Mineral Resources of the Blue Ridge & Piedmont

Region 1

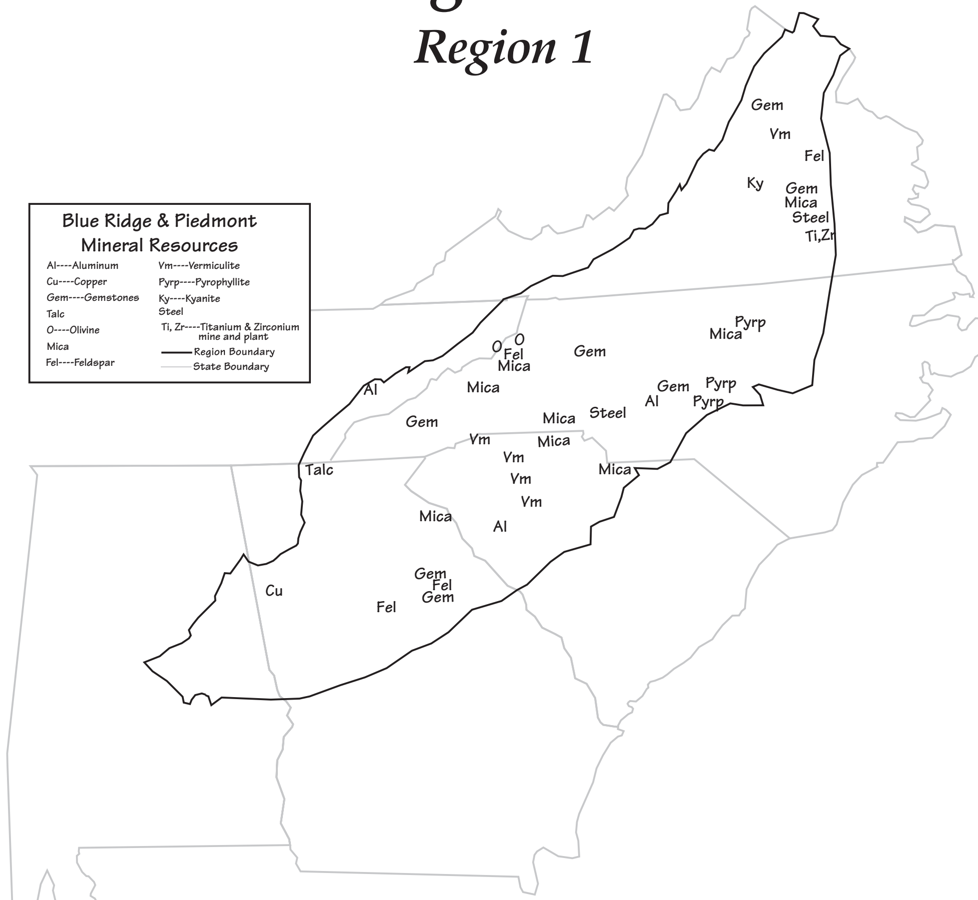
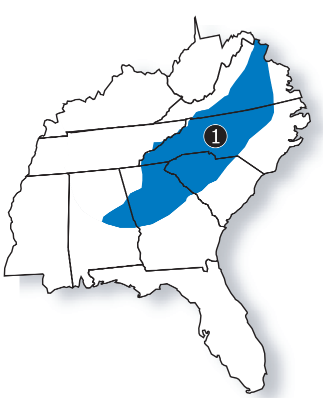


Figure 5.1: Principal current mineral-producing localities of the Blue Ridge & Piedmont region. Figure adapted from 1998 United States Geological Survey State Mineral Information, http://minerals.usgs.gov/minerals/pubs/state/

Blue Ridge & Piedmont can be divided into several sections with distinct mineral deposits:

see Geologic History, for more on the formation of rocks in the Blue Ridge & Piedmont



- *The* **Grenville rocks** *formed as a result of the Grenville mountain building event 1 billion years ago when the supercontinent Rhodinia formed and ocean floor sediment was pushed onto ancient North America.*
- *The* **Precambrian-Cambrian rift basin rocks** *include thick sediment deposits in rift basins along the ancient margin of North America formed as the Iapetus Ocean opened.*
- **Cambrian-Ordovician sediment** *was deposited on the margin of North America between mountain building events.*
- *The* **Iapetus rocks** *(Inner Piedmont) consist of sedimentary and volcanic deposits from the Iapetus Ocean floor, slivers of oceanic crust, and fragments of continental crust (including volcanic islands). This diverse assemblage was added to the margin of North America during the Taconic mountain building event, and further compressed during the Acadian and Alleghanian mountain building events.*
- *The* **Avalon rocks** *(Outer Piedmont) were once part of the Avalon microcontinent that collided with North America in the late Devonian.·*
- *The* **Triassic-Jurassic rift basin rocks** *in the Piedmont formed during the break-up of Pangea.*

Grenville Rocks

Metallic Mineral Deposits

Grenville rocks from Virginia to Georgia host scattered iron (Fe) and titanium (Ti) oxide mineral deposits, largely associated with 1 billion year old igneous intrusions from the Grenville mountain building event. The titanium oxide minerals ***rutile*** and ***ilmenite*** were mined in the Roseland District of central Virginia (western Amherst and Nelson counties.) Rutile was mined from about 1900 until 1949 and ilmenite was recovered from 1930 until 1971. The Roseland district once supplied a large percentage of the rutile that was consumed in the United States. The rutile occurs as grains disseminated in igneous rocks composed mainly of plagioclase feldspar. In addition, significant tonnages of apatite, a phosphate mineral, were recovered during the milling operations and stockpiled. A plant was operated at Piney River from 1937 until 1948 to produce phosphorous chemicals from apatite mined with the titanium minerals.

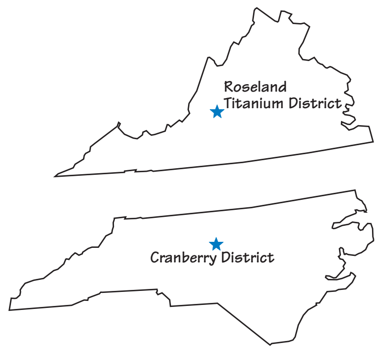


Figure 11: Virginia's Roseland titanium district and North Carolina's Cranberry district.

The Virginia Chemical Corporation and the American Cyanamid Company operated titanium-dioxide pigment plant at Piney River in Nelson County from 1931 to 1971. This site is now a 50-acre EPA Superfund site. The processing involved acidification of ilmenite with by-product copperas (ferrous sulfate) which was stockpiled at the site. Many fish kills occurred in the Piney River from 1977 to 1981 because of acidic run off from copperas and acidic leachate. In 1980, copperas was removed from the hillside and buried on site. Site concerns include degradation of the Piney River water quality, vegetation destruction by acidic leachate, and groundwater contamination. The groundwater is contaminated with iron sulfate and is highly acidic.

Small but rich ***magnetite*** (iron oxide) deposits at Cranberry, North Carolina occur in a 40-km long area associated with a large intrusion of the dark colored igneous rock, gabbro *(Figure 11)*. Around 1.5 million tons of high purity magnetite was produced in this area of North Carolina from 1882 to 1930.

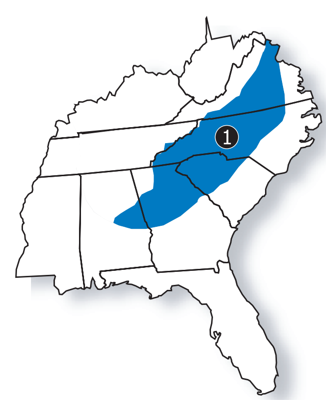
Mineral Deposit Processes

The processes that formed rock and mineral deposits in Grenville rocks are often obscured by strong metamorphism and deformation. In the Southeast Grenville rocks the mineral deposit processes that are still readily distinguished include magmatic and hydrothermal processes associated with igneous intrusions.

rutile: TiO_2

ilmenite: $FeTiO_3$

magnetite: Fe_3O_4



Precambrian Rift Rocks

Mineral Deposit Processes

The mineral deposit processes operating in the Precambrian rift basins were largely hydrothermal processes. Seawater circulated through the thick sequences sediments (some of which were volcanic in origin), heated by the geothermal gradient or magma below the surface. These hydrothermal fluids dissolved base metals, sulfur, and other elements from the sediments through which they migrated. Because the mineral-laden solutions were hot, they rose upward buoyantly to the surface of the rift basins. As the hydrothermal fluids cooled at the surface, the minerals were precipitated from the solutions to form blankets of sulfides (including iron, copper, and zinc sulfides) within the rift basin sediments. During the Taconic and Acadian mountain building events, these deposits were folded to form thick lenses, and recrystallized into coarse crystals of sulfides that were more easily milled, separated, and smelted.

galena: PbS, *an ore of silver and the one of the only sources of lead (Pb).*

Sphalerite: ZnS, *the most important ore mineral of zinc.*

Chalcopyrite: $CuFeS_2$, *the most common and important copper source.*

Pyrite: FeS_2, *an extremely common sulfide mineral.*

What is a gossan?
A gossan is the near surface, oxidized portion of a sulfide-rich ore body.

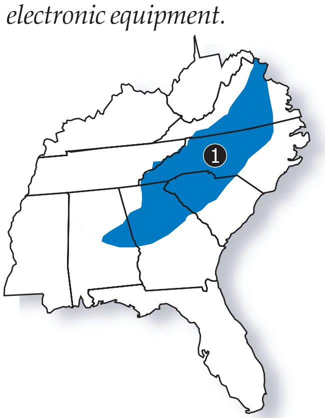
copper: *Cu, Copper is used extensively as wiring in the electrical industry as well as in alloys such as brass and bronze.*

zinc: *Zn, Zinc is used in metal alloys and galvanized steel. Brass is a copper-zinc combination; bronze combines copper, tin, and zinc.*

iron: *Fe*

gold: *Au*

silver: *Ag, Silver is used in photographic film emulsions, utensils and other tableware, and electronic equipment.*



Metallic Mineral Deposits

Sulfides make up the majority of ore minerals. They include iron, zinc, lead and copper sulfides such as ***galena***, ***sphalerite***, ***chalcopyrite***, and ***pyrite***. Numerous small deposits of sulfides are present from southwest Virginia to northeast Georgia, but the largest deposits are those of the ***Gossan*** Lead District in the Ashe Formation of Virginia and the Ducktown District in the Ocoee Basin of Tennessee (Figure 13). The Virginia Gossan Lead deposits extend for 28 km but are largely iron sulfide. Nine separate sulfide bodies in theTennessee Ducktown District total almost 200 million tons of ore averaging about 1% ***copper*** and 0.9% ***zinc***. The district also produced at one time ***iron***, ***gold***, and ***silver***. Ducktown was also an important source of sulfuric acid, a recovered byproduct of sulfide smelting operations.

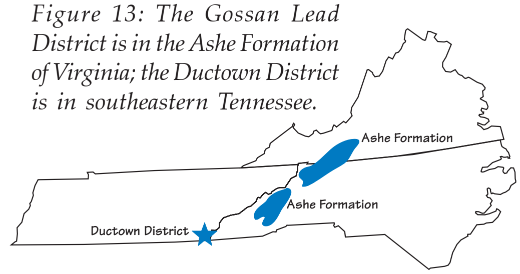


Figure 13: The Gossan Lead District is in the Ashe Formation of Virginia; the Ductown District is in southeastern Tennessee.

The Ducktown District was first worked in the early 1840s, initially for iron and later for gold in the iron oxide gossans formed by surface weathering of the sulfide ore bodies. Rich secondary copper ores were discovered below the gossans and mined from 1847 to 1879. Initially, the rich ore was piled on huge stacks of cordwood and set to burn for several weeks to oxidize the sulfur. The roasted ore was then placed in smelters fired by charcoal to recover the copper metal. The entire valley was denuded of trees to fuel the roasters and smelters, consuming 1500 acres of mature timber each year by 1876. By 1878 forty-seven square miles of forest had been consumed in and around the valley. Sulfur gases released by roasting and smelting fell with rain as sulfuric acid, killing virtually all remaining vegetation in the valley. High rainfall resulted in extensive erosion and gullying of the surface, producing terrain similar to a desert. The red soils and rocks of the valley were clearly visible amid the green of the surrounding mountains from the air and in early satellite images (Figure 14). Morning fog was so acidic as late as the 1960s that it would corrode nylon stockings in a matter of minutes. Mining of the primary sulfide ore bodies underground began in 1890, and continued to the end of mining in 1987. Cleaner smelting technologies and extensive reclamation and planting efforts in the 1970s through 1990s restored vegetation in much of the valley, an effort that continues to the present.

Figure 14: Severe erosion and loss of vegetation resulted from burning sulfide ores in the Ductown District, TN. Photo courtesy of the Library of Congress and EPA: http://www.epa.gov/region4/waste/copper/copphoto/1912erosion2.htm.

Manganese oxide deposits are locally present in the Precambrian rift basin sediment, especially in the Ashe Formation near the North Carolina–Virginia border *(Figure 13)*. These include the deposits at Bald Knob, North Carolina, composed of ***manganese*** oxides, ***carbonates***, and ***silicates***. The formation of the manganese deposits is similar to that of the sulfide deposits described above, but took place at lower temperatures.

silicates: *SiO_2*

Manganese *is used in the production of steel.*

carbonates: *CO_3*

see Minerals p.35, for more on **pegmatites.**

see Rock Resources, p.32, for more on **kaolin clay**

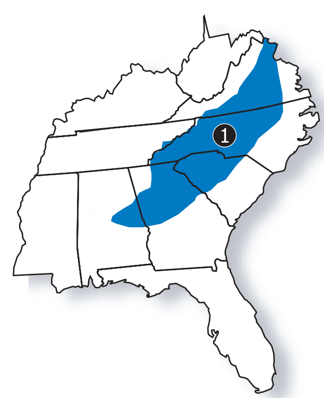
Non-Metallic Mineral Deposits

Numerous ***pegmatites*** intruded the Precambrian rift rocks throughout the Blue Ridge during the Taconic and Acadian mountain building events. Many of these pegmatites have been mined for ***feldspar***, ***kaolin***, quartz, and ***mica***.

Feldspars

Feldspars are very common group of rock-forming minerals found throughout the Southeast in all types of rocks, and used in ceramics and scouring powders.) There are two groups of feldspar: alkali feldspar (which ranges from potassium (K)-rich $KAlSi_3O_8$ to sodium (Na)-rich $NaAlSi_2O_8$) and plagioclase feldspar (which ranges from sodium (Na)-rich $NaAlSi_3O_8$ to calcium (Ca)-rich $CaAl_2Si_2O_8$). Potassium feldspars of the alkali group are commonly seen as pink crystals in igneous and metamorphic rocks, or pink grains in sedimentary rocks. Plagioclase feldspars are even more abundant than the alkali feldspars, ranging in color from light to dark.)

Among the most important districts are the Franklin-Sylva and Spruce Pine Districts in North Carolina, with hundreds of pegmatites intruded into the Ashe Formation *(Figure 16)*. These two districts have produced over half of all U.S. sheet and scrap



Two of the most common mica minerals are **muscovite** *(light colored) and* **biotite** *(black). Mica minerals are used in heating and insulating.*

Biotite: $K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$
Muscovite: $KAl_2(AlSi_3O_{10})(OH)_2$

beryl: $Be_3Al_2(Si_6O_{18})$

Ultramafic *rocks are dark green to black in color because they have a very low percentage of silica.*

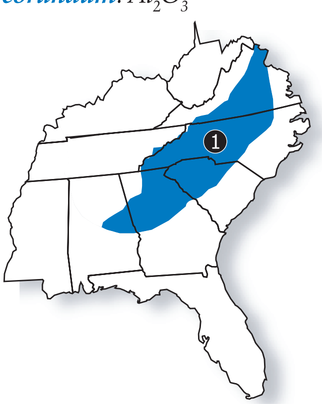
see Rocks*, p.32, for more on the* **Ultramafic Belt.**

olivine: Mg_2SiO_4

vermiculite: $(Mg, Ca)_3(Mg,Fe,Al)_3$*, a common, altered form of biotite.*

Asbestos is a very slow conductor of heat, and was commonly used as a fireproofing material and electrical insulation. Concerns over the health effects on the lungs of this fibrous mineral have led to its removal from common uses.

chromite: $FeCr_2O_4$
corundum: Al_2O_3



mica and feldspar since mining began in 1868, and North Carolina continues to be the nation's top producer. Ancient mine pits and shafts in the Blue Ridge Mountains of North Carolina were long thought to be pre-colonial silver and gold prospects attributed to the early Spanish explorers. These old prospects are now thought to be the work of Native Americans in the area, who mined the pegmatites for sheets of ***muscovite*** mica.

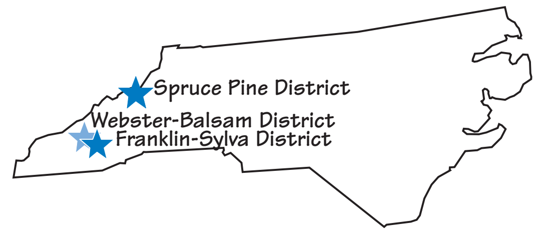


Figure 16: The Spruce Pine and Frank-Sylva Districts of North Carolina have hundreds of pegmatites. The Spruce Pine and Webster-Balsam districts have abundant olivine.

Pegmatites of western North Carolina have also produced minor quantities of uranium, rare earth elements, and secondary uranium minerals common in many of the Spruce Pine District pegmatites. ***Beryl*** is a common mineral in some pegmatites, and mines in the Spruce Pine District have produced gem quality aquamarine and emerald (varieties of beryl).

The mineral olivine, found in the ***ultramafic*** igneous rocks dunite and peridotite, is present throughout the Blue Ridge from Virginia to Alabama. It occurs in the highly deformed Precambrian rift rocks thrust westward onto the margin of North America during the Taconic mountain building event. Dunite and peridotite are composed of 50% to 90% ***olivine***. The Webster-Balsam district in Jackson County and the Spruce Pine district in Yancey and Mitchell counties, western North Carolina, have produced commercial olivine *(Figure 16)*. North Carolina leads the nation in olivine production, although active mining is presently limited to the Daybook Mine in Yancey County. There has also been minor production of ***vermiculite***, ***asbestos***, and ***chromite*** from these bodies.

Alteration of ultramafic rocks in the Blue Ridge during the Paleozoic mountain building events resulted in the formation of local deposits of ***corundum***. Corundum is used as an abrasive, and in gem form is known as ruby (red) or sapphire (blue). The Corundum Hill deposit in Macon County, North Carolina was mined as early as 1871. All corundum production in the United States came from North Carolina and Georgia until 1905. The Macon County area continues to produce gem quality forms of corundum, especially rubies and sapphires *(Figure 17)*.

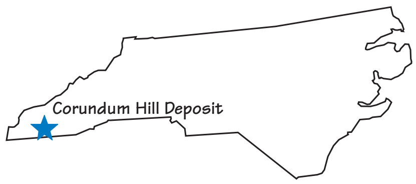


Figure 17: Alteration of ltramafic rocks in Macon County, North Carolina produced corundum.

Metamorphism of the Precambrian rift rocks also produced minable deposits of the non-metallic mineral ***garnet*** in the North Carolina Blue Ridge. Used as an abrasive, garnet was mined from several small deposits from 1900 until 1926.

Cambrian-Ordovician Sediment

Mineral Deposit Processes

No significant mineralization appears to be associated with the Cambrian-Ordovician sediment deposition that occurred between mountain building events, but hydrothermal fluids moved through some of these rocks during subsequent mountain building events (and in some cases the hydrothermal fluids migrated as far as the Mississippi Embayment.) The fluids followed units of permeable rock, but also migrated along fractures and especially thrust faults.

Metallic Mineral Deposits

Minor occurrences of zinc and lead ***sulfides*** are present in the Cambrian-Ordovician passive margin sediments in the Blue Ridge, but there are several large ***barite*** deposits formed along thrust faults. A good example is the barite deposits of the Hot Springs District in Madison County, North Carolina *(Figure 20)*.

Non-Metallic Mineral Deposits

Talc deposits are associated with the ***Murphy Marble*** in a belt extending through Cherokee and Swain counties, North Carolina. These deposits were mined as early as 1859 and well into the 1980s, but are currently inactive. The district produced over 200,000 tons of high-grade talc. The talc formed through tectonic-metamorphic alteration of the silty dolomite or associated sediments during one of the Paleozoic orogenic events.

Why is Talc Associated with Marble?

Talc is $Mg_3(OH)_2[Si_4O_{10}]$, a hydrated magnesium silicate. Marbles such as the Murphy Marble of western North Carolina and Georgia are not pure calcite ($CaCO_3$) marbles, but rather dolomitic ($MgCO_3$) and slightly silty with detrital quartz grains. During hydrothermal alteration accompanying metamorphism, the calcite, dolomite, and silica react to form talc. Talc is also formed from the alteration of ultramafic rocks, rich in olivine (Mg silicate), but may also contain asbestiform minerals and iron minerals. The talc formed from dolomitic marbles tends to be cleaner and more pure, which made the Murphy deposits economic.

*Two **rubies** totaling almost 1000 carats with an uncut value of around $40,000 were found in 1985 in Macon County, North Carolina. Rubies are gem-quality corundum.*

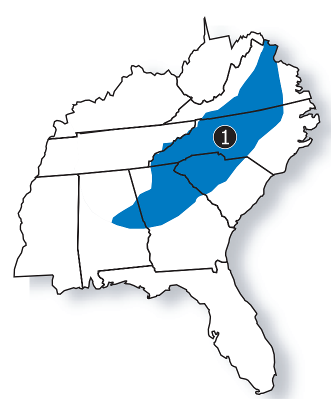
garnet: *$A_3B_2(SiO_4)_3$*
A and B may be substituted by different elements to produce a given variety of garnet. Pyrope is a variety of garnet that is currently mined in North Carolina and elsewhere in the Southeast.

see Minerals, p. 131 for more on **sulfides.**

barite: *$BaSO_4$*

talc: *$Mg_3Si_4O_{10}(OH)_2$, used in talcum powder, paint, ceramics, rubber, and paper. Talc is an economically valuable non-metallic mineral.*

see Rocks, p.35, for more on the **Murphy Marble.**



Inner Piedmont Rocks

Mineral Deposit Processes

*The volcanic rocks of the Inner Piedmont host numerous sulfide and gold deposits, although most were relatively small and largely mined out in the 19th Century. The gold and sulfide deposits occur generally through **hydrothermal** processes. Many of the high grade gold deposits occur concentrated within quartz veins. Subsequent **weathering** and **erosion** formed rich placer and residual gold deposits that were the initial target of mining in the Piedmont. Alluvial mining gave way to lode mining as the placer deposits were exhausted and the gold was traced to its source in the bedrock.*

Metamorphism and igneous intrusions into the Inner Piedmont rocks during the Paleozoic mountain building events also produced numerous small pegmatite deposits (through magmatic processes), and concentrations of aluminum silicates of the kyanite group.

Metallic Mineral Deposits

There are over 300 known gold, silver, and base metal mines and prospects in ***Virginia***, but the most important cluster in a narrow zone of volcanic rocks called the Virginia Gold-***Pyrite*** Belt that extends for about 100 miles *(Figure 18)*. At least 100 old gold mines are present along this trend, opened along veins and sulfide deposits of hydrothermal origin. Total gold production from Virginia from 1804 through 1947 was 300,000 troy ounces.

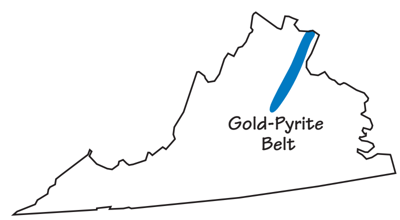


Figure 18: The Virginia Gold-Pyrite Belt.

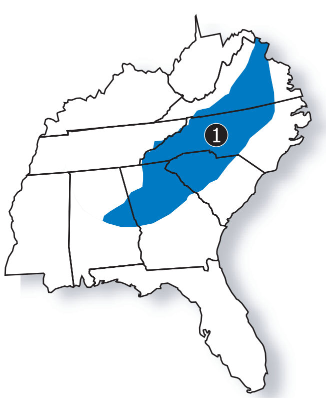
Copper, zinc, and lead from sulfide deposits also were mined in this area.

The Dahlonega Belt of volcanic rocks in northern Georgia produced over 500,000 ounces of gold between 1838 and 1941 from mining of gold-bearing quartz veins and sulfide deposits *(Figure 19)*. These deposits occurred through hydrothermal processes. There were dozens of small mines, and several large mines including the Battle Branch, Calhoun, and Findley. The Creighton (Franklin) Mine in Cherokee County was active between 1840 and 1909, and produced almost 50,000 ounces of gold. A branch of the U. S. Mint operated in Dahlonega between 1838 and 1861, striking United States coins from Dahlonega gold. The state of Georgia has produced between 1 and 1.5 million ounces of gold since 1828.

Figure 19: North Georgia's Dahlonega Belt.

*Thomas Jefferson reported on a gold-bearing rock found along the Rappahannock River, **Virginia**, in 1782 but mining did not begin in the Virginia Piedmont until 1804.*

pyrite: *FeS*



Dahlonega and the Trail of Tears

The "official" discovery of gold in Georgia was made by Frank Logan in present day White County in 1828, well within the territory of the Cherokee Nation. The Cherokee were aware of the presence of gold on their lands, and gold mines were operated illegally in Cherokee Territory as early as 1819. As word of the discovery spread, a systematic campaign to remove the Cherokee and open the area to gold mining was crafted in Georgia and Washington, D.C. In 1830 Congress quickly passed the Indian Removal Act. In December 1835, the U.S. government signed a treaty with a small group of disaffected Cherokee, none elected officials of the Cherokee Nation. Twenty signed the treaty, ceding all Cherokee territory east of the Mississippi to the U.S., in exchange for $5 million and new homelands in the Indian Territory (Oklahoma). More than 15,000 Cherokees protested the illegal treaty, but it was ratified by the U.S. Senate by one vote in 1836. Most of the Cherokee people were forced to leave their ancestral home in Northern Georgia and adjacent states, and relocate to the Indian Territory in the winter of 1838-1839. Over 4000 Cherokee died as a result of the removal, nearly a fifth of the Cherokee population. Their journey is called "The Trail of Tears."

Dahlonega *is a corruption of Ta-lo-Ne-Ga, the Cherokee name for the yellow color of gold.*

There is also a wide variety of metallic mineral deposits scattered throughout the Inner Piedmont outside the belts of volcanic rocks associated with the Taconic mountain building event, although few have been large producers. Several small deposits of ***copper*** and ***zinc*** sulfides are known, and extensive though not economical occurrences of ***tin*** and zinc were explored as recently as the late 1990s.

Residual weathering and stream action formed numerous deposits of heavy mineral concentrates in the Inner Piedmont. Heavy minerals include ***monazite***, a major source of ***thorium*** , and ***rutile*** and ***ilmenite***, important ores of ***titanium***. These minerals are hard, resistant to weathering and erosion, and are concentrated and segregated by stream flow due to their high density. They originated in lower grade concentrations from high temperature metamorphic rocks and granite intrusions from the Taconic mountain building event. Almost all monazite production in the United States from 1880 to 1918 came from the Western Monazite Belt in the Inner Piedmont of North and South Carolina *(Figure 20)*.

copper: *Cu*

zinc: *Zn, used in metal alloys and galvanized steel.*

tin: *Sn*

monazite: $(Ce, La, Y, Th)PO_4$

thorium: Th

rutile: TiO_2

ilmenite: *$FeTiO_3$, an ore of titanium, produced for use as a white pigment in paint.*

titanium: Ti, *important because of its lightweight nature, strength and resistance to corrosion.*

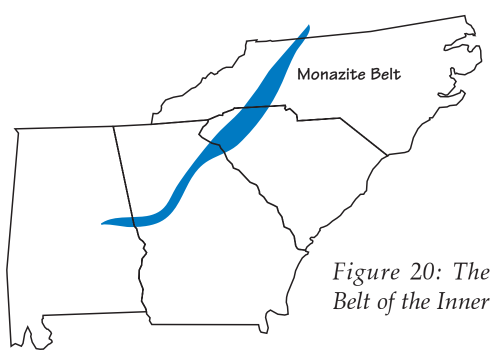
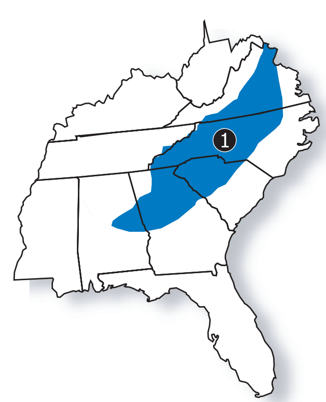


Figure 20: The Monazite Belt of the Inner Piedmont.



see *Minerals*, p. 131 for more on **pegmatites.**

lithium: *Li, used in the manufacture of ceramics, glass, greases, TV glass, and batteries.*

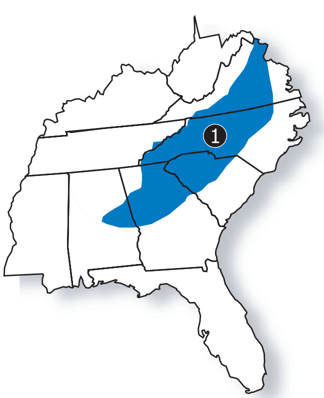
spodumene: *$LiAlSi_2O_6$, used to produce lithium carbonate, lithium metal, and chemical compounds.*

sillimanite: Al_2SiO_5

kyanite:

see *Minerals*, p. 134 for more on **sillimanite** and **kyanite.**

vermiculite: $(Mg,Ca)_3(Mg,Fe,Al)_{5-}$



Non-Metallic Mineral Deposits

Pegmatites are widespread in the Inner Piedmont, although generally no longer mined. An unusual group of ***lithium***-bearing pegmatites in Alexander County, North Carolina produces gem quality emeralds and hiddenite, a gem form of ***spodumene*** *(Figure 21)*. Lithium is produced in North Carolina from a series of large lithium-rich pegmatite deposits extending into South Carolina. The lithium occurs in the mineral spodumene, and these deposits represent one of the largest concentrations of silicate lithium in the world. The pegmatites contain approximately 20 percent spodumene.

Figure 21: Alexander County, NC, produces emeralds and spodumene.

Sillimanite and ***kyanite*** in the Inner Piedmont, formed through recrystallization of aluminum rich sedimentary or volcanic rocks during metamorphism. Extensive deposits of varying grade (10-20%) formed in rock formations in the Blue Ridge and Inner Piedmont. Because they are hard and chemically non-reactive, kyanite and sillimanite may become concentrated by residual weathering. Kyanite deposits are more common in the Blue Ridge, and sillimanite-rich schist form a broad belt in the Inner Piedmont from North Carolina to Georgia *(Figure 22)*. Although there has been minor production in the past, kyanite and sillimanite deposits of the Blue Ridge and Inner Piedmont are not economic concentrations.

Alteration of ultramafic rocks in the Inner Piedmont during the Paleozoic mountain building events has formed deposits of vermiculite, used in lightweight concrete aggregates, insulation, agriculture, and other products. The United States is one of the two largest producers of vermiculite in the world. All U.S. production comes from deposits in the Inner Piedmont of Virginia and South Carolina.

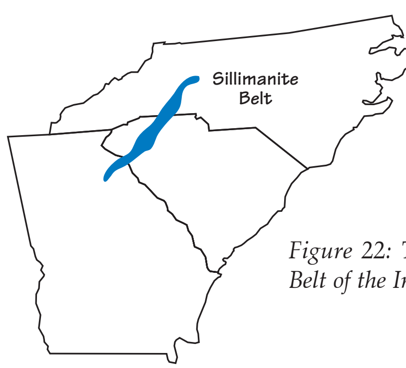


Figure 22: The Sillimanite Belt of the Inner Piedmont.

Avalon Rocks

Mineral Deposit Processes

Hydrothermal *processes associated with active Precambrian to Early Cambrian volcanic activity in the Avalon Rocks (before they were attached to North America) produced numerous deposits of sulfides (copper, lead, and zinc), gold mineralization, iron and manganese formations, barite, and a major tungsten deposit. Many of these deposits were modified, and in some cases further concentrated, by hydrothermal processes accompanying the Acadian and Alleghanian mountain building events.*

Volcanic activity and igneous intrusions in the Avalon Rocks were often accompanied by ***hydrothermal alteration*** *so intense that economic deposits of aluminum silicate minerals of the kyanite family were formed.*

Metallic Mineral Deposits

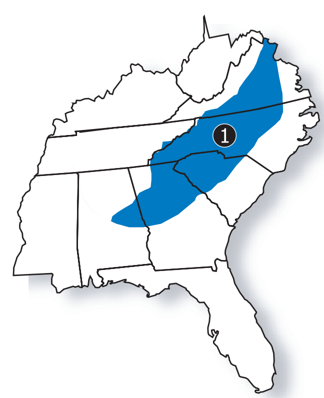
The ***Avalon Rocks*** hosts a wide variety of metallic mineral deposits, but many are clearly associated with Precambrian to Cambrian volcanic activity and igneous intrusions that occurred before the terrane was attached to North America. Among the most interesting geologically and historically are the gold deposits.

The **Avalon Rocks** *are an unusually gold-rich geologic environment, with hundreds of small deposits (<10,000 ounces), dozens of medium sized deposits (~50,000 ounces), and several large deposits (>1 million ounces).*

Gold was first reported in ***North Carolina*** in 1774, but the Carolina Gold Rush began after 12 year old Conrad Reed found a 17-pound gold nugget on the family farm in 1799. Early gold mining in the Southeast exploited placer deposits and shallow enriched zones, using primitive, labor intensive techniques with little scientific or engineering consideration. Mining was largely a secondary, part-time enterprise in the agricultural Piedmont. Despite these limitations, mining had begun at deposits in five North Carolina counties by 1820, and 500 ounces of North Carolina gold arrived at the U.S. Mint in Philadelphia during 1824. Mining experts and engineers were recruited from Britain, Germany, Italy, and South Africa, and miners came to the Southeast from more than a dozen countries. New mining and milling technologies were introduced, including the first stamp mill in the United States, erected at the Capps Mine near Charlotte, North Carolina in 1829. The Carolina Gold Rush spread through the Southeastern Piedmont from Virginia to Alabama and westward across the Blue Ridge by 1830, and included the deposits of the Inner Piedmont.

North Carolina *supplied all domestic gold to the US Mint before 1928, totaling about 4000 ounces through 1926 and another 1000 ounces in 1927. It is estimated that only one-half to one-third of all gold produced was sent to the US Mint, the rest going to individuals, manufacturers, artisans, etc.*

Total gold shipments to the US Mint in Philadelphia from North Carolina during 1834 were over 18,000 ounces, with another 20,000 ounces from Georgia. Under intense lobbying pressure, Congress voted in 1835 to open a new US Mint in New Orleans, with branch mints in Charlotte, North Carolina and Dahlonega, Georgia.

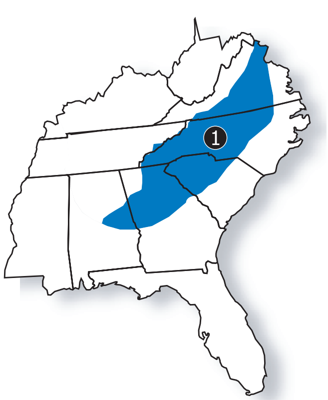


The **price of and ounce of gold** *has varied dramatically through the history of gold production in the Southeast. From 1793 to 1833 the price of gold was ~$19.39. The value of gold increased to as much as $47.02 during the Civil War. From 1934-1972 the price varied between $35-$40 per ounce, until in 1972 the Federal Government deregulated the price of gold. The price of gold climbed steadily and peaked in 1980 at around $800 per ounce amid a flurry of investment speculation. The price fell rapidly to around $400 per ounce, and has generally remained between $300-$400 to the present.*

CA Gold Rush

Some miners from the Southeast Piedmont joined the **gold rush to California** *in 1849, although North Carolina gold production peaked that year. Spectacular placer discoveries were largely a thing of the past in the Southeast, and lode mining was hard, dangerous work. Many of the miners who joined the CA Gold Rush were looking for quick, easy riches. The thousands of miners who remained continued to work successfully until the beginning of the Civil War in 1861.*

copper: *Cu*
zinc: *Zn*
lead: *Pb*
silver: *Ag*
tungsten:



The Charlotte Mint was opened in 1837 to purchase the gold being produced in the piedmont of the Carolinas and Virginia and mint gold coins. The Dahlonega branch opened in 1838 to mint gold coins from the gold produced in the piedmont of Georgia.

Major gold mining districts in the Avalon Rocks include the Gold Hill District (160,000 ounces) and the Charlotte District (100,000 ounces) in North Carolina, the Haile-Brewer Area (350,000 ounces) and Dorn Mine (50,000 ounces) in South Carolina *(Figure 23)*. The deposits are volcanic hydrothermal gold and base metal sulfide mineralization, probably enhanced by tectonic-metamorphic hydrothermal processes.

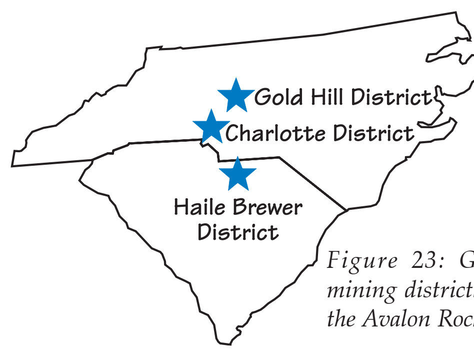


Figure 23: Gold mining districts in the Avalon Rocks.

Modern-day Gold Rush

South Carolina was the scene of a modern-day gold rush between 1985 and 1999, with four major open-pit mines in operation, plus widespread exploration. At the peak of activity, the Ridgeway Mine (Fairfield County), Barite Hill Mine (McCormick County), Brewer Mine (Chesterfield County), and Haile Mine (Lancaster County) were in production. South Carolina produced about 400,000 ounces of gold from 1827 to 1939. Total production of about 1,650,000 ounces between 1985 and 1999 brings the total gold production for South Carolina to over 2 million ounces. Total gold production from the entire Southeastern Piedmont through 1969 is estimated at 2.7 million ounces. South Carolina production from 1985 to 1999 increases this figure to about 4.35 million ounces of gold.

In addition to gold, mines of the Avalon Rocks produced minor ***copper***, ***zinc***, ***lead***, ***silver***, and ***tungsten*** before 1939. Production came from numerous small (<500,000 tons) sulfide deposits and vein deposits of hydrothermal origin. Iron and manganese were produced during the 18th and 19th centuries. Like the gold deposits, these ores were from a combination of hydrothermal processes associated with volcanic activity and igneous intrusions, often concentrated by hydrothermal fluids associated with the Paleozoic mountain building events. The Hamme deposit in Vance County, North Carolina was the largest tungsten mine in the

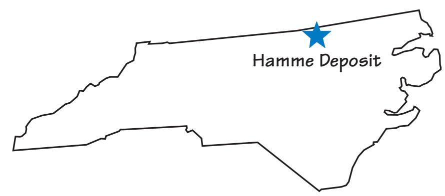


Figure 24: The Hamme deposit of North Carolina was an important tungsten mine.

U.S. from 1951 to 1958, and produced over a million tons between 1942 and 1963 *(Figure 24)*. The primary tungsten mineral is ***huebnerite*** and occurs in quartz veins as a result of hydrothermal processes associated with Precambrian igneous intrusions. Considerable reserves of tungsten ore remain in the area.

huebnerite: *$MnWO_4$*

Banded iron formation deposits extend for almost 85 miles through the Avalon Rocks in North and South Carolina. Hydrothermal in origin, the iron was deposited as sediments on the ancient seafloor. These deposits were first mined for local forge products just before 1760, and supplied iron for the weapons of the Continental Army during the American Revolution. The profitability of these and similar small districts were greatly reduced after 1855 with the discovery and development of the vast iron deposits of the Lake Superior District in Michigan. The Avalon Rocks banded iron formations were a major source of iron for the weapons of the Confederate armies during the Civil War, including shot, cannonballs, and armor plates for naval ironclads. Production declined after the war and ended around 1900.

Banded Iron Formations

Weathering and stream erosion have produced residual deposits of heavy mineral concentrates in the eastern Avalon Rocks, especially in association with granite intrusions. ***Monazite*** deposits form an "Eastern Monazite Belt" in North Carolina and Virginia.

see Minerals, p. 131 for more on **monazite.**

monazite: *$(Ce,La,Y,Th)PO_4$*

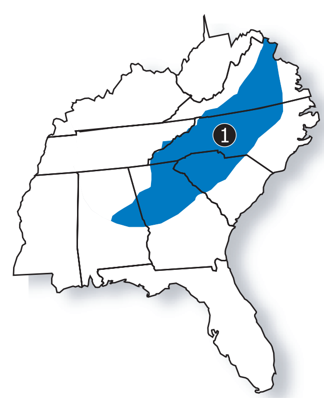
Non-Metallic Mineral Deposits

Extensive deposits of ***barite*** are present in the Avalon Rocks, associated with gold and base metal mineralization, as well as extensive areas of hydrothermal alteration. Because it is heavy, soft, and chemically inert, barite is widely used as an additive and filler, largely to increase the density of lubricating muds used in oil and gas drilling.

barite: *Fe_3O_4*

Until federal laws were passed to prevent the practice, finely ground **barite** *was often added to flour and other foods to increase the weight.*

The hydrothermal aluminum silicate deposits of the Avalon Rocks often contain a remarkable and highly prized assortment of rare and unusual minerals, formed by the concentration of insoluble elements in the host rock and the introduction of new elements. Some of these minerals, in addition to kyanite and pyrophyllite, include rutile, topaz, lazulite, diaspore, tourmaline, and pyrite. Many of these deposits contain abundant pyrite, sometimes in crystals up to eight-inches across.



Major deposits of ***kyanite***, ***pyrophyllite***, and ***andalusite*** are also present in the Avalon Rocks. Major pyrophyllite deposits in the Avalon Rocks include those at Hillsborough, Snow Camp, Glendon, and Robbins in North Carolina and Boles Mountain in South Carolina. Important kyanite deposits include Henry's Knob, South Carolina and ***Graves Mountain***, Georgia.

Graves Mountain, *Georgia, is a world-renowned locality for rutile, producing crystals up to six inches long.*

Aluminum Silicate Minerals

The kyanite family of minerals includes kyanite, sillimanite, pyrophyllite, and andalusite. All have the formula Al_2SiO_5 and are polymorphs, minerals with the same composition but different crystal structures. These different crystal structures form under different conditions of heat and pressure, and reflect the geologic history and degree of metamorphism of the rocks in which they are found. Pyrophyllite, kyanite, and sillimanite form a metamorphic progression of aluminum silicate minerals formed at increasingly higher temperature and pressure. Andalusite forms at high temperatures but low pressures. All of these minerals form mullite when heated to very high temperatures. Mullite is used in manufacturing glass and ceramics that can withstand very high temperatures.

Triassic-Jurassic Rift Rocks

see Geologic History, p. 3, for more on the **Triassic-Jurassic Rift Basins.**

Mineral Deposit Processes

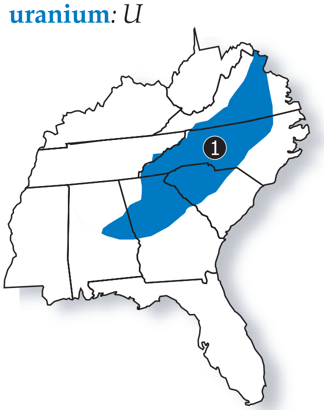
Sedimentation *was the dominant process occurring in the Mesozoic Basins. Igneous intrusions and local volcanic activity in the Jurassic was also accompanied by minor* ***hydrothermal*** *activity, and the formation of small deposits of copper and iron mineralization. Low temperature* ***rift basin hydrothermal*** *circulation of groundwater formed a few small copper deposits, and a major* ***uranium*** *deposit.*

copper sulfides *include minerals such as ... (XXX: Cu_3SO_4)*

hematite: Fe_3O_4

The mineral name **hematite** *has its origins in the Greek word* haimatos, *meaning blood. The vivid red pigment that iron lends to the mineral is valuable as a commercial pigment. Iron from hematite is also used in the manufacture of steel.*

uranium: *U*



Metallic Mineral Deposits

Scattered small occurrences of ***copper sulfides*** and ***hematite*** formed in association with hydrothermal activity in the rift basins, and low temperature hydrothermal circulation of groundwater through the sediments, but none are of major economic importance in the Southeast.

In 1982 the Marline Uranium Corporation announced the discovery of a 30-million ton deposit of ***uranium*** ore in Pittsylvania County, Virginia. The ore body is developed in an intrusion of gneiss in the Danville rift basin *(Figure 25)*. Uranium originated in the rift basin sediments, and was transported in dissolved form by groundwater, and deposited. The Uranium deposit was never developed, due to a drop in uranium ore prices and local opposition to the project.

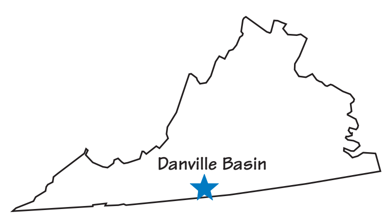


Figure 25: Virginia's Danville rift basin contains a uranium ore body.