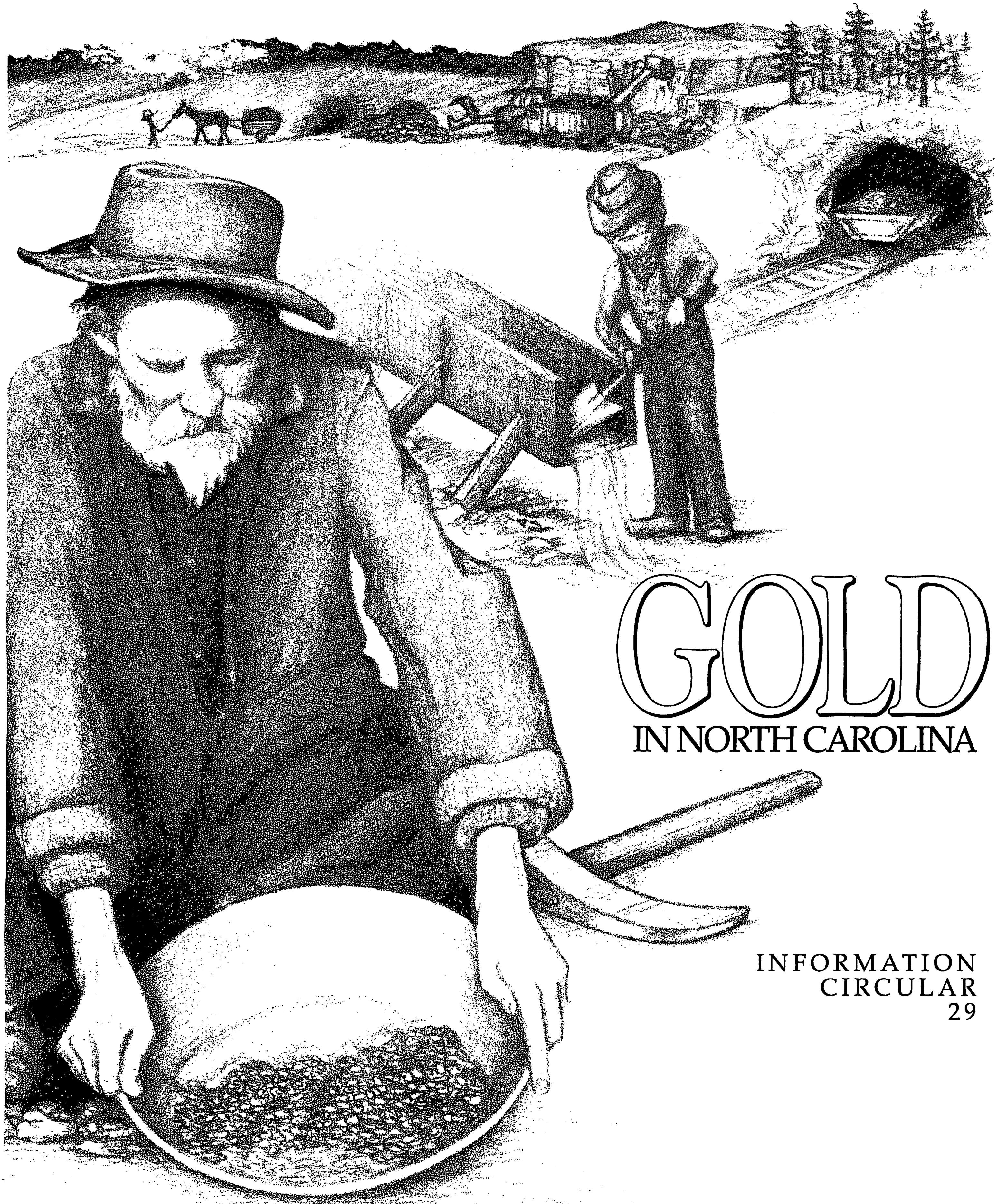

GOLD IN NORTH CAROLINA

INFORMATION
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29

DEPARTMENT OF ENVIRONMENT,
HEALTH AND NATURAL RESOURCES

Charles H. Gardner
Director and State Geologist

GEOLOGICAL SURVEY SECTION

The Geological Survey Section examines, surveys, and maps the geology, mineral resources, and topography of the state to encourage the wise conservation and use of these resources by industry, commerce, agriculture, and government agencies for the general welfare of the citizens of North Carolina.

The Section conducts basic and applied research projects in environmental geology, mineral resource exploration, and systematic geologic mapping. Services include identifying rock and mineral samples submitted by citizens and providing consulting services and specially prepared reports to agencies that need geological information.

The Geological Survey Section publishes Bulletins, Economic Papers, Information Circulars, Educational Series and Geologic Maps. For a list of publications or more information about the Section contact the Geological Survey Section, Division of Land Resources, at Post Office Box 27687, Raleigh, North Carolina 27611-7687, or call (919) 733-2423.

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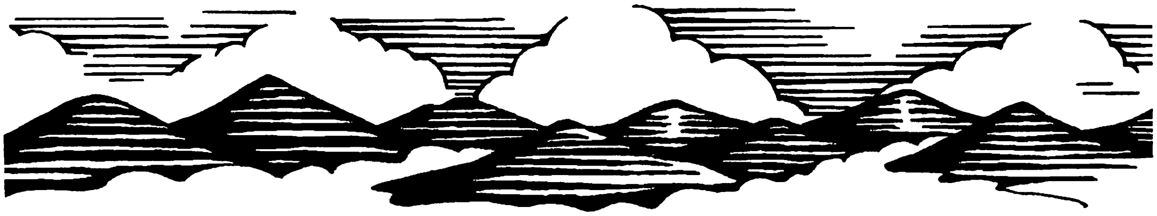


GOLD
IN
NORTH CAROLINA

by

P. Albert Carpenter III

NORTH CAROLINA GEOLOGICAL SURVEY

INFORMATION CIRCULAR 29

STATE OF NORTH CAROLINA

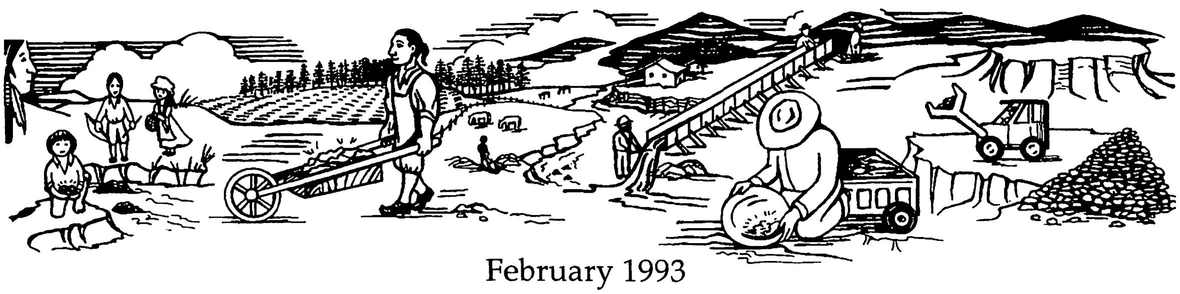
James B. Hunt, Jr., Governor

DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

Wayne McDevitt, Secretary

DIVISION OF LAND RESOURCES

Charles H. Gardner, Director and State Geologist



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GOLD IN NORTH CAROLINA

by
P. Albert Carpenter III

ABSTRACT

Gold has been an important part of North Carolina's history since 1799 when a young boy found a 17-pound gold nugget in Little Meadow Creek in Cabarrus County. This discovery initiated America's first gold rush. North Carolina soon became the nation's first gold-producing state and was the only gold producer until 1828.

Over 600 inactive gold mines and prospects are scattered throughout the Piedmont and Mountain regions of the state. The deposits are concentrated into six geologic belts: 1) the Eastern slate belt, 2) the Carolina slate belt, 3) the Charlotte belt, 4) the Kings Mountain belt, 5) the Inner Piedmont belt, and 6) the Blue Ridge belt. Even though some of the deposits never produced significant quantities of gold, many were major producers and were extensively developed. Total gold production in North Carolina through 1991 is estimated at approximately 1.1 million ounces. The value of this production is estimated as high as $25 million based on historical prices for gold. At today's prices of $350 an ounce, this would represent a value of $385 million.

Both placer and lode deposits were mined in North Carolina. The placer materials were usually mined first, and later operations moved underground to obtain gold from the lodes. Copper, lead, zinc, and silver were sometimes the major product with gold as a by-product.

Even though gold is an important part of North Carolina's past, there is currently no commercial gold mining in the state. The last major production was from 1954 to 1963, as a byproduct of copper mining at the Ore Knob Mine in Ashe County.

Many streams flowing through old mining districts still contain small amounts of placer gold that can be recovered by panning. Although it is not possible to obtain large quantities from these streams, the possibility of finding gold "colors" in a pan lures many weekend prospectors to the state.

Gold has always been highly valued and it was one of the first metals used by man. Its rarity, beauty, and durability allow for a variety of uses in jewelry, electroplating, dentistry, decorative purposes, and medicine, and as a monetary standard. Gold's unique physical properties, many of which cannot be duplicated by substitutes, will continue to make gold a valuable mineral resource.

This report summarizes information from many publications, some of which are out-of-print, that describe the gold deposits of North Carolina. Much of the historical information is from the reports by Bryson (1936), Kerr and Hanna (1893), Nitze and Hanna (1896), Nitze and Wilkins (1897), Pardee and Park (1948), and Stuckey (1965). During the 1980's, there were significant developments in gold processing technology and in the understanding of ore-forming processes. A review of these new developments is included in the text. Where information was available, new ideas on the formation of individual ore bodies is included in the individual mine descriptions.

INTRODUCTION

OCURRENCE

Gold deposits occur as one of two main types: placer deposits and lode deposits. Within these two large categories, the deposits can be separated in greater detail. Placer deposits can be classified as either recent placers (such as active stream valleys) or fossil placers (older sedimentary rocks). Most of the world's gold production is from fossil placer deposits. Lode deposits can be grouped into many types including skarn, porphyry, polymetallic vein and replacement, quartz vein, disseminated sediment- and volcanic-hosted, bonanza, massive sulfide, and iron-formation deposits (Tooker, 1989).

Placer Deposits

The largest gold deposits are fossil placer deposits. Because gold is heavy (high specific gravity) and is not destroyed by weathering processes, it is easily concentrated by mechanical processes to form placer deposits. These deposits form when gold-bearing veins or zones are weathered and the gold is mechanically separated from the lighter minerals. Placer accumulations usually occur where the flow of streams carrying gold is deflected or obstructed. The obstruction or deflection in the stream causes the heavier, coarser gold to settle to the bottom of the stream. The richest and coarsest gold particles are normally found with the coarser sedimentary material, closer to the source of the gold, or at the bottom of steep gradients. Gold also accumulates in cracks, joints, and bedding planes in bedrock.

Ancient placers, or paleoplacers, occur when placer deposits are buried beneath overlying rocks. The largest gold deposits in the world are paleoplacers in conglomerate beds in the Witwatersrand, South Africa (fig. 1). No ancient placers are known in North Carolina.

Lode Deposits

Lode deposits can be grouped into many types including skarn, porphyry, polymetallic vein and replacement, quartz vein, disseminated sediment- and volcanic-hosted, bonanza, massive sulfide, and iron-formation deposits (Tooker, 1989). There is much debate among geologists concerning a classification for gold deposits. Many gold deposits were

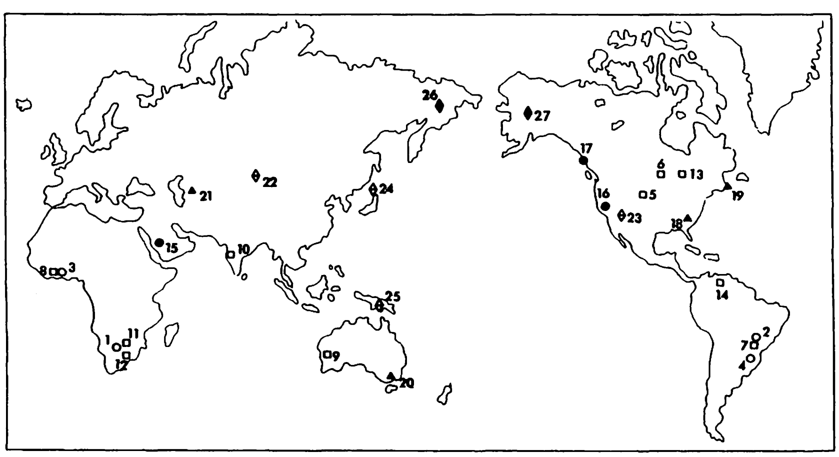


Figure 1. Distribution of some important world gold deposits (modified after Hutchinson, 1987).

● **Upper Precambrian to lower Phanerozoic greenstone-hosted lodes**
15 Mahd adh Dahab, Saudi Arabia
16 Mother Lode, California
17 Juneau, Alaska

▲ **Late Precambrian to Phanerozoic graywacke- or turbidite- hosted lodes**
18 Southeastern USA
19 Nova Scotia
20 Ballerat-Bendigo, Australia
21 Muruntau, Russia

◇ **Other lode deposits**
22 Trans-Baikal, Russia
23 Southwest USA
24 Hokkaido, Japan
25 Porgera, New Guinea

◆ **Placer deposits**
26 Magadan Oblast, Russia
27 Alaskan deposits

○ **Paleoplacers**
1 Witwatersrand, S. Africa
2 Serra de Jacobina, Brazil
3 Tarkwaian, W. Africa
4 Moeda, Brazil

□ **Archean greenstone-hosted lodes**
5 Homestake, S. Dakota
6 Kerr-Addison & Hemlo, Ontario
7 Morro Velho, Brazil
8 Ashanti, W. Africa
9 Kalgoorlie, W. Australia
10 Kolar, India
11 Zimbabwe
12 Barberton, S. Africa
13 Quebec, Canada
14 El Callao, Venezuela

Type	Characteristics	Examples
Skarn	Irregular replacement of fractured carbonate rock adjacent to granitic intrusives to form gold-bearing calc-silicate mineralized rock. Gold may be primary or secondary to base metals.	Nevada (Fortitude, McCoy)
Porphyry (Dispersed)	Large-volume, low-grade, vein and disseminated sulfides in sheeted zone or stockwork of an associated subvolcanic porphyry. Gold may be primary or secondary to base metals.	Utah (Bingham); Montana (Golden Sunlight); New Mexico (Ortiz);
Polymetallic and replacement	Sulfide-rich fissure and replacement deposit in vein and sedimentary or igneous host. Gold may be primary or secondary to base metals and other precious metals.	Colorado Front Range (Central City); Tintic district, Utah (Mammoth)
Quartz lode	Vein and shear zone deposit generally in regionally metamorphosed sedimentary and igneous rocks and composed primarily of gold with quartz pyrite gangue. May contain minor base-metal sulfides.	Sierra foothills, CA (Mother Lode); Southeast Alaska (Juneau)
Disseminated-sediment- and volcanic-hosted	Large-volume, low-grade, bulk-minable, generally epithermal deposit of primary gold, which may or may not be associated with intrusive rocks.	Carlin Trend, Nevada (Getchell, Cortez); Southeast Appalachian (Haile, Ridgeway, Brewer, SC); California (McLaughlin); Nevada (Round Mtn.)
Bonanza	Exceptionally rich ore shoot of primary and oxidized epithermal gold generally in a volcanic host, but also as an enriched quartz lode, replacement, stockwork or breccia pipe.	Nevada (Comstock Lode); Colorado (Cripple Creek)
Massive sulfide	Irregular peneconformable concentration of sulfide minerals in volcanic, metavolcanic, and metasedimentary rocks of mobile belts or accreted terranes. Gold occurs secondary to base metals.	South-central Arizona (Jerome)
Iron-formation	Local concentration of primary gold in stratabound stringers and fracture-fillings of "banded" (layered) marine metasedimentary and volcaniclastic rocks that contain more than 15 percent iron, abundant chert, and fine-grained quartz segregations.	Western South Dakota (Homestake)
Saprolite	Secondary enriched deposit of gold in place, localized in soft clay-rich decomposed igneous or metamorphic rocks by chemical weathering.	Southern Appalachians

After: Tooker (1989)

formed by more than one process, and a single mining district may contain deposits formed by a combination of processes. The preceding classification is a descriptive classification as proposed by Tooker (1989).

The disseminated sediment- and volcanic-hosted deposits and massive sulfide deposits were formed millions of years ago in hydrothermal systems. Recent studies show that gold is deposited presently by modern hydrothermal systems both on land and in the oceans. Gold is deposited from vents and black smokers on volcanically active midoceanic vents and oceanic rifts. Some of these volcanically active areas are in the Pacific Ocean off the west coast of North and South America (Juan de Fuca Ridge, Axial Seamount, Guyamas Basin, and others). Gold is deposited during mixing of the vent fluids and black smoke with sea water.

Active hydrothermal systems also occur on land as high-temperature geothermal systems, such as Broadlands, New Zealand, and Steamboat Springs, Nevada. These modern geothermal systems are recognized as analogues of ancient volcanogenic gold deposits. Studies show that the modern and ancient volcanic systems are similar with respect to chemical elements, temperature and pressure ranges, compositions of fluids, isotope relationships, and mineralogy of gangue, ore, and alteration minerals (White, 1981). Through the processes of plate tectonics, ancient deposits that formed in oceanic basins were transported to sites that are now inland, many miles from the ocean.

The Kuroko deposits of Japan are considered the classic volcanic-hosted massive sulfide deposits. These stratiform deposits are in a belt of volcanic and sedimentary rocks that accumulated during fault-controlled subsidence in Miocene time. The deposits are believed to have formed on or near the seafloor by precipitation from hydrothermal fluids. In the Carolina slate belt in North Carolina, Kuroko-type massive sulfide deposits are found in the Cid and Gold Hill districts (Union Copper Mine and Silver Hill Mine). These slate belt deposits are strata-bound to stratiform in nature and are associated with volcanic rocks. They may have formed on the sea floor during Proterozoic or Cambrian time.

Gold deposits may also be classified according to their age of formation. The most important deposits are associated either with Cenozoic volcanism or with Precambrian rocks. Deposits associated with the younger, Tertiary (Cenozoic) volcanism normally occur as veins and disseminated deposits in volcanic rocks and as replacement bodies in sedimentary sequences (Carlin-type deposits). These deposits are common in certain parts of Colorado, Nevada, and Utah. Examples of this type of deposit are Round Mountain, Utah, and the McLaughlin Mine in California.

The older, Precambrian deposits may be broadly grouped as Precambrian (Archean) greenstone-hosted (or volcanic-sedimentary) lodes and relatively younger (upper Precambrian to lower Phanerozoic) graywacke- or turbidite-hosted ores (Hutchinson, 1987). The Archean greenstone-hosted lodes are the oldest in the world and are the second largest producers, following only the South African paleoplacers. Examples of the older deposits include: the Homestake Mine, South Dakota; Kerr-Addison Mine and Hemlo district, Ontario, Canada; and Morro Velho Mine, Brazil. Many of these mines are associated with massive sulfides, iron formations or host sedimentary-volcanic rocks.

The younger (late) Precambrian or early Paleozoic gold deposits have not been large producers on a world-wide scale. These deposits are associated with metasedimentary rocks and smaller amounts of volcanic rocks than the Archean greenstone-hosted deposits. Deposits grouped with this type include deposits in Nova Scotia and possibly Newfoundland (Chetwynd deposit), the Southeastern United States gold belt (includes Carolina slate belt), the Ballarat-Bendigo in Victoria, Australia, and Russian deposits at Muruntau (Hutchinson, 1987).

SOURCES AND PRODUCTION

Total world resources of gold (1991) were estimated at 75,000 metric tons (approximately 2.4 billion troy ounces), of which the Republic of South Africa has about one-half (U.S. Bureau of Mines, 1992). Brazil, Russia, and the United States have approximately 12 percent each. Total world gold production in 1991 was about 2,060 metric tons (64.5 million troy ounces), a slight increase over 1990 levels.

World Sources and Production

The world's gold supply is changing because of new exploration techniques and models, new processing technology that allows the development of lower-grade deposits, new discoveries in many parts of the world, higher gold prices, and declining production in South Africa. The Republic of South Africa, the largest gold producer in the world, is experiencing a decline in its gold production. During the 1980's, South Africa's contribution to the world gold supply fell from a high of 70 percent in 1980 to about 36 percent in 1990. This decline is expected to continue because of declining grades, the exhaustion of reserves, and higher costs associated with deeper mining. Current annual production for the Republic of South Africa is about 20 million ounces, over one million ounces less than it was in 1981. The United States, Canada, and Australia have seen their production increase to six times higher over the last ten years because of increased gold prices and improved recovery methods.

Most of the Republic of South Africa's production comes from the Witwatersrand near Johannesburg in the Transvaal. Gold in the Witwatersrand was discovered in 1886. It is mined from metamorphosed conglomerate beds called reefs. The conglomerate beds and associated sedimentary rocks were folded into a synclinal trough and were faulted. The mineralized horizons average 0.1-0.3 troy ounces of gold per ton and also contain uranium-bearing minerals, as well as other heavy minerals. Most of the gold occurs between grains in the conglomerates and in banded quartzites.

Paleoplacers are also mined at Serra de Jacobina, Bahia, Brazil. These deposits average 0.25-0.45 ounces of gold per ton. They occur with significant quantities of uranium in Lower Proterozoic conglomerates. The deposits probably formed by a combination of placer processes and remobilization during metamorphism.

Other major gold producers in order of rank are the United States, Russia, Australia, and Canada. In 1990, the United States passed the former Soviet Union in gold production for the first time in 50 years.

The most important gold-producing region in Russia is in a portion of Siberia referred to as the Magadan Oblast. This is a part of the Chukotka Peninsula, which protrudes eastward toward Alaska. The major portion of the production is from placer mining. The most important lode deposits are in the Trans-Baikal region.

Australian gold production has risen dramatically, doubling from 1987 to 1990. The Yilgarn Block, Western Australia, has been the site of approximately one-third of the country's gold production. Many of the mines in the area are Archean greenstone-hosted deposits.

Canada's major production comes from lodes in the Superior Province of Ontario and Quebec. This is the largest exposed Archean craton in the world and has accounted for more gold production than any other Archean craton, more than 150 million troy ounces. The significant deposits are within or immediately adjacent to greenstone belts and are within major tectonic, or deformed, zones.

United States Sources and Production

Major gold production in the United States is from Nevada, California, Utah, South Dakota, Idaho, and Montana. Many new domestic mines opened in the late 1980's and the capacities of existing mines were expanded. The 25 leading gold producers accounted for 61 percent of the total domestic production in 1991 (U.S. Bureau of Mines, 1992).

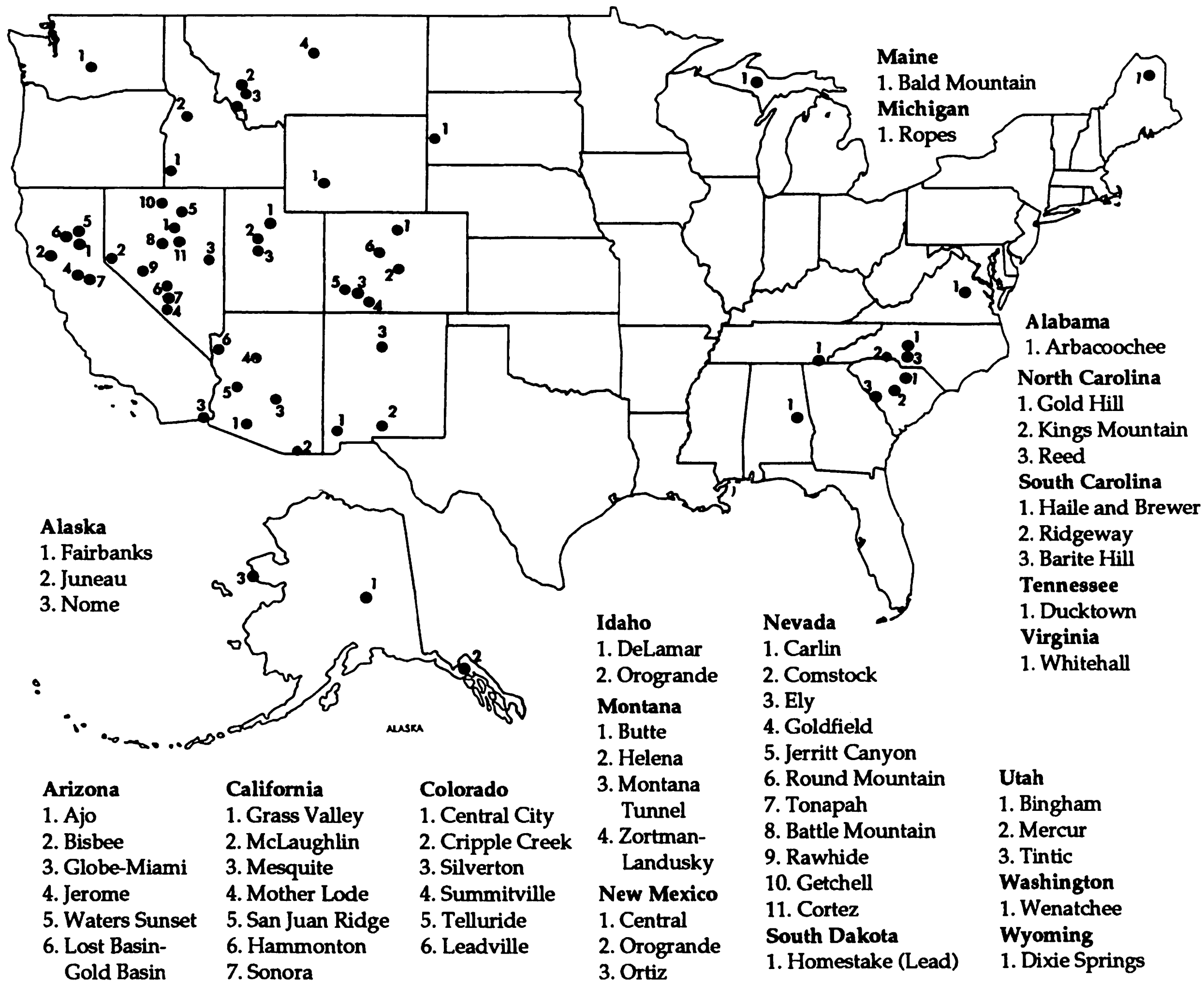


Figure 2. Location of gold deposits in the United States (modified after Tooker, 1989).

Most of the production was from several hundred lode mines in the western United States and from a dozen or more placer mines, mostly in Alaska (fig. 2). Production was approximately $3.5 billion in 1991.

In 1991 Nevada produced 5.7 million troy ounces of gold and was the fourth largest gold producer in the world. Gold production has risen more than 50 percent since 1988 and is expected to remain constant for the next few years. The Carlin Gold Belt of northeastern Nevada is one of the richest gold districts in the United States. The district accounts for more than 60 percent of the U.S. production. The largest deposits are Newmont's Gold Quarry deposit and American Barrick's Post and Betze deposits. These three deposits contain more than 50 percent of Nevada's known reserves. The gold deposits are in Cambrian to Devonian siliceous and carbonate assemblages and are hydrothermal disseminated-replacement deposits of Tertiary age. Felsic intrusive bodies are spatially related. Primary ore controls are north-, northwest-, and northeast-trending high-angle faults.

For many years, the Homestake Mine at Lead, South Dakota, led the nation in gold production. Gold is mined by underground methods in altered and folded Precambrian sediments. Additional open-pit mining is in the Open Cut, the site of the original discovery of the Homestake lead, in 1876. South Carolina, primarily because of production at the Ridgeway Mine, became the eighth largest gold producer in the United States in 1990, producing 220,000 troy ounces.

MINERALOGY AND PHYSICAL PROPERTIES

Gold, one of the native metals, is recognized chiefly by its weight (high specific gravity), malleability and yellow color. It is found normally in varying shades of yellow, but may be silver-white to orange-red, depending upon the impurities present. It has a hardness of 2.5-3 and has a specific gravity of 19.3 when pure. It is insoluble in all acids except aqua regia (a mixture of hydrochloric and nitric acids). Even though it crystallizes in the isometric system, normally forming octahedral crystals, it usually is seen as irregular plates, scales, and masses, rather than as crystals.

Gold is located in group IB of the periodic table. It is grouped with the siderophile elements–those with a geochemical affinity for metallic iron. As a result of its siderophile characteristics, gold concentrates in residual fluids and later metallic or sulfide phases, rather than in earlier silicate phases of cooling magmas. Gold can substitute for other chemically similar elements and forms inclusions in such minerals as pyrite, arsenopyrite, chalcopyrite, and stibnite.

Gold occurs in nature mainly as the native metal and as alloys with other metals, primarily silver. Gold forms a complete solid-solution series with silver (ions of gold can substitute for silver ions and vice versa). Almost all gold contains some silver and frequently copper and iron. When silver is present in amounts greater than 20 percent, the alloy is known as electrum. Gold is commonly referred to according to its fineness or purity, which is expressed in parts per thousand. Most gold contains about 10 percent other metals and thus has a fineness of 900. Gold is weighed according to the troy system which is based on 480 grains per troy ounce or 20 pennyweight.

1 troy ounce = 480 grains = 20 pennyweight = 1.097 ounces avoirdupois = 31.1035 grams

12 troy ounces = 1 troy pound = 0.823 pounds avoirdupois

Note: All gold weights in ounces in this publication are in troy ounces.

USES

One of the oldest uses of gold is in jewelry. The jewelry industry consumes almost 60 percent of the total gold used annually. Industrial applications, primarily electronic, account for approximately 34 percent of gold usage and dental uses account for 6 percent.

Gold is highly valued in the jewelry industry because it is chemically inert and does not corrode or tarnish with use. Its malleability and bright, pleasing color are especially desirable qualities in the jewelry industry. Because it is soft, gold is usually alloyed with other metals to increase hardness. Much of the gold used in jewelry is used for electroplating and as rolled gold plate and gold fill. Gold in jewelry is usually referred to in terms of karats. Karat means a 24th part, and gold is expressed according to its weight proportion in an alloy. An 18 karat alloy contains 18/24's or 75 percent gold. Gold is most widely used as a 14 karat alloy. Below this content, corrosion resistance drops sharply.

Gold is used extensively in a variety of solid-state electronic devices, in industrial control and monitoring instruments and in corrosion-resistant chemical process equipment. The most important strategic and industrial uses of gold are in sophisticated electronic equipment, such as in printed circuit boards, connectors, keyboard contactors, miniaturized circuitry and as a dopant (a substance used to alter the properties of another substance) in some semiconductors. Computers and a variety of electronic systems use gold in connectors, switch contacts, soldered joints, and other components where resistance to tarnish and chemical and metallurgical stability are critical.

Gold is used in dentistry for inlays, crowns, bridges, and orthodontic appliances. Many of the characteristics that make gold desirable for jewelry also make it desirable for dentistry. Other uses of gold include gold coatings for decorative purposes on glass and porcelain, as a reflector of infrared radiation in radiant heating and drying devices, heat-insulating windows for large buildings, spacecraft, and in medicine as treatments for arthritis and certain types of cancer.

In 1975, gold was again legalized for private ownership in the United States. As a result, gold is now used in items for investment such as fabricated bars, coins, and medallions.

No other metal or alloy has been discovered that possesses all the desirable characteristics of gold. The use of substitutes always risks losing some of the desirable qualities of gold. Platinum and palladium are sometimes substituted for gold in jewelry; however, they are more expensive and lack the color and appeal of gold. Silver is occasionally substituted in electrical uses but is much less resistant to corrosion than gold and is less ductile. Other metals have applications in dental uses.

PRICES

The United States Congress, in 1792, established a bimetallic (gold-silver) standard for the United States (Shawe, 1988). The price of gold was set at \$19.39 per troy ounce, equal to the British pound sterling. The fixed ratio of gold to silver values was 1 to 15. The price remained constant until 1834 when, because of inflation, the price was raised to \$20.67 per troy ounce, at a fixed ratio of gold to silver of 1 to 16. Gold prices remained constant until the U.S. Civil War when unofficial gold prices soared. Prices dropped significantly during the "silver panic" on September 24, 1869, referred to as "Black Friday." During the panic of 1873, prices were lowered by the federal government to their earlier fixed price.

Following the 1929 stock market crash and the failure of the U. S. banking industry, the Congress prohibited U. S. citizens from owning gold. In 1934, the price of gold was fixed at \$35 per ounce, and in 1944, the U. S. dollar became the world's monetary standard based on the \$35 per ounce gold value. This fixed price remained in effect until 1971 when the U. S. government abandoned the gold standard.

In December 1971, the Federal government devalued the dollar, raising the official gold price by 8.57 percent to \$38.00 per troy ounce. In 1972, free market gold prices began to rise, and by mid-August, London quotes were up to a record \$70.00 per ounce. Gold prices continued to rise throughout 1974, reaching a high of \$197.50 per troy ounce near the end of the year. On December 31, 1974, regulations on private ownership of gold were removed. In 1975, prices began a downward trend and were around \$140.00 at year's end. Prices continued to fluctuate in 1976, but in 1977 began to rise, averaging \$160.00 for the year. In July 1978, gold prices broke the \$200.00 barrier for the first time in history. Prices continued to climb in 1979 reaching a record \$517.00. This trend continued into 1980 when a record price of \$850 was reached. From 1981 through 1987, prices moderated, fluctuating between a high of \$599.25 to a low of \$276.75. During the late 1980s and early 1990s, gold prices became more stable but remained around the \$350-\$400 per ounce range. Figure 3 illustrates the fluctuations in gold prices from 1975 until 1991.

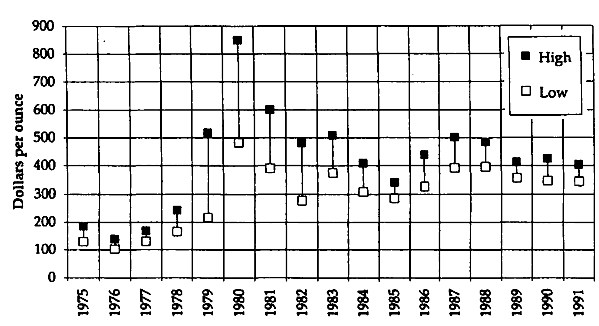


Figure 3. Annual high and low gold prices, 1975-1991.

In response to the rise in gold prices from the mid-1970's to the present, many companies increased their worldwide search for gold. The higher gold prices allowed companies to develop low-grade deposits and to carry out exploration in remote parts of the world. As a result many new deposits were discovered in Brazil, Australia, Canada, New Guinea, the United States, and other countries.

MINING METHODS

The method of mining and processing of gold ore varies, depending upon the size and shape of the deposit, type of deposit (placer or lode), composition of the ore (minerals present in addition to gold), and depth of the deposit. Mining and processing costs vary depending upon the deposit, but in 1988, the average direct operating costs among 225 primary producers worldwide was $256 per ounce (Mining Journal, 1989). South African mines are among those with the highest costs (19 mines with costs above $350 per ounce). Twenty-six of the lowest cost mines (less than $205/oz) were in the United States. The mining of lode deposits most commonly consists of one of two types—open pit and underground.

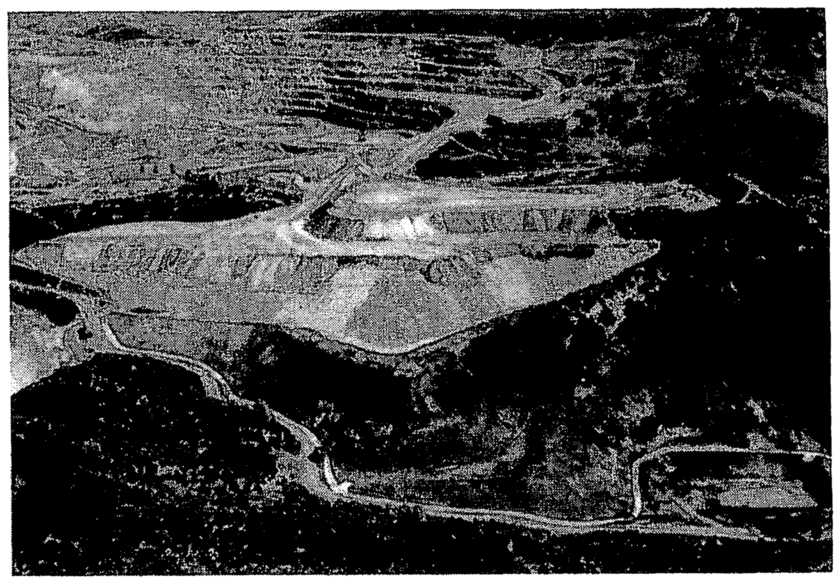


Figure 4. Aerial view of the Homestake Mining Company's McLaughlin Mine, California (Reprinted from Mining Engineering and published with permission.)

Open Pit Mining

Open-pit mining is much less costly than underground mining and is most often used in deposits of large tonnage and low grade (fig. 4). Most deposits that can be worked profitably by open pit methods would be unprofitable using underground methods. In open pit mining, the overburden is first removed and then the ore is removed by using hammers, rotary drills and blasting to cut benches that spiral downward to the bottom of the pit. The ore and waste are removed from the pit by trucks or railroad cars.

Underground Mining

Underground methods vary depending upon the nature of the deposit. Normally, the ground is entered by a vertical or inclined shaft or, in mountainous areas, by tunnels (adits). Levels are then driven from the shaft to the ore at different depths down the shaft. The ore is removed by cutting drifts, cross-cuts, raises, winzes, and stopes. The ore is loaded into skips and hoisted to the surface. As the ore is removed, the remaining voids are frequently filled with waste rock or sand or supported by timber. In South Africa, underground mines reach depths of more than 12,000 feet below the surface.

Placer Mining

Small placer deposits can be worked by the simplest methods and require only the removal of the material containing the gold and the recovery of the gold by mechanical devices, such as sluices, pans or rockers. These recovery methods are all based upon the principle that gold is heavier than the other minerals present in the deposit and can be concentrated at a specific location in the sluice, pan, or rocker. Many of the devices used in small placer operations are portable and moderately priced, so they are popular with amateur prospectors.

Mercury can be placed into riffles and jigs to recover the very fine or flake gold. Precautions must be taken to prevent the mercury from entering the water supply. Gold is separated from the mercury in a retort by boiling off the mercury in a closed system to prevent the escape of mercury vapors into the air.

In mining large-scale placer deposits, either hydraulicking or dredging methods (fig. 5) are used. Hydraulicking is used in working unconsolidated gravels and requires the use of large amounts of water. The gravels are worked in place by forcing powerful jets of water onto the deposit and channeling the material into sluices.

Dredging is used on a much larger scale than hydraulicking and can be used in deposits submerged in water. The dredging machine normally consists of a mechanical excavator and washing, screening, pumping and propulsion equipment. A dredge can recover material to a depth of 100 feet below the water level and can process 300 to 500 cubic yards of gravel per hour.

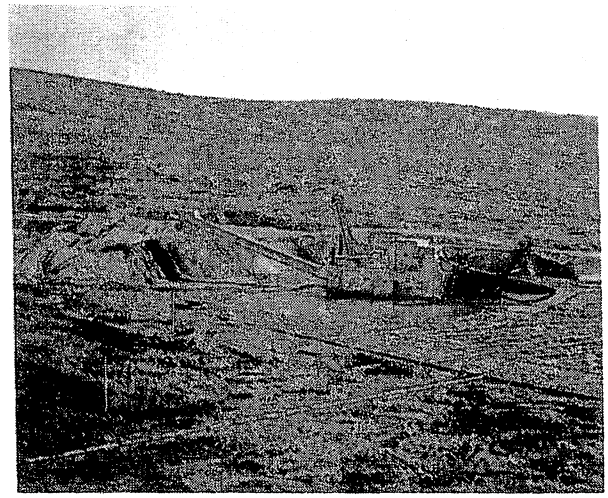


Figure 5. Dredge No. 5, Alaska Gold Company, near Nome, Alaska. (Reprinted from Mining Engineering and published with permission.)

RECOVERY METHODS

After ore has been mined, it must be milled or processed to obtain the desired final product. The type of processing depends primarily upon the character of the ore, including mineralogy and nature of the gold associations. Gold ores can be classified into three main groups for processing: 1) non-refractory or readily leachable ores; 2) refractory ores and; 3) ores containing free gold.

Non-refractory Ores

Cyanide (NaCN) has been used to treat non-refractory or leachable gold ore for more than a century. New applications of cyanide technology allow the profitable treatment of lower grade ore. Ores that once were discarded as unprofitable are processed, and gold deposits that were considered too low-grade for profitable mining are now mined. In heap or vat leaching, up to 50 tons of ore are treated to yield one ounce of gold. Where cyanide is used, precautions are taken to protect the environment from contamination. Cyanide does not persist in the environment for long periods of time and quickly forms metal cyanides of minimal to low toxicity. Most cyanide easily decomposes in sunlight and oxygen and, at a pH of less than 8, into carbon and nitrogen compounds. Impermeable liners are used under leach heaps, in solution ponds, and in tailings ponds to protect groundwater and to allow the solutions to be recycled and evaporate. (For additional information on cyanide in mining see Throop, 1989.)

The treatment of non-refractory ores normally involves a combination of open-pit mining and a sodium cyanide heap-leach process. In a heap-leach process, ore containing as little as 0.02 ounces of gold per ton is piled onto an impermeable synthetic or natural pad, such as a synthetic membrane or a geotextile fabric. A weak cyanide solution is sprayed over the ore piles. As the solution slowly trickles down through the ore, microscopic gold particles are dissolved. When the gold-bearing solution, referred to as the pregnant solution, reaches the bottom of the leach pad, it is collected in pipes for transfer to holding tanks or ponds. Gold is separated from the pregnant solution by passing the solution through tanks containing charcoal or zinc dust (where silver is abundant). The gold attaches to the surface of the carbon or zinc. The remaining cyanide solution is reused to process additional ore. A stronger solution of cyanide at high temperature and pressure dissolves the gold off the carbon. The gold is then recovered by electrowinning onto steel wool. The steel wool/gold mixture is melted in a furnace, where iron and other impurities are separated from the gold. The gold, referred to as dore, is then poured into gold bars that may be 90 percent gold. The final process is the refining of the gold bars. Gold recoveries in a heap-leach process average 90 percent.

The Haile Mine north of Kershaw, South Carolina, was the first gold mine in the southeast to use the heap-leach method for processing a low-grade gold ore. Figure 6 illustrates the heap-leach process used at the Haile Mine. Processing of the oxidized ore resulted in recoveries of over 90 percent with an average leach time of approximately four to six weeks. Leach pads and recovery plant are shown in figure 7.

Vat-leach and agitation-leach methods, such as carbon-in-pulp (CIP) and carbon-in-leach (CIL), also use cyanide to treat low-grade gold ores. These methods are applicable with low-grade ores that cannot support fine grinding. The ore is treated with the cyanide solution in large vats containing charcoal. The activated charcoal adsorbs gold from the cyanided pulp. Gold with accompanying silver is stripped from the carbon with a strong alkaline cyanide-alcohol solution. The alcohol strip so-

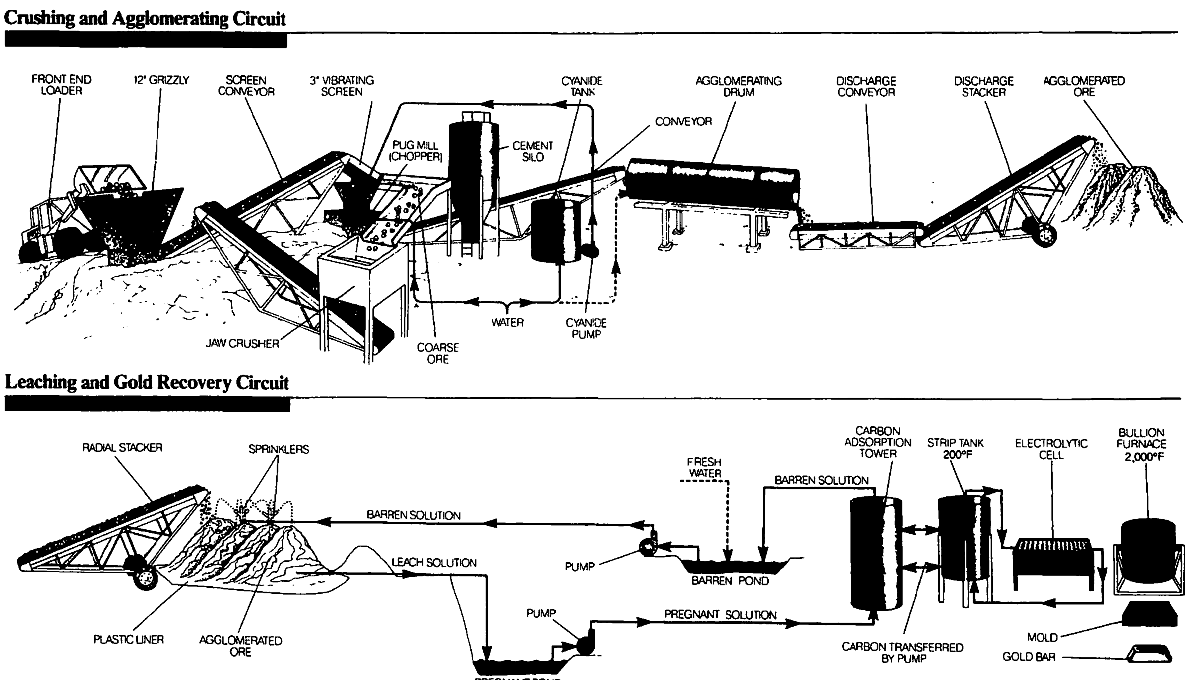


Figure 6. Flowchart of the heap-leach process at the Haile Mine, South Carolina. (Reprinted from Skillings' Mining Review and published with permission.)

Figure 7. Heap pads and recovery plant at the Haile Mine, South Carolina.

lution is currently used less because of safety problems and loss of alcohol through evaporation. Pressure stripping is now the most popular method. The precious metals are removed from the strip solutions by electrowinning on stainless steel wool cathodes. The final process is to refine the gold into bullion or dore. The carbon is reused. Gold recoveries are from 80-97 percent. Figure 8 is a flowsheet of the carbon-in-leach process used at the Ridgeway Mine in South Carolina. The carbon-in-pulp process uses one or more of the first tanks exclusively as leaching tanks, while the remaining tanks are carbon-in-pulp tanks.

Refractory Ores

Refractory ores, or problem ores, include ores that contain associated sulfide minerals, organic matter or gold inclusions in siliceous gangue and chemically combined gold (tellurides). Gold associated with sulfides cannot be processed by the cya-

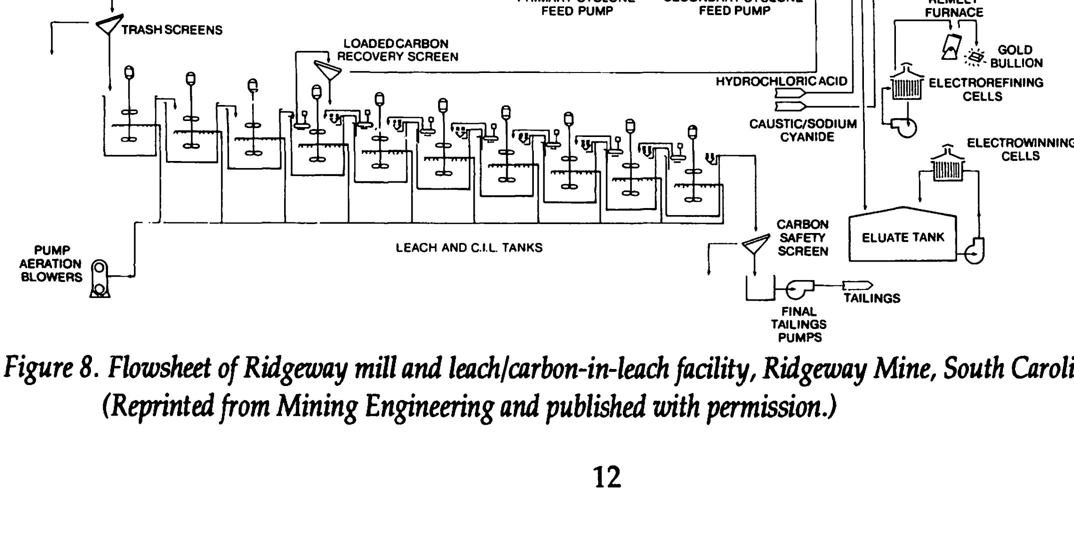


Figure 8. Flowsheet of Ridgeway mill and leach/carbon-in-leach facility, Ridgeway Mine, South Carolina. (Reprinted from Mining Engineering and published with permission.)

nide method unless the ore is roasted. Roasting is more expensive and the grade of ore must be higher. Where sulfides are present, many plants add a flotation step to the circuit to produce a gold-rich sulfide concentrate that can be treated by amalgamation (if free gold is present), cyanidation, or roasting. Bacterial leaching, pressure oxidation, and high pressure/low alkalinity cyanidation are alternatives to roasting.

Bacterial leaching is an alternative to roasting or pressure oxidation because it presents no pollution problems and may have a lower cost. By using bacteria, such as thiobacillus ferroxidans, all metal sulfides can be oxidized to sulfate and all elemental sulfur compounds to sulfuric acid. The gold concentrates can then be treated by standard cyanidation or cyanidation CIL processes. U.S. Gold Corporation is experimenting with bacterial oxidation methods at its Tonkin Springs mine in Nevada.

Ores Containing Free Gold

Ores containing coarse free gold can be processed using gravity concentration methods. These are the oldest concentration methods and are usually inexpensive to use. Gravity methods may be used to minimize losses in conventional recovery methods where coarse gold is present. Gravity concentration methods include the use of jigs, spirals, tables, and various hydrostatic and centrifugal concentrators. Several of these methods will be discussed in more detail under Prospecting for Gold. Hydraulicking is a mining method where free gold in saprolite or gravel is washed away by powerful jets of water and carried into sluices where the gold accumulates.

GOLD REFINING

Refining is necessary to separate gold from the impurities or undesirable metals that may be present. Gold is refined either by the chlorination process in the molten state (Miller process) or by electrolysis (Wohlwill process). The fineness of gold refined by the Miller process is 996 to 997; whereas, gold refined by the Wohlwill process is 999.5 to 999.8 fine.

SOURCES OF INFORMATION

This report summarizes information from many reports, some of which are out-of-print, that describe the gold deposits of North Carolina. A list of these references is included at the end of the report. Much of the historical information is from the reports by Bryson (1936), Kerr and Hanna (1893), Nitze and Hanna (1896), Nitze and Wilkins (1897), Pardee and Park (1948), and Stuckey (1965). Portions of the text were taken from Information Circular 21, Gold Resources of North Carolina (Carpenter, 1972). During the 1980's there were significant developments in gold processing technology and in the understanding of ore forming processes. A review of these new developments is included in the text. Where available, new ideas on the formation of individual ore bodies are included in the individual mine descriptions.

GOLD IN NORTH CAROLINA

HISTORY OF MINING

The first gold mining in North Carolina may have been by the Indians in Cherokee County before white settlers arrived. There are also reports that, in 1540, Hernando de Soto attempted to mine gold along the Valley River northeast of Murphy. Early in the 20th Century, attempts at mining in that area intersected old mine workings, possibly those opened by de Soto, containing bark rope, metal picks, and other materials used in mining in the 16th Century (Stuckey, 1965, p. 295). Reports also state that, prior to the American Revolution, the Oliver Mine in Gaston County, and the Dunn Mine in Mecklenburg County were operated. U. S. Mint records show the receipt of gold from North Carolina as early as 1793.

Since none of these early reports of gold have been substantiated, it is generally agreed that the first authenticated discovery of gold in the United States was in 1799. This discovery was made by Conrad Reed on the farm of his father, John Reed. A nugget, supposedly weighing about 17 pounds, was found in Little Meadow Creek while Conrad and his sister and younger brother were shooting fish with a bow and arrow. Conrad showed the heavy, yellow rock to his father who took the rock to the silversmith in Concord. The silversmith said the rock had no value, so Reed returned home with the rock and used it for a doorstop for three years.

In 1802, Reed took the rock to a jeweler in Fayetteville. The jeweler recognized the sample as gold and purchased it for $3.50. Reed returned home but eventually learned that the jeweler sold the gold for several thousand dollars. Reed returned to the jeweler in Fayetteville and received about $3,000 additional compensation.

Following that experience, John Reed returned to the creek and began finding additional nuggets. Reed, with three other men, found nuggets ranging in size from 16 pounds down to small particles. In 1903, a 28-pound nugget was found. One-hundred and fifty-three pounds of nuggets were found on the property.

The discovery of gold on the Reed farm initiated America's first gold rush. As word of the gold discovery spread, the search for gold began in nearby counties. Gold was soon discovered in Montgomery County and then in Stanly, Mecklenburg, Union, Gaston, Rowan, Davidson, and Randolph counties. This early mining was restricted to the gravels along streams. On the Tobias Barringer farm in Stanly County, gold was mined from the alluvium along Long Creek and from a small tributary to the creek. As the men worked upstream, they noticed that the gold disappeared. At this point Barringer decided to dig into the hillside to see if he could find the source of the gold. Within a few feet of the surface, a gold-bearing quartz vein was found. This 1825 discovery marked the beginning of lode mining in North Carolina. Other veins throughout the area were soon prospected, and in 1831 the veins on the Reed property were discovered.

About 1828, gold was first worked in the South Mountains district of Burke and McDowell counties. According to legend, gold was discovered there when a traveler stopped at a shoemaker's home and spent the night. The next day the traveler, Sam Martin, noticed specks of gold in the mud that was used to fill the spaces between the logs of the house. This discovery led to mining along Brindles Creek, now known as Brindletown Creek. Soon placer mining spread to the First and Second Broad Rivers, Muddy Creek, and Silver Creek. Mining in the South Mountains later spread to the hillsides where both bench gravels and lodes were worked.

By 1831, gold had become such an important resource in North Carolina that gold coins were minted to make the gold easier to handle. Gold coins, minted by Christian Bechtler, were minted as $1.00-, $2.50-, and $5.00-pieces and had the name C. Bechtler, Rutherford County, North Carolina on one side. On the reverse side was the value, number of grains and karats fine. The gold coins of Bechtler were the first minted in America. In 1837, the United States mint opened a branch in Charlotte, and the first coin was struck in 1838. Because of the high quality of the Bechtler coins, the Bechtlers were allowed to continue minting. The Charlotte mint continued operation until 1861 when halted by the Civil War. Coins were never produced there again but the mint was later used as an assay office. The building was later moved and is currently the Mint Museum of Art. The Bechtlers stopped coin production in 1847.

The discovery of gold on the Portis property in Franklin County in 1838 initiated gold mining in the Eastern slate belt. Mining was soon undertaken in Nash, Halifax, and Warren counties. About this same time, mining began in the Cid district of Davidson County.

In 1842, mining began in the Gold Hill district of southeastern Rowan County, perhaps the best known mining district in the state. The Randolph Shaft was opened at Gold Hill in 1843 and was the deepest and richest of the Gold Hill mines. By 1848, there were at least 15 active mines in the district.

Mining flourished in North Carolina until 1849 when gold was discovered in California. With news of the great California gold deposits, many of North Carolina's most experienced miners left for the west. As a result, many of the state's mines closed. Some of the most profitable mines remained open until the Civil War when all the mines closed. Following the war, many mines reopened and produced until 1891, and again during the periods 1902-1906 and 1912-1915. Many of the mines during those later years were used as speculating properties for stock manipulation, although some were legitimate producers.

In 1934, when the price of gold was raised from $20.67 per ounce to $35.00 per ounce, the search for gold was again renewed in North Carolina. Only a few scattered mines were still operating at that time but with word of a higher gold price, many of the old abandoned properties were reworked and exploration was undertaken for new deposits. This period of activity continued until about 1944. Since then, most of the state's gold production has occurred as a by-product of other metal mining, primarily from the H and H copper-lead-zinc mine in Halifax County, the Ore Knob copper mine in Ashe County and the Hamme (Tungsten Queen) Mine in Vance County.

In response to rising gold prices from the mid-1970s to the present, many companies increased their search for gold worldwide. The higher gold prices allowed companies to develop low-grade deposits and to carry out exploration in remote parts of the world. As a result many new deposits were discovered in Brazil, Australia, Canada, New Guinea, and the United States. Gold exploration activity, particularly for low-grade, disseminated deposits has also increased in the southeastern United States. South Carolina now has gold production from four mines. The old Haile and Brewer Mines and Barite Hill in South Carolina produce gold by the cyanide heap-leach method. The Ridgeway Mine, the largest gold mine in the eastern United States, began producing gold in late 1988 (fig. 9). Gold at Ridgeway is processed by the vat-leach method.

Higher gold prices, advances in heap-leach recovery methods and new ideas on gold formation encourage continued gold exploration in North

Figure 9. Aerial view of the Ridgeway Mine, South Carolina (Photo courtesy of Kennecott Ridgeway Mining Company).

Carolina. Many old mines, particularly in the Carolina slate belt, have been drilled and sampled. New targets are also being studied with the latest exploration techniques. Many geologists expect to find gold deposits in North Carolina that can be mined using the same methods that are used in South Carolina.

PRODUCTION

From 1803 through 1828, North Carolina was the only recorded producer of gold in the United States. Gold valued at approximately $156,000 was produced during that period at a price of $19.39 per troy ounce. The period 1829-1855 was the most important with 393,119 ounces of gold produced. In 1834 the gold price was increased to $20.67 per troy ounce. Approximately thirty percent of the total state production was recovered during that time. The other main periods of production were 1882-1891, 1902-1906, and 1912-1915.

When the price of gold increased to $35.00 an ounce in 1934, the state's gold production was revived. From 1935 to 1944, 17,241 ounces valued at $603,600.00 were produced. There was no production recorded from 1945 to 1948 and from 1950 to 1953. The last recorded production was in 1971, when a small amount of gold was obtained as a by-product from the Tungsten Queen tungsten mine in Vance County.

Gold production figures for the state from 1804 through 1990 are shown in Table 1. Accurate figures were not kept until 1880, when the United States Bureau of Mines began publishing statistical reports on the mineral production of the United States. Prior to 1880, production figures were based on United States Mint returns and estimates.

GENERAL GEOLOGY OF NORTH CAROLINA'S DEPOSITS

North Carolina's gold deposits occur as two main types, lode, and placer. The lodes may be subdivided into veins and disseminated deposits (or mineralized zones).

Vein Deposits

The veins are generally narrow, less than four feet wide, but may be up to 30 to 40 feet wide. They pinch and swell along their length and depth, and frequently several veins may occur close together. The length of the veins varies from tens to hundreds of feet. Most of the veins in North Carolina are steeply dipping and trend to the northeast. The veins normally have sharp contacts with the country rock which frequently is sheared to phyllite or schist adjacent to the vein.

The veins are composed primarily of quartz with varying amounts of accessory minerals. Minerals most frequently associated with the veins include pyrite, limonite, magnetite, calcite, sericite, and chlorite. The most common ore minerals in the veins are gold, chalcopyrite, sphalerite, and galena. Not all of these minerals are found in each vein; some veins are completely barren of mineralization.

Gold in veins is normally bright yellow. In the upper oxidized zones of the deposits, it occurs as free gold, apparently released by weathering of sulfides. Below the oxidized zone, gold may be found in small fractures, around grain boundaries or as irregular masses in quartz. Gold production from quartz veins in North Carolina was minor.

Disseminated Deposits

Most of North Carolina's gold production was from disseminated deposits or mineralized zones in the Carolina slate belt. The mineralized zones are zones in sheared volcanic country rock that were altered and mineralized, chiefly to quartz, sericite, and chlorite. These zones may be more than 100 feet wide and have indefinite boundaries, commonly grading gradually into the country rock. Ore grade varies throughout the zone and gold frequently occurs in only a small portion of the zone. Normally, the gold in mineralized zones is so finely

TABLE 1. Gold Production in North Carolina 1804–1992
(Troy ounces)

Year	Troy Oz.	Value	Year	Troy Oz.	Value	Year	Troy Oz.	Value
1804-1823	2,274	$ 4,700	1880	4,596	$ 95,000	1937	949	$ 33,203
1824	242	5,000	1881	5,564	115,000	1938	1,878	65,730
1825	822	17,000	1882	9,192	190,000	1939	495	17,325
1826	968	20,000	1883	8,079	167,000	1940	1,943	68,005
1827	1,016	21,000	1884	7,596	157,000	1941	3,313	115,900
1828	2,225	46,000	1885	7,354	152,000	1942	4,396	153,860
1829	6,483	134,000	1886	8,466	175,000	1943	137	4,795
1830	9,869	204,000	1887	10,885	225,000	1944	21	735
1831	14,224	294,000	1888	6,580	136,000	1945		
1832	22,158	458,000	1889	7,102	146,795	1946		
1833	22,980	475,000	1890	5,733	118,500	1947		
1834	18,384	380,000	1891	4,596	95,000	1948		
1835	12,724	263,000	1892	3,801	78,560	1949	13	455
1836	7,165	148,000	1893	2,593	53,600	1950		
1837	5,656	116,900	1894	2,330	48,167	1951		
1838			1895	2,622	54,200	1952		
1839			1896	2,143	44,300	1953		
1840			1897	1,674	34,600	1954	214	7,500
1841			1898	4,064	84,000	1955	190	6,650
1842	140,232	2,898,505	1899	1,669	34,500	1956	882	30,870
1843			1900	1,379	28,500	1957	1,373	48,000
1844			1901	2,685	55,500	1958	876	31,000
1845			1902	4,388	90,700	1959	965	34,000
1846			1903	3,411	70,500	1960	1,826	64,000
1847			1904	5,994	123,900	1961	2,094	73,000
1848	22,910	473,543	1905	6,081	125,685	1962	460	16,000
1849	23,502	485,793	1906	3,973	82,131	1963	33	1,000
1850	17,200	355,523	1907	3,976	82,193	1964		
1851	15,814	326,883	1908	4,716	97,480	1965		
1852	19,512	403,295	1909	1,946	40,230	1966		
1853	13,334	275,622	1910	3,292	68,045	1967		
1854	10,018	207,073	1911	3,400	70,282	1968		
1855	10,954	226,416	1912	8,032	166,014	1969		
1856	8,276	171,070	1913	6,117	126,448	1970		
1857	4,058	83,870	1914	6,344	131,141	1971	**	
1858	9,325	192,742	1915	8,321	172,001	1972		
1859	10,381	214,574	1916	1,269	26,237	1973		
1860	7,556	156,182	1917	590	12,187	1974		
1861	536	11,088	1918	79	1,631	1975		
1862	112	2,313	1919	5	101	1976		
1863	63	1,309	1920	72	1,479	1977		
1864	295	6,094	1921	156	3,229	1978		
1865	614	12,693	1922	95	1,971	1979		
1866	6,818	140,937	1923	68	1,415	1980		
1867	3,208	66,306	1924	220	4,540	1981		
1868	4,350	89,906	1925	897	18,540	1982		
1869	5,645	116,672	1926	79	1,631	1983		
1870	4,892	101,111	1927	49	1,015	1984		
1871	4,633	95,766	1928	114	2,366	1985		
1872	5,557	114,863	1929	245	5,054	1986		
1873	5,822	120,332	1930	705	14,582	1987		
1874	5,180	107,070	1931	368	7,598	1988		
1875	5,255	108,628	1932	367	7,591	1989		
1876	4,411	91,181	1933	725	18,522	1990		
1877	3,872	80,026	1934	509	17,779	1991		
1878	3,634	75,123	1935	2,176	76,145	1992		
1879	3,971	82,076	1936	1,940	67,900			

** Small by-product production from tungsten mine in 1971.

Source: Pardee and Park, 1948 and U.S. Bureau of Mines disseminated that it is difficult to detect with the unaided eye. It also occurs locally within the sulfide minerals, particularly pyrite. The shape of the zones may be tabular, lenticular or pipe-like, normally trending parallel to the regional strike. It is common for quartz stringers to cut through the zones.

Primary minerals in the mineralized zones include quartz, sericite, chlorite, and pyrite. Other minerals commonly present are chalcopyrite, pyrrhotite, galena, sphalerite, limonite, molybdenite, and gold. The mineralized zones normally carry low-grade gold ore.

Many mineralized zones in the Carolina slate belt are associated with extensive alteration systems. Each alteration system is zoned, and each zone has its own characteristic mineral assemblage (fig. 10). These alteration systems and their association with gold occurrences help enlarge the target during gold exploration. The outer zone, called the propylitic zone, consists of chlorite-epidote-calcite-rich rock that grades outward into unaltered country rock. This zone is typically poorly exposed. The propylitic zone may enclose argillic zones composed of quartz-sericite-pyrite rock. Siliceous zones (silica rich) containing pyrite may be mixed with the argillic zone. Pods and lenses of high-alumina alteration contain quartz-sericite-pyrophyllite-kaolinite and may contain andalusite and topaz. Many old gold mines are located along the margins of the high-alumina zones.

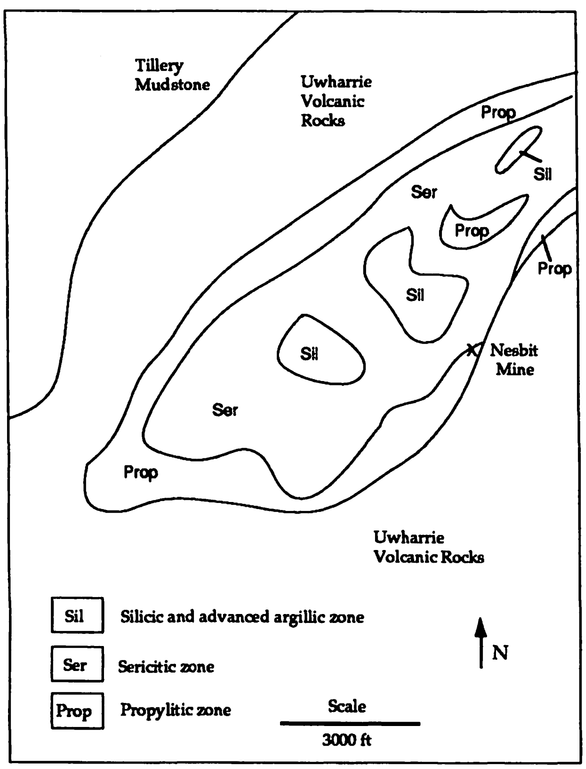


Figure 10. Map of alteration zones in the Nesbit Mining area, Union County, North Carolina (After McKee, 1985).

In the Carolina slate belt, studies have established a relationship between gold mineralization and stratigraphic contacts (fig. 11). Worthington and Kiff (1979) recognized the close relationship of gold deposits with the contact between the predominantly volcanic Uwharrie Formation and the overlying predominantly sedimentary Albemarle Group. More than half of all Carolina slate belt gold mines and prospects are within a mile of either side of this contact. During the last stages of volcanic activity, the Uwharrie volcanic pile generated hydrothermal cells that silicified (altered the rocks by the introduction of silica) portions of the upper Uwharrie Formation. These cells also carried gold that was deposited in hot spring or relatively shallow (epithermal) environments. This activity continued into the overlying Tillery mudstones. The gold was remobilized by a later event which produced high-alumina alteration and concentrated the gold along the stratigraphic horizon.

The three most productive gold mines in South Carolina, the Haile, the Brewer, and the Ridgeway Mine (which opened in 1988) are located near the contact between Precambrian felsic metavolcanic rocks and overlying Cambrian volcanicastic and sedimentary rocks. Similar relationships have been established in many epithermal precious metal deposits in recent volcanic piles in the western United States.

Structural controls of Carolina slate belt deposits are not well understood. Faulting and folding probably played a part in creating channels along which ore solutions migrated and were concentrated.

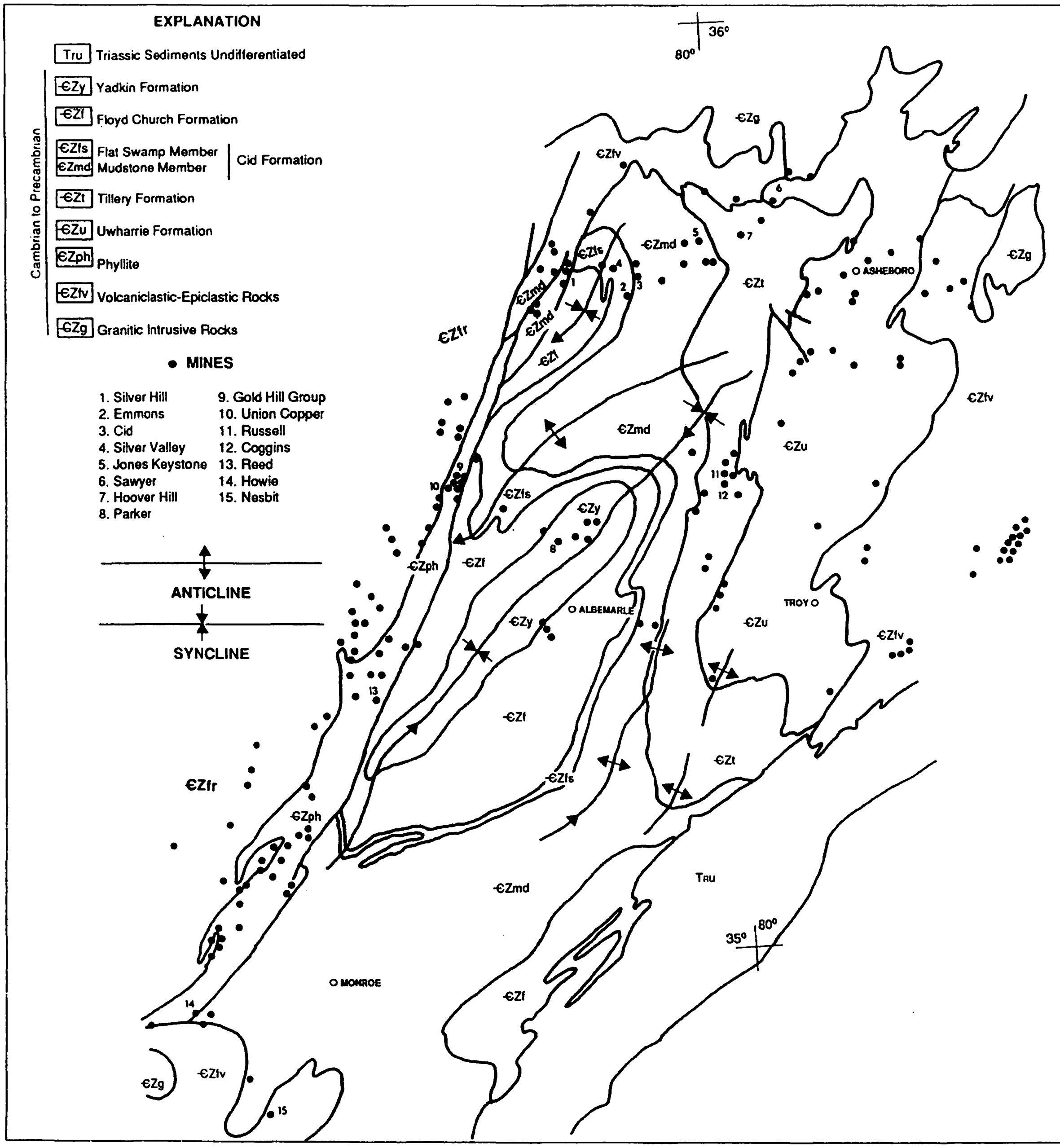


Figure 11. Generalized geologic map showing major gold mines in the central and southern Carolina slate belt in North Carolina (Base modified from North Carolina Geological Survey, 1985).

Placer Deposits

Placer deposits are found most commonly along small streams flowing through areas where lode deposits occur. The placers include deposits in existing stream channels, in old stream gravels on hillsides above the stream bed and in residual deposits in saprolite overlying weathered lode deposits. In alluvial deposits (stream deposits), the gold is found with the coarser gravels, usually near the bottom of the deposit close to bedrock. Other heavy minerals such as magnetite, rutile, ilmenite, and zircon frequently are concentrated with the gold. Placers vary in thickness and width depending upon a number of factors including the amount of material available for transport, the size and velocity of the stream and the terrain through which the stream flows.

PROSPECTING FOR GOLD

Although all of the known easily accessible gold deposits in North Carolina have been worked previously, there are still streams where small amounts of gold can be obtained by panning or using small portable dredges. It is unlikely that significant new gold deposits can be discovered in North Carolina without using the latest exploration techniques and sufficient capital to carry out extensive investigations. For the amateur or vacation prospector, the search for small amounts of gold can be an exciting and rewarding experience that requires only a minor financial investment.

Many of the gold-bearing placers already have been worked at least twice, once during the 1800s and again during the depression of the 1930s. Streams draining known gold-producing areas are the most logical sites for panning. Such streams as Little Buffalo Creek in Rowan and Cabarrus counties, Dutch Buffalo Creek in Cabarrus County, Cabin Creek in Moore County, the Uwharrie River in Montgomery County, and the streams in the South Mountain area are good places to try panning. Many of the tributaries to these streams, and many smaller streams draining areas where lode deposits were worked, are also logical sites for panning. It is also possible that some gold might be panned from streams that have not previously been mentioned in relation to gold production. Probably, those streams were prospected at some time, but no significant deposits were found. Gravels quarried in the Lilesville area are also known to contain gold.

Permission should be obtained from the landowner prior to prospecting on private land. Having obtained the landowner's permission to prospect, the individual should use common rules of courtesy and leave the property in the same condition as it was when the prospecting began. Prospecting is prohibited in North Carolina State Parks and in National Parks. Information for prospecting on other state-owned land should be obtained from the department having charge of the land, such as state Division of Forest Resources or Wildlife Resources Commission. Panning is permitted in many parts of the National Forests, but panners should check with the district ranger first. In some National Forest areas, mineral rights are privately owned and panners will need to obtain written permission from the mineral owner. The use of metal detectors and suction dredges in state and national parks and forests is prohibited.

For those who are more serious about prospecting and are interested in developing a deposit, a lease to prospect and mine should be obtained or the mineral rights should be purchased. Any mining that will affect more than one acre of land must be carried out in accordance with the North Carolina Mining Act of 1971. A copy of this law and permit application information are available from the Land Quality Section, Division of Land Resources, Department of Environment, Health, and Natural Resources, Post Office Box 27687, Raleigh, North Carolina 27611. Operations that process large quantities of water or discharge water or waste into the state's waters require a permit from the Division of Environmental Management, Department of Environment, Health, and Natural Resources at the same address given above. A *North Carolina Environmental Permit Directory* is also available from the department. Detailed prospecting in National Forests requires a Forest Service or Bureau of Land Management permit.

Only a small amount of equipment is needed to begin prospecting for placer gold. The two basic items needed are the miner's pan and a shovel. Sixteen-inch diameter pans are available, but the smaller 10-inch and 12-inch pans are easier to handle. Other helpful equipment includes a geologist's pick, some type of sturdy hook or spoon for gouging out crevices in bedrock, a magnet for removing magnetite from the heavy mineral concentrates, a magnifying glass and containers in which to keep the gold and concentrates. Additional equipment such as portable dredges, rockers, long-toms, or sluices can be used when larger volumes of material are being worked. Information on building and using rockers, long-toms and sluices is in U.S. Bureau of Mines Information Circular 8517, *How to Mine and Prospect for Placer Gold* and Bureau of Land Management Technical Bulletin 4, *Placer Examination-Principles and Practice.* Rockers and Long Toms are illustrated below (figs. 12 and 13).

One important step in prospecting for placer gold is knowing where to look. Good places to start are where streams of moderate gradient begin to widen or change their flow direction—any place where currents begin to slow (fig. 14). Gold tends to be deposited in streams at a point where the current has slowed, such as in the gravels along the quiet sides of streams (the middle portions of streams flow faster than the portions near the banks), on bars and on the insides of bends in the stream. Gold tends to work its way to the bottom of the sediment and often accumulates in crevices, depressions and potholes in the bedrock underlying the stream. Therefore, the ultimate target in stream prospecting should be the bedrock.

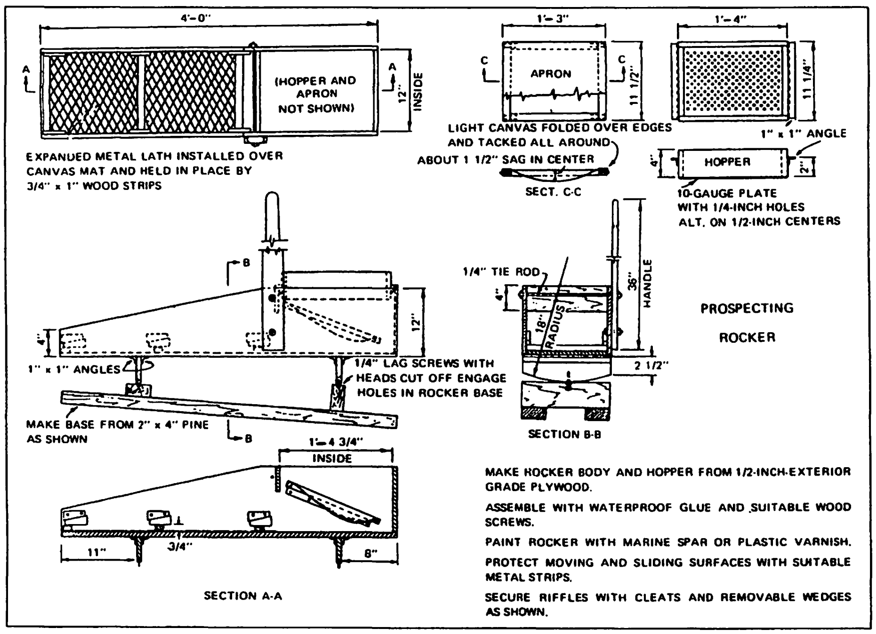


Figure 12. Prospecting rocker (From Wells, 1969).

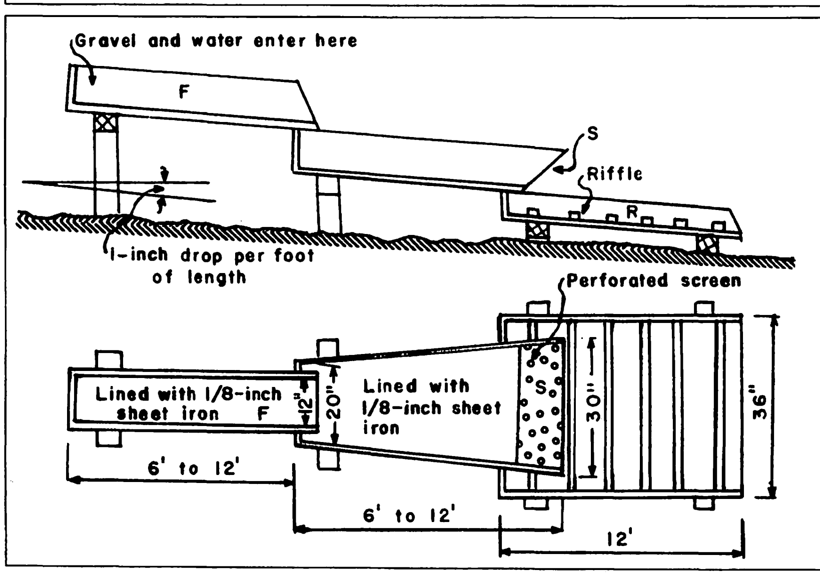


Figure 13. Long Tom (From Moen and Huntting, 1975)

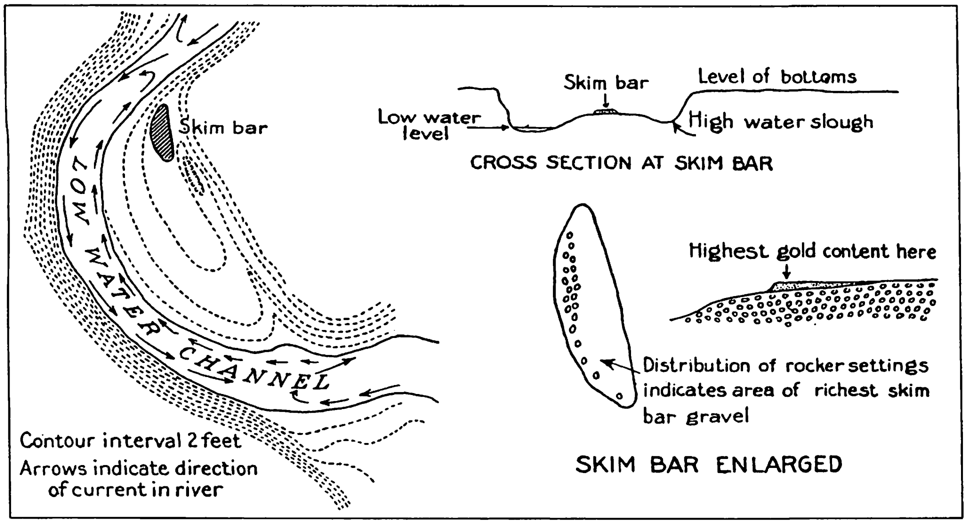


Figure 14. Skim bar and distribution in skim-bar gravels (From Hill, 1916).

Gold panning is one of the most basic prospecting methods but it takes practice and patience to develop gcod panning techniques. The objective in panning is to slowly work the heavier minerals to the bottom of the pan where they can be separated easily from the other minerals. The following steps are not described in detail but should give the beginning panner a start.

1. Fill the pan with stream material approximately level with the top of the pan. Submerge the pan in water and begin to massage the material with both hands to break up the clay and remove sticks, rocks, and trash. Slow-flowing water one-half to one foot deep is best for this procedure.
2. While the pan remains under water, grasp both sides of the pan and twist it back and forth vigorously to work the gold and other heavy minerals to the bottom of the pan. (This is the point at which technique comes into play.) During this process, the largest and lightest materials will migrate to the top and can be gradually removed with the fingers.
3. During this step you will continue to work the gold to the bottom of the pan, but will begin to wash lighter particles over the top of the pan. Raise the pan partially above the water and tilt the pan forward, away from the panner. As the pan is raised above the level of the water, the top particles will be washed over the side. Continue alternating between steps 2 and 3, periodically removing large particles that work themselves to the surface.
4. As washing continues, finer sand will be washed away from the darker, heavier minerals, including gold. The final concentrate will be mostly dark, heavy minerals and gold, if it is present. This heavy-mineral concentrate can be processed further at the site or can be collected in a container for processing later. The minerals can be separated by tilting and slowly rotating the pan while gently swirling the water around the bottom of the pan. Any gold will remain near the rear of the trail of minerals.
5. Gold may be removed from the "heavies" by removing the magnetic minerals with a magnet. After the remaining sand is dried, it may be separated from the gold by gentle blowing and then picking out the gold with tweezers.

New prospectors can develop their panning technique at one of the tourist attractions now open to the public. This will enable the amateur to pan from material that is known to contain gold and will allow him to pick up useful hints from more experienced panners. Information on these commercial operations is available from the N.C. Geological Survey. Panning is also available at the Reed Gold Mine State Historic Site at Stanfield in

Cabarrus County. Gold-bearing material is trucked from the Cotton Patch Mine to the Reed Mine where it can be panned. At the Reed Mine, a visitors center offers an introductory film, exhibits on the history of gold mining and a tour through a restored section of the old underground workings.

Different techniques can be used in prospecting for lode deposits; however, the gold pan can still be used when there is sufficient water available. Lode prospecting usually requires the vein material to be crushed and then panned to determine if gold is present, or assays must be run. (A list of assayers is available from the North Carolina Geological Survey.) Determining the value and extent of a lode deposit requires systematic surface sampling with chemical analysis for a variety of elements. If surface analysis indicates the presence of economic minerals, core drilling is necessary to determine the value and extent of the deposit at depth.

NORTH CAROLINA GOLD MINES

The gold mining districts of North Carolina are spread throughout the Piedmont and Mountain sections of the state and are usually grouped into one of six belts (fig. 15). These belts are: (1) the Eastern slate belt; (2) the Carolina slate belt; (3) the Charlotte belt; (4) the Kings Mountain belt; (5) the Inner Piedmont belt; and (6) the Blue Ridge belt.

There are approximately 660 inactive gold mines and prospects in the state, most of them in the Piedmont area. Both placer and lode deposits were worked, although most of the production was from the lodes.

The general nature of this report does not allow for a detailed description of each gold mine. Instead, a few of the most important and best known mines in each major belt are described. Detailed descriptions of other mines in the state are available in older publications, particularly those by Nitze and Hanna (1896), Nitze and Wilkins (1897), Laney (1910), Pogue (1910), Bryson (1936), Pardee and Park (1948), and Carpenter (1976). Most of these publications are out-of-print, but can be found in many public and university libraries and also in the North Carolina Geological Survey administrative office.

Most of the mines have been inactive for many years, and all that remains of the workings are caved-in and water-filled shafts, weathered dumps of waste rock and dilapidated buildings. Many of the shafts have been used as garbage dumps; others have been filled with the remaining waste rock from previous mining. In some of the more populated areas, housing developments are encroaching upon the mines. Recent construction has destroyed many of them. Most of these mines are on private property and should be visited only with permission of the landowner.

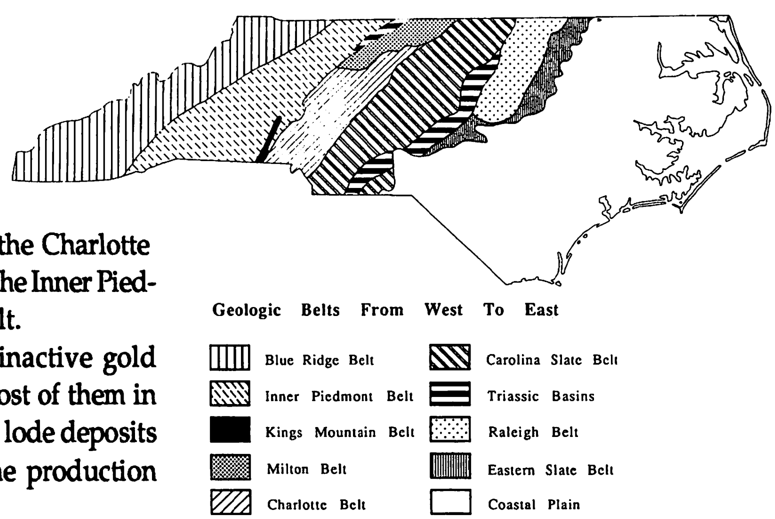


Figure 15. North Carolina's geological belts.

EASTERN SLATE BELT

The Eastern slate belt lies east of the Raleigh belt and is overlain to the east by Cretaceous to Recent Coastal Plain sediments. The Eastern slate belt is a thick sequence of Precambrian to Cambrian volcaniclastic and epiclastic sediments interbedded with felsic to mafic volcanic rocks. These rocks have all been metamorphosed to greenschist facies and, toward the Raleigh belt, to the lower amphibolite facies. Several post-metamorphic granitic intrusive bodies intrude the metamorphic rocks. Most of the volcanic and sedimentary rocks most likely were deposited in a submarine environment on the flanks of a volcanic arc terrane.

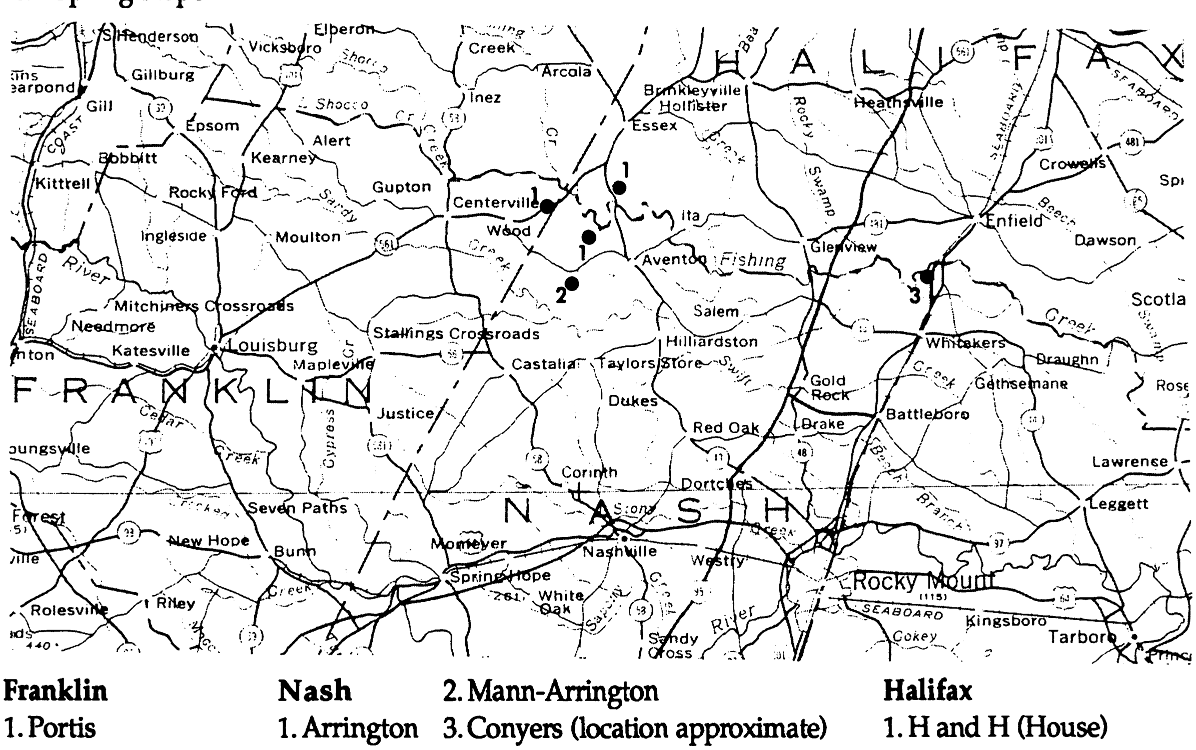
Most gold mining in the Eastern slate belt was in southern Warren and Halifax counties, northern Nash and northeastern Franklin counties (fig. 16). Quartz veins intruded rocks throughout the area. The earliest reports on the gold deposits (Kerr and Hanna, 1893; Nitze and Hanna, 1896) indicate that the gold is commonly associated with the smaller, stringer veins. Much of the original mining in this region used hydraulic methods to recover residual gold in the soils. Near the larger creeks, such as Shocco and Fishing creeks, rounded quartz gravels 2 to 3 feet thick also contained gold but were not extensively worked. Older publications mention placer workings along the Tar River near Spring Hope.

Portis Mine

The Portis Mine was the first mine discovered in the Eastern slate belt (1835) and was also the most productive. It is located in northeastern Franklin County 2.4 miles northeast of Wood and 0.4 mile due west of the Franklin-Nash County line (on N.C. Highway 561).

Most of the production at this mine came from the hydraulicking of 15 to 30 feet of surface material. There were three main periods of activity. The first was between 1835 and the Civil War; the second was in the 1880s; and the third was in the 1930s. In 1935 the Norlina Mining Company acquired 955 acres in the Portis tract and 713 acres in the White House tract near Fishing Creek. The company invested $150,000 in building a recovery plant. The operation was uneconomical and mining ceased in 1936.

In 1975 Newmont Mining Company conducted exploratory drilling on the property. In 1982 Petromet International, Inc. began exploration of the property by drilling core holes and dig-



Franklin	**Nash**		**Halifax**
1. Portis	1. Arrington	2. Mann-Arrington 3. Conyers (location approximate)	1. H and H (House)

Figure 16. Mines of the Eastern slate belt.

ging trenches. Petromet dropped its lease in 1986. In 1988 exploration was conducted by Texasgulf Minerals and Metals, Inc.

Earlier reports on the Portis Mine (Kerr and Hanna, 1893; Nitze and Hanna, 1896; Bryson, 1936; and Pardee and Park, 1948) describe the country rock as a deeply weathered schist into which two westerly dipping sheets or sills of diorite or granodiorite were intruded. The sills weather to a light-colored clay referred to as the "White Belt." A recent study (Corbett, 1987) suggests that the "White Belt" is probably a vitric tuff layer. The "White Belt" was the source of most of the gold found in the residual soil and the placers along Fishing Creek. The numerous quartz veins that cross-cut the schist and the "White Belt" usually contained free gold.

The upper sill was described as approximately eight feet thick, and the lower one somewhat thicker. The two sills are separated by only a few feet of schist. The gold content ranged between 0.03 ounce and 0.6 ounce per short ton and averaged about 0.15 ounce (Stuckey, 1965, p. 301). Recovery of gold at the Portis Mine was always hampered by the sticky clay with which the gold was associated. The total amount of gold mined here is not known, but its value has been estimated from several hundred thousand to nine million dollars.

Corbitt (1987) studied drill cores from the property and determined that the rocks were deposited in a possible distal submarine environment on the flanks of a volcanic arc terrane. Primary rock types are metagraywacke, metamudstone, metasiltstone, amphibolite, biotite phyllite, and quartz amphibolite. The amphibolites represent mafic pyroclastic units deposited as probable flows or as submarine fall-out. The "White Belt," probably a vitric tuff layer, is described as a 2-meter thick ore zone in quartz-rich amphibolite. The dense and compact texture of the zone was attributed to silicification and stockwork quartz veins. Gold is in stockwork quartz veins in the ore zone and in adjacent quartz-rich amphibolite. The gold formed with the earliest quartz veins which represent a hydrothermal event either preceding or during greenschist facies metamorphism.

H and H Mine

The H and H Mine is near Powells Creek in southwestern Halifax County 4.2 miles southeast of Hollister and 4.2 miles southwest of Ringwood. This mine produced gold, lead, zinc, copper, and silver and was worked as recently as 1957. The first exploration was in 1940, but the principal mining activity was between 1954 and 1957. Total gold, silver, copper, lead, and zinc produced was valued at $35,542. The mine was developed in a quartz vein carrying galena, sphalerite, chalcopyrite, bornite, and gold. The vein is enclosed by silicified, sericitized phyllite that is enriched with chlorite, quartz, epidote, and calcite next to the vein.

Mann-Arrington Mine

The Mann-Arrington (Argo) Mine in northwestern Nash County was last worked in 1894, although some exploratory work was carried out in the early 1930s. A shaft was opened to a depth of 108 feet. Smaller pits and trenches were opened over an area approximately 1,500 feet long and 400 feet wide. Mining was carried out in quartz veins and stringers enclosed by chlorite phyllite that strikes N 60 E and dips 40 SE.

Conyers Mine

The Conyers Mine is 7 miles north of Whitakers on Fishing Creek. A shaft 30 feet deep was sunk in an 18-inch wide quartz vein containing hematite and sulfides. Placer material was also worked at this mine.

Arrington Mine

The Arrington Mine is in Nash County one mile southeast of the Portis Mine. The mining tract included approximately 2,000 acres down Fishing Creek (Kerr and Hanna, 1893). The mine is described as the most important mine in the belt, after the Portis, but there is no detailed description in the literature.

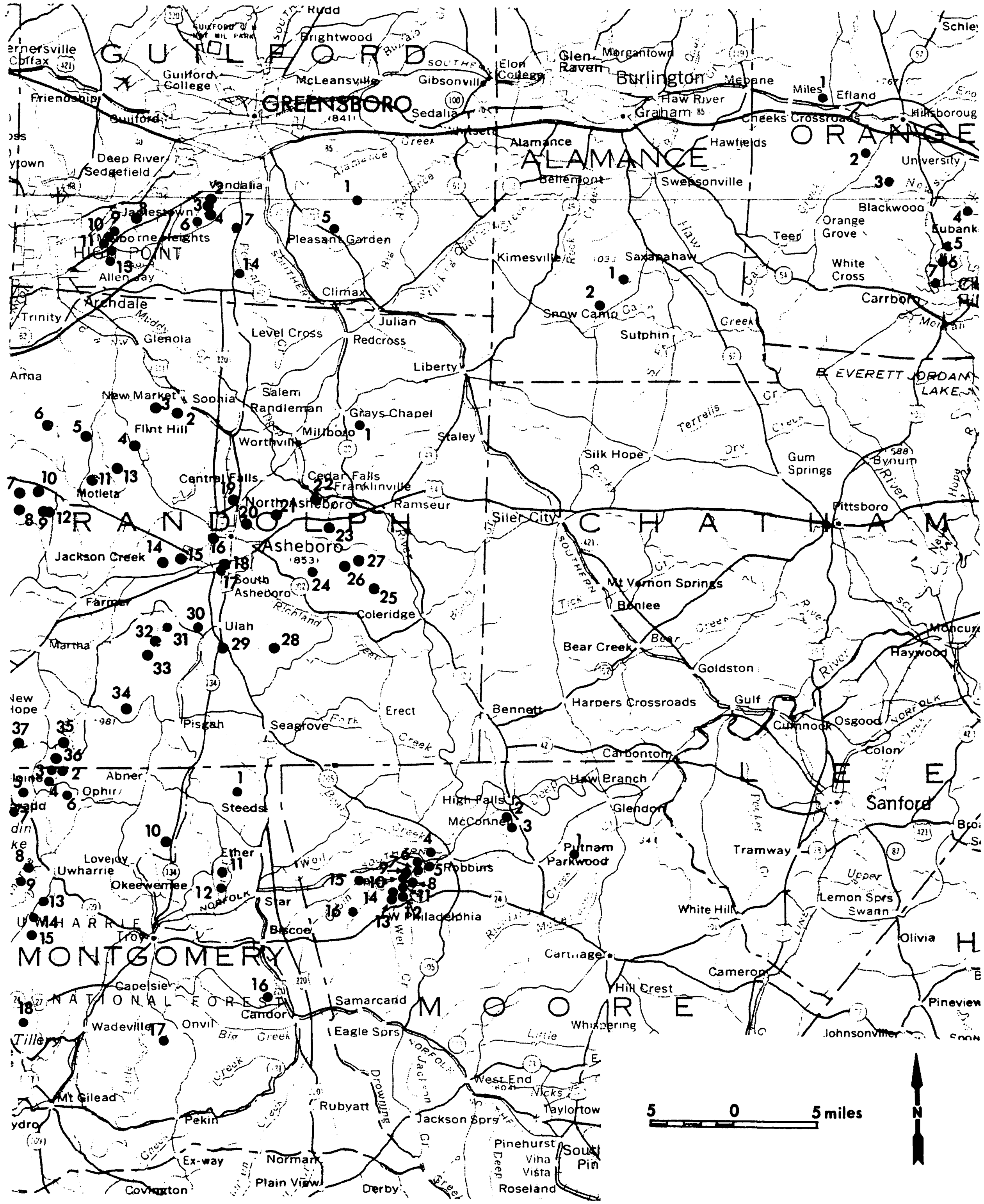


Figure 17. Mines of the central Carolina slate belt.

Figure 17. Mines of the central Carolina slate belt (listed by county).

Alamance
1. Faust
2. Robeson

Guilford
1. Heath
2. Fisher Hill
3. Millis Hill
4. Punkey
5. Pine Hill
6. Beard
7. Hodges Hill
8. Gardner Hill
9. Jacks Hill
10. North State
11. Lindsay
12. Deep River
13. Harland
14. Fentress

Montgomery
1. Black Ankle
2. Riggon Hill
3. Russell & Palmer
4. Coggins
5. Morris Mountain
6. Steel
7. Crump
8. Sally Coggins
9. Grandman
10. Troy
11. Star
12. Carter
13. Tebe Saunders
14. Moratock & Worth
15. Harbin
16. Golconda, Montgomery Iola, and Martha Washington
17. Sedberry
18. Sam Christian

Moore
1. Bell
2. Ritter
3. Cotton
4. Wright
5. Clegg
6. Cagle
7. Red Hill
8. Allen
9. Burns
10. Brown
11. California
12. Dry Hollow
13. Richardson
14. Jenkins
15. Shields
16. Monroe

Orange
1. Bradsher
2. Womble
3. Shambley
4. Duke Forest
5. Weaver-Carr
6. Nun Mountain
7. Haw

Randolph
1. Allred
2. New Sawyer
3. Merrill
4. Sawyer
5. Jones & Laughlin
6. Copple, Spencer & Ruth
7. Southern Homestake
8. Delph
9. Parish & Kindley
10. Jones-Keystone
11. Hoover Hill
12. Wilson Kindley
13. Pierce Mountain
14. Newby
15. Davis Hill & Davis Mountain
16. Gray
17. Asheboro & Jones
18. McGrew
19. Scarlett
20. Pritchett
21. Winningham
22. Redding
23. Gold Bowl
24. Spoon
25. Porter & Pilot Mountain
26. Harney
27. Pine Hill
28. Goliham & Smith
29. Lowdermilk
30. Branson
31. Colburn
32. Dowd & Rush
33. Gluyas
34. Uharie
35. Griffin
36. Stafford
37. Talbert & Hill

CAROLINA SLATE BELT

The Carolina slate belt was the most important gold-producing area in North Carolina and continues to be the major focus of gold exploration (figs. 17 and 22). The belt is a northeast-trending series of rocks that crosses the central part of the state, extending from the South Carolina line in Union and Anson counties to the Virginia line in Person and Granville counties. The belt ranges in width from 25 to 70 miles. It is bordered on the east by Triassic sediments and Coastal Plain sediments and on the west by metamorphic and igneous rocks of the Charlotte belt and Milton belt. Although there are few rocks in the belt that are truly slate, the name slate belt has been maintained from the time it was first used by Denison Olmsted in 1825. Olmsted used the term slate in describing the well developed cleavage of the rocks.

The Carolina slate belt is a late Precambrian to Cambrian volcanic arc sequence that was metamorphosed to the lower greenschist facies (low-grade metamorphism). The stratigraphy for the slate belt is complex and is best understood in the central and southern slate belt. In this area the slate belt consists of a thick sequence of felsic volcanic rocks, the Uwharrie Formation, overlain by a volcano-sedimentary sequence, the Albemarle Group (Conley and Bain, 1965). The Uwharrie Formation, dated at 586 ±10 million years old, is a complex pile of subaerial to shallow marine, predominantly felsic to intermediate, volcanic breccias, crystal tuffs, lithic tuffs, and dense, fine-grained tuffs and flows. The Albemarle Group is mostly fine-grained well laminated mudstones interbedded with felsic to mafic flows and tuffs deposited in a submarine environment. Major fold axes, faults, and regional cleavage trend in a northeast direction. Two major faults, the Gold Hill and the Silver Hill faults, are near the western border of the slate belt.

In the northern part of the slate belt, north of Durham, mafic to intermediate volcanic and sedimentary rocks of the Virgilina sequence crop out.

These rocks have been dated at 620±20 million years old (Glover and Sinha, 1973) and have been divided into three formations: the Hyco Formation; the Aaron Formation; and the Virgilina Formation. The rocks were folded and faulted by the Virgilina event between 620 and 575 million years ago.

Rocks of the Virgilina sequence may extend southwestward into the central slate belt in Randolph County (Harris, 1982). The Virgilina sequence is considered older than the Uwharrie Formation and is considered to underlie the Uwharrie Formation in eastern Randolph County. More detailed geologic mapping is needed to determine the southwestward extent of the Virgilina sequence and to establish the nature of any contacts that may exist between the Virgilina sequence and the Uwharrie Formation.

The best-known mining districts in the state are found in the slate belt. These districts include the Gold Hill district in southeastern Rowan and northeastern Cabarrus counties and the Cid district in southern Davidson County. The southern Guilford County area was also an important producer.

Over half of the Carolina slate belt gold mines are within one mile, geographically, of the contact between the Uwharrie Formation and the overlying Albemarle Group. The gold mines are related to the last stages of volcanic activity in the Uwharrie volcanic pile. Hydrothermal cells carrying gold silicified portions of the upper Uwharrie Formation and the overlying Tillery mudstones. A later event remobilized the gold, produced high-alumina alteration and concentrated the gold along the stratigraphic boundary (Feiss, 1988).

The Gold Hill district contains several of the largest and most productive gold mines in the Southeast. Total production from 1842 to 1935 from the Gold Hill mines is estimated at $3,300,000 (based on 160,000 oz. at $20.67 an ounce) and $700,000 in copper. Important mines in the district include the Gold Hill Mine (Randolph Shaft), the Barnhardt Shaft, the Miller Shaft, the Honeycutt Mine, the Troutman Mine, the Union Copper Mine and the Barringer Mine.

The Cid district also contains many important producers, the largest of which was the Silver Hill Mine. Other than the Gold Hill Mine, the Silver Hill Mine was the deepest and most extensively developed mine in the state during the early gold-mining years. Other important mines in the Cid district include the Conrad Hill, Emmons, Silver Valley and Cid Mines.

Gold Hill Mine

The Gold Hill Mine (Randolph Shaft) is in southeastern Rowan County 0.6 mile southwest of the town of Gold Hill. The main shaft, the Randolph, reached a depth of 820 feet. Drifts and crosscuts on the 800-foot level totaled 2,000 feet in length and penetrated 11 mineralized zones or veins. There were several thousand feet of lateral workings in the upper levels. The largest vein, the Randolph, varied from 2 to 15 feet wide. Mining removed about 1,500 feet of the vein along its length to a depth of 700 feet. In the upper levels of the vein, the ore was very rich and free milling, but at depth, gold values decreased as sulfides were encountered. At the 800-foot level, the vein assayed at one-tenth ounce per ton in gold, but the vein was beginning to narrow.

At the 800-foot level, crosscuts at right angles to the schistosity of the country rock intersected 11 mineralized zones. Drifting was then carried out along those zones, which included the Miller vein, the Barnhardt vein, and North or W.G.N. vein. Where exposed in the drift, the North vein was striking N 15-20° E and averaged 3 feet wide for a distance of 60 feet. Assay samples ranged from one-half to almost 19 ounces per ton in gold and less than 1 percent copper. Figure 18 is an 1882 drawing of veins in the Gold Hill district.

Ore was removed from the Barnhardt vein for a length of 200 to 250 feet down to the 300-foot level. It contained less gold but more copper than the Randolph vein carried (fig. 19).

The ore occurred in mineralized zones in chlorite-sericite phyllite striking N 35° E and dipping 80° NW. The veins were not gold bearing across

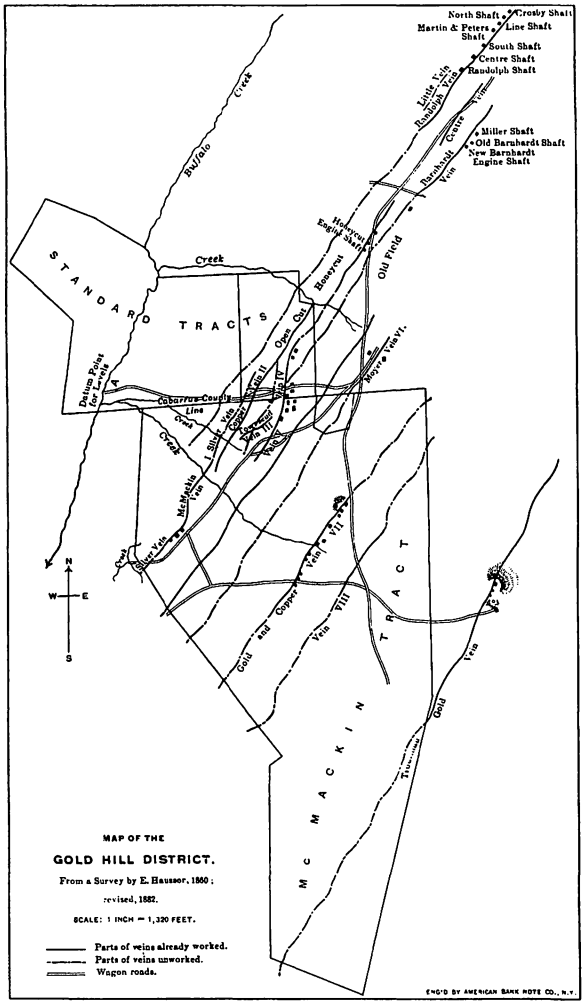


Figure 18. Map showing distribution of Gold Hill veins (From Nitze and Wilkens, 1897)

their entire width but consisted of narrow gold-bearing zones in the phyllite. The phyllite contained chalcopyrite, chalcocite, and abundant small pyrite cubes disseminated throughout the rock. Modern geologic mapping places the Gold Hill mines in sheared metasiltstone and metaclaystone of the Tillery Formation within the Gold Hill-Silver Hill shear zone (Stromquist and Sundelius, 1975).

Gold production from the Gold Hill Mine through 1935 is estimated at $1,650,000. During the last period of operation(1914-1915) 7,250 tons of ore were milled with a recovery of 3,877 ounces of gold, 603 ounces of silver, and 23,112 pounds of copper. All of this last production came from the North vein.

In 1991, Gold Hill residents formed the Historic Gold Hill and Mines Foundation to preserve the history of the Gold Hill mines and rebuild some of the mine structures. The old Mauney's Store was rebuilt in 1991 and contains a museum with photographs and artifacts from the mining years. The residents plan to uncover the Barnhardt and Miller shafts and build replicas of the original headframes.

Howie Mine

The Howie Mine is in west-central Union County, 2.9 miles northeast of Waxhaw and 3 miles northwest of Mineral Springs. This mine was discovered before 1840 and became the largest mine in Union County. It was worked on a small scale until 1854, when Commodore Stockton acquired the property. He operated the mine until the

Figure 19. Gold Hill Mine: Barnhardt shaft and Eames stamp mill, about 1893 (From Nitze and Wilkens, 1897).

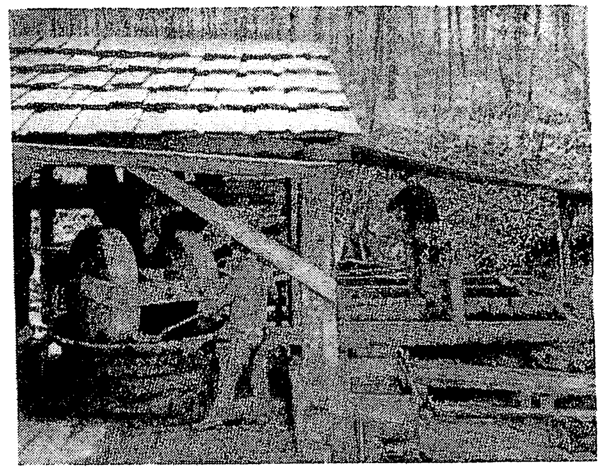


Figure 20. Log rockers and Chilean drag mill and rockers near Gold Hill, about 1896 (From Nitze and Wilkens, 1897).

Civil War, after which the mine was operated by various companies until it finally closed in 1942.

The mine was worked along a belt 100 to 300 feet wide and 2,800 feet long, trending about N 60° E. The mine was worked by a series of shafts. One of these shafts, the Cureton, was 365 feet deep. Levels were driven at 147, 262, and 347 feet. In 1935, this shaft and connected workings totaled about 3,500 feet in length in a part of the lode that was 800 feet long and 150 feet wide. On the second level, the ore zone was 6 to 8 feet wide. Assays ran from one-half ounce to 14 ounces of gold per ton. At the 347-foot level, assay values ran over one-tenth ounce per ton. Other shafts developed were the Bracy, Bull Face, and Pansy Shafts; but these were less extensively developed than the Cureton. Ore in the Bull Face Shaft ran approximately 2 ounces of gold per ton.

The shafts were opened in sheared and silicified felsic volcanic rocks which strike N 60° E and dip steeply to the northwest. Pyrite is disseminated throughout the rock. Earlier reports described the ore bodies as parts of the lode where gold-bearing seams were abundant. The ore bodies were tabular to cylindrical in shape and consisted of very fine-grained, flinty, pale greenish-gray quartz. The quartz was banded and gold was found along cleavage surfaces in the rock.

Schroeder, Nance, and Allen (1988) studied geologic relationships of the mine area during exploration by Cominco American in the mid-1980s. They describe the mine as lying within subaqueous, laminated argillites of the Tillery Formation. Thin beds of crystal-lithic tuff indicate continuing periods of volcanic activity. The felsic volcanics are highly mylonitized and silicified. Phyllitic schistosity trends to the northeast and zones of quartzo-feldspathic ultramylonite are nearly perpendicular to bedding and subparallel to an earlier cleavage in the less sheared rock surrounding the mine.

Mineralization is attributed to three stages that accompanied Acadian polyphase dextral shear on the Gold Hill-Silver Hill fault system. 1) Initial mineralization and silicification of the shear zone was caused by hydrothermal fluids generated during greenschist facies metamorphism. The fluids were enriched with gold by leaching of gold-bearing host volcanic rocks. 2) Auriferous blue-grey quartz veins were formed by redeposition of silica, potassium and gold immediately following silicification. 3) During later folding, vein gold was remobilized along microfractures and redeposited at fold closures. Schroeder, Nance, and Allen (1988) state that the Howie Mine lacks many characteristics common to stratabound deposits. The deposit does not contain chemical cherts, stratabound sulfide, and oxide formations or trace metal sulfides and stockwork veins. The volcanic horizon in which the mine lies may have simply provided a favorable site for gold deposition or the volcanic conditions may have aided in the development of prior syngenetic enrichment at or below the mine horizon.

Production figures for the Howie Mine are incomplete. Reports indicate that by 1854, the mine had produced $250,000 worth of gold from workings less than 80 feet deep. In 1934, the mine was credited with having produced 41,300 oz. of gold. In 1940, 1941, and 1942, the mine (then called the Condor Mine) was the leading gold producer in the state. An additional 10,000 oz. of gold was produced. In 1955, and again in the early 1960's, the mill at the mine site was used for processing gold ore from the Star Mine in Montgomery County. The mine was dewatered and evaluated by Cominco American in 1984. This work included underground sampling and surface and underground drilling (Schroeder, Nance, and Allen, 1988).

Reed Mine

The Reed Mine is in southeastern Cabarrus County, 2 miles south of Georgeville and 2.8 miles northwest of Locust. The mine is reached by following Secondary Road 1100 south from NC Highway 210, or north from NC Highway 24-27. Gold was first discovered on this property in 1799, the first authenticated discovery of gold in the United States. The mine was originally worked as a placer operation and was perhaps the richest placer deposit in the state.

One hundred and fifty-three pounds of nuggets, ranging in weight from 1 pound to 28 pounds, were found on the property. The lodes were first worked in 1831. Ore found near the surface commonly ran $100 or more to the bushel (about 100 pounds). Production from 1803 until 1835 is estimated at more than $1,000,000. The mine was idle for a while after 1835 but in 1854 work resumed. Sporadic mining was carried out between 1881 and 1887 and from 1894 to 1899. A 10-stamp mill was built in 1895, and the last mill run was ore from a 20-foot zone that yielded 3 ounces of gold per ton. Some placer mining was carried out in 1934.

Lode mining at the Reed property was from quartz veins and veinlets, ranging in width from 1 to 6 feet, in a zone approximately 200 feet wide. The zone trends northeast and dips 45-70° SE. The lode extends about 2,000 feet along strike and forms a ridge east of Little Meadow Creek. The country rock is primarily fine-grained felsic tuff. Most of the rocks are sheared and have a cleavage striking approximately N 35° E and dipping 70° NW.

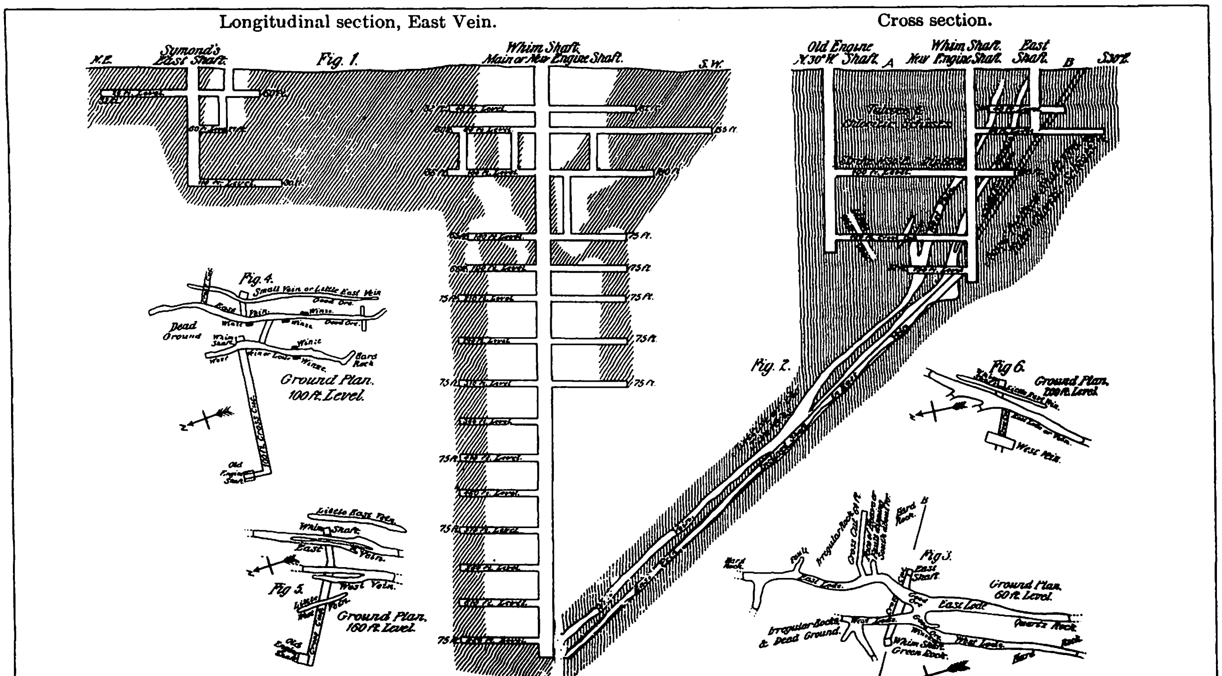
The workings are divided into Upper, Middle, Lower and Lake Hills. Most of the lode mining was on the Upper and Lower Hills. Underground development was not extensive, and the ores most likely were not worked below a depth of 120 feet.

Feiss (1980, 1982) suggested a possible metamorphic origin for the Reed deposit. Quartz veins parallel to bedding and foliation appear cherty to sugary in texture in contrast to the massive "bull" quartz in discordant quartz veins. Feiss proposed that the gold and associated sulfides originally occurred as disseminations in the felsic tuffs or cherty exhalite beds and were remobilized during metamorphism.

In 1971, the Reed property was purchased by the State of North Carolina from the Kelly family of Springfield, Ohio. The Reed Mine is now preserved as a State Historic Site. A portion of the underground workings has been restored, and a visitor center offers exhibits illustrating the history of the mine. Tours are conducted through the underground workings, and a series of trails provide access to above-ground workings. For a small fee gold may be panned at the site from material obtained from the Cotton Patch Mine in Stanly County. Additional information is available from the Reed Gold Mine, Route 2, Box 101, Stanfield, North Carolina 28163 [telephone: (704) 786-8337].

Silver Hill Mine

The Silver Hill Mine, in south-central Davidson County, is 8.9 miles south-southeast of Lexington and 7 miles northwest of Denton. This mine was discovered about 1838, and was worked primarily as a silver, lead, and zinc mine. During



SILVER HILL MINE, DAVIDSON COUNTY.
Unshaded spaces and the ground plans showing the area worked out up to May, 1854. Scale: 1 inch=150 feet.

Figure 21. Underground workings at the Silver Hill Mine, 1854 (From Kerr and Hanna, 1893).

the Civil War, lead from the mine was used to make bullets. There has been only minor production since 1882. Total production is estimated at $1,000,000 or more.

In 1942 the property was drilled by New Jersey Zinc Company. Nineteen core holes (totaling 5,971 feet) did not intersect valuable ore. In 1958 the Tennessee Copper Company drilled 16 holes on the property. Drilling showed the extension of the ore body down dip. In 1959 the old workings were dewatered and the shaft was extended to a depth of 876 feet. Drifts were driven on five levels but the deposit was considered too small to mine. Additional holes (14) were drilled by Cyprus Mines Corporation in 1973-1974. Some of these cores intersected sulfides near the margin of the ore body. Phelps Dodge Corporation carried out additional drilling and trenching on the property in 1976.

The mine is located in sheared rocks of the Tillery Formation west of the Silver Hill fault (Stromquist and others, 1971). Pogue (1910) described the ore zone in a sericite schist containing two main lodes, the "east vein" and the "west vein." They strike to the northeast and dip 50° to 60° NW. The main shaft extended 725 feet down the east vein to a total depth of 570 feet. Drifts and additional shafts explored the lode along a horizontal distance of 700 feet. In the upper levels of the mine, the ore consisted chiefly of lead carbonate (cerussite) and disseminated native silver, but at depth galena, sphalerite, pyrite, and chalcopyrite were present. The average composition of 200 assays from the mine was 21.9% galena, 17.1% pyrite, 59.2% sphalerite, 1.8% chalcopyrite, and 0.025 % silver and gold (Nitze and Hanna, 1896). Underground workings are illustrated in figure 21.

Indorf (1978) studied the mine based on surface observations and drill core. He described the ore body as a stratiform deposit 15 meters wide, 5 meters thick, and at least 550 meters long. The deposit is in chloritic phyllite in a sequence of andesitic to rhyolitic submarine pyroclastic-flow tuffs. The ore body is "beds of fine-grained sulfides; chert, calcite, and dolomite, (metamorphosed to tremolite) that precipitated with the sulfides; and argillite" (Indorf, 1978, p. ii). Primary ore minerals are pyrite, sphalerite, galena, chalcopyrite, pyrrhotite, arsenopyrite, silver, freibergite, pyargyrite, mackinawite, cubanite, bismuthinite, bismuth, and pentlandite. Sulfide content throughout the ore body is variable.

Indorf concluded that the ore precipitated as a chemical sediment from a hydrothermal solution in an ocean basin. Sedimentary textures are common throughout the ore body. The deposit probably formed during a period of submarine volcanism. Topography of the sea floor during ore deposition controlled the shape of the ore body.

Phoenix Mine

The Phoenix Mine is in eastern Cabarrus County, 6 miles southeast of Concord and 4.9 miles southwest of Mount Pleasant near the Green Oaks Golf Course. It was first worked before 1856 to a depth of 140 feet. The mine was worked until 1889 and again from 1900 to 1906. The two deepest shafts were opened to depths of 600 feet. The ore was worked from two main stopes, one from above the 425-foot level and one above the 200-foot level. A total of $400,000 in gold was taken from veins carrying pyrite, chalcopyrite, free gold and galena. Gangue minerals include quartz, barite, calcite, ankerite, and siderite. Scheelite also is in the veins. The mine is situated west of the Gold Hill Fault in fine-grained, dark-greenish-gray tuff in the Mudstone Member of the Cid Formation.

Hoover Hill Mine

The Hoover Hill Mine is in western Randolph County, 9.6 miles west of Asheboro and 10.7 miles southwest of Randleman. The deposit was discovered by Joseph Hoover in 1848 and was worked for several years. The mine was reactivated in 1881 and production continued until 1895. Minor production was reported in 1914 and 1917. There were two main shafts, but most of the work was carried out from the 350-foot-deep Briols shaft. Levels were driven at six depths from this shaft. Gold production has been estimated at $350,000.

The mine is in volcanic rocks interlayered with Tillery Formation mudstones. The ore was in pockets and chimney-like shoots in sheared zones in the country rock. The main ore shoot was 12 feet wide at one level and 70 or more feet in length. Assays averaged one-third to one-half ounce per ton. Six other ore bodies were worked from the Hawkins shaft. The main ore shoot consisted of randomly oriented quartz seams in sheared felsic volcanic rock. Gold occurred as free gold, primarily along planes of contact between the quartz and volcanic rocks. Pyrite formed a small percent of the ore.

Gardner Hill Mine

The Gardner Hill Mine is in southwestern Guilford County, 8.1 miles southwest of Greensboro and 2.6 miles east-southeast of Jamestown. The mine was most extensively developed prior to 1856, and only minor work has been done since 1865. Emmons (1856) estimated that $100,000 in gold was produced from the lode and placer workings. The vein was worked for a distance of 5,000 feet by a series of five shafts, ranging in depth from 110 feet on an incline to 258 feet vertically (Nitze and Hanna, 1896). Levels averaging 500 feet in length were driven at depths of 60, 100, 150, and 228 feet.

In 1934, the mine was dewatered and examined. The examination showed that the ore bodies mined out were 1 to 6 feet or more thick, and one of them was 60 to 120 feet long and 270 feet or more deep. The parts of the vein remaining were from 1 to 7 feet wide and consisted of quartz with pyrite and chalcopyrite. The country rock is coarse- to fine-grained diorite and granite or granodiorite.

Of the three veins on the property, the main vein was the most extensively developed. The veins were up to 20 feet thick, striking about N 20° E and dipping northwesterly. In the upper levels, the ore was quartz and brown iron-oxides that varied from 6 to 12 inches thick. At a depth of 60 feet, chalcopyrite was present. Ore below this level yielded 20 to 25 percent copper and one-tenth to one-half ounce of gold per ton.

Fentress Mine

The Fentress Mine is in southern Guilford County, 9.3 miles south of Greensboro and 8.1 miles southeast of Jamestown. The mine was opened prior to 1853 as a gold mine, but at a depth of approximately 50 feet, copper sulfides were encountered. The deposit then became the first copper mine in the state. The mine has been idle most of the time since 1865 except for intermittent production between 1901 to 1907. The vein was worked by three deep shafts, the deepest of which was 400 feet. Four levels, ranging from 300 to 500 feet in length, were run from the main shaft.

Gold production is estimated at $175,000 through 1935. Up to the end of 1855, $133,000 of this total was produced, and during the period 1901 to 1907, $26,000 was produced.

Pratt (1907) examined the mine in 1906, and described the vein as a composite of stringers, containing a little copper on the lowest levels and having gold associated with pyrite. Emmons (1856) described a sulfide ore body on the 310-foot level as being 80 to 90 feet long and 34 inches in maximum thickness and yielding ore containing 14 to 23 percent copper.

The veins are in sheared, fine-grained diorite and, in addition to quartz, contain siderite, limonite, chlorite, sericite, pyrite, chalcopyrite, and minor malachite, chalcocite, covellite, and cuprite. The vein strikes N 25° E and dips 38° to 60° NW.

CHARLOTTE BELT

The Charlotte belt is the second most important gold-producing belt in the state (fig. 23). It is a northeast-trending belt of rocks that lies west of the Carolina slate belt and east of the Inner Piedmont and the Kings Mountain belts. The boundary between the Charlotte belt and the Carolina slate belt is formed by the Gold Hill shear zone. To the west, the Charlotte belt is separated from the Kings Mountain belt, in places, by the Boogertown shear zone, but, in places, the boundary is poorly defined. It is separated from the Inner Piedmont belt by the Eufola fault.

The Charlotte belt consists of granitic to gabbroic stocks and batholiths that intruded gneiss, schist, metavolcanic rocks, and metamorphosed mafic complexes. The intrusive rocks include granite, quartz monzonite, gabbro, diorite, and syenite and range in size from small dikes to large, irregular-shaped plutons. They can be grouped according to similar ages as approximately 300, 400, and 550 million years (Wilson and Jones, 1986). Metamorphic rocks are amphibolite grade with slightly higher grade rocks near the center of the belt.

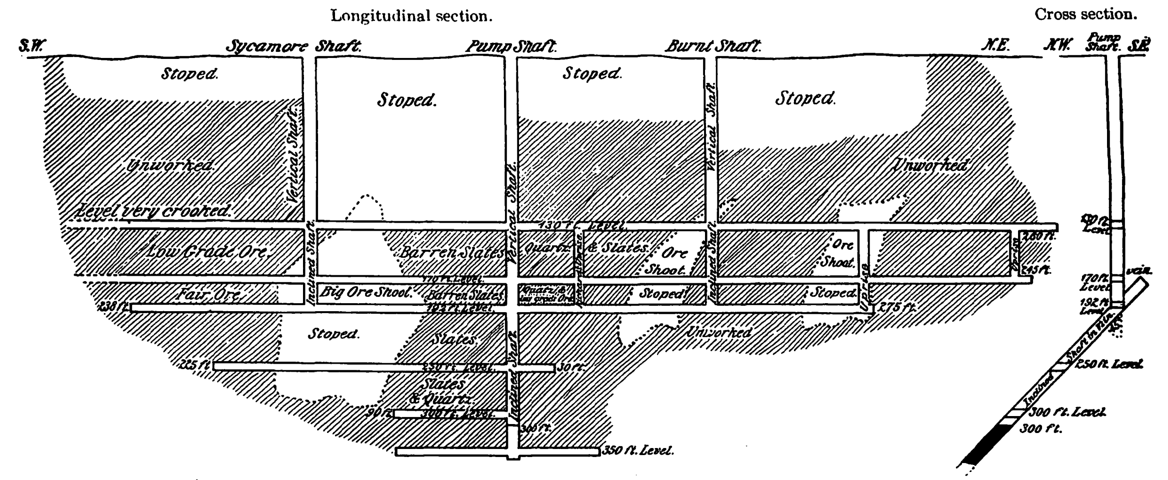
The gold deposits occur primarily in Rowan and Mecklenburg counties with Mecklenburg containing the largest number of mines. Many of the mines in this belt were developed in gold-quartz veins. In Mecklenburg County there were approximately 100 mines, many of which are now within the city limits of Charlotte. The most productive mine in a gold-quartz vein was the Rudisil Mine. The Capps Hill and the St. Catherine were also important mines in the Charlotte belt.

Rudisil Mine

The Rudisil Mine is within the city limits of Charlotte, approximately 1 mile southwest of the intersection of Trade and Tryon Streets. Pardee and Park (1948) give a good descriptive history the mine. Gold was first discovered on this property in 1829, and the mine became one of the largest in the state. In one month, more than $30,000 in gold was recovered. In 1837, the property was acquired by John E. Penman, who operated the mine successfully for several years. Operations continued until the Civil War and again from 1880 to 1887 and from 1905 to 1908.

The ore was worked by a series of vertical shafts and levels. The Pump Shaft was vertical for the first 192 feet and then followed the vein for 158 feet inclined at a 45° angle to a total vertical depth of 302 feet. Levels were driven from the Pump and other shafts for a total of about 2,400 feet (fig. 22).

Between 1904 and 1906, the mine was dewatered to within 50 feet of the bottom (Pratt, 1907). George E. Price made an estimate of the gold ore



RUDISIL MINE.
Vertical (in part) longitudinal and cross-sections, drawn from the notes of Wm. Jenkins and Wm. I. Smart, 1883. Scale : 1 inch = 110 feet. The black color in the lower portion of the cross section indicates the unworked portion of the vein.

Figure 22. Underground workings of the Rudisil Mine, 1883 (From Kerr and Hanna, 1893).

remaining in the stopes as 10,000 tons averaging one-third ounce per ton and another 10,000 tons averaging one-quarter ounce per ton. Later, "seams and bunches" of higher grade ore were hand picked, averaging 6 ounces per ton.

The mine was reopened in 1934 by the Carolina Engineering Company and was dewatered to a depth of below 250 feet (Pardee and Park, 1948). In 1935 a new mill was built. Several ore lenses were mined averaging 3 to 5 feet thick and 10 to 20 feet long with gold values of one-quarter to one ounce of gold per ton. These lenses consisted chiefly of pyrite and quartz. The mine closed in 1938 following 35 months of operation. During this time $130,000 in gold was produced. Value of the gold from the mine has been estimated at $1 million.

Mining was from a lode striking N 30° E and dipping 45° NW. The ore was in a belt of "slate or schist" between walls of massive granite and occasionally between granite and diorite or diabase. At depth, the slate almost disappears, and the ore bodies along the margins of the slate merge together as one vein at 200 feet. The ore consisted chiefly of pyrite and quartz. At depth minor chalcopyrite was present.

St. Catherine Mine

The St. Catherine Mine (also called McCombs or Charlotte) is in the city limits of Charlotte, approximately 2,500 feet N 25° E of the Rudisil Mine. These two mines are supposedly on opposite ends of the same vein. Opened before 1826, the mine was reported to be the first in Mecklenburg County and was active until about 1836. Following an idle period, the mine was sold in 1848. The mine was active in the 1880s and again between 1905 and 1908.

Mining was carried out in two parallel veins that lie near the contact between "slate" and granite. The "slate" was interpreted as a roof pendant in the granite (Pardee and Park, 1948). At a depth of 165 feet, the veins merge into a single vein. No high-grade ore bodies were found below the 250-foot level, but several low-grade bodies were worked between depths of 200 and 370 feet. The main shaft of the St. Catherine Mine was worked to a vertical depth of 370 feet, the first 155 feet of which was vertical and the remaining 305 feet inclined about 45°.

Capps Mine

The Capps Mine is in northwest Charlotte, south of SR 2050. It was operated as early as 1826.

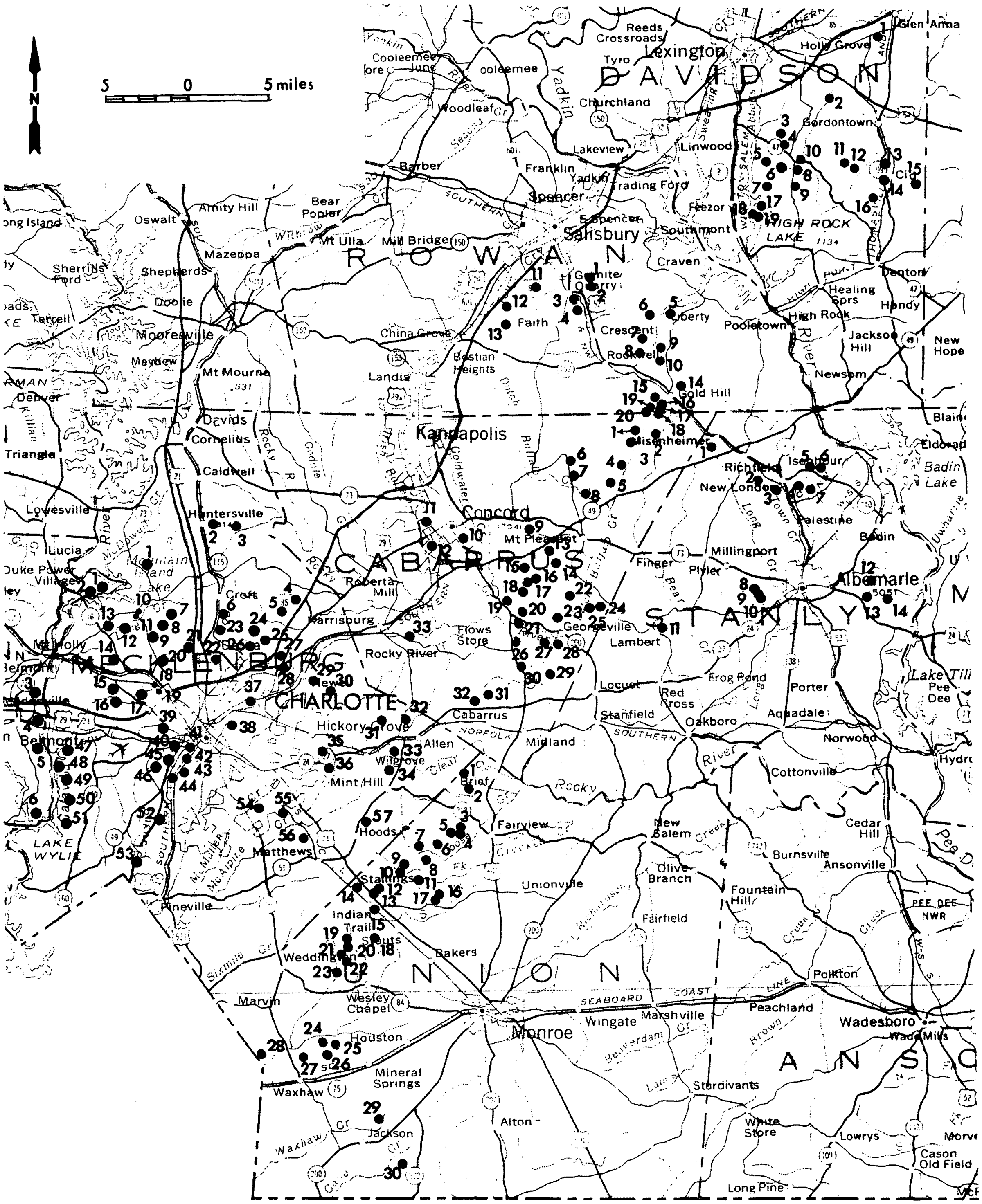


Figure 23. Mines of the Charlotte belt and southern Carolina slate belt.

Figure 23. Mines of the Charlotte belt and southern Carolina slate belt (listed by county).

Anson
1. Hamilton & Jesse Cox

Cabarrus
1. Hamilton & Jesse Cox
2. Troutman
3. Isenhour
4. Hunnicutt
5. Coates
6. Hopkins No. 2
7. Cline
8. Hopkins No.1
9. Heilig
10. Joel Reed
11. Montgomery
12. Allison
13. Nash
14. Quaker City
15. Faggart
16. Furniss
17. Phoenix
18. Tucker
19. Sanders
20. Barrier
21. Furniss-Furr
22. Ellsworth & Crosby No.2
23. Buffalo
24. Crayton
25. Nugget
26. Dan Boger
27. Rocky River
28. Allen Furr
29. Reed
30. Allen Boger
31. Dixie Queen
32. Pioneer Mills
33. Harris

Davidson
1. Black, Eureka & Lalor
2. Conrad Hill-Dodge Hill
3. Billy Allred
4. Baltimore
5. Morgan, Briggs, Plyler & Liberty Mining Co.
6. Nooe
7. Welborn
8. Ida
9. Silver Hill
10. Secrest
11. Hepler and Claud Hepler

Davidson, cont.
12. Silver Valley
13. Brown
14. Cid
15. Ward
16. Emmons
17. Peters
18. Hunt
19. Cross

Gaston
1. Oliver
2. Farrar
3. S.I. Pruitt
4. Morehead Alexander
5. Rhodes & Puett
6. Rumfeldt

Mecklenburg
1. Kearns Copper
2. Mayberry
3. S.I. Pruitt
4. Morehead Alexander
5. Dr. T.G. Deal
6. Gold Hill
7. Plummer & Hipp
8. W.L. Dunn
9. McCord
10. Dunlop
11. Clem Abernathy
12. James Hoover
13. Dunn
14. Hoover
15. Wilson
16. McCleary
17. Summerville
18. Means
19. Stuart
20. Capps Hill group
21. Nolan
22. Ellwood
23. Henderson
24. Alexander
25. Martin Alexander
26. McCombs
27. F. S. Neal
28. R. B. Orr
29. Empire
30. Bleck
31. Henson

Mecklenburg, cont.
32. Black Cat
33. Maxwell & Hagler
34. Surface Hill
35. Harris
36. Champion & Zeb Teeter
37. Caldwell
38. Queen of Sheba & King Solomon
39. Chinquepin
40. Davidson Hill
42. Rudisil
43. Isenhour
44. Trotter
45. Carson & Willmore, Woods-Smith & Palmer
46. Woodruff & Barringer
47. Cathey
48. Walker
49. Juggernaut
50. Dudley
51. Tom Ferris
52. Mrs. John Helms
53. Bob Hasner
54. Dr. Hunter
55. Frederick
56. Ray
57. Hook Prospects

Rowan
1. New Discovery
2. Dunn's Mountain
3. Reimer
4. Bullion
5. Dutch Creek
6. Gold Knob
7. Varnadore
8. Parks
9. Jacob Haltshauser & Graf
10. Camp Ridge
11. Barne
12. Harrison
13. Southern Bell
14. Rumple
15. Gold Hill
16. Miller Shaft
17. Barnhardt Shaft
18. Old Field Diggins
19. Honeycutt
20. Union Cooper

Stanly
1. Barringer
2. Mumford
3. Parker
4. Flint Springs
5. Crowell
6. Kimball Hall
7. Cotton Patch
8. Lowder
9. Haithcock
10. Hearne
11. Eudy
12. Fesperman
13. Ingram
14. Thompson

Union
1. Bright Light
2. Long
3. Moore (Blue Shaft)
4. Moore (Wentz Shaft)
5. New South
6. Stewart
7. Ford
8. Lemmonds
9. Sam Phifer
10. Fox Hill
11. Dulin
12. Secrest
13. Smart
14. Henry Phifer
15. Black
16. Butterfield
17. Crump
18. Brown Hill & Harkness
19. Hemby
20. East Hill & Ore Hill
21. Phifer & Lewis
22. Mint Hill, Folger Hill & Davis
23. Moore Hill
24. Howie
25. Bonnie Belle
26. Vinsons Half Acre & Wyatt
27. McClarty
28. Wiley Rogers & Grady Rogers
29. McNeely
30. Nesbitt

The mine was idle from 1840 until 1882, when it was reopened. During this later production, 6,000 tons of ore was mined above the 128-foot level and yielded $60,000 in gold (Pardee and Park, 1948). In 1934 the Capps Gold Mine, Ltd., of Toronto, Canada, carried out a program of diamond drilling on the property (Hoy, 1939). Two ore bodies were identified and a 100-ton cyanide plant was constructed. The mine soon closed because of poor grade and insufficient tonnage. In 1991 the mine site was included in an area being developed for a residential housing development.

The Capps Mine was in a group of veins that included the Capps vein and the Jane (McGinn) vein. The Capps vein had a trend of N 30°-35°W with a westerly dip of about 40°. The Jane vein ran N 40°-60° E with a steep eastward dip. Both veins extended in length about 3,000 feet. The Capps vein was worked to a depth of 130 feet. The upper portions of the ore were oxidized, containing quartz and free gold. At depth, pyrite and chalcopyrite were encountered. Hoy (1939) described the vein mineralization as quartz, dolomite, pyrite, calcite, and chalcopyrite in order of abundance. Lesser amounts of gold, bornite, and galena were also present.

The Capps Mine was noted for the quantity and high grade of the ore. There were four main ore bodies, the largest of which was worked from the Bissell shaft to a depth of 90 feet. At the 90-foot level, the vein was worked for 300 feet along its length. Ore encountered at the 130-foot level may have been part of the largest ore body. Closely spaced surface workings traced the vein for 2,000 feet along strike. Drifts and cross cuts totaled 3,000 feet in length.

The Jane vein on the Capps mining tract was worked to a depth of 160 feet. The northern extension of the Jane vein was worked from the McGinn Mine to a depth of 150 feet (Engine shaft). There were two additional veins on the McGinn property, an unnamed vein and the copper vein. The copper vein was mined for copper to a depth of 110 feet.

KINGS MOUNTAIN BELT

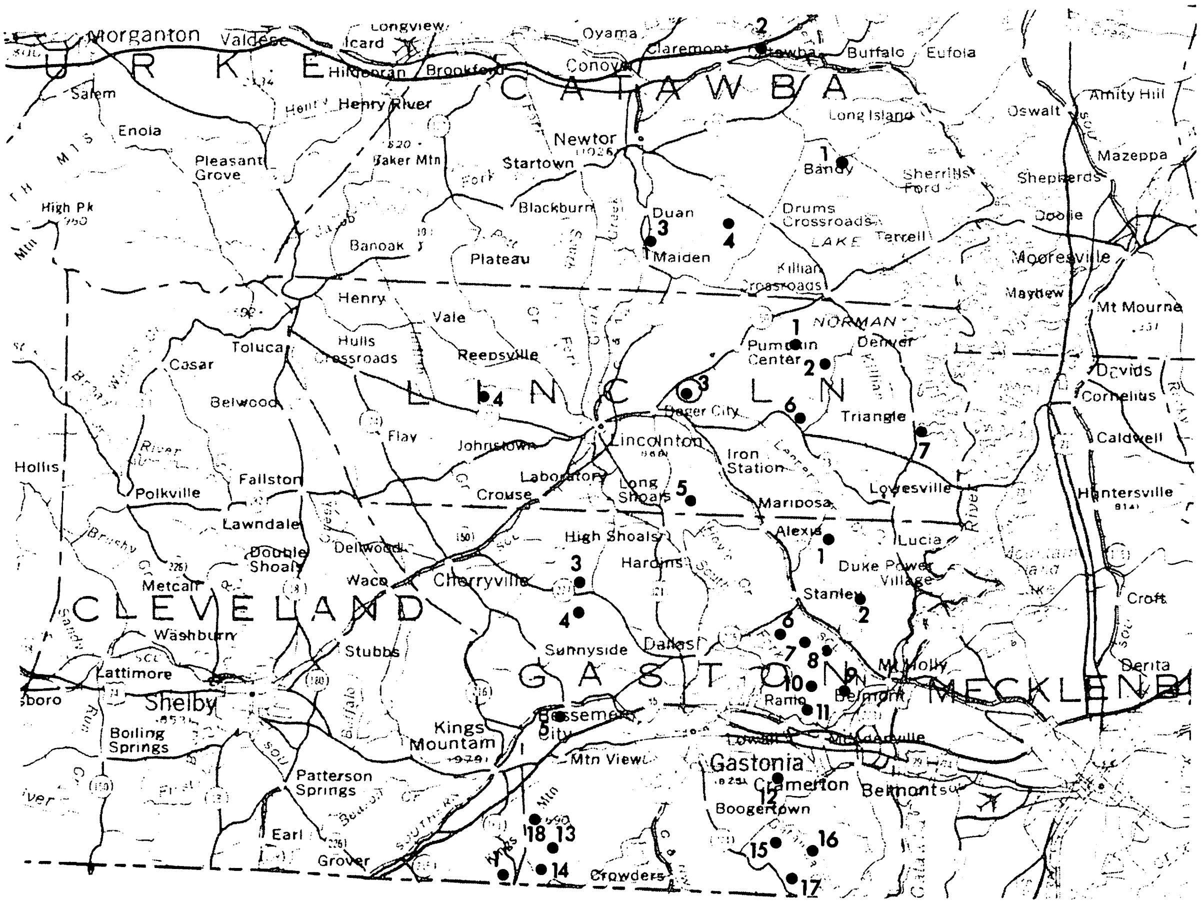
The Kings Mountain belt is a narrow, northeast-trending belt of metamorphic rocks that lies along the west side of the southern half of the Charlotte belt (fig. 24). It contains steeply dipping metasedimentary and metavolcanic rocks of Late Proterozoic age ranging in grade from greenschist to amphibolite facies. The metamorphic rocks are divided into two main formations, the Blacksburg Formation and the Battleground Formation (Goldsmith and others, 1989).

The Blacksburg Formation is west of the Kings Creek and Blacksburg shear zones. It is primarily sedimentary in origin and consists of sericite schist or phyllite with lenses or beds of marble and calc-silicate rock, micaceous quartzite, and amphibolite. Amphibolite lenses may have been basaltic flows or sills. The Battleground Formation is east of the two shear zones. The lower part of the Battleground Formation consists of metavolcanic rocks interlayered with quartz-sericite schist. The metavolcanic facies include hornblende gneiss and biotite gneiss with schistose or phyllitic metavolcaniclastic rocks. The upper part of the Battleground Formation is quartz-sericite schist interbedded with kyanite and sillimanite quartzite, quartz-pebble metaconglomerate, spessartine-quartz rock, and quartzite. Rocks of the Kings Mountain belt are complexly folded and sheared, making stratigraphic relationships between the two formations difficult to determine.

Metatonalite and metatrondhjemite intrusions of probable late Proterozoic age are most common in the lower Battleground Formation. These bodies may represent shallow sills and plugs that intruded their own volcanic ejecta (Goldsmith and others, 1989). The 317-million-year-old High Shoals Granite batholith occupies much of the center of the Kings Mountain belt.

Kings Mountain Mine

The Kings Mountain Mine was the most important gold mine in the Kings Mountain belt. The mine is in southeastern Cleveland County, 3 miles



Catawba
1. Shuford
2. Rufty
3. Maiden
4. Abernathy

Cleveland
1. Durham

Gaston
1. Gap
2. Rhyne
3. Asbury
4. McCarter Hill & Dixon
5. Ormond
6. Reese
7. Clemmer
8. McClurd
9. Oliver
10. Duffie
11. Robinson
12. Lineberger
13. Patterson
14. Caledonia (Crowders Mtn.)
15. Eddleman
16. Wright
17. Dameron
18. Kings Mountain

Lincoln
1. Graham
2. H.C. Tucker
3. Mullen
4. Hauss
5. Hole
6. Graham
7. Cherry

N

5 0 5 miles

Figure 24. Mines of the Kings Mountain belt and vicinity.

southeast of the town of Kings Mountain. Placer gold was discovered at the site in 1829 in a small creek (Supplee, 1986). In 1830 the vein was discovered 200 yards upstream. Although records were not kept prior to 1836, it is reported that $50,000-$60,000 in gold was produced by the end of January 1840. Most of the gold was sold as bullion or minted as coins in Charlotte. The mine was worked at irregular intervals until 1895. In the mid-1980s, Texasgulf Metals and Minerals, Inc., conducted core drilling on the property.

The weathered, or oxidized, ore consisted of sugary and cellular quartz and was mined by hydraulicking methods. The lodes were worked by twelve or more shafts and some open-cuts. The two deepest shafts reached depths of 330 feet with others ranging from 50 to 200 feet in depth. The mine was worked over a strike length of 1,500 feet. Some of the shafts were connected by drifts, crosscuts, and stopes.

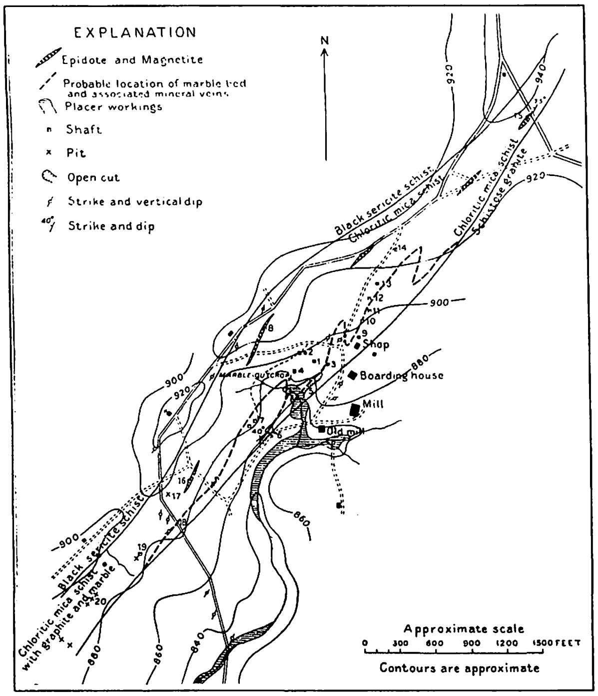


Figure 25. Sketch geologic and topographic map of the region around the Kings Mountain Gold Mine, 1913 (From Keith and Sterrett, 1931).

The mine is of interest in the southeast because it is a carbonate-hosted deposit. There are three veins associated with beds of blue to gray, banded, dolomitic marble enclosed by chlorite-mica schist (Keith and Sterrett, 1931; fig. 25). The rocks strike N 70° E and dip northwest at steep angles. The veins ranged from 2 to 20 feet thick and consisted of iron-stained, cellular quartz in a decomposed earthy matrix. Below the water table, the veins consisted of siliceous, dolomitic marble containing quartz, pyrite, pyrrhotite, chalcopyrite, galena, sphalerite, and minor quantities of other minerals. Gold averaged a little over one-tenth ounce of gold per ton, and reports estimate production at between \$750,000 and \$1,000,000. The richest ore consisted of small veins or stringers of quartz and pyrite, but some of the limestone near the veins was rich enough in gold to be mined and milled.

Supplee (1986) describes ore in three different rocks at the mine: in gold-bearing carbonates; in silicified portions of the metatrondhjemite unit; and at the base of an iron formation. Mineralization is at the contact between metavolcanic and metasedimentary rocks. Mineralization includes pyrite, pyrrhotite, sphalerite, chalcopyrite, galena, tetrahedrite, altaite, gold, arsenopyrite in a quartz, dolomite, and sericite ± chlorite, albite gangue (Supplee, 1986). Supplee suggested that the ore possibly formed during emplacement of the metatrondhjemite, as a subaqueous epithermal deposit with syngenetic formation of iron formations.

Crowders Mountain Mine

The Crowders Mountain (Caledonia) Mine is 4 miles east of the Kings Mountain Mine. Work was started here after 1865 and included two shafts about 500 feet apart. Work was in an 8- to 10-foot-wide northeast-trending mineralized zone enclosed by quartzite and schist. Assays of the rock ranged from one-hundredths to almost one-half ounce of gold per ton.

Long Creek Mine

The Long Creek Mine is in Gaston County, 8 miles northwest of Gastonia. The workings are west of Pasour Mountain and south of NC Highway 277. The mine was last worked in 1892. Three veins, the Asbury, Dixon, and McCarter Hill, were worked by a series of shafts. The lodes trend to the northeast and are enclosed by schist striking N 20°-25° E and dipping 85° NW. Minerals present included gold, pyrite, psilomelane, pyrrhotite, fluorite, sphalerite, arsenopyrite, and galena. Rocks in the vicinity of the mine are mapped as Blacksburg Formation (Goldsmith and others, 1986).

The McCarter Hill vein was opened by three shafts for about 250 feet along the strike of the vein. The vein was stoped to a depth of 160 feet and a width of 4 to 6 feet. The ore assayed as 0.40 ounce of gold per ton and 0.15 ounce was recovered by amalgamation. The Dixon vein was at least 3 feet wide and was worked by two shafts 300 feet apart and by extensive surface pits. The deepest shaft was 140 feet with drifts to the north and south. In 1934, the shaft was dewatered and sampled by the American Smelting and Refining Company. The deepest shaft on the Asbury vein was 110-feet deep. It exposed a vein 6 to 8 feet wide. The vein contained native silver (Bowerman, 1954). The property was drilled, dewatered, and sampled by Phelps Dodge in the early 1980s.

Shuford Mine

The Shuford Mine is in eastern Catawba County, approximately 5 miles southeast of Catawba. The deposit is a zone about 300 feet wide and 1,000 to 2,000 feet long in which the schist and gneiss contain seams of gold-bearing quartz. Rocks in the vicinity of the mine are mapped as Blacksburg Formation (Goldsmith and others, 1986). Shaft and open-cut methods were unsuccessful in extracting the ore, and a drag-line scraper was found to be most economical in working the deposit. A pit was opened to a depth of about 90 feet in the saprolite, and 85 percent of the gold was recovered. Five hundred and eighty-six ounces of silver and 1,716 ounces of gold were recovered between 1902 and 1911.

INNER PIEDMONT BELT

The Inner Piedmont belt is between the Charlotte and Kings Mountain belts on the east and the Blue Ridge belt on the west (figs. 24, 26, and 27). The belt consists of mica schist and biotite gneiss interlayered with amphibolite, calc-silicate rock, hornblende gneiss, quartzite, and minor marble (Goldsmith and others, 1989). Much of the rock has been migmatized. The rocks are probably predominantly sedimentary in origin but include some metavolcanic rock. Goldsmith and others (1989) discussed the possibility of two stratigraphic suites in the Inner Piedmont belt. They suggested a structurally lower, mostly mafic suite and an upper suite of interlayered mica schist and biotite paragneiss. The upper suite occupies the central core of the belt, and the lower suite is on the flanks to the northwest and east. Granitic bodies, mostly of granitic and granodioritic composition, are scattered throughout the belt. Some of the largest bodies of granitic to granodioritic rocks are the Toluca Granite, the granite of Sandy Mush,

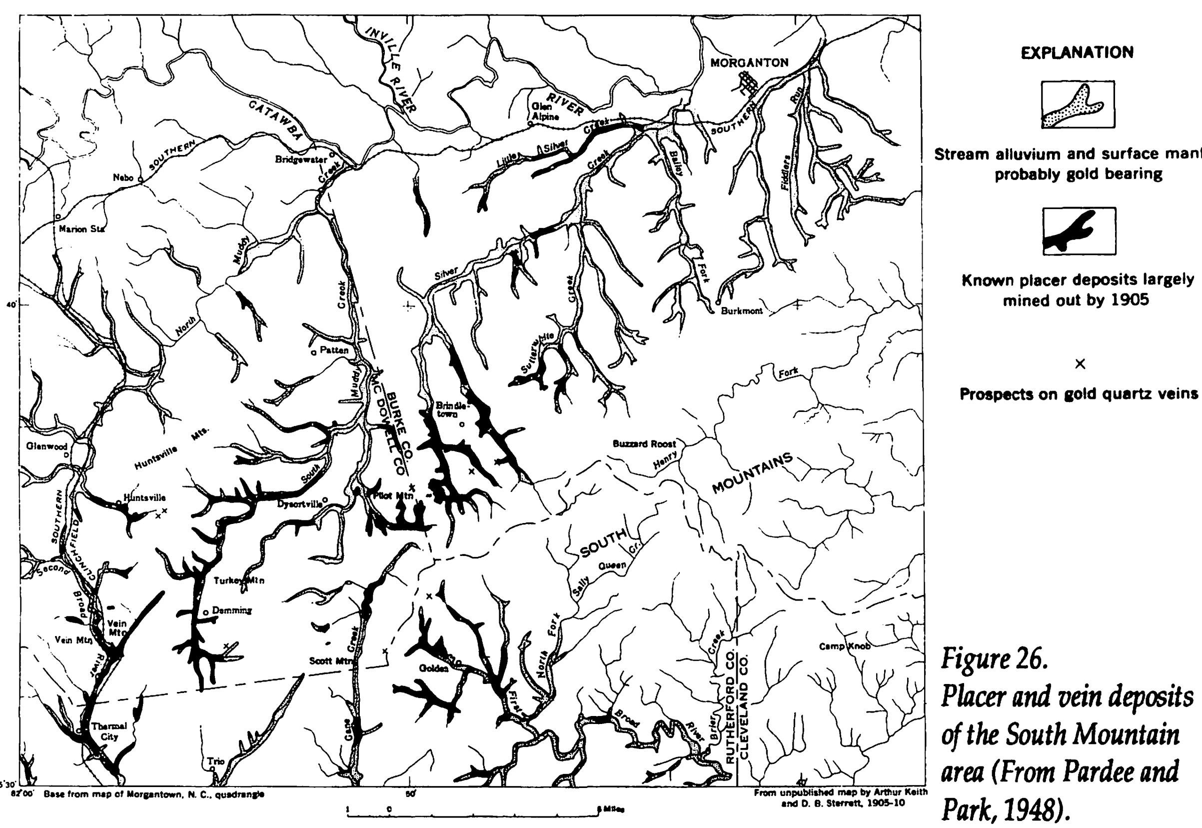


Figure 26. Placer and vein deposits of the South Mountain area (From Pardee and Park, 1948).

the Henderson Gneiss, and the Cherryville Granite. Most of the bodies have gneissic texture but may also display more massive and porphyritic phases.

The central core (upper suite) of the Inner Piedmont belt is within the sillimanite zone (amphibolite facies) of regional Barrovian metamorphism (Goldsmith and others, 1989). Lower-grade staurolite-kyanite zone rocks (lower suite) are on the flanks of the core. The Inner Piedmont rocks have been folded and faulted many times and the structure is poorly understood.

The South Mountain district has been the center of most of the gold activity in the Inner Piedmont belt. The district includes an area of about 300 square miles in Burke, McDowell, and Rutherford counties underlain by mica and hornblende gneisses and schists. These metamorphic rocks have been intruded by felsic and mafic dikes and by quartz veins ranging in size from small stringers to veins as much as 4 feet wide. The district is mountainous; elevations range up to 3,000 feet above sea level and average 1,100 feet above sea level. Rich placer deposits formed along the major streams. The major mining was from placers along Silver and Muddy Creeks and the First Broad River (fig. 26). Quartz veins in this belt were generally too small (less than 1 inch thick) to be worked profitably; so there was no large-scale, underground mining. Some deposits, where quartz veins were numerous enough, were worked by hydraulicking of the saprolite.

A few diamonds were found in the gold placers in the South Mountain area (Kunz, 1907). The first diamond discovered in North Carolina was found on Brindletown Creek in 1843. A diamond was found at Twitty's Mine, Rutherford County, and two or three were found on the headwaters of Muddy Creek in McDowell County. The largest diamond found in the state was found near Dysartsville and weighed 4.33 carats. The primary source of these diamonds has not been determined. Recent studies on lamproites may provide clues to the source of these diamonds.

A new potential source of low-grade gold was found during studies for the Charlotte CUSMAP project (Gair and D'Agostino, 1986 and Gair and others, 1989). Siliceous zones in saprolite were shown to yield small bonanza pockets of gold. The siliceous zones are horizontal to gently dipping layers 2 inches to 16 inches thick. The bedrock is Late Proterozoic to Cambrian age quartz-muscovite schist containing disseminated auriferous pyrite. The siliceous zones are white to gray, compact to vuggy quartz containing flakes of gold 0.02 to 0.25 inches in diameter. Some flakes are as large as 1 inch and weigh as much as 1 ounce.

Mills Property

The Mills property is in southwestern Burke County, 13 miles southwest of Morganton. Mining began here in 1828, on Brindle Creek. Many placers were mined on the property and, in 1916, the estimated production of the tract was more than $1,000,000. Gold occurred mainly as small grains with only a few nuggets being found, the largest weighing 1.5 ounces. The gold was 0.825 to 0.827 fine. A considerable amount of monazite was recovered with the gold and the placers also contained zircon, fergusonite, xenotime, rutile, garnet, and corundum. Several small veins and stringers of gold-bearing quartz were later discovered. For a while the gold was recovered from the veins with a 5-stamp mill.

Sprouse Mine

The Sprouse Mine is near Demming in southeastern McDowell County. It was worked from placers and lodes from 1885 to 1935, by Captain J. J. Sprouse. At least 635 ounces of gold were recovered from the placers. Quartz veins 1 to 6 inches wide were on the property. One vein yielded gold at 0.35 ounce per ton. A 125-foot-deep shaft exposed a vein carrying galena and sphalerite.

Vein Mountain Mine

The Vein Mountain Mine is in southern McDowell County near the Second Broad River approximately 5 miles south of Glenwood. The mine

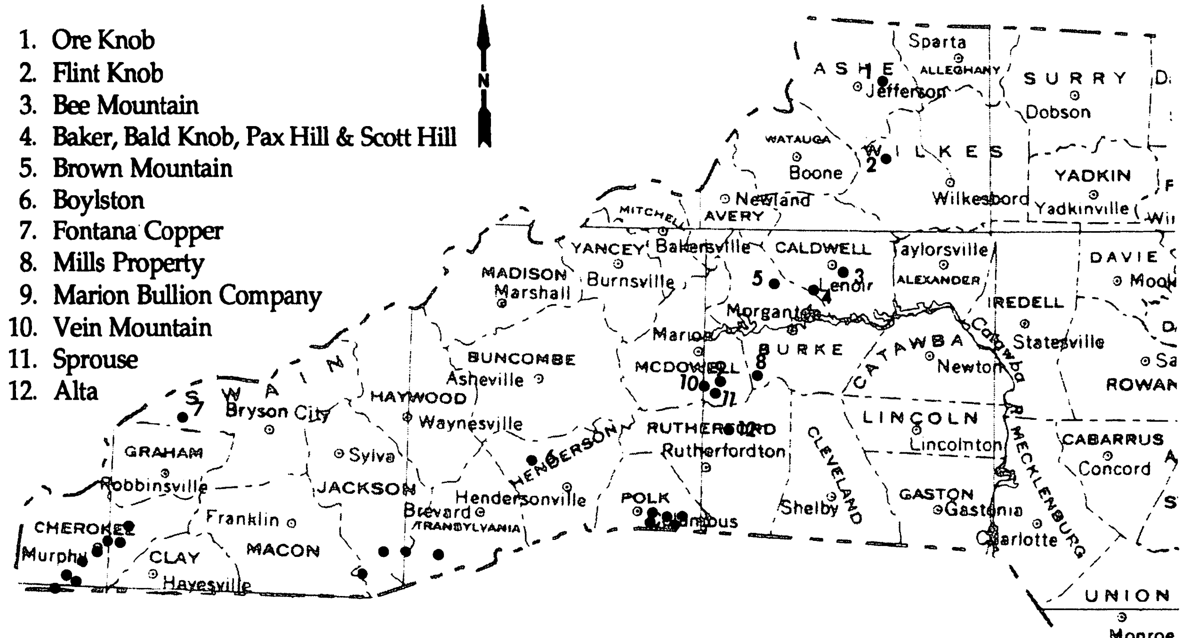


Figure 27. Mines of the Blue Ridge and Inner Piedmont belts.

was worked extensively by hydraulic methods prior to 1908. The gold was mined from a series of at least 33 parallel quartz veins that cross Vein Mountain in a belt not over 0.25 mile wide. The Nichols Vein was the largest and was prospected by four shafts, the deepest of which was 117 feet. The strike of the vein is N 80° E, and the dip varies from 75° NW to vertical. The veins are enclosed by schist striking N 10-20° W and dipping 30° NE. The ore averaged about three-quarters of an ounce of gold per ton.

Marion Bullion Company Mine

The Marion Bullion Company Mine is at Brackettown near the headwaters of South Muddy Creek in McDowell County. A number of quartz veins were prospected, and a 126-foot-deep shaft was sunk on a series of six, narrow, closely spaced veins. The quartz contains galena, sphalerite, chalcopyrite, and pyrite and is enclosed by biotite gneiss striking N 10° W and dipping 10-15° NE. Assays of the quartz ran from two-tenths to one ounce of gold and silver per ton.

Alta Mine

The Alta Mine, in Rutherford County 5 miles north of Rutherfordton, was worked from 1845 to 1893 by a series of shallow open-cuts, pits, and shafts. Thirteen parallel quartz veins were explored in a zone 0.5 mile wide.

Baker Mine

This mine is in Caldwell County, 1.2 miles southeast of Adako and east of Johns River. It was the most extensively worked mine in Caldwell County. Mining was in quartz veins enclosed by northeast-trending biotite gneiss and schist. Kerr and Hanna (1893) describe four principal veins striking N 35°- 45° W and dipping northeast. The veins ranged from 20-inches to 5-feet wide and carried galena in addition to gold. Streams nearby were worked for placer gold.

BLUE RIDGE BELT

The Blue Ridge belt is separated from the Inner Piedmont on the east by the Brevard fault zone. It is separated on the west from the Valley and Ridge belt by the Great Smoky thrust fault. The Blue Ridge is cored by Middle Proterozoic-age basement rocks. Younger cover rocks flank the older rocks to the northwest and southeast. The structure of the Blue Ridge is a series of stacked thrust sheets. Thrust faults form the contacts between many lithologic units.

The older core rocks are mostly massive to layered biotite-hornblende gneiss, biotite gneiss, biotite granitic gneiss and granodioritic gneiss. At many places, these mostly plutonic rocks were metamorphosed to granulite facies during Proterozoic time. Younger cover rocks overlie the basement rocks. The oldest cover rocks include the Late Proterozoic-age Tallulah Falls Formation, Ashe Metamorphic Suite, and the Alligator Back Formation. These original sedimentary, volcanic and plutonic rocks were metamorphosed to muscovite-biotite gneiss and schist, feldspathic gneiss, and amphibolite. A younger sequence of Late Proterozoic-age metamorphosed sedimentary rocks overlie the basement rocks and older cover rocks. These younger cover rocks include the Ocoee Supergroup and the Grandfather Mountain Formation. Lower Paleozoic sandstones and shales of the Chilhowee Group are exposed along the western margin of the Blue Ridge and in a few structural windows in the belt. Intrusive rocks ranging in composition from granite to ultramafic are scattered throughout the Blue Ridge.

Most gold deposits in the Blue Ridge (fig. 27) were small and produced only minor amounts of gold. The largest quantities of gold were obtained as a by-product of copper mining from massive sulfide deposits.

Fontana Copper Mine

The Fontana Mine is in southwestern Swain County, 2.5 miles northeast of Fontana Village. The ore body was discovered and prospected by the Montvale Lumber Company prior to 1926. In 1926, the property was acquired by the Fontana Mining Corporation which worked the mine until 1931. The North Carolina Exploration Company operated the mine from 1931 until 1944 when it closed because of construction of the Fontana Dam on the Little Tennessee River by the Tennessee Valley Authority. In the 1980s, the property was absorbed into the Great Smoky Mountains National Park.

The Fontana Mine is in feldspathic metasedimentary rocks of the Ocoee Supergroup. The deposit is a single, pod-like lens that strikes N 60° E and plunges S 15° E at a 45° angle (Espenshade, 1963). The body was worked from several adits and an inclined shaft with 18 levels at intervals of 31 to 155 feet. The total vertical depth of the workings reached 1,700 feet. The ore consisted of pyrrhotite, pyrite, chalcopyrite, sphalerite, and galena. The average ore grade from 1931-1942 was 7.37 percent copper, 2.11 percent zinc, 0.385 ounce per ton of silver and 0.0072 ounce of gold per ton (Espenshade, 1963).

Ore Knob Mine

The Ore Knob Mine, in eastern Ashe County, is 8.2 miles east of Jefferson and 1 mile north of N.C. Highway 88. The mine is the largest massive sulfide deposit in North Carolina. During the early mining, begun in 1855, four shafts were sunk to depths of 90, 40, 30, and 40 feet. Work continued until 1856. The mine was not worked again until the period 1873 to 1883. During this second period of activity, rich ores were discovered underlying the gossan, and the shafts were extended to depths of 400 feet. The mine was worked sporadically until 1953, when the Nipissing Mines, Ltd. began exploration. In 1954, work was carried out under the name of Appalachian Sulfides, Inc. Production continued until December 1962, when the ore body was depleted. A vertical shaft was completed in 1955 to a depth of 1,039 feet.

The ore body was a tabular body striking N 64° E and dipping 70° with a rake of 20° to the southwest enclosed by gneisses and schists of the Ashe Formation. The ore shoot, at least 4,000 feet long, 14 feet wide, and between 200 and 550 feet in vertical height, was along a narrow shear and breccia zone in mica gneiss. Much of the ore was massive sulfides composed of pyrrhotite, pyrite, and chalcopyrite with quartz, biotite, and amphiboles. Minor minerals were sphalerite, tetrahedrite, stibnite, bornite, chalcocite, and galena. Through 1961 total production at the mine was 9,400 ounces of gold, 35,000 tons of copper and 145,000 ounces of silver (Kinkel, 1967).

Boylston Mine

The Boylston Mine, west of Boylston Creek in Henderson County 12 miles southwest of Asheville, was worked primarily for gold. The quartz veins were prospected during 1885 and 1886. The Boylston Mining Company was formed in 1886. Operations continued sporadically until 1889. The mine was reopened in the 1930's. Exploration was undertaken in 1935, but there was little production.

The quartz veins crop out on the southern slope of Forge Mountain. The mountain is underlain by mica and hornblende gneisses and schists that strike N 20-30° E and dip steeply to the northwest. Four main gold-bearing quartz veins striking N 30° E and dipping northwest at 25-75° were mined. The veins range in thickness from 1 to 4.5 feet with a pay streak from 1 to 8 inches wide along the hanging wall side. Free gold was in the upper levels; and gold, pyrite, and minor galena were below the water table.

The No. 2 vein was the most extensively developed and all of the ore milled on the property was obtained from this vein. Workings were along the length of the vein for 1,500 feet with an estimated 3,000 tons of two-tenths ounce per ton of ore removed. Assays from the vein ranged from two-tenths to over 5 ounces of gold per ton. The highest values were obtained from the rich pay streak of reddish-brown quartz along the hanging wall. The ore was processed in a stamp mill, but only 24.63 percent of the assay value was recovered.

Other Mines

In Jackson County, the Fairfield Valley on Georgetown Creek was worked for placer gold. It is reported that between $200,000 and $300,000 in gold was recovered from gravels that extend several miles along the creek. Most of the gold was obtained near the base of a steep wall formed by a gray gneiss.

Gold has been mined in Cherokee County from the sands of Valley River, from veins near Murphy, and along the lower slopes of the mountains from near Valleytown to Vengeance Creek.

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GLOSSARY

Adit - In underground mining, a horizontal entry driven into deeper zones of a mine so that broken material can be removed by gravity.

Amalgamation - The process in which mercury is used to separate gold from an ore. An ore containing gold is crushed and then passed over metal plates coated with mercury. The gold is absorbed by the mercury, forming an amalgam. This amalgam is then heated in a retort to separate the gold from the mercury.

Anticline - A fold in rocks; it is convex upward; upfolded layers.

Assay - A test or analysis to determine the proportions of metals in an ore.

Contact - The surface or boundary between two different types or ages of rocks.

Country rock - a) The rock enclosing or traversed by a mineral deposit; b) The rock intruded by and surrounding an igneous intrusion.

Crosscut - In underground mining, a horizontal tunnel used to connect drifts.

Cyanidation - The process in which a solution of potassium cyanide is passed through crushed ore to remove the gold. This process is not used when the ore contains copper.

Dip - The angle that a geologic surface, such as bedding or a fault plane, makes with the horizontal. The direction of dip is measured perpendicular to the strike of the surface.

Dredging - The process of using a large floating machine for scooping up or excavating material from the bottom of a body of water, raising the material to the surface, and processing the material to remove the gold.

Drift - In underground mining, a horizontal tunnel which follows the ore.

Fault - A surface or zone of rock fracture along which there has been displacement. This displacement may range from a few inches to a many miles.

Felsic - An adjective used to describe a rock in which light-colored minerals, most commonly feldspar and quartz, predominate.

Flotation - A process of mineral separation in which water, oil, and chemicals are combined to make a froth of air bubbles to which certain minerals adhere and can be collected in a trough.

Hydraulicking - A mining method used for processing placer deposits where gravels are excavated and swept away by powerful jets of water into sluiceways.

Hydrothermal - Referring to hot water or the action of hot water, such as a mineral deposit precipitated from a hot aqueous solution.

Igneous rocks - Rocks which solidified from molten material.

Lode deposit - a) A mineral deposit consisting of a zone of veins; b) A mineral deposit in consolidated rock as opposed to placer deposits.

Mafic - An adjective used to describe a rock in which dark-colored minerals, commonly biotite, hornblende, olivine or pyroxene, predominate.

Malleability - The ability of a mineral to be plastically deformed under compressive stress such as hammering.

Matrix - The fine-grained interstitial material of an igneous rock or the smaller, fine-grained particles of a sediment which occupy the spaces between the larger particles.

Metamorphism - The mineralogical and structural adjustment of solid rocks to physical and chemical conditions which differ from those under which the rocks originally formed.

Native gold, copper - Any element (gold, copper, etc.) found uncombined with other elements.

Ore - The naturally occurring material from which a mineral or minerals of value can be extracted economically.

Pinch - A thinning or squeezing of a rock layer or vein.

Pipe - A cylindrical, more or less vertical ore body.

Placer deposit - A surficial mineral deposit formed by mechanical concentration of mineral particles from weathered debris. This is a natural gravity separation of heavy from light minerals by means of water or air.

Pluton - A large igneous intrusion.

Raise - In underground mining, vertical or inclined openings driven upward to connect workings at different levels.

Residual deposit - The residue formed by weathering in place. The weathered material that has not been moved from the site where it formed.

Rocker - A device used for concentrating gold in small-scale placer mining operations work. The rocker is usually hand operated and is used by shoveling gravel into a hopper, bailing water into the hopper, and rocking the device from side to side to wash the gravel and concentrate the gold.

Saprolite - Soft, earthy decomposed rock formed in place by chemical weathering of igneous and metamorphic rocks, in which many of the structural features of the original rock are visible.

Shaft - A vertical or steeply inclined opening sunk from the surface of the ground into or near an ore body.

Sill - A tabular igneous intrusion that parallels the planar structure of the surrounding rock.

Skip - In underground mining, a container used to carry ore to the surface of the ground.

Sluice - A narrow, inclined trough used in placer operations to collect gold. The sluice contains riffles in the bottom which provide collecting sites for the gold.

Smelting - The process of melting ores in blast or reverberatory furnaces to obtain metals.

Specific gravity - A number that expresses the ratio between the weight of a mineral and the weight of an equal volume of water at 4° C. If a mineral has a specific gravity of 2, it means that a given specimen of that mineral weighs twice as much as the same volume of water. This is frequently a helpful aid in identifying minerals.

Stope - In underground mining, the area from which the ore is removed.

Strike - The direction or trend that a geologic surface, such as a bedding or fault plane, takes as it intersects a horizontal plane.

Surficial - Lying in or near the earth's surface.

Swell - A thickening or enlarged place in an ore body or vein.

Syncline - A fold in rocks; it is concave upward; down-folded layers.

Vein - A thin, sheet-like igneous intrusion or mineral filling in a fracture or crevice in country rock.

Winze - In underground mining, a vertical or steeply inclined passage driven downward.