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THE NORTH CAROLINA GEOLOGICAL AND ECONOMIC SURVEY

JOSEPH HYDE PRATT, State Geologist

BULLETIN No. 21

THE GOLD HILL MINING DISTRICT

OF

NORTH CAROLINA

BY

FRANCIS BAKER LANEY, Ph.D.

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LETTER OF TRANSMITTAL

RALEIGH, N. C., Oct. 1, 1909.

To His Excellency HON. W. W. KITCHIN,
Governor of North Carolina.

SIR: I herewith submit for publication as Bulletin 21 of the reports of the North Carolina Geological and Economic Survey a report on The Gold Hill Mining District of North Carolina, prepared by Dr. Francis Baker Laney under the supervision of the State Geologist.

This report covers a Geological investigation of the Gold Hill region embracing an area about one hundred and fifty square miles, as well as a detailed description of the occurrence of the ore deposits, and will therefore be of interest to the Geologist as well as to the practical miner.

Yours respectfully,

JOSEPH HYDE PRATT,
State Geologist.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

PREFACE

In the following report the author has endeavored to describe as fully as possible the Geology, Petrology, and Mineralogy of the Gold Hill Mining District in Rowan, Stanly, and Cabarrus counties.

Since the first discovery of gold in this region in 1799, there has been a great deal published regarding the locality and the occurrence of gold and copper ores, but most of these publications have been more of a general character. Even as early as 1823, a Geological investigation or exploration was made by Denison Olmsted, then State Geologist; and since that time numerous investigators have made brief studies of certain portions of the district, but the first systematic investigation of the district as a whole was begun in 1906 and continued through part of 1908, the result of this investigation being the present report. The work has been done principally by Dr. Francis Baker Laney, who has been assisted in the field work by Dr. Joseph E. Pogue, under the general supervision of the State Geologist. Dr. Laney has made a detailed examination of the district, and practically all the under-ground workings have been carefully examined either by Dr. Laney, Mr. A. A. Steel or the State Geologist.

The greater portion of the laboratory investigations have been made in the laboratories of Yale University, where Dr. Laney had the assistance, guidance and advice of Prof. L. V. Pirsson, and the State Geologist takes pleasure at this time in expressing his appreciation to Prof. Pirsson for his assistance in the preparation of this report.

The traverse map, which is the base for the geological map, is almost wholly the work of Mr. R. L. Harrison, of the United States Geological Survey, who was especially detailed for this work. In the preparation of the geological map, Dr. Laney was assisted by Dr. Pogue, and much of the field work necessary to complete the map represents the work of the latter. The mapping was done on a scale of 1:24000 and then reduced to 1:48000, the scale used for the map accompanying this report.

Chapter I is a short introductory chapter, taking up the location of the district and its history.

The next two chapters give a detailed description and classification of the rocks of the district. The subject-matter of Chapter III is largely of a scientific character, but the work was necessary as it was essential that the rocks be classified and their relations to each other determined, before satisfactory work could be done on the origin and extent of the ore deposits.

Chapters IV and V deal entirely with the structural geology and physiography of the district, subjects that are of importance to the student of geology and also to the practical miner.

The descriptions of the ore deposits are taken up in Chapter VI and it is this Chapter that will appeal most strongly to the miner and layman. It gives descriptions of the different types of ore, their occurrence, the relation of the ore to the gangue minerals and the origin of the ore.

One feature of this report marks the beginning of a new line of work on the North Carolina ores, and that is in working out the direct relation of the sulphides to each other and of the gold to the sulphides. Dr. Laney has been very successful in devising a method and equipment for this work by means of the metallographic microscope. These in-investigations have thrown a great deal of light on the relation of the gold to the pyrite and chalcopyrite in the North Carolina ores.

A number of new theories and ideas are advanced in this report, which the Geological Survey believes are fully warranted from the data obtained from the field work and laboratory investigation.

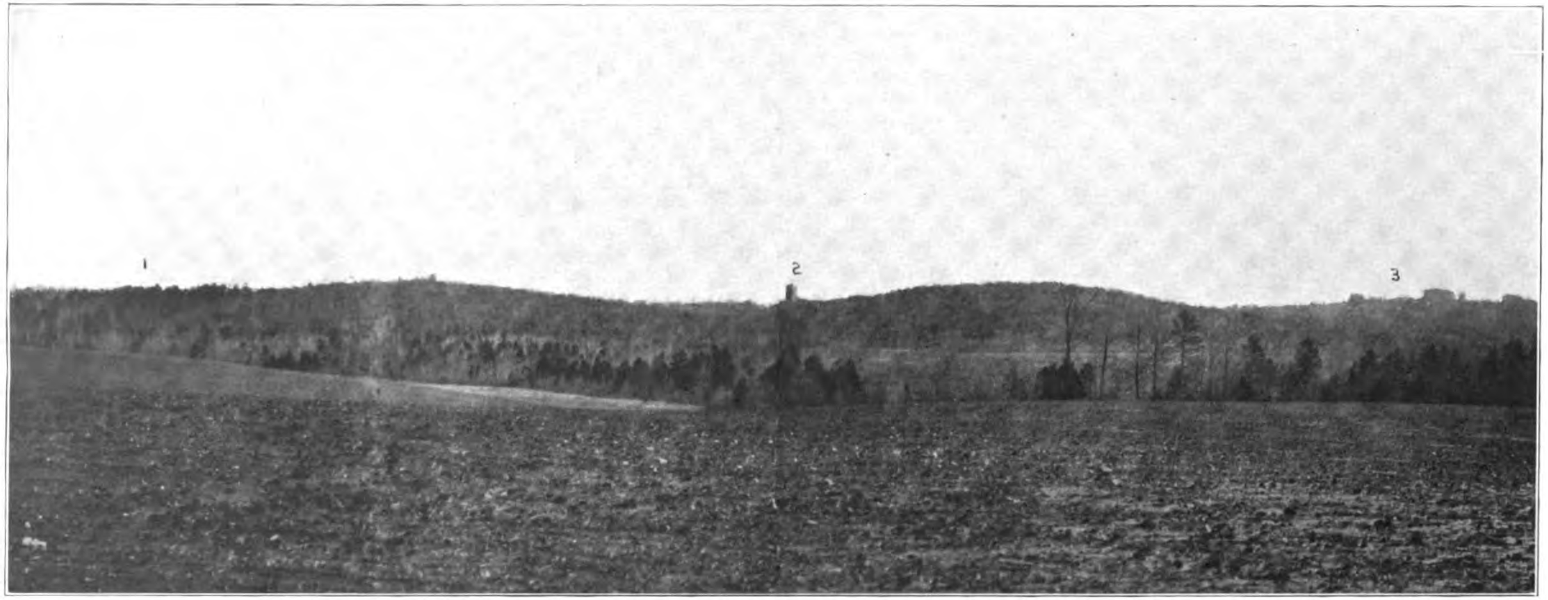
JOSEPH HYDE PRATT,
State Geologist.

AUTHOR'S PREFACE

The writer wishes to thank Dr. Joseph Hyde Pratt for the privilege of studying the area, for careful supervision of the field work, and for many very helpful suggestions during the course of the investigation. He wishes also to express his gratitude to Professor L. V. Pirsson for assistance, guidance and advice throughout all the laboratory work and the preparation of the manuscript. To Professors Joseph Barrell and J. D. Irving he is under many obligations for criticisms and suggestions during the preparation of the report.

He also wishes to acknowledge many kindnesses shown him by different operators in the district, especially to Mr. J. S. Shepherd, of the Gold Hill Copper Company; Mr. H. L. Griswold, of the Union Copper Company; to the management of the Whitney Company; and to the management of the Southern Copper and Gold Mining Company. All these gentlemen spared neither personal effort nor time in placing information in the hands of the writer, and without this assistance it would have been practically impossible to have studied the ore deposits in detail.

FRANCIS BAKER LANEY.



VIEW OF GOLD HILL RIDGE.
TAKEN FROM PROSPECT NORTHWEST OF UNION MINE.

1. GOLD HILL MINE.
2. HONEYCUTT SHAFT.
3. UNION MINE.

THE GOLD HILL MINING DISTRICT OF NORTH CAROLINA

By Francis Baker Laney, Ph.D.

CHAPTER I.

GEOGRAPHY AND HISTORY

LOCATION.

The Gold Hill Mining District comprises the southeastern portion of Rowan County, a part of the northeastern portion of Cabarrus County and a narrow strip of the northwestern part of Stanly County, North Carolina. It lies in the south-central portion of the State and its eastern boundary is about 35 miles west of the eastern limits of the Piedmont Plateau. It consists of a strip about 18 miles long and 8 miles wide, extending from the Yadkin River on the northeast to near the village of Mount Pleasant on the southwest. The village of Gold Hill, the center of mining, is located approximately in its center. (Pl. II.)

The principal surface features are a long, low-lying, flat-topped ridge, the Gold Hill Ridge, extending from about 2 miles southwest of the village of Gold Hill to and beyond the Yadkin River, and a series of hills, the Beaver Hills, lying between the village and Buffalo Creek. For the most part there is little relief except the hills just mentioned, and the northeast portion of the Gold Hill Ridge, especially the latter. The Gold Hill Ridge forms the watershed of the district, the streams to the northwest flowing northeast into the Yadkin River and those to the southeast flowing southeast into Rocky River. The principal streams are the Yadkin River, which forms its northeast boundary, Second Creek,which flows northeast into the Yadkin, and Buffalo Creek, flowing southeastwardly across the southwestern portion. (See Pl. I.)

The soil, for the most part, is lean and not considered first-class farming land. It was once heavily wooded, but this has been cut out and there now remains only the culled timber.

The district may be reached by the Southern Railway, the Norwood branch of which crosses it at Gold Hill nearly at right angles. The nearest town of any size is Salisbury, which is about 15 miles northwest of Gold Hill.

PREVIOUS GEOLOGICAL WORK IN THE GOLD HILL DISTRICT.

The first geological exploration of the country included in and surrounding the Gold Hill district was undertaken in 1823 by Denison Olmsted[1] who had that year been appointed State Geologist by the North Carolina Board of Agriculture. Even before this the "slates" were known to be gold-bearing and, indeed at this date active placer mining was in operation at the Reed Mine[2] situated only a few miles southwest of this district. Also some attention had been given to the diabase dikes within the district, and accounts of these "Natural Walls" were published in the Medical Repository[3] as early as 1799, and in the American Journal of Science[4] in 1822.

Denison Olmsted published his report in 1824 and therein is found the first geological account of this district. He recognized the "slate formation" and noted its complexity, occurrence of both gold and copper within the slates; also of beds of porphyry. He says:

"The slates of this district are of various complexions. The predominant color is a yellowish gray, but we may often find within a short space, shades of yellow, green, blue and black. The dark varieties are not so common as is usual in so extensive a slate formation. * * On the eastern borders of the slate formation are found a great number of beds of porphyry. This rock may be easily recognized by its speckled appearance. * * * It is a hard rock diversified in its colors, but usually presenting some shade of green, purple or black. Hone or whetstone-slate is found in great abundance in various parts of the slate formation." These quotations show clearly that Olmsted recognized the fact that the "slate formation" differed radically from the ordinary slates, but he did not suggest any reason for the variation.

The next geological work of any importance was by Ebenezer Emmons and was published in 1856 as "A Report on the Geology of the Midland Counties of North Carolina." He studied the slate formation very carefully, noting its many pecularities and variations, and regarding the whole series as normal sediments. In speaking of these rocks he says:[5]

"The slates are variable in color and composition. They are mineralogically clay, chloritic, and talcose slates, taking silica into their composition at times, and even passing into fine grits or honestones, but still variable in coarseness. In the order in which they lie, the talcose slates

[1] Olmsted, Denison. Report on the geology of North Carolina, 1824, pp. 23–41.
[2] Wheeler, J. H. Historical sketches of North Carolina, p. 64.
[3] Hall, James. An account of a supposed artificial wall. Letter to James Woodhouse and Dr. Woodhouse's reply. Medical Repository, v. 2 (1779) pp. 272–278.
[4] Beckwith, John. Memoir on the natural walls, or solid dikes in the State of North Carolina. Am. Jour. Sci., Ser I, v. 5 (1822) pp. 1–7.
[5] Emmons, Ebenezer. Geological report of the Midland counties of North Carolina, pp. 41 *et seq.*

and quartzites are the inferior rocks, though quartzites occur also in the condition of chert, flint, or hornstone, in all the series. * * * But the foregoing slates with their associates, standing by themselves, though they might be regarded as sediments, yet the proof thereof would be wanting, and geologists might consistently differ as to their origin. But it fortunately happens that after diligent search, numerous beds containing rounded pebbles were discovered and hence it follows that their origin is established."

He recognized the volcanic breccia, but only as a conglomerate, and apparently did not suspect its true origin. He describes it as follows:

"*Brecciated Conglomerate.*—This is the most remarkable mass of this division of the system. It has an argillaceous or chloritic base. The mass is composed in the main of fragments of other rocks, mostly retaining an angular form, but frequently rounded and worn rocks are enclosed in the mass. The fragments are sometimes 18 inches or even 2 feet long. The series by which the mass is reached is through the thin bedded clay state, which passes into thicker beds with conglomerates imperfect chloritic sandstones, and which pass upward into the superior rock. This rock is frequently porphyrized, or is traversed by porphyry more frequently than the inferior beds."

From the above it is clear that he is describing the coarser tuffs and breccias with the associated flows and that he does not suspect their true origin. In point of age, he placed the whole formation in his "Taconic System," basing his conclusions upon certain lithologic resemblances to the rocks in his original Taconic area, and also upon certain nodular masses which he described as fossil sponges, naming them Paleotrochis major[6] and Paleotrochis minor. These have later been shown beyond a doubt to be only spherulites and not fossils at all.

He gives a detailed description of the Gold Hill Mine, its veins, ore shoots, "pockets," the wall-rock, the methods of working, and some statistics regarding output. He offers no theory as to the origin of the vein and its ores, but regards the free gold in some of the "slate veins" as of sedimentary origin, holding that it was deposited contemporaneously with the slates.

Nothing further regarding the general geology of the Gold Hill district appeared until 1875. Upon this date W. C. Kerr[7] published his "Geology of North Carolina," including a geological map of the entire State. He places the whole slate formation in the Huronian,[8] which, according to his geological column, is a division of the Archæan, regarding them as sediments. He adds nothing to the detailed descriptions of Emmons.

[6] Op. Cit. pp. 60–64.
[7] Kerr, W. C. Geology of North Carolina, Raleigh, 1875.
[8] Op. Cit pp. 110–111.

He believed the greater part of the free gold in the slates to be of sedimentary origin and to be contemporaneous with the slates.

In 1888 appeared Kerr's and Hanna's[9] "Ores of North Carolina." Nothing is said of the geology of the slate formation beyond a very meager and general description of the most important mines and prospects, mentioning in a few paragraphs the general conditions at Gold Hill and giving a map of the principal veins and a vertical section to represent the location and the pitch of the ore shoots in the Gold Hill Mine.

The next and most important contribution to the geology of the slate formation is an article by G. H. Williams[10] on "Ancient Volcanic Rocks along the Eastern Border of North America," published in the Journal of Geology in 1894. While this article does not deal directly with the territory included within the Gold Hill district, but with the region lying to the east of this area, it does give the first correct interpretation of the slate formation. He speaks of a small area near Chapel Hill as follows:[11]

"Here are to be seen admirable exposures of volcanic flows and breccias with finer tuff deposits which have been sheared into slates by dynamic agency."

While this statement was made only for a small area, it is applicable, with little modification, to the whole formation. He cites Emmons's descriptions of some of the rocks within our present district and surmised that they also are probably of volcanic origin.

In 1896 the character and origin of the slate formation was taken up by H. B. C. Nitze and G. B. Hanna.[12] After a summary of the earlier views upon the question, they begin a discussion by trying to distinguish between the more highly schistose facies of the formation, calling these sericite schists, and the more massive portions which they call the "argillaceous type." They say:[13]

"The argillaceous types might more properly be called slates (clay-slate, Thonschiefer, argyllite, phyllite) as they contain more uncrystalline matter, and possess a more definitely slaty structure. So also, bedding planes are more easily distinguishable in these, if at all, and altogether their sedimentary or clastic origin is more evident. * * * Now as to the origin of these schistose and slaty rocks; in part, it seems they must be sedimentaries altered by dynamo and hydro-metamorphism. * * * It does not seem probable, at the present stage of the investigation, that these slates have been derived from the

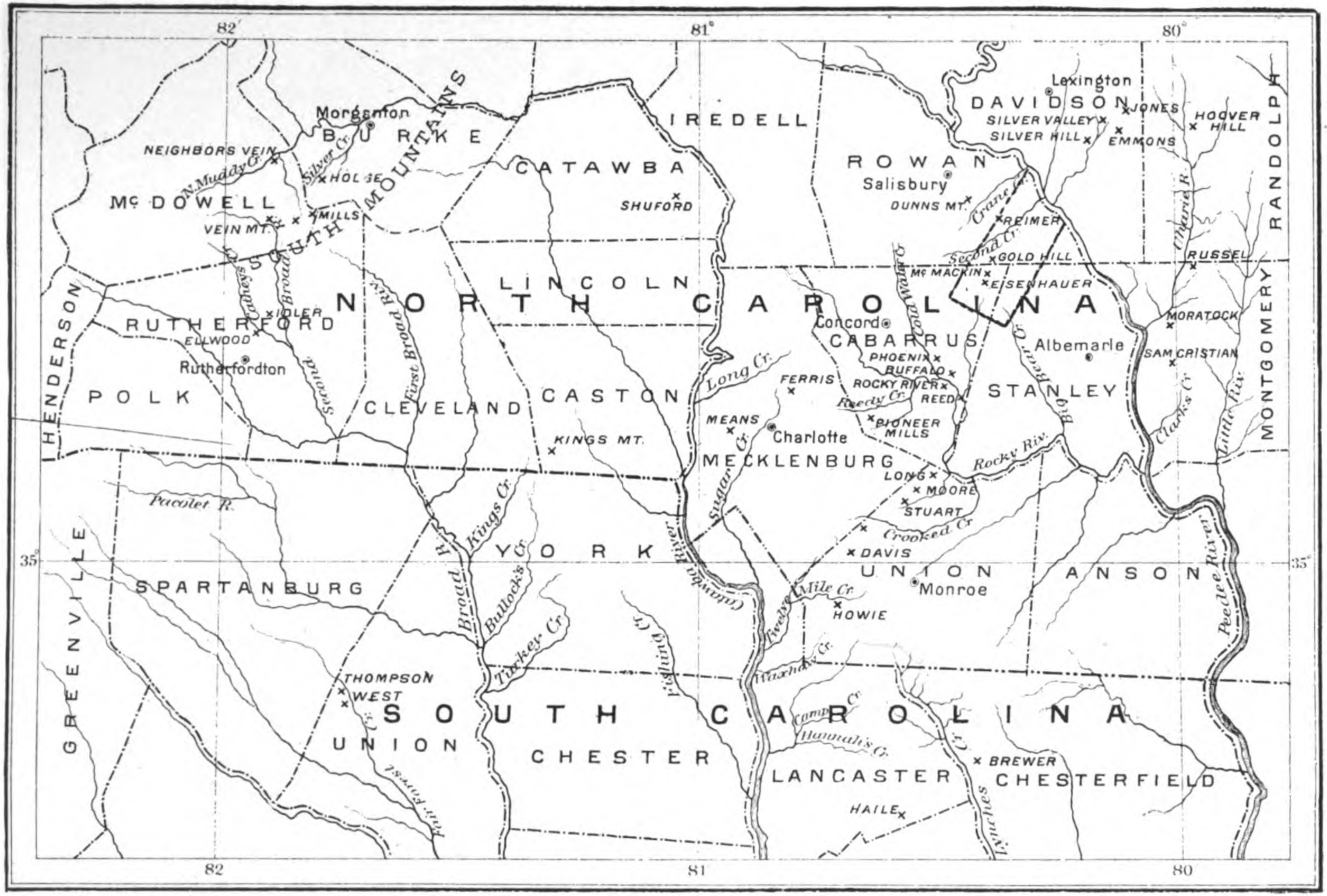
[9]Kerr, W. C., and Hanna, G. B. The ores of North Carolina, Pt. 2, Vol. 2 of Kerr's Geology of North Carolina, pp. 265–268.

[10]Williams, G. H. The distribution of ancient volcanic rocks along the eastern border of North America, Jour. of Geol., v. (2), (1894) pp. 1-31.

[11]Op. Cit. p. 28.

[12]Nitze, H. B. C. and Hanna, G. B. Gold deposits of North Carolina. N. C. Geol. Survey, Bull. 3. pp. 28–44.

[13]Op. Cit. p. 34.



*MAP OF CENTRAL NORTH CAROLINA, SHOWING LOCATION OF GOLD HILL MINING DISTRICT AND PROMINENT COPPER AND GOLD MINES (X).

*Reproduced from Map of U. S. Geological Survey.

granitic and other more basic igneous masses lying to the west, for as noted further on, these are supposed to be later intrusive bosses."

They also recognize what they call chloritic schists and speak of these as probably being sheared eruptives, but do not assign to them any definite place in the series.

They now come to a new member in the slate series which they call the "Monroe slates."[14]

"At Monroe in Union County a considerable area of truly bedded and but litttle indurated or metamorphosed slates was discovered. Very similar slates were later on found at the Parker Mine, at the town of Albemarle, in Stanly County, and at the Sam Christian mine in Montgomery County. Thus they presumably cover a large area in the southeastern portion of the 'Carolina Slate Belt.' * * * These slates were not recognized by either Emmons or Kerr. That they are of sedimentary origin and of later age than the slates and schists to the north can scarcely admit of doubt. * * * They might appropriately be named the 'Monroe slates.'" They regarded these slates as of Algonkian age as defined by C. R. Van Hise.[15]

Nitze and Hanna recognize the volcanic flows and tuffs that Dr. Williams pointed out, but do not seem to have had any definite ideas of the relations of these to the slates and schists, except that the aporhyolites might have been mashed, sheared and metamorphosed into a sericite schist.

In 1903, while investigating the quarries of North Carolina, Dr. T. L. Watson[16] made extensive observations upon the relations of the plutonic rocks of the Piedmont Plateau to each other, and came to the conclusion that the granite and gabbro are intrusive into the diorite, and that the granite is the younger of the two. There were some rather puzzling occurrences of diorite dikes clearly cutting the granite, possibly indicating that the diorite might be younger than and intrusive into the granite, but sufficient evidence for settling the relative ages of the two rocks could not be obtained in the limited time available for study of the respective areas. It was, therefore, left in this condition and the statement made that the diorite is probably the older of the two. In April, 1908, H. N. Eaton[17] published in the Journal of the Elisha Mitchell Scientific Society, an article on certain rocks near Chapel Hill which in the field appear to be identical with the rocks of the slate area of the Gold Hill district. He says:

[14]Op. Cit. p. 56.
[15]Van Hise, C. R. Correlation papers, Archæan-Algonkian. U. S. G. S., Bull. 86, p 4.
[16]Watson, T. L., Laney, F. B., and Merrill, G. P. Building and ornamental stones of North Carolina. N. C. Geol. Survey. Bull. 2.
[17]Eaton, H. N. Micro-structure and Probable Origin of Flint-like slate near Chapel Hill, North Carolina, Elisha Mitchell Scientific Society, Journal, vol. 24 (1908) pp. 1-8.

"Microscopically, this slate is seen to be a true crypto-crystalline rock, containing the minerals feldspar, quartz, kaolin and epidote. The groundmass is composed of very fine quartz crystals and minute feldspar fragments through which kaolin scales are plentifully scattered. Larger crystals of feldspar form a prominent feature and occur individually or in groups throughout the groundmass. * * * The feldspar is plagioclass and occurs in crystals varying in size from the very minute particles of the groundmass up to 286 mm. in diameter. * * * The form is usually subangular, although rounded crystals are seen, suggestive of a clastic derivation. * * * Some crystals are intimately interlocked. Others have deep reentrants into which the silica of the groundmass protrudes, suggesting a partial resorption of the feldspar by the groundmass."

He then gives a partial analysis of the rock as follows:

	Per cent.
SiO_2	77.54
Al_2O_3	13.51
Fe_2O_3 / FeO	1.17
CaO	1.10
MgO	0.23

Finally, his conclusion as to the nature and origin of the rock is:

"That the rock has remained essentially unchanged since its consolidation, and that its formation was similar to that of an arkose, viz: that its component minerals are the detrital fragments of a rock or rocks rich in quartz and feldspar."

This paper is noted in detail because the conclusions of its author are diametrically opposite to those to which the present investigations have led. It seems that the conclusions he has drawn are not warranted from the descriptions given. If the petrographic description as quoted be read, it will be seen that it tallies far more closely with that of a mashed and altered rhyolite than with a normal sedimentary rock—an arkose as he suggests in his conclusion. The analysis, also, as far as it goes, is that of a typical rhyolite.

The information regarding the geology of the Gold Hill district, at the time of undertaking the present work, may be summarized as follows:

The rocks of the region consist of a slate formation in which the ores are deposited and to the west of this is an area of intrusive granitic rocks. The slate series consists of three types, sericite schists, argillaceous slates, and the Monroe slates, very distinct from and younger than the other members of the series. Among the first two members were known to occur volcanic flows, breccias, and tuffs, but nothing was known as to the relations of these to the slates, nor of the slates to each other. Of the structure of the district, practically nothing was known. A certain amount of faulting had been surmised at the various mines. Nothing was certain of the relation of the ore bodies to this supposed faulting, nor was anything known concerning the relation of the ore deposits to the intrusive rocks near by. The petrographical study of the formations had not been attempted, and the previous classifications were based upon cursory field observations and a few chemical analyses.

CHAPTER II.

GENERAL DESCRIPTION OF THE ROCKS OF THE DISTRICT.

The area is about equally divided between igneous and sedimentary rocks. The eastern portion comprises the great series of sedimentary slates, interbedded in which are irregular bands and long lenses of volcanic rocks, representing tuffs, breccias and flows, of which there are two types, rhyolitic and andesitic. The western portion is made up wholly of igneous rocks. These are of three general types—greenstone diorite, and granite—together with numerous dikes of both acid and basic character, each type showing more or less variation and local differences. In a general way, it may be said, taking the rocks in order of their relative ages, that the greenstone with its local tuffaceous phases, is the oldest and most highly metamorphosed rock in the area, the diorite next in order and the granite least of all. There are at least four types of rock occurring as dikes, the character of the dike varying as to the relative time of intrusion. The oldest dikes are those of diorite which cut the greenstone only. Following this series, are the granite and quartz-porphyry dikes, which cut both the greenstone and the diorite; next in order are the fine-grained diorite dikes, which cut both the granite and the diorite; and last is the series of diabase dikes, probably of Triassic age. (See Geological Map, Plate III.)

The Greenstone.—This is probably the oldest rock in the area and in consequence is more highly metamorphosed than the other rocks. Its massive phases are dark and of medium to fine grain and present phenocrysts of both plagioclase and green hornblende. With this are found tuffaceous phases of the same rock which, from their general appearance lead to the conclusion that they were laid down by water. The tuffaceous phases of the rock lie to the east of the more massive facies and are in the area which has suffered the greatest dynamic metamorphism. So great, indeed, has been this metamorphism that the rocks of the greater part of the area may be characterized as "greenstone schists." This is the rock into which the great diorite masses were intruded, a fact which is conclusively shown by the nature of the contact between the two rocks. These contacts are scarce, usually obscured by the great mass of residual decay, but where they are found, the diorite clearly makes a contact against the greenstone. That is, the diorite nearest the contact is very dense; when only a short distance away, is clearly porphyritic; and when entirely removed from the contact, is medium to coarse and evenly granular. Where contacts can not be found, the diorite in near proximity to the greenstone shows the phenomena just enumerated to a greater or less extent, and dikes of the diorite are found cutting the greenstone. This rock is widely distributed throughout the area. A line drawn from a point near the Peddler's store nearly south, following closely but lying to the west of Little Buffalo Creek, would mark its eastern boundary. Extending westward from this line it occupies an irregular area varying in width from one to three miles, and is typically exposed in many places in the valley sides and stream beds in the Beaver Hills, and on the roads following the ridge tops to the southeast of Five Pines.

The Diorite.—This rock comes next in point of age and is, as has just been stated, intrusive into the greenstone. It varies greatly in character both as to composition and texture, sometimes carrying much quartz, resembling a typical "grano-diorite," and again being free from quartz and becoming a normal diorite. The texture varies from finely granular to very coarse. At times the feldspar predominates over the ferromagnesian content of the rock; at others, the reverse is true, and again they are rather evenly balanced. It seems that there is a tendency on the part of the finer grained variation to be quartz-bearing. There is, however, no gradation into a granite; the nearest approach to this is the quartz-bearing diorite. A magmatic differentiation that would show a gradation of the granite and diorite into each other, each a differentiate of the same batholith, might be expected in such an area, but this is not true in the case at hand. The granite and diorite, wherever they come in contact, have sharp and distinct boundaries. It is believed that there may have been more or less differentiation on the part of the diorite magma itself which would account for the local variations encountered.

Although this rock occupies nearly half of the whole igneous portion of the area, it is by no means well exposed at the surface; the exposures are limited to boulders and to small areas on valley sides and in stream beds. It does nor resist weathering well and is generally deeply buried in its own decay. Probably the best and most typical exposures are those in the vicinity of St. Peter's church and near Rothrock's mill on Second Creek. Typical exposures and also variations may be seen in the Beatie's Ford wagon road between Gold Hill and Lower Stone church, and it is fairly well exposed in many places on Jennie Wolf Creek and Black Run.

The Granite.—The youngest of all the igneous rocks, excepting the dikes, is the granite. This rock is a fairly massive, generally medium grained, light gray granite, sometimes having a slight pinkish tinge of color. There are two distinct phases of this rock, one as described above, a normal gray granite of medium grain; the other is an aplitic facies, very fine grained and carrying only a small amount of ferro-magnesian minerals. This latter phase is of limited extent and was found in abundance in but one place, on the road leading from Lower Stone church to Rockwell, about one mile north of where the road crosses Second Creek. It may be that this exposure represents only a large dike and consequently that this variation of the rock occurs only as dikes. Some strength is given this hypothesis by the fact that many of the small granite dikes which are found in considerable quantity near the borders of the granite mass can not be distinguished in the hand specimen from the fine grained variety. The main mass of the granite varies in texture, from a coarse-grained rock as it occurs in the vicinity of Tyack's store, to the medium, fine-grained facies exposed in the railroad cuts near Rockwell.

The granite makes a contact against all other rocks with which it is found, except the "slate" series lying to the east. This is remarkable and is strong evidence in favor of a fault at this contact. This question will be taken up in detail later.

Although the granite occupies a considerable portion of the area, exposures of the rock are by no means plentiful. Probably the best exposure of the fresh granite occurs about one mile north of the Peddler's store where a small amount of the rock has been quarried for local use. Other exposures of the deeply weathered and sappy rock occur in the vicinity of Tyack's store, and along the Gold Hill-Salisbury road, a short distance northwest of Second Creek.

The Slates.—The rocks here included under the general term "slates" make up the entire eastern half of the area, and, while having many local variations, seem clearly to represent a great sedimentary series of shales with which are interbedded volcanic flows, breccias, and tuffs. At and near the western boundary of the formation, that is, at and near the contact with the igneous rocks to the west, the series is closely folded and highly schistose. Near this contact the schistosity has a prevailing dip of about 80° to the northwest, strikes approximately 30° east of north, and is developed without regard to the bedding planes of the rocks. To the southeast the effects of this intense dynamic metamorphism gradually die out, the schistosity almost wholly disappears, and the rocks present only such structural phenomena as moderately close folds and joints. The dip, while prevailingly to the northwest, becomes flatter, even changing at times toward the southeast, and the series becomes more massive and shows clearly its sedimentary origin. In their fresh and massive condition, the slates are dense, bluish rocks which show in many places well-defined bedding planes and laminations.

The volcanic flows, breccias and tuffs, which are interbedded with the slates, apparently represent two kinds of lava, a rhyolitic and an andesitic type. The former occurs in most typical development in Flat Swamp Mountain, a short distance northwest of Bringle's Ferry; the latter in the southwest portion of the area, especially in the long ridge which lies to the west of Little Bear Creek.

The "slate" series tends to form a low-lying, flat country with low, well-rounded ridges which mark the location of the volcanic beds. The character of the ridges depends directly upon the nature of the material forming them. The rhyolitic flows and breccias of Flat Swamp Mountain form the most prominent topographic relief in the district, while the andesitic flows and breccias near Little Bear Creek are next in importance as ridge makers. The normal slates form slopes and wide, flat valleys.

Dikes.—Dikes are numerous in all parts of the district and, as has been stated, are probably of four distinct types, which, in order of age, are: diorite, granite or quartz-porphyry, fine-grained, dense diorite, and diabase, and, in a few places, gabbro.

The older diorite dikes are not numerous, and are found only in the vicinity of Foil's mill, on Buffalo Creek, where they occur in the greenstone. The rock is much altered, but does not differ essentially from the fine-grained facies of the diorite.

Granite and quartz-porphyry dikes are numerous, especially near the contacts of the granite with the other rocks. They are of two general types, ordinary quartz-porphyry and very fine-grained aplitic granite. They cut both the greenstone and the diorite, but are not found in the slate area. As rock masses these dikes are of little importance other than from a scientific standpoint. Their location is generally determined only as light-colored bands cutting the dark-colored country soil.

The second diorite dikes differ from the ordinary massive diorite of the area only in that they are made up of exceedingly fine-grained material and occur cutting the granite, granite dikes and the diorite. These have not resisted weathering as well as the rocks which they cut and consequently are recognized only as narrow bluish bands in the other rocks. Fresh boulders of this diorite seldom occur and when found are small and deeply imbedded in the decay of the dike.

Next in order are the diabase and gabbro dikes, the latter being few in number. The diabase dikes are plentiful and are represented on the surface by numerous well-rounded, black boulders known locally as "nigger heads," which are confined to narrow strips that may extend laterally for considerable distances. At times this rock is decidedly porphyritic, the feldspars large and numerous, forming a rock similar to the so-called "labradorite porphyrite." This rock occurs in considerable abundance along the County Line wagon road about one mile northwest of the Whitney Company's mines. It is known locally as "spotted rock." It also occurs along the Gold Hill-Salisbury road about ¼ mile southeast from the Peddler's store. Typical diabase dikes are found cutting all rocks of the area and appear to be especially numerous in the mining districts, each mine showing up one or more of them. In this relation they will be discussed in detail later. They are probably most abundant in near proximity to the granite-slate contact.

Gabbro dikes occur in both the slate and the diorite formations, but it is uncertain whether the two occurrences are contemporaneous. Those in the slates are completely saussuritized, while those in the diorite are fresh. Their distribution in each formation is limited, but many of them are of large size. In the slates they are best exposed near Corinth church and in the diorite near St. Peter's church and near the Cline Mine.

In trend all the dikes are dependent upon the structure of the region and invariably follow one or another of the numerous joint systems. This subject will receive detailed attention later.

CHAPTER III.

DETAILED DESCRIPTIONS OF THE ROCKS.

THE SLATE SERIES.

The term slate is applicable to these rocks only in the most general way, and, when used to designate the series as a whole, it must be borne in mind that a large portion of the rocks are not slates at all, and indeed not even sedimentary rocks The finer-grained and denser facies are of varying type. On the one hand they are probably ordinary slates, and on the other, a fine-grained tuff much silicified, which was in all probability a fine volcanic ash, and may represent both water-laid and æolian material. Between these two types of dense rocks every gradation seems to occur, apparently indicating an alternation, or a periodicity of volcanic activity. During the active periods the material supplied for the formation of these rocks was probably for the most part ash and tuff, but during periods of quiescence more or less land waste was necessarily intermixed.

The coarser, fragmental material of the slate series consists of rocks varying in texture from the fine, dense tuffs just mentioned to those in which the fragments may be very large; although those with larger fragments are unusual. Interspersed throughout the groundmass with the fragments are numerous phenocrysts which are readily discernible by the unaided eye; the groundmass itself is very fine grained. Often the proportion of phenocrysts to groundmass is large.

At times, especially in areas in which the rock has suffered intense dynamic metamorphism, *e. g.* near the fault line between the tuffs and the greenstone, the fragmental character of the rock can not be distinguished at first glance. It is readily brought out by slight weathering, such as, for example, exposure upon a mine dump for a few years.

The flow types of rocks of the series are two in number, rhyolite and andesite. The former has a limited distribution and was found in but one locality, the north end of the portion of Flat Swamp Mountain which lies south of the Yadkin River. The best exposures occur along the roadsides between Mauney's mill and Bringle's Ferry. This rock in color is either black or greenish, at times possessing a purplish tinge, the greenish tint predominating. It is very dense and fine-grained in texture and contains a few feldspar and quartz phenocrysts.

The andesitic type is found in most typical occurrence in the low ridge lying to the east of Dry's schoolhouse. It also occurs along the road leading from Lentz's store to Little Buffalo Creek. This rock, probably a hornblende andesite as seen in its best exposures, is usually massive, of greenish color, and is able to resist weathering better than the surrounding rocks. In texture, as seen by the unaided eye, it is medium to rather coarse. It is composed of phenocrysts of both feldspar and a light green hornblende imbedded in a dense, fine-grained groundmass. The weathered surface generally has a strong rust color due to the concentration of iron oxide in the surface of the rock as weathering goes on. If the rock be broken this deeply colored crust is found to be not more than one-eighth to one-fourth of an inch in thickness. Succeeding this is a thin layer of bleached and more or less discolored material which in turn gives way at the depth of a few inches to fresh rock. The latter is exceedingly tough and has a high specific gravity.

THE SLATES.

The slates, as they are generally known, consist for the most part of dark colored or bluish shales, which in the field are usually massive and fairly thick bedded; the beds occasionally showing very finely marked bedding lines. This rock in places, especially along the western side of the sedimentary area, near the granite and greenstone contact, is much sheared and possesses a very well-defined secondary cleavage, and is cut by innumerable joints with predominating northwest and northeast directions. (See Plates IX and X.) The cleavage or schistosity does not correspond with the bedding planes of the rock. In this zone of intense dynamic metamorphism, and especially in near proximity to the ore deposits, the rock is often very highly silicified. This is especially true of a large part of the rock at the Union Copper Mine, where much of the "slate" on the dump has the appearance of dark-colored chert. Outside this zone the rock resumes its usual characteristics.

By referring to the accompanying geological map (Pl. III.) it will be seen that the slates, tuffs, etc., are interbedded, the tuffs occurring as bands of varying widths in the slates having the same dip and strike. At times the contact between the two is sharp and distinct. Often a single hand specimen will contain both facies of the rock. Again, there is more or less of a gradation, and, when this occurs, it appears to be invariably through bands of the fine, dense, acid tuffs. This appears to have been caused by a more or less rapid increase in the amount of volcanic ash supplied and a proportional decrease in the amount of land waste and mud, the finer-grained material often occurring against the slate, while by a gradual increase in the size and character of the volcanic material the rock becomes the typical tuff. This gradation may occur on one or both sides of the tuffaceous band, and there are often considerable bands of the finer rock and slate interbedded in the midst of a wide band which for the most part consists of tuff.

Macroscopic description.—Both the slate and the finer tuffs are so dense and fine grained that little or nothing can be distinguished in the hand specimen with the unaided eye as to their mineralogical composition. The principal feature that may be discerned by such examination is the color which becomes lighter as the amount of tuffaceous material increases, until when the pure fine-grained tuff is reached, the color becomes a very light bluish or yellowish gray; the latter being produced for the most part by many small granules of iron ore. As the material becomes coarser, the crystals and fragments of crystals of feldspar and quartz that occur as phenocrysts in the groundmass are observed, giving the rock a porphyritic appearance.

Microscopic description.—The slates are so fine grained that very little as to their mineralogical content can be learned even by means of the microscope. About all that even the strongest objectives can bring out is a dense mosaic, cryptocrystalline, or chert-like groundmass which seems to be made up of quartz and feldspar intermingled with black dust-like particles possibly carbonaceous in character, a few small elongated areas of chlorite and numerous small scales of sericite. The latter is present in greatest abundance in the more highly metamorphosed rocks. Scattered here and there through the coarser slates are sometimes found fragments of quartz and feldspar crystals, the latter much kaolinized. Where by chance anything can be learned as to the nature of the feldspar, it is found to be orthoclase, microcline or one of the more acid plagioclases.

Chemical analysis.—Two specimens considered to be representative of the slate were selected for chemical analysis with the results given below. To these analyses is added, for comparison, an analysis of a similar rock from the Haile Mine in South Carolina, a short distance southwest of the Gold Hill district but in the same zone of mineralization.

ANALYSES OF SLATES.

	1	2	3[18]
SiO_2	52.62	62.46	61.02
Al_2O_3	33.20	16.10	25.54
Fe_2O_3	4.04	1.17	4.04
FeO		5.49	
MgO	0.27	2.27	0.14
CaO	2.52	0.36	0.60
Na_2O	3.80	2.16	2.19
K_2O	0.49	2.85	1.81
H_2O-		0.53	4.20
H_2O+		2.53	
CO_2	0.66		
S		0.26	
	97.60	96.17	99.96

1. Partial analysis of typical black slate, Gold Hill-Stokes Ferry road, 4 miles from Gold Hill. R. T. Allen, analyst.
2. Partial analysis of typical banded blue slate, Gold Hill-Stokes Ferry road, 1½ miles from Gold Hill. A. S. Wheeler, analyst.
3. Analysis of "slate" from Haile Mine, South Carolina. Chas. Baskerville, analyst.

[18]Gold deposits of North Carolina, H. B. C. Nitze and G. B. Hanna, North Carolina Geological Survey, Bull. No. 3 (1896), p. 34.

It may be seen at a glance that these analyses show a marked difference from those of normal slates in that they all contain a high percentage of soda, equal to or predominating over the potash.

It has been found that soda, because more readily soluble than potash, is carried away in the weathering processes and that potash is relatively concentrated A study of many analyses of shales has shown that in general average, the potash content is about twice that of the soda. The rocks under consideration, however, contain nearly twice as much soda as potash.

It will also be noted that the analyses, especially No. 2, have a close resemblance to those of acid andesites or dacites. Analysis No. 2 is almost typical of this group of rocks, in which soda is equal to or predominating over potash. Nos. 1 and 3 are similar, differing essentially only in the amount of alumina, which may be readily accounted for by the intermixture of varying amounts of land waste, clay, etc., which took place during deposition. In the coarser rocks, tuffs, etc., of this series the microscope clearly reveals such admixtures of clay.

Classification.—It is realized that the few analyses presented do not justify any extensive conclusions as to the origin of these rocks, but it is believed that, when the facts here presented are compared with the analysis of silicified tuffaceous rocks, similar in all respects except in degree of comminution of the material, and in its subsequent silicification, p (41) in which there is seen to be a reversal of the ratio of the alkalis, some conclusions may be drawn. It is, therefore, believed that the slates represent largely material furnished directly by the volcanic activity which built up the tuffs and flows with which they are interbedded, and that the slates were formed largely of practically pure, very fine medium acid volcanic ash, intermixed with more or less land waste and that the material thus furnished never went through the cycle of erosion which is necessary for the production of normal slates.

THE FINE GRAINED TUFFS.

Macroscopic description.—In general appearance these rocks differ from the slates only in color and hardness, and are usually of a grayish or yellowish tint, very hard and dense. They possess no uniformity in color and texture and pass by gradual gradation into the slates. The rock is brittle and breaks with a well-marked conchoidal fracture. In the field it generally has the appearance of a chert or fine quartzite. In addition to the gradation into the slates, there is a gradation into the coarser tuffs. The unaided eye can make out very little as regards the character of the fine-grained facies of the rock, but as it becomes coarser in texture, its fragmental nature is apparent. The fragments consist of broken crystals of both quartz and feldspar, and sharply angular pieces of rock similar to the tuff itself.

Microscopic description.—The microscopical examination of the densest of these rocks is nearly as unsatisfactory as that of the slate. Even the highest powers of the microscope fail to show more than a groundmass consisting of a mosaic of feldspar and quartz in which are more or less plentifully scattered specks of black iron ore, sometimes a few shreds of chlorite and a few granules of zoisite and epidote, the latter minerals occurring abundantly in some specimens. A large amount of extremely fine-grained, non-polarizing material is seen to be arranged in irregular small areas throughout the whole rock. This material is generally of a brownish gray color and seems to be extraneous matter and to bear no definite genetic relationships to any other minerals. From its position with respect to the minerals, fragments, small cavities, etc., it appears that it is clay that may have been deposited contemporaneously with the volcanic material making up the rock. Its fragmental nature is not difficult to ascertain even in case of the very finest grained specimens. Sometimes this is best seen in ordinary light and in such cases the fragments appear as white or colorless angular areas imbedded in a matrix which shows bands and areas of the material referred to above as clay. In a few instances the sharply angular fragments showed lines running through their mass which closely resembled lines of flow in a recent lava. These lines of flow in all cases end abruptly against the matrix and the different fragments possessing them have no uniform orientation with respect to each other. When such a rock as the above is examined between crossed nicols, the whole field, fragments and groundmass alike, shows up only as a very fine-grained mosaic of quartz and feldspar in which the dark, non-polarizing areas of clay may be distinguished. The matrix and fragments alike have been devitrified and silicified until the whole rock takes on a cryptocrystalline or cherty texture and the boundary between fragments and matrix can not be distinguished. On the other hand, some specimens fail to show their clastic nature in ordinary light but show it beautifully between crossed nicols. In such cases, while the whole rock has the cryptocrystalline texture, there is a variation in size of the mosaic of the fragments and that of the groundmass which delimits each fragment very clearly.

As the rock becomes coarser and the minerals and rock fragments larger, one may readily distinguish the phenocrysts of the different minerals. There is no distinctive difference between the matrix of the coarser or porphyritic tuffs and those just described, and what has been said in regard to the matrix of the denser rocks is equally applicable to these.

The Phenocrysts.—Feldspars and quartz are practically the only minerals occurring as phenocrysts, and of these the feldspars are most abundant; and, while both orthoclase and plagioclase occur, the latter seems to predominate. In one or two instances however, the reverse is true. Sometimes quartz is fairly plentiful, but, as a rule, sparingly present as phenocrysts and at times is apparently lacking and occurs only in the cryptocrystalline groundmass.

Plagioclase.—The plagioclase occurring as phenocrysts is rather acid, seemingly varying from albite to labradorite. It occurs both as idiomorphic crystals and as irregular and sharply angular fragments. They are generally much altered by weathering and at times are almost wholly destroyed, leaving only a general outline of the crystal with small areas which remain intact and show by their characteristics what the mineral formerly was. The alteration seems for the most part to be to kaolin and takes place in the ordinary manner. These feldspars are clearer and apparently less altered than the orthoclase in the same rock, which is usually cloudy. This statement appears to hold for all the rocks of the district in which the two feldspars occur, but it is not believed to indicate that the orthoclase is more easily altered than the plagioclase. Merrill (*a*) and Lemberg (*b*) both note the tendency of orthoclase in older rocks to present a muddy or cloudy appearance as if in an advanced stage of decomposition, when it is in reality fairly fresh or very slightly altered. These writers state that this apparent decomposition may be due to physical causes such as disintegration, inclusions of some easily decomposible silicate, or to originally water-filled

(*a*) Merrill, Geo. P., Rocks, rock-weathering, and soils, New York, 1906, p. 17.

(*b*) Lemberg, J. Zur Kentniss der Bildung und Umwadlung von Silicaten. Zeitschrift der Deutchen geol. Gesellschaft, V. 35 (1883), p. 575.

cavities, the contents of which have been absorbed by the formation of secondary hydrous silicates. The last statement seems to be readily applicable to the case in hand, since the microscope clearly shows that while both feldspars contain a great many inclusions, some of which are apparently liquid, they are far more numerous in the orthoclase.

Orthoclase.—This mineral occurs as does the striated feldspar in both idiomorphic crystals and as sharply angular fragments. In amount it seems to be subordinate to the other feldspars and in one or two sections was present only sparingly. It possesses its ordinary aspects as to crystal habit, alterations, etc. Both feldspars contain numerous minute inclusions, but these appear to predominate in the orthoclase. Some of the inclusions thus occurring seem to have been once of a glassy nature, but now devitrified.

Quartz.—This mineral occurs as phenocrysts in nearly every specimen of the rock examined. In a few cases it was present only in a cryptocrystalline condition in the groundmass. It is usually in small rounded grains, or angular fragments and contains numerous inclusions, some of which are solids while others appear to be gaseous. They are all small and could not be definitely determined. In one or two instances secondary enlargements of these grains of quartz were detected, the boundary of the original grain being marked by a fine line of dark-colored specks—probably iron ore. The secondary material extinguishes simultaneously with the original quartz, but it has not restored any crystal faces to the original grain.

Quartz is generally much subordinate in quantity to the feldspar and, indeed, as has been stated above, was not found as phenocrysts in a few specimens.

Hornblende.—Hornblende was sparingly present, and never in well defined forms, but only as angular pieces and shreds. In color it is brownish green, not strongly pleochroic. It was not seen at any time in a fresh condition, but was always more or less altered to chlorite or associated with epidote and clinozoisite. The interiors of nearly all the sections of this mineral were spongy, probably due to alterations, and were filled with chlorite and quartz, or in many instances, epidote, clinozoisite, and quartz. Many areas of dark green chlorite which show the ultra-blue polarization color now appear to occupy positions that once were held by hornblendes.

There also occur the secondary minerals—epidote, zoisite, clinozoisite, and chlorite, generally, a small, and at times a large, percentage of calcite. This last mineral occurs as a rule in irregular areas or patches and occasionally in rather long prismatic forms. It often contains much non-polarizing clayey material in its midst as though it had in its growth enveloped this from the groundmass. It shows no other peculiarities worthy of note.

Classification.—The field relations, the macroscopic and microscopic characteristics of this rock, appear to preclude any other conclusion than that it is a tuff which has been derived from a rather acid-magma—an andesitic dacitic tuff.

THE COARSER TUFFS AND BRECCIAS AND VOLCANIC FLOWS.

These rocks have a wide distribution throughout the slates in which they occur in more or less parallel bands having the same strike and dip as the slates. This statement seems to hold for the entire slate formation as well as for the small portion included within the area under consideration. Two or three traverses extending almost across the entire formation failed to disclose anything contrary to this statement. These rocks resist erosion far better than the slates in which they occur, and, on this account, are the prominent ridge makers of the region. In the area under discussion there are two prominent ridges made up of these rocks—the Gold Hill ridge extending, as has been said, from about 2 miles southwest of the village of Gold Hill to and beyond the Yadkin River, and the ridge between Little Bear Creek and Little Buffalo Creek. The northeast end of the Gold Hill ridge near and northeast of the Yadkin is called Flat Swamp Mountain and forms the most rugged topography in the area. By reference to the accompanying geological map it may be seen that this ridge, which is 1¼ miles wide, is almost wholly made up of tuffs and breccias interbedded with which in places are narrow bands of fine-grained tuffs and slates. At the northeast end of the ridge, just west of Bringle's Ferry, occurs a small area of typical rhyolite, now entirely devitrified, but very hard, dense and fresh.

These rocks have their most typical development in Flat Swamp Mountain and are best exposed on its summit and along the wagon road leading up the Yadkin River from Bringle's Ferry. They are probably as well developed in the ridge west of Little Bear Creek, but the conditions are unfavorable for good rock exposures, everything as a rule being covered with a heavy mantle of rock decay and soil.

The conditions at Flat Swamp Mountain are most favorable for a study of the tuffs, breccias and slates in their relations to the rhyolite, for it is in this locality and associated with the rocks just mentioned that the only flow of rhyolite which can be definitely identified as such occurs in the area included on the map. Other flows and larger ones are found in many places within the slate formation.

The relations at this locality appear to be as follows: slate, rhyolite, flow breccia, ordinary breccia, coarser tuff and finer tuff of light grayish color which gradually grades into the normal slate of the region.

THE RHYOLITE.

Macroscopic description.—In the hand specimen the rhyolite is dense, not decidedly porphyritic rock of either black, very dark, grayish purple, or decidedly grayish green color, and on fresh fracture has a kind of greasy or pearly luster. It is hard and brittle and breaks with a conchoidal fracture, the fragments coming off with thin and sharp translucent edges. Phenocrysts are small and quite uniformly distributed through the rock and give it a speckled appearance. Upon closer inspection, the phenocrysts are for the most part found to be made up of small lath-shaped feldspar. Quartz phenocrysts are not prominent and indeed seem to be entirely lacking in certain areas of the rock. Flow structure, spherulites, remains of lithophysae, are not usually well shown in this area, although a few well-defined flow structures were noted. In other portions of the slate area there occur characteristic and well-defined spherulites of large size. It is these structures that Dr. E. Emmons described as fossil sponges, naming them "Paleotrochis."[19] The rock has been closely jointed and in places mashed to a greater or less extent, and in many of the fracture lines are thin seams of calcite and quartz with more or less epidote.

In weathering the rock assumes a dirty gray color. It resists weathering agencies well, and, in general, the discolored layer extends to only a shallow depth. The lines of flow, lithophysæ, etc., are seen to best advantage on the weathered surface, but even here they do not show up well. (See Pl. V, A.)

Microscopic examination.—Under the microscope the following phenocrysts are present in a groundmass consisting of a mosaic of quartz and feldspar. Feldspar, both orthoclase and plagioclase, the latter predominating, and quartz are present, the last sparingly and in some sections, not at all.

The orthoclase occurs in small, well-defined crystals with numerous minute inclusions the nature of which could not be ascertained, and are usually twinned according to the Carlsbad law. They are never entirely fresh, invariably showing more or less kaolinization.

The plagioclase belongs in the acid end of the series, probably an acid andesine. It possesses no characteristics differing from ordinary minerals of the type, shows polysynthetic twinning, with numerous indeterminable inclusions, and, while more or less altered (kaolinized) is still apparently fresher than the orthoclase. These crystals, as well as those of the orthoclase, are at times fragmental, broken, and in rare instances bent, showing movement in the magma after they were formed.

[19] E. Emmons. Geology of the Midland counties of North Carolina. pp. 60–64.

Quartz, when present as phenocrysts, is in grains and anhedra rather than in idiomorphic crystals. Like the feldspar, it carries inclusions the nature of which could not be determined. It, together with the feldspar, shows the undulatory extinction characteristics of rocks which have suffered strong dynamic metamorphism.

The groundmass consists of a pepper-and-salt mixture of quartz and feldspar in which, in addition to the phenocrysts, occur numerous motley or patchy areas of spongy quartz filled with little feldspar laths—the typical micropoikilitic groundmass characteristic of this type of rock. There also occur, especially in the greenish colored variety, many small irregular patches and shreds of chlorite, which accounts for its green color and probably represents the remains of the original ferromagnesian constituents. The black ores are present in great abundance as minute specks well distributed throughout the rock. Calcite, epidote, a few small zircons, and cubes of pyrite conclude the list of its constituent minerals.

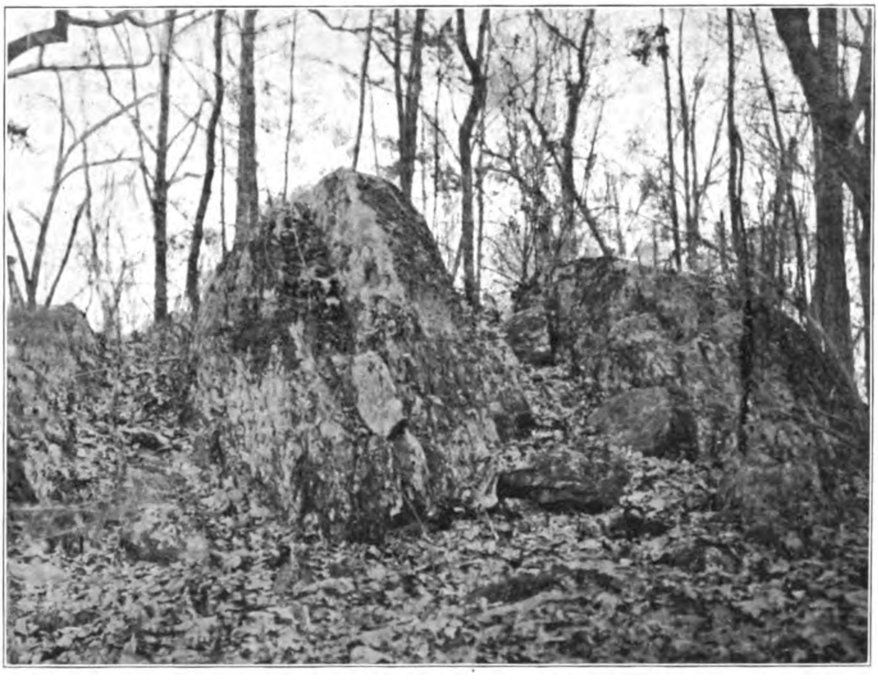
The spherulitic, flow, and other structures of surface volcanic rocks are seen only when the section is examined in ordinary light, in which position they show up well and are similar to the structures typical of fresh lavas. When the analyzer is used the whole phenomena disappear and there remains only the fine mosaic-like mass of quartz and feldspar, showing that the rock has been completely and wholly devitrified.

ANDESITE.

In the southeastern portion of the slate area, between Little Bear Creek and Little Buffalo Creek, is a prominent, long, narrow ridge, made up for the most part of breccias and tuffs similar to those just described. In the midst of this mass of breccia and tuffs there occurs a surface flow of a rock which has to a very marked degree the characteristics of an andesite. This mass, while its exact boundaries could not be determined accurately because of scarcity of outcrops, is known to be possibly two miles long and about one-half mile in width. It is bounded both above and below by the ordinary tuffs and breccias and appears to bear a relation to them somewhat similar to that which the rhyolite bears to the tuffs and breccias of Flat Swamp Mountain. Probably the best exposure of this rock is along the wagon road leading from Dry's mill westward to Little Buffalo Creek. Where this road crosses the ridge there are numerous fair-sized boulders of this rock.

Macroscopic description.—There are two distinct phases of the rock, one massive and the other amygdaloidal. Each has a predominantly greenish gray color and the weathered surfaces present a decidedly rusty brown appearance. The amygdaloidal facies is at the lower

A. PHOTOGRAPH OF WEATHERED SURFACE OF RHYOLITE. VARIATIONS IN TEXTURE AND LINES OF FLOW ARE WELL SHOWN ON WEATHERED SURFACE OF THIS ROCK.



B. OUTCROPPING OF TUFF BEDS, 2 MILES SOUTHWEST OF GOLD HILL.

contact of the andesite with the underlying slates and breccias and consists of only a narrow band which seems to grade gradually into the massive phase simply by a decrease in the number of amygdules.

In the hand specimen this phase is of greenish gray color closely dotted with elliptical white spots, the amygdules, which are filled largely, as the microscope shows, with light-colored feldspar. The amygdules are always small. In a few instances they were filled with a greenish mineral having the general appearance of epidote and in others the cavities were unfilled and gave the rock a cellular or honeycomb appearance.

The groundmass has very much the same greenish gray color of some of the phases of the slates, and is so fine grained that nothing of its structure can be determined with the unaided eye.

The massive type of this rock presents in the hand specimen a decidedly greenish gray color and interspersed throughout this as a background are numerous dark greenish black areas of hornblende. Upon close scrutiny numerous small laths of feldspar often showing the plagioclase structures may be distinguished. In weathering, this rock assumes on its surface a thin, rust-colored layer in which no textures are visible. Immediately beneath this is a thin layer of lighter gray material in which are remains of the different minerals. This grades gradually into the fresh rock through a narrow area which has a kind of greasy appearance and is stained with iron oxide. The rock is exceedingly tough and breaks with conchoidal fracture.

Microscopic description.—Under the microscope the amygdaloidal phase of this rock is seen to contain the following minerals; microcline, orthoclase (?), a rather acid plagioclase, probably a medium andesine, quartz in small quantity, epidote, zoisite, clinozoisite, uralitic hornblende, chlorite, and a few more accessories.

The feldspars occur in the amygdules and have a decided tendency to project from the walls toward the interior of the cavity. The microcline presents the usual gridiron structure, is in small irregular grains, and badly altered. It seems to prefer the interior of the cavities and apparently does not project from the walls like the plagioclases.

The plagioclase makes up by far the larger amount of the filling of the amygdules and it is in the spaces between the crystals of this mineral that the quartz and other feldspar occur. In the sections studied no crystals were found that could be definitely determined, but the width of the striæ and the contrast in color between the respective portions of the twinned crystals indicate a medium to fairly acid plagioclase. Quartz is present only in subordinate amount and may represent a secondary infiltration.

The epidote, zoisite and clinozoisite are present in considerable quantity, but present no features essentially different from those of the breccias already described.

The hornblende occurs in the groundmass and is of the usual stringy and irregular shapes of uralite and possesses the usual colors and other optical characteristics of this mineral. There is a decided tendency on the part of the slender hornblende crystals of the groundmass when in near proximity to the amygdules to be arranged with their greatest length tangent to the wall of the cavity.

The massive rock presents practically the same minerals as the amygdaloidal variety. The plagioclases are larger and so badly altered that an accurate determination of their character was not possible; as far as could be determined, they present the same characteristics of the plagioclase of the other variety. Microcline is wanting. Quartz seems to be clearly secondary and the hornblende, while present in larger masses, for the most part seems to be clearly of the uralitic variety. Some of it occurs in good idiomorphic crystals and may be an original amphibole. The groundmass is made up of narrow laths of feldspar more or less grouped into irregular patches. The ferromagnesian minerals are interspersed among the feldspar laths in such a way as to strongly suggest that it has been derived from a pyroxene. The texture, while badly obscured by alterations which have taken place in the rock, appeared to be clearly that of a porphyritic andesite.

Classification.—The characteristics enumerated above, while not sufficient to positively identify this rock as an andesite, very strongly indicate this type and it is therefore provisionally called an andesite.

VOLCANIC BRECCIA.

In the hand specimen this rock is seen to be made up of a groundmass similar in color, phenocrysts, etc., to that of the rhyolite. Scattered throughout this groundmass are numerous angular fragments, many of which are apparently of the same material as the groundmass itself, appearing as if the viscous lava in flowing along had solidified upon the surface, and further movements had broken this hardened layer into fragments which were included in the rock mass. In addition to this class of fragments there are others of all the associated rock types, and at times small ones of some basic rock. The fragments as found are small, never more than two and one-half to three inches in longest diameter and usually less than one inch.

Microscopical examination.—Thin sections show little difference, if any, from the regular coarser breccias in the way of phenocrysts, alterations, etc. They differ from them, however, in that with the class of rocks designated as flow breccias the groundmass shows the many and contorted lines of flow, which that of the ordinary breccias does not. They do not carry in their groundmass the great amount of non-polarizing material, probably clay, of the other breccias. It is because of these differences and the difference in color that these rocks were separated from the other breccias.

While the rocks of this type in the area included within the present report contain only small fragments, localities are known to exist in other portions of the slate area in which the fragments are large, even 2 or 3 feet in diameter.[20]

THE COARSER TUFFS.

As was stated at the beginning of this chapter, these rocks occur as long narrow bands or beds in the slates. They have the same dip and strike as the slates, and by a gradual decrease in the size and amount of the volcanic material and at the same time an increase in the amount of land waste they grade gradually one into the other. The usual order of this gradation is slate, fine, dense tuff, the "novaculite," "hornstone," "honestone" of early observers, coarser tuffs, fine dense tuffs, and finally slate again. This order is not invariable, and at times one or more members of the series may be lacking, as, for example, in the cut on the Southern Railway southeast from Gold Hill, where a narrow bed of the coarser tuff occurs in the slate without any of the dense variety, and at a casual glance resembles a dike. There is also much variation in the beds themselves, especially the thicker beds which in their widest areas are more than a mile wide. In such beds there are often many narrow bands of the fine tuffs as well as narrow elongated lenses or beds of slate, as though indicating considerable variation in the physical conditions of a period which was predominantly volcanic.

The distribution of these rocks as indicated on the accompanying geological map is in the main believed to be correct, but, since in many places and over wide areas all rocks are obscured by soil, some of the boundary lines are only approximately correct.

Macroscopic description.—In the field and in the hand specimen these rocks are of a bluish gray color, while the weathered surface is a rusty brown, or a light greenish gray almost the exact color of the lichens which cover them. They resist weathering better than any rocks of the district except the rhyolite, and hence always form the most prominent outcrops. (See Pl. V, B and VI, B.) Upon a close examination they are found to be made up of small, more or less, sometimes sharply angular fragments of various rocks imbedded in a fine, dense bluish or grayish

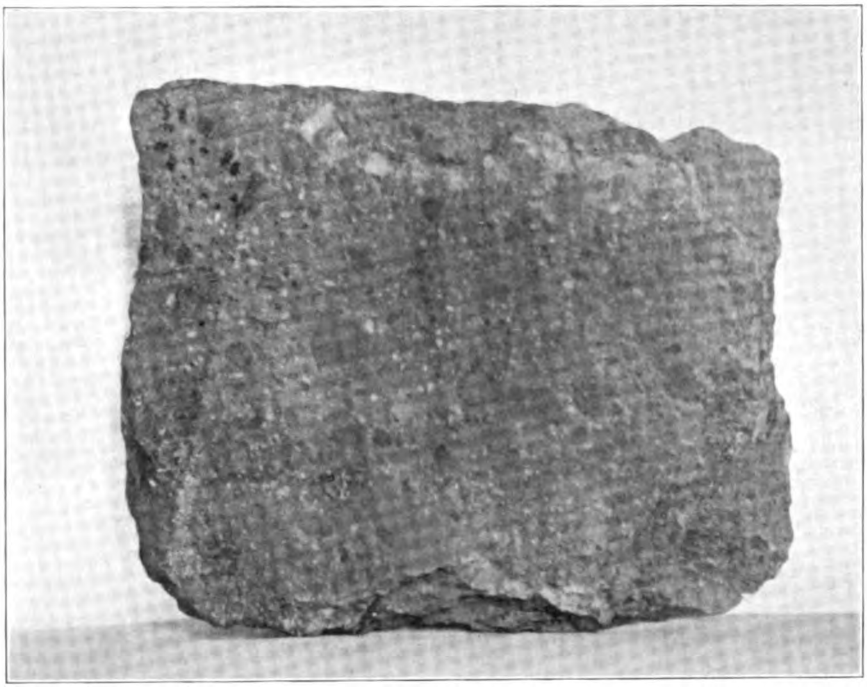
[20] Emmons, Ebenezer. Geological report of the Midland counties of North Carolina, p. 67. p. 28

matrix in which lie numerous well-shaped feldspar phenocrysts. In the less metamorphosed portions of the area these rocks are massive and show clearly their brecciated character, but in the immediate proximity to the fault zone at Gold Hill they are badly mashed, sometimes passing into sericitic schists and are not so easily recognized as breccias. The mashing to which they have been subjected at this place has drawn out the fragments and rounded them into lens-shaped masses and even, as it seems, welded them into the matrix until the rock very closely resembles a mashed conglomerate. (See Pl. VI, A.) The fragments vary greatly. They generally consist of pieces of the denser tuffs and slates with which they are associated, although numerous small fragments of some dark-colored basic rock are not rare. When the fragments are predominantly of the dense light-colored, felsitic tuff, as in an area along the Gold Hill-Bringle's Ferry wagon road near Pooltown, the rock has very much the appearance of a porphyry with large feldspar phenocrysts. Close examination readily shows its true brecciated nature. The fragments, whatever their character, are always small. While this statement is apparently true for the area included within the map, it does not hold for the slate area as a whole. In many places to the east of the mapped area the fragments are large, sometimes nearly 2 feet in diameter.

The matrix or groundmass is so dense and fine grained that little or nothing of its nature can be made out by the unaided eye. In color it differs very little from the slate. Indeed it looks as if a paste of the slate had been made and the various fragments, crystals, etc., had been thickly sprinkled into it. The fragments and phenocrysts seem in the majority of cases to make up the greater part of the rock.

Microscopic description.—Under the microscope the following minerals are seen to be present as phenocrysts and fragments of phenocrysts: orthoclase, plagioclase, probably about medium oligoclase to labradorite, quartz, and hornblende. The following minerals of secondary derivation are present: quartz, chlorite, epidote, zoisite (?), clinozoisite, calcite, kaolin, and little scales of muscovite, and at times much biotite.

The orthoclase is usually twinned according to the Carlsbad law. It occurs in well-defined crystals or fragments of crystals and contains numerous inclusions which could not be determined. The mineral is invariably badly altered, the resulting mineral being kaolin or certainly, at times, sericite. The latter is best developed when the rock has been subjected to intense mashing and more or less hydrothermal metamorphism. In the mashed rocks the predominant feldspar shows the "basket" or gridiron twinning of microcline rather than the ordinary Carlsbad twins of orthoclase. The fact that the alkalic feldspar



A. POLISHED SPECIMEN OF COARSED GRAINED TUFF, SHOWING ANGULAR ROCK FRAGMENTS AND FELDSPAR PHENOCRYSTS. FOUND NEAR MORGAN'S SAWMILL.
(Three-fourths natural size.)

B. OUTCROPPING OF TUFF BEDS NEAR MORGAN'S SAWMILL, $1\frac{1}{2}$ MILES EAST OF GOLD HILL.

in the massive rocks shows only orthoclase characteristics, while when the same rock is mashed and metamorphosed it presents those of microcline, suggests that the mashing and metamorphism to which the rock had been subjected has developed the microcline structure in the orthoclase.

The plagioclase varies much as to character and is generally pretty well up toward the acid end of the series, but a number of sections of a basic feldspar, at least as basic as andesine, were noticed. A few phenocrysts were cut so that at least an approximate determination by the Michel-Levy method was possible. These were found to correspond with basic albite.

Quartz is not plentiful as a phenocryst, but when present, occurs in rounded grains or anhedra rather than in idiomorphic crystals. It contains small inclusions of solid matter and also small gas and liquid cavities. The major portion of quartz is apparently of secondary origin, probably in part of extraneous infiltration.

Hornblende is a somewhat rare mineral in these rocks, but when found occurs in typical idiomorphic development. The crystals are generally small and present the usual characteristics of ordinary hornblende. The mineral also is present in long slender crystals and groups of crystals, possessing all the characteristics of uralite, and in such occurrences it is thought to be due to an alteration of pyroxene. No pyroxenes that could be identified as such were seen in the sections examined. Often the largest and best formed hornblende phenocrysts are spongy or patchy in the interior and filled with quartz, epidote, and clinozoisite as though these minerals were replacing the hornblende. It shows in many instances alterations to chlorite and many of the chlorite patches in the rock are believed to represent the hornblende fragments of the original tuff. (See Pl. VII, A and B.)

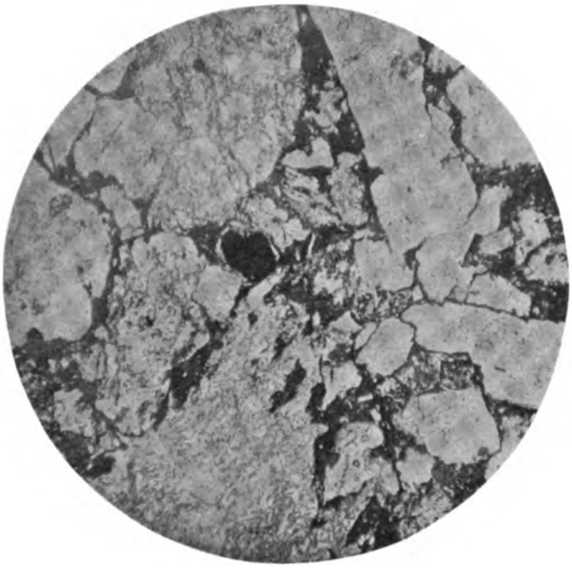
The secondary minerals present no unusual features, except possibly the great number of grains of the mineral possessing a rather high index of refraction, and very low "ultra-blue" polarization colors, which has been called clinozoisite. This mineral in an instance or two apparently was gradually passing, as it were, into epidote, one end of a mass showing clearly the characteristics of epidote and the other those of clinozoisite, one gradually fading into the other. There may be mentioned the occurrence of clear and fresh scales and plates of typical biotite associated with the chlorite in the more highly schistose phases of the rock in such manner as to suggest the formation of the biotite from the chlorite.

Calcite is widely distributed throughout the rock, in some places plentifully. Its presence and the presence of epidote and zoisite are probably due to alterations of the lime-bearing plagioclase and are evidence of the intermediate character of the magma from which the rock was derived.

Fragments.—The fragments as seen under the microscope are for the most part sharply angular in form and consist of rock not essentially different from the groundmass itself, except that they contain none of the brownish gray non-polarizing material. By far the greater number of these are of the slate and the finer, denser, felsitic tuff, and intermixed at times are pieces of basic rock with a basaltic texture. They are all, excepting the basaltic fragments, best seen in ordinary light, by which means their boundaries may be clearly distinguished. Under crossed nicols the whole field, except the phenocrysts, resolves itself into a cryptocrystalline mosaic in which fragments can not be distinguished from groundmass. The basaltic fragments are best seen under crossed nicols when they are resolved into a mass of narrow interlocking feldspar laths imbedded in a matrix of some badly decomposed ferromagnesian mineral.

The groundmass.—The minerals and fragments above described are irregularly scattered through a very fine-grained, cryptocrystalline groundmass. The individual minerals of this mosaic are so small that they can not be resolved, even with the highest powers of the microscope. With this groundmass, there is present, generally in considerable quantity, a finely granular yellowish gray, non-polarizing material which is believed to represent clay which was intermixed with the fragmental material at the time of its deposition. This material is confined wholly to the groundmass and is seen to bend or wrap itself around the rock fragments. The groundmass forms a varying proportion of the rock, probably never more than 50 per cent.

Chemical analysis.—The chemical analyses presented in the following table were made from specimens so chosen as to show the normal tuff, that which has suffered a moderate amount of silicification, and that which had been highly silicified.



A. PHOTOMICROGRAPH OF COARSE GRAINED TUFF, SHOWING FRAGMENTAL CHARACTER OF THE ROCK
ORDINARY LIGHT. X 20.

B. SAME IN POLARIZED LIGHT, SHOWING THAT MANY OF THE FRAGMENTS ARE OF ROCK SIMILAR TO THE GROUNDMASS.
X 20.

ANALYSES OF COARSE TUFFS.

	1	2	3	4	5	6
SiO_2	56.94	72.16	72.46	80.42	84.45	86.10
Al_2O_3	20.96	9.00	8 34	3.84	3.71	3.24
Fe_2O_3	{ 3.97	2.47	{ 6.72	1.44	{ 3.27	0.58
FeO	{ ------	3.30	{ ------	3.58	{ ------	2.21
MgO	0.41	3.03	--------	1.74	--------	1.41
CaO	6.01	0.43	--------	0.35	--------	0.55
Na_2O	3.96	3.69	1.44	0.61	0.93	0.74
K_2O	1.29	0.24	1.20	1.97	2.87	2.30
H_2O-	{ 0.19	1.86	--------	0.53	--------	0.42
H_2O+	{ ------	2.22	--------	0.86	--------	1.56
CO_2	2.52	--------	--------	--------	--------	0.00
S	--------	1.85	--------	2.05	--------	0.10
	96.25	100.25	--------	97.36	--------	99.21

1. Typical coarse tuff, near Morgan's sawmill, R. T. Allen, analyst.
2. Tuff, more or less silicified, Union Mine, A. S. Wheeler, analyst.
3. Tuff, more or less silicified, Union Mine, A. S. Wheeler, analyst.
4. Tuff, highly silicified and containing Cu., Union Mine, A. S. Wheeler, analyst.
5. Tuff, highly silicified, Union Mine, A. S. Wheeler, analyst.
6. Tuff, highly silicified, Union Mine, A. S. Wheeler, analyst.

Analysis No. 1 is of the first, Nos. 2 and 3 of the second, and Nos. 4, 5 and 6 are of the third type. The noteworthy items of these are that in the less altered rocks soda is in excess of potash, while in the more highly altered the reverse is true, the relative amount of each possibly bearing some relation to the degree of alteration, and that as the silicification becomes more prominent there is a decrease in alumina as well as in soda. The first of these has an important bearing upon the interpretation of the origin of the finer-grained facies of the formation in that it shows in the very rocks under discussion, as alteration (which in this case seems to be analogous to portions of the process of weathering) has proceeded, there has been a decided decrease in the amount of soda in the rock and at the same time a relative increase in the amount of potash. This is taken as further evidence that the slates of the region are, as has been stated elsewhere (pp. 26-28) not normal slates, but made up largely of volcanic material similar to that of the flows and tuffs. The apparent decrease in alumina is not understood, but appears to indicate that as silica was deposited, alumina, together with soda, was removed.

Classification.—The analysis of the fresher rock seem to agree fairly well with the characteristics of the rock and to indicate that it represents a tuff possibly derived from a dacitic lava, and with which there was more or less land waste intermixed at the time it was deposited.

SUMMARY AND CONCLUSIONS.

From the facts presented, the conclusion is that the slate series as a whole is probably sedimentary. The material was volcanic flows, breccias, tuffs, ash and possibly mud. Mixed with the tuffs and ash were varying amounts of land waste, which were in large part derived from the rapid erosion of masses of tuff and ash. The series is much compressed and considerably metamorphosed locally, especially in the vicinity of the Gold Hill fault, but for the most part it is fairly massive, presenting only the alterations which take place in such rocks as the result of weathering.

It is, therefore, believed that the series is a unit and represents a period of continuous deposition, the original variations in the material laid down depending upon the intensity of the volcanic activity at that time. It is also believed that the "chloritic" and "argillaceous" slates and schists of Nitze and Hanna are only the results of local metamorphism since deposition.

No basis for a younger series of true slates, the "Monroe slates" could be found. Indeed, it is clear that no such series exists, and that the "Monroe slates" differ from the other slates and schists of the region only in degree of metamorphism which different areas in the formation have suffered.

GREENSTONE.

Lying to the west of Little Buffalo Creek, between the slate contact and the diorite area on the western edge of the district, is a rather large area of highly metamorphosed basic igneous rock, which will be described under the general term greenstone. The rock, while in some places fairly massive, is so highly altered that the microscope reveals very little as to its original character. Along its eastern border near the Gold Hill fault, it is highly schistose — a greenstone schist, probably more correctly called a chlorite epidote schist. In some places, especially in the Beaver Hills, it is fairly massive and presents a decided porphyritic appearance, which suggests a surface flow of basic lava. Associated with this porphyritic facies of the rock, and along its eastern border where the metamorphism has been most intense, it contains elongated areas or bands of decidedly tuffaceous material; if not tuffaceous, at least fragmental, possibly a flow breccia. It is best exposed in the Beaver Hills, especially at Five Pines, along Swope's Branch, and in many places on Buffalo Creek, especially well in a bluff near Barringer's mill. In places, it carries a little auriferous copper ore and is well exposed at some of the prospect holes. The porphyritic variety is seen on the dump of an old shaft about one mile northwest of St. Stephen's church. The massive phase, not decidedly porphyritic, is seen at the Hopkins Mine and at the Cline Mine (see p. 113) and the tuffaceous rock is well exposed at two or three prospect shafts between Five Pines and the Coates's diggings.

Macroscopic description.—In the hand specimen this rock represents a very dark greenish gray color, the weathered surface being deep rusty brown. In the more massive facies there are readily distinguished two kinds of phenocrysts, black or very dark green hornblende and greenish yellow epidotized feldspars. The hornblendes are either in short stocky prisms or have an elongated prismatic development, sometimes being 1.5 cm in length by .3 to .5 cm in width. It is uniformly present and is plentifully distributed throughout the rock. The feldspar phenocrysts are not discernible in all phases, but when present are usually abundant. They have either a flat tabular or a lath-shaped development, and are always more or less epidotized, presenting a greenish yellow color. In size they are smaller than the dark phenocrysts, never being more than one centimeter in length. When present, they give the dark greenish gray rock a decidedly spotted appearance. The groundmass is of a dark greenish gray color and is so fine in texture that the unaided eye can not distinguish its character.

The tuffaceous facies is so badly mashed and so fine in texture that its character can not be recognized with the unaided eye. It appears to be a greenish gray, highly schistose rock, with irregular, drawn out patches of varying color. These patches mark the position of the original fragment which differed more or less in character from the matrix in which they were enclosed.

In all phases of the rock, jointing is prominent, the fractures often being filled with quartz and epidote, the surface presenting an irregular network of these veinlets. In certain places the quartz-epidote veins attain considerable size, 12 inches to 5 feet in width, and are often more or less mineralized, the minerals being pyrite, chalcopyrite, bornite, and chalcocite. (See p. 112).

Microscopic description.—Thin sections were made from a number of specimens of the more massive phases of this formation and the microscope reveals the presence of the following minerals named in the order of their formation: iron ores (magnetite and ilmenite), feldspar (orthoclase, plagioclase varying from andesine to basic labradorite), green hornblende, a slightly pleochroic pyroxine, probably augite, and such secondary minerals as epidote, zoisite, chlorite, calcite, kaolin, and quartz.

The feldspars were either too badly decomposed or were not cut properly for definite determination. A few sections were determined by the Michel-Levy methods and were found to range from medium andesine to rather basic labradorite, medium labradorite predominating. The feldspars seem to have a good crystal development, and show both albite and pirecline twinning and in many instances, good zonal structure. Orthoclase is doubtfully present, and if it does appear is restricted in development.

Hornblende of two varieties occurs; the ordinary green uralitic, and very sparingly developed a dark brown variety. Both present no unusual characteristics. The green variety seems clearly to be of secondary origin, possibly developed from an original pyroxene, probably augite. In weathering it begins to show, first, a kind of "mottling;" next a bleaching and loss of color; and finally loses its birefringence and becomes chlorite. It shows a good prismatic development when occurring as phenocrysts, but does not have well defined crystal outlines. The edges and ends of the crystals always present a ragged or "frayed out" appearance, and generally are well sprinkled with grains of the black iron ores.

Pyroxene is not extensively present in the rock, but was recognized in nearly all the sections examined. It is brownish in color, only slightly pleochroic and is thought to be augite. It also tends to include grains of the black ores or to be surrounded by them.

The secondary minerals, epidote, zoisite, kaolin or sericite, chlorite, sphene, calcite and quartz, the latter sparingly present, possess apparently the same characteristics as in the diorites. (See pp. 45-52).

Variations.—As was stated in the beginning of the chapter, there are two prominent varieties of this rock, the massive phase and the tuffaceous. In addition to this there is a slight variation in texture of the massive rock. It is sometimes more decidedly porphyritic than others. The tuffaceous facies is also variable in that the fragments vary in size and number. Near the contact with the slate formation to the east, the greenstone is mashed and metamorphosed into a fairly typical chlorite-epidote schist. This seems to be only a local metamorphic phenomenon, since as distance from this contact increases, the rock begins to assume its more massive character.

Classification.—Both macroscopic and microscopic characteristics of this rock indicate that it was originally a basalt, although some characteristics point toward the andesitic origin. But it is believed that the evidence is stronger in favor of its being metabasalt. Since the material at hand will not permit a definite determination without a series of chemical analyses, for which there has been neither time nor opportunity, the rock is tentatively called a greenstone.

Weathering and soil.—Like the other rocks of the region, the greenstone is deeply weathered and for the most part covered with a thick mantle of residual decay. The tuffaceous and schistose facies weather much more rapidly than the massive rock, and exposures of these are rare, and are found only in stream beds or in artificial cuttings and excavations. The more massive variety resists weathering much better, and forms the highest elevations of the southwestern part of the area—a long, deeply dissected ridge known as the Beaver Hills.

The soil from this rock is a deep, slightly brownish red, highly plastic clay with very little grit. The color is a deeper and more intense red than that of the diorite and there is never the bluish gray soil which is found in the adjacent diorite area. The soil differs also from that of the diorite in that it contains less sand. It is only fairly fertile and is not first-class farming land.

Relations to other rocks.—Thus far it has been possible to fix definitely the relation of this formation to only two other formations of the area, the diorite and the granite. These relations are given in detail in the descriptions of these rocks. The diorite and granite are both younger than the greenstone and intrusive into it. For details as to its relation to these see pp. 51, 55.

Its relation to the slate formation, which in many ways the schistose facies closely resembles, can not be definitely determined. The line of contact is the Gold Hill fault line. It is believed that the basaltic flows and tuffs of this formation represent material nearly contemporaneous with the volcanic material in the slates and possibly from the same source only at a different period of volcanic activity. It is believed also that the greenstone area is on the up-throw side of the fault line (see pp. 68-71), and if this be true, this formation probably represents a period of activity prior to the rhyolitic, dacitic, and andesitic lavas, and is only a more basic differentiation from the same magma.

DIORITE.

Diorite is the predominant rock of the northwest portion of the district, occupying as it does one third of its western half. It forms an irregular area of varying width extending from near where the Salisbury-Stokes Ferry wagon road crosses Second Creek, about one mile northwest of Garfield (Tyack's store), to the extreme southwest end of the district. Its greatest width is in the southwest end of the area a short distance west of Five Pines, where the map includes a strip about 3 miles wide. The narrowest portion is near where the Gold Hill-Salisbury wagon road crosses Second Creek. At this point the width is about one mile. A line drawn from Cross Roads to Second Creek at the crossing just referred to would represent a distance of about 15 miles and would lie wholly within the diorite area.

Although this rock has a very considerable distribution, it is by no means prominently exposed at the surface. Indeed, exposures are rare and for the most part limited to rounded boulders, and it is only in some of the stream beds and in road excavations that exposures of the solid rock were found. Probably the best locality for field study of the rock is in the immediate vicinity of St. Peter's church and in the area lying to the northwest of this church. It is also exposed along the Salisbury wagon road west of the Peddler's store, along the Beattie's Ford road immediately northeast of Lower Stone church, and in the vicinity of Cross Roads. Even though the exposures are scarce, there is little difficulty in delimiting the area of this rock. The soil which it produces is quite different in color and character from that of the other rocks, and its contacts can be followed with a reasonable degree of accuracy. (See Pl. VIII, A.)

Macroscopic description.—In the hand specimen the diorite is a fine to coarse granular rock of dark or medium gray color, and generally has a slight greenish tinge. The finer-grained facies is always darker in color than the coarser rock. It varies greatly in texture, at times becoming a coarse rock in which large and distinct crystals of dark hornblende lying in irregular areas of light gray feldspars may readily be distinguished. Again, it may be so fine grained that it is difficult to distinguish the character of any of the component minerals with the unaided eye. Between these two extremes there is every gradation. There is readily seen to be a great variation in the relative amounts of the dark and light-colored minerals present, the rock sometimes being highly feldspathic and again showing a preponderance of the dark minerals. Upon close examination, almost every specimen shows the presence of quartz, and at times there is an appreciable amount present, enough to cause the rock to be called a quartz-diorite or granodiorite. The quartz is more plentiful in the finer-grained variations of the rock and can scarcely be distinguished in the coarser varieties; but the microscope reveals its presence in them.

In field exposures this rock is usually a rusty gray color, the boulders in which it occurs somewhat resembling those of diabase, but always of a more decided greenish gray color than the diabase boulders. The rock has been closely jointed and in some places shows the evidence of considerable mashing; but, as a rule, is fairly massive. The joint blocks weather into rounded boulders to which the people of the region apply the name "nigger heads."

Microscopic description.—The microscope reveals the presence of the following minerals, named in the order of their formation: black ores, magnetite and ilmenite, apatite, biotite, green hornblende, augite, orthoclase, plagioclase varying from albite to labradorite, and quartz. The following are also present but are of secondary origin: epidote, zoisite, sphene, kaolin or sericite, chlorite, quartz and a small amount of calcite.

Apatite is not plentiful and shows its usual prismatic development. The iron ores occur as grains, or anhedra, and are usually in close relation to the hornblende and pyroxene, either included in these or having an irregular distribution at their immediate borders. The black grains often show a white border with high index of refraction and strong birefringence. This is especially true when the rock is badly altered.

The hornblende is the common green hornblende and occurs in crystals of varying size, according to texture of the rock; at times being 1 to 2 cm. long and .5 to 1 cm. in thickness. The crystal outlines are only fairly good and the boundaries are generally ragged. Basal sections show well the typical hornblende cleavage without good crystal boundaries. Prismatic sections present ragged and "frayed out" edges around and in which the grains of the ores tend to concentrate. At times this mineral shows a decided tendency to include small rounded grains of feldspar poikilitically, and at others it appears to hold its own boundaries against the feldspars. It presents the usual pleochroism and is often twinned in the usual manner. The most notable phenomena presented by this mineral is its tendency to intergrow with or include the pyroxene when this mineral is present in the section. In these intergrowths the two minerals present very irregular boundaries. These are always sharp and distinct and each mineral possesses up to the very edge its own peculiar optical properties. There appears a decided tendency on the part of the intergrowths to have parallel orientations.

The pyroxene is of a somewhat light brown color, not strongly pleochroic, does not have good crystal outline, and is generally intergrown with the hornblende as described above. From its general optical properties, it is thought to be an augite, probably diallage. It includes grains of ores and from its relations to the hornblende seems to be contemporaneous with it in formation. It is sparingly present, but is widely distributed.

The feldspars range from orthoclase to labradorite. Orthoclase is sparingly present and occurs in medium-sized crystals, often beautifully zoned and generally showing the usual Carlsbad twins. The zoning is of the usual order and the different zones tend to have better crystal outlines than the whole crystal which they form.

The plagioclase is medium to fairly acid. The few sections that were cut so as to permit determination by the Michel-Levy method showed medium andesine and labradorite. Some sections which could not be determined presented much finer striations than those that were measured, and in the position of extinction did not present so much contrast between the different portions of the crystal. These seem to be more acid in character, probably oligoclase. The plagioclase presents the usual phenomena as to twinning and at times shows well developed zonal growths.

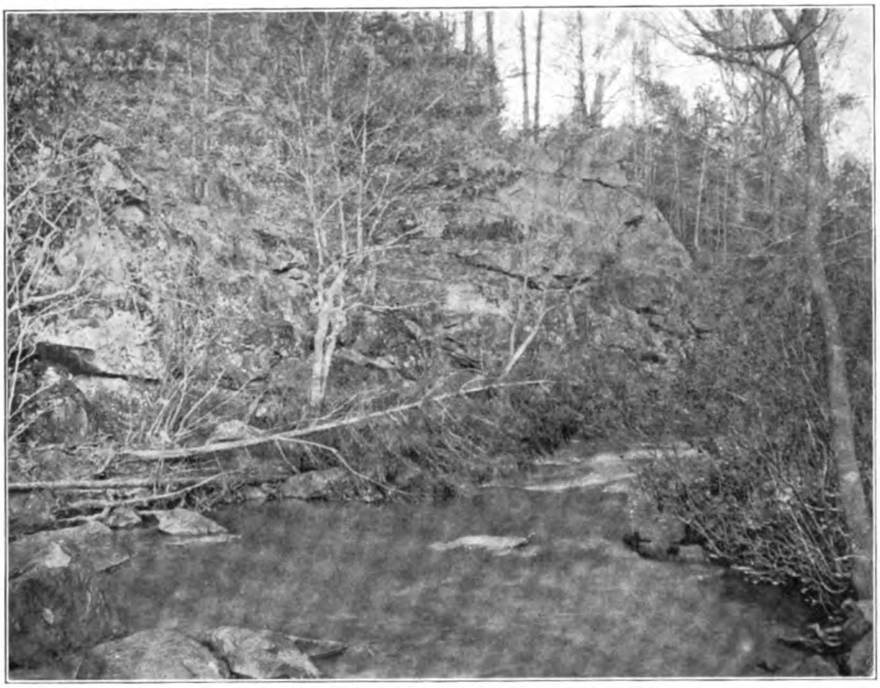
The feldspars are all badly altered and, in addition to the usual kaolin, sericite, etc., contain many large and small grains of epidote and zoisite.

Biotite is not an abundant mineral and, when present, is in rather close relation with the amphibole. It occurs as irregular scales and plates with ragged edges, and is likely to be in close proximity to the ores. It presents no unusual characteristics. In several specimens examined it was not present and seems to be confined to the finer-grained quartz-rich variety of the rock.

Quartz is present in every specimen examined, but has a greater development in the finer-grained facies of the rock. It is allotriomorphic in form and is clearly the last mineral to solidify. A part of the quartz is probably of secondary origin, but it is believed that when it holds well developed and fresh anhedra of hornblende and feldspar as it does in these rocks in many cases, it is an original mineral of the rock. That it is a constituent mineral of the rock is further indicated by the prevailingly sandy soil produced by the weathering of the finer grained diorite.

Sphene is not abundant but is present in nearly every section studied. It generally occurs in close relations to the ilmenite or in many cases with the hornblende. It possesses no unusual properties. Its relations as just stated, suggest a secondary origin for the mineral.

Alteration products.—The minerals mentioned as secondary are the results of the alteration of the original minerals of the rock. They consist of epidote, zoisite and probably clinozoisite, chlorite, kaolin, sericite, biotite (?), sphene, quartz and calcite. Almost every section of the rock presents numerous examples of nearly all these minerals; those of rarer occurrence being biotite and calcite. The others are invariably present. The first minerals to alter appear to be the feldspars. This is the usual kaolinization and presents no unusual phenomena. Next in order follow the amphiboles and pyroxenes, the incipient stages being shown in the hornblende, for example, by a mottling and finally a fading of the color. This is best seen in the prismatic sections in which the patches of lighter color are readily noticeable. Following this and probably contemporaneous with it, there occurs the formation of black iron ores and in some cases apparently sphene. The progressive steps of the alterations could not be followed. The final product seemed clearly to be a chlorite for the bisilicate mineral, and either zoisite or epidote around the borders of the space originally occupied by the hornblende, and in the adjoining feldspars. In some instances, especially where the rock has been mashed slightly, instead of the usual chlorite, were often developed numerous small scales and plates



A. Typical diorite outcrop, east of Gold Hill district.

B. Granite dike cutting diorite, near Miller's old mill place, 5 miles northwest of Gold Hill.

of biotite. The feldspars, in addition to the widespread and usual kaolinization, show an extensive change into epidote and zoisite grains; irregular areas of these minerals were present in nearly every feldspar.

In the hand specimen of the coarser phase of the rock the weathered surface is deeply pitted and exceedingly rough owing to the weathering out of the feldspathic constituent, thus leaving the irregular, projecting areas of hornblende.

Variations.—As previously stated, this rock presents numerous variations in color, texture, and the proportions in which the constituent minerals are present. There appears to be no regular distribution of the different facies of the rock, although it does seem that the coarser variety has its best development in the region around and to the northwest of St. Peter's church. It is probably true that the best development of the fine-grained and quartz-rich variety is immediately southwest of the Peddler's store, near Bethany schoolhouse. This statement, however, can be true only in the most general way, for great variations take place in short distances.

These variations can not, with the present knowledge, be described in great detail. It appears, that the three following facies are well defined:

1. A coarse variety in which the dark mineral is equal to or exceeds the feldspathic constituent of the rock. This gives a coarse granular rock of dark gray color with a slight greenish tinge.

2. A rock similar in texture to the above, in which the dark-colored constituent is subordinate to the light colored feldspathic constituents. This rock is similar to the first, but it is of lighter color. This facies is of limited distribution, and was found only in the region immediately west of Five Pines.

3. A close-grained, dense, granular rock, rich in quartz, forms the other prominent variation. This is the prevailing type of rock over most of the diorite area. It is by no means a uniform rock and many variations toward each of the other types occur. It is characterized by its fine grain, its abundance of quartz—seen readily with the unaided eye—and its dark gray color. It is well exposed in a small ravine northwest of Bethany schoolhouse, along the Beattie's Ford road near California Branch, near Mount Olive church, and in the vicinity of Cross Roads.

While the three facies just mentioned appear prominent when examined in the field and in the hand specimen, the microscope shows the presence of the same minerals in each type; the only difference being one of texture and the relative abundance of certain of the constituent minerals. The variations then seem clearly to be all of one magma solidifying possibly under slightly differing physical conditions which might allow a difference in the size of the minerals and a slight local variation in the composition of the magma.

Classification.—It is seen from the foregoing that this rock, in mineral composition and in habit a massive, granular, plutonic rock of decided granitic texture, agrees well with the diorites. The variety rich in quartz might be termed a quartz-diorite or a granodiorite.

Weathering and soil.—The first marked feature in the weathering of the diorite of this region is a whitening or "deadening" together with more or less staining of the feldspar. This is immediately followed by a bleaching of the hornblende and oxidation of the ferrous iron, giving a decided reddish brown color to the mass. The intensity of the color depends apparently upon the extent of decomposition of the bisilicate minerals and the amount of hydration of the resulting iron oxide. Many of the granitic rocks, especially granite, in this region show the effects of weathering by only a decided disintegration with varying degrees of decomposition. This is true of the diorite only to a limited degree. Decomposition seems to be the prevalent feature of the weathering process—that is, the phenomena consist of chemical changes to a greater extent than physical. There are two distinct types of soil produced by this class of rocks, seemingly depending upon the physical condition under which the process takes place. One type consists of a deep, slightly brownish red, highly plastic clay with a moderate amount of free quartz, this latter feature depending upon the amount of quartz in the original rock. In this type the process seems to have been carried to completion and the resulting soil is simply a clay with which is mixed more or less humus.

The second type of soil has a decided bluish gray color, is not very plastic and is gritty from both quartz and partially decomposed particles of the other minerals. This type of soil does not appear to be as fertile as the former. Between these two extremes there is every gradation. It would seem that while the two types of soil appear to be distinct, they are really only two stages in the weathering process; in the former the process has been carried to completion, while in the latter it has not. The former has by far the wider distribution and excellent examples may be seen in almost any portion of the area. Probably the most typical soil of this type is found near where the Gold Hill-Salisbury road crosses Second Creek. The latter type is much restricted and is found only locally. The best example is in the vicinity of Cross Roads. In all cases the decay extends to great depth from 50 to 150 feet, and exposures of the fresh rock are not numerous except as rounded boulders, and even these are wanting over large portions of the area. The soil, however, is distinctive, even when the rock is hidden, and forms a not exceedingly difficult criterion for delimiting the formation.

Relation to other rocks.—The diorite is clearly an intrusive rock, in relative age the oldest intrusive of the district. The greenstone which forms the greater portion of its eastern boundary, is considered the rock into which the intrusion took place, while the granite is clearly intrusive into both the diorite and greenstone. Actual contacts between the diorite and greenstone could not be found, for everything was deeply buried beneath the rock decay. Thus the relation of these two rocks to each other is to a certain extent a matter of inference. The conclusion is based upon the following observations:

1. The greenstone is more highly metamorphosed than the diorite.

2. Dikes of diorite are found cutting the greenstone. These dikes are of two distinct periods of intrusion; one set cutting the other and both cutting the greenstone.

3. The diorite clearly appears to make a contact against the greenstone. In every instance where specimens of the diorite could be obtained in near proximity to the greenstone, they were finer in texture than the main diorite mass, or presented a more or less well-developed porphyritic texture.

Although the rocks were not found in actual contact with each other, it seems reasonably safe to conclude from the above observations that the diorite is younger than and intrusive into the greenstone.

The conclusion that the granite is intrusive into the diorite and does not represent a differentiation from the same magma is based upon the following observations:

1. The granite is by no means as highly metamorphosed as the diorite.

2. Numerous dikes of the granite are found cutting the diorite. The reverse is not true. (It must be stated here that there is a set of fine-grained diorite dikes which do cut the granite. This for a long time produced great confusion, but finally an exposure was found which showed a fine dike of granite in the typical diorite with two dikes of the fine-grained diorite cutting both the typical diorite and the granite dike. This exposure is in the bed of a branch of Second Creek near Miller's mill place).

3. The granite and diorite were found in actual contact in one place—at Godman's spring near St. Peter's church where is a well-defined and distinct contact. The granite for a short distance from the contact is decidedly porphyritic—resembles a quartz porphyry and, as the distance from the contact increases, it gradually resumes its usual texture. The diorite at the contact is changed into a well-defined hornblende schist, highly micaceous at the immediate contact. As

distance from the contact increases; the diorite gradually assumes its usual character.

THE GRANITE.

There are two areas of granite included within the map. One extends as an irregular area from the northwestern corner of the sheet to a short distance southwest of the Peddler's store. The other area is smaller and shows in the district near Rockwell extending as a kind of blunt projection with irregular boundaries, northeastward for a distance of about 2 miles. In addition to these two main areas, there are two or three small patches standing up as islands in the diorite. The largest of these "islands" is located on a branch of Second Creek near Miller's old mill place. It is typical granite and does not differ essentially from the main granite mass. It has a circular outline and is about one-half mile in diameter. The other, a small patch only a few square yards in extent is located about one mile southwest of the Peddler's store. This exposure, though small, is interesting in that it contains as inclusions a number of fragments of the greenstone, thus showing clearly the relative ages of the two rocks.

Many granite and aplitic dikes are found in both the diorite and greenstone in near proximity to the granite. These vary in width from a few inches to a number of feet. They are well exposed in the vicinity of the old mill place referred to above, and in the wagon road and the beds of Black Run and Buffalo Creek at Foil's mill. This latter exposure appears to be more extensive than a set of dikes and may represent another "island" of the granite in the greenstone.

It is remarkable that no dikes of the granite of aplite are found in the slate formation. Along this line of contact extending from the Peddler's store to the Yadkin River, a distance of more than 15 miles, not a single granite dike was found in the slate, while near its contact with the other formations dikes are numerous. This is strong evidence in favor of a fault contact between the granite and the slate. (See pp. 68-71)

The granite has a wide distribution, but as a surface rock is rare. It yields readily to weathering agencies and is generally so deeply buried beneath its own residual decay that about the only surface indication is the light colored sandy soil. A few exposures are found here and there. Large "sappy" boulders are found along the Gold Hill-Salisbury wagon road about one-fourth mile northwest of Second Creek. It is exposed in the railroad cuttings near Rockwell, in the bed of a small branch near Miller's old mill place and in an open field about one-half mile southwest of Garfield, (Tyack's store). The best exposure of the fresh granite is on the land of Mr. Holtzhauser about one mile north of the Peddler's store. At this point there has been a small quarry opened in order to obtain stone for local use. The rock here is perfectly fresh and easily accessible.

Macroscopic description.—There are two distinct facies of the granite, one a medium-grained light gray variety which contains a moderate amount of biotite, and in which the feldspathic constituent has a greenish yellow tinge due to epidotization.

It is highly quartzose and is by far the prevailing type forming probably nine-tenths of the whole granite area. The other is a fine-grained rock with a decided aplitic appearance. This phase has a less lively gray color than the other and is poorer in both quartz and biotite. In color, texture, and mineral content it closely resembles the granite dikes. It is deeply weathered, poorly exposed, and found in most characteristic development along the wagon road leading southward from Rockwell. Boulders of this rock occur in many places throughout the Rockwell area, except near the center where it has about the same characteristic as that of the main mass. It is thought that this phase may represent a border facies and that the magma of both areas is one and the same intrusion. In the field and hand specimens it appears to be comparatively free from segregation patches or "Schlieren"; and inclusions of the country rock are rare, and were found in only one locality—the small area referred to about one mile southwest of the Peddler's store. At this point the granite contains good, fresh and little metamorphosed fragments of the massive phase of the greenstone. A boulder found at this place contained as an inclusion a small piece of the typical diorite.

Microscopic description.—When examined in a thin section under the microscope, this rock was seen to be made up of the following minerals named in the probable order of their formation: apatite, zircon, biotite, orthoclase, microcline, plagioclase and quartz. As secondary minerals, the following are present: epidote, zoisite, muscovite, kaolin and chlorite. The texture or fabric of the rock is typically granitic, the quartz and feldspars being present in two sizes. Medium-sized, fairly well-developed phenocrysts of feldspar and quartz lie in a groundmass of the same minerals of a decidedly finer grain, thus giving the rock a texture, which somewhat suggests a granite porphyry.

Apatite appears in the usual needles and presents only its normal characteristics. Zircon, sparingly present, occurs in small grains. Biotite, not widely distributed, is more or less stringy with ragged edges, and possesses its usual pleochroism.

Orthoclase is present in fairly well-formed tabular crystals, often showing the usual Carlsbad twinning, and generally much kaolinized.

In addition to the crystals it is present in more or less irregular areas and in these often shows a decided tendency toward a micropegmatitic intergrowth with the quatrz. Microcline is subordinate to orthoclase. Plagioclase occurs in fairly well-formed crystals, shows narrow striations and much zonal development. Determinations by the Michel-Levy method indicate albite and oligoclase with a considerable amount of more basic feldspar. Plagioclase is present in a larger amount than the alkalic feldspar. It shows the usual alterations and, when near the ferromagnesian minerals, it is very likely to have epidote and zoisite largely developed in its interior and also in and around its margins.

Quartz is abundant, is clearly allotriomorphic, and shows strong undulatory extinction.

The minerals all show that the rock has been subjected to rather intense dynamic metamorphism. Their borders are generally granulated and all show markedly the undulatory extinction.

The secondary minerals occur in their customary manner and possess no unusual features.

Chemical analysis.—The following is an analysis of a representative specimen of the freshest rock that could be obtained.

ANALYSIS OF GRANITE.

SiO_2	76.89 per cent	H_2O-	0.00 per cent
Al_2O_3	11.47 " "	H_2O+	0.16 " "
Fe_2O_3	1.77 " "	TiO_2	0.11 " "
FeO	0.87 " "	MnO	0.05 " "
MgO	0.36 " "	S	0.00 " "
CaO	1.63 " "		
Na_2O	4.42 " "		100.23 " "
K_2O	2.50 " "		

Classification.—The microscopical and chemical examinations both show that the rock is highly silicious granite. It is seen to be rather rich in soda, but this is characteristic of the Southern Appalachian and Piedmont granites. Very little accurate chemical work has been done upon the granites of North Carolina, but texturally and mineralogically, they correspond closely with the granites of Georgia and may be expected in a general way to conform chemically with the Georgia granites. Watson[21] says of the Georgia granites.

"Their (the granites) most distinguishing feature is their relatively high percentage of soda, which is above the average for normal granites. The soda and potash contents approximate nearly equal percentage amounts in a majority of the analyses; but, in some, the potash exceeds the soda while, in others, the soda is in considerable excess over the potash. * * * An average of twenty, ten and twelve analyses of the normal granites, porphyritic granites and granite-gneisses, respectively, gave the following mean percentages of soda and potash, 4.73

[21]Granites and Gneisses of Georgia, Thos. L. Watson, Bull. 9. A Geological Survey of Ga., p. 23, *et seq.*, Atlanta, 1902.

per cent Na_2O and 4.71 per cent K_2O, for the normal granites; 4.33 per cent Na_2O and 4.59 per cent K_2O for the porphyritic granites; and 4.16 per cent Na_2O and 4.63 per cent K_2O for the granite gneisses."

Weathering and soil.—In weathering, the first change that takes place in the granite is one of color; the weathering film becomes dull and grayish or a rusty brown of varying intensity. The feldspars lose their luster and the dark minerals are bleached, while the whole layer loses its tenacity and varies from fairly firm and solid material to that which will crumble upon the slightest touch. The staining and loss of luster of the component minerals extend to considerable depth from a few inches to several feet—but it is only a thin layer that crumbles so easily. The feldspars seem to be the first minerals to alter and often the weathered rock surface presents a pitted appearance with the quartz forming the irregular projections. The final stage is generally a light-colored sandy loam, which in places apparently depending upon physical conditions, vegetation, etc., is decidedly clayey and colored a deep rust red. Granite soil is generally fairly fertile, and is considered good farming land. The granite is the least resistant to weathering of all the rocks in the district and good, or even any, exposures are rare. The resulting soil has such decided characteristics when contrasted with that of the other rocks that it forms a fairly safe criterion for delimiting this formation from the others.

Relations to the other rocks.—This subject has been discussed in more or less detail elsewhere (see pp. 45, 51) and will only be summarized here.

The field and laboratory evidence clearly warrant the statement that the granite is intrusive into the diorite and greenstone. Inclusions of each of these rocks are found in the granite, and dikes of the granite are found cutting both. Also the granite clearly makes an intrusive contact with good metamorphic effects against both diorite and greenstone.

The relation to the slate formation seems to be different. There is, as far as could be determined, absolutely no thermo-metamorphic effects upon either formation. The granite is normal, except for slight mashing, up to the very contact, and the slates at such points show no such results of metamorphism as the diorite shows at its contact with the granite. (See p. 51). There are also no granite dikes penetrating the slates. The nearest approach to such are many quartz veins which are by no means confined to the near proximity of the granite. They are more numerous near the latter. All these facts, therefore, point strongly to a fault contact between these formations, and such is believed to be the case.

DIKES.

This subject has been mentioned in a general way in another place (see pp. 23-24), but will now be discussed in greater detail.

In this area, as in all parts of the Piedmont Plateau, dikes are numerous and one of its interesting geological features is their great number and variety. No formations are exempt from them and as regards age, they probably extend from the early Paleozoic to the late Tertiary.

The dikes of the Gold Hill district may be divided into the following groups or classes, named in their probable age order: diorite, granite and quartz-porphyry, gabbro, diorite and diabase.

DIORITE.

During previous work in many parts of the Piedmont Plateau,[22] the relation of the diorite dikes to each other and to the granite which was clearly younger and intrusive into the main diorote masses, caused no little confusion. At one point the granite was clearly intrusive into the diorite and presented a series of dikes cutting the diorite near the borders of the granite rock, with no dikes of diorite in the latter. At another point, the relations of the two rocks were apparently similar, but the granite was cut by dikes of typical diorite, with, or without the presence of the granite dikes in the diorite. With this in mind, close and detailed observations were made in and around the granite borders where dikes of the two rocks were likely to occur. The study indicates that there are present in the district diorite dikes of two different periods of intrusion, one older than and in no case cutting the granite, and the other younger than either granite or diorite and cutting both. The best exposures of the older series of dikes are in the bed of Black Run near Foil's mill where a large diorite dike is exposed in the greenstone.

The younger diorite dikes are well exposed in the bed of the creek at Miller's old mill place. At this point the typical massive diorite is cut by a well-defined granite dike and both rocks are cut by younger dikes which appear to be diorite.

Macroscopic description.—The two systems of diorite dikes present no essential differences in texture and mineral composition, except possibly that the rock of the older dikes is more highly altered than that of the younger series. To the unaided eye they present a greenish gray color, usually possess a dense, fine-grained texture in which the individual minerals are not easily distinguished. At times, especially when the texture is very fine, the rock resembles a diabase, but by a close scrutiny reveals the feature of a diorite.

[22] Building and ornamental stones of North Carolina, Thos. L. Watson and F. B. Laney, Bull. 2, N. C. Geol. Survey, 1906.

Microscopic description.—Under the microscope the rock is seen to be composed of the same materials, as far as could be determined, as those in the finer-grained facies of the diorite, of smaller size and without the abundance of quartz which when present at all, appeared to be wholly secondary. In all the specimens obtained the feldspars are so badly altered that their identification was impossible. The texture of the rock, while much finer, is similar to that of the diorite.

GRANITE AND QUARTZ PORPHYRY.

Acid dikes are numerous, especially near the periphery of the granite stock. They consist for the most part of a fine-grained aplite-like phase of the granite of the main stock. Indeed, in the hand specimen, it is impossible to distinguish between the specimens from the larger dikes and those of the fine-grained granite. Dikes of quartz-porphyry are rare; only two were found in the whole area. One of these is crossed by the County Line road about one mile west of the Whitney Company's mine, and the other shows in the roadside of Beattie's Ford road about one mile northwest of Gold Hill. Both these dikes are small; about 15 to 20 feet wide. They are much fresher than the schists into which they have been intruded and do not show the effects of such intense dynamic metamorphism as these rocks.

Granite dikes are seen in their best and most typical development near Miller's old mill place where two occur in the bed of the branch, and four or five more may be seen along the Rockwell road near this place. These dikes are small, perhaps never more than 50 feet in width (See Pl. VIII, B.)

Microscopic description.—The freshest material available from the granite dikes was selected for microscopic examination, but even this was so much weathered that it was unsatisfactory. The feldspars were so badly altered that they could not be definitely determined. Both orthoclase and plagioclase are present in about equal amounts. The plagioclase shows rather narrow twinning lamination and seems to be near the acid end of the series. Biotite is present in every section examined and shows its usual pleochroism and other characteristics. In some instances it shows incipient alteration by a bleaching, and finally passes into chlorite. The usual secondary minerals, kaolin, epidote, zoisite, and chlorite, are present and do not differ in character from similar minerals in the granite of the main stock. The texture is finely granitic—similar to that of the main mass, but finer grained.

The sections of quartz-porphyry show both quartz and feldspar phenocrysts in a cryptocrystalline groundmass of quartz and feldspar with oftentimes a decided suggestion of the micropoikilitic texture.

The quartzes show the usual embayments and anhedral forms common in such rocks and contain inclusions of both solid and apparently gaseous matter. The feldspar phenocrysts consist of both orthoclase and rather acid andesine. They often have irregular boundaries or rounded outlines, with sometimes "frayed out" edges and are apparently more numerous than the quartz. Nothing in the way of ferromagnesian minerals was identified in the sections studied. The usual alteration products were present.

GABBRO.

Badly altered rocks, apparently belonging to this group, have a wide distribution throughout the district. They were found in all other formations. In the diorite this rock was found in abundance in the region between St. Peter's church and the Gold Knob Mine. It is well exposed in a field lying immediately south of the granite tongue that protrudes into the diorite at this place, where the rock is fresh and has a considerable development. It probably occurs in the form of a large dike, but no definite boundaries could be determined. It is again found in the vicinity of the Moose schoolhouse near Mount Olive church and is well exposed in the bed of Black Run near the Cline Mine. At this point it is clearly a dike.

In the slate formation northeast of Corinth church is an elongated lens-shaped area of badly altered intrusive rock that has the characteristics of a saussuritized gabbro. Similar material, probably a continuation of the same intrusion, shows along the roadside about three-quarters of a mile southeast of Bringle's Ferry as a series of three large dikes. This rock seems to have resisted erosion better than the slates and a series of rapids mark the place where the Yadkin River crosses the dikes. It was not found in slates of the central or southern portion of the area. It is known to have an extensive development immediately to the northeast of the limits of the map, some reconnaissance trips having been made into this region which disclosed two or three large areas of the rock.

While these two areas are thought to be similar and in this paper are so classified, the latter is so badly metamorphosed that its original character can not be positively demonstrated without a more extensive chemical and field examination than the importance of the rock appears to warrant. The two occurrences will, therefore, be described in detail separately.

Macroscopic description of the fresh gabbro.—As seen in the hand specimen, this is a coarsely granular rock of a black or very dark gray color and possesses a kind of glossy luster on a freshly fractured surface. Upon close examination this luster is seen to be caused by large dark glossy areas which give parallel reflecting planes. Upon still closer examination these areas are found to be really large sponge-like phenocrysts of hornblende in which are included numerous other constituents of the rock, notably little grains of feldspar. Other black or greenish crystals, smaller than the great hornblende sponges and apparently free from inclusions, are well distributed throughout the rock. The feldspars are generally small and add nothing to the appearance of the rock except its gray color. At times is observed a large feldspar which, when examined in proper light, is seen to possess much of the beautiful iridescence of labradorite. Pyrite in small grains has a wide distribution throughout the rock.

In the field the weathered blocks of this rock are likely to have a pitted surface due apparently to differential weathering among the constituent minerals. This is probably caused by the resistance of the purer phenocrysts of augite which withstand weathering better than the great hornblende sponges and hence are left as projecting masses. The feldspars do not withstand weathering as well as the ferromagnesian minerals.

Microscopic description.—The thin section of this rock under the microscope shows the presence of the following minerals named in their probable order of formation: black iron ores, olivine, hypersthene, augite (probably diallage), plagioclase, quite basic varying from labradorite to anorthite; and hornblende. The following secondary minerals are present: epidote, zoisite, uralitic hornblende, chlorite, sphene, kaolin, calcite, and a small amount of quartz. The texture of the rock is somewhat peculiar in that it has characteristics of both gabbro and diabase, with those of gabbro probably predominating. The large hornblende phenocrysts are seen to be veritable sponges filled with grains, anhedra and crystals of the other minerals giving a typical poikilitic texture. The groundmass of the rock presents long lath-shaped feldspars and has a decided pilotaxitic structure. In some sections there is a remarkable scarcity of black iron ores, while in others they are numerous and large, suggesting more or less segregation of the ores. Some sections show a decided flow structure in that the minerals manifest a tendency to have their longer diameters oriented in the same direction.

The hornblende has more of a brownish tinge than the regular hornblende of the diorite. Aside from this, it possesses no noteworthy optical peculiarities. The phenocrysts are large, at times 1 or 2 cm. long and 1 to 1.5 cm. wide, and are irregular in outline, the edges being nearly always ragged. The order of arrangement of the minerals held as inclusions in the hornblende seems to be as follows: olivine is included in the hypersthene, and this, together with augite and plagioclase grains and crystals is engulfed in the hornblende.

The hypersthene seems in part to be older than the monoclinic pyroxene and in part contemporaneous with it. Hypersthene is found enclosing olivine which is clearly older than either of the pyroxenes, but was not seen in this relation to the augite. Again, there is at times a well-defined intergrowth between the two pyroxenes.

The feldspars occurring in the groundmass are in elongated, fairly well-formed, lath-shaped crystals, while those poikilitically included in the hornblende tend to be stouter and do not have such good crystal outlines. Measurements by the Michel-Levy method showed the feldspar to be rather basic, varying from labradorite to anorthite, the greater part being medium to basic labradorite.

The augite is probably the diallage variety. It is light greenish brown and possesses no marked pleochroism. In age it is younger than the feldspar in which it occurs and seems to fill up the interstices between the feldspar crystals. It occurs in irregular grains or masses rather than in well-formed crystals and is the predominant ferromagnesian mineral of the rock.

Chemical analysis and classification.—A number of chips from the freshest portions of this rock were taken for chemical analysis and gave the results shown in column No. 1 below. The other analyses are of gabbro from various parts of the world. They are taken from Rosenbusch's Elemente Gesteinslehre[a] and are given for comparison with the rock in question.

CHEMICAL ANALYSIS OF HORNBLENDE GABBRO.

	1	2*	3*	4*	5†	6‡	7*	8*
SiO_2	44.54	49.90	49.15	46.85	48.11	46.96	39.84	45.11
Al_2O_3	20.72	16.04	21.90	19.72	14.74	14.13	19.71	19.67
Fe_2O_3	5.84	7.81	6.90	3.22	2.54	0.76	7.73	4.32
FeO	7.30		4.54	7.99	11.85	14.95	8.89	8.57
MgO	5.56	10.08	3.03	7.75	5.10	15.97	7.33	5.65
CaO	12.67	14.48	8.22	13.10	6.72	2.32	13.52	10.45
Na_2O	1.49	1.69	3.83	1.56	2.92	0.35	1.59	3.87
K_2O	0.24	0.55	1.61	0.00	1.92	1.68	0.53	0.64
H_2O-	0.38	1.46	1.92	0.56	0.27	0.07	0.86	0.17
H_2O+	0.54				1.73	1.26		0.83
TiO_2	0.40		0.18		3.17	0.62	0.08	0.21
P_2O_5			0.33		0.44	0.03	tr	0.25
MnO	0.17				0.19	0.93	tr	
BaO	0.03				0.04			
S	0.19				0.07			
FeS_2					0.13			0.33
	100.13	102.01	101.31	100.84			100.08	100.07

* H. Rosenbusch, Elements der Gesteinslehre (2d Ed., 1901) p. 155.
† F. W. Clarke, Analyses of Rocks from the Laboratory of the U. S. Geological Survey, 1880 to 1903. Bull. No. 228 U. S. Geological Survey (1904) : 69.
‡ F. W. Clarke. Op. Cit. : 95.

1. Hornblende gabbro, near St. Peter's church, Rowan Co., N. C.
2. Gabbro, Hollmuhle bei Penig, Sachsen.
3. Hornblendegabbro, St. Louis-Fluss bei, Duluth, Minn.
4. Hypersthenegabbro, Durchschnitt von 15 Handstucken Baltimore, Md.
5. Gabbro. Limestone Cove, Unicoi Co., Tenn.
6. Granulitic Hypersthene gabbro, Minn.
7. Hornblendegabbro, Pavone bei Ivrea, Piedmont.
8. Hornblendegabbro, Lindenfels, Odenwald.

a. Elemente Gesteinslehre. H. Rosenbusch (2d ed. 1901): 155.

Analysis No. 1 was made in the chemical laboratories of the University of North Carolina by Prof. A. S. Wheeler, from material representing the typical gabbro near St. Peter's church. With this analysis there are presented seven analyses (Nos. 2-8) of typical hornblende-bearing gabbros, representing rocks of this type from various parts of the world.

By comparing this group of analyses with that of the Gold Hill rock, it will be seen that the latter rock falls naturally into this group. Its petrographic features also agree well with those of the hornblende-bearing gabbros. It is therefore classified as a hornblende gabbro. The rock also appears to be allied with both the gabbro and the diabases, and could probably be classified under either group. The resemblances to the gabbros seem to predominate slightly over those to the diabases. The fact that the rock contains hypersthene in considerable quantity, shows some tendency toward the norites; but, since the monoclinic pyroxene is present in larger amount, it is not so regarded. A somewhat similar rock has been described by Dr. Watson[23] as follows:

"Microscopic study of thin sections of the rock show it to be a norite containing much biotite composed of monoclinic and orthorhombic pyroxenes, largely hypersthene, plagioclase, a little orthoclase, some hornblende, a sprinkling of quartz and titaniferous magnetite.

"The texture is intermediate between typical ophitic and granitic with a stronger tendency toward the former or diabasic texture. Hypersthene is in massive, irregular individuals without definite crystal outline, displaying the usual cleavage and strong pleochroism. The remaining pyroxene is non-pleochroic and of very pale greenish color by polarized light. * * * Many deep brown, strongly pleochroic plates of biotite are distributed through the thin section. * * * Abundant small grains and crystals of black iron oxide form inclusions in the pyroxene, biotite, and feldspar. Plagioclase is abundant and is of the usual kind in such rocks, forming stout laths which in many instances display beautiful zonal structure."

The rock thus described occurs as an intrusive in the same diorite mass about twenty-five miles northwest of the area included within the Gold Hill District. Except for the presence of biotite, a hand specimen from one locality could hardly be distinguished from one of the other.

THE ALTERED GABBRO.

Macroscopic description.—In the hand specimen, this rock presents a decided greenish gray color, and in texture varies from medium fine

[23] Watson, Thos. L., Laney, F. B., and Merrill, Geo. P., Building and ornamental stones of North Carolina. North Carolina Geol. Survey, Bull. 2., p. 121 *et seq.*

grain in which crystals of the component minerals are distinguished only upon close examination, to a coarse-grained rock in which fair sized hornblende crystals are prominent. The color of the coarser variety is generally darker than that of the finer. In the field the finer facies, that occurring in the large dike northeast of Corinth church, upon a casual examination resembles to a certain extent a diorite, but the color is lighter gray with a more decided yellowish or greenish tinge. The coarser facies, that found in the dikes near Bringles Ferry, would not be confused with diorite.

Microscopic description.—The microscope fails to reveal anything very definite as to the original mineralogical composition of the rock. Alteration has been so complete that few of the original constituents of the rock remain. It consists of a groundmass made up of zoisite, epidote, stringy alteration products of the feldspar in which are imbedded numerous irregular, ragged crystals of uralitic hornblende, and patchy areas of badly altered pyroxenes, with probably both orthorhombic and monoclinic varieties present. The alterations are typically those of saussuritization and the rock is therefore regarded as a saussuritized gabbro.

DIABASE.

The most widely distributed dike rock of the district is diabase. It occurs in all parts of the area, is found cutting all the other formations, and is therefore regarded as the youngest of all rocks of the region. There are two distinct types: one, the ordinary dense, fine-grained diabase, the other highly porphyritic and apparently older than the former. The first mentioned facies is similar in every respect to the Triassic diabase and is regarded as of Triassic age. The latter has a similar groundmass possibly of finer texture, in which are thickly scattered long, narrow feldspar phenocrysts, which give the rock a decided porphyritic appearance, which closely resembles "Labradorite porphyrite." This type of the rock, from its general field relations, seems to be older than the ordinary diabase. It occurs only in narrow dikes, never, in this area, more than one hundred feet in width, and has a limited distribution. It is well exposed along the Gold Hill-Salisbury road about one fourth mile southeast of the Peddler's store. At this point a large dike is crossed by the wagon road and numerous boulders of the typical rock may be found along the trend or the dike. This dike occurs at the contact between the slate formation and the greenstone. Other good boulder exposures occur along the County Line road about one mile west of the Whitney Company's mine. This locality is in the general trend of the dike at the above mentioned place and many small outcrops are met with between the two localities. This type of rock was not found in the slate area.

The ordinary diabase is a dense, fine-grained, dark gray rock, the texture being so close and the component minerals so small that one can distinguish very little of its character with the unaided eye. Its characteristic occurrence in the district is as rounded boulders, which are distributed over the surface as it were in long, narrow bands. These boulders are exceedingly tough and resist weathering as well as any other rock in the district. It weathers into a deep rust-red clay, plastic and with little grit. The dikes are always narrow, but have such distribution that no considerable area is free of them. They always follow one of the numerous systems of joints, the greater number having a northeast trend. They produce no contact effects whatever upon the rocks which they cut, but may have some relation to the ore deposits in which they frequently occur, the prospectors always regarding them as good omens.

Microscopic description.—The fresh diabase of the finer-grained facies shows under the microscopic the following minerals named in order of their probable formation: black iron ores, olivine, plagioclase in narrow laths, augite, and hornblende. The texture is typically ophitic and the feldspar laths show no tendency toward parallel orientation.

The ores are plentiful and lie imbedded in the ferromagnesian minerals or around their borders. They are usually small and at times show a white border, probably leucoxene.

Olivine has its usual development and is fresh, except the serpentinization along the fractures. It is present in good sized grains, not in regular crystal forms, and is widely scattered throughout the rock. It is sometimes imbedded in the pyroxene.

Augite is light brown with a greenish tinge and is not strongly pleochroic, basal sections showing good pyroxene cleavage. The mineral holds the laths of feldspar in the usual ophitic structure and presents only the usual optical phenomena. It shows more or less alteration to green hornblende in the freshest rocks, and in those more extensively weathered, is entirely replaced by this mineral. The alteration is generally marked by the separation of numerous grains of black ore.

Feldspars occur in long, narrow laths and show medium to broad twinning lamellæ. A few were measured according to the Michel-Lévy method and found to correspond to medium to basic labradorite.

The hornblende has the usual green color and is strongly pleochroic. The crystals do not have good outlines and when seen in prismatic sections always present ragged or "frayed out" edges in which are scattered numerous grains of the black ores. This mineral is probably of secondary origin and was derived from the original pyroxene. The usual alteration products, epidote, zoisite, chlorite, calcite, and quartz, are present in amounts which vary in proportion to the freshness of the rock.

The porphyritic facies presented under the microscope essentially the same minerals as the rocks just described. The feldspars are in two generations, large lath-shaped crystals occurring as phenocrysts, and very small ones as little laths in the groundmass. The phenocrysts were all badly altered and could not be satisfactorily determined. Some of the freshest ones were measured and found to correspond to labradorite. The groundmass is very fine grained, being scarcely more than a mosaic of feldspar laths and green hornblende, little of the original pyroxene remaining. The usual alteration products are present and, aside from the large feldspar phenocrysts, the rock presents no unusual features.

CHAPTER IV.

STRUCTURE.

The structure of the Gold Hill district is complicated, and on account of the great amount of residual rock decay is difficult to interpret. Jointing, folding, faulting and metamorphism are all well developed, but the folding and faulting are both very much obscured by the rock decay. Jointing, however, has not been so obscured and is one of the most evident structural features of the district.

The greenstone, diorite, and granite areas are, for the most part, reasonably massive, but closely jointed, and only locally present mashed or schistose facies. It was not possible to work out the structure very satisfactorily for these formations. Jointing is closely spaced and prominent, and many of the joint surfaces are beautifully slicken-sided, but no important or well-defined faults were located. By observation on the dikes and along contacts between the different members of this portion of the area, the relative ages of the different rocks were made out as follows: greenstone, diorite, and granite. The older formations show more clearly the effect of metamorphism.

The slate series presents entirely different structural phenomena, and it has been possible to work out to a limited degree a plausible structure for these rocks. The series is separated from the plutonic rocks by a great fault of undetermined throw—the Gold Hill fault. Contemporaneous with the development of this major fault, there was formed a series of minor and parallel faults, and it is in this fault zone that the ore deposits have been developed. In addition to the Gold Hill fault, there was found another important fault, the magnitude of which could not be satisfactorily determined. It occurs along the east side of Flat Swamp Ridge and has a linear extent of four or five miles in the Gold Hill district and is known to extend several miles northeastward beyond its borders. In addition to these two main faults, the series as a whole has been rather closely folded and many small and minor faults have been developed. Near the contact with the igneous rocks, the folding has been close and the dynamic metamorphism intense, and in this vicinity the tuffs and slates have been altered more or less completely into schists. As the distance from this contact increases, there is a marked decrease in folding and schistosity and the formation becomes reasonably massive except for the jointing. The different structural features of the district will now be taken up and discussed in detail.

FOLDING.

As has been stated, it was possible to work out the structural phenomena of the district only in the slate series. These rocks with the exception of those in the immediate vicinity of the western contact have suffered comparatively little dynamic metamorphism, and for the most part are reasonably massive. The whole series has been thrown into a series of rather closely compressed folds, probably either isoclinal or monoclinal, the axes of which have an approximate north 25°—30° east trend and a steep northwest dip. This folding is much closer and the resulting metamorphism much more intense in the vicinity of the Gold Hill fault than in any other portion of the district, and the nature of the folding in this portion of the area has been exceedingly difficult to interpret. At first it was thought that the schistosity corresponded to the bedding planes of the rocks, but later it was found that in many places there is a great discordance between the two. After much study in the laboratory, and a subsequent examination of the rocks in the field, it was decided that the most plausible interpretation is that stated above—closely compressed folds. With this theory in view, several traverses were made across the slate area, and it was found that the recurring beds of tuffaceous materials which are for the most part reasonably massive, probably occupy the crests or the troughs of these folds. The areas intervening between these would thus occupy the limbs of the folds, and be in a position to suffer the greatest amount of metamorphism.

As distance from the contact with the igneous rocks increases, the folding becomes less and less prominent, and along the extreme eastern edge of the area studied, the rocks are massive and present little or no important effects of dynamic metamorphism. A traverse of between twenty and thirty miles beyond the confines of the area mapped, showed that the intensity of the folding continued to decrease. In many places the strata were practically horizontal. The traverse, however, was not continued across the entire formation, which has a width of from forty to fifty miles, and it is impossible to state what the broader features of the folding are. It is believed, however, that the slate formation has yielded to the deforming forces as a unit and that the minor features above noticed are applicable on a large scale to the formation as a whole. It also seems possible that the formation may be regarded as a large synclinorium upon which are imposed the faulting and minor folding above discussed. Only a small portion of the whole slate formation is included in the limits of the map herein presented, indeed, so small a portion that no general conclusion applicable to the formation as a whole can be drawn and the theories presented are therefore offered only as probabilities.

JOINTING.

One of the most noticeable features of the Piedmont Plateau is the great number of joints. These joints, while well distributed throughout the whole 360 degrees of the circle, show a decided preference for certain directions and are thus as it were grouped around three main directions. Out of a total of 141 measurements of the joints scattered throughout the whole of the Piedmont Plateau region, Dr. Watson[24] found that they could be roughly grouped as follows:

Total number of joints that strike north 10°—80° east, 61. Total number of joints that strike north 10°-70° west, 52. Total number of joints that strike north and south, 18. Total number of joints that strike east and west, 10. Similar measurements of the trend of basic dikes in the same region give the following group: Total number of dikes with strike north 10°—50° west, 20. Total number of dikes with strike north 20°—40° east, 21. Total number of dikes with strike north and south, 6. Total number of dikes with strike east and west, 1. Thus while a slight majority of the joints have a northeast strike, the dikes appear to be about equally divided between northeast and northwest quadrants. East and west, and north and south trending joints and dikes are rare. In the above observations the dip of the joint planes receives no attention, but in the study of the Gold Hill district both trend and dip were carefully noted.

In the slate formation there are not so many joints with northeast trend as there are in other portions of the district. It will be remembered that the strike of the schistosity in this portion of the district has a trend of north 25°—30° east, and it is probable that the joint-producing force was able to relieve itself along the planes of schistosity, and thus produce only a few joints trending in this direction. The strike of the prominent joint systems of the different formations has been plotted. (Plate IX.) This was done to show graphically, if possible, whether or not the different formations might in each have a system of joints differing in the average strike from those of the others.

In the near proximity of the Gold Hill fault line, the jointing is so prominent and so many of the joint planes have slicken-sided surfaces that not only was the strike plotted, but also the dip. This was done by projecting both dip and strike upon the faces of a cube orientated in a definite position. (Plate X.) The object of this is to show graphically the great number and irregular shape of the blocks produced by the various joint systems, and if possible to show the effect that a displacement along any one of these planes might have upon the

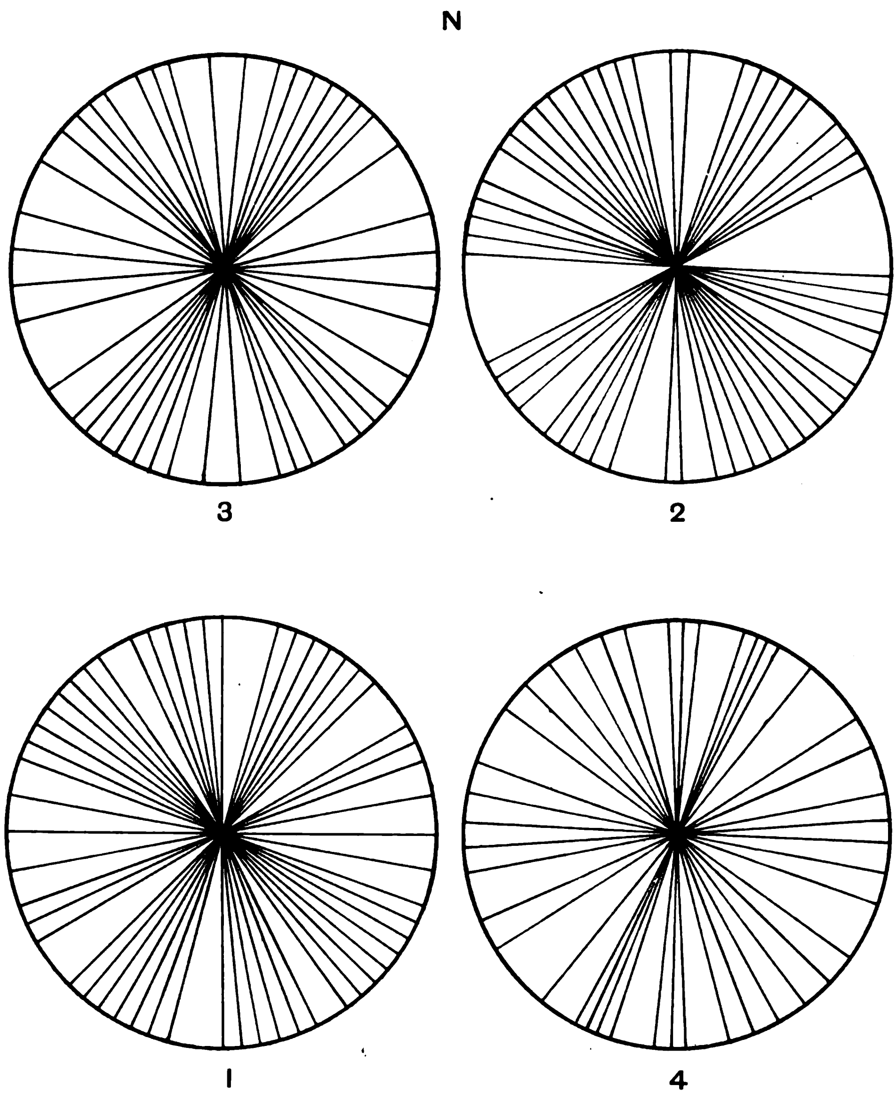
[24] Building and ornamental stones of North Carolina, Thomas L. Watson, F. B. Laney and Geo. P. Merrill, North Carolina Geol. Survey, Bull. No. 2, 1906 pp. 184-185.

ore-bearing veins. In making the figures only the important joints were plotted and in a majority of cases the surfaces of the joint planes were slicken-sided and many of them were definite fault planes. Only those in the immediate vicinity of the mine were plotted.

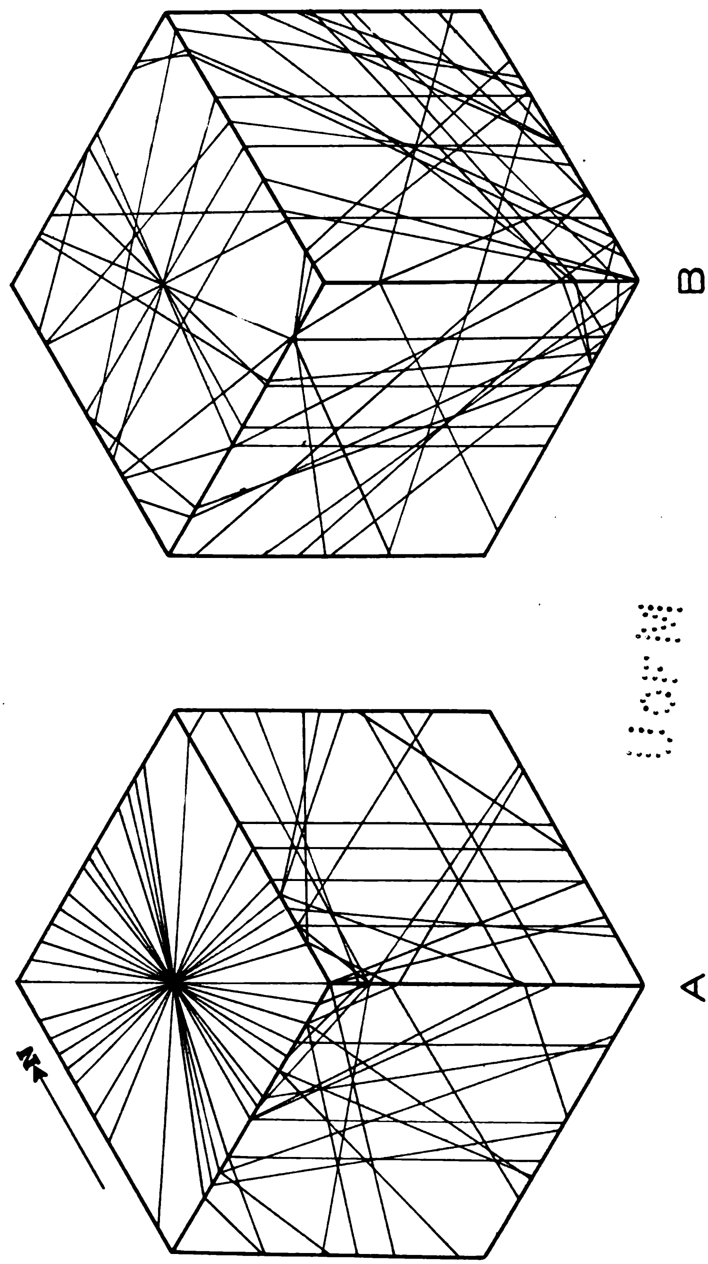
FAULTING.

Numerous insignificant dislocations occur in nearly all portions of the district. These with few exceptions, as far as noted, never amount to more than a few feet, and are probably only the adjustments due to the folding of the region and are not of any great structural importance. In the mine workings, especially those of the Union Copper Mine, there are a few "offsets" in the vein due to faulting, but from as close observation as it was possible to make of these specific instances it is believed that while the fractures are true faults they occurred prior to the mineralization.

In addition to the minor faults above mentioned, there are believed to exist two faults of considerable magnitude. One of these is the Gold Hill fault and contemporaneous with its development there was formed the zone of minor faults, in the vicinity of Gold Hill. This supposed fault has had, it is believed, a most important effect upon the development of the ore deposits and also upon the relations of the different formations to each other and upon the general physiography of the district. It marks the western contact of the slate series. It is only after a very close and detailed study of this contact that the fault is admitted, every other theory to account for the conditions as they exist having failed. This fault extends through the entire district with an approximate trend of north 15° east. It enters the district from the southeast near the confluence of Little Buffalo Creek and Buffalo Creek and passes out about one-quarter of a mile northwest of the mouth of Second Creek. A straight line drawn between these two points would mark approximately the contact of the slate formation on the east, with the greenstone and the granite on the west. This line would also very nearly mark the courses of Little Buffalo Creek which flows southwest and Reedy Branch which flows northeast. Both these streams lie a short distance to the east of the line of contact, but flow approximately parallel to it. In no place was the actual contact between the formations the actual fault plane visible. Everything at or near this line is so deeply buried beneath the residual rock decay, that it was impossible to find the different formations in actual contact. It is, therefore, only upon secondary evidence that the existence of this fault was determined. This will now be stated and discussed.



THE STRIKE OF THE PROMINENT JOINT SYSTEMS OF THE GOLD HILL DISTRICT SHOWN GRAPHICALLY.



DIP AND STRIKE OF THE JOINTING SYSTEMS IN VICINITY OF THE GOLD HILL FAULT PROJECTED UPON THE FACES OF A CUBE.

1. The relation of the slate series to the granite and greenstone. The granite clearly cuts the dip and strike of both the bedding and schistosity of the slates. This precludes the assumption that the granite is older than the basement upon which the slate series was deposited. The granite is clearly younger than the slates in that they have suffered a period of dynamic metamorphism that the granite has not. The greenstone is certainly older than the granite. This relationship has been discussed in detail in another place (p. 55).

2. The absence of thermo-metamorphism in the slate series at the granite contact. If the granite had been intruded into the slates, this contact should be marked by more or less thermo-metamorphism. Nothing of this kind was noted.

3. The absence of granite and aplitic dikes in slates near the granite contact. The granite is clearly intrusive into the greenstone and diorite, and these formations present numerous granitic dikes near the contact with the granite. A very careful search was made along the entire length of the granite and slate contact, and not a single granite dike of any type was found in the slate area.

4. Actual faults observed in the mines with strikes approximately parallel to this line of contact. In trend these minor fault planes always cut the schistosity of the slates at an acute angle.

5. The very prominently developed system of joints with a trend approximately parallel to this line of contact, many of which have slicken-sided surfaces. In point of age these joints are assumed to be contemporaneous with the development of the fault zone.

6. The fact that within the district the streams near this line flow parallel to it and do not follow the schistosity as they do farther away from the contact. If there had been faulting attended by the formation of a zone of brecciation, this zone must necessarily have been more easily eroded than the unbroken rocks. The streams would consequently find favorable ground along this line in which to work, but in the territory more remote their courses would be controlled by the hard and soft layers in the formation, and they would thus tend to follow the schistosity. The streams above mentioned, Reedy Branch and Little Buffalo Creek, follow this line of contact and flow across the schistosity at an acute angle and entirely regardless of the hard and soft beds of the formation. The slate formation is a volcano-sedimentary series, and the hard and soft beds were formed under conditions approximating ordinary sedimentation. The fact that this line of contact transgresses all beds alike, without any regard to hard or soft layers, is regarded as strong evidence in favor of the assumed fault.

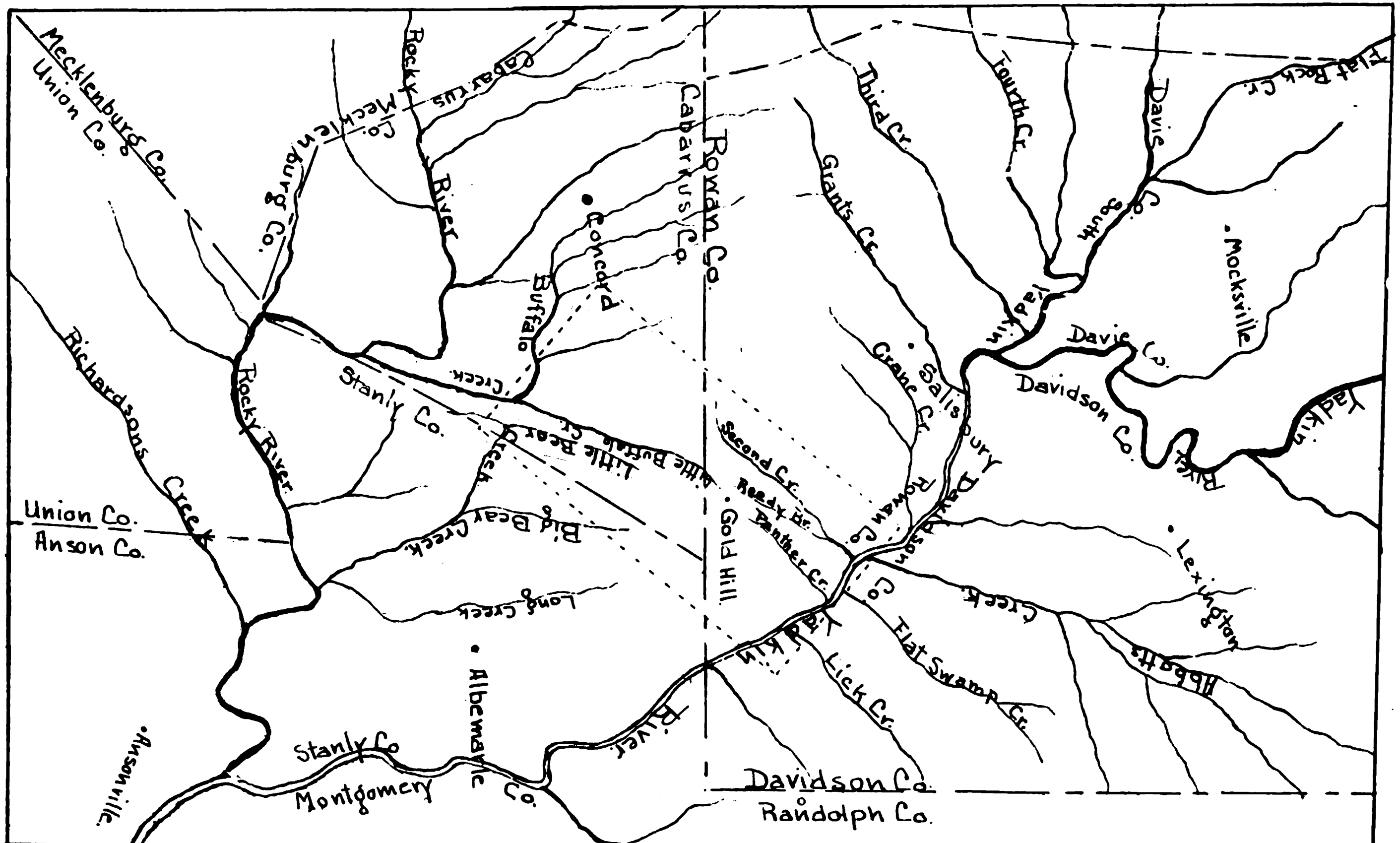
7. The relations of the streams to this line when it is produced beyond

the district in both directions. The sketch map (Pl. XI) is taken from a map of North Carolina published in 1892 by the North Carolina Geological Survey. An examination of this map will show that there have probably been some exceptional causes for the approximately straight line of Abbott's Creek, Reedy Branch, Little Buffalo Creek, Buffalo Creek and Rocky River. These stream courses taken together form a line at least 75 miles in length, and this line is really only an extension of the line of contact between the slate series and the granite and greenstone. It seems hardly probable that Abbott's Creek would have a course which cuts the schistosity of the slates at an acute angle while the other streams follow it, unless there had been some exceptional cause—something that would afford easier ground in which the stream could work. From a hasty examination of the country contiguous to Abbott's Creek, no such reason, unless it be faulting, appears to exist. A similar cause may have operated to account for the peculiar relation of Buffalo Creek to Rocky River. It seems possible that these streams may represent cases of stream capture, that perhaps at one time Buffalo Creek reached Rocky River through the channel now occupied by Bear Creek and at the same time made its way to the Yadkin by way of a roughly parallel course, now indicated by the small stream south of Bear Creek and just east of the elbow in Rocky River. Given these streams in the relation just mentioned and a smaller tributary working headward along the soft and easily eroded material that might be produced in a fault zone, and the phenomena now seen upon the map might easily result.

8. The line of contact throughout its entire length is marked by numerous springs, while the region remote from it is not well supplied with them, nor is there such abundance of springs along the granite-diorite contact.

9. Continuous mineralization along this line of contact and its extension. By reference to map (Pl. XII), it will be seen that a large number of mines lie close to the line formed by the extension of this line of contact. The majority of the ore deposits at these mines are described as fissure veins, either of mineralized quartz or as stringers of ore in fractured or splintered slate, and furthermore, they are described as having a strike a few degrees east of north. It is not clear how a mere local cause could result in the formation of fissures or zones for mineralization along a line something like 50 miles in length. Neither is it certain how such extensive mineralization could occur along a line of such great length simply as the result of local causes.

It is realized that the facts above presented do not prove conclusively that such fault exists, but the evidence seems to be strong enough



MAP OF THE YADKIN AND ROCKY RIVERS AND THEIR TRIBUTARIES, SHOWING THE RELATION OF THE STREAMS TO THE GOLD HILL FAULT LINE WHEN IT IS PRODUCED BEYOND THE DISTRICT IN BOTH DIRECTIONS.

to warrant such assumption. It is not possible to state definitely which is the down-throw and which is the up-throw of this fault. From observations as to the hade of the fault plane in the minor parallel faults in the mines and the appearance of the slicken-sided walls in such faults, it is believed that the northwest side is the up-throw. This appears also plausible when we consider that the intrusion of the great stocks of diorite and granite must necessarily have had considerable effect upon the equilibrium of the crust in the vicinity of the intrusion. This could probably have been placed in adjustment by the down-sinking of an adjoining block. The magnitude of the fault as shown by the amount of dynamic metamorphism in its neighborhood and by the length of the fault line, probably 75 miles all around, is great. The steepness of the hade of this fault indicates that the stress relieved by it was far more nearly vertical than horizontal, and it seems logical that this vertical stress was produced by up-welling of the granite and diorite magmas into the upper portions of some great series of rocks, possibly the slates. After considering all these items, it is believed that the fault was caused by adjustment of equilibrium rendered necessary by intrusion of the diorite and the granite and that the portion to the southeast represents the down-throw side of the fault.

The other fault occurs along the east side of Flat Swamp Ridge, and it seems probable that the steep eastern slope of this ridge is an escarpment caused by the fault. Two principal reasons may be given for the assumption of this fault. The manner in which broad bands of rock which appear on the west side of the ridge are not repeated on the eastern side, which the structure indicates as the corresponding limb of the syncline. It is hardly probable that such thick beds could pinch out so abruptly. The other reason is the great number of very closely spaced, north-trending joints in the slates just east of the ridge. These have a trend approximately parallel with the fault. Conditions as they were observed seem to indicate that this is a thrust fault, the direction of thrust being from northwest to southeast.

This fault appears to be of considerable magnitude, but there is no known means of determining even an approximation of the amount of thrust. The fault line is of considerable length. There is reasonable basis for assuming a length of 4 to 5 miles in the limits of the region mapped, and similar conditions are known to exist for a number of miles beyond the district to the northeast.

By studying the trend of this fault line in its relation to the ore deposits at Gold Hill, it seems at least possible that it may extend southwestward until it reaches the Gold Hill fault. No very positive evidence for assuming this was found, and the statement is here made only as a possibility.

IGNEOUS ACTIVITY.

The relations of the various rocks of the northeast portion of the district; the greenstone, diorite, gabbro and granite, to each other has been discussed in detail in other places and needs no repetition here. Hence it will only be stated that there are probably represented in this portion of the district a period of lava outpouring, shown by the greenstone; and three separate and distinct periods of intrusion, which, mentioned in the order of their occurrence are the diorite, the gabbro, and the granite. These were all followed by a later period of intrusion in which the diabase dikes were formed. This last period of igneous activity, believed to be of Triassic age, took place since the faulting and the development of the ore bodies (see p. 98), and represents the last period of such activity in the region.

METAMORPHISM.

The metamorphism of each type of rock has already been considered in detail in the chapter on the petrography of the different rocks, but a short summary may not be out of place here.

The contacts between the different intrusive igneous rocks are marked by only slight metamorphic effects.

That portion of the slate series and the greenstones in the vicinity of the Gold Hill fault have suffered greater dynamic metamorphism than any other rocks in the district, but even this has not been intense enough to change rocks into typical schists. A prominent slaty cleavage has been developed entirely independent of, and often with an almost complete obliteration of the original bedding planes. The amount of schistosity varies directly with the character of the rock. The softer beds of slate have been far more completely altered than the harder bands of tuffs and flow rocks with which they were interbedded. It appears that in the region of most intense metamorphism the slate bands were wholly within the zone of flowage, while the harder and firmer bands of tuff and flow rocks were in a zone of combined fracture and flowage. As distance from this fault zone increases the metamorphic effects gradually die out and the rocks, except on the limbs of the folds, become more and more massive.

A very notable phenomenon, especially in the zones of mineralization, is that of silicification. This is especially evident in the rocks in the Union Mine, and prominently at all other mines and prospects in the district. Tuffs and slates which normally contain from 50 per cent to 60 per cent of silica, have in the Union Mine so changed by this process that they carry from 80 per cent to 90 per cent of silica. This process of silicification is believed to have been contemporaneous with the deposition of the ores, and also to have been genetically connected with the intrusions of the great stocks of granite.

CONDITIONS OF THE DEPOSITION OF THE SLATE SERIES.

This question has been discussed in detail elsewhere (see p. 25) but it may be well to give a brief resume here. The series as a whole represents a period of volcanic activity in which quantities of rhyolitic and andesitic or dacitic lavas were thrown out, probably with considerable violence. The great period of volcanism was evidently made up of shorter periods of greater activity during which the tuffs were formed and the flows of rhyolite in the north end of the district and of andesite in the south took place. These were followed by periods of quiescence during which the beds of finer material were deposited. It seems probable that the region was partly under water, possibly immediately off shore, and that the tuffs and finer materials were water-laid, and even possibly the flows took place under water. The period was one in which volcanic activity predominated. This is evident from the constitution of the fine material as well as of the tuffs and flows. Even the so-called slates which in the field seem to be very similar to ordinary slates have a chemical composition which leads one to think they are for the most part composed of fine andesitic ash with which is mixed varying amounts of land waste. This question has been discussed in detail in another place. (pp. 28, 41).

The center of volcanic activity and the location of the land may have been only a short distance east of the Gold Hill district. From numerous accounts, it is known that this region contains a far more extensive development of ancient lavas than the district under consideration.[25]

GEOLOGICAL HISTORY.

The relative ages of the slate and greenstone members of the Gold Hill series can not be definitely stated from the information at present in hand. It seems possible they were both deposited under somewhat similar conditions. They each contain lava flows and tuffaceous beds. The slates certainly, and the greenstone, in part, probably contain varying amounts of land waste. The tuffs, flows, breccias, and finer sediments show that in each case there were violent outbursts of volcanic activity, followed by extrusion of lavas, and then probably a longer period of quiescence, in which the materials furnished were made up to a greater or less extent of sediments derived from the land. The basement upon which each was deposited is unknown, and the geological age of both has not been determined. The slate series is mentioned in the literature as probably of pre-Cambrian[26] age, and has been called Algonkian. Ebenezer Emmons[27] regarded the slates

[25]The distribution of ancient volcanic rocks along the Eastern border of the United States, Geo. H. Williams, Jour. of Geol., Vol. 2, pp. 27-29.

[26]Gold deposits of North Carolina, H. B. C. Nitze and H. B. Hanna, North Carolina Geol. Survey, Bull. 3, 1896, p. 37.

[27]Geological Report of the Midland counties of North Carolina, Ebenezer Emmons, 1856, p. 41 *et seq.*

as belonging to his Taconic system, and placed them as the lowest members of the Paleozoic. At the present time the information upon which to base a definite determination is still lacking. They are regarded by Arthur Keith[28] of the U. S. Geological Survey, as probably of pre-Cambrian age. There is no way, as far as present information goes, to determine the age of the greenstone. Its general character, the alternation of flows and tuffs, and the somewhat similar nature of the lava, lead to the conclusion that it is contemporaneous with the slate series and belongs to the same great period of volcanic activity. As to whether it is older or younger than the slates no definite statements can be made, but it is believed that it lies on the up-throw side of the Gold Hill fault and is therefore possibly older than the slates. After the greenstone and slates were formed, there followed a long period of mountain building and erosion, and of numerous oscillations of the land, lasting possibly through the Paleozoic era. During all this time the land was continuously above the sea, and undergoing erosion.

At some period since the building up of the slates and the greenstones, and also, probably, since the time of folding and development of schistosity, they were intruded by great masses of diorite, with an attendant set of diorite dikes quite prominent in the greenstone. Following the diorite there came in great stocks of granite with numerous granite and quartz-porphyry dikes. Later there came numerous diorite and gabbro dikes which are now found cutting both diorite and granite. These periods of intrusion were followed by the development of the Gold Hill fault zone and the deposition of the ores. The last and final igneous and structual activity was the intrusion of the diabase dikes, probably during Triassic time.

To summarize the geological history of the region comprises the following events:

1. Building up of the greenstones and the slates.
2. Folding and development of large part of the schistosity.
3. Intrusion of the diorite.
4. Intrusion of the granite.
5. Intrusion of the younger diorite dikes.
6. Intrusion of the gabbro dikes.
7. Formation of Gold Hill fault zone.
8. Development of the ore deposits.
9. Intrusion of the diabase dikes.
10. Continuous erosion to present time.

[28]Personal communication to the writer, 1908.

CHAPTER V.

PHYSIOGRAPHY.

The Gold Hill mining district lies wholly within the Piedmont Plateau. Its eastern boundary is about 35 miles northwest of the eastern limits of this physiographic province. In a general way it presents the surface features common to this portion of the plateau. The topography is mature and the hills well rounded. The rocks are deeply decayed—oftentimes to a depth of 100 feet, and exposures are by no means plentiful, being confined for the most part to the stream beds and the steeper hill slopes. Streams are numerous, and heavily laden with sediment and the relief in general is much subdued. In only two localities within the district is it well marked, the north end of Gold Hill Ridge and the Beaver Hills. The former is in the extreme northeast end of the district while the latter are in the southwest.

Surface features.—The most prominent topographic feature of the area is a low, flat-topped ridge extending from about one mile southwest of Gold Hill in a northeasterly direction to several miles beyond the Yadkin River. This ridge reaches its greatest elevation at Gold Hill, but at this point the slopes are so very gentle that the village hardly appears to be on a ridge at all. In both the northeast and the southwest portions of the area the relief is much more pronounced. In the northeast the ridge is known as Flat Swamp Mountain and rises abruptly to an elevation of about 250 feet above the flood-plain of the Yadkin River. In the southwest end of the area the topography is very different. Instead of a single ridge there is a series of well-rounded hills, the Beaver Hills. The stream courses in this portion of the district are irregular as to direction and are apparently controlled by the great diorite mass which seems to have resisted weathering somewhat better than the granite and greenstone. It is true, however, that the more massive portions of the greenstone near Five Pines form probably the most prominent relief in the whole southwestern portion of the area. This prominent relief is also characteristic of the massive portion of the same rock where it is crossed by Buffalo Creek and is well exhibited in the vicinity of Barringer's mill. (See Pl. I.)

Between the Union Mine and the mines of the Whitney Company, there is a rather prominent depression which marks the termination of Flat Swamp Ridge (probably best called Gold Hill Ridge) and the beginning of the Beaver Hills. This depression or notch is prominent both to the north and to the south of the Whitney Company's mines. In the former direction it forms the valley of Reedy Branch and southward it is the valley of Little Buffalo Creek. This line of the two valleys besides being a well-defined lowland follows closely the fault contact between the slates and the granite to the north, and the slates and greenstone to the south.

It seems clear that Flat Swamp Ridge owes its origin to rocks massive in character which have resisted erosion better than those of the surrounding country. These consist, for the most part, of silicified tuffs and breccias together with rhyolitic flows. The long ridge which lies to the east of Buffalo Creek is similar to Flat Swamp Ridge and consists of tuffs more or less silicified, and volcanic flows, which seem to be andesitic in character rather than rhyolitic. Thus it appears that in this portion of the area there is a decided tendency on the part of the tuff beds to form the hills and ridges. The Beaver Hills are made up for the most part of the more massive phases of the greenstone and probably owe their origin to the usual action of erosion.

Drainage.—The streams of the northwest half of the area have a general northeast course while those of the southeast half flow toward the southeast. The streams in the slate area have a decided tendency to flow in the direction of the strike of rock, and seem to have carved out their valleys in the softer beds of the formation. There are two notable exceptions to this, Reedy Branch, which flows nearly north along the granite-slate contact, and Little Buffalo Creek, flowing a few degrees west of south into Buffalo Creek which after the junction of the two streams continues in the direction of the smaller creek. Both these streams cut across the strike of the rocks at acute angles and find attractive conditions for valley making in the much broken and mashed rocks along the Gold Hill fault line.

The great master-stream of the area, the Yadkin River, holds its general southeast course and cuts across Flat Swamp Ridge nearly at right angles, making only a narrow V-shaped gap through the ridge, with narrows and rapids marking the location of the harder and less easily eroded beds. It is interesting to note the relations of Little Bear Creek to Buffalo Creek. This stream, after flowing southwest practically parallel with Little Buffalo for a distance of perhaps six miles, to a point directly in the line of flow of Buffalo Creek, makes a right angle turn and assumes, as it were, the course of Buffalo Creek, and flows on southeastward into Rocky River. This has the appearance of a case of stream capture, but there is not sufficient evidence at hand to warrant a definite statement regarding it. By referring to the sketch (Pl. XI) it is clear that Buffalo Creek continues its southwest course until it meets Rocky River, which has repeated the phenomena of the former creek and, after the confluence of the two streams, Rocky River continues the southwest course for a distance of 12 to 15 miles where it makes an acute-angled turn to the northeast and then flows on into the Yadkin. It is very interesting to note that the map from which the sketch was made shows a small stream bearing exactly the same relation to Rocky River at the point where it turns to the southwest, that Little Bear Creek bears to Buffalo Creek. It will also be noted that Abbott's Creek is almost a direct continuation of this fault-line. There may be at least two explanations of this abnormality of the drainage—the strike of the slate beds or the influence of faulting which might produce more or less brecciation, and would necessarily form a zone more readily eroded than the massive beds. That these southwest flowing streams do not follow the strike of the slate is shown by the fact that the minor streams, (Panther Creek, for example,) which do follow the strike have a more eastward trend than the streams in question. Also the strike of the slates varies from N. 20° E. to N. 60° E. and there is no such variation of direction in case of the Buffalo-Reedy Branch combination in the area studied. Thus it seems that the influence of a possible fault in the determination of these stream courses is plausible. It is not intended to maintain that the apparently abnormal courses of Abbott's Creek and Rocky River are due to the influence of a fault, but it is interesting to note that these streams have practically a straight course for about 75 miles and that the line of the two streams is only a direct continuation of the course followed by Reedy Branch and Buffalo Creek.

Thus by summing up the drainage, we have two main classes of streams in the area—antecedent and consequent, the Yadkin River being the antecedent stream holding its general southeast course irrespective of structure and rock variation. All the other streams fall into the class of consequent streams, but this class probably includes two varieties of consequent streams; those that owe their course to the nature of the rock—kind of rock over which they flow—such streams as Panther Creek, Second Creek, and those whose courses may possibly have been determined by some structural feature-faulting. This variation may be said to be represented by the Buffalo Creek-Reedy Branch combination.

CHAPTER VI.

THE ORES AND MINES OF THE DISTRICT.

HISTORICAL INTRODUCTION.

The earliest mining undertaken within the Gold Hill District was for gold, but as the mine workings increased in depth, the sulphide ores were reached which carried copper as well as gold. These two metals, with which occurs a little silver, are the objects sought by the present day miners. (See Pl. XII.)

Gold was first discovered within this district at the Barringer Mine prior to 1824,[29] but the country lying to the southwest and southeast had been the seat of gold mining since the beginning of the century. This mining began at the Reed Mine which lies only a few miles from the southwest limits of the map. The first authenticated discovery of gold in North Carolina occurred here in the year 1799, at which date a nugget weighing 3½ pounds avoirdupois was picked up in the bed of Meadow Creek on the plantation of Joel Reed. Further search resulted in the discovery of a number of large nuggets, the largest of which weighed 28 pounds avoirdupois. Fourteen large nuggets found at this mine between the above date and 1835 aggregated a total weight of 115½ pounds avoirdupois.

With the discoveries at the Reed Mine, active prospecting began and spread throughout the whole surrounding country, although confined for the most part, to the slate area which was found to be more promising. Indeed at a very early date in the century the slate formation was known as the "Gold Country." Denison Olmsted[30] writing in 1824, says:

"They (the gold mines) are situated in the southern part of the State, not far from the borders of South Carolina and somewhat west of the center. Through the Gold Country flows the river Peedee, (Yadkin) receiving within the same district two considerable streams, namely; Rocky River from the south and Uwharee River from the North. * * * The Gold Country is spread over a space of not less than 1,000 miles. * * * From a point taken eight miles west by south of the Uwharee, with a radius of 18 miles, describe a circle—it will include most of the county of Montgomery, the northern part of Anson, the northeastern corner of Mecklenburg, Cabarrus as far as

[29] A report on the Geology of North Carolina, Denison Olmsted, Raleigh, 1824, p. 34.
[30] Olmsted, Denison. Report on the geology of North Carolina, v. 1, p. 33.

a little west of Concord, and the corners of Rowan, Davidson and Randolph. * * * In almost any part of this region gold in greater or less abundance, may be found at or near the surface of the ground."

The area just described includes all the Gold Hill District. The principal veins, those at Gold Hill, were not discovered until 1842.[31] The outcroppings were not prominent, and it is said that they were discovered by accident. Between the date of discovery and the beginning of the Civil War, mining was carried on at Gold Hill with considerable profit and the place became widely known as a mining center, producing in this time it is said something like three million dollars.

At the beginning of the war, the main shaft, the Randolph, was down to a depth of 700 feet and the richer portions of the vein for about 1500 feet were worked out to a depth of about 350 feet. The upper, or oxidized portions of the vein were very rich and the gold was easily concentrated, amalgamating, it is said, very readily. The methods used in concentration were crude. The ore was first ground in a Chilian mill made of two large granite "runners" and a large granite "bed," and then washed through a system of wooden rockers.

During this period of active mining a number of smaller mines and prospects were opened up at considerable profit. Among these are the Barnhardt, the Old Field the McMackin (known as the Whitney mines), the Troutman and the Honeycutt mines. The three latter are said to have paid well until the upper portions of the veins were worked out. In these cases as at the Gold Hill Mine, the operators were unable to handle the ores satisfactorily as the depth increased and the unaltered sulphides began to come in. Their methods of concentration were too crude for ores that did not amalgamate easily. The copper of the sulphide ores, of course, could not be saved by such processes and in general received no attention.

Until the discovery of the gold-bearing vein in situ at the Barringer Mine about 1824, all the gold was obtained from small placer workings along the streams. The methods of work were most primitive sluice-boxes and log rockers. With the discovery of the gold bearing veins came the introduction of the Chilian mill or "gold grinders," as they were called, and these were still in use when the Civil War caused a cessation of all mining.

The mines were not opened up again until some years after the close of the Civil War. When the work was resumed, better and more extensive machinery was installed and attempts were made to save both gold and copper but with indifferent success. Apparently the operators very soon after the reopening, began to use the mines as speculating

[31]Wheeler, J. H. Historical sketches o North Carolina, p. 64.

properties, and while probably, considerable legitimate and bona fide mining was carried on, the principal object was one of stock manipulation.

The earliest attempt at a geological study of the Gold Hill Mines was by Ebenezer Emmons in 1856.[32]

He described in considerable detail the veins and ores and their manner of occurrence. He says:

"The veins belong exclusively to a slate which has usually been regarded as a talcose slate. * * * All the slate, however, should be regarded as a clay slate, differing scarcely if at all, from the clay slate toward the Yadkin, or which is so common in Stanly County. It occupies, I believe, the same position, and is the same geologically. * * * The veins which carry gold are composed of quartz and quartziferous slate, and the sulphurets of iron and copper. Of these vein stones, the sulphuret of iron is the richest; the gold attaches itself to this mineral more freely than to the sulphuret of copper. * * * The vein which represents the series belonging to Gold Hill is the Barnhardt (Randolph.) The vein stone is principally a combination of iron and copper pyrites intermixed with seams and masses of quartz. In these minerals the gold is mechanically mixed."

These statements are essentially true to-day. Emmons also recognized that the veins in dip and strike followed neither the dip nor the strike of the schistosity of the slates, and that the rich ore is not distributed uniformly throughout the vein, but lies in shoots which have a pitch of their own. As to the origin of the veins he suggests two views; one that they were filled by gaseous emanations, the other, that they were filled "by the eruptive mode, and in a mass, and in a state of incandescence." He favors the former, but does not discuss either.

W. C. Kerr,[33] in 1875, again takes up the geology of the ores. He says: "The gold deposits, which are contemporary with the slates themselves, are far greater in importance than the true gold veins (quartz veins). The talcose, chloritic, micaceous or arenaceous slates in which they occur, contain portions which are more or less charged with gold. The gold in these slate beds, like the slates themselves, is derived from the destruction of the older rocks, and has been deposited simultaneously."

The next reference to the mode of occurrence and the genesis of the ores is by Nitze and Hanna, 1896.[34] They treat the subject superficially and theoretically, citing a few examples among North Carolina pros-

[32]Emmons, Ebenezer. Geological report of the Midland counties of North Carolina, p. 154 *et seq.*

[33]Kerr, W. C., "Geology of North Carolina," Vol. 1, p. 285, *et seq.*, Raleigh, 1875.

[34]Nitze, H. B. C., and Hanna, G. B. "Gold Deposits of North Carolina," North Carolina Geol. Survey, Bull. No. 3, p. 44, *et seq.*

pects in proof of their theories. It amounts to little more than a restatement of Emmons's view in the light of more recent theories.

They discussed the question under three heads:

1. Nature of the deposits.
2. Causes of the formations of the spaces occupied by the ores.
3. The manner of their filling.

Under the "nature of the deposits" they say:

"The gold ores exist in two principal structural forms, namely, as quartz fissure veins; and as impregnations, lenticular, stringer form, and irregular disseminations in the country schists and slates." The latter mode is stated to be the more usual. Under the "origin of the spaces occupied by the veins" they account for the openings, on a basis of jointing associated with faulting. Their treatment is only theoretical and no examples of actual faulting are mentioned. Fissures are divided into two classes; *paraclastic*, or fissures made along entirely new lines, and *diaclastic*, or fissures opened up along existing fractures. Diabase dikes are cited as examples of the former and ore veins are representative of the latter. The abundance of diabase dikes is noted and it is stated that they are supposed to have a favorable influence upon the richness of the ore bodies, and that the veins may have derived part of their metallic contents from the basic magma of the dikes.

The treatment of the manner of vein filling is nothing but a restatement of various theories according to which the phenomena might have taken place and they believe that the veins were filled as a result of circulating aqueous solutions.

By way of summary it may be stated that the theories regarding the origin and deposition of the ores of the slate formation, and their relations to the country rock are as follows:

1. The gold is confined to a stratum of mud in the gravel in the valleys and stream beds, and that the gold of these placers was derived from "an extensive stratum of auriferous earth" situated within the slate formations (Denison Olmsted, 1824).

2. Two modes of occurrence of the gold, in true quartz veins, and as sedimentary deposits in the slate and contemporaneous with them, the latter class of far greater importance than the former. (Ebenezer Emmons, 1856 and W. C. Kerr, 1875).

3. That the gold ores exist in two principal structural forms, namely, as quartz fissure veins, and as "impregnations, lenticular, stringer form, and irregular disseminations in the country schists and slates"; the latter of far more importance. These veins, etc., were formed along preexisting fractures and were filled by circulating waters. The improbability of the sedimentary and contemporaneous origin of the

gold with the slates was pointed out. (Henry B. C. Nitze and George B. Hanna, 1896).

These theories were presented as applicable to all the gold deposits of the State of North Carolina, and not with especial reference to those of the Gold Hill district. The ore deposits will now be considered in detail, and if possible, a theory of their origin and deposition will be developed.

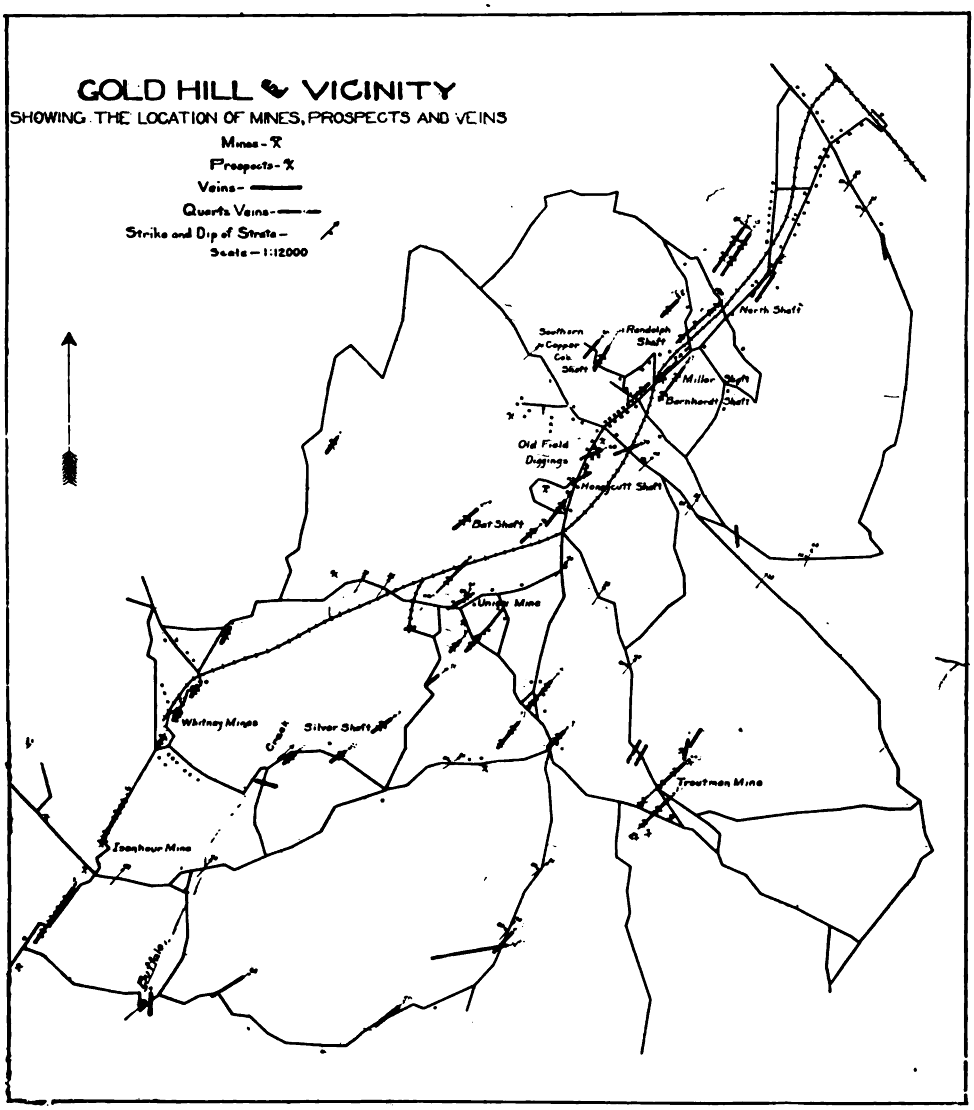
DESCRIPTIVE GEOLOGY OF THE MINES AND PROSPECTS.

Four mines and numerous prospects locally called mines represent the workings of the Gold Hill mining district. They are well confined to the western edge of the slate formation, and apparently to the immediate zone of the Gold Hill fault. The important openings, the Gold Hill Mine, owned by the Gold Hill Copper Co., the Union Mine, owned by the Union Copper Co., the Whitney Mine, owned by the Whitney Reduction Co., and the Southern Copper and Gold Mining Co.'s openings, together with numerous diggings and prospects, make up the Gold Hill Mines. Of these, the first two and the last one are located upon the Gold Hill Ridge, the Gold Hill Mine in the village of Gold Hill, the Union Mine about three-fourths of a mile southwest of the village and the Southern Copper and Gold Mining Company's shaft, a few hundred yards west of the Randolph shaft. The Whitney Mine lies to the west of Buffalo Creek and is not on the Gold Hill Ridge, but in the same fault zone, and on the same side of the main fault line. Of these only the Gold Hill, Union Mines and the Southern Copper and Gold Mining Company's property are in operation at the present time (1907). (See Pl. XII.)

If a line be drawn through the Gold Hill and Whitney mines and produced to the southwest limits of the district, running roughly parallel with the fault line, and crossing it just west of St. Stephen's church, at which place it passes into the greenstone, it will be marked throughout its length by more or less prospecting and evidence of mineralization. The principal prospects that have been opened in this portion of the district—the greenstone area—are the Kluttz, Harkey and Hopkins diggings. In addition to these there are numerous outcroppings of quartz and epidote veins with more or less stainings of malachite that have not been opened.

Lying about one and three-fourths miles northwest of the Hopkins Mine is another group of prospects known as the Cline Mine and the Dan Hopkins diggings. The last of these is located in the diorite, and the former in the greenstone, very near the diorite contact.

The fourth and last group of prospects of the district, is located near



MAP OF THE GOLD HILL COPPER DISTRICT, SHOWING LOCATION OF COPPER MINES, VEINS AND PROSPECTS.

Garfield post-office (Tyack's store) and consists of two divisions, one lying in the granite to the east of Second Creek, and the other to the west of the creek and in the diorite very near the granite contact. These are known as the Dutch Creek and the Gold Knob mines, respectively.

TYPES OF DEPOSITS.

These four groups of mines and prospects represent four classes or types of deposits. They may for convenience of description be designated as follows:

1. Gold Hill type, in which the ores consist of auriferous pyrite and chalcopyrite in more or less quartzose gangue, or as narrow stringers in the schist with little or no gangue. The Gold Hill Mine, and the Union Mine are good examples of this type.

2. Greenstone type, in which the ores consist of slightly auriferous bornite and chalcocite in a gangue of quartz and epidote, with little or no chalcopyrite. The Kluttz, Harkey, and Hopkins prospects are typical examples of this type. This is exactly similar to the ores of the Virgilina district, which W. H. Weed[35] has described as the "Virgilina type" of southern copper deposits.

3. The Cline type, in which the ores consist of auriferous pyrite and chalcopyrite in a gangue of quartz, hematite and siderite. The Cline Mine and the Dan Hopkins diggings are the typical examples of this type. This type of gangue is characteristic of the old Conrad Hill Mine,[36] which is located northeast of the Yadkin River, on the continuation of the Gold Hill fault line.

4. The Dutch Creek type, in which the ores consist of auriferous pyrite, and a small amount of chalcopyrite in a quartz gangue, the vein being located in the granite. The Dutch Creek mines are examples of this type.

THE GOLD HILL TYPE.

This type of deposit includes two classes of veins, one consisting of stringers of ore filling narrow spaces between thin layers of schist, and presenting little or no evidence of silicification, the other filling larger openings and being highly silicified. The former are largely copper-bearing. The ore consists for the most part of chalcopyrite, and carries very little gold. The latter contains as a rule, only a small amount of chalcopyrite, and is largely made up of auriferous pyrite. There are exceptions to this statement, but, in general, ores that carry high values in gold have only a small amount of copper, while those high in copper

[35]Weed, W. H. Types of Copper-Deposits in the Southern United States. Am. Inst. Min. Eng. Trans., v. 30 (1900) pp. 449-504.

[36]Whitney, J. D. Metallic wealth of the United States, p. 130.

are very low in gold. Both classes have been developed along fractures which may or may not run parallel with the schistosity of the country rock. As a rule there is a general conformity between the strike of the veins and that of the rocks.

There is still another type of vein—a true quartz vein, which is usually barren. These are not confined to any one portion of the district.

The schists at the mines have a strike varying from N. 30° E. to N. 45° E. and dip about 80° to the northwest. The outcroppings of the veins are obscure and it is next to impossible to trace them on the surface. The usual outcrop consists of only a narrow band in the schists which stands up a little more prominently than the surrounding rock, and which generally shows a more decided staining due to the oxidation of the iron. Where the vein is quartz, this mineral marks its trend by fragments. The largest and richest veins are not true quartz veins, but only highly silicified bands or stringers in the schists. These, as the microscope shows, are made up for the most part of a mosaic of very fine, cryptocrystalline quartz, and do not differ from the schists except in degree of silicification. This fact accounts for the lack of prominence of the outcrops.

The Rocks.—The country rock has already been described in detail, (see pp. 32-41) but a short summary will be given here. The rocks of the Gold Hill Ridge consist of highly metamorphosed, coarse and fine acid volcanic tuffs intermixed with which during the time of deposition was more or less land waste. The rocks, as seen now, are of three phases, one of which is a coarse breccia-like tuff carrying phenocrysts of feldspar so mashed as to appear in places like an "Augen-gneiss." Both fragments and phenocrysts lie in a dense, dark, close-textured matrix which the microscope shows to be a mosaic of cryptocrystalline quartz intermixed with which was more or less clay. The phenocrysts are apparently not present in all parts of this coarser fragmental rock, and some beds of it show only the mashed and stretched out fragments. The coarser rock is best seen in the dump of the Union Mine and those of the diggings near by, but it is also seen at the Gold Hill Mine. At this point the metamorphism has been more intense and the original texture of the rock has been almost completely destroyed. A second phase is a dense, felsitic rock of dark gray color, of a chert-like appearance, which contains no fragments and no phenocrysts, and which at times shows very pretty banding. The microscope shows that the rock is almost wholly composed of exceedingly fine cryptocrystalline quartz, in which are scattered a few mashed and badly altered crystals of orthoclase and microcline. (See p. 33). This rock is not at all unlike the Swedish "Halleflinta" and probably represents a highly silicified, exceedingly fine-grained rhyolitic or dacitic tuff. The other phase is not clearly defined, as to characteristics, but seems to represent a mixture of land waste in varying proportions with the materials of the other two types.

VEINS.

As previously stated, the productive veins in the slates are of two types that which presents a high degree of silicification and that which presents little or none.

The first type varies greatly in degree of silicification; at times the veins and walls resemble chert, with the ores distributed through this silicious groundmass. At other times there is only a relatively small degree of silicification, and the walls and fragments have suffered little alteration. This type of vein usually has well-defined walls which often show slicken-sided surfaces.

The second type of veins is peculiar in that when examined for only a short distance they may seem to follow the schistosity, when, in reality, if they be plotted for a long distance, they are readily seen to have been developed in fractures which cut the schistosity at acute angles. It would seem that the force which formed these fractures was often relieved for considerable distances by simply opening up the already formed planes of schistosity. This would continue until the force would become great enough to again break across the schistosity. The result as a whole is a break which in part consists of rifts in the rocks parallel with the schistosity, and in part of fractures cutting it at acute angles. In such fractures the veins of this type were developed. They present a minimum amount of silicification, and often appear as simply thin leaves of ore in the opened-up planes of schistosity.

The two types of veins above mentioned are the so-called "slate veins." In addition to these there are the true quartz veins. These, when they occur in the slates, are for the most part narrow and lean or wholly barren. In trend and dip they bear the same relation to the slates as the "slate veins." In two other formations they often carry considerable values both in gold and copper. Such veins are always well defined, vary from a few inches to a few feet in thickness, and in dip and strike conform to a joint plane. Veins of this type occur at the Gold Knob, Dutch Creek, Dan Hopkins and Cline mines.

The following sketch (Fig. 1) is presented to show diagramatically the relation of the veins to the dip and strike of the schistosity of the slates. From it, it may be readily seen that while at times the two correspond, the general dip and strike of the vein does not conform to those of the slate.

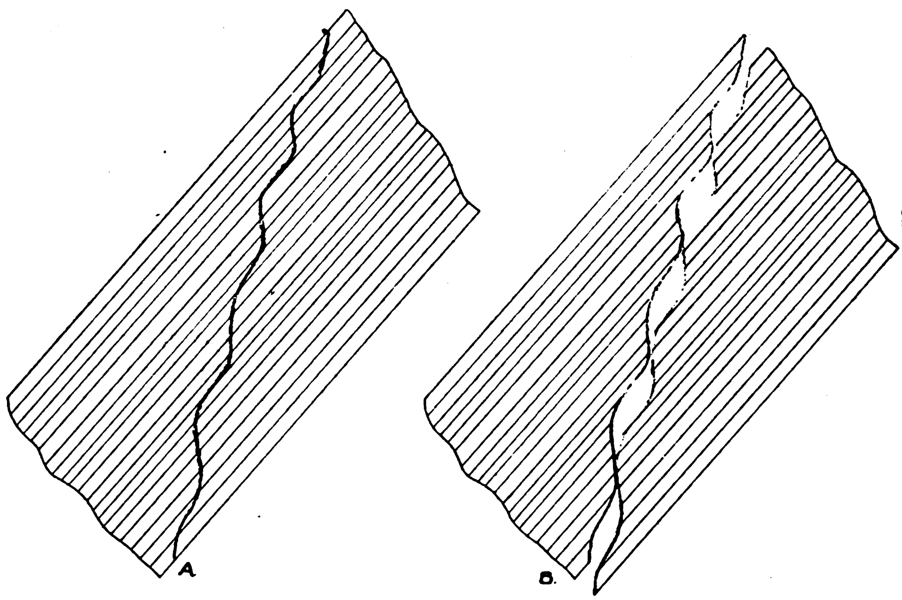


FIG. 1—DIAGRAM ILLUSTRATING OCCURRENCE OF COPPER VEINS IN SCHISTS, AT GOLD HILL. THE SCHISTS HAVE OFTEN BEEN DISTURBED, SO THAT THE RIFTS NOW HAVE THE APPEARANCE AS SHOWN IN B.

Sketch to show the relation of faulting to schistosity and the formation of lenticular veins.
A. Vertical and horizontal sketch showing relations of faulting to schistosity.
B. Lenticular spaces formed by movement along fault line.

From this it is seen that the trend of the veins as a whole is not quite as strongly to the east as that of the slates and that they really do cut the schistosity at acute angles. The vertical section shows that the veins may have a steeper vertical dip than the slates, though at times the offset occurs in the other direction, and so gives the vein a flatter dip than the slates. The best example of this is seen in the relation of the north vein to the country rock, 800 foot level of the Gold Hill Mine which is now being worked. (See sketch, fig. 2.) This sketch, made from an actual survey, shows well the great number of small veins or stringers of ore, no less than eight associated with three workable veins in a distance of 800 feet. These smaller veins, while sometimes high in values in either gold or copper, are always too narrow to work. They present the same features as regards vein matter and ores, and have similar relations to the country rock as the larger veins. That is, they may follow either the schistosity or one of the numerous lines of fracture or both, crossing from one plane of schistosity to another, following the line of fracture leading across it.

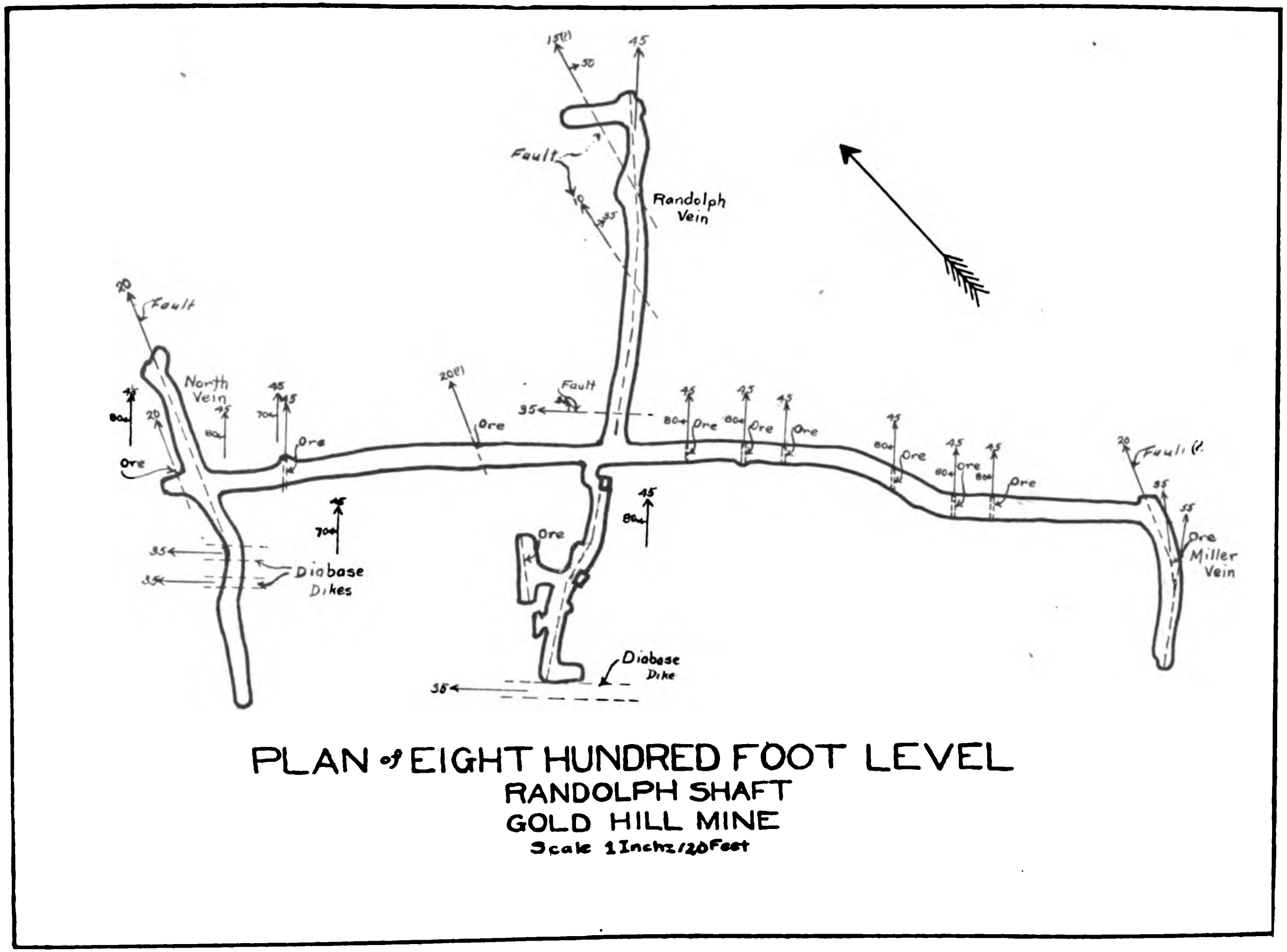


FIG. 2—SKETCH SHOWING EIGHT SMALL VEINS OR STRINGERS OF ORE ASSOCIATED WITH THE THREE WORKABLE VEINS IN A DISTANCE OF EIGHT HUNDRED FEET.

That the veins follow fractures in the schists is evident from the nature of the vein contents, their relations to the country rock, and the prominent development of slicken-sides upon the walls in many places. The vein in many instances contains numerous angular fragments of hard, silicified rock not unlike many of the bands of denser schists. In other instances the vein, instead of being a breccia, is made up of numerous stringers of ore filling narrow spaces between shreds of schists. This appears as though the rock had been torn apart and somewhat suggests a fracture in a piece of tough wood in which the main fracture consists of many small ones with splinters extending between them from wall to wall. Sometimes these breccias and stringers show that considerable replacement—metasomatism has taken place since their formation—quartz and ore more or less replacing them. In other instances they are apparently fresh. (See Pl. XV.)

The veins, as well as the ore shoots within them, have a well-defined lenticular structure, sometimes attaining a width of five to fifteen feet and again gradually narrowing to a width of only a few inches, or even pinching out entirely, leaving only slicken-sided walls in contact with each other. This lenticular structure is prominent in both longitudinal and vertical sections of the vein. If the figure (1) showing the relation of the vein to the country rock be examined (see p. 86) it is clearly seen how even a slight movement of either wall in any direction must necessarily tend to produce just such lenticular spaces as have been described. In addition to their lenticular character the veins possess other irregularities. Stringers of ore may lead off from the main vein along the planes of schistosity, or at times may follow one of the numerous joint systems.

Origin of the vein.—The above discussions make so clear the supposed origin of the veins that only a few words need be said upon the subject. The openings which they fill or fractures in which they occur were perhaps produced by a series of jointing and faulting prominently developed along the western contact of the slates. The most important of these is the great Gold Hill fault which is described on page 68. This fault has an average strike of about 15° E. of N., varying more or less from place to place. There is a well-developed series of joints throughout the whole region of a similar trend, which often show evidences of dislocation. It is probable that the fissures now occupied by many of the veins are minor fault lines in the main zone of faulting. The brecciated character of some of the veins, their slicken-sided walls and the fact that they often cut across the schistosity at approximately the same angle as the main fault line, are all regarded as strong evidence of such an origin.

Origin of the Spaces Occupied by the Veins.

Various investigators who have written upon the origin of the spaces in which the ores are now found have offered two theories to account for these openings:

1. That the ore-bearing solutions working along fractures in the country rock have replaced the rocks and rock fragments with the gangue and ore.

2. That the ores were deposited in fissures which remained open until filled with the ores and gangue minerals.

The detailed examination of the mines in course of the field work showed, as has been stated, two types of veins, one showing much silicification and probably much replacement of rock by ores, the other consisting of narrow fractures sometimes as thin as a knife-edge, filled with ore and showing little or no silicification and no replacement as far as could be determined.

The first theory, that of replacement, may account for the first type of veins, but certainly not for the second class in which the ore occurs in stringers in perfectly fresh slates. This type of course can readily be accounted for by supposing that the ores found the spaces open and waiting to be filled. This seems impossible, since it is not believed that such spaces could have remained open at the great depths to which the ores now extend or have extended. There is another theory, recently applied to instances of this kind, which may account for the phenomena presented by the second type of vein, and also have considerable application in connection with the first type. This is the force exerted by growing crystals.

Messrs. Becker and Day[37] have recently done some experimental work upon this subject with the surprising results of finding that:

"It became reasonably certain that it (the force of growing crystals) is actually of the same order of magnitude as the ascertained resistance which the crystals offered to crushing stresses."

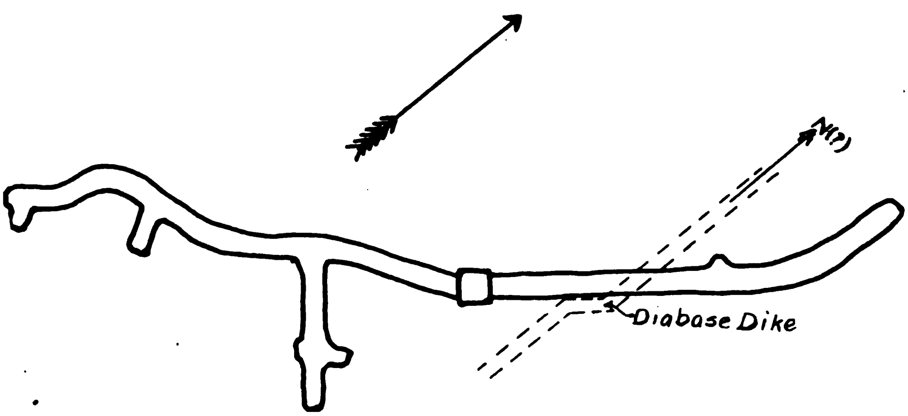
They furthermore say: "It is manifest that we here have to deal with a force of great geological importance. If quartz, during crystallization, exerts a pressure on the sides of a vein which is of the same order of magnitude which it offers to crushing, then this force is also of the same order of magnitude as the resistance of the wall rocks, and it thus becomes possible that, as indicated by observation, the mother lode and other great veins have actually been widened to an important extent, perhaps as much as 100 per cent or even more, by pressure due to this cause."

This theory appears to offer a plausible explanation, not only for the formation of the spaces which veins occupy in the country rock, but also for the cracks in the pyrite in which the chalcopyrite is seen in

[37] Becker, George F., and Day, Arthur L. The Linear Force of Growing Crystals. Wash. Acad. Sci., Proc., v. 7 (1905) pp. 283–288.

knife-edge seams, and possibly for spaces which the gold fills in its gangue minerals. It is, therefore, believed that it accounts for the conditions in the mines of the Gold Hill district far more satisfactorily than either or both the others. The second theory, presuming the existence of open spaces at such great depths, is regarded as untenable as far as the conditions of these veins are concerned.

It appears probable that there has been little or no important faulting since the deposition of the ores. It is true that in some instances the miners report slight offsets in the veins, but it seems probable from observation in a few instances in the Union Mine that the dislocation in the vein was due to an offset of the original fault line in which the vein had been formed, and not to faulting since the formation of the vein. It is true that joints, and in a few cases, diabase dikes are found cutting the veins. Every occurrence of a diabase dike in this relation in both the Union and the Gold Hill Mine was examined in detail and in no place was there found any appreciable dislocation in the vein at the dikes. The vein, in every instance in which the dike had been cut through, was found to resume its regular trend on the other side of the dike. The dikes often run parallel with the veins, sometimes following one or the other wall for greater or less distances. In the Barnhardt vein, a dike occurred which came up to the vein on one side, followed it for about 20 feet and then crossed it at nearly right angles and disappeared in the other wall. The following sketch (Fig. 3), was made with a view of showing the relation of dikes and veins.



PLAN OF 435 FOOT LEVEL BARNHARDT SHAFT GOLD HILL MINE, SCALE 1 INCH-120 FEET.

FIG. 3—SKETCH TO SHOW RELATION OF DIKES AND VEINS.

Thus, it is concluded that the formation of the veins and the deposition of the ores are comparatively late phenomena in the geological history of the district. Probably the only disturbances of any consequence since the deposition of the ores took place during Triassic times. In the mines this is represented by the intrusion of the diabase dikes and this has not produced any marked disturbances in the veins and ores.

THE ORES.

The ores of the Gold Hill district are auriferous pyrite and chalcopyrite with which is more or less gold-bearing quartz. The latter is the only gangue mineral of any importance. The gold values run higher in proportion as the copper decreases. That is, the gold seems to occur with the pyrite to a greater extent than with the chalcopyrite. From detailed examinations of the respective "gold veins" and "copper veins" of the Gold Hill and the Union mines, it seems probable that the copper and gold infiltrations are of two separate and to a certain extent distinct periods of mineralization, the one furnishing the copper with a small amount of gold and the other furnishing the gold with a small percentage of copper. Both copper and gold are younger than the pyrite. It is believed by the operators that the "gold veins" are more highly quartzose than the "copper veins." With the pyrite and chalcopyrite also occur small amounts of sphalerite and galena, but in such small quantities that they are of no value. There is, however, one exception to this, the "silver shaft" of the Union Copper Company which has produced considerable silver from an argentiferous galena.

Relation of Ores and Gangue.

The ores all contain more or less gold which will amalgamate readily, but there is always a high value remaining in the chalcopyrite and pyrite concentrates which have passed over the amalgamating plates—values representing from one-fourth to one-third the assay value of the ore. The gold in the quartz and also a part of the gold in the sulphide is known to be in the free state. Because of the high value of the concentrates, it has been assumed that at least a portion of the gold was present in chemical combination with either the sulphur, or isomorphous with the iron in the pyrite. With the hope of determining the condition of the gold in the sulphide and the relation of the sulphides to each other, a large number of typical specimens of these ores rich in gold were selected and ground down to a smooth surface and polished for microscopic study.

Microscopic description.—The equipment for the microscopic study of opaque substances consists of the ordinary microscope to which is affixed some device for reflecting a strong light upon the object being examined. There ought to be means at hand for varying the angle at which the light strikes the object. Very good results may be obtained with the ordinary metallographic microscope in the tube of which is placed a prism, which reflects a strong beam of light down through the objective upon the section. An objection to this is the fact that in artificial light the common minerals have colors very different from those they show by diffused sunlight. A good equipment for employing ordinary daylight consists of a parabolic reflector which is clamped upon the objective by means of a spring which holds it tightly in place. It is well to have a microscope with a double nose-piece and a reflector on each objective. This is a convenience to avoid loss of time in changing objectives. The section should be well polished so that the mineral will not show scratched surfaces. It will often be found necessary to etch the surfaces of the sections studied. This brings relative relief to the minerals and is very helpful in determining them.

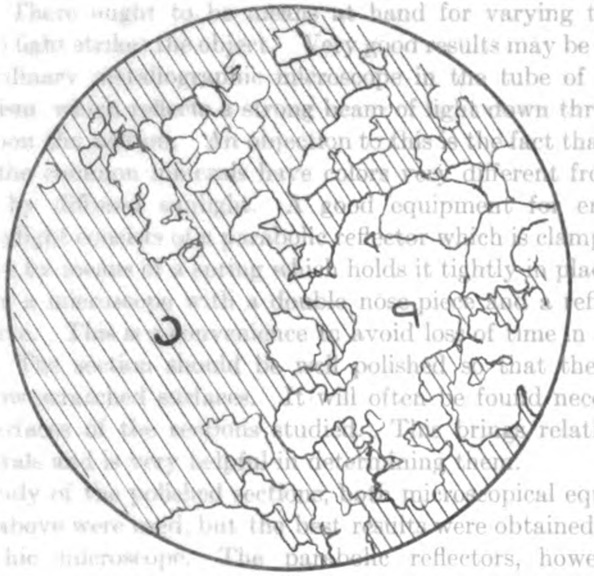
In the study of the polished sections, both microscopical equipments mentioned above were used, but the best results were obtained with the metallographic microscope. The parabolic reflectors, however, are excellent for use with low powers.

Relation of the Sulphides.

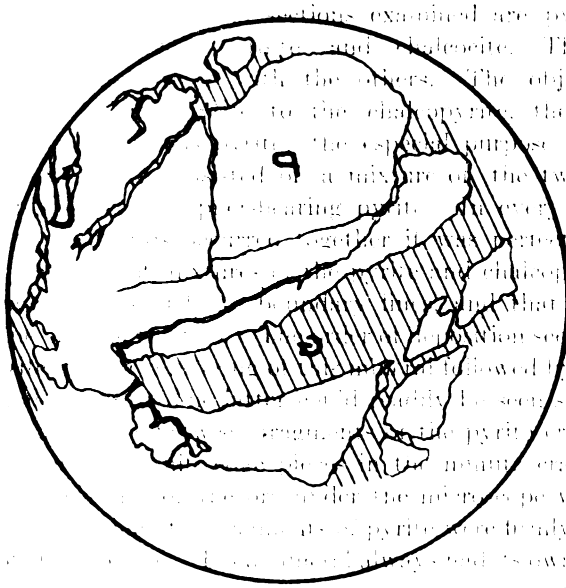
The sulphides present in the sections examined are pyrite, chalcopyrite, galena, sphalerite, bornite and chalcocite. The bornite and chalcocite do not occur with the others. The object sought was the relation of the pyrite to the chalcopyrite, the ore used was the so-called cupriferous pyrite; the especial purpose was to determine whether the ore consisted of a mixture of the two minerals or whether it was really copper-bearing pyrite. In every section in which these two minerals occurred together it was perfectly evident that the ore consisted of mixtures of the pyrite and chalcopyrite, each mineral having its own definite boundary lines, and that the pyrite was always the older of the two. The order of deposition seems to have been first pyrite, then a shattering of this mineral followed by the introduction of chalcopyrite. The latter could readily be seen surrounding and filling in the spaces between fragments of the pyrite crystals, and often running out into knife-edge pieces in the minute cracks in the pyrite. The appearance of the ore under the microscope was exactly that of a breccia in which the fragments of pyrite were firmly imbedded in a matrix of chalcopyrite. Each mineral always had its own boundary line, clear-cut and sharp. There was absolutely no gradation of one into the other. Some of the areas of chalcopyrite seemed to have

A—PHOTOMICROGRAPH SHOWING RELATION OF PYRITE TO CHALCOPYRITE.
P—PYRITE. C—CHALCOPYRITE.

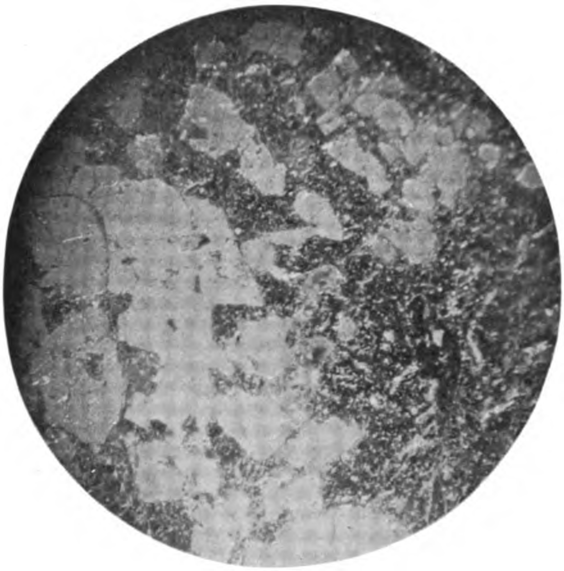
B—PHOTOMICROGRAPH SHOWING GOLD FILLING CRACKS IN PYRITE.
G—GOLD. P PYRITE.



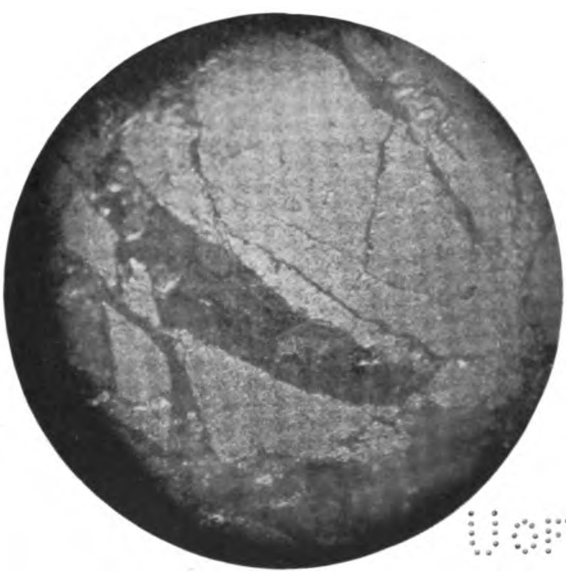
A. PHOTOMICROGRAPH SHOWING RELATION OF PYRITE TO CHALCOPYRITE.
P—PYRITE. C—CHALCOPYRITE.



B. PHOTOMICROGRAPH SHOWING GOLD FILLING CRACKS IN PYRITE.
G—GOLD. P—PYRITE.



A. Photomicrograph showing relation of pyrite to chalcopyrite.
P—Pyrite. C—Chalcopyrite.
X 40.



B. Photomicrograph showing gold filling cracks in pyrite.
G—Gold. P—Pyrite.
X 60.

the form of pieces of pyrite and it is possible that these may represent a replacement of the pyrite by the chalcopyrite. Quartz was present in the ore but its definite relative age could not be determined. In part it appeared to be contemporaneous with the pyrite, and in part was contemporaneous with and later than the chalcopyrite. The microphotograph (Pl. XIII, A) was made with the intention of showing as clearly as possible the relations described above.

When galena and sphalerite occurred, both seemed to be subsequent to the other sulphides, and of these two the galena was subsequent to the sphalerite. These minerals were only sparingly present in the sections examined.

Only a few sections of bornite and chalcocite were examined. In every section of these ores the surface consisted of a mass of bornite clearly distinguished by its peculiar bronze color, through which was a mesh or network of bright, glistening chalcocite, the amount of the respective minerals varying greatly. If the section happened to be largely chalcocite, the lines of the network of this mineral were broader and many irregular areas of it occurred; while, if the bornite were present in greater amount, the lines of the network of chalcocite were narrower and fewer in number and there were only a few of the irregular areas just mentioned. The bornite did not, as a rule, present very clear-cut boundary lines against the chalcocite, but had a kind of ragged or indistinct appearance.

No very positive statements can be made as to the relative age of the two minerals, but their appearance and their relation to each other strongly suggests that the chalcocite is secondary to and derived from an alteration of the bornite.

Relation of Gold to Sulphides.

One of the principal objects of the microscopic examination of the ores was to determine, if possible, the condition of the gold in the sulphides. Many of the sections were from lean ore and no gold could be seen in them, even when careful panning would show its presence, but in the majority of the sections, especially of the richer ores, it was not difficult to detect. The ores used in making the sections assayed from $5.00 to as high as $375 per ton.

In every section in which gold could be distinguished in the sulphides, it had its own distinct and clear-cut boundaries and was obviously subsequent to the sulphide. Its manner of occurrence was not essentially different from that of the chalcopyrite in the pyrite. It occurred in irregular areas and cracks in the pyrite, frequently running out to the very extremity of a narrow knife-edged crack, oftentimes filling two or more roughly parallel cracks with stringers running from one to the other. It was in no case distributed evenly through the sulphide, but seemed to be more or less concentrated in certain areas. In only a few doubtful instances was it seen in the chalcopyrite, but there was no difficulty in finding it in the pyrite. The pyrite in all the sections was examined with great care to ascertain if it presented any peculiarities of structure, form, or color that might indicate a chemical union with the gold, but with only one or two doubtful exceptions were any such features detected. These, when seen, appeared to consist of striped areas in the midst of a fair-sized grain of pyrite which had a slightly different luster and color from the other portions of the grain. These areas were always small, had irregular boundaries, and their nature could not be determined. While it is possible that they may represent some kind of combination of gold with the sulphide, it is believed that they are due to irregularities resulting from grinding and polishing the section.

When the gold occurred in connection with galena in the pyrite, there was always difficulty in determining the relative age of the two. Sometimes the evidence seemed to favor the idea that the galena was subsequent, while again the reverse appeared to be true. The gold in such occurrences always had clear-cut and well-defined boundaries against the galena. From the few instances in which the two were seen in juxtaposition it is not possible to make any definite statement as to the relative ages. It is believed, however, that the galena is subsequent to the gold.

As to the condition of all the gold in the sulphides, the work thus far done does not warrant definite statements, but it is believed that it occurs only as free gold and not in a chemical combination with the sulphide or as a sulphide itself. The fact that in every instance in which the metal was detected in the sulphide it was in the native condition and also that the pyrite in which it occurred always had, with only doubtful exceptions, its usual characteristics, favor this opinion.

The fact that all the gold will not amalgamate may be urged against the above conclusion, and this has been given due consideration. There is one very strong reason why the values can not all be extracted by amalgamation. This is the fact, well shown under the microscope, that the gold runs out into such minute cracks in the pyrite that it would be impossible to crush the ore finely enough for all the gold to come in contact with the mercury without sliming the whole mass. Microscopic examination of the gold panned out from the ores examined adds weight to this statement in that it shows that the gold occurs in exceedingly thin scales and very small irregular particles. There is also opposed to the possible combination with the sulphides the well-known fact that iron or ferrous salts will immediately precipitate gold from its solutions.[38]

The following microphotograph (Pl. XIII, B) was made from a section of one of the richest ores. It shows fairly well the relation between the metal and the sulphide as it is seen under the microscope.

NATURE OF THE ORE BODIES.

It has been stated that the veins have a lenticular structure, as seen in both horizontal and vertical plan. All portions of the vein are not of equal richness, although throughout the entire lengths of the exposed veins there is more or less mineralization, but it is only in certain portions that this has been of sufficient magnitude to form workable ore bodies. These ore shoots, of course, lie within or rather are simply the richer portions of the vein. They, however, present irregular outlines and have a decided pitch to the southwest. In extent they vary longitudinally from 20 to over 100 feet, vertically from 100 feet to the greatest depths of the mines, about 800 feet. The values are not uniform throughout these distances and the shoot shows all the "pinches" and "swells" of the vein. Ore shoots are best exhibited in the Gold Hill Mine, the workings of which seem to indicate three and possibly four of them. The following vertical section of the mine made from an actual survey in 1886 and extended and modified to include the conditions up to 1907, shows diagramatically an approximation of the extent and relations of the ore shoots. (Pl. XIV.)

In the detailed examination of these ore shoots, it was interesting to find that the slicken-sides on the walls of the veins were not vertical but were inclined to the southwest at an angle approximating the pitch of the ore shoots. This and their shape and pitch may indicate that the dislocation along the lines of faulting now marked by the vein had both a vertical and longitudinal component. The slicken-sides in the 300 foot level of the Barnhardt shaft showed a similar inclination, but the workings in this mine have not been extensive enough to indicate anything very definite as to the pitch of the ore shoots, two of which have been worked to a limited extent.

Relation of ore and gangue.—As has been stated above, there are two types of veins; one in which the ores occur as stringers in the schist, the other in which they occur with more or less quartz as gangue. In the first type the vein consists of numerous narrow stringers of ore

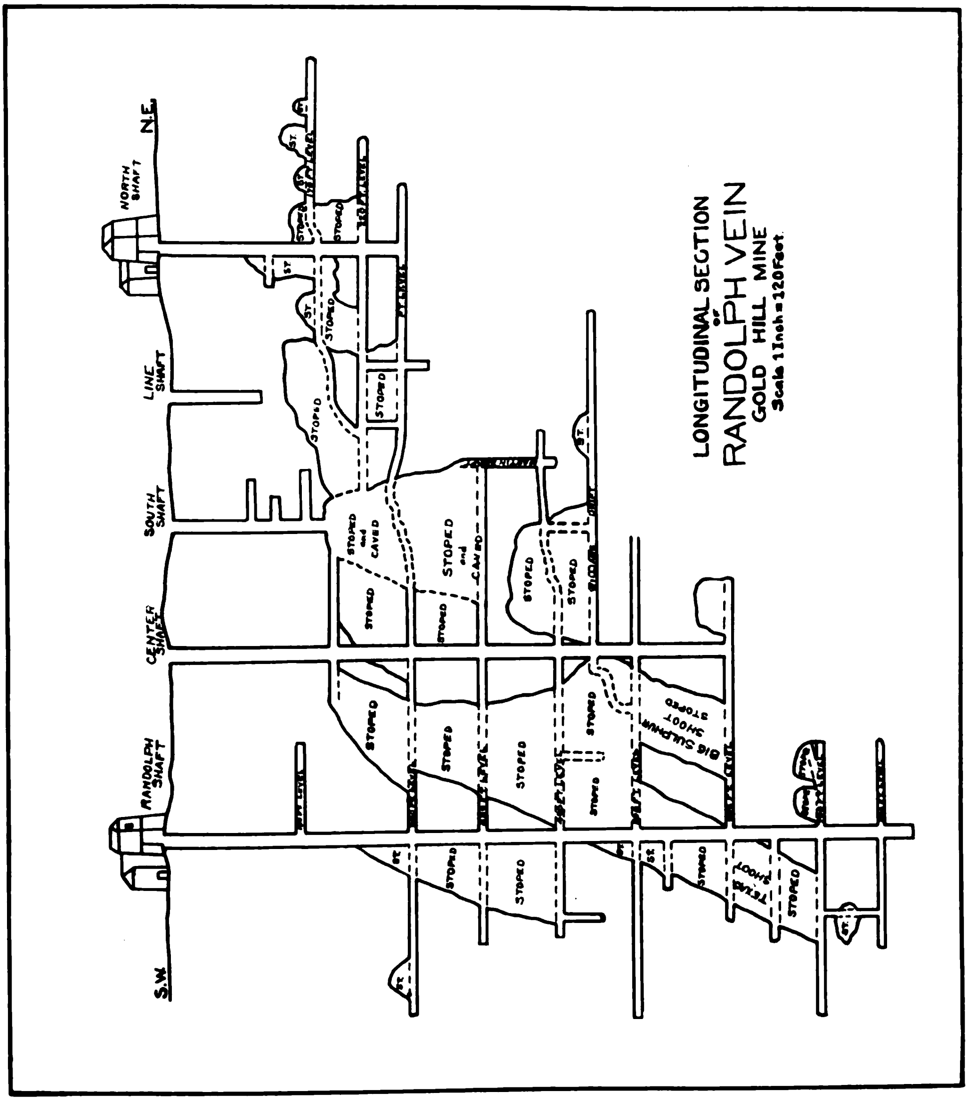
[38] Van Hise, C. R. A treatise on Metamorphism. U. S. Geol. Survey, Monograph 47, p. 1091 *et seq*.

which lie in the opened-up planes of schistosity of the rock and which are separated one from another by narrow bands of the schist. There is no gangue in such a vein. The ore occurs simply as a filling in the rifts in the slates, and the vein consists of a group of these stringers of ore and schist. In this type of vein there has been little or no silicification of the immediate schist, and only a very limited deposition of quartz. The diagram (Fig. 4, p. 97) is an attempt to illustrate this type of vein structure.

The other and prevalent type of vein differs from that described above in that it is more highly silicious, contains numerous mashed and drawn-out fragments of the country rock and much more white quartz. This type is likely to be larger and more persistent than the other and shows to a greater extent that the schists have been replaced by quartz, thus indicating possibly a more vigorous circulation. In this type of vein the ores may have a banding parallel with the schistosity of the rocks. The bands often spread out and include elongated areas of the silicified schists, the ore following around these and other smaller fragments in graceful curves. In some instances areas of the broken schist have been replaced by the ore. In the more highly silicious portions of these veins the ore has an irregular distribution through bluish gray quartzose groundmass. These ores usually carry their values in gold rather than in copper while those of the first type have their values in copper with but a small amount of gold. In each type it seems that the pyrite was the first sulphide deposited. Subsequently there came in, in one instance, considerable quantities of chalcopyrite which formed a kind cf cement as it were, filling the fractures and cracks in and around the pyrite; in the other there was very little chalcopyrite but considerable gold deposited in the manner described. The solutions which deposited the gold, especially in the Gold Hill Mine, seem to have been more highly charged with silica and to have had a much more marked effect upon the materials of the vein. The veins rich in gold in this mine are probably more highly silicious than those which carry copper and only a little gold.

Origin of the Ores.

The siliceous character of the greater number of veins and the amount of silicification of the country rock in their vicinity seem to offer a possible clue to the origin of the ores. All the veins, whether ore-bearing or not, are invariably more highly siliceous than the rocks in which they occur. This is especially evident in the greenstone area in which the ore occurs in typical quartz veins. It might be argued that in an acid tuff the circulating solutions might produce such local silicification without any outside influence, but it is not believed that even in this in-



LONGITUDINAL SECTION OF RANDOLPH VEIN, SHOWING DIAGRAMATICALLY AN APPROXIMATION OF THE EXTENT AND RELATION OF ORE SHOOTS.

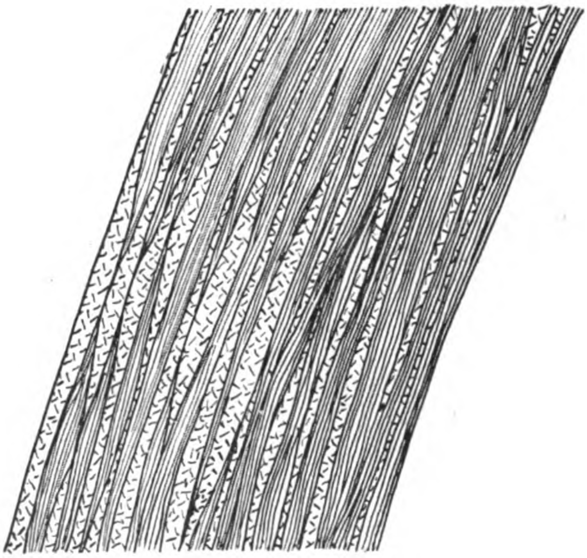


FIG. 4—SKETCH SHOWING THE MODE OF OCCURRENCE OF ORE IN RIFTED SCHIST. (AFTER WEED.)

stance such is the case. When we try to account for the formation of the quartz veins in a similar manner in a rock as basic as the greenstone, it is seen to be impossible, since the rock could by no means furnish the silica. Another item is the fact that in neither instance is the country rock ore-bearing. In every case the mineralization is closely connected with definite fractures and always attended by a great amount of silicification. From these facts it seems evident that an entirely different source must be sought for the ores. The formation of the fractures along which they have been developed has already been assumed to be connected with the intrusion of the vast stocks of granite. It is believed it would be perfectly logical to look to this same source for the ores. As having especial bearing on this subject may be mentioned the fact that in the Virgilina district where the ore deposits occur in quartz veins in greenstones—probably altered andesites and andesitic tuffs—feldspars, often orthoclase, are common gangue minerals. Indeed, the barren portions of a few veins in this district strongly resemble pegmatites, consisting for the most part of quartz and pink feldspar. Also it is well known that many of the largest copper and gold deposits of the world are associated genetically with acid rocks.

It is therefore believed that the ores of the Gold Hill district were derived from the great stocks of granite, and that they were developed immediately following the intrusion of the granite.

MINES AND PROSPECTS OF THE GOLD HILL TYPE.

As typical examples of this type of deposit, the following may be mentioned: mines and prospects of the Gold Hill Copper Company; the mines and prospects of the Union Copper Company; the mines and prospects of the Whitney Company; and those of the Southern Copper and Gold Mining Company. These will now be described somewhat in detail.

The Mines and Prospects of the Gold Hill Copper Company.

These consist of the Gold Hill Mine (Randolph shaft), the Miller and Barnhardt shafts, and the Old Field diggings.

The Randolph is one of the deepest shafts in the South, reaching a depth of 820 feet and the workings from it and from a line of caved and dilapidated shafts on the same vein immediately to the northeast have been more extensively stoped than any other mine in the State. From these shafts the workable ores of the largest vein in the mine (the Randolph) varying in width from 2 to 15 feet, have been removed from about 1,500 feet of the linear length of the vein to a depth of about 700 feet. In addition to this work, there have been numerous exploratory drifts

VIEW OF GOLD HILL MINE, OF THE GOLD HILL COPPER COMPANY, GOLD HILL, ROWAN COUNTY, N. C.

driven into the walls which show both the location and pitch of the ore shoots and to a certain extent the character of the wall rock. The ore shoots have been discussed in another place (p. 95) and will not be described any further than to state that the ore in the upper levels, in the oxidized zone—was an exceedingly rich free-milling gold ore and as depth increased the sulphides began to come in and the gold values greatly decreased. No records of the early workings were kept and the depth of oxidation, etc., can not be given. It appears, nevertheless, that the first sulphides encountered were fairly rich in gold and carried a low percentage of copper. Both values as well as the width and extent of the ore shoot appear to have decreased with depth. At the present depth, 800 feet, the assays from this vein show from a trace to $2.00 per ton in gold and from 1 to 3 per cent of copper, and the vein is narrow and unpromising.

The greatest amount of exploratory work has been done on the 800 foot level, about 2,000 feet of drifts having been driven both along the trend of the veins of the upper levels and across the schistosity of the country rock. This work was mentioned and discussed to a limited extent, and a sketch of the workings made from a recent survey was given in Pl. XV, but it may be well to describe it in greater detail here.

As the sketch shows, the drifting starting at the shaft, was driven in two directions approximately at right angles to the schistosity of the country rock to a distance of 440 feet to the south and 360 feet to the north, intersecting no less than eleven mineralized bands of greater or less importance. Three of these were of considerable size and drifts were driven along them for some distance in each case. These are the Randolph vein, which was very rich in the upper levels of the mine; the Miller vein which had been opened up by the Miller shaft in one place to a depth of 160 feet, and by the Barnhardt shaft in another to a depth of 435 feet; and the new North vein which was not known to exist prior to this work.

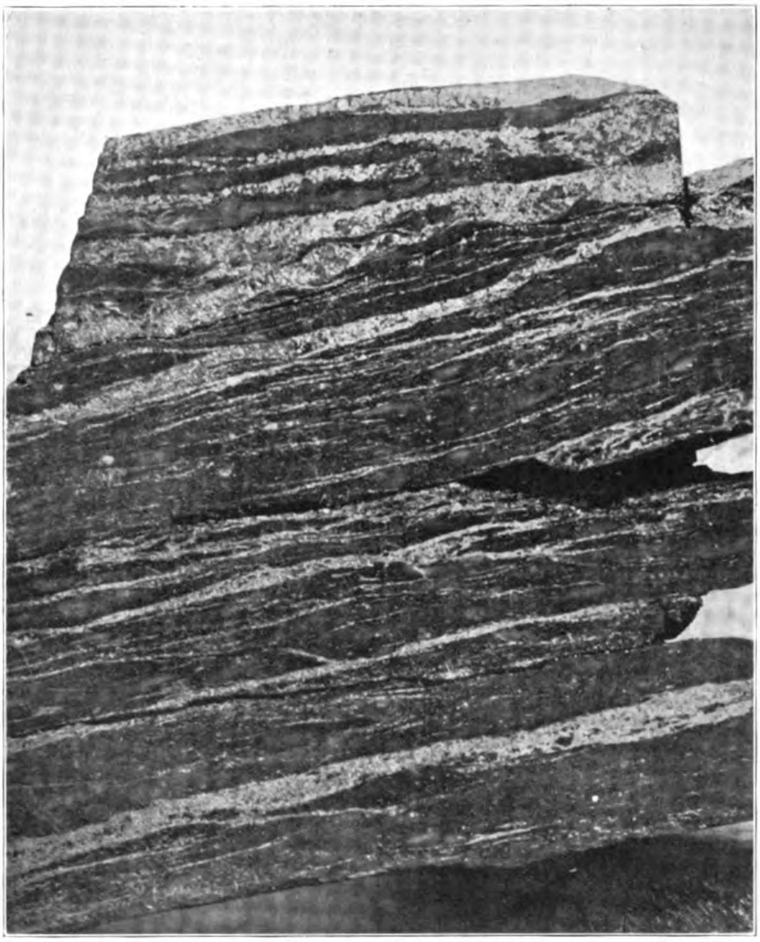
The small stringers are of no importance from an economic standpoint but of interest in that they show that the Gold Hill Ridge is made up of a zone of mineralization, and that this has taken place in fractures and openings formed by faulting. The fact that some of these veins "run" with the strike of the schistosity while others cross it at acute angles, shows that there was cross fracturing as well as fracturing along the planes of schistosity which was probably developed long before the faulting occurred.

The work along the strike of the Randolph vein showed conclusively that the rich ore shoot of the upper workings did not extend to this depth. It also showed that the fracture along which the mineralization took place not only extended to this depth but was mineralized, although to a less degree than in the upper levels. Furthermore, it revealed a series of fault planes trending N. 30° W. which presented more or less brecciation but no displacement of any moment.

The vein encountered at a distance of 440 feet south from the foot of the shaft is probably the one opened up by the Miller and Barnhardt shafts. This vein has been exposed along its trend for a distance of about 150 feet. Where first encountered, and in the northeast end of the drift, it is narrow, but as work was continued westward along its trend, it gradually increased in width until in the present southwest heading of the drift it has a width of about 12 feet. (By the word vein is meant that portion of the schists with which the ore is interleaved and not that the body of ore is 12 feet in width. If all the ore now showing in the heading of the drift were concentrated into a single vein of solid ore, it would not have a width of more than 12 or 15 inches). This amount of ore is simply interleaved with about 12 feet of rifted schist in the manner shown in the photograph (Pl. XVI, and Fig. 4, p. 97), and constitutes the "vein." Samples collected across the entire width of the vein in many places are said to have shown a copper value of from 1.5 to 3 per cent with a trace to $2.00 per ton in gold.

The investigations in the underground workings of this mine show that this vein, which during part of its course follows the schistosity of the country rock, as a whole, apparently follows a fracture trending about 15° or 20° east of north and approximately parallel with the North vein.

More interesting than these is the North vein which does not outcrop at the surface and which was not known to exist prior to this work. This is a well-defined, mineralized, and silicified band in the slates—as well defined as any vein in the district—and varies in width, vein matter and ore, from 2 to 8 feet, averaging perhaps 3 feet. The ore carried high gold values and very little copper, the gold running from $10 to $385 per ton with less than 1 per cent of copper. Drifting was continued along the strike of the vein for a considerable distance, and it was found that the rich portion was an ore shoot about 60 feet long, and that the vein was following a fracture which cut the strike of the schistosity of the country rock at an acute angle, having a more northerly trend than the schistosity. A rise was made at the northeast boundary of the shoot and a winze was sunk at the southwest extremity. These gave strong evidence that the shoot has about the same southwest pitch as those in the Randolph vein. The drifting along the vein encountered two diabase dikes each about 10 feet wide that cut it nearly at right angles. These produced no displacement, and, as far as could be



PHOTOGRAPH OF SMALL PORTION OF TYPICAL "SLATE VEIN," SHOWING ORE FILLING CREVICES IN RIFTED SCHIST. MILLER VEIN, GOLD HILL MINE.
(Three-fourths natural size.)

determined, had had no decided influence upon the values of the ore. Stringers of ore at one or two places left the general trend of the vein and entered the walls in a direction parallel with the strike of the schistosity, but were not followed. The ore from this vein is remarkably rich in free gold, the greater part of which is probably carried by the pyrite. The relation of one to the other and to other gangue minerals, has been described in detail on p. 93.

Some conclusions and surmises based upon the detailed study of the veins and ores in the mine, and of the ores in the laboratory are summarized below:

1. The rich ore shoot of the upper workings of the Randolph vein has pinched out.

2. Instead of one main vein well mineralized, there is a series of small and medium sized veins irregularly distributed through the schists.

3. There are clearly two types of veins; one highly silicious and somewhat quartzose, showing considerable replacement of the country rock by both silica and ore; the other presenting a series of narrow stringers of ore filling fissures which have been formed by splintering or tearing apart the schists along their planes of cleavage.

4. The veins may be expected to extend to great depths. The Miller vein is as well developed at a depth of 800 feet as at the 150 foot level; the Randolph vein is also persistent, and is well defined, at the lowest depth reached. Assays made from both the 160 and the 800 foot levels of the Miller vein show similar values in both copper and gold.

5. The veins relatively high in copper values will probably be low in gold, and when high in gold will probably be low in copper; that is, some of the veins are predominantly copper bearing while others are predominantly auriferous. The Miller vein is predominantly chalcopyrite in pyrite, while the North vein carries very little chalcopyrite, but high values in free gold in both quartz and pyrite. This has been discussed in detail on p. 91.

6. The free gold in the pyrite in the North vein is not the result of secondary alterations by oxidizing waters. The pyrite is perfectly fresh and shows no trace whatever of secondary alterations. This depth of 800 feet is certainly 400 feet greater than the oxidized zone has reached in any other veins in the district. The gold, therefore, was probably deposited in the pyrite originally as free gold and was probably brought up from the unknown depths by the waters which produced the silicification of the country rock in the vein.

7. The fact that one vein is predominantly copper-bearing and another predominantly auriferous, leads the investigator to suspect that there were two periods of mineralization, or at least two sources for the mineralizing solutions.

8. The fact that the North vein with high gold values, does not outcrop at the surface and has not been cut by the upper workings, suggests that there may be a large quantity of gold ore in the portion of the vein between this depth and the surface. The fact that the vein does not outcrop at the surface also gives hope for a considerable future to mining in the Gold Hill district and that systematic prospecting legitimately done is certainly warranted in many places in the courses of the veins that have been supposedly worked out at one place, and which are known to have greater linear extension.

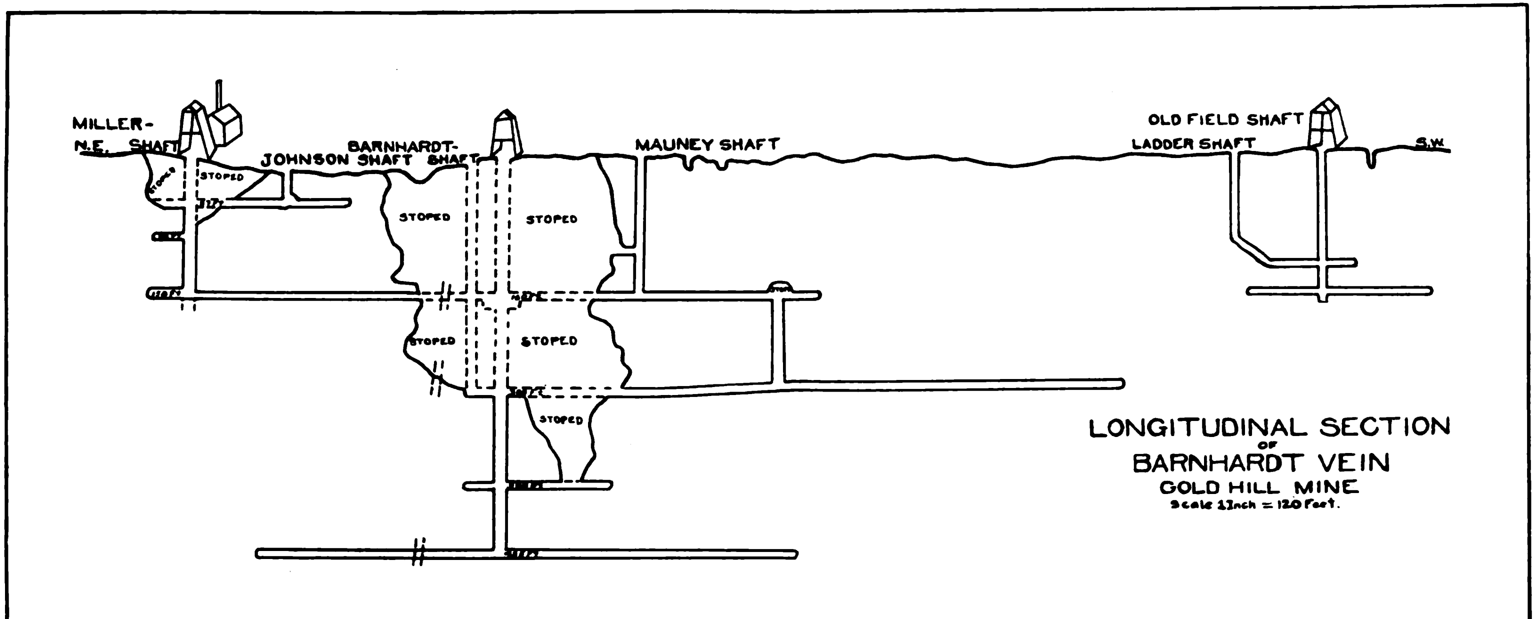
The Barnhardt and Miller shafts.—These shafts have already been discussed and there is but little additional information to be given. They are situated about 500 feet southeast of the Randolph shaft and are presumably on the same vein, but probably in two distinct ore shoots. The ores from each shaft are similar and occur in somewhat the same way. This is a "slate vein;" that is, a mineralized and silicified band in the country rock, from which it differs only in the degree of silicification, and in some places there is but little. The vein consists of the splintered and torn apart schists with the ore filling the spaces between the shreds of rock. The walls show well-developed slicken-sides in many places and there are numerous little stringers of the ore in the rocks near the main vein. These sometimes follow the schistosity and at others follow fractures that cut it at acute angles with a trend that is generally more to the northward than the schistosity.

It is in this vein that the diabase dike mentioned on p. 90 occurs. Careful examination of the ores in close proximity to the dike failed to show that it had had any apparent influence upon their character. The dike came up to the vein in the foot wall, followed it for a short distance, crossed it and then disappeared in the hanging wall.

The workings on the lower level of the Barnhardt shaft do not extend far enough to give much information as to the character of the Miller ore shoot at the place where it was intersected by the drift. It is certain, however, that these two shafts are each in an ore shoot and that the Barnhardt pitches to the southwest approximately parallel with the striation on the slicken-sided walls of the vein. The Miller ore shoot probably has a similar pitch.

The following longitudinal section of the vein (Pl. XVII) shows the conditions as they appear to be.

The "Old Field" workings.—This group of prospects and shallow shafts lies a few hundred feet to the southwest of the Barnhardt shaft apparently on the southwest continuation of the same mineralized zone. They were filled with water at the time of examination and were inaccessible. The work has extended only to water level, but it is said that



LONGITUDINAL SECTION OF THE BARNHARDT VEIN OF THE GOLD HILL MINE, SHOWING EXTENT OF UNDERGROUND WORKINGS, DECEMBER, 1908.

a considerable quantity of free gold was obtained from them. No large and well-defined vein is reported but only numerous narrow stringers of ore in a comparatively narrow space in the country rock.

The Gold Hill Copper Company is fairly well equipped for handling the ores. The shafts are in good repair and are furnished with good hoisting machinery. The general equipment consists of a small 40-stamp mill, amalgamating plates and Wilfley concentrators. They have a good boiler house and machine shop, dynamo and air compressor room.

Mines and Prospects of the Union Copper Company.

This company is operating (1907) two mines and has opened numerous prospects in the Gold Hill district. The mines in operation are the Union and the Old Honeycutt, the latter now known as "No. 12."

The Union Mine.—This mine, Shaft No. 3 of the company, is, with the exception of the Gold Hill Mine, the most extensively developed in the State. The shaft has been sunk to a depth of about 600 feet and extensive workings have been made on five levels. One large lens or shoot of ore extending from the surface to the seventh level has been practically worked out. This ore body, an irregular lens-shaped mass over 100 feet long and possibly 50 feet in greatest width, extended from the surface down to the seventh level of the mine, about 500 feet. It presented some rather suggestive irregularities of form as shown in the plan of the workings given below (Fig. 5, p. 104).

The open cut, the sub-level, the first and a portion of the second levels, present an ore body with a trend which cuts the schistosity at acute angles. The schistosity is about N. 40° E. while the trend of the ore body in these three levels is approximately N. 25° E. In the south end of the second level a portion of the ore body has a trend of nearly 65° E. of N. The third level presents an ore body with a trend approximately parallel with the strike of the schistosity. Besides these, there is a small ore body near the north end of this level with a trend N. 35° W. A few feet south of this is another small deposit of ore with a trend parallel with the schistosity.

It is clear from a detailed examination of all the underground workings that the ore bodies have been developed in a fault zone in which the hade and strike have been very irregular. It is probable that the vein in the open cut, the first and sub-levels, and a portion of the second level, follow a fracture roughly parallel with the strike of the Gold Hill fault, and that the abrupt turn in the trend of the ore body in the south end of this level is caused by the development of this portion of the ore body in a cross-break, a fracture extending across the schistosity and connecting the ore body as it is found on the third level where

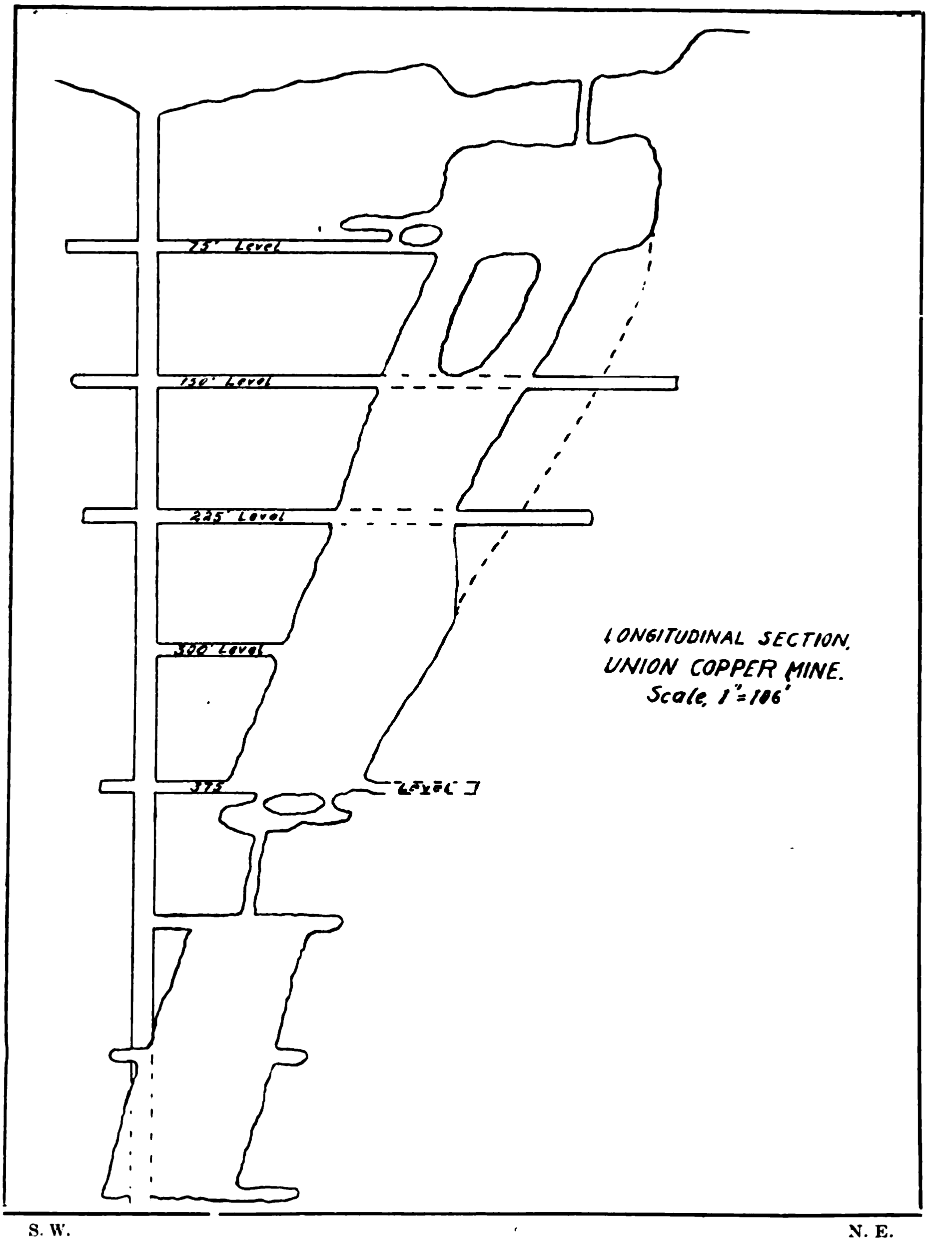
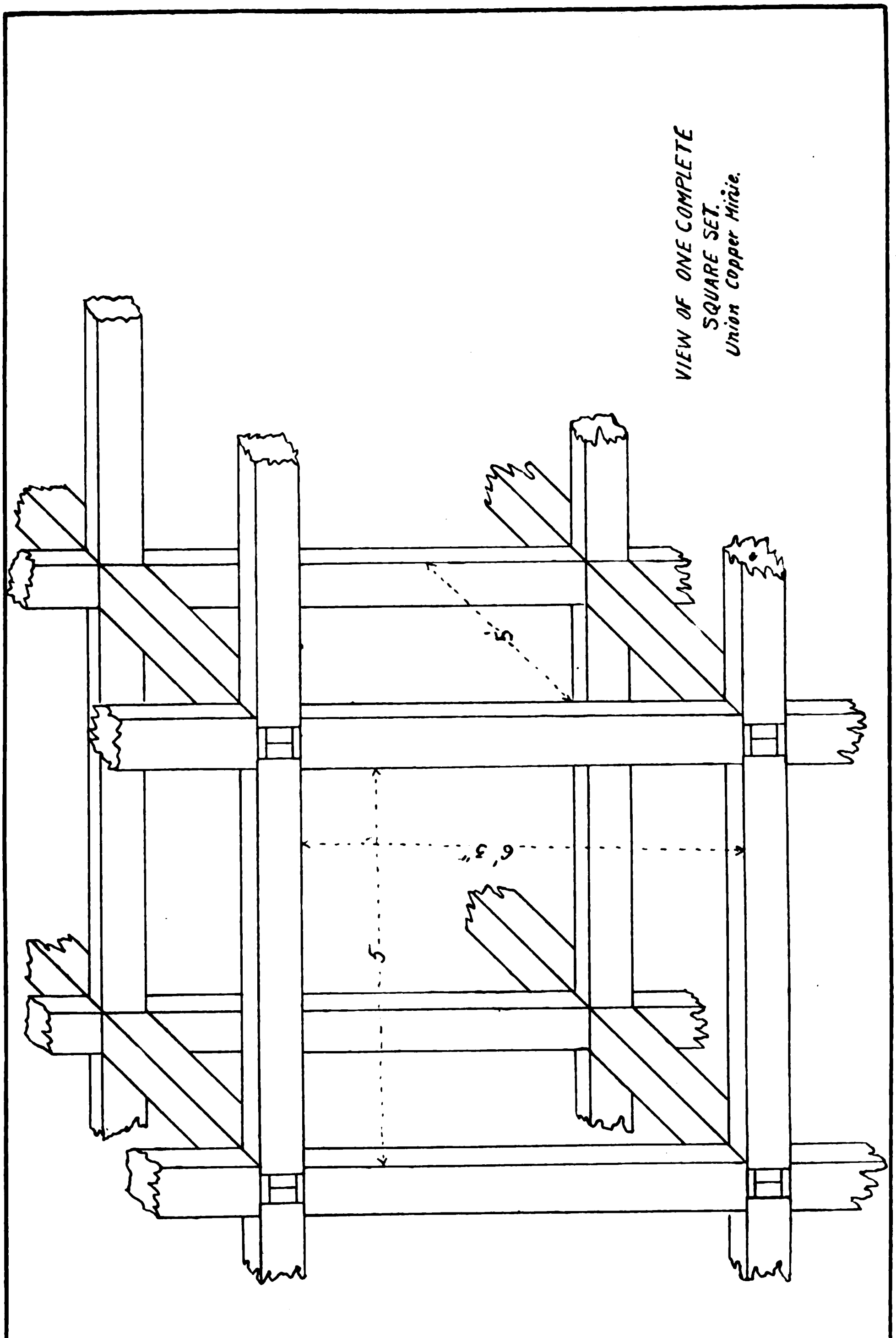
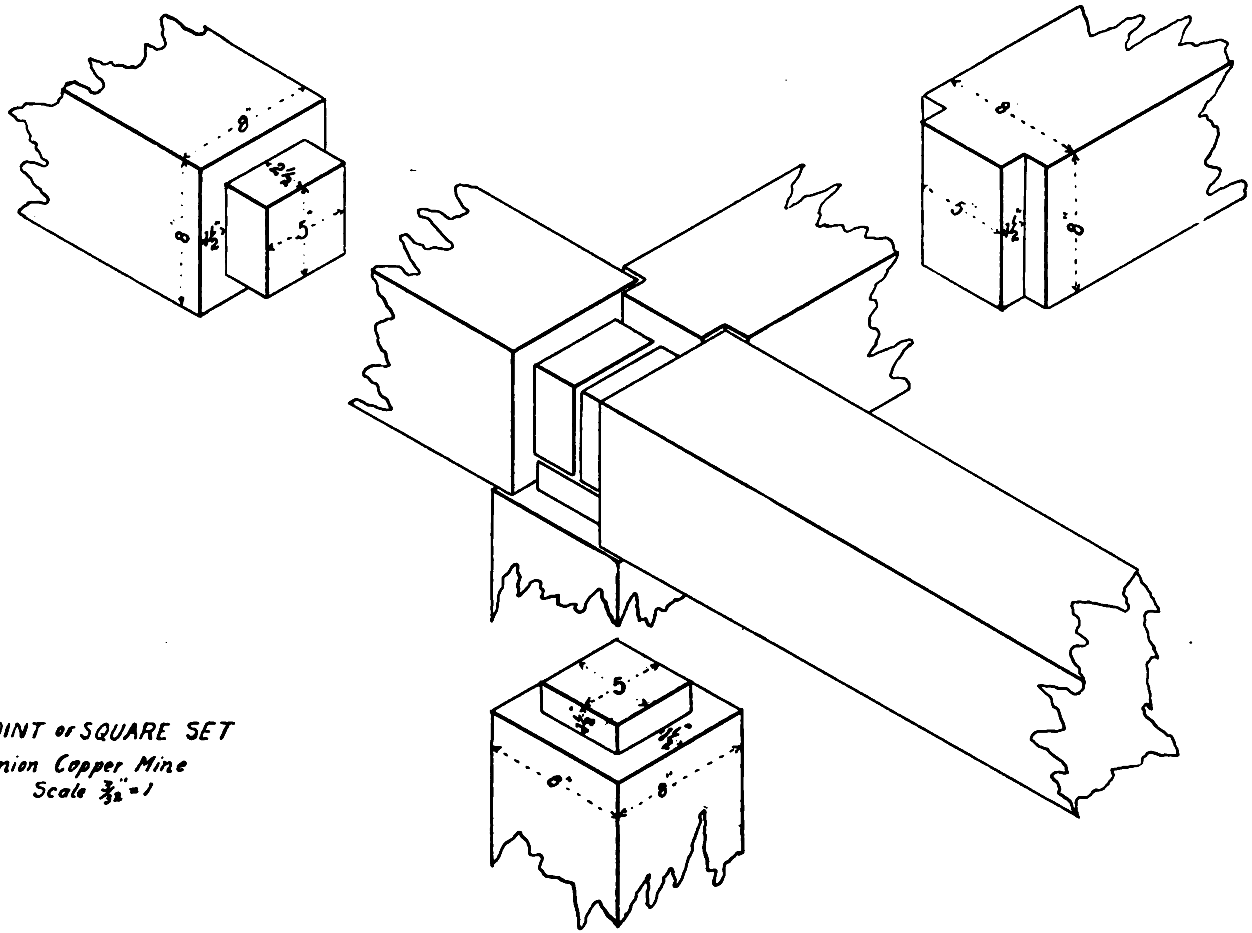


FIG. 5—LONGITUDINAL SECTION OF UNION COPPER MINE


VIEW OF ONE COMPLETE
SQUARE SET.
Union Copper Mine.
5
6' 3"
5



JOINT or SQUARE SET
Union Copper Mine
Scale 3/32" = 1

it follows the schistosity, with that of the upper workings. The small ore body at the north end of the third level is clearly following a fault with a strike of about N. 35° W. Fig. 5 shows plainly that the ore shoot has a decided pitch to the southwest. It was interesting to note in this case, as in the Gold Hill Mine, that the striations of the slicken-sided walls were inclined strongly to the southwest, approximately parallel with the pitch of the ore shoot.

The small shoot of ore trending N. 35° W. was also encountered on the first level. The size and trend were the same as on the third level. This line, N. 35° W., is one of prominent jointing throughout the whole district, and often presents slicken-sided walls and is frequently followed by dikes. The Cline Mine, and the Dan Hopkins digging are situated on well-defined and well-mineralized quartz veins, which have a parallel trend in this direction. Faulting has been discussed in detail (pp. 68-71). If the irregularities of these veins be compared with the sketch showing the general type of faulting for the district, it will be seen that this, together with the direction of movement indicated by the slickensides, will explain the irregularities here encountered.

The ore of this mine is a low grade copper ore consisting of chalcopyrite with pyrite, a little sphalerite and some galena. The relation of sulphides is the same as that at the Gold Hill Mine. (See p. 92). The ore always yields a small gold value, though rarely over $1.00 per ton, and is worked as copper ore. The vein matter consists of fragments of silicified country rock, a small amount of secondary reddish brown, semi-translucent quartz, together with much silicification of the adjoining schists. The ore occurs both in the quartz and in the altered schists. The average run of the vein is about 1½ to 3 per cent of copper, but the ore is "bunched" in the vein so that it may be raised to 8 or 10 per cent of copper by hand cobbing.

Methods of mining.—An interesting feature of the Union Copper Mine is the method of mining used in working out the large ore body in the upper levels. This ore body, about 40 feet in greatest width, is so large and so soft in the upper works that it could not be taken out satisfactorily by the old methods of timbering—stulls, truss and lock-sets. To secure this ore and at the same time to reduce the danger of mining it to a minimum, Mr. H. L. Griswold, the superintendent, introduced the square set used by Western miners. This has proven so successful that a detailed description of this method of mining is given here. The descriptions and drawings, the work of Dr. Joseph Hyde Pratt and Professor A. A. Steel, were published in Economic Paper No. 14[39] of the North Carolina Geological and Economic Survey.

[39]Pratt, J. H. Mining industry in North Carolina during 1906. North Carolina Geol. Survey, Economic paper 14, p. 26 *et seq.*

"This method was introduced by Mr. H. L. Griswold, superintendent of the Union Copper Company's Mine at Gold Hill, N. C. In former mining the old stopes were held open by miscellaneous timbering such as stulls, lock-sets and truss-sets. Such methods were not satisfactory and prevented the stoping of the ore in the most economical manner. By the introduction of the western square set method of timbering, the stoping of the ore is being done safely, completely and economically. The perspective cross-section (Pl. XX), illustrates the use of the square set. The sets are made of 8 x 8 inch sawed oak, and the mine carpenter can easily frame timber for this work. The framing is shown in the accompanying isometric sketches. (Pls. XVIII and XIX). The sets are 6 feet 3 inches high and 5 feet across in the clear. The posts are, therefore, 6 feet 3 inches long between the shoulders and have a 5 x 5 inch tenon 1½ inches long at each end; the caps are 5 feet 3 inches between shoulders and have a 5 x 5 inch tenon 2½ inches long at each end; the tiers are 5 feet between shoulders and have a 5 x 8 inch tenon 1½ inches long at each end.

"The size of the timbers will, of course, vary with the weight to be sustained. The style and proportions of framing are very good for oak timbers; but for pine, which crushes so easily across the grain, it is better to have the ends of the post tenons to touch each other. The light timbers are, of course, cheaper and much more easily handled. As the stopes get large, they are more or less completely filled with waste rock which is usually obtained in mining and would otherwise have to be hoisted out in working underhand stopes. This filling also holds the posts in position and helps to prevent them from buckling or "jack-knifing," if any timber yields, which might otherwise endanger the whole system. Since most of the pressure is downward, as soon as the ore is blasted away to make room for a new set, all the sets below are relieved and tend to come back to their original position. Thus, even light timbers will hold very well if the stope is worked rapidly enough.

"In the Union Copper Mine the square sets were founded upon a platform built upon the old, solid-looking truss-sets. As soon as a heavy load came upon them the trusses buckled sidewise and everything caved in. A new foundation was then made upon reinforced stulls and there has been no trouble since.

"A new set can be added in any position, at any time, without disturbing the adjoining timbers and the old timbers can easily be supported by temporary props while making room for an additional set. When the old timbers have been replaced, the entire flooring of sets is easily put in as the ore is removed, a temporary plank covering placed across the old timbers to protect the men from falling rocks. Temporary plank floors are placed upon the sets for the men to stand upon, and, as the system becomes higher, chutes and mill holes are put in to conduct the ore to the car or the track below. Any waste rock mined is merely dumped in and around the lower sets. In the diagram, (Pl. XX) these lower floors are omitted for the sake of clearness.

"There has been little or no trouble in introducing the square set method of timbering and at the Union Copper Mine the work is done under the immediate supervision of Messrs. B. V. and Mat. Hedrick, skillful North Carolina shift bosses who have had no previous experience with square sets. Some of the miners, especially negroes, when first stoping by means of square-set timbering, are a little nervous because they are so close to the roof that they can see how loose the rocks are; but this passes away as soon as they realize that they can pick down the loose rock or prop it up and, therefore, are safer than when they are so far away that they can not tell at what moment the rock may fall upon them. Also, when working at the bottom of a high, underhand stope, a blow from even a small rock would be dangerous."

The mine is fairly well equipped; the shaft and the machinery in general are in good repair. The company has no concentrating plant, and the ore is all shipped after being handcobbed.

There are numerous old prospects on other mineralized bands or veins in the immediate vicinity of the Union Mine, but they had all been abandoned and were filled with water and hence inaccessible. Their location and the trend and character of the vein, as far as they could be determined, are indicated on the detailed map of Gold Hill. (Pl. XII.)

The Honeycutt shaft, now known as No. 12, is located a short distance west of the Old Field diggings, and is apparently on the westward continuation of the same mineralized zone. This mine was opened in the early days of mining on Gold Hill and is said to have produced considerable free-milling gold ore. Like the other veins of the district as depth increased, the sulphides were encountered and work was abandoned. Another vein lying about 100 feet northwest of the Honeycutt vein was also prospected in the early days, but was found to carry principally copper and only a little gold. It is now being worked from Shaft No. 7. The vein is narrow and umpromising but is well defined and apparently follows the strike of the schistosity. It is interesting to find here a repetition of the conditions at the Gold Hill Mine, two veins close together, one carrying a gold value with little copper and the other copper with little or no gold.

Mines and Prospects of the Whitney Company.

These mines were not in operation at the time (1906 and 1907) the field work was in progress. They were, therefore, inaccessible and little can be said about them. Three shafts have been sunk, the deepest to a depth of 700 feet. Much underground development has followed and it is reported that there are a million and a half tons of gold ore averaging about $2.50 per ton now blocked out. (Plates XXI and XXII).

These mines were formerly known as the McMakin and the Isenhour mines. They are located a short distance to the west of Little Buffalo Creek and on rather low ground, but clearly in the Gold Hill fault zone and only a short distance east of the greenstone contact. All the mines are in the tuff area and not in the greenstone.

The vein, as far as could be determined, is the ordinary slate vein. That is, it consists of auriferous pyrite interleaved with the schists, and the ore fills narrow spaces parallel with the schistosity—really the opened planes of schistosity of the rifted schists. In character and mode of formation it does not differ essentially from the Miller vein of the Gold Hill Mine, except that in the Whitney vein there appears to have been a concentration of gold rather than of chalcopyrite as in the Miller vein. Judging from the material on the dump, both veins have been developed in precisely the same way, probably by the force of the crystallization of the pyrite in opening and widening spaces in the planes of schistosity as it was being deposited. Much of the gold seems to have been deposited in a similar manner, and many specimens of the ore show the thinnest films of gold, almost like gold-leaf in the planes of schistosity of the rock. From accounts of the ores in the copper-bearing portions of the vein, it seems that the larger percentage of gold occurred in this manner. The pyrite, which contains a small amount of chalcopyrite, also carries free gold, as all the concentrates show when panned.

This vein has an almost continuous outcrop for a distance of nearly 2 miles. Many little pits have been sunk in it in various places and each one is reported to have shown more or less gold, none of them containing very high values. As regards its length and continuity of outcrop, it is probably the strongest single vein in the Gold Hill district. (See Pl. XII).

From data and drawings furnished by the Company, it appears that the values in the vein or ore shoot are very irregular. It was not possible at the time of the field work to examine the ore body, but it appears from reports by the engineer, the late Mr. W. J. Parker, who was in charge of the exploration and test work done at the mines, that the ore is concentrated in certain layers or "floors" in the vein

GENERAL VIEW OF THE M'MAKIN MINE, PROPERTY OF THE WHITNEY COMPANY.

delimited by joint planes. To state it in other words, it appears that, since joint planes may often serve as channels for circulating solutions, they have in this instance largely controlled the deposition of the ores, especially the gold. In one report on file in the Company's office, Mr. Parker says: "I have surveyed the 370 foot stope in the Whitney Mine and will send you a drawing[40] of it in a few days. The ore shoot in this stope follows a so-called floor or slide, which is in reality a bedding or structural plane of the slates. These bedding planes all over the mine undulate considerably; but, taken as a whole, dip to the north-east. This individual floor is lying nearly flat in the stope and for this reason goes over the top of the 370 foot north drift, north of the rise. When within 30 feet (vertical depth) of the 260 foot level (in the rise) another bedding plane is encountered and above this there is but very little gold. (See Pl. XXII).

"It seems that all the better ore in this mine is confined to certain strata of the slate and the reason that the ore is only 5 to 20 feet wide in these strata is because all the gold has been segregated to within that space."

When it is known that the schistosity of the slates is often mistaken for their bedding planes, a fact which Mr. Parker apparently did not recognize, it is evident that by "floor," "slide," "structural plane" and "bedding plane," he is referring to the numerous nearly horizontal joint planes which are so prominently developed in the vicinity of Gold Hill.

The ore in this vein, as in all others of the district, lies in fairly well-defined shoots. The main shaft is located in one and the Isenhour in another, but the amount of work thus far done is not sufficient to warrant any statements as to their pitch and general character.

In regard to the width of the vein and value of the ores, Dr. Pratt[41] and Mr. Steel say:

"The vein varies from 3 or 4 feet wide to 25 feet, and Mr. E. B. C. Hambley, the manager of the Whitney Company, assumed an average of 14 feet. His engineer, the late W. J. Parker, reported a million and a half tons of ore blocked out. As the vein was more definitely proved to be of value, the prospecting shafts were sunk larger so that they can be easily changed to three compartment shafts and the mine equipped for an output of 1,000 tons a day. Part of the vein is very low grade, less than $1 a ton, but this shows occasional rich spots and can-not well be left. In the more quartzose parts there are some rich shoots or lenses 50 to 100 feet across of as high grade as $14 to $16 per ton.

[40]The drawing is produced as Pl. XXIII, A.

[41]Pratt, J. H. Mining industry in North Carolina during 1906. North Carolina Geol. Survey, Economic paper 14. Raleigh, 1907. pp. 144.

"During the development work, ore from the various drifts and cross-cuts was tested in the old McMakin mill of 10-stamps with chlorination annex. Tests made of 4,950 tons gave per ton of ore: free gold, $0.51 to $38.75, average $4.52; gold in concentrates per ton of ore $0.10 to $0.83, average $0.34; gold in tailings per ton of ore $0.31 to $2.75 average $0.83. The ore yielded from 1.83 to 12.87 per cent of concentrates which had an average value of only $4.17 per ton. Chlorinating the concentrates gave an average gold recovery from them of $3.33 per ton and a loss in the tailings of $0.84. The amount of gold amalgamated was 79.44 per cent, while that recovered from the concentrates was only 4.78 per cent of the total value of the ore. They will, therefore, not bother with concentration, but merely save as much gold as possible by amalgamation. Cyaniding has not been investigated as yet, but will hardly pay on tailings which will be so low grade.

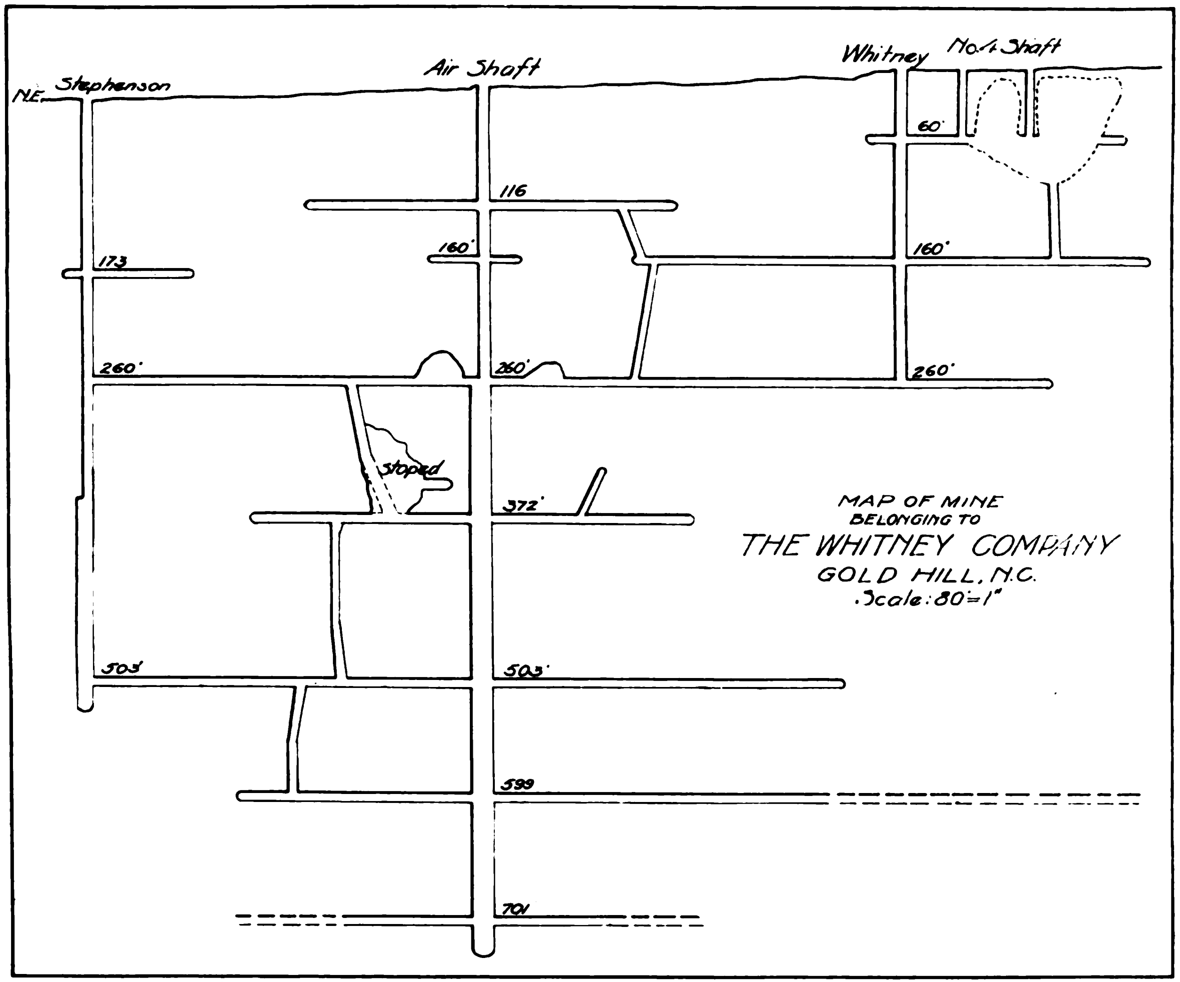
"There was a special report for each mill test, naming the place from which the ore was taken, and all details. By careful sampling in the mine they have figured that the ore will give an average recovery of $2.50 per ton, but in the same proportion as that tested. On the basis of 1,000 tons per day, Mr. Parker expected to mine the ore for $1.03 per ton, transport it to the mill for $0.12, and mill it for $0.26, total expense $1.42 per ton, showing an expected profit of a little over $1 per ton. Of course this involves equipment for electric hoist and haulage plant, etc. They will use double deck cages since the slaty ore is expected to give trouble in loading skips. It was Mr. Hambley's intention to push the development work only fast enough to keep a half million tons of ore blocked out. He states that the vein can be followed on the surface for a distance of 2 miles, but it is very probable that there are a good many barren spots along this length, and at the North and at the old Isenhour workings there seems to have been a number of small, richer deposits pretty badly scattered. The whole mine was quite dry, especially at depth. Mr. Hambley and others said that the Isenhour vein was 9 feet thick and of good grade, and it is over 6,000 feet from the other workings."

The equipment for mining and handling the ore appears to be good, and it is stated that work will be resumed at an early date.

Mines and Prospects of the Southern Copper and Gold Mining Company.

The mines of this Company consist of two shafts, an old prospect and a few pits along outcropping of two and possibly three veins or mineralized areas in the schists. They are located upon a hill a few hundred yards southwest of the Randolph shaft.

One shaft and the old prospect hole are probably on the same vein



LONGITUDINAL SECTION OF McMAKIN MINE.

which appears to have the same trend as the schistosity, while the other is on a vein lying about two hundred feet to the southeast. The rock in which the two veins occur is very different in texture, showing well the variations that are found in the country rock. The rock at the shaft and old prospect is light in color and very fine and dense in texture and is either a fine tuff much silicified or a mashed rhyolite, while that at the other shaft, that nearest the boiler house, is a typical mashed, coarse-grained tuff. The ore in this shaft is very different from that in the former and consists of auriferous pyrite and chalcopyrite with small amounts of sphalerite and galena in a silicified and quartzose portion of the country tuff. There is considerable evidence of replacement of the schists by the ores and by quartz. This ore, while not so rich as that in the North vein of the 800 ft. level of the Randolph vein, in general appearance does not differ essentially from it. It clearly belongs to the silicious type of vein.

The shaft on this vein is about 200 feet deep and drifts are now being driven at right angles to the trend of the vein with the intention of exploring two more so-called veins that lie near the main vein, one to the northwest of it and the other to the southeast.

The ore in the other shaft, that nearest the mill, consists for the most part of sphalerite, galena, and pyrite with more or less chalcopyrite. All the sulphides are auriferous and occur in narrow seams in the country rock—the opened planes of schistosity. There is apparently little or no replacement of the country rock either by ore or quartz, and the vein is apparently of the rifted schist type. The ore and the country rock of this vein resemble very closely those of the Silver Hill Mine.

A few hundred tons of the upper and decomposed ore have been hoisted and milled. The values are said to have been high, but the gold was reported to be "rusty" and not to amalgamate well.

Aside from air tools, the mine is fairly well equipped. There is a small well-built mill equipped with ten stamps, amalgamating plates and Wilfley tables.

The Barringer Mine.—This mine, situated near Misenheimer station and about 4 miles southeast of Gold Hill, was opened prior to 1824[42] and was probably the first mine in the State to be opened upon a true gold-bearing vein. It was possibly the discovery of this vein that caused prospecting for other veins in the "gold country" to be begun. Prior to its discovery, the gold was thought to occur only in the placer workings.

The vein is located in the slates at the contact of a mass of igneous rock, diabase, probably a large dike, and differs from the other veins

[42]Olmsted, Denison. Report on the geology of North Carolina, p. 34.

of the district in that the gangue mineral is largely calcite. The vein is said to have been very narrow, and very rich, especially in the upper workings. Specimens from a 3-inch seam are reported to have been nearly one-half pure gold, but the values throughout the vein were very irregular, varying in assay value from about $2.00 to more than $500 per ton. The vein is also said to have been much disturbed by faulting. It has been estimated that nearly $100,000 have been taken from the one ore shoot of the mine. The workings have been very irregular and much money was spent in trying to find more ore like that of the upper levels, but with little success. Plans and elevation made from surveys of the mine, now in the office of the Whitney Company, the owners of the mine, show the character of the work and the relation of the vein to the wall rock and the diabase dike. (See Pl. XXIII, B).

GREENSTONE TYPE.

Southwest of the Whitney Mine the zone of mineralization passes into the greenstone area and in this formation occur numerous small veins which have a distribution similar to those of the Gold Hill type, that is, many small veins in parallel and closely spaced fractures. These veins have the same general northeast trend as those at Gold Hill, but in character and kind of ore and gangue material they differ radically from the type.

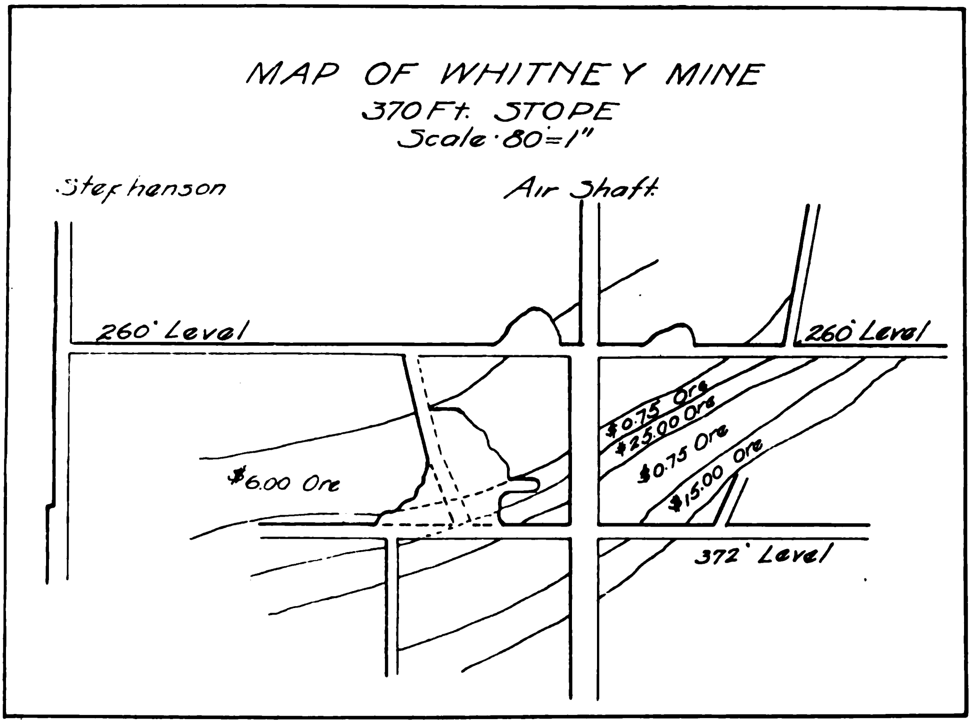
The ores consist of bornite and chalcocite in a quartz and epidote gangue. The veins are generally well defined and may be easily traced on the surface by the debris of quartz and epidote. At times they consist only of stringers of ore in narrow fractures in the rock, which in such instances shows more or less epidotization.

Little prospection has been done on these veins and consequently little could be learned as to their character. The prominence of the outcroppings depends upon the character of the vein material; quartz and epidote veins have prominent outcroppings while those with little or no gangue materials are inconspicuous and possibly consist of a slight prominent exposure of the rock but with copper stainings. Generally they are considered as "copper veins" rather than "gold veins" although they all carry a small value in gold.

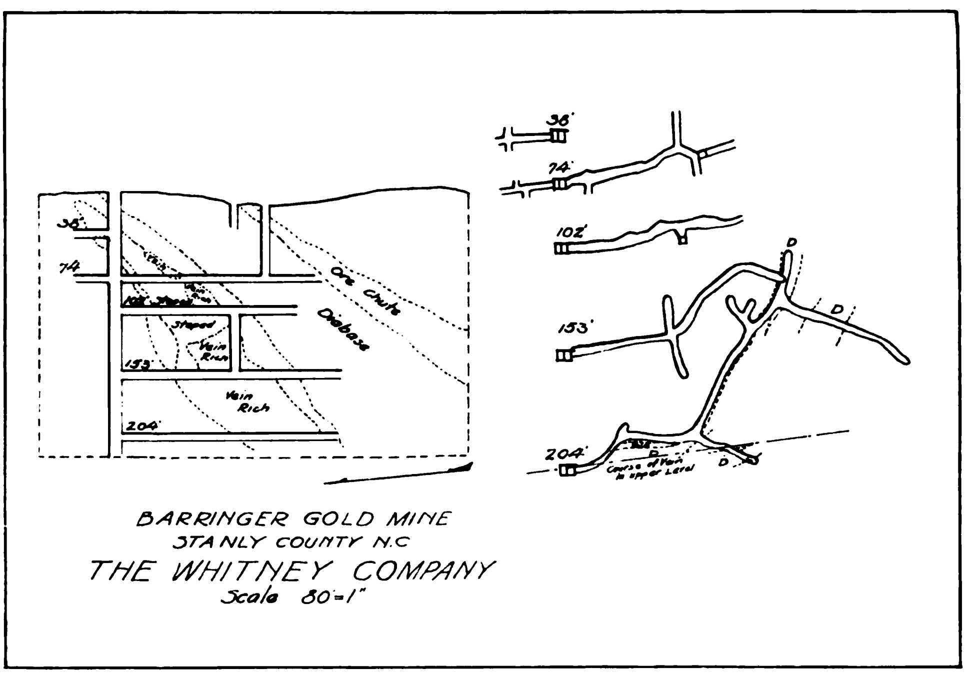
In character these veins are exactly like the Virgilina type of vein. The definition given by Mr. W. H. Weed[43] for this type of southern copper deposits is equally applicable to these. He says:

"The first type of deposit is that of a true fissure vein, the quartz vein formed by the filling of open cavities—with only minor and acces-

[43] Weed, W. H. Types of Copper deposits in the Sourthern United States. Am. Inst. Min. Engineers, Trans., v. 30 (1900) pp. 452.



A. Vertical Section of Lower Levels of Whitney, (McMackin Mine).



B. Underground Workings of Barringer Mine.

sory replacement of country rock. The Virgilina deposits are representatives of this type. The ore is glance and bornite with little or no chalcopyrite or pyrite."

Some of the prospects in veins of this type are as follows: two shallow shafts on the Barringer plantation a short distance southwest of the Isenhour Mine, several shallow pits on land belonging to George P. Kluttz, the Harkey diggings near Five Pines, and the "Hopkins Mines" near Foil's mill. In all of these the veins appear to be small and unpromising.

THE CLINE TYPE.

This type of deposit differs from the greenstone only in the gangue minerals and the ore. The character of vein is the same. The ores consist of auriferous pyrite and chalcopyrite in a gangue of quartz, calcite and siderite, associated with varying amounts of specular hematite. This type occurs in both greenstone and diorite near their contact.

Only two prospects of this type have been opened, the Cline Mine and the Dan Hopkins diggings near Cross Roads, neither of which was accessible at the time of the field work. Little, therefore, can be said about them. Both, however are said to have contained considerable gold. Only a small amount of work has been done at these places, but the trenching and cross-cutting as well as the shafts show well-defined veins which vary in width from 2 to 4 feet and trend N. 35° W.

THE DUTCH CREEK TYPE.

This type is similar in all respects to the Cline Type, except that the veins occur in the granite. The ore is auriferous and consists of pyrite, a small amount of chalcopyrite and a little siderite in a gangue of quartz. The prospects of this type are the Dutch Creek Mines, the Gold Knob Mines, and the diggings in the vicinity of Garfield. They are all, except the Dutch Creek prospects, long since abandoned, but it is said that in the early workings considerable gold was obtained from them. The trend of the veins or stringers appears to be invariably toward the northeast.

The Dutch Creek Mines.—These are simply prospects belonging to Mr. A. H. Graf of Salisbury. Several years ago a considerable amount of prospecting was done in this vicinity and three or four shallow shafts were sunk upon the richer veins. A small mill was erected and it is reported that considerable gold was secured in the upper workings from the shafts and from pits. The veins are narrow and irregular but the ores are reported to carry high gold values.

Recently Mr. Graf has reopened one of the most promising of the old shafts which was sunk so as to intersect a small vein outcropping on the surface and having a rather flat southeast dip, about 45°. The ore shoot at the surface, while the values were exceptionally high, was short and narrow. As it was followed downward, the values remained good, and the shoot lengthened and widened very materially, until at a depth of about 60 feet, it has a width of from 3 to 6 feet and is about 60 or 100 feet long. The vein is in the granite at the contact with a decomposed basic dike which appears to be a gabbro. The ores consist of free gold, pyrite and a little chalcopyrite. The values are high and it is probable that there is a small but valuable deposit of ore at the place. The work has not been extensive enough to warrant any definite statements as to the value of the deposits.

CHAPTER VII.

GENERAL SUMMARY.

The rocks of the Gold Hill mining district are about equally divided between the sedimentary and the igneous groups. The sedimentary series consisting of slates, tuffs and breccias, intercalated with which are minor flows of rhyolite and andesite, makes up its southeastern portion.

The igneous rocks which consist of greenstone into which are intruded diorite and granite, make up the northwestern half. These are separated from each other by a great fault of undetermined throw, the Gold Hill fault, which extends across the whole district in an approximate N. 15° E. direction.

The sedimentary series.—This consists of thick strata of bluish or grayish slates interbedded with which are minor rhyolite and andesite flows and heavy beds of tuff.

The rhyolite is normal rhyolite similar in type to that which is so widely distributed along the eastern border of the continent. It has a limited distribution in the district, and was found in only one place, the northeast end of Flat Swamp Mountain, where it is well developed and is characterized by structures typical of ancient rhyolitic flows. Associated with it is a small amount of flow-breccia.

Andesite was found in typical development in but one locality, the long ridge between Little Bear Creek and Little Buffalo Creek where a flow about 3 miles long is interbedded with a series of tuffs. The lower portion, at the contact with the tuffs beneath is typically amygdaloidal, the amygdules filled with feldspars, epidote and zoisite. This phase grades gradually into the massive rock which has all the characteristics of an extrusive andesite.

The tuffs vary greatly, but are usually of medium texture, and, within the limits of this district are never very coarse. The coarser phases consist of sharp angular fragments of both rock and feldspar crystals imbedded in a dense, fine-grained groundmass containing more or less clay. By a decrease in the size of the component fragments there is a gradation into an exceedingly fine-grained rock, felsitic in character and so dense that the microscope does not resolve it. This material has the chemical composition of a rhyolite or a silicified dacite, and is regarded as a fine volcanic ash.

The slates differ from the fine, dense tuffs only in the amount of land waste. By a decrease in the amount of ash and at the same time an increase in the clay, mud, etc., the fine, dense tuff passes gradually into the typical bluish slate.

The series as a whole consists of alternating layers or bands of these types of rock in which the slate largely predominates. The rocks as a rule are fairly massive and reasonably fresh, with only local occurrence of mashed and schistose facies. They all, however, show much silicification and the rhyolite is completely devitrified.

The Greenstone.—This term is applied to a much metamorphosed basic effusive rock with local tuffaceous phases extending northeastward somewhat in the shape of a wedge from the center of the southern boundary of the district. This rock along its northwest boundary is fairly massive and has the appearance of a basaltic flow. To the east it becomes locally tuffaceous and is so highly metamorphosed that its original textures are almost wholly destroyed.

The Diorite.—This is intrusive into the greenstone and varies in texture from a coarse, highly feldspathic, quartz-free rock to a dense fine-grained, dark-colored quartz-diorite. It has suffered less metamorphism than the greenstone, and while badly jointed throughout and locally sheared, is generally fresh and fairly massive. It has a wide distribution throughout the igneous portion of the district.

The Granite.—This rock is intrusive into both greenstone and diorite. Two types are found, a medium-textured light gray facies, and a fine-grained aplite variation which seems for the most part to be confined to dikes or local areas. This is subordinate to the coarser variety which is a medium, light gray highly siliceous granite in which soda appears to predominate over potash. It is massive but closely jointed and deeply weathered.

Dikes.—Dikes are numerous throughout the whole district and are of at least four types, diorite, granite, gabbro and diabase. They are named in the order of their respective ages, beginning with the oldest. There are, however, diorite dikes of two periods of intrusion, one, the oldest dike rocks of the region, the other younger than, and cutting both the massive diorite and the granite.

STRUCTURE.

The district presents a fairly complex structure. Probably the most important feature is the Gold Hill fault which separates the igneous rocks of the western portion of the area from the sedimentary series of the eastern. This fault extends the entire length of the district and is marked by a zone of highly mashed and schistose rock, much minor and local faulting, and numerous closely-spaced joints.

In addition to this main fault there is a second one of considerable magnitude immediately east of Flat Swamp Mountain. The linear extension of this fault is not known, but is probably four or five miles. The steep east face of Flat Swamp Mountain is regarded as an escarpment formed by this fault, and if this is true it probably extends a number of miles beyond the northern boundary of the district.

Folding is also very prominent. The slate series near the contact with the igneous rocks has been thrown into closely compressed isoclinal folds, the axes of which have a steep northwest dip. This close folding has developed prominent schistosity near the contact with the igneous rocks. This is only local and as distance from this contact increases, the folding becomes less prominent and the schistosity largely disappears.

In the igneous portion of the district the diorite is intrusive into the greenstone and the granite into both greenstone and diorite. There is very little local metamorphism at any of these intrusive contacts. Jointing is very prominent in all portions of the district and often the joint planes present slicken-sided surfaces. In trend they are pretty well distributed throughout the three hundred and sixty degrees of the circle, but they are probably somewhat more prominent in the northeast quadrant. The schistose portions of the district, in which there are few northeast-trending joints, form a notable exception to this statement. It appears that where schistosity has been prominent the joint-producing forces found relief along the planes of schistosity and thus no such joints were formed. In dip they vary from nearly horizontal to practically vertical.

THE VEINS AND ORES.

The ore-bearing veins are developed in the zone of minor faulting immediately to the east of the Gold Hill fault. They appear for the most part to follow the trend of the fault, but are often found following the strike of the schistosity. They are of two types, one of which is marked by an extensive silicification of the wall rock. The other presents a minimum of silicification and consists of a zone of narrow rifts in the slate parallel with the schistosity. These two types also differ as to the metal they carry. The former is largely gold-bearing with only a small percentage of copper, and the latter largely copper with only a small amount of gold.

The ores are auriferous pyrite and chalcopyrite associated with trivial amounts of galena and sphalerite. Much of the pyrite appears to be the oldest of the sulphides, but there are instances when it is probably contemporaneous with or even younger than the other ores.

Broadly speaking, however, it may be stated that the pyrite is the oldest mineral, and after deposition was more or less shattered by further movements. This shattering was followed on the one hand by the deposition of chalcopyrite and more pyrite, and on the other by the introduction of pyrite and gold—the auriferous pyrite. Since the veins rich in gold are usually, if not always, lean in copper, and those carrying much copper contain little gold, it is believed that they may represent two separate and distinct periods of mineralization, or possibly two sources for the ore-bearing solutions.

APPENDIX.

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