GEOLOGY AND ORE DEPOSITS

OF THE

CAPPS GOLD MINE

MECKLENBURG COUNTY, NORTH CAROLINA

Thesis by

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ABSTRACT

The Capps gold mine is located five and one-half miles northwest of Charlotte, in Mecklenburg County, North Carolina. The area lies wholly within the igneous belt of the southern Appalachian gold region in approximately the central part of the Piedmont province of eastern United States.

The ore deposits consist of lenticular quartz-dolomite-pyrite veins irregularly replacing sheared zones of the granite country rock. The wall-rock alteration and vein mineralization indicate that the deposits belong to the mesothermal rather than hypothermal zone into which most of the southern Appalachian gold deposits have been classified.

The immediate future of the Capps district does not present an optimistic picture, because the Capps Company is in the hands of receivers. Nevertheless, it is possible that successful mining could be carried out, if deposits were carefully blocked out in advance of extraction. The best possibilities for future exploration are extensions of the deposits beneath old excavations, especially those above which rich ore has been obtained.

GEOLOGY AND ORE DEPOSITS
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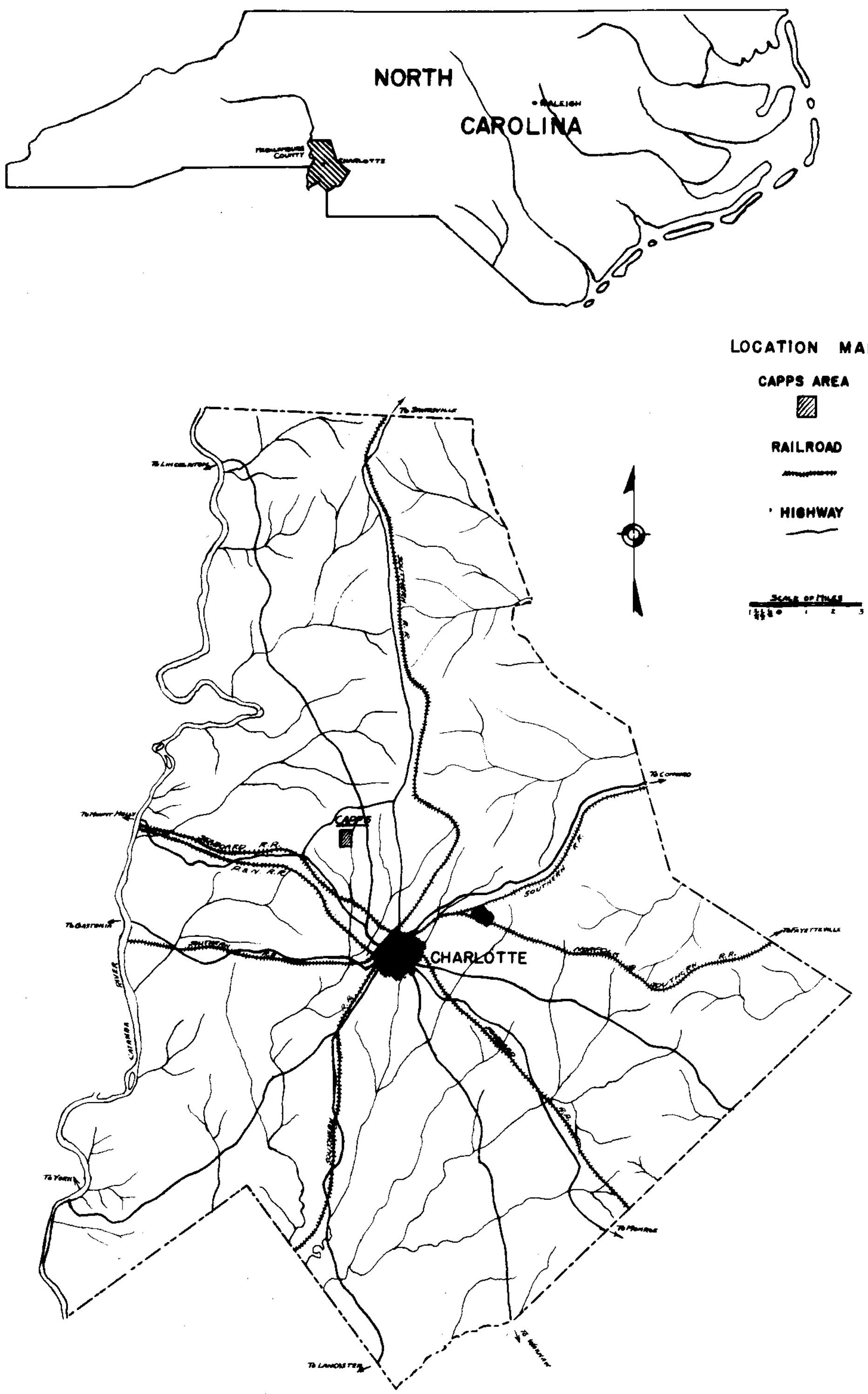
Mecklenburg County, North Carolina

INTRODUCTION

LOCATION

The Southern Appalachian Gold Region includes scattered gold-bearing deposits found extending over a wide belt in the Piedmont province of the Appalachian Region of the United States from a point in Maryland near Washington, D. C., southwestward to Alabama.

The area under consideration lies near the central part of the Piedmont province in the Igneous Belt of the Southern Appalachian Gold Region. It is in southern North Carolina in Mecklenburg County, five and one-half miles northwest of Charlotte, between the Rossel's Ferry and Beattie's Ford roads (Plate I). Outside of Charlotte and the many small towns, the country is rather thinly populated, but roads are numerous and generally good. Transportation is facilitated by several railroads. Two branches of the Southern Railway and one each of the Seaboard and Norfolk & Southern have terminals in Charlotte.



MECKLENBURG COUNTY

HISTORY OF MINING[1]

Regional History

Although gold mining in the region started as early as 1800, operations were confined to placer mining until 1825 when the first lode, Barringer's, was discovered. By 1829 a real boom had started. The many delays in transportation and communication during this early period led to the use of gold dust as a medium of exchange. In Rutherfordton, North Carolina, Christian Bechtler started a private mint in 1830 which operated until the United States Mint was built in Charlotte in 1836.

Production records show that the boom reached its height about 1833. With exhaustion of some of the richer deposits, activity declined somewhat until 1840 when better methods of recovery were applied. The following period of increased activity lasted until the outbreak of the Civil War in 1861. During this period Gold Hill, North Carolina, was one of the largest producers and the town boasted a population of over two thousand.

An almost complete cessation of mining during the war was followed by intermittant activity from 1870 until 1916. Many of the mines were reopened and deepened, the shaft at Gold Hill being sunk to a depth of 820 feet, the deepest shaft

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[1]Bryson, H. J., Gold Deposits of North Carolina, N. C. Dept. Conservation and Development, Bull. 38, pp. 7-12, 1936.

in the region. The most productive operation was at the Haile Mine in South Carolina, where low-grade pyrite ore was successfully treated by a modification of the chlorination process.

Activity almost ceased during the period of inflation caused by the World War, and not until 1933 was there any sign of a revival.

In 1934, following the increase in the price of gold, underground development work was revived in many of the lodes of the region such as those of the Dorn, Haile, Bar Kat, Brewer, Landrum, and Terry Mines in South Carolina and the Howie, Capps, and Crayton in North Carolina.

At the present time, 1939, the most successful operation is that at the Haile mine, where low-grade pyrite ore is being successfully treated in a 400 ton cyanide plant. Noteworthy is the successful use of geophysical exploration at the Haile. Several auto-potential areas have been located, of which one, checked by churn and diamond drilling, has proved to be a valuable reserve or high-grade ore. The Howie mine was taken over by the Condor Consolidated Mines, Ltd., Toronto, Canada in 1935 after a series of drill cores showed over one million dollars worth of fairly high-grade ore; mining operations are to be started soon.

History of the Capps Mine

Old reports mention the Capps mine as being operated as early as 1826, and production records show that most of its production of over $1,000,000 was mined before 1840. Early reports suggest that some very rich pockets were mined in this early period. After this early activity the mine was idle until about 1882 when Captain John Wilkes reopened and worked it for several years. Mint records show that 6,000 tons of $10.00 ore were mined during this period. There followed another period of idleness until the present operators began development in 1934. Nearly $150,000 worth of ore was produced by the summer of 1938.

PHYSIOGRAPHY

Regional Physiography

The gold deposits of the Southern Appalachians, are found in the Piedmont province, the gently sloping plateau lying east of the Blue Ridge and extending from Alabama to New England. In the Carolinas the plateau is about 100 miles wide, descending from an elevation of 1,500 feet at the foot of the mountains to 500 feet at the edge of the Atlantic Coastal Plain. The stream valleys are moderately developed and are usually entrenched 50 to 100 feet below the general surface. The interstream areas are flat to gently rolling, with the exception of a few hills which rise up to a thousand feet above the plateau.

Physiography of the Capps Area

The Capps area, which lies between the elevations of 700 and 850 feet, is near the center of the Piedmont province. Here the gently sloping plateau is moderately dissected by southward flowing streams, whose valleys are some fifty feet below the general plateau. A few hills, such as Capps Hill, rise slightly above the plateau, but none rise sharply above it as they do farther west in the Kings Mountain area. See topographic map, Plate II.

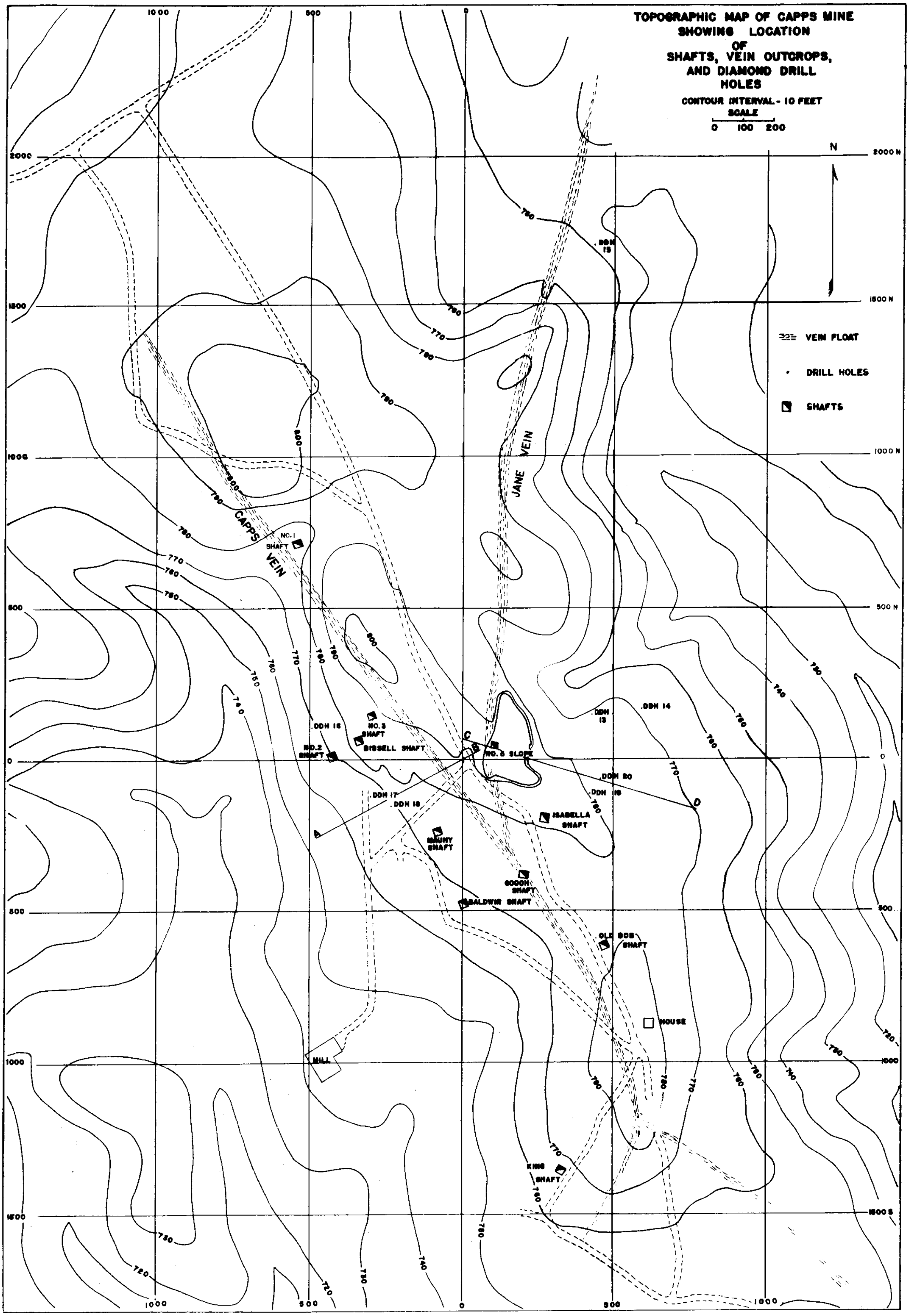
CLIMATE AND CULTURE

The Capps area, having a mean rainfall of fifty inches well distributed throughout the year, enjoys the usual mild climate of the Piedmont province. Deep fertile soils are suitable for the cultivation of cotton, tobacco, and corn. Areas too hilly for cultivation are grown over with deciduous trees, pines, and a rather dense underbrush.

PAST GEOLOGIC WORK

This portion of the United States was one of the first mineral regions of the country to become of economic importance. It has, therefore, attracted much attention from the leading geologists of the country, particularly before the Civil War. It is interesting to note that the North Carolina Geological Survey, established in 1824 under the leadership of Denison Olmsted, was the first state survey on this continent. The South Carolina Geological Survey followed next, in 1826, with Vanuxem at its head. Tuomey, Lieber, Ebenezer Emmonds, Kerr, Hanna, and Nitze, working on these surveys, have all made contributions to the Geology of the Carolinas that have become well known.

PLATE II


TOPOGRAPHIC MAP OF CAPPS MINE
SHOWING LOCATION
OF
SHAFTS, VEIN OUTCROPS,
AND DIAMOND DRILL
HOLES
CONTOUR INTERVAL - 10 FEET
SCALE
0 100 200
N
VEIN FLOAT
DRILL HOLES
SHAFTS
CAPPS VEIN
JANE VEIN
NO. 1 SHAFT
NO. 2 SHAFT
NO. 3 SHAFT
BISSELL SHAFT
NO. 5 SLOPE
ISABELLA SHAFT
MAUNY SHAFT
GOOCH SHAFT
BALDWIN SHAFT
OLD BOB SHAFT
KING SHAFT
HOUSE
MILL
DDH 13
DDH 14
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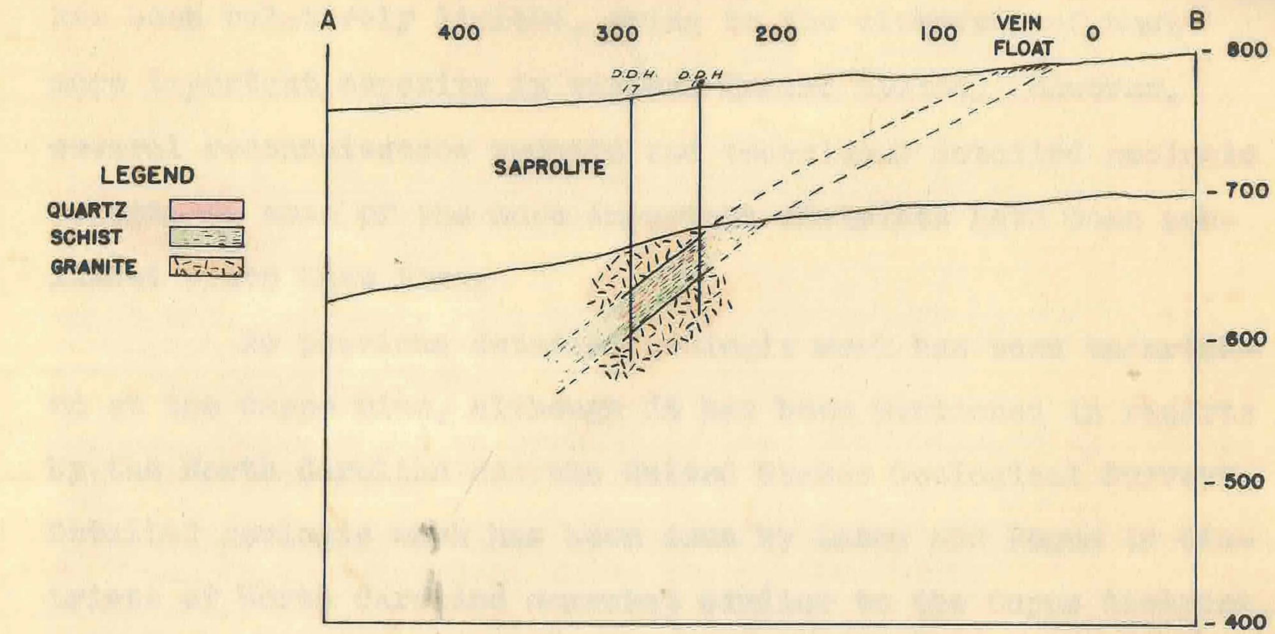
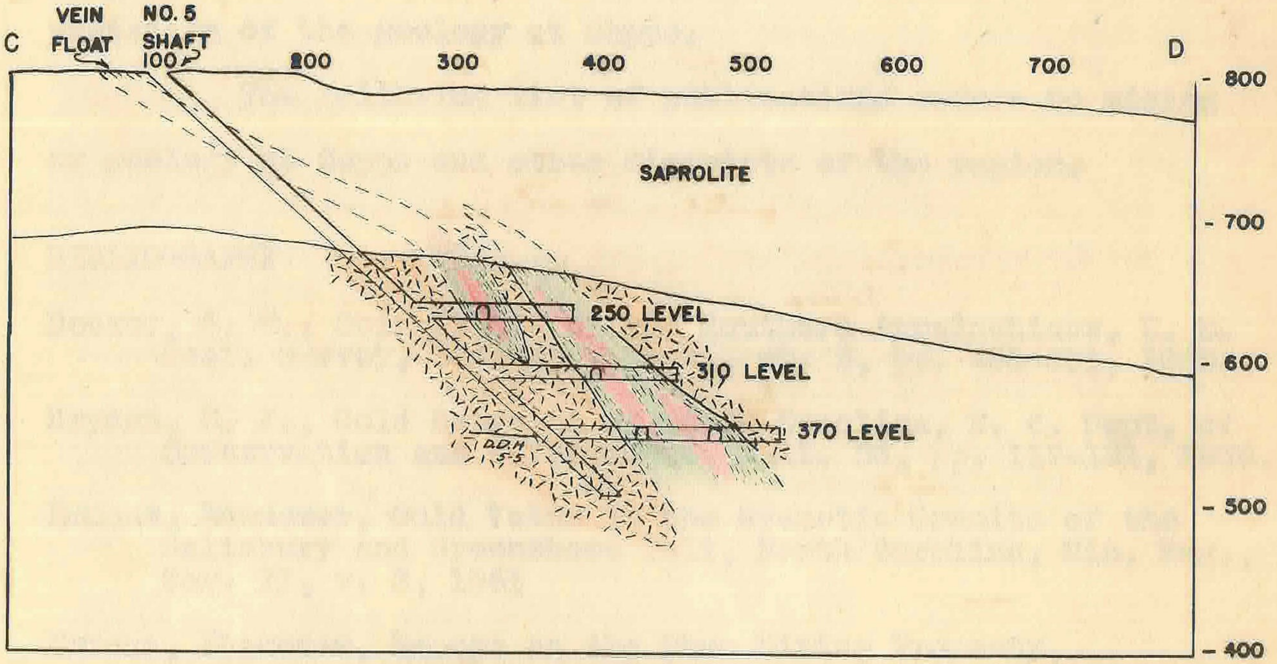


GEOLOGIC CROSS-SECTION A-B



GEOLOGIC CROSS-SECTION C-D

SCALE

0 100 200

Later geologic work, especially on the gold deposits, has been relatively limited, owing to the discovery of much more important deposits in western United States. However, several reconnaissance reports and occasional detailed geologic reports on some of the more important districts have been published since that time.

No previous detailed geologic work has been undertaken at the Capps mine, although it has been mentioned in reports by the North Carolina and the United States Geological Surveys. Detailed geologic work has been done by Laney and Pogue in districts of North Carolina somewhat similar to the Capps district, and reference to the resulting reports has aided in the interpretation of the geology at Capps.

The following list of publications refers to mining or geology at Capps and other districts of the region.

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SCOPE OF PRESENT WORK

The field work upon which this report is based was begun July 10, 1938, and completed August 15, 1938. Maps were made to show the relations of veins to topography and to show the structural relations between the ore bodies and the country rock. Unfortunately, the field evidence upon which this report is based is necessarily limited, because the underground excavations examined are of limited extent and no bedrock outcrops within the area mapped. Various other districts of North and South Carolina were visited with the view of obtaining a broader geologic background for the detailed work at the Capps mine.

While the investigation was being performed, the following features were studied: (1) the petrography of the various rocks, (2) the succession of geologic events, and (3) the character and the occurrence of ore bodies. Throughout the present work careful attention was given to all details which might lead to the discovery of new ore bodies.

ACKNOWLEDGMENTS

The field work and the compilation of this report were completed while the author was attending the California Institute of Technology in the Balch Graduate School of the Geological Sciences. The choice of the Capps district as a subject for the thesis was made possible by the financial aid of the Capps Gold Mine, Ltd., Charlotte, N. C. The preparation of the report was carried out under the direction of Dr. Horace J. Fraser to whom the writer wishes to express sincere thanks for assistance with the laboratory work and criticism of the manuscript. Invaluable aid was given in the field by Josephy P. Jennings, Jr., geologist of the Capps company.

GENERAL GEOLOGY

GENERAL GEOLOGIC SETTING

Rocks of the Gold-bearing Areas[1]

The major rocks of the region are either igneous or metamorphic. The igneous may be divided into two subdivisions, acid and basic. The acid rocks consist mostly of granite, varying in color from light gray to pink, but there are also some rhyolites, acid tuff, and breccia. The basic group includes gabbro, diabase, diorite, andesite, basic tuff, and breccia. The metamorphics may be divided into gneisses, schists, and slates derived from both igneous and sedimentary rocks. Altered sedimentary rocks include quartzites, marbles, and slates.

The area may be roughly divided into belts according to rock types, the belts paralleling the regional structure, trending northeast-southwest. In North Carolina these belts may be outlined as follows:

1. The Slate Belt.
2. The Igneous Belt.
3. The Schist-Gneiss-Granite Belt.

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[1]Pardee, J. T., Preliminary Report on Gold Deposits in North and South Carolina, P. W. 29021, pp. 6-8, 1935.

Bryson, H. J., Gold Deposits in North Carolina, N. C. Dept. of Conser. and Develop., Bull. 38, pp. 42-51, 1936.

The Slate Belt

This belt, occupying a strip 30 miles wide along the eastern edge of the Peidmont plateau is composed largely of light, greenish-gray, thin bedded, water-laid tuff. To the north these beds give place to a variety of greenish and grayish rocks representing altered volcanic tuffs and flows. Altered basic intrusives are associated with them. The bedded rocks have been closely folded and strike northeast. They generally have a cleavage striking the same way. Near the granite this cleavage becomes so pronounced that it completely obscures the bedding.

The Igneous Belt

The igneous belt is about 40 miles wide, lying parallel to and just west of the slate belt. As the name implies, the rocks are mostly igneous, ranging in composition from granite to gabbro. A coarse-grained, gray granite, locally rich in biotite and hornblende is widespread in Mecklenburg County, the location of the Capps area. A dark-gray diorite is next to this granite in abundance. It is the rock which underlies many of the areas of dark soil known as blackjack lands. A coarse-grained greenish gabbro occupies relatively small areas. Toward the west, in the vicinity of Bessemer City, the granite is intensely metamorphosed to a sericite schist. Associated with this schist in many places is a resistant quartzite which forms such peaks as Kings and

Crowder Mountains. The mine described in this report lies wholly within the granite portion of this belt.

The Schist-Gneiss-Igneous Belt

This belt includes the western part of the Piedmont plateau just east of the foothills of the Blue Ridge, and is composed mostly of foliated rocks that may be described as mica schists and gneisses. In some places, however, there are large bodies of coarse-grained igneous rock.

Diabase Dikes

The entire Peidmont plateau is intruded by diabase dikes which trend in a northwesterly direction and cross-cut all the older rocks. These dikes range in width from less than a foot up to several hundred feet and from a few rods up to many miles in length. They are everywhere younger than the other rocks and the included ore bodies.

Saprolite

Becker[1], some forty years ago, named the thick layer of decomposed rock which mantles most of this province saprolite. This material, which at places is over a hundred feet thick, is claylike and generally retains the structure of the rock from which it was formed, but differs from it in composition and color, although some places the more resistant minerals are preserved. It grades upward into the soil and

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[1] Becker, G. F., Gold Fields of the Southern Appalachians, U. S. Geol. Survey, 16th Ann. Rept., pt. 3, pp. 253, 1895.

downward into the bedrock. Although the structure remains undistorted in level places, creep on hillsides causes movement; so that the structure is often either considerable altered or completely destroyed. Near lodes the saprolite usually retains most of the gold that was released by weathering, and in addition it has generally been enriched by gold descending from higher layers which in the course of time have been completely weathered away.

Nature and Structure of Ore Deposits

The known occurence of gold ores in this region may be classified as follows:

1. Veins.
2. Lodes or mineralized zones.
3. Placers.
4. Saprolite.

Veins

Gold ores occuring in veins are found well distributed throughout the area. The fissures in which the veins occur are apparently fault zones, both normal and reverse. These faults were caused by stresses from the northwest and southeast. The vein material is usually quartz with such minerals as pyrite, chalcopyrite, gelena, sphalerite, argentite, and gold. The principal gangue minerals are quartz, siderite, and rhodochrosite. The secondary ore minerals are cerrusite, chalcocite, malachite, tenorite, and anglesite. The principle secondary gangue minerals are limonite, hematite. Chlorite, actinolite, calcite, and sericite are present as alteration products.

Lodes or Mineralized Zones

This type of deposit has produced as much ore more gold than the vein type of deposit. Lodes or mineralized zones may be divided into two types, (1) those with quartz stringers and (2) those with little or no quartz. Deposits of this type are usually wide, sometimes a hundred feet or more, and are of considerable length. Frequently, however, the entire zone is not sufficiently mineralized to warrant mining, so richer streakes are mined out. These deposits are formed in shear zones of faults like the vein deposits. If quartz is present, the gold is usually associated with the quartz stringers, but in cases where there is little quartz, the gold occurs as thin leaves between the laminations of the schist or slate.

Placer and Saprolite Deposits

Placers have produced almost one-half of the gold produced in the region. They were discovered long before the first vein in areas coextensive with the gold bearing lodes. They may be either concentrates formed by streams from the mantle of weathered rock or simply unconcentrated mantle that happens to be rich enough to work. The latter have often been residually enriched through removal of part of the rock by differential weathering. The two types commonly grade together, so that between the lodes and residual deposits there is a zone which, according to the method employed in mining it, may be classified as either lode or placer.

GEOLOGIC SETTING OF CAPPS

The Capps area lies wholly within the granite of the Igneous Belt. The granite, with numerous greenstone inclusions and associated aplite dikes, is cut by two reverse faults whose shear zones have been hydrothermally altered and mineralized.

Triassic diabase dikes, intruded after the mineralization of the ore bodies, comprise the youngest rock type.

A heavy cover of saprolite, reaching to depths of 135 feet, testifies to the tremendous time the area has been subjected to weathering.

PETROGRAPHY

The rocks described under this heading include all the varieties observed in the underground workings and diamond drill cores. Other rock types, however, may exist within the area mapped, a considerable portion of which has been neither diamond drilled nor penetrated by mining operations. No outcrops other than vein float were observed, but red soil in the north-east portion of the area suggest more basic rocks there.

Rock specimens were collected from all the accessible underground workings and available diamond drill cores. The specimens were selected to illustrate the variety of rock types and the degree of wall-rock alteration. Twenty-five thin sections were made from specimens selected because they best illustrate the significant features of the petrography.

The various rock types will be discussed in the order of their genesis.

Greenstone

Greenstone, included as xenoliths in the granite, is the oldest rock. It is an altered basic effusive or hypabyssal rock, the green color resulting from the abundant chlorite and epidote produced by alteration. Three varieties, classified into the same age group, were recognized, all having similar composition and mode of origin, but different textural relationships. The three varieties are differentiated into two porphyries (one having plagioclase phenocrysts and the other having pyroxene phenocrysts) and a fine-grained variety. The fine-grained variety is found in widespread abundance, but the porphyries were found only in one place, a diamond drill core west of the 370 foot level of the number five shaft (Specimens 108 and 135).

Megascopic description. These rocks are a greenish gray color, weathering to a rusty brown. The one pophyritic variety has highly epidotized plagioclase phenocrysts varying in size up to laths five millimeters in length and two millimeters in width. The other porphyry has pyroxene phenocrysts which are much smaller, the largest dimension rarely exceeding two millimeters. In all cases the groundmass is so fine-textured that the minerals cannot be distinguished. All phases of this rock are prominently jointed, the fractures often being filled with quartz and epidote.

Microscopic description. Five thin-sections were made of these rocks, one each of the two porphyritic varieties and three of the fine-grained variety. The fine texture of the groundmass plus the intense alteration obscure the primary minerals and texture, making a classification of the rock difficult (Figure 1).

The texture of the groundmass is holocrystalline, fine-grained, and reticulate. The porphyritic varieties have a hypidiomorphic fabric and a seriate granularity.

The primary constituents in order of crystallization are apatite, magnetite, sphene, labradorite, diopside, common hornblende, and biotite. The secondary minerals are pyrite, epidote, chlorite, zoisite, uralite, carbonate, albite, and quartz.

Saussuritization, chloritization, and uralitization are the predominant alteration processes in evidence. Labradorite is usually altered to albite, epidote, and calcite; pyroxene to uralite; uralite and hornblende to chlorite. Quartz was found only in specimens near the vein and probably was introduced by vein solutions.

Porphyritic varieties have almost the same compo-

Figure 1. Porphyritic greenstone, containing phenocrysts of hypersthene (hy) and showing reticulate texture in the groundmass. 112 X.

Figure 2. Monzo-granite, containing zoned plagioclase (pl), orthoclase (or), quartz (q), hornblende (hb), and biotite (bi). Note hypidiomorphic fabric. 30 X.

sition as fine-grained varieties. The plagioclase phenocrysts are so completely altered that no clue other than composition of alteration products can be used to identify them. The predominance of epidote and calcite over albite produced by saussuritization indicates a fairly calcic plagioclase, probably labradorite (Specimen and section 135). Both hornblende and pyroxene phenocrysts were found in the other porphyritic variety. Hornblende is in cases only slightly chloritized, but the pyroxene is nearly always uralitized and chloritized (Specimen 108, Figure 1).

Classification. The majority of the megascopic and microscopic characteristics indicate that this rock was a basalt, although the presence of brown biotite and the doubt as to the composition of the plagioclase prohibits definite classification. The term greenstone is used because similar rocks have been given this name in adjacent areas[1].

Granite

Granite is the most abundant rock type. It is batholithic in extent, being the predominant rock of the igneous belt.

Megascopic description. This rock is fairly light-colored, medium to fine-grained, and of typical granitic texture. It has no apparent primary structure, but is jointed

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1 Laney, North Carolina Geol. Survey, Bull. 21, p. 42, 1910.

everywhere and is considerably altered in the vicinity of the vein.

Microscopic description. Six thin-sections, selected to show variety in alteration, composition, and texture, were made from typical specimens of this rock. Quantitative determinations were made by the Rosival method with an integrating stage. The following is the average percentage composition obtained from three thin-sections (Specimens 2 shaft, 124, and 194):

Mineral	Percentage
Quartz	23
Orthoclase . . .	34
Plagioclase . .	17
Biotite . . .	14
Hornblende . . .	8
Accessories . .	4
	100

The primary constituents in order of crystallization are apatite, magnetite, zircon, sphene, hornblende, biotite, andesine, oligoclase, albite, orthoclase, and quartz. Secondary minerals are sericite, chlorite, uralite, epidote, carbonate, and kaolin. The fabric of the rock is hypidiomorphic, the hornblende, plagioclase, biotite, and accessories being idiomorphic (Figure 2).

Apatite has crystallized in its usual needle-like form. Magnetite is found in small grains usually associated with the hornblende and biotite. In some cases the grains have chlorite about their borders. Small grains of zircon are partly redissolved. Sphene is not abundant, but is found associated with hornblende or biotite in most specimens. Hornblende has good crystal outlines, many of the cross-sections showing perfect crystal form. It is strongly pleochroic and often is intergrown with or includes the biotite. Though these intergrowths sometimes show irregular boundaries, the minerals are always distinctly separated, each showing its own optical properties up to the very edge. Biotite, possessing strong pleochroism from dark brown to yellowish brown, is more abundant than the hornblende and has irregular crystal outlines. Plagioclase, frequently zoned from andesine to albite, is so abundant in some specimens that they must be classified as quartz monzonites (Specimen 194, Figure 3). Unzoned crystals are albite. Orthoclase is irregularly formed about the early minerals. Sometimes one orthoclase crystal completely surrounds a plagioclase crystal, so that upon casual observation, it appears to be merely an additional zone of plagioclase. Quartz, clearly the latest mineral to form, is abundant in all specimens, and may be easily distinguished from the altered orthoclase by its wavy extinction and lack of alteration.

Alteration, though found in every specimen, is much more intense near the vein (Figure 4). Plagioclase is altered to epidote, calcite, and sericite; orthoclase to sericite and kaolin; biotite to magnetite, uralite, and chlorite; and hornblende to chlorite and magnetite. The calcic centers of the

Figure 3. Adamellite containing zoned plagioclase (pl), orthoclase (or), quartz (q), hornblende (hb), and biotite (bi). 30 X.

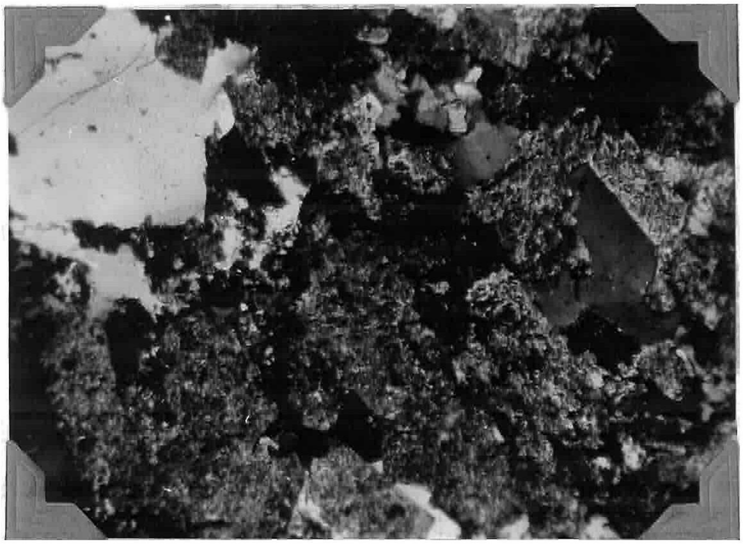

Figure 4. Hydrothermal alteration of granite near the Jane vein. Epidote, sericite, and chlorite are important alteration products. 30 X.

plagioclase show the most intense alteration, some specimens near the vein being so completely altered that the twinning is obscured.

Classification. The average mineral percentages place the rock in the granite class near the granite-quartz monzonite boundary line. One specimen had sufficient plagioclase to be classified as a quartz monzonite (Adamellite). According to Johannsen's classification, the predominant rock is a monzo-granite.

Aplite

A small aplite dike, striking parallel to the vein and dipping 80 degrees east, intrudes the granite in the wall of the number 5 shaft at the 310 level of the Jane vein. Its walls, though fairly straight, are not sharp and grade gradually into the granite. Increased jointing and alteration near the vein indicate pre-vein intrusion. The dike is probably associated with the granite intrusion, its presence being further proof of the proximity to the granite-greenstone contact.

Megascopic description. The aplite is a fine-grained, sugary textured, light-colored rock with a small percentage of biotite as the mafic mineral (Specimen 2 shaft).

Microscopic description. The aplite has xenomorphic-granular texture, the grains frequently being sutured and interlocked (Figure 5).

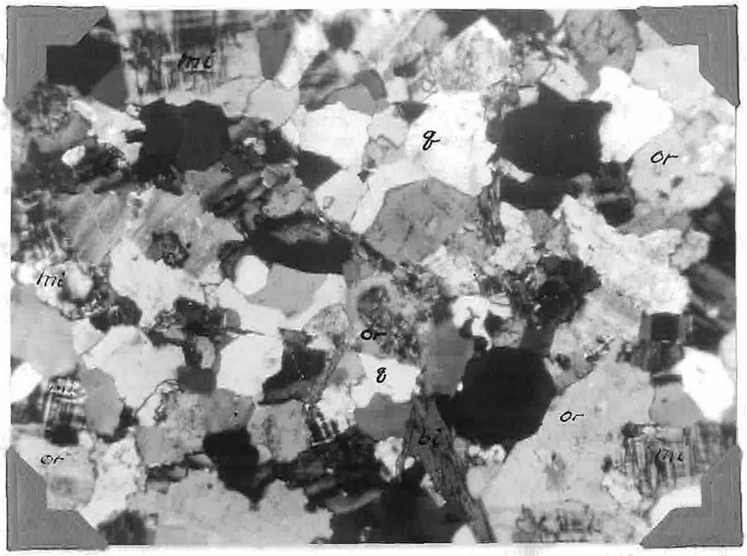

Figure 5. Aplite having xenomorphic-granular texture and composed of orthoclase (or), microcline (mi), and quartz (q) with a small percentage of biotite (bi). 30 X.

Figure 6. Greenstone and granite veined by calcite and showing intense hydrothermal alteration. 30 X.

The essential minerals are quartz, orthoclase, and microcline. Biotite and albite are present in percentages less than 5 percent. Accessories in order of abundance are apatite, magnetite, zircon, and sphene. The alteration products are sericite, kaolin, and carbonate. The composition by mineral percentage is as follows (Specimen 2 shaft):

Mineral	Percentage
Quartz	30
Orthoclase	45
Microcline	15
Albite	4
Biotite	3
Apatite	1
Magnetite	T
Zircon	T
Sphene	T

The probable order of crystallization is sphene, apatite, magnetite, zircon, biotite, albite, orthoclase, microcline, quartz.

Specimen 2 shaft was sectioned across the granite-aplite contact for microscopic examination. The indefinite contact suggests that the aplite was intruded before the granite was completely crystallized, for the minerals of the two rocks are so well intergrown that the difference in mineral composition is the only criterion by which they may be distinguished.

<u>Classification</u>. This rock falls into Family 115 of Johannsen and may be classified as an alaskite-aplite.

Diabase

A diabase dike, striking N 21° E, and dipping 83° W, may be observed intruding the granite in the wall of the number five shaft of the Jane vein at a depth of 250 feet. It is fourteen inches across, having straight, sharp walls. The granite is slightly altered near the contact, but the alteration is not intense and extends but a few inches into the granite.

Megascopic description. The material of the dike is extremely fine-grained and is of greenish-black color. Individual minerals cannot be distinguished by the unaided eye (Specimen 1 shaft).

Microscopic description. The diabase has a typical ophitic texture, feldspar laths having random orientation in augite and other mafic minerals (Thin section 1 shaft).

The primary minerals, in order of crystallization, are iron oxides, labradorite, olivine, augite, and hornblende. Alteration products are epidote, zoisite, chlorite, and calcite.

Iron oxides, associated especially with the pyroxene, show some white borders of leucoxene which indicates a content of titanium. Plagioclase, a calcic labradorite, in small laths, is slightly altered to epidote, calcite, and zoisite. Olivine, in irregular grains, is next in abundance to augite and labradorite. It alters to chlorite and possibly to serpentine, although the serpentine, if present, is in such amounts as to be negligible. Augite, having a pleochroism suggesting a content of titanium, is abundant and show some alteration to green hornblende. Tiny octahedral crystals, often included in the olivine are probably perofskite.

Classification. The mineral composition of this rock definitely classes it as an olivine diabase.

Age. Similar dikes, found over the entire Piedmont province have been dated as Triassic[1].

STRUCTURE

The great thickness of mantle plus the limited extent of mine excavations makes interpretation of the structure of the Capps area difficult. However, igneous structures, faulting and jointing are well developed and can be observed to a limited extent underground.

THE GRANITE BATHOLITH

The granite batholith with its associated intrusions extends from Georgia across portions of South Carolina and North Carolina to Central Virginia, a distance of more than two hundred miles. It attains its maximum width of 40 miles in Rowan County about 30 miles northeast of Capps. At the Capps mine the width is about 35 miles. This, however, includes an inlier of schist nearly 5 miles wide, lying 3

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[1] Laney, F. B., The Gold Hill Mining District, N. C. Geol. Survey, Bull. 21, p. 62, 1910.

to 6 miles from its western edge, and extending for 50 miles parallel to the intrusion. The general trend of the batholith, N 35° E, is parallel to the intruded metamorphics.

The batholith apparently dips outward on both sides, thus widening in depth[1]. Areas of gabbro and diorite present along the margins appear to be differientiated older phases of the parent batholith[2].

XENOLITHS

The orientation of the greenstone inclusions could not be deduced from the scanty exposures. These inclusions are irregular in shape, vary in size from inches to tens of feet, and are at times veined by the granite. The nature of their boundaries indicates that they originated through a combination of stoping and magmatic assimilation of the overlying country rock by the intruding magma. Some have nearly straight matched boundaries separated by dikes of granite, while others have exceedingly irregular ones about which the intrusive rock has a more basic character. These basic

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[1]Laney, F. B., The Gold Hill Mining District, N. C. Geol. Survey, Bull. 21, Plate III, 1910.

[2]Pardee, J. F., Preliminary Report on Gold Deposits of N. C. and S. C., P. W. 29021, pp. 11-12, 1935.

Bryson, H. J., Gold Deposits of North Carolina, N. C. Dept. Conser. and Development, Bull. 38, pp. 103-105, 1936.

borders gradually change to granite an inch or two away from the inclusions, implying magmatic assimilation. Most of the inclusions are xenoliths, because they are detached from the roof of the batholith; some, however, whose upper extremities are concealed, may be roof pendants.

FAULTS

The two vein systems found in the Capps District are in zones of intense shearing. Their surface trace is marked by the resistant vein quartz which remains as float after the other rocks are wasted away. These two structures (Plate 2 and 3), known as the Capps, striking N 33° W and dipping 40° W, on the west side, and the Jane, striking N 10° E and dipping 45° E, on the east, were interpreted as reverse faults, the Jane being the older of the two.

The best evidence for faulting is the character of the shear zone. It is composed of quartz-sericite schist derived from the granite. The orientation of the vein minerals parallel to the fault surface over widths of 45 feet in the Jane fault and widths of 35 feet in the Capps is caused by replacement of the shear fractures by the hydrothermal alteration. The shear zone maintains a fairly constant width; the size or position of the included fissure veins is variable and independent of the width of the shear. In the Jane zone, at shaft 5 (Plates 2 and 3), the vein may be near the foot or hanging wall of the shear zone, a fact proving that the limit of shear is not dependent upon the proximity to the vein. It seems evident, therefore, that the structure predated and controlled the position of the vein, and that the vein may have modified but did not cause the schistosity.

The unusually straight outcrops of the vein systems likewise suggests that they follow fault zones. The Capps system is almost straight along three thousand feet of outcrop, and the Jane system can be traced in a fairly straight line for over two thousand feet.

The orientation of gash and shear fractures in the hanging wall of the Jane vein on the 370 foot level of the number 5 shaft presents good evidence that faulting was reverse and dip-slip. The gash fractures are almost horizontal and are filled with vein material. They extend over a foot into the hanging wall and are an inch wide near the vein. The shear fractures strike parallel to the main shear zone and dip 80° E, the same direction as the vein. The shear fractures do not cut the vein-filling of the gash fractures, but they can be traced between gash fractures. The attitude of these fractures in the hanging wall presents a text-book illustration for reverse dip-slip faulting.

The central block between the two faults has more and larger greenstone xenoliths than either of the adjacent blocks. This could be explained if the two faults were reverse in character, because the central block would be relatively lower, therefore nearer the batholith roof.

The absence of slickensides, gouge, and breccia may be attributed to the subsequent alteration and to the great depth at which the faulting took place. There was evidently a tendency for recrystallization instead of fracturing.

The dating of the Jane fault as pre the Capps faulting is admittedly open to question. This time relation is based upon evidence observed on the surface and upon records of old mine excavations. The Jane and Capps systems join in the vicinity of the Gooch shaft (Plate 2). They separate to the north, but continue as one outcrop along the strike of the Capps system 950 feet to the south. Here they again split up, one system continuing the strike of the Capps fault, and the other roughly paralleling the strike of the Jane fault farther north. The ridge at this point splits into two ridges conforming to the strike of the two veins (the silicified shear zones are more resistant than the granite; hence they tend to form ridges). Records of the Old Bob shaft, which is on the vein system between the two bifurcations, state that the vein dips to the west , the direction of dip of the Capps vein farther north. It is assumed that the Jane is the older of the two faults; hence the 950 foot horizontal dis-

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[1] Files of Capps Gold Mine, Ltd., Charlotte Office.

placement on the Jane fault could be explained by thrust faulting on the Capps fault. Gash and shear fractures suggest that the Capps fault is a dip-slip fault. On this assumption, the vertical displacement on the Capps fault is approximately 900 feet. That this approximates the horizontal displacement on the surface is but a coincidence resulting from the fact that the angle between the strikes of the two faults is nearly the same as the angle of dip of the Capps vein. The displacement on the Jane fault is probably greater, for the shear zone is considerably wider.

Admittedly, the evidence for this interpretation is meager, but no other hypothesis seems to fit the facts.

Little definite information can be cited regarding the geological age of faulting. Both faults intersect the granite, hence they are post-intrusion. The Jane fault predates the Capps fault, if the preceeding interpretation of the structure is accepted. The faulting is pre-mineralization, for nowhere does the vein show any disturbance resulting from post-mineralization faulting.

JOINTS

Jointing has been observed in nearly all rocks of the Piedmont Plateau. These joints are distributed throughout the whole 360 degrees of a circle, but from a total of

141 measurements scattered throughout the province, Dr. Watson[1] found they could be grouped roughly into four main directions. He found the total number of joints striking N 10-80° E to be 61; the total number striking N 10-70° W, 52; the total number striking N-S, 18; and the total number striking E-W, 10. In his observations, Dr. Watson makes no mention of the dips of the joint surfaces.

Jointing was best observed in the Capps area in a crosscut east of the Jane vein on the 370 foot level of the number 5 shaft. Here four main systems were observed. The most prominent has a strike N 10° E and dips 45° E, hence is parallel to the Jane fault. Another well developed system has a strike of N 30-40° E and dips 65° southeast. A third system has a strike of N 20-30° W and dips about 70° northeast. The least developed of the major systems has a strike almost E-W and dips 45° S. Other minor systems were noted, but these four systems prevailed. These fall within the rather wide limits set by Dr. Watson, although a greater number of N-S strikes were recorded at Capps.

DIKES

The relation of the aplite dike and the diabase dike to the other rocks was discussed fully under petrography

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[1]Watson, T. L., Laney, F. B., and Merrill, G. P., Building and Oramental Stones of North Carolina, N. C. Survey Bull. 2, pp. 184-185, 1906.

and needs no further mention here.

SLUMPING

An examination of the geologic cross-section (Plate 3) shows that the surface outcrops of the veins do not coincide with positions which sould be occupied by the veins if their underground dips were projected to the surface. In both cases the position of the outcrops indicates that the veins decrease in dip in the weathered zone. If this change of attitude were recorded in solidrock, a curve in the vein system would be suspected. However, the upper portion of the veins extend into a zone composed of intensely weathered rock, most of which is so completely decomposed that considerable portions of it have been removed by solution. The resultant decrease in volume caused slumping which produced the present positions of the veins in the weathered zone.

Weathering also enriched upper portions of the ore bodies, for the removal of portions of the wall rock and gangue resulted in concentration of the ore, and oxidation of the pyrite permits the use of simpler methods for extracting the gold.

GEOLOGIC HISTORY

The oldest rocks encountered in the Capps area are greenstones. Since they are metamorphosed basic intrusives, it seems reasonable to correlate them with similar rocks observed by Laney[1] in the Gold Hill Mining District, some forty miles northeast of the Capps District. Laney correlated the greenstones with slates (metamorphosed tuffs) found in the eastern part of the Gold Hill District and dated by Nitze and Hanna[2], and later by Keith[3], as pre-Cambrian, probably Algonkian. The outpouring of these lava flows was probably followed by a period of tectonic activity producing the metamorphism now observed in the greenstones. Following this period of deformation, the granite with its associated aplite dikes was intruded. Later the Jane fault, followed by the Capps, displaced all the older rocks. The fault zones were mineralized to form bodies of ore. The last structural and igneous activity was the intrusion of the diabase dikes in Triassic time[4].

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[1]Laney, F. B., The Gold Hill Mining District, N. C. Survey, Bull. 21, p. 73, 1901.

[2]Nitze, H. B., and Hanna, H. B., N. C. Geol. Survey, Bull. 3, p. 37, 1896.

[3]Nitze and Hanna, idem., p. 37.

[4]Laney, F. B., The Gold Hill Mining District, N. C. Geol. Survey, Bull. 21, p. 62, 1910.

The following events comprise a summary of the geologic history of the district:

1. Extrusion of the lava flows.
2. Deep burial of lava flows by other flows and sediments.
3. Folding and metamorphism.
4. Intrusion of granite.
5. Intrusion of aplite dikes.
6. Displacement on Jane fault.
7. Displacement on Capps fault.
8. Deposition of ore deposits.
9. Intrusion of diabase dikes.
10. Continuous erosion to present time.

ECONOMIC GEOLOGY

EARLY MINING OPERATIONS

Early mining operations in the Capps area were confined entirely to the weathered zone in which the pyrite was oxidized to limonite, because the primitive mills could not extract the gold from the sulphides. Numerous shallow shafts were sunk to permit access to the veins. Records show that there were five rich bodies of ore[1]. Four of these were mined from the Capps vein and one from the Jane vein. The first of these was immediately to the south of the Gooch shaft (Plate II) near the intersection of the Capps and Jane veins, and was located between the 78 and 128 foot levels. The second rich deposit was found above the 78 foot level from the Mauny shaft (Plate II). A third and very large ore body was mined from the Bissell shaft (Plate II) to a depth of 90 feet. The entire length of this level is 300 feet, of which 200 feet are to the north and 100 feet to the south of the shaft. The ore is not oxidized below the 90 foot level, and was not mined although the gold values continue to a greater depth. A fourth ore body was found in the Capps vein south of the number 1 shaft (Plate II). The stopings to the south of this shaft are very extensive, and some sulphide ore supposedly

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[1] Bryson, H. J., Gold Deposits of North Carolina, N. C. Dept. of Conserv. and Development, Bull. 38, pp. 117-122, 1936.

still remains at the bottom of the old excavations. The Jane vein was also mined from several shafts. The only record obtainable, however, is that of the Isabella shaft (Plate II). The ore body was mined to a depth of 150 feet, the lower part being refractory ore, and produced fairly high gold values. Other shafts shown on the map, the King shaft, the Old Bob shaft, the Baldwin shaft, and the Number 2 shaft, probably represent other ore-bodies; however, no other information could be discovered concerning them.

PRESENT MINING OPERATIONS

The Capps Gold Mine, Ltd., Toronto, Canada, started exploration at Capps in 1934. A limited diamond drilling program (Plate II) disclosed the presence of two ore bodies, one on the Capps vein underneath the old excavations of the Bissell shaft, and the other on the Jane vein north of the old excavations of the Isabella shaft. The Number 3 vertical shaft was sunk on the Capps ore-body and the Number 5 incline was sunk on the Jane ore-body. A 100-ton cyanide plant was constructed and operations were underway. Unfortunately, the grade of ore was not so high nor the extent of the deposit so large as was anticipated from the diamond drill cores; so the ore could not be mined at a profit. Consequently, the company is now in the hands of the receivers. It is hoped, however, that the mill can be used for custom milling of ore from several small mines in adjacent districts until better and bigger ore-bodies are discovered at Capps.

DESCRIPTION OF THE DEPOSITS

Ore deposits of the Jane vein were the only deposits which could be studied in detail, because the Number 5 shaft was the only shaft in operation while the field work was under way. The Number 3 shaft was also unwatered, but the mine water supply was obtained from this shaft; so only a brief survey was permitted by the mining company. However, a close similarity was recognized between the deposits of the two veins, therefore the description of the deposits of the Jane vein holds true, generally for the Capps vein as well.

The ore deposits are lenticular quartz-dolomite-pyrite masses replacing and filling portions of the schist of the shear zone. The largest vein in the excavations of the Number 5 shaft was 150 feet deep, 200 feet long, and 10 feet wide, all dimensions taken at the largest part. This deposit bottoms at the 370 foot level north of the Number 5 shaft. Several smaller deposits were found south of the shaft, having the same general shape. The veins consist principally of quartz with minor amounts of dolomite and disseminated pyrite in lenses parallel to the trend of the vein. The veins are generally parallel to the shear zone, and may be near either the foot or hanging wall. The vein walls are not sharp and grade into schist on both sides. Oriented xenoliths of schist are frequently included in the vein, and small veins penetrate the shear surfaces throughout the width of the shear zone. Usually these small veins are parallel to the schistosity, but sometimes they are transverse, cutting the schistosity at greater or less angles but usually the same strike as the main veins.

The high grade ore is found in the larger veins, although in some places the partially replaced schist contains sufficient gold to be classified as ore.

Replacement was the predominant process in the deposition of the veins, although it is probable that filling played a minor role. The irregular vein walls, xenoliths of schist, and microscopic texture of the pyrite suggest replacement, but some places where veins attain considerable widths with no evidence of replacement except at the margins, it is possible that vein filling operated.

ORIGIN OF THE ORE-BODIES

Shearing

Faulting at fairly great depths produced zones of intense shearing, in which granite and associated rocks were metamorphosed to sericite and chlorite schists. The partings of the shear planes and the laminae of the schist were oriented parallel to the surface of the fault. The fractures of the shear zone permitted penetration by mineralizing solutions which produced ore-bodies.

Hydrothermal Alteration

A series of thin-sections from diamond drill core 5-5 of the 370 foot level of the number five shaft (Plate IV) was studied to determine the cause and effect of the alteration of the shear zone.

Shear fractures of the schist were penetrated by hydrothermal solutions carrying silica, dolomite, and sulphides which replaced parts of the schist. The composition of any portion of the shear zone is directly dependent upon the extent to which this process operated. Some places, where numerous fractures were accessible to the solutions, wide-spread replacement took place and ore bodies were formed. From this condition there is every gradation to schists exhibiting no metasomatism.

Thin-sections of schists near the vein show wide bands of quartz and dolomite separated by narrow bands of sericite and chlorite (Specimens 3 and 5). Farther from the vein silicification and carbonatization is reduced to narrow bands between wider bands of sericite and chlorite (Specimen 25). Shearing of greenstone xenoliths probably produced certain schists found to contain high percentages of chlorite (Specimen 31).

The effects of hydrothermal alteration continue in the granite outside the limits of the shear zone. Feldspar is altered to sericite and calcite, hornblende and biotite are altered to chlorite, magnetite, and epidote. Pyrite, carbonate, and quartz replace parts of the granite, the mafic minerals being more easily replaced. In some cases the cleavage of the biotite is retained by streaks of magnetite, although the rest of the crystal is completely replaced by calcite, sericite, and chlorite. In one specimen calcite was found veining both granite and greenstone (Specimen 60, Figure 6). The granite becomes increasingly fresher until 100 feet from the shear zone the alteration becomes so slight that it can be ascribed to normal deuteric alteration (Specimen 194, Figure 3).

Mineralization

The same silicate and carbonate mineralization that produced the hypothermal alteration described in the previous section gave rise to the gold deposits at Capps. Gold is found to a limited extent throughout the shear zone, but ore deposits are restricted to the larger quartz-dolomite-pyrite lenses.

The mineralization consists chiefly of quartz, dolomite, pyrite, calcite, and chalcopyrite in order of abundance. In addition, gold, bornite, and galena are found in lesser quantities. Sericite, chlorite, epidote, and limonite are present, but probably result from incomplete replacement of the schists rather than vein mineralization.

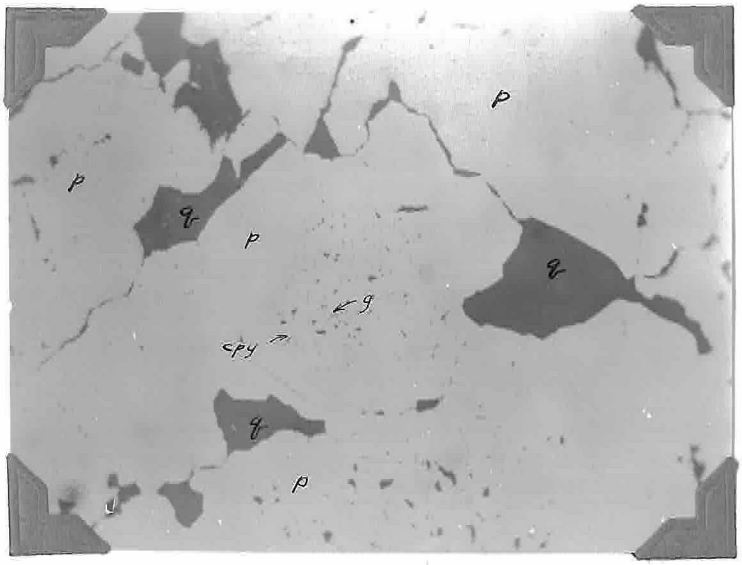

Figure 7. Pyrite (p) containing blebs of gold (g) and chalcopyrite (cpy) in the centers of grains. The inclusions in the grain centers probably represent unreplaced schist. 110 X.

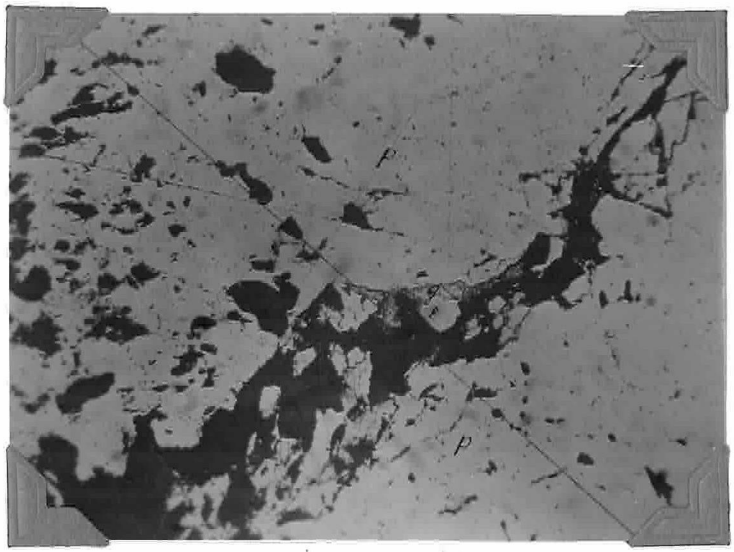

Figure 8. Pyrite (p) veined by gold (g) and quartz (q). The paragenesis is pyrite, gold, and quartz. 110 X.

The sequence of deposition is pyrite, gold, bornite, chalcopyrite, galena, quartz, dolomite, quartz, and calcite.

Pyrite, by far the most abundant sulphide, is in most places the earliest mineral, although inclusions are found in the centers of some pyrite grains which may be either early quartz or unreplaced schist (Polished-section 3-7, Figure 7). These inclusions are found in nearly all specimens to a greater or lesser extent, the texture most often resembling that of unreplaced schist (Polished-section 3-7). Occasionally, fine blebs of gold and chalcopyrite are associated with these inclusions, suggesting early gold and chalcopyrite. The outer portions of the pyrite have no inclusions, but some places a difference in relief and grain size suggests two ages of pyrite having different composition. The later generation is finer grained and contains most of the gold. Relationship of the pyrite to the quartz and schist indicates that the pyrite was the earliest vein mineral.

Gold is found in two generations, both intimately associated with pyrite. The early gold, extremely fine in grain size, appears to have unmixed in small blebs while the pyrite crystallized (Specimen 3-7, Figure 7). However, the majority of the gold, found in cracks and veins in the pyrite, is clearly later (Polished-specimens 2-3c, 3-2, 3-2-1, and 3-7; Figures 8, 9, 10, and 11). Gold was found in quartz in only one specimen (Specimen 1).

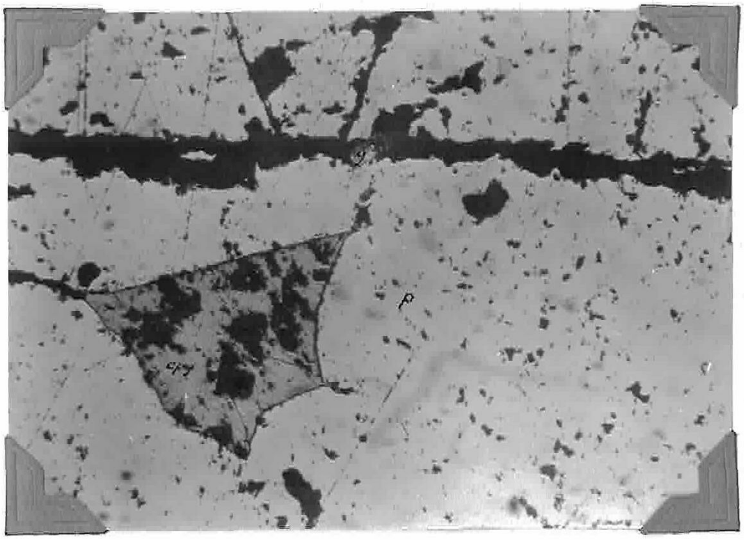

Figure 9. Pyrite (p) containing gold (g) in a crack and being replaced by chalcopyrite (cpy). 110 X.

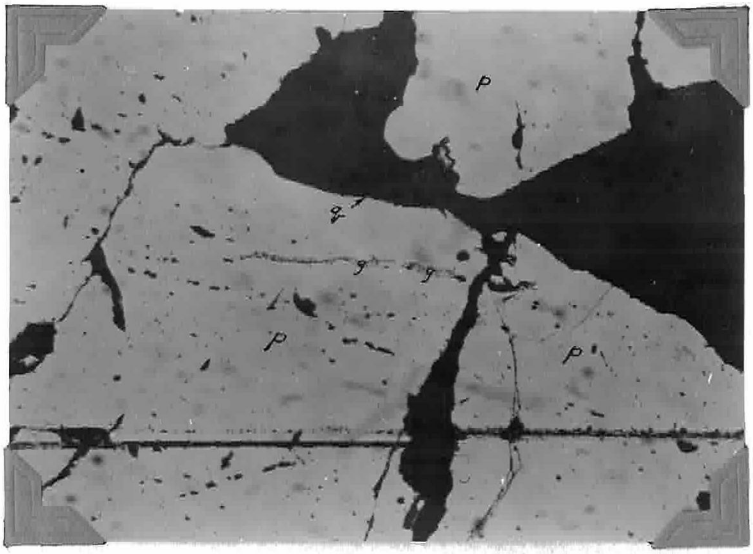

Figure 10. Pyrite (p) veined by gold (g) and quartz (q). The paragenesis is pyrite, gold, and quartz. 110 X.

Figure 11. Gold (g), chalcopyrite (cpy), and quartz (q) replacing pyrite (p). The paragenesis is pyrite, gold, chalcopyrite, and quartz. 110 X.

Figure 12. Chalcopyrite (cpy) replacing pyrite (p), and being replaced by quartz (q). 110 X.

Bornite, though extremely rare, is intimately associated with the chalcopyrite (Polished-specimen 3xa). The two may be contemporaneous.

Chalcopyrite, the sulphide next to pyrite in abundance, is found in small blebs or stringers in nearly every specimen. It is intimately related to the pyrite, though, in some cases, it is found in the quartz (Specimen 3-2-1, Figure 12). Chalcopyrite frequently follows the same veins and cracks occupied by gold (Polished-sections 3-2-1, 3-7, 2-3c, and 2b; Figures 8, 10, 11, 12).

One polished section shows galena replacing pyrite and chalcopyrite (Polished-specimen 3-6).

Two generations of quartz, the early being far more abundant, are separated by a generation of dolomite, and followed by calcite. The early quartz, a coarse-grained milky form, and dolomite, as well as pyrite exhibit a shear pattern, along the fractures of which fine-grained quartz and calcite are deposited (Thin-section 3-9a, Figure 13). The late quartz, a glassy and transparent form is found replacing dolomite, early quartz, and pyrite (Polished-specimen 3-6). The quartz, even the first generation, is later than the pyrite. It surrounds fairly well-formed pyrite crystals, slightly encroaching and sometimes veining them. Veins of quartz in pyrite always show a replacement texture (Hand-specimen and polished-section 3-6). Dolomite, in veins and rhombs, replace all the

Figure 13. Two generations of quartz (e.q. and l.q.) separated by a generation of dolomite (do) and followed by calcite (ca). The early quartz exhibits a shear pattern. 30 X.

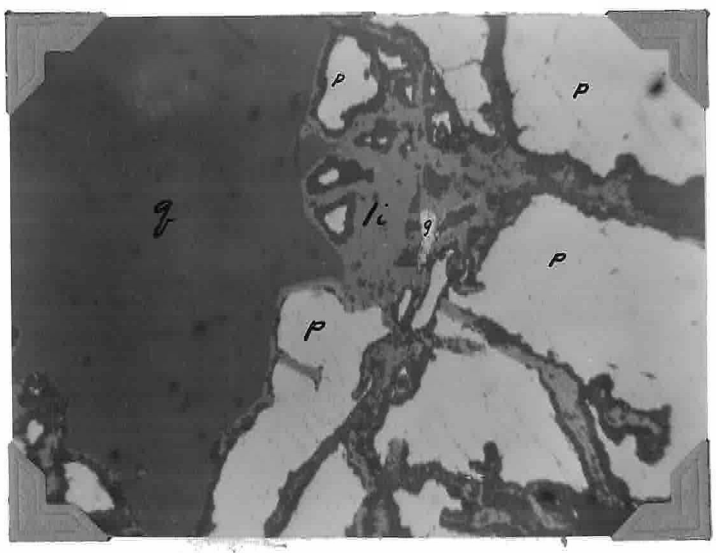

Figure 14. Oxidation of pyrite (p) to limonite (li). Relations of gold (g) to limonite are the same as the gold-pyrite relations in the unaltered zone. 110 X.

earlier minerals; it in turn, is replaced by veins of calcite and fine-grained quartz.

Summary of Mineral Paragenesis

Pyrite, containing small amounts of gold and chalcopyrite in solution, was the first mineral to penetrate and replace the schist. The chalcopyrite and gold unmixed, forming small blebs in the pyrite grains. Later gold and sulphides closely followed, veining and replacing both pyrite and schist. Quartz and carbonates, replacing schist between the pyrite lenses were the final minerals.

The interrelationship of the vein minerals indicates that the mineralization epoch was completed uninterrupted, except, possibly, by a slight deformation toward the close of the period.

Age of the Mineralization

The age of mineralization of the gold deposits of the Appalachian region has not been definitely established. The wall rocks of the veins are pre-Cambrian except those of the Kings Mountain District which were placed in the Cambrian by Arthur Keith in 1931[1]. Since the rocks of the Kings Mountain District contain gold, at least some of the ores must be post-Cambrian. The Triassic formations to the east, especially the basal conglomerate, contain placer gold; therefore,

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[1]Keith, Arthur, Gaffney-Kings Mountain Folio, 1931.

the deposits must be pre-Triassic. This leads to the conclusion that the age of the gold deposits is Paleozoic.

OXIDATION

Oxidation and hydration, processes which have reached to depths of 135 feet, produced the free-milling ores which constituted the early production of the Capps district. Undoubtedly, concentration caused by solution of soluble minerals accompanied the alteration of the pyrite to limonite. If this is true, it accounts for the high grade of some of the shallower deposits.

Polished sections of oxidized ores (Polished-sections N-3, N-Y, and Figure 14) show that the limonite occurs as pseudomorphs after the pyrite. Relations of the gold to limonite are the same as the gold-pyrite relations in the unaltered zone. No secondary copper minerals were found below the oxidized zone, but it seems likely that the sulphate solutions produced by the oxidation of the pyrite decomposed the chalcopyrite and deposited the resulting minerals beneath the zone of oxidation.

CLASSIFICATION OF THE DEPOSITS

The ore deposits of the Capps district have developed under medium temperature and pressure, hydrothermal conditions. Several characteristics place them in the mesothermal rather than the hypothermal zone into which most of the southern Appalachian gold deposits have been classified:

(1) The gangue minerals are typical of mesothermal deposits.

(2) No gangue minerals typical of hydrothermal deposits are present.

(3) Zoning of wall-rock alteration from silicification through sericitization to propylitization is characteristic of mesothermal deposits.

(4) Rocks under the high pressures necessary for hydrothermal alteration do not exhibit shear fractures such as those of the Capps and Jane shear zones.

FUTURE EXPLORATION

Judging from the experience of the present operators, the immediate future of the Capps district does not present an optimistic picture. Nevertheless, the limited program of diamond drilling has proved that there <u>are</u> gold deposits beneath the old excavations, and it is possible that successful mining could be carried out, if ore-bodies were carefully blocked out in advance of extraction. The main difficulty which led to the present failure was the inability of ore production to keep pace with ore processing. It would have been far better to have conducted an extensive and thorough diamond drilling investigation before constructing the mill and starting the underground development work.

The best possibilities for future dxploration are the extensions of the deposits beneath the old excavations, especially those above which rich ore has been obtained. The largest of these, at the Bissell shaft, was extracted by the present operators and did not prove to be as large as was anticipated. However, this might be expected, because the greater portion of the deposit had already been mined out. It is possible that some of the smaller operations, such as those of the Gooch, Mauny, Number 1, and Isabella shafts, may have extracted only the upper portions of large deposits which continue to greater depths. The area in the vicinity of the Gooch shaft deserves special consideration, for it includes the northern intersection of the Capps and Jane vein systems. The southern portion of the district has smaller veins, but structural evidence[1] indicates another vein intersection which may contain ore deposits.

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[1]Pp. 30-31.