Geology Hike to the Falls Outline

Big Idea

Rocks and soils—and the processes by which they are made—play a vital role in understanding GSMNP ecosystems.

Essential Questions

- How have forces within the Earth and on the Earth's surface shaped the southern Appalachians region and GSMNP?
- In what ways are the southern Appalachians and GSMNP being changed by natural and human forces?

Vocabulary

- Bedrock—a layer of sedimentary rock the is marked off above and below by surfaces that can be seen and is made up of material that is the same in all parts
- Erosion—the movement of natural materials by wind, water, and gravity
- Fault—breaks or cracks in the earth's crust caused by the movement of tectonic plates
- Fold—a bend in a rock mass, such as a bend in a series of strata rocks
- Geology—the study of the earth and the processes that have formed the earth
- Granite—a coarse-grained acid plutonic rock consisting essentially of quartz, feldspar and mica. The most common intrusive rock.
- Igneous rocks—formed by the solidifying of lava or magma
- Limestone—a sedimentary rock containing more than 50% of calcium carbonate, CaCO
- Metamorphic rocks—rocks that have been transformed by heat, pressure and other natural agents: meta = form and morph = change
- Mineral—a solid inorganic substance of natural occurrence (such as quartz)
- Phyllite—a metamorphic rock produced by regional metamorphism at low temperatures
- Plate tectonics—plate tectonics is the theory that earth's outer layer is made up of plates, which have moved throughout earth's history. This theory explains the how and why behind mountains, volcanoes, and earthquakes.
- Quartz—a hard mineral, chemical composition: silica, SiO
- Sandstone—a sedimentary rock. Most sandstones are composed mainly of quartz grains.
- Sedimentary rocks—formed from sediment deposited by water or air and subjected to pressure over a long period of time. Fossils can sometimes be found within the layers of rock.

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- Weathering—the process of breaking down natural materials by chemicals, water, wind, freeze/thaw or friction

Lesson Outline

- Introduction: What is Geology?
- Rock-Rockity-Rock
- Scavenger Hunt to the Falls
- Falls Illusion
- Moving Water, Moving Rocks
- Rock Painting
- Conclusion

Optional Activities

- Erosion Explosion
- Geologic Time Line
- Soil Resource Sheet
- Cherokee Creation Myth
- Rock Collection

Geology Hike to the Falls Activities

WHAT IS GEOLOGY?

20 Minutes

Lead In

Tell the students that in this lesson, they will be studying geology and the processes that formed the Smoky Mountains. During their studies they will make their way out to one of the park's most beautiful waterfalls, Spruce Flats Falls. Give them a quick overview of the activities they will be doing. Ask them, what is geology? (the study of the earth: rocks, soil, how the earth was formed)

Most of all, it is a study of cycles and processes. It is also the study of water (hydrology), oceans (oceanography), minerals (mineralogy), and fossils (paleontology).

How can people study geology? (by observation, and piecing together a puzzle of rocks)

Procedures

Parts of the Earth

Using Earth Balls, review the layers of the Earth and discuss how the crust is "floating" on the mantle and is made up of plates. The plates periodically run into each other or pull apart from each other and this changes the surface of the Earth. Using your hands explain how the African plate, which is made up of very hard rock, crashed into the North American plate. The North American plate is made up of softer rock and buckled when the harder rock crashed into it. This is how the Appalachian Mountain range was formed, of which the Smoky Mountains are the southern end of this mountains chain.

Changing Mountains

The Appalachian Mountains have changed over time because of other forces acting upon them. Wind, rain, plants, and animals are constantly breaking down the rock or weathering it into smaller and smaller pieces until some of those pieces blow or wash away through a process called erosion.

Rock Formation & the Rock Cycle

Igneous rocks are formed when magma (molten rock in the Earth's mantle) rises into the crust layer, cools, and solidifies. Igneous rocks are often made up of many different minerals. If the rock cools quickly (such as pumice and volcanic glass, rocks that form from volcanic eruptions), it may be impossible to see the individual minerals. However, individual minerals are visible in many cases (such as granite) where rocks have cooled slowly underground.

Sedimentary rocks are formed from deposits of pieces of other minerals or rocks (including igneous, metamorphic, or sedimentary rocks).

The accumulation occurs in layers, with the oldest pieces on the bottom. The pieces may be carried by water, wind, and glaciers. Also, there are some types of rock which are chemically deposited or precipitated, like limestone. Chemically precipitated sedimentary rocks can be distinguished from other types by their crystalline texture (individual grains cannot be distinguished).

Metamorphic rock means "changed rock." Any type of rock can be changed into a metamorphic rock. Change generally occurs when rocks are subjected to extremes of pressure and temperature. Under these conditions, the minerals will often be squashed together, or concentrated, into layers or bands. This is called *foliation* and is often confused with layering in sedimentary rocks. Use the example of cookies. The raw cookie dough is the sedimentary or igneous rock, but once they are cooked the materials change because of the heat and become a different thing, still made out of the same ingredients; minerals, or in the case of cookie dough, eggs, milk, sugar, flour, etc.

Since the raw materials that make up any of the rock types could have come from any of the three types of rock (i.e., the sediments that make up sedimentary rocks could have come from igneous, metamorphic, or even another sedimentary rock), the three types of rock considered together form the *rock cycle*. The three types of rock are undergoing a continual recycling process, transforming from one type to another. The Earth is essentially a closed system—aside from extraordinarily small amounts of material from outer space, no new material is introduced on the planet. While there are some rocks that have formed relatively recently (perhaps igneous rocks from a recent volcanic eruption), there is no such thing as "new" rock. Every rock is made from materials as old as the Earth; these materials may have taken on many different forms over the ages.

ROCK-ROCKITY-ROCK

20 Minutes

Lead In

Explain that we are now going to review how igneous, metamorphic, and sedimentary rocks are formed by playing a game.

Procedures

Have the students stand in a circle around you. They need to be able to reach the person next to them and have their hands free. When the instructor points at a student and says a rock type, the student has to perform a certain movement, while the students on either side perform complementary movements. They need to be doing the correct movement before the instructor can finish saying 'Rock-Rockity-Rock.'

- Igneous movements: the center student 'becomes' a volcano,

simulating an explosion from the top of their head. The side partners become the lava that flow down the sides.

- Metamorphic movements: the center student forms a mountain with their arms while the side partners push on the 'mountain.' Be careful!
- Sedimentary movements: the center student forms layers with their arms while the side students add their arms into the layers.

Increase speed as the students become comfortable with the game. This can also be played with an elimination round.

Wrap Up

Now that the students are comfortable with the three ways rocks are formed, you're ready to hike!

Teacher's Note: This lesson is designed so that it can be done in a variety of ways, depending on your teaching style. There is much flexibility in the content as well as the progression of activities. At this point the group will be divided into two parts for cooperative teaching. Here is a suggested format for the lesson. Group One will begin hiking immediately and do the scavenger hunt, followed by the activities at the falls and then the concluding activity. Group Two will do an optional activity, then begin hiking and working on the scavenger hunt, followed by activities at the falls and return to Tremont. The number of stops for the trail activity is optional, depending on time and depth of coverage. There will not be enough time to do all the activities in this lesson, so knowledge of what you want to cover is necessary beforehand. Be familiar with the material. Another option is for one group to do some or all of the scavenger hunt on the return trip to Tremont.

1 HR

SCAVENGER HUNT TO THE FALLS

One Hour

Lead In

Explain that on the hike to the falls, the students will be participating in a scavenger hunt to further improve their observation skills while also noticing the forces that have shaped the Smokies. Review hiking expectations with them. (respect the flora and fauna, do not pick anything that is alive, walk single file, stay on the trail, no running, no throwing rocks or sticks, no walking sticks)

Procedures

Give each student a scavenger hunt card. (See list and key at end of lesson.) Explain that some of these things are difficult to find, and they will have to use deductive reasoning as well as good observational

skills. Tell the students that when they find the object on their card, they need to point it out to everyone else. Stop at that point to look at the object and discuss what has occurred or what will happen. The key will help give direction to the discussion. Again, the number of stops is optional, but think about each stop as part of a puzzle they are trying to solve. The more pieces present, the better the picture. Each of these 'pieces' helps explain how the geology of this area makes the Smokies a unique ecosystem.

Wrap Up

Upon completion of the Scavenger Hunt, ask the students to gather around for a short discussion. Use the results of the discussion to help the students better understand soil formation and erosion. Ask them the following questions:

- From what they have observed on the slopes, how does the geology of an area affect the plant life?
- In what ways might the forest here be different if there were no mountains?
- How are rocks broken into smaller pieces? (Gravity naturally pulls down mountains; freeze-thaw action enlarges fractures created by regional stresses, i.e., plate tectonics, chemical breakdown, physical weathering from streams, glaciers—though not here in the Smokies—wind, etc.) This process is called *weathering*. Did they see evidence of this on the hike?
- What do these rocks become after they break down? (other rocks, sediment, soil)
- Is this the only action necessary for soil to form? (No; soil formation also requires decomposition of organic material.)

Activities At The Falls

Safety Note: Close supervision is critical at the waterfall area. Keep students on one side of the water, and do not allow wading or climbing up the steep hillsides or the waterfall itself. Remind the students that wet rocks are slippery and that they should not drink the water.

5 MINS

FALLS ILLUSION

5 Minutes

Lead In

This activity is done after arriving at the falls. Tell the students that once again they have done a great job observing a wide variety of things. Now you are going to show them that, while many things can be learned from observation, our minds can also play tricks on us.

Geology Hike to the Falls Activities

Procedures

Gather the students together so that each of them can see both the waterfall and the large rock face to the right of the falls. Explain that they must each choose a spot on the waterfall where the water is moving. They must stare at that spot, without looking away, for about 60 seconds. They should not follow the water's motion downstream, but should instead stare at a single spot while water flows over it.

At the end of the time period, you will tell them to look immediately at the rock wall. If they have followed the directions properly, the rock wall will appear to waver up and down (you do not have to tell them what will happen beforehand).

Teacher's Note: The reason for the optical illusion is that the brain has become accustomed to motion and cannot readjust quickly, much the same as when people feel the land is moving after they have been on a boat for a long period of time.

Wrap Up

People cannot always trust their eyes. That is why humans use other senses and also sometimes use more sophisticated equipment.

MOVING WATER, MOVING ROCKS

10 Minutes

Lead In

With the group still gathered together, begin by making the following observation: the movement of the water over the falls and downstream can be easily seen. The students have just experienced an optical illusion by tricking their minds into thinking that the rock by the falls was moving. Is there movement here that cannot be seen, yet they know is happening? Ask them to use imagination and the observation skills that they have sharpened during the scavenger hunt to discover the hidden movement.

Procedures

Give the students a few minutes to look around, from where they are seated, before asking the following questions:

- Where do they see movement? (in the water, the falls, leaves on trees or caught in little whirlpools)
- Where did all this moving water come from? (rain, run off, seeping from springs)
- How old is the water? (Some might have fallen as rain today, yesterday, or last week; some might have been snowmelt from last winter; and some might have been slowly filtering down from the mountains through the rocks and soil for thousands of years.)
- Are the rocks moving? (Yes; water erodes rock and carries it

down hill or downstream.)

- Is the waterfall moving? (Yes; the water is moving, but so is the location of the falls itself. As the water erodes the rock, the face of the waterfall moves upstream higher into the mountains.)
- What evidence do they see that supports this? (The fallen rock at the face of the falls, the stair-step appearance of smaller falls and pools downstream; these are places where the face of the falls used to be, so at one time the face of the falls was much nearer to the river.)
- Where might all these tiny bits of rock and soil that the water is carrying someday come to rest? (the Mississippi River Delta or the Gulf of Mexico)

Wrap Up

Ask the students:

- What natural force is at work here? (water power or erosion)
- What two natural cycles have they seen evidence of? (the water cycle and the rock cycle)
- How do the rocks and soil affect the water that seeps through them? (Rocks and soil can filter out impurities.)
- What is water doing to the Smoky Mountains? (It is eroding the mountains.)

When they return to Tremont, they may have the opportunity to play a game, Erosion Explosion, that will show more about the relationships between water, soil, and plants.

ROCK PAINTING

10 Minutes

Lead In

The students have been careful observers, learning about some of the rocks in the Smokies and how the rocks, soil, water and plants are all tied together. One thing which has not been discussed is how humans have used and benefited from rocks and soil.

Procedures

Ask the students how humans use rocks and soil. Some possible answers include:

- fuel
- dyes
- jewelry
- building materials
- sculpture
- medicine
- weapons
- grow crops
- money
- plastics
- glass
- iron and steel
- pottery
- tin cans
- paint
- aluminum cans

Gather colored stones from the stream. Stones and soils were two sources from which the Native Americans obtained pigments, and today people still use rocks, minerals, and soil to create paints and dyes.

Show the students how to make paint. This is done by first wetting the rock and then rubbing it against another rock. The more you rub, the thicker, and sometimes the darker, the paint becomes. Let the students search for colored rocks to make their own paints. Tell them that they can paint on each other's faces, paper, or the rocks. However, if they paint the rocks around them, they should wash off the paints before leaving.

While the students are doing their various activities, keep a close eye on them to make sure they are following safety procedures (no rock hopping, no rock throwing, stay within set boundaries).

Wrap Up

Gather the group back together. Tell the students that by making their own paints they have learned another way that humans use rocks.

Teacher's Note: Hike back to Tremont, doing any of the trail activities not yet covered as time allows. Allow at least 45 minutes just for the hike back and the concluding activity.

Conclusion

Teacher's Note: If there is no time for the Geologic Timeline or the Erosion Explosion game, go over the questions below as a wrap-up to the geology lesson, near the end of the trail or when you have returned to Tremont.

- What is geology? (study of the earth)
- What are some of the effects of geological processes seen today? (smoothed rocks, rounded mountain tops, north/south slopes, 'creep', cracked rocks)
- How does geology shape the Smoky Mountains and the organisms living here? (North/south slopes and elevation changes create micro-habitats suitable for certain species of plants and

animals; changes in soil types create different plant and animal communities.) How would the forest be different if there were no mountains?

- How can living organisms affect geology? (Plants and animals decompose to become soil; plants can change soil chemistry and break rocks down into soil; humans create artificial landforms; etc.)
- What other national parks can they think of that have interesting geological features? (Grand Canyon, Yellowstone's geysers, Volcanoes National Park in Hawaii, Arches National Park, Yosemite's mountains and waterfalls, etc.)

OPTIONAL ACTIVITIES

EROSION EXPLOSION

15 Minutes

Lead In

Ask the students what term describes the washing away of soil. (erosion) What is the relationship between soil and plants? (Plants prevent erosion by trapping soil with their roots.) Tell the students they will now play a game demonstrating the importance of plants in preventing soil erosion. In this game they will play the role of plants or grains of soil; the object of the game is to not be eroded. A good place to play this active game is in the field area near the blacktop.

Procedures

Hand out cards labeled with the various roles. All of the students will be grains of soil and water. Place three hula-hoops at the end of a playing field to represent three types of plants. The job of the trees is to provide a safe refuge for the grains of soil that do not want to be eroded.

Assign one of the plants (hula-hoops) to be an old oak tree, another to be a pine tree, and the remaining plants should be smaller shrubs (mountain laurel, rhododendron). Larger trees have the ability to hold more soil because of their deeper root systems and more extensive shallow feeder roots, while the smaller shrubs can protect fewer grains. This is expressed by the number of grains indicated on the cards, which are placed inside the hula-hoop. For example, the oak tree's card has the number three. This means that the tree can hold three grains of soil. The pine tree will have a number two and the shrubs will each have a number one.

One student will play the role of water. His or her job is to run and tag the grains of soil before they can attach (jump inside the hula-hoop)

themselves to one of the plants.

On the teacher's call, the grains of soil are to run and try to latch onto one of the plants before they are tagged by the water and before the plants are filled to their capacity with other grains of soil. If a grain of soil is tagged, it has been eroded and must return to the established starting point. A grain of soil must also return to the starting point if it runs to a plant which is full.

In the first round, expect only a couple of grains of soil to be eroded. Ask the students if the erosion of a few grains of soil is a serious problem. (No, erosion is a natural process that is not necessarily problematic.) Before starting the second round, explain that you need to cut down the old oak tree for firewood and that you need to cut down the pine tree for notebook paper. Remove one of the trees by removing a hula-hoop and explain to the students that it is now dead and consequently cannot hold any grains of soil. Then play again and watch what happens. In the second round there will be a marked increase in the number of grains of soil who get eroded.

Wrap Up

Ask the students why there was such a dramatic increase in the amount of soil erosion. Have them explain the relationship between plants and soil erosion. (When trees are stripped from the land, the amount of soil erosion increases.) Ask the students how or why this is a problem.

Has there been a time in the past when erosion along these hillsides was greater than it is today? (Yes, when this area was logged in the first half of the 20th century.)

What would happen if the trees died from a lightning strike and were left in the forest? (They would decompose and turn into soil.)

Have students name some other things that are eroded. (mountains, rocks, river beds, etc.) Make certain they understand that this is a much slower process than soil erosion. It may occur over many millions of years.

GEOLOGIC TIME LINE

15 Minutes

Teacher's Note: These numbers that coincide with the time line are painted on the blacktop near the Friendship Circle and the staff apartments.

Lead In

Rocks are being created all the time. Because of this, some of the Earth's history has been captured and preserved in rocks. This allows geologists to create a time line for life on Earth.

Procedures

Tell the students they will travel in time, looking at the history of the Earth.

Wrap Up

Encourage the students to notice the distance from the beginning of the Earth to present day. Point out also how little time humans have existed in the history of the Earth.

Review some of the events on the time line which the students find most interesting. Is the Earth still changing?

Ask the students if humans, although one of the recent additions to this planet, will affect it more than other inhabitants. Why or why not? Can people change this fact? What are some ways that we can lower the effect or impact we have on the Earth?

SOIL RESOURCE SHEET

Soil Background

Lead In

Soil is the home of many kinds of plant and animal life that range in size from those too small to see even with a powerful microscope to large ones such as earthworms. Most of the living organisms in the soil are so small you will not be able to see them without a microscope. Some examples of life that is too small to be seen are bacteria, fungi, and algae. Animal life in the soil includes protozoa, microscopic animals larger than bacteria, earthworms, ants, snails, spiders, mites, and various other worms and insects.

Earthworms are among the most important group of the larger animals. They live in soils that are high in organic matter (from the decay of once-living plants) and are not too sandy. There can be as many as two hundred to one thousand pounds of earthworms in one acre of soil. Earthworms pass several tons of soil through their bodies each year. By doing this, they make burrows that let water and air move more freely through the soil. Earthworms also bring soil from lower levels to the surface, thus mixing the soil. Other animals, such as some rodents, ants, snails, spiders, mites, millipedes, centipedes, and other worm-like creatures, help the soil in the same ways and live there their whole lives.

Procedures

Show the students a patch of soil and explain what it means to take one square foot of soil. Describe several of the organisms that could be found in this square foot of soil.

- Worms (such as earthworms or nightcrawlers having no legs)
- Grubs (beetle and other insect larvae; they have a worm-like body with legs)
- Snails (snails without shells are called slugs)
- Insects (hard-shelled, soft-bodied animals with three pairs of

legs)

- Spiders, mites, ticks (animals with four pairs of legs)
- Animals with more than four pairs of legs (centipedes, millipedes, and sow bugs)
- Others (any animal not falling into one of the above groups)

The Greek philosopher Aristotle referred to earthworms as "the intestines of the earth."

Numerically speaking, there are probably more individual life specimens living below the ground than above it, if we consider the top layer of undecomposed litter as part of the soil. When you walk in the forest, every footstep covers a menagerie of life more fabulous than any zoo, regardless of its size. If you were to dig up one square foot of any rich forest soil to the depth of eight inches and examine it carefully, you would find, on average:

- 26.5 trillion cocci bacteria
- 4.30 trillion nitrogen-fixing bacteria
- 18.5 trillion bacilli organisms
- 320 billion yeast fungi cells
- 880 billion fungus mycelia

This totals about 50 trillion microscopic organisms! In addition to the microscopic life, you would also have typically found:

- 6,315 mites of various species
- 1,977 springtails
- 63 insect larvae
- 47 ants
- 43 telson tails
- 36 false scorpions
- 29 garden centipedes
- 28 insects
- 27 millipedes
- 27 spiders
- 12 pauropods
- 10 other centipedes

- 6 earthworms
- 5 species of animals large enough to see without the aid of a microscope

—from *The Soil*, by Ellwood J. Carr

Wrap Up

Soil is a critical element of any ecosystem. Where does soil come from? How does it impact the ecosystem? Use the questions below as discussion generators with the students:

What is soil? How is it made? (leaves, sand, silt and clay from rocks, animal parts, plant parts, water, and air rich in carbon dioxide)

What does decomposition mean, and how is it connected with soil? What are some examples of decomposing things? (rotting logs, dead animals) What causes the decomposition? (decomposers: worms, fungi and a host of microorganisms)

Do they think that these different kinds of soil are able to support various kinds of plant life? (Yes, they can and do support different types of plant life. The different kinds of soil allow for differences in the acidity, percolation, nutrient holding ability, etc.)

What kind of life is there in soil? How does this life affect the soil? How does this life depend on soil for its existence? What organisms depend in turn on that life for their existence?

Example: Plants depend on soil for nutrients and a foothold for growing. A deer depends on plants to eat for its survival. The soil quality depends on the plants because their roots aerate the soil and add organic matter, and the root-hold that the plants have in the soil keeps the soil in place, decreasing erosion and runoff. The soil nutrients depend on the deer because the deer will pass waste and eventually die, and its remains will become soil along with the dead bodies of plants.

Are all soils the same? Why or why not? (No, they are made up of different things: differing types and amount of minerals and organic matter, varying moisture and organisms, etc.)

Explain that the pattern of dependence discussed earlier (soil/plants/deer/soil) is called a cycle. What else is involved in this cycle? (sun = energy source for plants; water, soil and rock cycles; food chains = herbivores eating plants, carnivores eating other animals, all plants and animals dying and being returned to soil through decomposers)

Organisms living in the soil that act as decomposers make the soil one of the Earth's greatest natural recyclers. What would happen if these decomposers were killed off or were unable to do their job?

What are some ways in which humans are harming the natural recycling service that the soil provides? How are humans helping this process? Do people depend upon the soil? (Yes, humans need the soil because all food ultimately comes from the soil: vegetables, fruits, grains, and meat. Also, oxygen comes from plants.)

Geology Hike to the Falls Activities

CHEROKEE CREATION MYTH

15 Minutes

Lead In

Myths abound in many cultures. They are a way of interpreting and making sense of the world around you. Ask the students if they've ever heard or read any myths (Just So Stories is read by many children). They are usually based on careful observation of nature, and often have some elements that correlate with our best scientific understandings of the world. Many cultures have Creation Myths—stories of how the Earth and all its living things came to be. Students should be reminded that myths, though they may contain factual elements, are still just stories, and as such should be enjoyed, but not taken as the truth.

Procedures

The Creation Myth below can be read before the group begins the hike, or it makes a great activity for rest stops. Read the story below to the group:

The Creation Myth

At the beginning of time, all creatures lived in the sky. This was before the world was made. As the animals, birds, and insects grew in population, the sky world so became crowded that there was danger of some being pushed off. So a council was called of all the animals to decide what was to be done about the situation. They decided that they needed to find a new home.

Below the sky, water covered everything. The animals thought that it would be of no use to them, but they decided to send the water beetle down to see if he could find even a single inhabitable spot. Water beetle skimmed over the surface but could not find any solid footing, so he dove down to the bottom and brought up a little dab of soft mud. Magically the mud spread out in the four directions and covered a very large area.

In the beginning, the earth was flat, soft, and moist. All the animals were eager to live on it, and they kept sending down birds to see if the mud had dried and hardened enough to take their weight. But the birds all flew back and said that there was still no spot they could perch on.

Then the animals sent Grandfather Buzzard down. He flew very close and saw that the earth was still soft, but when he glided low over what would become Cherokee country, he found that the mud was getting harder. Grandfather Buzzard flew lower still to get a better view. When he flapped his enormous and powerful wings downwards,

they made a valley where they touched the earth. When he swept them up, they made a mountain. For each stroke of his wings, valleys and mountains were created.

After the mountains had risen up, the water collected in streams, and the streams gathered together into rivers, and the rivers drained the water from the mountains. At last the earth was hard and dry enough to live on, and so the animals descended from the heavens to occupy the new land.

—Adapted from Tom B. Underwood, *The Story of The Cherokee People*, and from the Cherokee Treaty Council meeting in New York City, 1975

Wrap Up

It turns out that much of how the Cherokees interpreted the history of the earth correlates with geologists' findings today. Great Smoky Mountains' rocks are composed largely of sediments of mud and sand that accumulated over long periods of time in an ancient ocean. The mountains themselves are erosion features carved out by rivers from a massive over-thrust fault mountain range.

Fancy scientific instruments or lots of training are not needed. The students can figure out much of the rock puzzle through careful observation. That's what we're doing today.

ROCK COLLECTION

Lead In

Begin by asking the students to use their powers of observation and curiosity to discover what types of rock may be deep below their feet or high above them in the mountains. The forest covers so much of the Smokies geology that they need to hike to a spot where the rocks can be seen. Can they come up with an idea of how this valley and the mountains got here?

Procedures

Use rocks from the Tremont rock collection and place several on the floor for students to observe.

Have the students look at each type of rock and observe and record the differences in the following characteristics:

- **Hardness.** One way to tell relative hardness is to take another rock and try to scratch the first rock. They could line up the rock types in order of hardness.
- **Texture.** Which rock types are smoothest? Rate each type on a smoothness scale from one to five. How do they think being in or near the river affects the smoothness of the different rock types? (In general, being transported by water makes all rock types smoother. Rocks of the same types found away from the

river might not be as smooth. The movement of water into cracks might also break apart rocks, continually keeping them angular, until they became broken up into their mineral components.)

- **Appearance.** This refers to the shine of the rock. Adjectives commonly used to describe luster include metallic (the way gold, silver, pyrite, or any opaque substance would shine), vitreous (like glass), and greasy (surface has the appearance of being oily, like talc).
- **Structure.** Look at the shape of the rock as a whole; it helps to have a larger piece. Is it layered? Are the layers thin? Thick? Uniform in thickness? Is the rock blocky with regular fractures? Is it massive (one big piece with few or irregular fractures)?
- **Color.** Describe the color or colors in each rock. Where do these colors come from? (Some come from the natural color of minerals that form the rocks, some are from oxidation of minerals within the rocks., i.e., iron oxidizes to red and yellow, copper oxidizes to green, manganese oxidizes to black.)
- **Minerals.** Using a hand lens, can the individual minerals in the rocks be seen? Granite is a good example of a rock that has visible individual minerals (quartz, biotite, feldspar).

Collect all the colored rocks, and tell the students that you will keep these as a rock "paintbox." Later on in class, they will have a chance to use these rocks in much the same way that the Native Americans used them: as face paints or to paint pictures.

Wrap Up

Tell the students that they have done a great job of observing and describing. Tell them that in addition to making observations, scientists must also use the information they have gathered to form hypotheses and to draw conclusions.

Tell the students that they must now decide the origin of each of the rock types. As students guess the origin of each rock, point out the ways that humans have used the different types of rocks.

- Coal—used for creating energy but also creates air pollution which is a reason why it is important to conserve energy.
- Slate—was used for school as a slate board to write on, but is used today for countertops, tiles, and slate roof shingles.
- Granite—used for statues, buildings, gravel driveways and roads.
- Quartz—mineral found in our watches and other electrical equipment. It can conduct electricity but does not have heat as a by-

product. When you strike two pieces of quartz together you will see a spark. This is called triboluminescence (light from friction).

- Limestone—used for fertilizers, statues, building materials.
- Rocks and minerals are all around us! Can you think of other ways that we use rocks in our everyday life? (decorations, gems, concrete, need them for our bodies to function properly—such as iron, calcium)

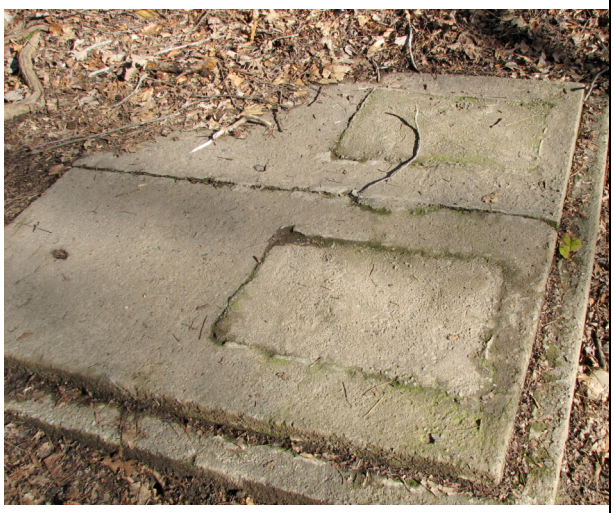
Geology Hike to the Falls Resources

Scavenger Hunt List

Black or dark brown soil	Cement foundation
Tree with rows of horizontal holes	Rotting tree
Area with human-caused erosion	First scenic view of the mountains
Layers of rock	Place that looks like a landslide
Plant roots breaking rocks	Rock with variety of lichens
Rock-eating tree	Rock with quartz veins
Place with water erosion	Pine/oak forest
Hardwood/ hemlock forest	A smile
Piece of sandstone	Rock split at 110° angle

Geology Hike to the Falls Resources

SCAVENGER HUNT KEY

	**Black or dark brown soil** Humus–how is it formed? (from decaying organic matter) What is *organic*? (comes from something once alive) What does this have to do with geology? (it's part of the soil cycle, which allows plants to grow) *This can be found in multiple places along the trail.*
	**Cement foundation** What is this object? Ask the students to observe its size, shape, and details. Hint: this area was once a Girl Scout camp, and this was something everyone needed. (the foundation for an outhouse) What is it made of? (cement, which is made from rocks) Will this ever decompose or erode? (after a long period of time; this type of material takes up a lot of space in landfills) How old is this foundation? (dates from 1940s) Do geological occurrences happen very quickly? (some do, like earthquakes, but most are very slow)
 	**Tree with rows of horizontal holes** What made these holes? (a woodpecker called a *Yellow-bellied Sapsucker.*) What does this have to do with geology of the Smokies? (the drilling helps create soil; woodpecker holes are often an indication of a dead or diseased tree, which will create more soil) What can happen if this tree dies or falls over? (erosion) Why? (no roots to hold soil)

Geology Hike to the Falls Resources

SCAVENGER HUNT KEY

	**Rotting tree** What is happening to this tree? (it's decomposing) What does it create? (soil) Is this good or bad? What would happen if no more soil was made? (nutrients would be locked up and unavailable for growth and life.) Have the students examine the log for signs of how decomposition helps living things. *This can be found in multiple places along the trail.*
	**Area with human-caused erosion** What caused the erosion? (humans) Where will the eroded material go? (to the Middle Prong River) Will this area recover? (depends on weather conditions, such as rain; and usage, such as people staying away) Is all erosion bad? (no; it helped form the Smokies, keeps rocks and minerals in the cycle of nature). *This can be found in multiple places along the trail.*
	**First scenic view of the mountains** Will Walker named the closest mountain across the river Fodderstack Mountain, because it reminded him of a stack of animal fodder. Look for the two parallel lines of evergreens running down the center. This is the Little Greenbrier Fault. What is a *fault?* (a crack or weak spot in the earth's crust.) The Little Greenbrier Fault separates layers of rock. What happens when the layers of rock slip against each other? (earthquakes or tremors) The last "big" quake here was around 1910 and was strong enough to knock chimney stones down.

Geology Hike to the Falls Resources

SCAVENGER HUNT KEY

	**Layers of rock** What kind of rock is this? (This is a metamorphic rock that was once sedimentary: phyllite, which is similar to slate. It was originally formed from mud.) What was here to cause this type of rock to form? (a shallow sea) Why are the layers tilted at an angle? (When the continents collided and the mountains formed, the flat layers of mudstone were pushed up.) These rocks are also found in the Little Greenbrier Fault line. *This can be found in multiple places along the trail.*
	**Place with water erosion** What evidence shows erosion? (smooth rock, valley sides) Does this happen quickly? How do you know? Is it still occurring? *This can be found in multiple places along the trail.*
	**Place that looks like a landslide** (after first stream crossing) This is a "block stream." What happened to cause the rocks to be like this? (gravity, weathering, erosion) Higher up, there is a cliff where weathering is breaking big chunks of rock, and gravity causes them to fall downward. How does weathering cause the chunks to break? (Water freezes in the cracks and expands. Over time, this causes the cracks to get bigger. Eventually the rock breaks off.) Ask the students to look around and see if they can figure out which was there first, the rocks or the trees. *This can be found in multiple places along the trail*.

Geology Hike to the Falls Resources

SCAVENGER HUNT KEY

	**Plant roots breaking rocks** How can roots break rocks? (They excrete a chemical that breaks the rocks and allows the roots to grow into and through it.) What will happen to this rock eventually? (It will turn into soil or fall down the slope.) *This can be found in multiple places along the trail.*
	**Rock with variety of lichens** What is a lichen? (an algae and a fungus living together) What significance does it have for geology? (It is the first step in the process of succession, helping break rocks into soil and allowing other plants to grow.) *This can be found in multiple places along the trail.*
	**Rock-eating tree** Which was here first, the tree or the rock? Ask the students to explain their answer. (Some possibilities are: the rock, and the tree grew around it; or the tree, and then gravity pulled the rock down the hillside where it landed on the tree, which then grew around it. No one knows for sure.) Does gravity affects plants in any other ways? Will the rock affect the growth of this tree? *This can be found in multiple places along the trail.*

Geology Hike to the Falls Resources

SCAVENGER HUNT KEY

	**Rock with quartz veins** Quartz is a very hard mineral, common in the Smokies. Have the students touch the rock to notice that the vein has not weathered as much of the rest of the rock, so it sticks out a little. How did the quartz get in the rock? (The ions that make up the quartz mineral precipitated out of the water from the shallow sea and filled in the cracks of the semi-hardened sedimentary rocks.) *This can be found in multiple places along the trail.*
	**Rock split at 110° angle** What caused it to split like this? (weathering, water freezing in the cracks and expanding to widen the crack) What will eventually happen to this rock? (It will break and the pieces will eventually make their way into the river.)
	**Hardwood-hemlock forest** Stop at the ridge, just before you start to walk downward. What type of trees do you see? (deciduous, also known as hardwood trees, and hemlocks. In general on the Falls Trail, an evergreen tree with short, flat needles and very small cones is a hemlock.) What conditions are found here? (cooler temperature, dark soil, more shade, moist) What direction does this slope face? (North or northwest, away from the sun.) *This can be found in multiple places along the trail.*

Geology Hike to the Falls Resources

SCAVENGER HUNT KEY

	**Pine-oak forest** Stop at the ridge, just before the trail starts to go downward. What type of trees do you see? (Pines, evergreen shrubs. In general on the Falls Trail, an evergreen with longer needles and fist-sized cones is a pine.) What conditions are found here? (warmer, drier, sunnier) What direction does this slope face? (South or southwest, towards the sun.) *This can be found in multiple places along the trail.*
	**Piece of sandstone** Most of the rocks in the area are called "Thunderhead Sandstone," named for nearby Thunderhead Mountain. This is a very hard sandstone which is resistant to erosion. Most of the waterfalls in the Smokies fall over Thunderhead Sandstone. Can the individual grains of sand in the rocks be felt? In what category of rock is sandstone? (sedimentary) *This can be found in multiple places along the trail.*

Erosion Explosion Cards

Oak Tree (3 grains)	Water
Pine Tree (2 grains)	Water
Shrub (1 grain)	Shrub (1 grain)
Grain of Soil	Grain of Soil
Grain of Soil	Grain of Soil
Grain of Soil	Grain of Soil
Grain of Soil	Grain of Soil

Geology Hike to the Falls Resources

Geologic Time Line

Walk beside the road below the Friendship Circle. At the appropriate places, stop and discuss what the state of the Earth was at that point in time.

Key: 1/10 (0.1) of an inch = 416,667 years
1 inch = 4,166,667 years
6 inches (1/2 foot) = 25,000,000 years
1 foot = 50,000,000 years
5 feet = 250,000,000 years
20 feet = 1 billion years

1.	0 feet	Estimated age of the Earth at 4.6 billion years
2.	80 feet	Development of multicellular marine organisms
3.	82 feet	Development of trilobites and marine invertebrates; **AGE OF MARINE INVERTEBRATES**
4.	83.35 feet	Earliest Appalachian Mountains formed 430,000,000 years ago
5.	83.5 feet	Life abundant in seas
6.	84 feet	First land plants, development of fishes, first air-breathing animals; **AGE OF FISHES**
7.	84.5 feet	First amphibians appear, development of crinoids, first forests spread over land; **AGE OF AMPHIBIANS**
8.	86 feet	Deposition of coal-bearing strata 300,000,000 years ago
9.	87 feet	Conifers abundant, reptiles developed, spread of insects and amphibians, extinction of trilobites
10.	87.5 feet	Latest Appalachian Mountains formed
11.	88 feet	First dinosaurs appear, first mammals appear
12.	89.5 feet	Dinosaurs dominate, first birds appear; **AGE OF REPTILES**
13.	90.5 feet	Extinction of dinosaurs, development of flowering plants
14.	90.75 feet	Rocky Mountains formed 63,000,000 years ago
15.	91.5 feet	Development of mammals; **AGE OF MAMMALS**
16.	91.65-91.85 feet	Development of man, rise of civilization, extinction of large mammals, ice ages; **AGE OF MAN**
17.	92 feet	Present

SOIL RESOURCE SHEET

Numerically speaking, there are probably more individual life specimens living below the ground than above it, if we consider the top layer of undecomposed litter as part of the soil. When you walk in the forest, every footstep covers a menagerie of life more fabulous than any zoo, regardless of its size. If you were to dig up one square foot of any rich forest soil to the depth of eight inches and examine it carefully, you would find, on average:

- 26.5 trillion cocci bacteria
- 4.30 trillion nitrogen fixing bacteria
- 18.5 trillion bacilli organisms
- 320 billion yeast fungi cells
- 880 billion fungus mycelia

This totals about 50 trillion microscopic organisms! In addition to the microscopic life, you would also have typically found:

- 6,315 mites of various species
- 1,977 springtails
- 63 insect larvae
- 47 ants
- 43 telson tails
- 36 false scorpions
- 29 garden centipedes
- 28 insects
- 27 millipedes
- 27 spiders
- 12 pauropods
- 10 other centipedes
- 6 earthworms
- 5 species of animals large enough to see without the aid of a microscope

—from *The Soil*, by Ellwood J. Carr

SOIL RESOURCE SHEET

Animal Groups in Soil

Show the students a patch of soil and explain what it means to take one square foot of soil. Describe several of the organisms that could be found in this square foot of soil.

- Worms (such as earthworms or nightcrawlers having no legs)
- Grubs (beetle and other insect larvae; they have a worm-like body with legs)
- Snails (snails without shells are called slugs)
- Insects (hard-shelled, soft-bodied animals with three pairs of legs)
- Spiders, mites, ticks (animals with four pairs of legs)
- Animals with more than four pairs of legs (centipedes, millipedes, and sow bugs)
- Others (any animal not falling into one of the above groups)

Soil Background

Soil is the home of many kinds of plant and animal life that range in size from those too small to see even with a powerful microscope to large ones such as earthworms. Most of the living organisms in the soil are so small you will not be able to see them without a microscope. Some examples of life that is too small to be seen are bacteria, fungi, and algae. Animal life in the soil includes protozoa, microscopic animals larger than bacteria, earthworms, ants, snails, spiders, mites, and various other worms and insects.

Earthworms are among the most important group of the larger animals. They live in soils that are high in organic matter (from the decay of once-living plants) and are not too sandy. There can be as many as two hundred to one thousand pounds of earthworms in one acre of soil. Earthworms pass several tons of soil through their bodies each year. By doing this, they make burrows that let water and air move more freely through the soil. Earthworms also bring soil from lower levels to the surface, thus mixing the soil. Other animals, such as some rodents, ants, snails, spiders, mites, millipedes, centipedes, and other worm-like creatures, help the soil in the same ways and live there their whole lives.

The Greek philosopher Aristotle referred to earthworms as “the intestines of the earth.”

Geology Hike to the Falls Resources

Adult Geology

THUNDERHEAD SANDSTONE—Characterized by large grains of quartz, this metamorphosed sandstone, or metasandstone, was originally deposited in an ocean trench far from shore, below the waters of the Ocoee Basin between 800 to 500 million years ago. Thunderhead Sandstone is a member of the Great Smoky Group of rocks, older than the limestone in Cades Cove but younger than Metcalf Phyllite. It is a hard, erosion-resistant rock that makes up much of the bedrock in the Great Smoky Mountains. It was named for Thunderhead Mountain, a 5,527-foot peak along the crest of the park that can be seen from some places on the Falls Trail.

METCALF PHYLLITE—When fine-grained sediments such as silt or mud pile up over long periods of time, they can form sedimentary rocks like shale. If shale is subject to enough heat and pressure, it will metamorphose to become slate, a low-grade metamorphic rock. Phyllite is the result of higher-grade metamorphism of the same basic mudstone or shale. Metcalf Phyllite is a member of the Snowbird Group, which is older than Thunderhead Sandstone. The original sediments that became this rock were deposited along the shores of the Ocoee Basin.

THE LITTLE GREENBRIER FAULT—A fault is any break in a body of rock where movement happens. This fault, visible from the first scenic overlook on the Falls Trail, is between the Great Smoky Group of rocks and the older Snowbird Group of rocks. Sometimes faults will complicate the rock record by pushing older rocks up and over younger ones, but this fault just moves the younger rocks around on top of the older ones, like pushing a tablecloth around on a table. The younger Great Smoky Group is represented here by Thunderhead Sandstone, while the older Snowbird Group is represented by Metcalf Phyllite. There have been earthquakes along the Little Greenbrier Fault in relatively recent human history: the last one recorded was in 1910 and was strong enough to knock down chimney stones.

HEMLOCK-HARDWOOD FOREST—Also known as a cove hardwood forest, this ecological community grows in protected coves on the mountainsides. The soil is nutrient-rich here, the water is plentiful, and the trees grow tall. The limiting factor here is sunlight, so plants try to grow quickly to reach up out of the shady understory. This is one example of the way geology affects natural communities.

Geology Hike to the Falls Resources

Adult Geology

MIDDLE PRONG OF THE LITTLE RIVER—In the Smokies, a prong refers to a main tributary of a river, and a branch is a smaller creek. The Middle Prong is one of three prongs of the Little River, which come together at a place called the Townsend Wye, about two miles downstream from Tremont. The Little River eventually joins the Tennessee, then the Ohio, and finally the Mississippi. Spruce Flats Falls is not on the Middle Prong, but on one of its tributaries, Spruce Flats Branch.

BOULDER STREAM—This area shows some of the more recent geologic history of the region. From about 1.8 million to about 10,000 years ago, the planet underwent several ice ages. While there were not glaciers here, the climate was much colder, especially in the winter. When water flowed into small cracks in rocks and froze in that colder climate, it would expand and widen those cracks. Eventually, huge chunks would break off the original rock outcrop and roll downhill. Usually if you climb uphill for long enough above one of these boulder fields, you can find some remnant of the original bluff they broke off from.

TILTED LAYERS OF ROCK—When you see rocks that have formed in layers, you can usually safely assume that the oldest layer is on the bottom and the youngest is on the top. Also, layers are usually deposited in a generally flat area, such as at a river delta or on a beach. So, how did these rocks form, and why are they at an angle?

VALLEY OR COVE—The valleys we see today on the sides of the Smoky Mountains were formed by a combination of two main forces: the tectonic action that folded the rocks and more recent erosion from flowing water. Water doesn't stand still much in the Smokies, and running water does a lot of work. Where do you think the water in this valley comes from? What else might flow down these valleys, carried by moving water?

ROCK WITH A VARIETY OF LICHENS—A lichen is a symbiotic relationship between an algae and a fungus. In this relationship, the algae produces food through photosynthesis. The fungus shelters the algae and also helps procure nutrients from the substrate, or the surface the lichen is growing on. Most of the lichens you'll see along the Falls Trail are light green, dry, and flaky, growing on rocks and trees. What do lichens have to do with geology? Well, slowly but surely they chemically break down the rocks they grow on. Also, they help make a thin layer of soil where small plants can take hold.

Geology Hike to the Falls Resources

Adult Geology

QUARTZ VEIN IN ROCK—A mineral has a definite chemical composition; a rock is a mixture of several minerals. Quartz is a common mineral here in the Smokies and a primary ingredient in Thunderhead Sandstone. It is very hard and resistant to weathering—has this vein been less weathered than the rock it runs through? How can you tell? The veins here probably formed while the rock was thousands of feet below the ground surface, when groundwater filled cracks in the rock and quartz minerals crystallized out of the water. How did the rock reach the surface after being so far down?

PINE-OAK FOREST—In contrast with the hemlock-hardwood forest, the pine-oak forest community is found on dry, exposed ridges. Soil is thin and sandy, plants have a scrubby look, and sunlight is abundant. This is another example of the way geology affects natural communities.

PLANT ROOTS BREAKING ROCKS—In this example of the interactions between earth materials and living things, the plant is assisting with the process of erosion. It may take a long time, and it may take many generations of plants, but this rock is being broken down by the action of the roots. What do you think will happen to the pieces of rock once they are finally broken apart?

ROTTING LOG—How is this important for the forest community? What does it have to do with geology?

PLACE WITH HUMAN-CAUSED EROSION—Incidences of human-caused erosion can be found in many places along this popular trail. How can humans be agents of geologic change? What are some consequences of human-caused erosion, both here in the park and in other places, such as construction sites? If you were in charge of managing this resource, what actions would you take?

SIGNS OF WILDLIFE (NON-HUMAN)—Geology has affected the biodiversity here by creating a complex set of interconnecting habitats. There are different organisms living in coves, on ridges, in streams, etc. Some plants in the Smokies are ice age relics, stranded on high peaks from colder times. What kind of wildlife sign is this? How do you think geology affects the life of the animal that left it?