MOVEMENT OF CONTINENTAL PLATES THROUGH TIME

More than one billion years ago, all of the present-day continents on Earth were combined into a single supercontinent, known as Rodinia, which was surrounded by ocean. Some of the rocks at the core of the present-day Appalachian Mountains once were part of this landmass.

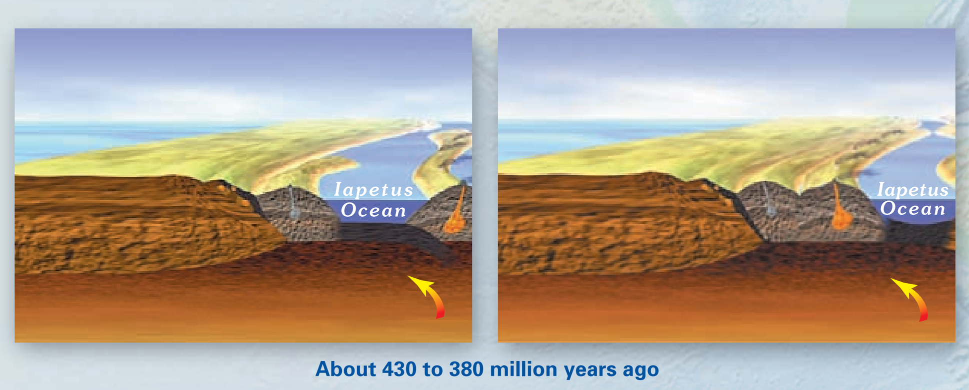
About 750 million years ago, forces deep within the Earth caused the continental crust to thin, fracture, and pull apart like warm taffy. Molten rock moved up along the fractures and formed volcanoes and lava flows at the surface. A deep basin, known as the Ocoee basin, formed when the crust began to pull apart near the margin of the continent in what is now the western Carolinas, eastern Tennessee, and northern Georgia. Seawater filled the basin and sediments carried by rivers from the surrounding hills spread out in layers on the basin floor. As the crust continued to move, the floor of the basin sank deeper into the Earth and the sediment layers became very thick.

About 750 million years ago

About 540 million years ago, as the continental crust continued to expand as the result of volcanism, the Ocoee basin stopped sinking. To the basin's east, the continental crust split into pieces that drifted away from each other. Seawater spread into low areas and formed new oceans. The ancient ocean that formed east of the North American continental plate is known as the Iapetus Ocean.

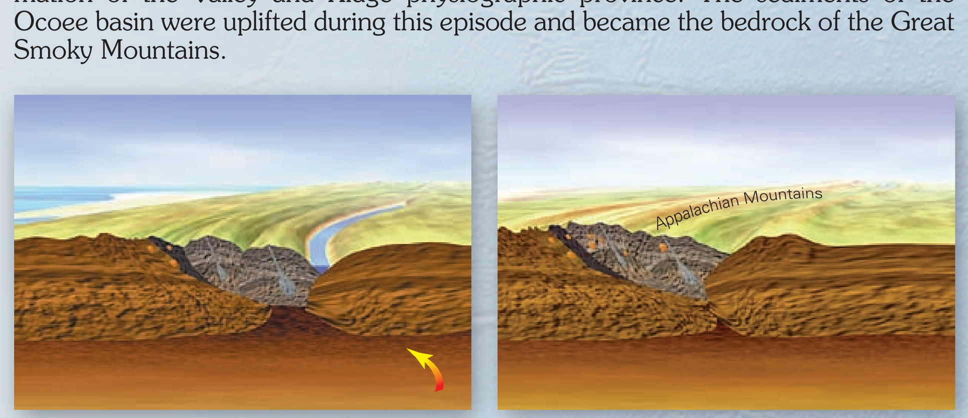
About 540 to 470 million years ago

About 470 million years ago, at the time when plants first began to appear on land, the motion of the continental plates changed. The ancestral North American and African continental plates began to move toward one another. As the continental plates moved closer, fragments of oceanic crust, ocean sediments, islands, and small continental masses were swept against the eastern margin of ancestral North America to form the bedrock of the Piedmont physiographic province and the eastern part of the Blue Ridge physiographic province.



About 430 to 380 million years ago

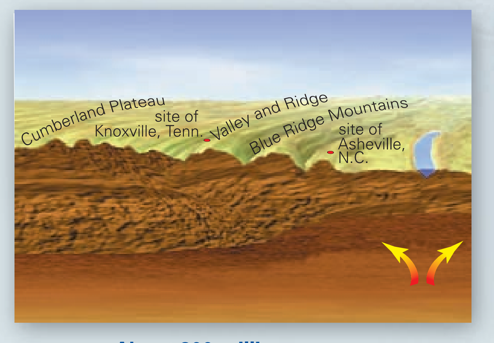
About 270 million years ago, the Iapetus Ocean closed up and disappeared when the ancestral North American and African continents collided to form a new supercontinent known as Pangea. During the collision, huge masses of rock slid across each other along thrust faults, like two enormous decks of cards being pushed together. These rocks, lifted to high elevations by the forces of the advancing continents, formed the mountains of the Blue Ridge physiographic province; folding and faulting, and subsequent erosion, to the west of the Blue Ridge resulted in the formation of the Valley and Ridge physiographic province. The sediments of the Ocoee basin were uplifted during this episode and became the bedrock of the Great Smoky Mountains.



About 270 million years ago

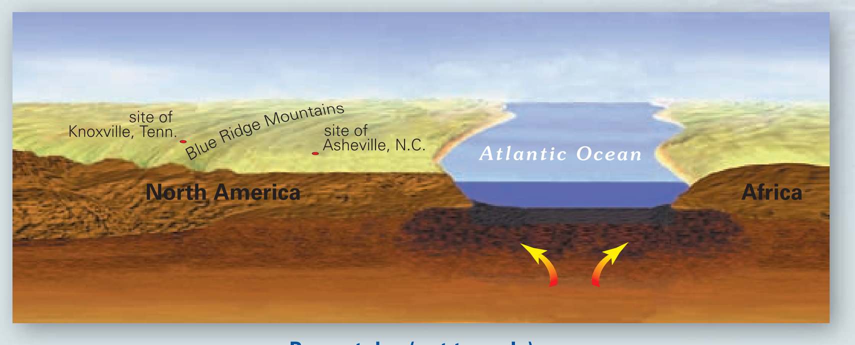
Pangea existed for about 100 million years until lava welled up from deep in the Earth along a giant fracture. Thus began the slow process of pushing the two halves of Pangea apart. Eventually, a new ocean basin, today's Atlantic Ocean, developed between what are now the continents of North America and Africa.

The present-day Atlantic Ocean began to open about 240 million years ago. The Atlantic continues to widen at a rate of about two centimeters per year as new oceanic crust forms at the mid-Atlantic Ridge. Today, a sailor following in the path of Christopher Columbus would have to sail across approximately 33 additional feet of ocean!



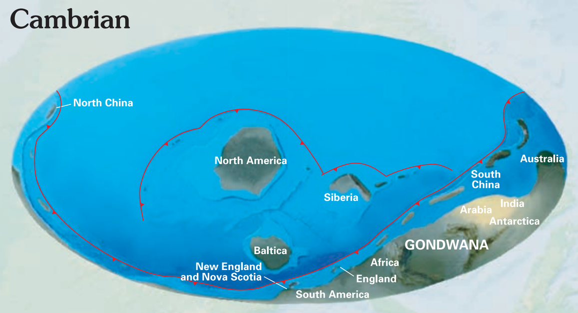
About 200 million years ago

About 150 million years ago



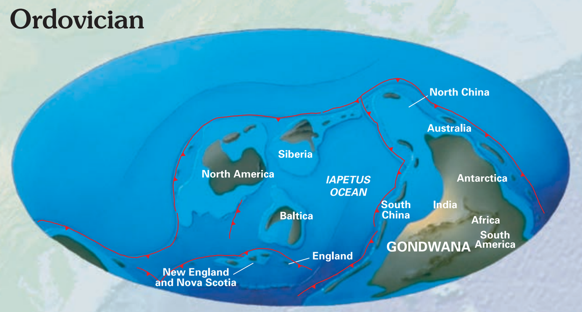
Present day (not to scale).

Cambrian



About 540 million years ago

Ordovician



About 470 million years ago

Devonian

About 380 million years ago

Mississippian

About 330 million years ago

Triassic

About 270 million years ago

Jurassic

About 175 million years ago

Cretaceous

About 70 million years ago

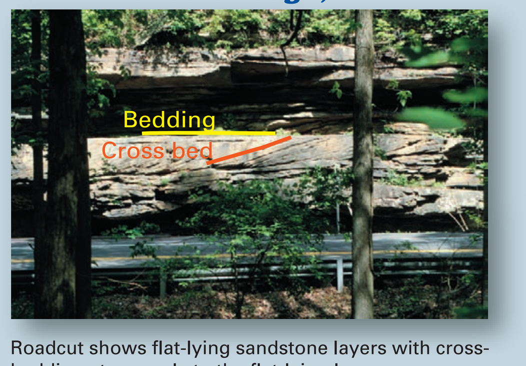
Present

Present location of land and continental masses and deep water

FOLDS AND FAULTS—HOW THEY FORMED

When sediments are deposited on the bottom of a body of water, they generally form horizontal beds. Water currents may deposit layers at an angle to the bedding; those beds are known as crossbeds.

Signal Mountain Road, Chattanooga, Tenn.

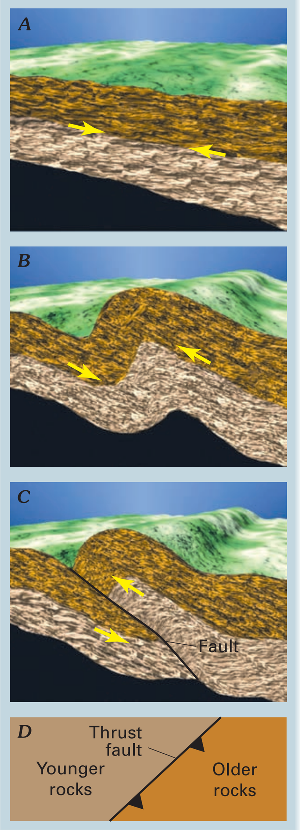


Roadcut shows flat-lying sandstone layers with cross-bedding at an angle to the flat-lying layers.

When continental plates collide, rocks are subjected to heat and pressure that causes them to fold (bend) or fault (break).

Folds in the Ocoee River gorge, southeastern Tennessee

Roadcut on U.S. Route 64 near Madden Branch. Folded layers of rocks with cleavage (planes along which the rock splits easily).



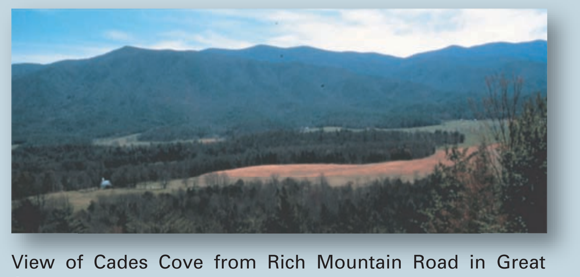
Faults are fractures in the Earth along which one side has moved relative to the other. When the Earth's crust pulls apart, normal faults form; when the crust is compressed, thrust faults form.

During the collision between the ancestral North American and African continents about 270 million of years ago, many huge slabs of rock moved tens of miles along many thrust faults and piled up on each other like a stack of dinner plates.

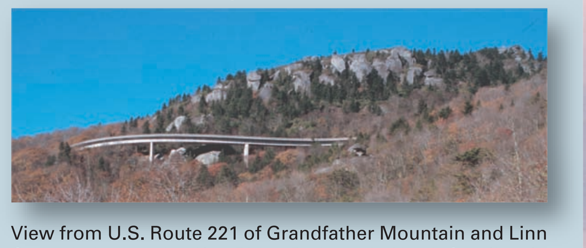
Diagrams A through C (to the left) are cross sections that show stages in the development of a thrust fault. Diagram D shows how a thrust fault appears on a geologic map. Sawteeth are on the overthrust block.

In areas of the continent where tectonic activity has not occurred, younger rocks usually rest atop older rocks; however, the opposite may happen when blocks of older rocks move over younger rocks along thrust faults.

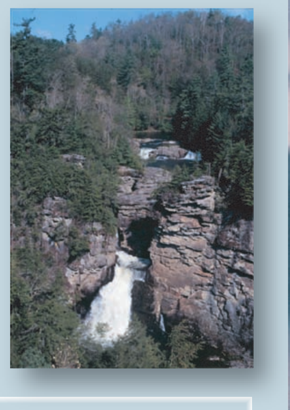
Cades Cove


View of Cades Cove from Rich Mountain Road in Great Smoky Mountains National Park, Tennessee. Limestones on the floor of Cades Cove are younger than those on surrounding ridges.

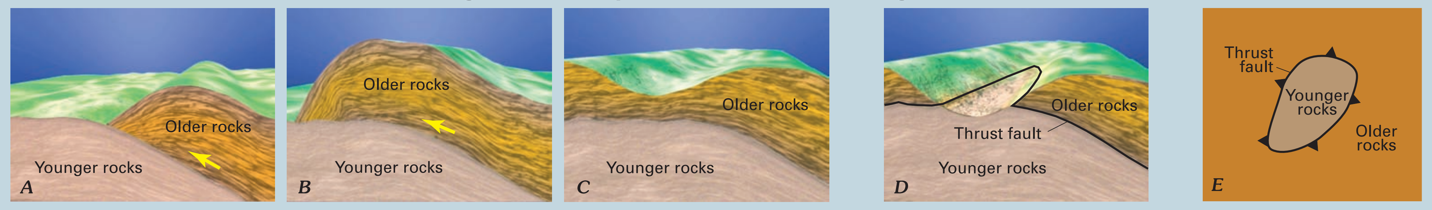
Grandfather Mountain


View from U.S. Route 221 of Grandfather Mountain and Linn Cove viaduct on the Blue Ridge Parkway in North Carolina. In contrast to the limestones at Cades Cove, some of the rocks in the Grandfather Mountain window are very resistant to erosion and form a mountain.

Linville Falls


View of Linville Falls from trail leading from Blue Ridge Parkway at milepost 316.4 in North Carolina. The mountains above Linville Falls were created by older, resistant rocks that were separated by a thrust fault from less resistant, younger rocks in the gorge below. The resulting structure is a geologic window.

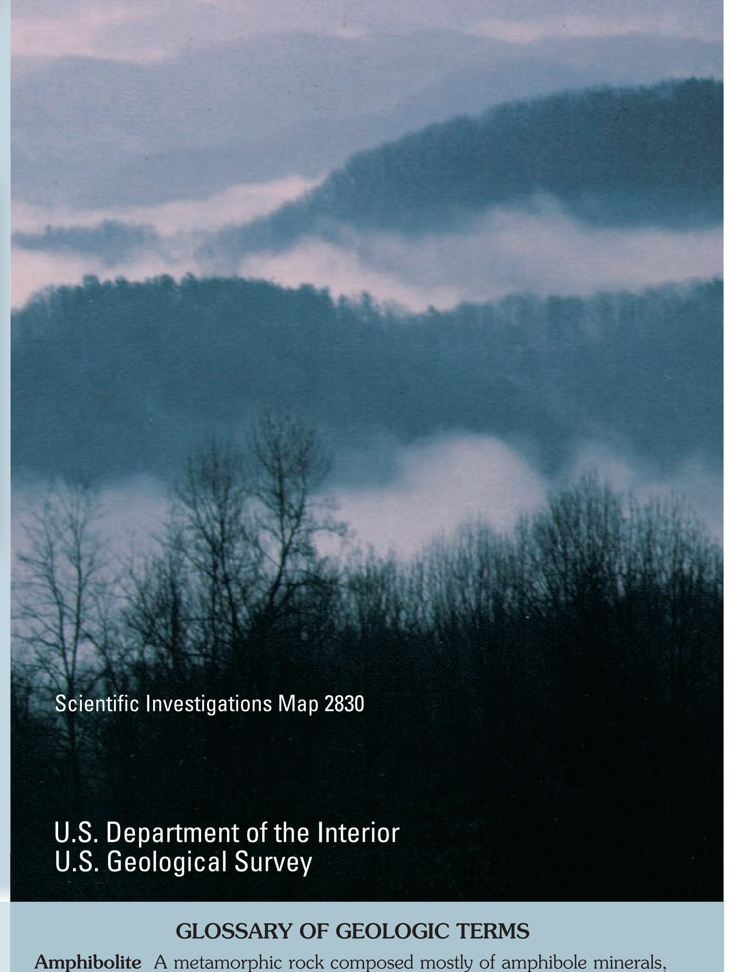
Stages in the Development of the Cades Cove Geologic Window



Diagrams A through C show how older, resistant rocks were transported over younger, less resistant limestone rocks by a thrust fault during tectonic activity. Diagram D shows how erosion, caused by water running off the mountain slopes, cut through the older rocks to expose the younger limestones in the floor of the cove as a geologic window. Diagram E shows the geologic map pattern for a geologic window. The term "geologic window" was devised to convey how younger rocks that have been covered by older rocks by a thrust fault can "show through" when the older rocks are eroded away.

USGS
science for a changing world

Geology of the Southern Appalachian Mountains

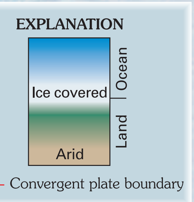


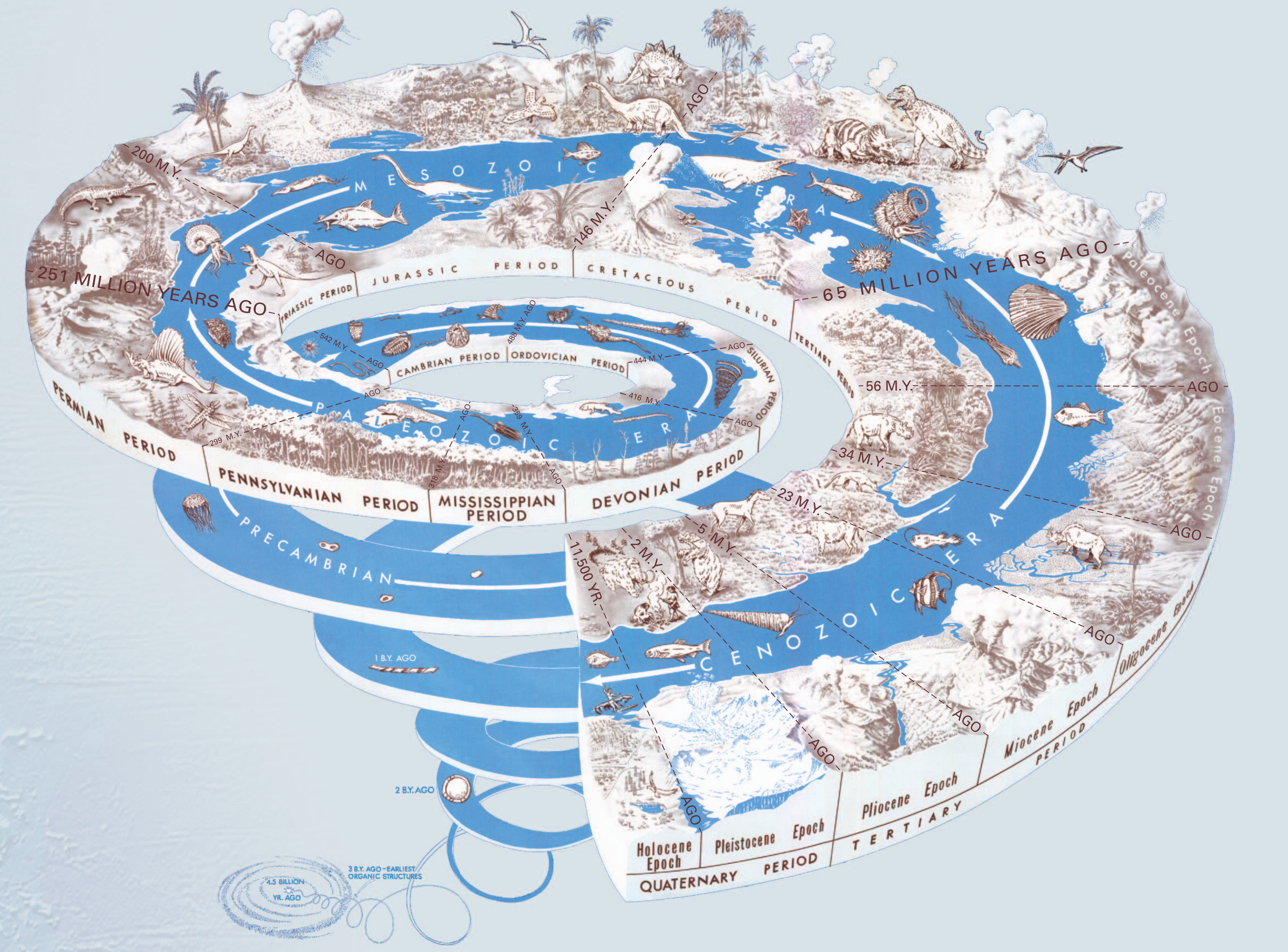
Scientific Investigations Map 2830

U.S. Department of the Interior
U.S. Geological Survey

EARTH'S LONG LIFE HISTORY

The maps left show one scientific interpretation of Earth's many changes—in locations of continents, sea level, and global climate—through geologic time. These maps, together with the geologic time spiral right, emphasize the dynamic processes operating for hundreds of millions of years and will continue far into the future. Maps modified from Scotese (2000). Time spiral modified from Newman (1994).





GLOSSARY OF GEOLOGIC TERMS

Amphibolite A metamorphic rock composed mostly of amphibole minerals, such as hornblende, which forms black needle-like crystals.

Carbonate Composed of calcium and (or) magnesium carbonate, as in limestone and dolomite.

Clastic Composed of fragments of broken rock.

Conglomerate A clastic rock made up of rounded pebbles, cobbles, or boulders.

Dolomite A variety of limestone rich in magnesium carbonate.

Extrusive Describes rock that formed when molten magma or lava erupted and solidified at the Earth's surface.

Fault A fracture, or zone of fractures, along which one side has moved relative to the other. Normal faults form when the Earth's crust pulls apart; thrust faults form when rock layers are pushed together.

Fold A curve or bend in rock layers.

Gneiss Coarse-grained metamorphic rock containing bands of light- and dark-colored minerals.

Granite An intrusive igneous rock consisting mostly of coarse grains of light-colored minerals rich in aluminum and silicon, such as quartz and feldspar.

Granitic Having a texture and composition like granite.

Graywacke Impure sandstone containing poorly sorted grains.

Igneous Describes rock that formed when molten rock (magma) rose, cooled, and hardened within the crust or at the Earth's surface.

Intrusive Describes rock that formed when molten magma solidified deep underground without erupting at the Earth's surface.

Limestone Any sedimentary rock composed mostly of calcium carbonate; forms from skeletal remains of organisms or by precipitation from water.

Mafic Describes igneous rock consisting mostly of dark-colored iron- and magnesium-rich minerals.

Marble Metamorphic rock consisting of recrystallized carbonate minerals.

Meta- A prefix used with sedimentary and igneous rock terms to indicate a metamorphism (change in form or composition) by high temperature and (or) pressure.

Metamorphic Describes pre-existing rock that has been changed by heat and (or) pressure.

Pegmatite An exceptionally coarse-grained igneous rock.

Phyllite A fine-grained metamorphic rock with microscopic mica grains that form shiny surfaces.

Quartzite Metamorphosed sandstone.

Sandstone A sedimentary rock formed of sand grains.

Schist A metamorphic rock like phyllite, but with larger mica crystals that are visible to the unaided eye.

Sedimentary Describes rock formed from fragments of older rocks or remains of living organisms that were transported and deposited by wind or water. Some form from minerals that precipitate out of water.

Shale A very fine grained sedimentary rock formed of clay minerals.

Siltstone A sedimentary rock that is like shale, but is slightly coarser grained, making a gritty rather than smooth powder when crushed.

Ultramafic Composed almost entirely of dark-colored and (or) green minerals rich in iron and magnesium.

Volcanic Describes rock that formed through volcanic processes, either on land or on the ocean floor.

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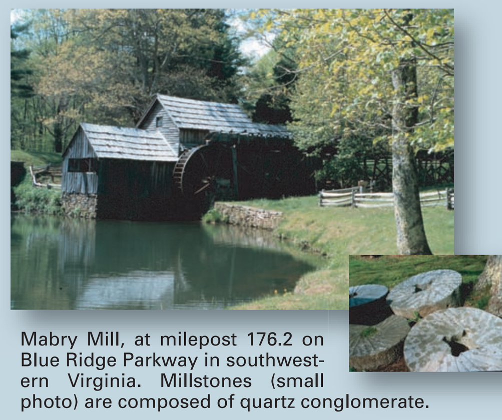
MINERAL RESOURCES


Mabry Mill, at milepost 176.2 on Blue Ridge Parkway in southwestern Virginia. Millstones (small photo) are composed of quartz conglomerate.

The Southern Appalachian Mountains contain important resources for fuel, industrial minerals, and metals that benefit both the region and the Nation. The occurrence of valuable mineral deposits played a major role in the history of the area and continues to be essential for growth and sustainable development.

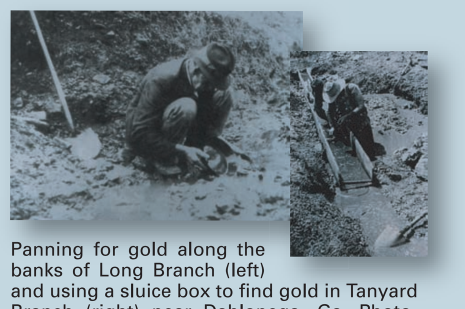
The Cherokee people, who arrived in the area more than 1,000 years ago, used the rocks and minerals of the region for utensils, tools, weapons, pipes, adornment, sports, healing, and trade. European settlers began to arrive about 250 years ago and used slabs of stone for buildings, walls, dams for millponds, millstones, bridge abutments, and similar types of construction.


Cherokee pipes made of soapstone. Photograph from Perdue (1989), used with permission of Michael Latil, Michael Latil Studio.

Fuel.—In terms of value of production, the most important mineral resource of the region is fuel, mainly coal and natural gas. Their sources are in the Pennsylvanian rocks of the Appalachian Plateaus and the Valley and Ridge physiographic provinces.

Industrial minerals.—The leading nonfuel mineral commodity in the Southern Appalachian Mountains is crushed stone. Limestone and dolomite are abundant and widespread in the Southern Appalachians, and constitute one of the principal mineral commodities of the region. The largest use of crushed stone is in concrete, aggregate, and road stone. Large amounts also are used in the manufacture of cement and lime for flux and agricultural uses.

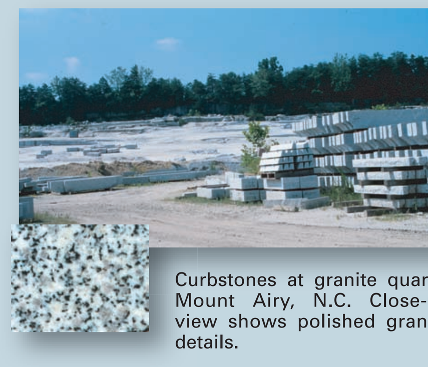
The region also is the Nation's leading producer of granite and marble dimension stone, which is used in buildings, monuments, paving blocks, curbing, flagging, and in structures such as retaining walls, sea walls, and bridges. The Spruce Pine mining district in western North Carolina is one of the chief mica- and feldspar-producing areas of the United States. Rocks in this district contain hundreds of pegmatites (coarse-grained igneous rocks) that have yielded many types of minerals.

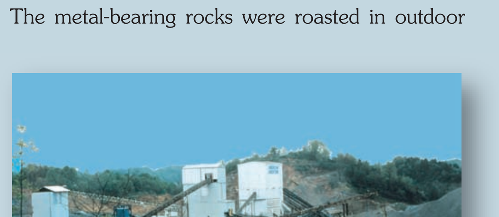

Panning for gold along the banks of Long Branch (left) and using a sluice box to find gold in Tanyard Branch (right) near Dahlonega, Ga. Photographs from Williams (1993), used with permission from Georgia Department of Archives and History, whose permission is required for further use.

Gold and other metals.—Gold has been mined in many places in the Southern Appalachian Mountains. Some of the first mines were located in the Dahlonega area of northeastern Georgia. The Cherokee knew about the gold, but it did not have the same significance for them as it did for the European settlers. The Georgia gold rush and the frenzy around it hastened the removal of most of the Cherokee people to Oklahoma on a forced march in 1838, known as the Trail of Tears, during which more than one-third of the Cherokee died.

The Copper Basin mining district surrounding Ducktown, Tenn., once was the largest metal mining district in the southeastern United States. During the early days of mining, miners cut trees for fuel and forests were cleared for the mines; widespread devegetation resulted in wasteland. The metal-bearing rocks were roasted in outdoor heaps to free the valuable metals, a process that released harmful sulfur-dioxide fumes into the air. Sulfur dioxide also mixed with moisture in the air and fell as acid rain, sterilizing the soil and killing what vegetation hadn't been cut for fuel. Through cooperative efforts of state and federal agencies and the mining industry over many years, the area has now been successfully reforested.

Since 1906, mines in eastern Tennessee and southwestern Virginia have produced a significant amount of the Nation's zinc. Zinc is used mostly for galvanizing iron and steel, which is used in automobiles, household appliances, and hardware.

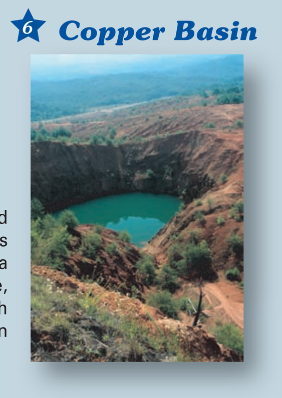

Curbstones at granite quarry, Mount Airy, N.C. Close-up view shows polished granite details.


Limestone quarry near Bristol, Va.

Minerals Produced from the Southern Appalachian Mountains

Fuels	
Coal	Natural gas
Industrial Minerals	
Abrasives	Mica
Asbestos	Nitric acid
Barite	Olivine
Cement	Ornamental stones
Clay and shale	Potassium
Crushed stone	Pyrophyllite
Dimension stone	Quartz
Feldspar	Salines
Gemstones	Sand and gravel
Gypsum and anhydrite	Silica
Kyanite	Sulfur
Lightweight aggregate	Talc and soapstone
Lime	Vermiculite
Lithium	Zircon
Metals	
Aluminum	Niobium
Cadmium	Tantalum
Chromium	Silver
Copper	Rare-earth minerals
Gold	Thorium
Iron ore	Titanium
Lead	Tungsten
Manganese	Zinc

Copper Basin


View of caved-in and flooded mine workings at the Burra Burra historic mine site, Ducktown, Tenn., which is in the Copper Basin mining district.