of earth resources.
- Ask students to think about their specific earth resource. Decide if they, or the country they are studying, could get along without this resource. Why is this resource important? What hardships might result if this resource were no longer available? Are there substitutes for this resource?

Extensions:

If you prefer to concentrate on North Carolina rocks and minerals, see the activities in the *Mineral and Rock Kit Guide* by Mary Watson of the N.C. Geological Survey. Refer to the References section for more resources from the Survey that illustrate the importance of earth resources in our daily lives.

WORD SEARCH **Name**________________

1. Substance made up of one or more minerals

   ___ ___ ___ ___

2. Rock that forms the ledges, peaks, and ridges of the Sauratown Mountains

   ___ ___ ___ ___ ___ ___ ___ ___ ___

3. Sedimentary rock composed primarily of quartz grains

   ___ ___ ___ ___ ___ ___ ___ ___ ___

4. Naturally-occurring substance with its own crystal shape

   ___ ___ ___ ___ ___ ___ ___

5. Rock type formed when heat and pressure change or recrystallize a rock

   ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

6. Term used when water carries away rock debris

   ___ ___ ___ ___ ___ ___ ___

7. Rock type formed when sand, clay or other materials are deposited in layers under water

   ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

8. The geologic process that breaks down rocks into smaller pieces

   ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

9. Name of mountain range that includes Hanging Rock, Moore's Knob, and Cook's Wall

   ___ ___ ___ ___ ___ ___ ___ ___ ___

10. One of the most common minerals (You can see veins of this throughout the park.)

    ___ ___ ___ ___ ___ ___

11. Scale used to describe the earth's history; includes eras and periods

    ___ ___ ___ ___ ___ ___ ___ ___   ___ ___ ___ ___

12. Describes how rocks are repeatedly made and destroyed

    ___ ___ ___ ___   ___ ___ ___ ___ ___

13. Rock type formed when molten (liquid) rock cools and hardens

    ___ ___ ___ ___ ___ ___ ___

14. The remains of prehistoric life, or some other evidence of once-living organisms

    ___ ___ ___ ___ ___ ___

15. The name geologists give to a section of the earth's crust that arches upward

    ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

WORD SEARCH - Answer Sheet

1. Substance made up of one or more minerals
   r o c k

2. Rock that forms the ledges, peaks, and ridges of the Sauratown Mountains
   q u a r t z i t e

3. Sedimentary rock composed primarily of quartz grains
   s a n d s t o n e

4. Naturally-occurring substance with its own crystal shape
   m i n e r a l

5. Rock type formed when heat and pressure change or recrystallize a rock
   m e t a m o r p h i c

6. Term used when water carries away rock debris
   e r o s i o n

7. Rock type formed when sand, clay or other materials are deposited in layers under water
   s e d i m e n t a r y

8. The geologic process that breaks down rocks into smaller pieces
   w e a t h e r i n g

9. Name of mountain range that includes Hanging Rock, Moore's Knob, and Cook's Wall
   S a u r a t o w n

10. One of the most common minerals (You can see veins of this in the park.)
    q u a r t z

11. Scale used to describe the earth's history; includes eras and periods
    g e o l o g i c   t i m e

12. Describes how rocks are repeatedly made and destroyed
    r o c k   c y c l e

13. Rock type formed when molten (liquid) rock cools and hardens
    i g n e o u s

14. The remains of prehistoric life, or some other evidence of once-living organisms
    f o s s i l

15. The name geologists give to a section of the earth's crust that arches upward
    a n t i c l i n o r i u m

WORD PUZZLE Name________________

R	D	S	E	D	I	M	E	N	T	A	R	Y	L	M
I	O	F	R	O	C	K	C	Y	C	L	E	A	N	E
W	G	C	A	Q	H	C	O	Y	T	Y	R	O	M	T
E	G	N	K	C	J	O	M	A	E	E	I	U	Q	A
A	S	E	E	X	C	M	R	L	N	S	I	W	U	M
T	A	O	O	O	H	B	G	I	O	R	S	X	A	O
H	U	D	P	L	U	U	M	R	O	T	C	I	R	R
E	R	L	D	Q	O	S	E	N	H	L	V	X	T	P
R	A	M	E	V	F	G	I	X	W	M	L	G	Z	H
I	T	M	H	W	Z	L	I	F	F	X	C	X	I	I
N	O	F	O	T	C	Q	H	C	O	G	W	D	T	C
G	W	G	R	I	K	H	O	T	T	S	A	I	E	D
B	N	A	T	G	P	M	T	X	N	I	S	F	G	C
U	U	N	R	J	H	M	M	U	U	T	M	I	S	C
Q	A	S	A	N	D	S	T	O	N	E	R	E	L	Q

ANTICLINORIUM	METAMORPHIC	ROCK CYCLE
EROSION	MINERAL	SANDSTONE
FOSSIL	QUARTZ	SAURATOWN
GEOLOGIC TIME	QUARTZITE	SEDIMENTARY
IGNEOUS	ROCK	WEATHERING

WORD PUZZLE - Answer Key

R	D	S	E	D	I	M	E	N	T	A	R	Y	L	M
I	O	F	R	O	C	K	C	Y	C	L	E	A	N	E
W	G	C	A	Q	H	C	O	Y	T	Y	R	O	M	T
E	G	N	K	C	J	O	M	A	E	E	I	U	Q	A
A	S	E	E	X	C	M	R	L	N	S	I	W	U	M
T	A	O	O	O	H	B	G	I	O	R	S	X	A	O
H	U	D	P	L	U	U	M	R	O	T	C	I	R	R
E	R	L	D	Q	O	S	E	N	H	L	V	X	T	P
R	A	M	E	V	F	G	I	X	W	M	L	G	Z	H
I	T	M	H	W	Z	L	I	F	F	X	C	X	I	I
N	O	F	O	T	C	Q	H	C	O	G	W	D	T	C
G	W	G	R	I	K	H	O	T	T	S	A	I	E	D
B	N	A	T	G	P	M	T	X	N	I	S	F	G	C
U	U	N	R	J	H	M	M	U	U	T	M	I	S	C
Q	A	S	A	N	D	S	T	O	N	E	R	E	L	Q

ANTICLINORIUM	METAMORPHIC	ROCK CYCLE
EROSION	MINERAL	SANDSTONE
FOSSIL	QUARTZ	SAURATOWN
GEOLOGIC TIME	QUARTZITE	SEDIMENTARY
IGNEOUS	ROCK	WEATHERING

Post-Visit Activity #3 "Do You Mine?"

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

Learning Skills:
- Predicting, communicating
- 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

Estimated Time: 90 minutes (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 Student's Information with maps, and a Possible Arguments page that either supports or opposes the mining project (pp 5.3.6 - 5.3.7)
Per class: Additional resources on mining – Call N.C. Land Quality Section at (919) 733-4574.

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 resource issue.

Educator's Information:

In this activity, students will explore many viewpoints surrounding mining adjacent to a state park. A realistic scenario is provided that centers on an imaginary state park in a fictitious county. Each student should 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.

The process for citizen participation in the 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 he/she 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 it must follow to minimize environmental impacts from the project.

Instructions:

1. Give each student a copy of the Student's Information and discuss the proposed mining project near Rocky Cliffs State Park. List pros and cons of the mining project on the chalkboard 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 solution. Discuss ways that environmental issues are resolved in a democratic society.

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, her 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 could 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.

Extension:

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?

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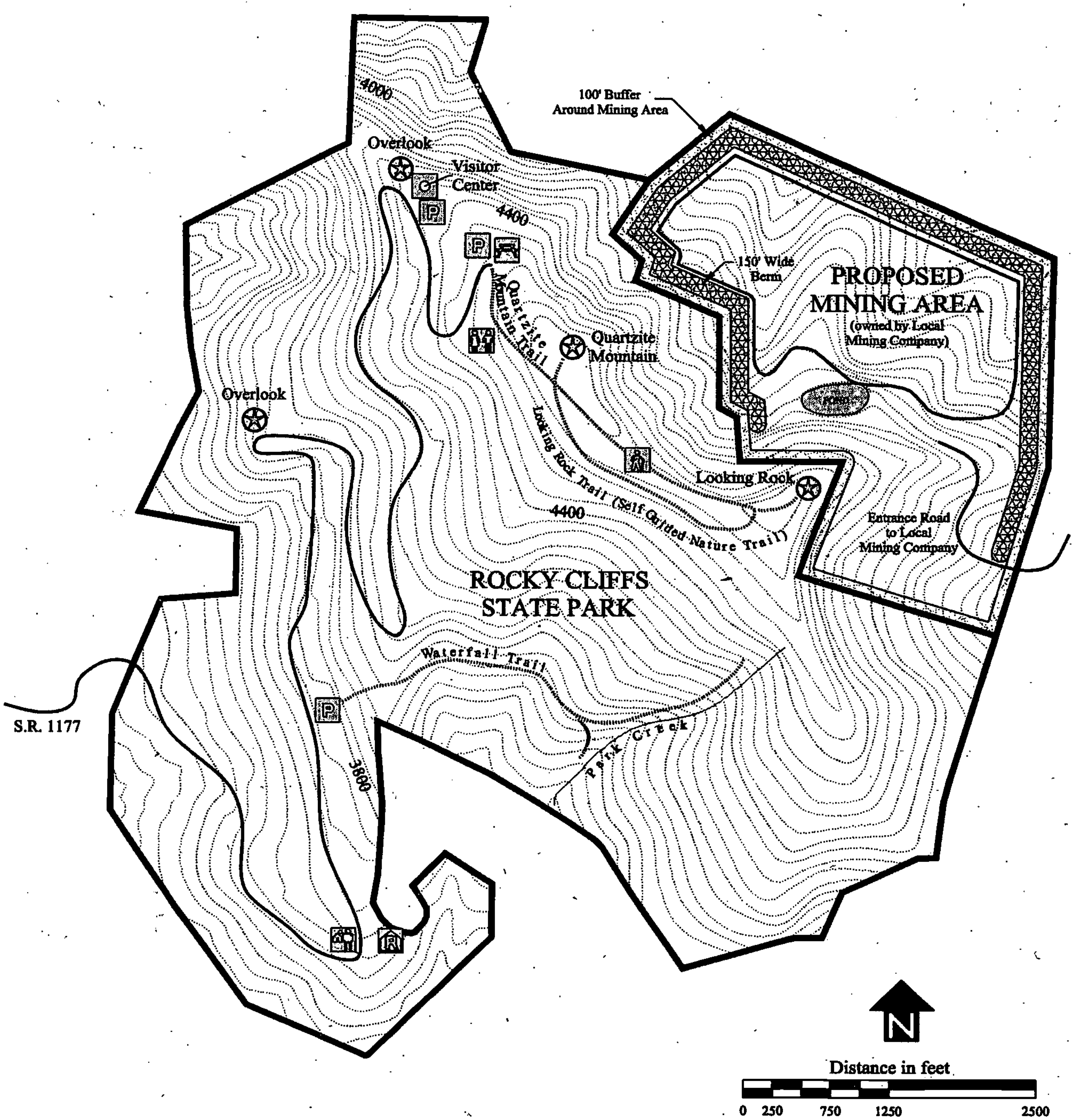
Rocky Cliffs State Park consists of 600 acres in the heart of the Sentinel Mountains. The Sentinel Mountains are an ancient mountain range with beautiful rock formations and waterfalls. Located in Quartz County, the park is only a two to three hour drive from several large metropolitan areas. It is one of the most popular places in the state for hiking, picnicking and relaxing. Several rare and endangered species reside in the park and are part of an ongoing research study by a local university.

To ensure that the entire ridge line of the Sentinel Mountains is preserved, the State Parks Department would like to add another 600 acres of land adjacent to the existing Rocky Cliffs State Park. Park visitation and demands for recreational services have increased greatly over the past ten years. To meet these demands, the State Parks Department would like to put a family campground at the base of the ridge line on this proposed addition to the park. The Department also has plans to connect the existing trail system with this campground, to add a mountain bike trail, and provide for horseback riding.

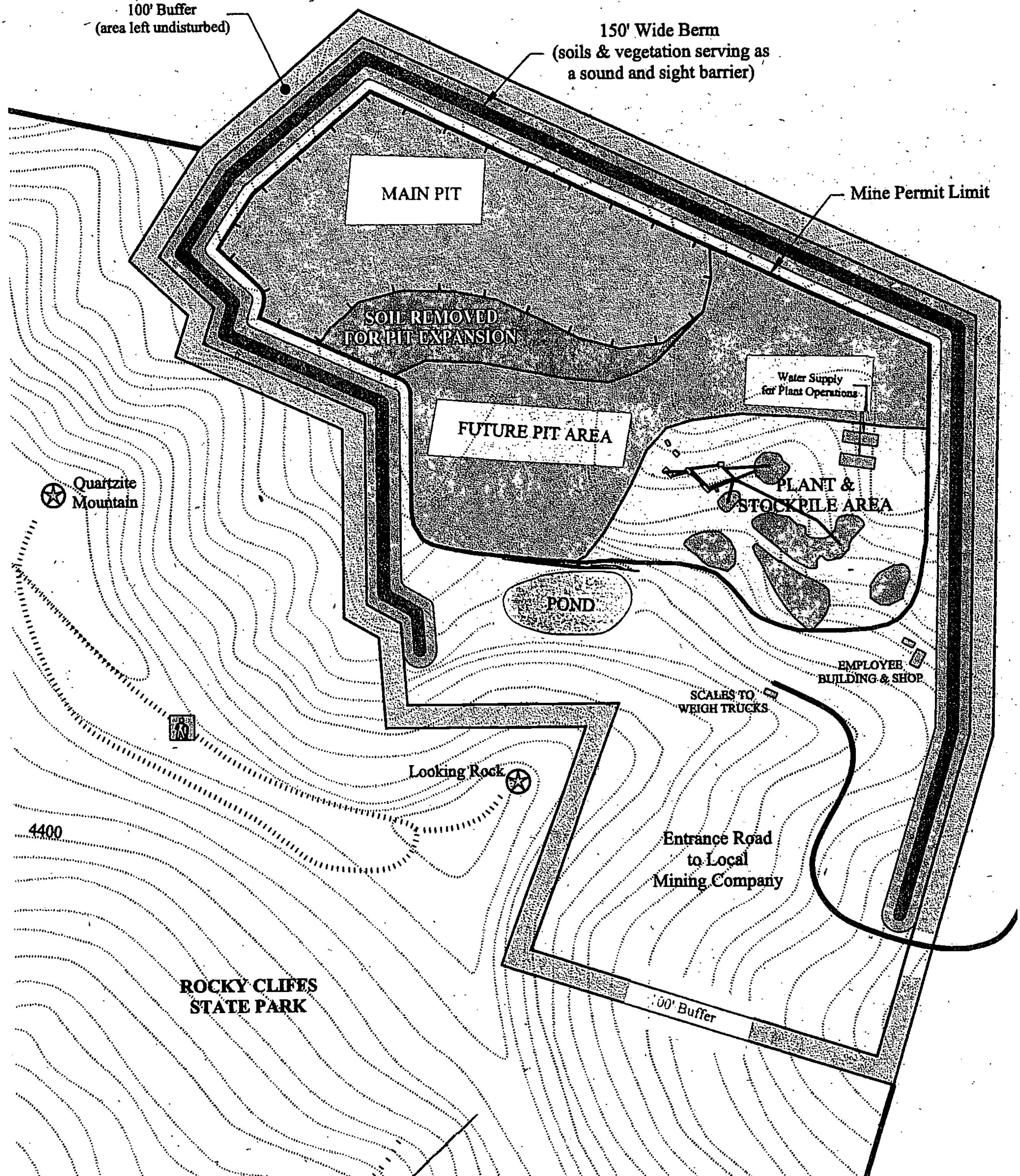
A local mining company owns this 600-acre parcel and would like to mine the quartzite for use as building stone. This company has applied for a permit from the State Mining Board to proceed with their mining operation. The mining company estimates it will take them 40-50 years to remove all the stone. They have found a potential market for their stone. A real estate development company has purchased a large area of land near Rocky Cliffs State Park with the intention of building expensive luxury homes. Famous for designing houses that blend into the countryside, this development company would like to use local stone in the construction of their luxury homes.

The State Mining Board has set up a 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 park. 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, they may help determine a fair price for the land – if the State Legislature should agree to purchase the 600 acres and increase the size of Rocky Cliffs State Park.



BEST COPY AVAILABLE

Map Provided by Martin Marietta Aggregates, Raleigh, NC



BEST COPY AVAILABLE

Map provided by Martin Marietta Aggregates, Raleigh, NC

Possible Arguments for Supporting the Mining Project

Local Mining Company

If you are allowed to mine the quartzite in Quartz County, 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. You plan to leave a 100-foot buffer area around the mining pit and provide a sight and sound barrier as well.

You have read the park's master plan. You know that the state would like to add at least another 600 acres to double the size of the park. You wonder...how much more land in Quartz County is the state going to take out of the tax base and make off limits to your mining company? You would be willing to sell your land to the state very cheaply after you remove the building stone in about 40 years. At that time, you will do your best to restore the area so that it can be used as a campground, community ball field, or other recreation area.

Real Estate Development Company

You are eager to work with the local mining company and local stone masons in the construction of a new housing development in Quartz County. Using local materials in home construction will increase your profits and lower housing costs – because the cost of transporting materials to the building site will be reduced. Furthermore, you think it is possible to minimize the impacts of mining and development. In your opinion, the loss of a few species of plants or animals is a small price to pay for progress. 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 and modern schools, which are very much needed in this rural area.

Chamber of Commerce

You support this project, with some reservations. Your mission is to bring business and industry to Quartz County to create new jobs and provide the county with extra tax money. This project sounds as if it could create new jobs and help your rural economy to grow. You are concerned that some of the jobs would be temporary – just during mining and construction. However, if more schools and a library were built with the tax money, then there would be more jobs for teachers, librarians and others. All the new development would mean more money in property taxes. You are a little worried about the project's effect on the state park. Some of the income in the county comes from tourists visiting the park. A mining operation near a state park might discourage tourists. Some local businesses might suffer.

Local Association of Stone Masons

You support this project because it will mean more work for you. You are happy to hear that stone is becoming popular in the construction of new homes. The quality of the local stone is excellent and you would prefer to work with it. However, you are willing to work with any kind of stone. You worry that if the local mining project is not allowed, it may be too expensive for the real estate company to transport stone from other parts of the United States. The real estate company may decide against using stone in the construction of the new homes. This would be a serious economic loss to the local stone masons.

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

State Parks Department

Your mission is to protect and preserve the natural environment, and provide recreational opportunities to the public. Park visitors often request camping facilities. The proposed addition to Rocky Cliffs State Park would be an excellent place for a family campground. This area is home to several rare and endangered plant species. A mining operation would destroy plant communities and valuable wildlife habitat. Trees would be removed, the ground would be bulldozed, and the resulting erosion and sedimentation might damage water quality in the pond, if not properly controlled. You are also concerned about visitor safety in and around a mining operation. Ensuring that park visitors do not wander off the park and into the proposed mining area would add to the park rangers' duties. Also, what happens when the mining operation ends? Old rock quarries fill up with water and can be dangerous places. In your opinion, after mining, this area would not be a safe place for a campground.

A Hiking or Wilderness Club

You are a large group of citizens including anglers, rock climbers, hikers, bird watchers and campers. You would like to see more land officially become part of the state park. You are also in favor of the proposed campground as it would provide a central location for camping. This would protect the wilderness by reducing the impact of many smaller campsites or picnic areas spread over the whole park. The park is one of the few undeveloped places in the area where people can go to "get away from it all" and enjoy a truly wilderness experience. A mining operation would destroy the breathtaking scenic views as well as the beautiful and rare plant communities. If not properly controlled, the erosion and sedimentation resulting from the mining operation could damage water quality and kill fish. Also, the noise from the trucks and the blasting is offensive to those people who come to the area for peace and quiet. Preserving the environment is more important than increasing tax revenues.

Local Residents

You are a group of Quartz County residents who live near the proposed mining operation. You believe this operation will lower your property values. 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. You want to know what kind of land reclamation the mining company plans to do after mining is over. You are also unhappy about having lots of new neighbors. You moved to Quartz County to get away from crowds and traffic. You hope that if the mining project is not allowed, the real estate company will drop its plans to build new homes in the area. You'd much rather see the land become part of a state park.

Local Ecotourism Businesses

You own one of the small businesses that cater to tourists who come to the state park to go fishing, hiking, camping, rock climbing, mountain biking, and horseback riding. Area businesses include restaurants, gas stations, and sporting goods stores that sell or rent outdoor recreational equipment to the tourists. You are opposed to the mining operation as you feel it would negatively impact your business by scaring away the tourists. You believe that the proposed family campground would increase your business by providing more recreational opportunities. You are in favor of anything that would increase park visitation.

VOCABULARY

Anticline - a type of fold in which rock units slope downward in opposite directions from a central axis, like the roof of a house. The oldest rocks are in the core of the fold.

Anticlinorium - an area where rocks units are arched upwards.

Abrasion - the process of wearing down, or rubbing away.

Chemical weathering - see Weathering.

Cleavage - the tendancy of a mineral to break along well-defined planes of weakness.

Cross-bedding - the arrangement of layers within a rock, such that the minor layers lie at an angle to the main layers of sediment. This is usually a sign of changing wind or water currents acting on the original sediments forming the rock.

Crustal plate - see Tectonic plate.

Deposition - term used when a mineral or sandy material settles out of water.

Eon - the largest unit of geologic time. Earth's history is divided into two eons.

Epoch - a unit of geologic time that is a division of a period.

Era - a unit of geologic time made up of one or more periods.

Erosion - the process whereby water, wind and ice loosen and carry away rock debris. This process continually wears down all rocks, creating sediments which eventually form new sedimentary rocks.

Extrusive - see Igneous.

Fault - a break in the earth's crust along which movement has occurred.

Fold - a bend in a rock layer caused by compression.

Foliation - the roughly parallel layers of minerals found in some metamorphic rocks.

Fossil - the remains of prehistoric life, or some other direct evidence of once-living organisms.

Fracture - a break, joint or crack in a rock along which NO movement has occurred. Also, the tendency of a mineral to break in an irregular way; e.g., quartz.

Geologic process - the breaking down and building up of rocks, such as weathering, erosion, sedimentation and volcanism; the ongoing process of shaping the earth.

Geologic time - the scale used to describe the earth's history. Geologic eras and periods are used instead of years because the span of time is so long.

Geology - the study of the earth and its history.

Gneiss - a coarse-grained, foliated metamorphic rock. This rock contains feldpsar and is usually banded.

Iapetus Sea - a shallow sea that existed off the east coast of the North American continent from 600 - 800 million years ago.

Ice wedging - a mechanical weathering process, when water seeps into cracks in a rock, then freezes and expands, widening the crack and eventually splitting the rock.

Igneous rock - a rock that was once melted or partially melted. Intrusive igneous rocks result from magma solidifying below the earth's surface. Extrusive igneous rocks form from volcanic material ejected onto the earth's surface.

Intrusive - see Igneous.

Itacolumite - a special type of weathered quartzite in which the mica grains are free to slide over one another, allowing the rock to bend without breaking. Also called "flexible sandstone."

Joint - a crack or break in a rock along which no movement has occurred; an area of weakness for weathering and erosion.

Lava - molten rock that issues from a volcano or a fissure on the earth's surface; the rock formed by the cooling and solidifying of this substance.

Lithification - the process of compressing and cementing sediment grains to form sedimentary rock.

Magma - molten rock beneath the earth's surface. When it reaches the surface, it is called lava.

Mechanical weathering - see Weathering.

Metagraywacke - (sometimes called biotite-muscovite gneiss) - a metamorphosed sandstone that has variable amounts of clay and feldspar minerals in it. It is weakly foliated.

Metamorphic rock - a rock that has undergone a solid-state change in texture, mineralogy or composition, usually as a result of heat and pressure in the earth's crust. Quartzite is a metamorphic rock that forms the cliffs, ledges and walls throughout the park.

Mineral - a naturally-occurring, inorganic substance with its own particular chemical make-up and characteristic crystal shape. Quartz is a common mineral in the park.

Pangaea - a supercontinent that formed about 400 million years ago when all the land masses on earth moved together. About 200 million years ago, this supercontinent began to stretch and break up as the crustal plates pulled apart again.

Period - a unit of geologic time that is a division of an era.

Quartz - a common rock-forming mineral with a hardness of 7; a form of silica, SiO_2.

Quartzite - a metamorphic rock formed when heat and pressure recrystallize the sedimentary rock, sandstone. Quartzite is among the hardest and most resistant of all rocks, thus it is often left after softer rocks have eroded away.

Recrystallize - term used to describe the change in texture or mineral composition that occurs during metamorphism. In quartzite, the recrystallization of quartz within the parent rock (sandstone) results in an interlocking texture. In other metamorphic rocks, recrystallization may result in a new mineral, as when the clay minerals in shale are transformed to mica during low-grade metamorphism, or to feldspar during high-grade metamorphism.

Rock - a substance made up of one or many minerals. Geologists classify rocks as igneous, sedimentary, or metamorphic.

Rock cycle - the process where rock is repeatedly made and destroyed; the sequence through which rocks may pass when subjected to geological processes.

Sand - usually composed of quartz grains mixed with other bits of rock and mineral. "Sand" is actually a term used to describe a particle ranging in size from 1/16 to 2mm.

Sandstone - sedimentary rock, composed primarily of quartz sand grains, that formed when these grains were compacted and cemented together under intense pressure over millions of years.

Sauratown Mountains - the mountain range located in Stokes and Surry counties and includes Pilot Mountain, Cook's Wall, Moore's Knob and Hanging Rock. The quartzite rock that forms the ridge line is believed to have originated from sandy sediments deposited in an ancient ocean.

Schist - a well-foliated metamorphic rock that generally contains conspicuous mica.

Sediment - term used to describe loose gravel, sand and silt that is suspended in water and can eventually settle to the bottom.

Sedimentary rock - rock made by the compaction and/or cementing of sediments in layers. Sandstone is an example of a sedimentary rock.

Tectonic plates - (also called crustal plates) - the large semi-rigid plates that move relative to each other, and together compose the earth's crust.

Texture - the size and arrangement of mineral grains in a rock; i.e., fine-grained, medium-grained, and coarse-grained.

Weathering - any of the destructive processes that wear rocks down at the earth's surface. Mechanical weathering is the disintegration of a rock by physical processes (wind, ice, gravity), while chemical weathering involves the breakdown of rock by changing its chemical composition (often by exposure to air and water).

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N.C. Division of Land Resources, Geological Survey. For publications, call (919) 715-9718. For assistance from the Survey's education specialist, call (919) 733-2423. Web – http://www.geology.enr.state.nc.us/

N.C. Division of Land Resources, Land Quality Section. For information on mining, the N.C. Mining Commission, and the state mining act, call (919) 733-4574. Web: http://www.dlr.enr.state.nc.us/mining.html

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SCHEDULING WORKSHEET

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) ______________________

8) Number of chaperones _______________

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 do you have these forms? ______
If not, mail contact person a Parental Permission form.

I, ______________________________, have read the entire Environmental Education Learning Experience and understand and agree to all the conditions within it.

Return to: Hanging Rock State Park
P. O. Box 278
Danbury, North Carolina 27016

PARENTAL PERMISSION FORM

Dear Parent:

Your child will soon be involved in an exciting learning adventure - an environmental education experience at Hanging Rock 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 will be notified as soon as possible.

______________________________ ____________
Parent's signature date

Parent's name ______________________________ Home phone ____________
(please print) 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.

Hanging Rock State Park
P. O. Box 278
Danbury, North Carolina 27016

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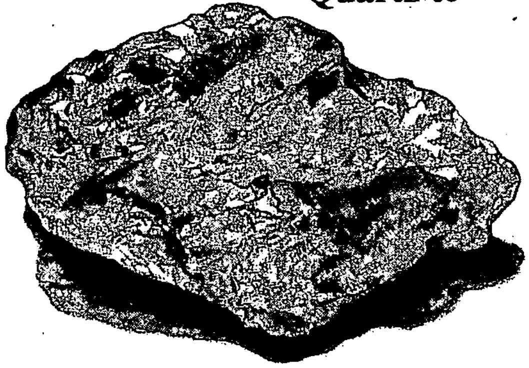
Notes

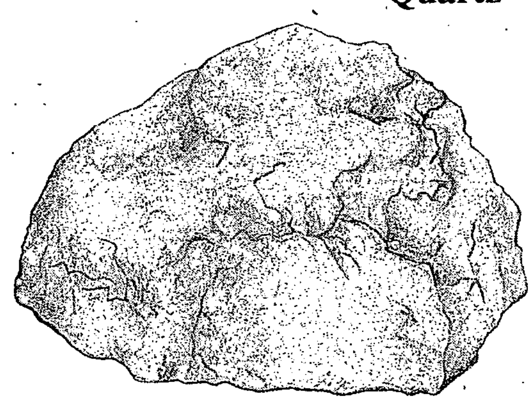


Quartzite

Notes

Muscovite

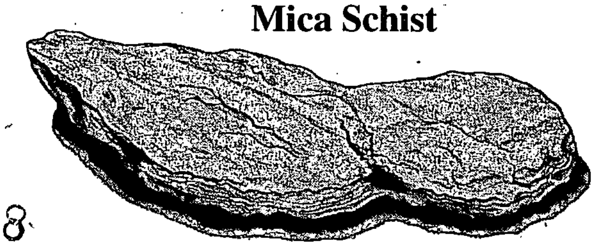
Notes



Quartz

Notes

Mica Schist



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