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Geology and geologic history of Great Smoky Mountains National Park
A simple guide for the interpretive program

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Introduction

The purpose of this U.S. Geological Survey Open-File Report is to provide the interpretive staff of the Great Smoky Mountains National Park with a simple description of the geology of the park including short answers to some of the most commonly asked questions about the park geology. The text is adapted and updated from "Geology of the Smokies," a single page handout provided by the Great Smoky Mountains National Park and the Great Smoky Mountains Natural History Association. The questions are from the interpretive staff of Great Smoky Mountains National Park.

GEOLOGY AND GEOLOGIC HISTORY OF GREAT SMOKY MOUNTAINS NATIONAL PARK

Sedimentary rock is formed

Most of the rocks in Great Smoky Mountains National Park are sedimentary rocks. These sedimentary rocks were formed some 450 to 800 million years ago from deposits of clay, silt, sand, gravel, and lime or calcium carbonate. The oldest sedimentary rocks were derived from vast amounts of this material that washed down into lowland basins from adjacent highlands. Rocks of the highlands are over one billion years old, and the eroded remnants of these old highlands are the ancient granite, gneiss and schist found in the eastern parts of the park. As more and more of these sediments were deposited, they were eventually cemented together and changed into layers of sedimentary rock totaling more than 50,000 feet! Early life on Earth during the formation of this great thickness of sedimentary rocks is thought to have been bacteria, algae, and small invertebrate animals. Because these creatures lacked internal or external skeletal parts, fossil evidence of them is very rare around the world and usually consists of tracks, trails, and burrows. None have been found in Great Smoky Mountains National Park.

The younger sedimentary rocks of the park are the compacted and cemented remnants of the ancient shallow-marine continental shelf that existed about 250 to 550 million years ago in what is the now the Appalachian region. Fossils found in limestone rocks in Cades Cove are about 450 million years old. By this time, small invertebrates such as trilobites and snails had well-developed hard parts, usually shells, that were preserved in rocks after death.

Mountain building

About 200 to 300 million years ago, the North American continent collided with the African and European continents. This process, known as "plate tectonics," ended sedimentation in the Appalachian region and uplifted the entire Appalachian mountain chain from Newfoundland, Canada to Georgia. These mountains may have been much higher than they are today, with elevations perhaps similar to the Rocky Mountains today. As the continents collided, tremendous pressures and heat were generated, which changed or "metamorphosed" the sedimentary rocks. For example, sandstone became hard quartzite, and shale became slate, as the rocks were heated, squeezed, and welded together. The original horizontal layers were bent or folded and broken by fractures and faults. Huge masses of older rocks were pushed westward, up and over younger rocks along nearly flat-lying faults during the "plate" collisions. In Cades Cove, younger overridden limestone was exposed by erosion, with older rocks exposed in the higher surrounding mountains. The older rocks were pushed at least 10 miles from the east to their present location.

Mountain erosion

Following this major episode of Appalachian mountain building, the new rugged highland was subject to erosion from water and wind, as well as breakdown from mechanical agents such as freezing, and chemical dissolution of rocks. As mountain valleys were carved, huge quantities of eroded sediment were transported to the Atlantic Ocean and Gulf of Mexico by rivers and streams. The layers of rock most resistant to these forces were left to form the highest peaks in the park, such as the hard metamorphosed sandstone on top of Clingmans Dome. Most of the beautiful waterfalls in the park were formed where downcutting streams encountered a ledge of very resistant sandstone that was eroded more slowly than the surrounding shale and siltstone. Today, streams and rivers are the dominant forces that continue to wear down the mountains. However, landsliding, chemical dissolution, cracking from roots, and freezing all contribute to wear away the Smokies. Scientists estimate that the mountains are being eroded about 2 inches every thousand years!

Glaciation

From about 11 thousand years ago to about 1.6 million years ago, great sheets of ice called continental glaciers advanced and retreated from Canada to as far south as central Pennsylvania and southwestern Ohio. During this time, known as the Pleistocene Epoch, these ice sheets, which were as close as about 200 miles north and west of the park, were up to two miles thick, and stretched all the way to northern Canada! The ice sheets had a profound effect on the climate in the Smokies, producing Alpine-like conditions in the higher elevations. Intense freezing and ice wedging, coupled with much snow, ice, and meltwater, fractured and broke down the bare rock outcrops at the higher altitudes into huge piles of boulders. These boulders then were moved by gravity, water, ice, and snow down the steep slopes to form the widespread rocky deposits found along the northwest part of the park. Today, these Pleistocene boulder deposits afford a unique habitat to many species of plants and animals.

Various species of Canadian-zone flora and fauna moved south, ahead of the advancing glaciers, to suitable cooler habitats throughout the Smokies region. When the glaciers retreated, these species found a home only at the highest elevations in the park that were similar to their northern Canadian homes. Thus the glacial influence on the Smokies climate, coupled with the great range in elevations, accounts for the great variety of living things in the park.

TEN GEOLOGY QUESTIONS AND ANSWERS
GREAT SMOKY MOUNTAINS NATIONAL PARK

1. How old are the Smokies?

Rocks in Great Smoky Mountains National Park range from a little over 1 billion years old to about 450 million years old. The mountains probably were formed about 200 to 300 million years ago and have been eroding since then.

2. How were the Smokies formed?

The Great Smoky Mountains are the result of the North American continent colliding with the African and European continents some 200 to 300 million years ago. During the collision, huge masses of rock at the edges of these continents were uplifted, folded, fractured, and faulted. Many of the rocks seen in the Smokies were pushed about 10 miles westward during the collision. At that time, the mountains may have been much higher than the eroded mountains we see today.

3. What are the rocks in the park?

In general, metamorphosed igneous and sedimentary rocks are the dominant rock types in the park. Igneous rocks crystallize from molten magma or lava. Sedimentary rocks form through a cycle of erosion and deposition in water. Rocks become metamorphosed when they are subjected to great heat and pressure. Metamorphosed sandstone, siltstone, and shale, predominate with minor amounts of limestone, dolomite, schist and gneiss. Metamorphosed granite and quartz veins are also present. Geologists have named about 20 different "formations" or groups of rocks that have different ages and physical properties within Great Smoky Mountains National Park. Some of these, such as the Thunderhead Sandstone or Anakeesta Formation, are named for places in the park where the typical rock type is best exposed (i.e., Thunderhead Mountain and Anakeesta Ridge).

4. What about earthquake faults?

Although several small earthquakes have occurred in eastern Tennessee, they are not associated with the numerous ancient geologic faults in Great Smoky Mountains National Park. These ancient faults formed some 200 to 300 million years in the past, and no evidence of recent movement along them has ever been found in the park. The earthquakes in eastern Tennessee are still under study, and just why they occur there is not yet known.

5. What processes are involved in rock erosion in the park?

Downcutting by rivers, streams, and creeks, under the influence of gravity, is the dominant erosive force responsible for the shape of the Smoky Mountains today. Rocks also are broken down by water that freezes in cracks, expanding the rock and breaking it down into smaller pieces. Trees and other plants also break rocks into smaller pieces when their roots grow and expand in rock fractures. Additionally, in very steep areas of the park, water-induced landslides erode rocks and soil, moving the material to the lower slopes and valleys. Weak acids, formed from rainwater percolating through leaf litter and soils, leach away minerals on rocks surfaces and lead to rock disintegration and soil formation. These same acids dissolved limestone and dolomite to form the flat valley and caves found in Cades Cove.

6. Is there any evidence of Alpine glaciation in the Smokies.

Most geologists agree that no real glaciers existed in the Smokies during the period of continental glaciation between 11 thousand years to 1.6 million years ago. However, because the thick ice sheets were only about 200 miles to the north and west of the park, the cold climate probably did have a profound effect on the park geology, as well as on its plants and animals. In the higher elevations and in shadow-filled northward-facing valleys, the average temperature was at or near freezing much of the time. Pockets of snow and ice, and frozen ground may have persisted in these areas for long periods of time. Under the influence of freezing and ice wedging, huge quantities of boulders were broken from bare cliffs to form boulder streams and boulder fields, which are common in the northwest part of the park.

7. How common are rock slides in the park?

Landslides are large masses of earth that slide catastrophically down mountain slopes. Rockslides are a type of landslides that generally involves only rocks. Debris flows are a type of catastrophic landslide that consists of rocks, soil, vegetation such as trees and brush, mud, and water. Debris flows are common in the central part of the park, particularly on the south slopes of Mount Le Conte, along Anakeesta Ridge, in the vicinity of Charlies Bunion, and east of Mount Mingus. Debris flows can be expected whenever there is a long period of heavy rain that saturates the ground on the steep slopes in these areas. Because these wetter-than-normal periods happen every few years, we should expect landslides to occur at the same time. Rockslides and debris flows have occurred elsewhere in the park but are rare.

8. How does the geology of the Smokies affect the vegetation found here?

Generally, the type of rock present directly relates to the elevation and shape of the mountains (the geomorphology), and to the soil chemistry. For example, hard metamorphosed sandstone and slate form the highest peaks, whereas easily eroded limestone and shale form the valleys. Thus, the plant and animal communities that are specifically adapted to these different areas are indirectly controlled by the geology. Soil type is related to the underlying bedrock. For example, rich soils, which are well suited for farming, occur in areas underlain by limestone. Soils have a great influence on plant ecosystems. Rocks of the Anakeesta Formation produce natural acids that affect the soils and water. Plants such as rhododendrons and evergreens do well in acid rich soils and are abundant and healthy in areas underlain by rocks of the Anakeesta Formation.

9. What minerals are found in the Smokies?

No museum quality mineral specimens have been found in Great Smoky Mountains National Park. Common minerals such as quartz, feldspar, and mica are abundant and are found in many of the rocks in the park. Other rock-forming minerals are less common but have been described by geologists. A variety of unique salt minerals are present on the surface of rock walls at Alum Cave, including copiapite, alunogen, halotrichite, pickeringite, melanterite, and rozenite.

10. What kind of mining activities have taken place in the park?

In the first half of the 20th century, two underground copper mines were in production in the southern part of the park. By-products of the mining included zinc and small amounts of silver and gold. Production ceased in 1944 when the filling of Fontana Lake cut off access to the mines. The mines are inaccessible and are now an important habitat for bats. No mineral or gem collecting sites or gold panning streams have been reported in the park.

References

Additional reading on the geology of the Smokies can be found in :

Moore, H.L., 1992, A roadside guide to the geology of the Great Smoky Mountains National Park: University of Tennessee Press, Knoxville, 178 p.

King, P.B., Neuman, R.B., and Hadley, J.B., 1968, Geology of the Great Smoky Mountains National Park, Tennessee and North Carolina: U.S. Geological Survey Professional Paper 587, 23p.