RECONNAISSANCE

OF THE

GOLD FIELDS OF THE SOUTHERN APPALACHIANS

BY

GEORGE F. BECKER

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PREFATORY.

In August, 1894, the Director ordered me to make a reconnaissance of the gold deposits of the Southern Appalachians, and the months of September, October, and November were spent in performing this duty. The field work was far from satisfactory, for scarcely half a dozen mines were in active operation, and in most cases old trenches and dumps only were accessible.

In the earlier portion of this report the gold-bearing region of the Carolinas and Georgia has been dealt with as a whole, and the attempt has been made to muster the more important available facts derived either from field work in 1894 or from previously published descriptions. In treating the material in this way, many details are necessarily omitted, and no very clear idea is conveyed of any one district or mine. Many readers will be satisfied with a general impression of the region, but others, more nearly interested, will expect to find local descriptions. Such are therefore presented in the concluding portion at the cost of some repetition, which, however, has been confined to the lowest limit compatible with the object in view. The material is mainly derived from my own notes, but references are given to other papers on the localities described.

At the close of the paper will be found a digest of the geology of the gold deposits of the Maritime Provinces of British America and the Green Mountains. This digest is merely a compilation, and its interest here consists in the fact that, as reported, these deposits resemble those of the Southern Appalachians in the most striking manner. With this addition this report may be regarded as a sketch of the gold deposits of the Atlantic slope.

Throughout the field and office work I have had the assistance of Mr. C. W. Purington. It happened that Mr. H. B. C. Nitze, of the North Carolina survey, was engaged in studying the South Mountain area at the time of my visit. He was kind enough to give me much information which I might otherwise have missed. Later he joined me in the more easterly auriferous region of North Carolina, and we visited many properties together, much to my advantage. Mr. Nitze's report will appear about the same time as this, in the Second Biennial Report of the North Carolina Geological Survey. I am also indebted to Prof. George B. Hanna, of Charlotte, N. C., for much valuable information, and other acknowledgments will be made in the course of the report.

GEOGRAPHY OF THE GOLD DEPOSITS.

Gold occurs along the Atlantic slope of North America from Newfoundland to Alabama. Northward of Washington it is found in commercially important quantities only in Nova Scotia, but some gold has been obtained to the eastward of the Green Mountains, both in Quebec and in Vermont. From near Washington southward the auriferous deposits are numerous, assuming their most important development in the Carolinas and Georgia.

In the Southern States the deposits may be divided into three groups, which bear interesting relations to the structure and the geographical features of the region. The first of these may be called the Georgian belt. It has been traced southward to the neighborhood of Montgomery in Alabama, and extends thence in a northeasterly direction through northern Georgia, passing near Canton and through the mining town of Dahlonega. It can hardly be said to reach northward beyond the boundary of North Carolina, but in that State a single vein has been worked which lies about on the strike of this belt. It is called the Boilston, and is about 17 miles west of south from Asheville.

The Georgian belt strikes substantially with the cleavage of the crystalline schists, or in the same direction as the folds and ridges of the main Appalachian ranges and the principal axes of folding which have marked the successive uplifts of that remarkable chain, but it lies to the southeast of these axes.

A second interesting area marked by gold deposits is the neighborhood of the South Mountains, in the heart of North Carolina. This isolated group of mountains does not conform to the ordinary Appalachian trend or configuration, a fact intimately connected with its geological structure. Though it is mainly composed of gneisses and schists, the principal cleavages strike to the west of north in this area, instead of to the east of north, as is the rule elsewhere. The relation of the quartz veins to the schistosity is also different from that characteristic of the two other regions, indicating some profound and quasi-permanent irregularity in the resistance of this part of the earth's external shell.

A third auriferous region lies parallel to the Appalachians, but far to the east. It is wider and less defined than the Georgian belt and is capable of subdivision. It is sufficient for the purposes of this paper to regard it as one belt, with Charlotte, N. C., near the center, extending to the southwest into South Carolina and, toward the northeast, two-thirds of the distance across North Carolina. It may be called the Carolinian belt. The deposits of Virginia lie substantially in the strike of this zone.

There are no mountains in the Carolinian belt, though some small hills have received from the population of the plains the name of the Uharie Range. There is a strong probability, however, that the topography was once varied by a range of volcanoes extending along this belt and reaching far to the northward.

The broad features sketched above can be followed on any topographical map of the United States. Sketch maps showing the position of the more important deposits visited, on a scale of 20 miles to the inch, will be found in the later portion of this paper. It would be desirable to display geological maps of the region, but the age of the rocks is at present too uncertain to justify the attempt. The immediate walls of those gold veins which have been mined are all, so far as known, pre-Cambrian; but the evidence on this subject is mainly negative.

Besides the three areas noted above there are other localities in which gold has been found. In Cherokee County, N. C., along the Valley River, a good many men have made wages in washing gravels, and other localities are noted in Messrs. Kerr and Hanna's Ores of North Carolina, but none of these are supposed to have yielded important quantities of the precious metal.

HISTORY AND STATISTICS.

The early European visitors to Florida and Georgia seem to have been impelled by the desire to acquire gold while saving souls. There is nothing remarkable, therefore, in the fact that the early narratives report the presence of gold in almost all regions—for example in New England. It is thus questionable whether some of the earliest reports of gold in the South were founded on observation or on hope. The first mention of the metal in this region is to the effect that on June 4, 1513, while Ponce de Leon lay near the southern end of the peninsula of Florida, he was informed that a cacique in the neighborhood had a quantity of gold.[1] No further mention is made of the matter in this narrative. In 1516, however, Diego Miruelo obtained a little gold from the natives,[2] and in 1519 Pineda, who coasted along the western side of the peninsula[3] and along the Texan coast, reported that many of the rivers contained gold, and that the natives wore golden jewels.

The first definite information as to the occurrence of gold seems due to Pamphilo de Narvaez, who landed at Tampa Bay in 1527. Here he saw traces of gold, probably ornaments, and was informed by the

[1] Herrera, Dec. 1, Book IX, chap. 5.
[2] Barcia, Ensaio Cronologico Año MDXVI, fol. 2.
[3] Navarrette, vol. 3, pp. 147-153.

natives that great quantities of it were found in a province called Apalache.[1] Hernando de Soto landed at Tampa Bay in 1539. He certainly made somewhat extensive explorations, but does not appear to have met gold in any abundance.[2] Soto is sometimes credited with having undertaken regular mining operations in the Nacoochee Valley and elsewhere; but the narrative of his expedition shows that he was too busily occupied with obtaining supplies and his favorite "sport of killing Indians" to undertake any serious mining operations.[3]

Somewhat more information appears in Lemoyne's Brevis Narratio of the journey made by Laudonnière in 1564.[4] The passages are curious enough to be worth extracting. Describing matters near the mouth of the river Mai (which is probably the Altamaha, though it has been thought to be the St. Johns[5]), he says: "Plenty of gold and silver is found among them, and they use them in internal commerce. As I learned from themselves, these metals were obtained from the wrecks of ships which had been thrown on the coast, and I am readily persuaded that this is true, for in the neighborhood of the Promontory [Florida] silver is more plentiful than to the northward. They assert, however, that in the Appalachian Mountains there are veins of copper (aes)."

Again he says: "That chief sent me a sheet of copper dug from those mountains, from the base of which flows a torrent rich in gold, or, as the Indians think, in copper: for from this stream they draw up sand in a hollow cane-like reed until it is full, then by shaking and jarring it they find grains of silver and copper mingled with sand. Hence they conjecture that there is a vein of this metal [sic] in those mountains."

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[1]Relation d'Alvar Nuñez Cabeça de Vaca; Ternaux-Compans, Chap. IV, p. 29.

[2]Narrative of the gentleman of Elvas in Hakluyt.

[3]Winsor quotes Oviedo as remarking the Governor's fondness for this sport. Narr. and Crit. Hist., vol. 2, 1886, p. 246.

I owe most of the foregoing notes to the kindness of Mr. Woodbury Lowery.

[4]This is a famous work, of which De Bry was publisher, issued in 1591. The illustrations are by Lemoyne, who as artist accompanied Laudonnière's expedition.

[5]Parkman regarded it as the St. Johns (Pioneers of France in the New World, 1883, p. 32), but Lemoyne's map shows it as the largest river of the South, its main branch extending to the northwest into the Montes Apalatci, and placed much farther north than one would expect to find the St. Johns. Laudonnière also speaks of the Mai as one of three great rivers rising in the Appalachian Mountains and as being navigable for small boats from these mountains to the sea. This would answer to the Altamaha but not to the St. Johns. The other rivers of the triad are, I suppose, the Savannah and the Santee. On this map it has a southerly branch ending in a lake. On Delisle's map, which was originally issued in Paris before 1707, according to Mr. Justin Winsor (Narr. and Crit. Hist. of Am., vol. 2, 1886, p. 294), the river appears without the southerly branch and is called the Caouctas or May. This map is wonderfully accurate, considering the time at which it was prepared, as may be seen by comparison with modern maps, and the mouth of the May is shown at a distance north of St. Augustine almost exactly corresponding to the real position of the Altamaha. The copy in the library of the Geological Survey was issued in 1739. On Ottens's map, issued in 1755, the Altamaha bears the alternative title of the George River. The Survey library contains also a map entitled "A new and accurate map of the province of Georgia in North America." It is without date or author and appears to have been a folded sheet in some book. It now forms a portion of a collection of American maps made in England. The collector assigned to this sheet No. 92 the date 1760. On it the river in question is labeled "Formerly river May, now Alatamaha or St. George's River."

This river seems to have borne a somewhat evil fame in the last century, if one may judge by Goldsmith's Deserted Village, in which a gruesome description begins:

"Through torrid tracts with fainting steps they go,
Where wild Altama murmurs to their woe."

The process thus described is illustrated by a drawing,[1] seemingly evolved from the description, upon which it throws no light. The legend of the drawing reads thus: "Manner of gathering gold in the rivers flowing from the Apalatcy Mountains. Far from the locality where our fort was built [the mouth of the Mai] there are great mountains, called Apalatcy in the Indian tongue, in which, as may be seen on the topographic map, rise three great rivers sweeping down sand with which is mixed much gold, silver, and copper. On this account the inhabitants of the region dig pits in the river so that the sand swept along by the water may fall into them by gravity. This, diligently extracted, is carried to a certain spot, and after some time, having removed the sand which had again fallen into the pits, they collect it and convey it in boats down the great river, called by us the Mai, which empties into the sea. Now, the Spaniards know how to convert to their own use the treasures thence obtained."

These passages need, and perhaps deserve, comment. It is remarkable that Laudonnière discriminates so imperfectly the three metals which he mentions. As for silver, it seems to me substantially certain that if the Indians possessed any it must have come from Mexico, possibly by hand to hand barter, but perhaps through the wreck of early Spanish ships. As for copper, there is little doubt that the French saw this metal in the possession of the Indians. There is no indication, however, that the natives ever mined copper in the Appalachians, although some native copper is to be found there, for example, in Alleghany and Ashe counties, N. C. Mr. R. L. Packard has discussed copper mining by the Indians,[2] and gives good reasons for believing that the only source of this metal in the United States was at Lake Superior. The Indians of Georgia no doubt possessed ornaments of this metal, received in barter, and highly valued by them. Indeed, early voyagers have stated explicitly that the Indians prized copper as highly as they did gold. When the French inquired whence the copper came, the reply would be, from the northwest, the same direction as that to which the gold was referred. There can be no doubt that the Indians also possessed gold. It was actually tested on the spot during Laudonnière's expedition,[3] and the locality from which the Indians said it came, as shown on Lemoyne's map, is the neighborhood of Dahlonega. Even within the last two years handsome nuggets of from fifty to a hundred pennyweights have been found in this region, and they must have been fairly abundant after rains in the sixteenth century. Mr. Packard suggests that a part of the confusion which arose as to aboriginal riches was due to the fact that mica was also a

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[1] This curious plate is substantially reproduced in Brückmann's Magnalia Dei in locis subterraneis, Braunschweig, 1727, Tab. XII; where, however, the picture is reversed and some unimportant additions are made to the landscape.

[2] American Antiquarian, vol. 15, 1893, pp. 67 and 152.

[3] Hakluyt's translation of Laudonnière.

treasure among the Indians. It seems certain that they actually mined this mineral.

The French certainly did not see the washing of gold in canes. It is possible, as Mr. Packard thinks, that the description of the process is a distorted account of panning as practiced by or learned from the Spaniards. It is conceivable, however, that separation of gold dust should have been carried on in tubes instead of dishes. While panning is a process known throughout the Eastern Hemisphere, with minor modifications, and is no doubt of prehistoric origin, I have met with no clear and authoritative statement of the means originally employed by the American Indians in gathering gold from sands.[1]

As for the supposed ancient workings in the Nacoochee Valley, they are described as almost too modern in character even for the Spaniards to have made.[2] Dr. D. G. Brinton thinks the Indians are to be credited with some mining development.[3] Mr. C. E. Jones refers these workings to Tristan de Luna, remarking, however, that J. Lederer reported that the Spaniards were at work at mines as late as 1669 or 1670.[4]

During the eighteenth century little attention seems to have been paid to gold in the Appalachians. The earliest reference with which I have met is by Thomas Jefferson in 1782. He describes a lump of ore of about 4 pounds weight from the north side of the Rappahannock, in Virginia. It was found about 4 miles below the falls, and yielded 17 pennyweight of gold. He heard of no other indication of gold in the neighborhood.[5] A large nugget of gold was discovered at the Reed Mine, Carbarrus County, N. C., in 1799, but for some years its nature was not known. When this was ascertained further search was made and many more lumps were found. One of them weighed 28 pounds.

The history of gold mining in the Appalachians from the discovery of gold on the Reed property up to the year 1853 has been given by Prof. J. D. Whitney in a work so accessible[6] that the details need not be repeated here. From 1804 to 1827 all the gold produced in the United States came from North Carolina, and the total amount, so far as the records go, was only $110,000. Up to 1825 all the gold of that State came from washings; in that year Mathias Barringer made a successful excavation in Montgomery County, and soon afterwards good quartz veins were found in Mecklenburg County.

South Carolina first sent gold to the mint in 1829, but during the next year deposits were worked in Chesterfield and Lancaster counties.

[1] I have been told that winnowing gold sands in half a gale of wind was practiced by the Indians in Arizona, and that the whites learned to work dry diggings from them; but I doubt these Indians going to so much trouble, and the report needs confirmation from early explorers.

[2] Hernando de Soto, by Charles E. Jones, jr. Savannah, 1880.

[3] Notes on the Floridian Peninsula, 1859.

[4] An abstract of Lederer's travels is given in Harris's Collection of Voyages and Travels, vol. 2, 1705, Appendix, p. 19, including references to the Spanish mines.

[5] Notes on Virginia. This work was completed in 1782 and a few copies were printed. The first English edition was issued in 1787.

[6] The Metallic Wealth of the United States, 1854.

In 1830 and 1831 from 100 to 200 hands are reported at work on the Brewer mine, in the first-named county.

The first discovery of gold in Georgia is said to have taken place in 1829 in Habersham County. A rush to the region took place, and as many as 6,000 or 7,000 persons were soon employed in gold washing in Northern Georgia. This excitement, however, soon abated.

After the date of Jefferson's note referred to above the first discovery of gold in Virginia is said to have taken place in 1831.[1] In 1836 there was considerable activity in gold mining in that State, as appears from the elder Silliman's report in 1837.[2] From the rediscovery to 1850 the product of Virginia is said to have been pretty steady, the annual value being between $50,000 and $100,000. In the early fifties an increased activity was manifested.

As for Alabama, there seem to be almost no recorded data. The discovery probably dates from the time of the gold fever in Georgia, 1830. "Of the yield of gold there is no record, or indeed of anything in connection with the matter, except that at such and such localities large numbers of men were engaged in the work and that at certain places it was said to be profitable."[3]

The civil war, of course, put an almost complete stop to mining operations in the South. The history of the mines of North Carolina from the close of the war to the end of 1886 has been very fully given by Messrs. Kerr and Hanna in a work to which I am greatly indebted.[4] No similar report has been published for the other gold-bearing States of the South.

The statistics of the gold production in the South have been collected by Mr. Stuart W. Cramer, and published in the production report of the Director of the Mint for 1892, and his table is reproduced below, with the addition of the Mint estimates for later years. These figures represent as the product of the respective States, not merely the gold actually deposited at the United States assay offices and the Mint, but a reasonable estimate of the remaining product.[5]

A curious bit of history affecting the accuracy of the statistics is the coinage of gold by one Bechtler, in North Carolina, about 1833 and for many years afterwards. It is said that for some time these coins and Mexican silver constituted the chief currency of large districts. To insure their reception the Bechtler coins were made slightly overweight, which of course led to their rapid disappearance.

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[1]According to Mr. Thomas Pollard, Commissioner of Agriculture, in a paper prepared for A. G. Lock's work, Gold, 1882, p. 187.

[2]Am. Jour. Sci., vol. 32, 1837, p. 98.

[3]W. B. Phillips, Geol. Surv. of Alabama, Bull. 3, 1892, p. 10.

[4]Ores of North Carolina, being Chap. II of vol. 2 of the Geol. of North Carolina, Raleigh, 1893.

[5]This is not explicitly stated, but according to Mr. George B. Hanna, op. cit., page 233, the official records of the United States to the end of 1886 give for North Carolina a little over eleven millions, while taking into consideration the gold used by local jewelers and the direct export from mines owned by foreign companies, Mr. Hanna estimates the real product at twenty-two millions In Mr. Cramer's table the product for North Carolina to the end of 1886 is nearly twenty-one millions.

Estimate of the production of gold and silver in the Southern States from 1799–1879, and annually since.

Years.	Maryland.	Virginia.	North Carolina.	South Carolina.	Georgia.	Alabama.	Tennessee.	Total.
1799–1879	$2,500	$3,091,700	$19,659,600	$2,587,900	$14,180,500	$365,300	$155,300	$40,042,800
1880	250	11,500	95,000	15,000	120,000	1,000	1,500	244,250
1881	500	10,000	115,000	40,000	125,000	1,000	1,750	293,250
1882	1,000	15,000	215,000	25,000	250,000	3,500	250	509,750
1883	500	7,000	170,000	57,000	200,000	6,000	750	441,250
1884	500	2,500	160,500	57,500	137,000	5,000	300	363,300
1885	2,000	3,500	155,000	43,000	136,000	6,000	300	345,800
1886	1,000	4,000	178,000	38,000	153,500	4,000	500	379,000
1887	500	14,600	230,000	50,500	110,500	2,500	500	409,100
1888	3,500	7,500	139,500	39,200	104,500	5,600	1,100	300,900
1889	3,500	4,113	150,174	47,085	108,069	2,639	750	316,330
1890	16,962	6,496	126,397	100,294	101,318	2,170	1,001	354,638
1891	11,264	6,699	101,477	130,149	80,622	2,245	519	332,975
1892	1,000	5,002	90,196	123,881	95,251	2,419	1,006	318,755
1893	114	6,190	70,505	127,991	100,375	6,362	250	311,787
1894	978	7,643	52,927	98,763	99,095	4,092	329	263,827
Total	46,068	3,203,443	21,709,276	3,581,263	16,101,730	419,827	166,105	45,227,712

An encouraging item for the production of 1895 is a nugget weighing 8 pounds 5 ounces troy, found at the Crawford mine, Stanly County, N. C., on April 8.

The fineness of gold with reference to its geographical distribution is a matter of interest in some auriferous regions, for example in Australia, where the gold grows finer with increasing latitude. I can not discover any regularity in the distribution of fineness in the Southern Appalachians. Throughout Georgia the fineness is great and averages something like 0.950, excepting at the Loud mine, where it was 0.880 in 1858, according to Prof. W. P. Blake, while at the time of my visit it was reported as only 0.800. No cause for this exception is apparent. In the South Mountain area the gold was 0.825 fine, according to Genth, writing in 1875.

In the Carolinian belt the fineness is reported at or above 0.900 at many localities in the following counties: Orange, in Virginia; Cabarrus, Gaston, Mecklenburg, Polk, Rowan, and Rutherford, in North Carolina; Chesterfield, York, and Lancaster, in South Carolina. It is reported as below 0.900 in McDowell, Moore, and Union counties, in North Carolina. In the Davis mine, in Union County, N. C., it has even been as low as 0.450 when mingled with galena, and indeed, in Professor Hanna's opinion, it is the presence of galena which usually carries down the tenor of the bullion.[1] In Union County, S. C., also, the Harman mine had bullion of about the same grade as the Davis, according to Tuomey.[2] While I am not prepared to contest Professor Hanna's opinion of the cause of low-grade bullion, it seems certain that some gold not found in contact with galena or in deposits containing any extraordinary quantity of lead sulphide is low grade, while some mines in which the amount of galena is considerable yield high-grade gold.

[1] Eng. and Min. Jour., vol. 42, 1886, p. 201. See also Ores of North Carolina, 1887, p. 234.

[2] Geol. South Carolina, 1848.

THE ROCKS.

In outlining the general geology of the Southern gold fields it seems expedient to begin by rapidly reviewing the distribution of formations and then to proceed to descriptions of the several rocks.

To the northwestward of the Georgian belt a large area is occupied by the Ocoee formation, concerning the age of which different views are taken. Mr. Hayes informs me that in Tennessee the Ocoee unquestionably rests upon the Cambrian, but whether by deposition or by overthrust is not finally determined. It is doubtful therefore whether it is Paleozoic or Algonkian. The gold-bearing region near Murphy, in Cherokee County, N. C., is largely occupied by the Ocoee. Along the Valley River there are limestones[1] referred to this period and gneisses believed to be Archean. Between them are schists carrying gold in small quartz stringers; they underlie alluvium, and are so ill-exposed that it was not possible for me to ascertain to which series they belonged. To the east of Murphy, however, there are many quartz seams in the sedimentary rocks. They are probably to some extent auriferous, but I am not aware that they have been tested.

There is limestone near the Boilston mine in Henderson County, N. C., but the mine itself is in gneissic schists.[2] In Georgia the Ocoee does not appear to reach within several miles of the gold belt, and, excepting recent deposits, I saw nothing on this belt which seemed of sedimentary origin. The rocks are gneisses and crystalline schists probably of Archæan age, sometimes intersected by granite dikes which I suppose to be Algonkian.

So far as is known the rocks of the South Mountain area are of the same age as and lithologically similar to those in the Georgian belt.

Conditions in the Carolinian belt are much more complex. Here a belt of rocks which are in large part of sedimentary origin is bounded on the northwest by a plutonic area (the pyrocrystalline of E. Emmons and the Lower Laurentian of Kerr) and on the southeast for the most part by the Munroe beds and the Newark system. This belt is from 8 to 40 miles in width. From the character of the contact between it and the pyrocrystalline masses to the northwestward Mr. Nitze believes the granitic rocks to be intrusive masses of later date. This belt seems largely composed of metamorphosed sedimentary rocks of great age, chiefly clay slate, which occasionally shows bedding not concordant with the slaty cleavage. To this metamorphic series belongs also the limestone of the Kings Mountain mine in Gaston County.

These sedimentary rocks are nowhere known to contain fossils. They are far more metamorphosed than the Cambrian of more northerly portions of the Atlantic slope, and they contain a great amount of volcanic

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[1] Small quantities of galena are found with the limestones, as well as gossans, such as overlie pyrrhotite deposits.

[2] Mr. Nitze found on the eastern side of Boilston Creek, nearly opposite the mine, contorted schists overlying the limestone. In the schists there are a few small quartz stringers which an assay proved slightly auriferous. The schists are probably Ocoee.

material which does not appear in the known Cambrian rocks of that slope. In the present state of knowledge they can only be referred to the Algonkian.

The volcanics occupy irregular patches in this slate belt. They are so sheared and decomposed as to have been taken for sedimentary material. Effusive lavas were first observed by the late George H. Williams.[1] They resemble the ancient eruptives of the South Mountain of Pennsylvania and Maryland. These are pre-Cambrian, and Mr. Keith has found fragments of them abundant in the Cambrian beds.[2] It seems to have been in these volcanic rocks that E. Emmons found the structures which he supposed to be organic and named Paleotrochis. Spherulites in the same rocks have apparently been mistaken for conglomeritic pebbles.

Near Monroe, in Union County, N. C., there are shales and slates far less modified than the Algonkian schists described. This series can be followed along the railroad from Monroe eastward to Polkton, a distance of some 20 miles. They appear at Albemarle, in Stanly County, and near the Sam Christian mine, Montgomery County. The Monroe beds were noticed by Prof. J. A. Holmes, who has not yet published his observations, and independently of him by Mr. Nitze and myself working in company. Professor Holmes observed them dipping beneath the Newark beds near Polkton. This series has not yet been studied and may prove fossiliferous. The prevalent degree of metamorphism is about the same as in the least-altered portions of the Ocoee.

The Newark system of the Carolinas is regarded as Triassic by Dana in the last edition of his Manual of Geology. Prof. I. C. Russell thinks it corresponds with the upper portion of the Trias and the lower portion of the Jura.[3] Messrs. Cope and Leidy have described vertebrate remains from this system in North Carolina, and many plants have been described by E. Emmons and others. In a quarry of red sandstone near Moncure, Moore County, N. C., I found a fragment of bone which Mr. F. A. Lucas reports as probably dinosaurian.

All the rocks of the Carolinian belt carry gold deposits. The main ore body of the Kings Mountain mine is in limestone; a long list can be made of the deposits in metamorphic slate; while eruptive or intrusive masses appear as wall rocks in the Hoover Hill, Parish, Jones, Silver Hill, Russell, Moratock, Sam Christian, Phœnix, Pioneer Mills, Ferris, Davis, Haile, and Brewer.

The Monroe beds are cut by a few stringers which have been worked for gold, though with small success. As compared with the older slates, this series seems to carry very little quartz. In a solitary instance it is reported that an auriferous quartz seam in the slates penetrates upward through the Newark sandstones. This case is reported by

[1] Jour. of Geol., vol. 2, 1894, p. 28.
[2] Fourteenth Ann. Rept. U. S. Geol. Survey, p. 302.
[3] Bull. U. S. Geol. Survey No. 85, 1892, p. 130. For a summary of the life records in North Carolina and elsewhere, see the same publication, p. 54.

Lieber from the Brewer and Edgeworth mine in Chesterfield County, S. C. He gives a figure showing the vein, but his description amounts only to a few words, from which it is not certain whether or not he saw the vein himself. He mentions it as "entirely worked out," which may mean that he saw only a trench through the sandstone to the underlying slates.[1]

Transported gold certainly occurs in the Newark sandstones. The only published note on this subject known to me is by Mr. Jules Marcou, who, in 1862, stated that the red sandstone of North Carolina contained gold washed into it during its formation.[2] Near Moncure, in that State, I washed out some allothigenetic gold from Newark beds, as will be mentioned in describing the ore deposits.

The greater part of the gold I believe to have been deposited at the close of the great volcanic era, or during the Algonkian. In the Carolinian belt this conclusion seems inevitable, and I know of no good ground for supposing the ore and the granitic dikes of the South Mountain area and of Northern Georgia to be younger. Gold deposition was seemingly renewed with diminished activity after the Ocoee and after the Monroe beds were laid down. Perhaps there were veins formed after the Newark system, but the evidence of this is too meager to be satisfactory. A similar report comes from Nova Scotia, but is not credited by geologists familiar with the locality.

Much the most abundant rock in the gold-bearing regions of Georgia and the Carolinas is gneiss, or schist immediately recognizable as derived from gneiss. Such is the greater part of the Georgian belt and almost all of the South Mountain area. In the Carolinian belt gneiss is abundant, but so also are other rocks. The composition of the gneiss is variable, even in small areas. Some of it contains orthoclase and microcline, but in much of it, and seemingly in the greater part, the predominant feldspars belong to the albite-anorthite series. The quartz is fairly abundant as a rule, but sometimes present in very small quantities. Biotite and muscovite prevail in some portions, while hornblende characterizes much of the mass, and augite is not infrequent. Of the rare minerals so abundant in the South Mountain area, Mr. Nitze has found monazite in the gneiss.

In this area there are many of the dark, globular blebs so abundant in various granitic regions, but none such were observed in the Georgian and Carolinian belts. Near Brindletown these blebs retain their coherence after the gneiss is completely rotten. These masses are almost wholly made up of augite or hornblende, or both, and in one case hypersthene was found to be abundant. There is apparently an ill-defined concentric structure in the blebs, which is developed by weathering, but it is not sufficiently marked to be clearly seen in hand specimens. In two cases observed the augite is about half decomposed to serpentine, and in one case hornblende is changed to talc.

[1] Survey of South Carolina, First Ann. Rept., 1856, p. 51.
[2] Proc. Boston Soc. Nat. Hist., vol. 9, 1862, p. 47.

In the Georgian belt the banding of the gneisses is exceedingly sharp, and it is manifest that the mineralogical character of the mass often changes within a millimeter from highly ferromagnesian to highly feldspathic. This is a phenomenon common in all gneissic areas. Messrs. Geikie and Teall have studied such banding or sheeting of rocks in Tertiary gabbros. They conclude that it arises from the intrusion of magmas which were already heterogeneous before they reached their present position.[1] This conclusion seems to me inevitable. I feel inclined to go a step farther. If the heterogeneous mass was fluid, it was certainly composed of miscible fluids, for the minerals composing the different bands are as a rule substantially the same, the relative quantities only being different. All prevalent ideas of the history of granitic magmas would also lead one to believe that these fluid masses must have been in contact for a very long time, probably for many years. Now if two miscible fluids are placed in contact with each other the process of mixture begins of itself, and diffusion continues until a uniform state of mixture is attained.[2] Either then the gneisses were fluid for a very short time relatively to the rate of diffusion of the fluids, which is hard to believe, or the magma was not really a fluid at all. This also appears at first difficult of belief; but a mass having the physical properties of tallow at ordinary temperatures might apparently be intruded, under great pressure, as well as the granitic magmas, and tallow is a true solid. The hypothesis of a substantially solid magma, perhaps moistened throughout with a small amount of a real fluid, would also explain thoroughly granular structure; for in a mixture of fluids capable of diffusion minerals would separate out successively, and not almost simultaneously, as must be the case to produce granular structure. In a magma such as that suggested the chemical composition would vary from point to point, and so would the chemico-physical reaction which involved the most rapid evolution of heat or the maximum dissipativity.

The gneisses are sometimes nearly devoid of structure, but truly structureless granitic rocks are somewhat rare in the gold fields. Some granite proper is reported to exist upon Yonah Peak, near Nacoochee, Ga.; at Dunn's Mountain, in Rowan County, N. C., there is a granite quarry, and there is a large amount of this rock between the Haile and Brewer mines. Granite dikes occur in the South Mountain area, and they are abundant near Nacoochee, as well as in the vicinity of the Franklin mine. In almost all these cases the dike rock contains much microcline. The rock is often very light in color and much coarser toward the center of the dike than at the edges. There are also very fine-grained granite dikes, however, near Brindletown, at Nacoochee, and on Setting Down Creek in the neighborhood of the Franklin mine. These do not seem to differ in any definable respect from the coarser granites excepting in grain and in the amount of mica they contain.

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[1] Quart. Jour. Geol. Soc. London, vol. 50, 1894, p. 652.

[2] See for example Clerk Maxwell on Diffusion, Encyc. Brit., 9th ed.

Some of them are much wider than some of the coarse or pegmatitic dikes occurring within a few yards of them, and why they should have failed to develop large crystals it is hard to imagine.

In the Georgian belt there are bodies of dark amphibolite schist, such as are often produced by dynamometamorphic processes from basic massive rocks. No such unsheared masses, however, were observed at the mines visited; but Mr. Hayes has found in Cobb County, to the southwest of the Franklin mines, areas of dark diorite some miles in diameter which pass over into schists similar to those at Dahlonega and elsewhere.

The porphyries of the Carolinian belt are so decomposed in the neighborhood of the mines that little can be made of them. They seem to belong in great part to the acid series and to be allied in the closest manner to those in the South Mountain of Pennsylvania, as has already been mentioned. They show flow structure in some cases and were probably in part glassy and tuffaceous rocks, yet they were most likely deeply buried at the time of the formation of the deposits.

In some instances the ores occur in close association with dioritic and diabasitic rocks which do not appear to be mere dikes. Thus, at the Phœnix mine the dumps show great quantities of a plagioclase porphyry carrying hornblende, augite, and biotite. This porphyrite contains many stringers of ore, and it was reported to me that most of the ore in the mine occurred in it. The workings were entirely inaccessible. At the Reed, Pioneer Mills, and Hoover mines similar porphyrites appeared from the dumps to be wall rocks, but no exposures could be seen.

There are dike rocks in the Carolinian belt which seem clearly connected with the deposition of ore. Much the clearest case is that of the Haile mine. Here the dikes are diabase, which is fresh, excepting where the ore bodies lie along it. At the Silver Hill also, a dike rock which seems to be a decomposed diabase lay in contact with ore, as appears from masses on the dump, and at the Gold Hill, a diabase dike passes through the ore-bearing ground. Near Charlotte, at the Ferris mine, a granite dike lies in contact with ore. In the neighborhood of the same town there are great numbers of dikes and also many ore deposits, but as scarcely any of the mines are open it was impossible to study the relations of the intrusives to the auriferous material.

Besides such dikes there are later ones which cut the Triassic sandstones of North Carolina, for instance near Moncure. It is lithologically an ophitic olivine basalt. A dike rock entirely similar to this was found near the Howie, and is probably of the same age. It is needless to say that it may sometimes be difficult to distinguish between dike rocks of different ages in the Carolinian gold belt.

When the gneisses are reduced to schists by dynamometamorphic action, the feldspars appear to be resolved into quartz, muscovite, and calcite. Many of the schists have a composition answering to the complete resolution of the feldspars and the removal of the calcite; in other words, they consist of quartz, biotite, and muscovite. This muscovite seems to correspond to the variety sericite. It is conceivable, however, that more or less vermiculite should be mingled with the mica, though in the studies made for this paper none has been detected. When the muscovite is present only in very small scales, the schists look as if they might be talcose. In most descriptions of the Southern gold fields talcose schists are frequently referred to. Attention was long ago called to the fact that this term is in many cases a misnomer,[1] and in no case have I met a true talcose schist. Talc indeed occurs in the South Mountain district as a decomposition product of the amphibole-pyroxene blebs in the gneiss, and where such masses are reduced to schist of course these may be talcose. It is safe to say, however, that the great mass of the supposed talcose schists of the region are muscovite schists, containing much mica in small scales.

Quartzites have been reported from the region of Dahlonega. I observed no rocks in that region which seemed recognizable as sedimentary, but there are fine-grained, highly quartzose schists similar to the so-called talcose schists excepting that they carry less mica. These may have been called quartzite.

In the Carolinian belt, at many of the points where ancient volcanic rocks have been detected, there are flinty masses which have been called quartz rock, chert, etc. They pass over into highly siliceous schists. Under the microscope they show small interlocking grains of quartz looking very much like vein quartz and giving no evidence of growth from fragments, but always mingled with minute scales of muscovite. There seems strong reason to suppose these masses due to decomposition and recrystallization of the acid volcanics.

The simple quartz-mica schists are more abundant than any other schistose rocks. Chloritic schists often carrying epidote are also common, however, and appear to answer to the amphibolic and pyroxenic gneisses and the diorite. Amphibole schists are less abundant and seem to originate in the dioritic rocks mentioned above. At the Franklin mine zoisite makes its appearance in some of the schists; also near the Sixes mine, Cherokee County, Ga., and the same mineral was recognized in the slate of the Bonny Bell mine, Union County, N. C.

In view of the fact that some of the garnets of the region are auriferous, the localities in which garnet-bearing schists have been noticed are of interest. Some of the schistose rocks of the South Mountain area are garnetiferous. At the Lumsden property, near Nacoochee, the schist contains many disseminated garnets, as well as numerous stringers of auriferous quartz. With Mr. Lumsden I gathered many garnets from the rotten schists. These crystals were carefully cleansed, then crushed and panned. They showed an amount of gold answering to

[1] See C. H. Hitchcock, Proc. Am. Assoc. Adv. Sci., 1859, p. 321. Dana states that most of the so-called talcose schist is sericite schist: Manual, 1895, p. 89.

many dollars per ton. The schists at the Findley mine, Dahlonega, and at the Hedwig, near Auraria, are garnetiferous, and at the latter locality they are also auriferous. Garnets are extraordinarily abundant at the Battle Branch mine, Auraria. Professor Credner mentions garnetiferous schist on the Chestatee River. There is garnet in the wall rock of the Franklin mine and at the Sixes. Credner found this kind of schist at the Burnt Hickory mine, 12 miles southwest of Ackworth. In Alabama it is reported from Silver Hill, Tallapoosa County.

Near the town of Ellijay, Ga., Mr. Arthur Keith has found ottrelite schist closely associated with garnet-bearing schists, and it is very probable that some such may occur near some of the gold mines.

It is very manifest, both macroscopically and microscopically, that the garnets (and the ottrelites) have crystallized in the schists after the schistose structure was fully developed. The energy of crystallization was sufficient to push apart the schistose laminæ and make space for the new growth. This seems to imply that a portion of the constituents of the mineral must have been derived from solutions, and the fact that garnet also appears in quartz veins at Dahlonega shows that all of the constituents may have existed in solution. It is very difficult for me to understand how garnets, pyrite, and other minerals can attain good crystallographic development in solid, tough rocks. In view of this fact, is good idiomorphism an infallible sign of the early genesis of crystals in igneous rocks?

STRUCTURE.

In the southeastern States almost the entire mass of the older rocks is schistose, the strike of the planes of cleavage in most cases being that of the Appalachian range, or N. 30° to 50° E. Where sedimentary strata occur, they too usually strike in approximately this direction in consequence of the folding which has built up the range; and as a consequence of this fact the cleavage of the schists has very often been mistaken for bedding.

In the Georgian belt the schists (and the banded gneisses as well) strike in the usual direction, the prevailing dip being to the southeastward at angles ranging from 40°, or somewhat less, upward. To this general rule there are some exceptions. At Nacoochee the western portion of the area shows schists with a westerly dip. Mr. Keith informs me that this change is local, but that in the Blue Ridge, to the westward of Nacoochee, there is what may be called an anticlinal axis of schistosity. By a similar analogy the change at Nacoochee may be likened to an undulation. In other parts of this belt there are abnormal dips, but they prevail over areas so small that they must be regarded merely as local irregularities. Such are particularly noticeable at Dahlonega, where, for example, in the Lockhart and Preacher mines, the schists dip and strike in various directions. In spite of such divergences the representative strikes and dips at Dahlonega are northeasterly and southeasterly, respectively, and this is true of the entire belt from Nacoochee to the Sixes mine, below Canton, and beyond.

The structure of the South Mountain area is peculiar. The strikes of the schists are more irregular than in most parts of North Carolina, but over an area of at least 400 square miles the representative strike is N. 20° W., and the schists dip to the northeastward. To the north and south of this region the strikes and dips resume their normal directions, so that if one considers an area stretching entirely across the Carolinas the strike undergoes a deflection in the South Mountain area, the schistose surfaces being bent to the westward, but recovering their ordinary position after this area is passed.

This deflection must be caused by some inequality in the resistance of the earth's outer shell, and I was anxious to ascertain whether the irregularity in structure was purely local or extended into the main range. On inquiry of Mr. Keith, he informs me that the area in question is on the direct prolongation of a zone of shear or warping, traced by himself through Tennessee and into North Carolina. "The zone is marked by a motion of the northern masses past the southern ones so as to produce an abnormal strike. It is attended by other structural irregularities."

In the Carolinian gold belt the strike of the schists is usually nearly the same as in the Georgian belt, but the prevailing dip of the schists is northwesterly, and there are very few exceptions. The average dip is about 60°, notably steeper than in the Georgian belt. At the Jones mine, Randolph County, a steep southeasterly dip was noted by Emmons, but I saw only steep northwesterly dips, and at the Russell some of the schists strike northwestward, dipping northeast, but this is a mere local twist, less extensive than the mine workings. At the Means mine, near Charlotte, the dip is easterly. At the Brewer mine, in South Carolina, opposite dips appear within a few yards of one another, and near the West and the Thompson mines the dip is southeasterly, though in these mines it is northwesterly. Lieber's description of the Mud Vein, in the same region, seems to indicate a southeastery dip of the schists at that point.

Near the Virginia boundary of North Carolina, at the Portis and Mann-Arrington mines, the dip is southeasterly, and throughout the auriferous region of Virginia this appears to be the rule.

To the eastward and to the westward of the Carolinian belt, as well as to the northward, the prevailing dip is southeasterly. Thus this belt is marked structurally by an axis of schistosity which dies out to the northward.[1]

In the foregoing remarks the surfaces of schistose cleavage have been referred to as if they were wholly uncomplicated by other allied structures. It would have been more accurate to describe them as

[1] Much of the schist in the country to the eastward is concealed by the Newark system, but there are exposed patches, and Kerr has recorded the dips in the Reports of the Geological Survey of North Carolina, vol. 1, 1875, p. 131.

the more prominent surfaces of schistose cleavage. In almost any exposure of a few yards in area it can be shown that there are schistose partings at a large angle to the most pronounced surfaces, and very frequently spots occur in which two schistosities are about equally developed, the intersection of the two being more or less nearly horizontal, so that the strikes of each are approximately the same. Occasionally, but much more rarely, there are other schistose cleavages striking at something like a right angle to the predominant cleavage; these, however, play a small part in the structure. When there is no second schistose cleavage its place is often taken by joints which form under conditions sometimes indistinguishable from those which produce cleavage.[1]

When two slaty cleavages are distinctly developed, or when a regular system of joints clearly replaces a second cleavage, the "amount of shear" to which the mass has been subjected can be determined with an approach to accuracy. In the strain called a shear there is one direction in which there is a maximum elongation, so that a line originally of unit length attains a length α, the elongation being $\alpha-1$. In a plane at right angles to this direction there is a direction of maximum contraction, and here the line of unit length is reduced to $1/\alpha$, so that the contraction is $1-1/\alpha$. Now, what is called "the amount of shear" is the sum of the elongation and the contraction, or $\alpha-1+(1-1/\alpha)=\alpha-1/\alpha$. Where the sole deformation of the rock is such as to produce two systems of schistose partings (which do not need to be equally well developed) the mass will split into prisms with rhombic cross sections. If θ is the acute angle of this rhomb the "amount of shear" is $2 \cot \theta$. Thus, if $\theta=84^\circ$, the amount of shear is 0.21. It is also true that $1/\alpha=\tan(\theta/2)$, so that when $\theta=84^\circ$, $1/\alpha=0.9$.

I have measured very many such prisms in the Southern gold fields and found more of them in which the angle in question exceeds 84° than in which it sinks below this value. Sometimes the prisms are nearly square. In supposing that the angles of the prism assign a value to the amount of shear the deformation is exaggerated. Where schistosity is produced by a simple direct pressure acting against uniform resistances, as in Daubrée's beautiful experiments,[2] there are two shears, the contractile axes of which coincide, while the axes of elongation are at right angles to each other. Even in the simplest cases to be found in the field such a second shear has probably contributed in some degree to the deformation, rendering the acute angle of the prisms more acute than they would otherwise have been.[3] For this reason I am led to the conclusion that as a rule the amount of shear is less than two-tenths, or

[1] I have discussed these structures and their relations at length in Bull. Geol. Soc. Amer., vol. 4, 1893, pp. 66 and 86.

[2] Géol. Exp., 1879, p. 319.

[3] If the ratio of the second shear is β, the unit length in the direction of greatest contraction becomes $1/\alpha\beta$. If this second shear escapes recognition, the amount of shear estimated will be $\alpha-1/\alpha\beta$, and since both β and α exceed unity this is greater than the true amount, or $\alpha-1/\alpha$.

the greatest linear compression less than one-tenth, in the schists of these gold fields. Such distortions would seem to a physicist enormous; to a geologist they appear extremely moderate, and although they accord well with Daubrée's experiments I was much surprised to find that such perfect cleavage could be induced with so little deformation.

The shearing is of course orogenically equivalent to faulting; that is to say, the same amount of warping or uplift might be accomplished either by one or more faults with a given total throw or by shearing of the same total amount unaccompanied by rupture. In the second case the movement is distributed over an infinite number of surfaces. and does not reach the rupturing strain on any one.

When the amount of shear does not exceed two-tenths and the cleavage is prismatic it should be possible to determine within narrow limits the local direction of the force producing the schistosity. This force was in a plane cutting the axes of the prisms at right angles, and it very nearly bisected the obtuse angles of the rhombic cross sections. In an area like the Southern Appalachians, where (according to the results of Messrs. Willis, Hayes, Campbell, and Keith) overthrust faults and shears are far more numerous than normal deformations, the lines bisecting the obtuse angles of the prismatic cleavage prims should be nearly horizontal. No doubt in the country at large they will be found to be so. Mines are usually at points or on lines of more or less unusual character and do not fairly test general structure by themselves. I must, however, record the fact that in several cases I observed subordinate cleavage intersecting main cleavage in such a manner that a force bisecting the obtuse angle would have produced normal faulting or shearing on the main cleavage surfaces. Such instances were found at the Franklin mine, at the Boilston, and at several points in the Carolinian belt.

In the Carolinian belt, as has been mentioned, the dips are rather steep and toward the northwest. One might suppose the abnormal dips of this region to be independent of or only remotely connected with those of the surrounding country. Indeed, on the theory that slaty cleavage is due to forces at right angles to the cleavage planes, the local forces in the Carolinian belt would need to be nearly at right angles to those in the adjoining regions. I have shown that this theory is untenable, being founded substantially on the misinterpretation of Tyndall's very striking experiments.[1] Daubrée's experiments, referred to above, and my own, together with the mechanics of viscous solids, show that there should be a tendency to two cleavages at nearly 45° to the line of force, of which one will often be more pronounced than the other. It would take too much space to discuss here the circumstances determining which cleavage will be the better developed. It is sufficient to say that a relatively small irregularity in resistance would suffice to bring out one of the two associated sets of cleavage in a certain strip of country and the other set in an adjoining strip. This I

[1] Bull. Geol. Soc. Amer., vol. 4, 1893, p. 86.

believe to be the case in the Carolinian belt, but, while it accords with the information at my command, a special examination, such as I had no time for, would be needed to put the matter beyond question.[1]

When a rock is converted into slate there is an elongation in the direction of the "grain" of the slate and a contraction at right angles to the grain in the cleavage plane. If the pressure continues after the cleavage planes are developed, these planes will be thrown into undulations by further contraction and elongation. Sometimes this puckering is very close and fine, and I have taken specimens in slate quarries the surfaces of which resembled crape. More usually the undulations are on a larger scale, from an inch or two to 2 or 3 feet across. Like the ripples made by a breeze on the water, or like the ripple-marks on sand, the undulations are rarely continuous waves, and usually die out rapidly in trend, being replaced by similar mounds a little behind or in front. Such a surface may be termed a carunculated one.

When the rock converted into schist is not very uniform in its properties some portions of it will acquire schistose structure at an earlier period in the process of deformation than other portions. If the strain is carried far enough the resulting schist will show bands or sheets marked by caruneulation associated with sheets in which the cleavage is flat. It seems to be in such unevenly deformed ground that fissures have opened most readily, as might be expected, and that veins are most abundant as well as widest. Carunculated surfaces are therefore properly regarded as favorable indications by the miners. At the Franklin mine such surfaces are said to be most abundant in the hanging wall; at the Kin Mori, in the foot wall, but these appear to be merely local rules.

The opening of the fissures now occupied by ore, or which afforded the ore-bearing solutions access to the spaces now occupied by impregnations, took place later than the movements which rendered the country schistose. The fact that angular fragments of schist are often inclosed in the quartz is all-sufficient proof of this statement, though by no means all that is available. While in the Georgian belt and the South Mountain area the connection between the ore deposits and the dikes is not a very close one, they appear to me to be coeval on structural grounds. Neither the ore deposits nor the dikes have been greatly disturbed since their formation. They are here and there cracked by subsequent slight movements, but not crushed, or slickensided, or faulted to any notable extent. In short, there is no sign that

[1] As I have stated that detailed observations at some of the mines indicate normal shearing which is perhaps strictly local, it is only proper to observe that the explanation offered for the westerly dips of the Carolinian belt is quite compatible with reverse faulting. If the schistose surfaces which dip easterly make an angle with the horizon of 40° and those of westerly dip an angle of 60°, each set having the same strike, the obtuse angle between them would measure 100°, and a direction bisecting this angle would dip westward at only 10°. A force in this direction would produce reverse faulting on either set of schistose cleavages. To produce normal faulting the sum of the dips of the two planes would have to fall short of 90°. These remarks, however, are merely suggestive, for the dips outside of the Carolinian belt can not be transfered to it without the careful examination of sections across the belt, undertaken with a special view to this feature.

disturbances so violent as must have accompanied the opening of the ore fissures or the opening of the dike fissures have followed the filling of either. In the Carolinian belt the connection between ores and intrusive rocks is very close and is sufficiently described elsewhere.

In a vast number of cases throughout eastern North America the fissures follow the schistose partings somewhat closely, though not accurately. This shows that there must have been a certain degree of correspondence between the forces which produced the schistosity and those which opened the fissures. Nevertheless, it can be shown that the movements were not in general identical in direction. On the schistose partings the movement which produced schistosity was at right angles to the grain of the slate or to the long axis of the undulations or of the caruncles. It is often possible to detect grooves incised during the dislocation of the schists which accompanied the opening of the fissures, and these grooves are not, as a rule, at right angles to the grain of the schists. Of course, the occurrence of veins at various angles to the schistose surfaces also demonstrates the lack of harmony between the two movements.

There are a few small faults on the veins. Several such were observed at Brindletown and at the Brackett mine. There are a considerable number at Dahlonega, and in the Carolinian belt one was noted at the Rocky River mine. These faults did not appear to me to have occurred after the deposition of ore, but before it, and they seem to indicate the direction of the movements accompanying the fissuring. They are all normal.

There is another set of phenomena which appears to indicate the direction of motion during fissuring. Where the rocks are schistose and the main ore bodies are intercalated, stringers almost always cut into the walls, and these are divisible into two classes, one steeper than the schists and the other flatter. As a rule these stringers are not straight, but sinuous, and it then appears quite practicable to ascertain whether they have been formed by normal or by reverse faulting. If the stringer is on the whole flatter than the schists, reverse faulting on the schistose plane would open up those portions of the stringer which are flattest and the walls would not undergo great disturbance by mutual opposition. On the other hand, normal faulting would bring shoulders of the fissure into opposition, and faulting could take place only by breaking up of the walls. If the average pitch of the stringer is greater than that of the schist, normal faulting may take place without disintegration of the walls, while reverse faulting can not. Furthermore, since there is greater resistance to movement in one case than in the other, steep stringers will be more abundant in connection with fissure systems opened by normal faulting, and flat stringers in those opened by reverse faulting.

Such relations as those described are illustrated in the accompanying diagram. The figure *a* shows merely a crack steeper than the schists.

In *b* this crack is opened by a normal fault, while *c* shows the sort of result to be expected from a reverse fault.

I have observed great numbers of these stringers with care and made inquiries of the miners concerning them. In both the Georgian and the Carolinian belt I found the steep stringers much more common than those which dipped at a lower average angle than the schist. These steep stringers were also opened as in *b* of the diagram. In some cases I found flat stringers with marks of great disturbance of the walls, analogous to those shown in *c*. The information I received from miners was to the same effect, and it appears to me clear that as a rule normal faulting has been the means of opening the vein fissures in those deposits which I have had an opportunity of inspecting. If, then, the general tendency in the Southern Appalachians is to overthrust movements, it was a temporary reversal of this tendency which opened the fissure system of the region.

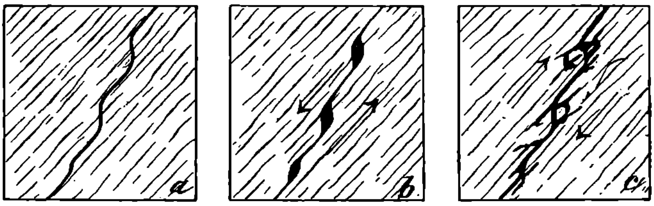

FIG. 1.—Faulting in schists.

It is frequently objected to any purely mechanical theory of the opening of ore chambers that these sometimes exceed in size any which seem likely to be self-sustaining. Certain it is that many large chambers can not be exploited without a vast amount of artificial support. There are, however, two or three considerations to be advanced on the opposite side of this argument. When openings are formed, rock masses from the walls almost invariably fall into them, and not infrequently they wedge in such positions as to be equivalent to timbering. If such an opening fills with ore and is then mined out, these supports (perhaps already rotten) are commonly cut away. Again, at points beneath water level the immersion of the rocks in water deprives them of more than a third of their weight, which they regain when a mine is sunk and drained. These facts, however, only help to explain great ore chambers on a mechanical theory of openings. The most important consideration seems to me to be that large ore bodies are highly exceptional. If one supposes a country fissured by mechanical action, he would expect to find, perhaps, one in a hundred of the subterranean cavities so produced of unusual if not of astonishing dimensions, these cases being due to the accidental arching of rock masses. Now, the profitable ore deposits are perhaps no more than one in a hundred of those which have been discovered. Within a few miles of the famous Almaden quicksilver mine 77 points are known at which cinnabar has been found, but only a single one of these has afforded any great supply of quicksilver. So, too, in almost any region where copper and iron sulphurets are successfully mined, there are scores, if not hundreds, of deposits too small to pay.

In regions where the ore deposits are recent, the veins ramify near the surface, as is the case, for example, at the Comstock lode. This is clearly because the surface rock is not supported by masses of overlying rock, so that relatively little work is performed in such dislocation. On the other hand, at considerable depths the pressure on the walls would be such as to crush fragments of rock or other obstacles to the closure of a fissure, although these might suffice to keep it open near the surface. At still greater depths the rock would flow, like the shales of some coal mines. Apparently, therefore, far from the original surface, veins should grow narrower; yet, if the ore was brought up from remote depths in solution, the veins must be traceable to that source.

THE GANGUE MINERALS.

The subject of the mineral association of gold is of interest, not merely because of the indications of the presence of the precious metal afforded by its habitual companions, but also because it supplies the most evident means of reaching a valid theory of the genesis of gold deposits.[1] It is clear that all the minerals which are truly undecomposed gangue minerals have been deposited from the same bodies of gas, vapor or solution as the gold itself. It is not to be forgotten, indeed, that such gases or solutions may be either mixtures or homogeneous compounds, but on the other hand this is one of the questions regarding composition which can be settled only by a study of the vein material.

With a view to contributing to this subject, the data as to gangue minerals in the Southern Appalachians have been compiled from various sources and are tabulated below. No occurrence is supposed to be included in this table excepting that of true gangue minerals. There are, however, two sources of uncertainty in this respect; an observer may either err in determination or he may so describe an occurrence as to leave it doubtful whether or no the minerals which he mentions form a part of the gangue. Thus, an excellent authority states that at a certain mine the presence of tourmaline is considered as a favorable indication, but whether this tourmaline is found in the auriferous quartz, or in barren proximate veins, or elsewhere, he does not mention. The intention has been to exclude all such uncertain cases.

Ordinary products of decomposition have been altogether omitted from the list. It is a matter of no interest whatever to know that limonite, malachite, and azurite are found near the croppings of veins

[1] The direct association of gold and diamond anywhere in the world is known in only one instance, and this has never before been described in print. Professor Arzruni showed me the specimen exhibiting it some years ago, and now gives me permission to make it known. In 1887 the Royal Polytechnic High School, at Aachen, acquired from Mr. Ernst Winter, a diamond dealer in Hamburg-Eimsbüttel, a gray, opaque, flawed, Kimberly diamond, which shows at two points inclusions of native gold in grains. It seems that this native gold must be considered as a constituent of the basic eruptive rock in which the Kimberly diamonds occur.

containing pyrite and chalcopyrite. A few decomposition products have been included on account of their rarity or their importance from an economic point of view. Some minerals, which in rocks are ordinarily secondary, are primary constituents of veins. Chlorite is in rocks almost always a decomposition product, but it seems to be an original part of the filling of certain fissures. In some cases it is questionable whether or no a mineral is primary. Analogy seems to me to indicate that stolzite is an oxidation product, but I am not aware of observations which prove such an origin for it. Where such a doubt exists the mineral is tabulated as primary.

The class of gold-quartz veins must be somewhat arbitrarily limited. Deposits which would ordinarily be classed as silver mines have not been included in the tabulation. Thus the McMakin mine in Cabarrus County, N. C., is said to have contained proustite, and it is in general evident that the entire list of silver ores may be regarded as companions of gold. The auriferous silver deposits are not included in the table. On the other hand, the Silver Hill, Silver Valley, and Emmons mines, which were auriferous, yet contained some silver and much lead, have been included. No absolute line can be drawn between gold mines containing a little galena and those which contain much.

The table is arranged alphabetically so far as minerals, mines, and counties are concerned. The States are arranged in the geographical order: Virginia, North Carolina, South Carolina, Georgia, and Alabama. The information was derived from various writers, whose names and papers are given in a footnote,[1] and from the field work done for

[1]The following is a list of the publications used in compiling the table of gangue minerals:

Adelberg and Raymond, Report on O'Neil property, Georgia, 1866.
W. R. Balch, Mines of the United States, 1882.
Booth and Garratt, Prospectus of Gold Mining Company in North Carolina, 1866.
T. M. Chatard, oral communication, 1895.
T. G. Clemson, Transactions of the Geological Society of Pennsylvania, 1835, p. 317.
Herman Credner, Neues Jahrbuch der Mineralogie, 1867, p. 442.
American Journal of Mining, passim, 1868 and 1869.
J. D. Dana, System of Mineralogy, 1892.
W. Darlington, superintendent of the Rocky River mine, oral statement to the writer.
W. B. Devereaux, Engineering and Mining Journal, vol. 31, 1881, p. 39.
M. W. Dickeson, Report of Phoenix Mining Company, 1860.
Report of Brown and Edwards property, 1860.
Report of the Rhea mine, 1860.
E. Emmons, Geology of the Midland Counties of North Carolina, 1856.
F. A. Genth, American Journal of Science, vol. 19, 1855, p, 18.
American Journal of Science, vol. 28, 1859, p. 246.
Report of the Geological Survey of North Carolina, vol. 1, 1875, appendix.
Bulletin of the United States Geological Survey No. 74, 1891.
C. T. Jackson, Report on McCullock Mining Company, 1853.
Report on Lincoln Gold Mining Company, 1854.
W. C. Kerr, Report of the Geological Survey of North Carolina, vol. 1, 1875.
Kerr and Hanna, Ores of North Carolina, 1887.
O. M. Lieber, Reports on the Geological Survey of South Carolina for 1856 and 1857.
George Little, Report on the Geological Survey of Georgia, 1874.
M. F. Maury, American Journal of Science, vol. 32, 1837, p. 325.
Orange Grove Mining Company's Report, 1847.
W. B. Phillips, Bulletin of the Geological Survey of Alabama, 1892.
C. U. Shepard, Report on Mines at Gold Hill, 1853.
American Journal of Science, vol. 27, 1859, p. 39.
M. Tuomey, Geology of South Carolina, 1848.

this reconnaissance. The authorities cited in the table, with the list of publications just mentioned, will enable the reader to pursue the subject. The alphabetical arrangement makes it easy to pick out the various minerals identified at any mine in the list, which includes most of the mines of considerable reputation. The most profitable gold mine of the region, however, does not appear. This is the Haile, in Lancaster County, S. C., which is opened on a deposit consisting substantially of an impregnation of country rock with gold, pyrite, and quartz.

Table of gangue minerals, excepting quartz and pyrite, in the gold veins of the Southern Appalachians.

(Secondary minerals are italicized.)

	Mine.	County.	State.	Authority.
ACTINOLITE	Parish	Randolph	N. C	This report.
ALBITE	Steele	Montgomery	Do	Genth, 1859.
ALLANITE	Chestatee River	Lumpkin	Ga	Shepard, 1859.
ALTAITE	King's Mountain	Gaston	N. C	Genth, 1875.
Anglesite	Silver Hill	Davidson	Do	Genth, 1875.
APATITE	Chestatee River	Lumpkin	Ga	Shepard, 1859.
ARGENTITE	Silver Hill	Davidson	N. C	Genth, 1875.
	Reynolds	Montgomery	Do	Emmons, 1856.
BARITE	Phœnix	Cabarrus	Do	Emmons, 1856.
	Rocky River	Do	Do	Darlington, 1894.
	Tucker	Do	Do	Kerr and Hanna, 1887.
	Flowe	Mecklenburg	Do	Genth, 1859.
	Lincoln	Lincoln	Ga	Jackson, 1854.
BARNHARDITE	Pioneer Mills	Cabarrus	N. C	Genth, 1875.
	Phœnix	Do	Do	Dana, 1892.
	McGinn	Mecklenburg	Do	Genth, 1875.
	Wilson	Do	Do	Genth, 1875.
BIOTITE	Valley River	Cherokee	Do	This report.
	King's Mountain	Gaston	Do	This report.
	Franklin	Cherokee	Ga	This report.
Bismite	Asbury	Gaston	N. C	Genth, 1891.
	King's Mountain	Do	Do	Genth, 1875.
	Brewer	Chesterfield	S. C	Tuomey, 1848.
BISMUTH	Brewer	Chesterfield	S. C	Tuomey, 1848.
BISMUTHINITE	Gold Hill	Rowan	N. C	Genth, 1875.
BISMUTITE	Asbury	Gaston	Do	Genth, 1891.
CALCITE	Barringer	Cabarrus	Do	Dana, 1892.
	Rocky River	Do	Do	This report.
	Hoover Hill	Davidson	Do	Genth, 1891.
	King's Mountain	Gaston	Do	Devereaux, 1881.
	Flowe	Mecklenburg	Do	Booth and Garratt, 1866.
	Steele	Montgomery	Do	Genth, 1891.
	Davis	Union	Do	This report.
	Moore	Do	Do	This report.
	Franklin	Cherokee	Ga	This report.
	Findley	Lumpkin	Do	This report.
	Field	Do	Do	Shepard, 1859.
CASSITERITE	Brewer	Chesterfield	S. C	Chatard, 1895.
Cerussite	Silver Hill	Davidson	N. C	Genth, 1891.
CHALCOPYRITE	Franklin	Fauquier	Va	Credner, 1869.
	Snead	Fluvanna	Do	Credner, 1869.
	Walton	Louisa	Do	Credner, 1869.
	United States	Spottsylvania	Do	Maury, 1837.
	J. C. Mills	Burke	N. C	This report.
	Bangle	Cabarrus	Do	Genth, 1859.
	Pioneer Mills	Do	Do	Emmons, 1856.

Table of gangue minerals, excepting quartz and pyrite, etc.—Continued.

	Mine.	County.	State.	Authority.
CHALCOPYRITE	Phœnix	Cabarrus	N. C.	This report.
	Rocky River	Do	Do	This report.
	Tucker	Do	Do	Kerr and Hanna, 1887.
	Conrad Hill	Davidson	Do	Genth, 1891.
	Emmons	Do	Do	Genth, 1891.
	Headrick	Do	Do	Emmons, 1856.
	Silver Hill	Do	Do	Emmons, 1856.
	Silver Valley	Do	Do	This report.
	King's Mountain	Gaston	Do	Emmons, 1856.
	Gardner	Guilford	Do	Emmons, 1856.
	McCullock	Do	Do	Jackson, 1853.
	Vein Mt	McDowell	Do	This report.
	Brackett	Do	Do	This report.
	Baltimore & N. C.	Mecklenburg	Do	Kerr and Hanna, 1887.
	Capps	Do	Do	Kerr and Hanna, 1887.
	Dunn	Do	Do	Kerr and Hanna, 1887.
	Ferris	Do	Do	Kerr and Hanna, 1887.
	Flowe	Do	Do	Genth, 1859.
	Means	Do	Do	This report.
	Rhea	Do	Do	Dickeson, 1860.
	Rudisill	Do	Do	Emmons, 1856.
	Steele	Montgomery	Do	Genth, 1859.
	Cagle	Moore	Do	Kerr and Hanna, 1887.
	Clegg	Do	Do	Kerr and Hanna, 1887.
	Brown & Edwards.	Randolph	Do	Dickeson, 1860.
	Dunn's Mountain	Rowan	Do	Kerr and Hanna, 1887.
	Gold Hill	Do	Do	Emmons, 1856.
	Reimer	Do	Do	Kerr and Hanna, 1887.
	Idler	Rutherford	Do	This report.
	Lemmond	Union	Do	Kerr, 1875.
	Long	Do	Do	This report.
	Moore	Do	Do	This report.
	Stewart	Do	Do	This report.
	Brewer & Edgeworth.	Chesterfield	S. C	Lieber, 1856.
	Hagin	Lancaster	Do	Lieber, 1856.
	Potts	Do	Do	Lieber, 1856.
	Darwin	Union	Do	Lieber, 1857.
	Wilson	York	Do	Lieber, 1856.
	McDonald	Cherokee	Ga	This report.
	Kin Mori	Dawson	Do	This report.
	Lockhart	Lumpkin	Do	This report.
	Yahoola	Do	Do	This report.
	Moore Girls	Rabun	Do	This report.
CHLORITE	Valley River	Cherokee	N. C.	This report.
	Emmons	Davidson	Do	This report.
	Steele	Montgomery	Do	Genth, 1859.
	Mann-Arrington	Nash	Do	This report.
	Gold Hill	Rowan	Do	Shepard, 1853.
	McDonald	Cherokee	Ga	This report.
	Field	Lumpkin	Do	Shepard, 1859.
	Lockhart	Do	Do	This report.
Chrysocolla	Pioneer Mills	Cabarrus	N. C	Genth, 1891.
	Gardner Hill	Guilford	Do	Genth, 1891.
COPPER (NATIVE)	Orange Grove	Orange	Va	Rept. Orange Grove M. Co., 1847.
COPPER-GLANCE	Pioneer Mills	Cabarrus	N. C	Genth, 1891.
	Silver Hill	Davidson	Do	Genth, 1891.
	Phœnix	Guilford	Do	Dickeson, 1860.
Covellite	Brewer	Chesterfield	S. C.	This report.
Cuprite	McGinn	Mecklenburg	N. C	Genth, 1891.
	Hodge's Hill	Rowan	Do	Emmons, 1856.
ENARGITE	Brewer	Chesterfield	S. C.	Lieber, 1856.
EPIDOTE	Valley River	Cherokee	N. C	This report.
	Moore	Union	Do	This report.

Table of gangue minerals, excepting quartz and pyrite, etc.—Continued.

	Mine.	County.	State.	Authority.
FLUORITE	King's Mountain	Gaston	N. C	Devereaux, 1881.
GALENA	Snead	Fluvanna	Va	Credner, 1869.
	Walton	Louisa	Do	Credner, 1869.
	United States	Spottsylvania	Do	Maury, 1837.
	Eagle	Stafford	Do	Credner, 1868.
	Rappahannock	Do	Do	Clemson, 1835.
	Rocky River	Cabarrus	N. C	This report.
	Emmons	Davidson	Do	This report.
	Silver Hill	Do	Do	Genth, 1875.
	Silver Valley	Do	Do	This report.
	Cansler & Shuford.	Gaston	Do	Genth, 1891.
	King's Mountain	Do	Do	Emmons, 1856.
	Boilston	Henderson	Do	This report.
	Brackett	McDowell	Do	This report.
	Vein Mountain	Do	Do	This report.
	Steele	Montgomery	Do	Genth, 1859.
	Conrad Hill	Rowan	Do	Balch, 1882.
	Davis	Union	Do	Kerr and Hanna, 1887.
	Hemby	Do	Do	Kerr and Hanna, 1887.
	Lemmond	Do	Do	Kerr, 1875.
	Lewis	Do	Do	Kerr and Hanna, 1887.
	Long	Do	Do	Genth, 1891.
	Moore	Do	Do	Genth, 1891.
	Phifer	Do	Do	Genth, 1891.
	Smart	Do	Do	Genth, 1891.
	Stewart	Do	Do	Genth, 1891.
	Dorne	Abbeville	S. C	Dana, 1892.
	Parson's Mountain.	Do	Do	Tuomey, 1848.
	Brewer & Edgeworth.	Chesterfield	Do	Lieber, 1856.
	Potts	Lancaster	Do	Lieber, 1856.
	O'Neil	Cobb	Ga.	Adelberg and Raymond, 1866.
	Findley	Lumpkin	Do	This report.
GARNET	Findley	Do	Do	This report.
	Field	Do	Do	Credner, 1867.
	Lockhart	Do	Do	This report.
	Hedwig	Do	Do	This report.
	Lumsden	White	Do	This report.
Hematite	Dunn	Mecklenburg	N. C	Emmons, 1856.
ILMENITE	Fisher Hill	Guilford	Do	Genth, 1891.
	Field	Lumpkin	Ga.	Shepard, 1859.
LEUCOPYRITE	Asbury	Gaston	N. C	Genth, 1875.
Magnetite	Gold Hill	Rowan	Do	Shepard, 1853.
MARCASITE	Fisher Hill	Do	Do	Emmons, 1856.
Melaconite	Silver Hill	Davidson	Do	Genth, 1875.
	McGinn	Mecklenburg	Do	Genth, 1875.
	Gold Hill	Rowan	Do	Shepard, 1853.
MISPICKEL	Melville	Spottsylvania	Va	Credner, 1868.
	Barringer	Cabarrus	N. C	Genth, 1875.
	Allen	Davidson	Do	Dana, 1892.
	Gold Hill	Do	Do	Genth, 1875.
	Asbury	Gaston	Do	Genth, 1875.
	King's Mountain	Do	Do	Devereaux, 1881.
	Long Creek	Stanley	Do	Emmons, 1856.
	Lemmond	Union	Do	Genth, 1875.
	Stewart	Do	Do	Genth, 1875.
	Dr. Charles	Cherokee	Ga	This report.
	Sixes	Do	Do	Credner, 1867.
	Kin Mori	Dawson	Do	This report.
	Findley	Lumpkin	Ga	This report.
	Jones's Pit	Tallapoosa	Ala	Phillips, 1892.
MOLYBDENITE	Pioneer Mills	Mecklenburg	N. C	Genth, 1875.

Table of gangue minerals, excepting quartz and pyrite, etc.—Continued.

	Mine.	County.	State.	Authority.
MUSCOVITE	Brackett	McDowell	N. C.	This report.
	Franklin	Cherokee	Ga	This report.
	Kin Mori	Dawson	Do	This report.
	Barlow	Lumpkin	Do	This report.
	Battle Branch	Do	Do	This report.
	Field	Do	Do	Credner, 1867.
NAGYAGITE	King's Mountain	Gaston	N. C	Devereaux, 1881.
	Carter	Montgomery	Do	Emmons, 1856.
ORTHOCLASE	Silver Hill	Davidson	Do	Genth, 1875.
	Steele	Montgomery	Do	Genth, 1859.
Pyrolusite	Beck	Gaston	Do	Genth, 1891.
	Hodge's Hill	Rowan	Do	Emmons, 1856.
	Johnson	Lancaster	S. C	Lieber, 1856.
PYROMORPHITE	Snead	Fluvanna	Va	Credner, 1869.
	United States	Spottsylvania	Do	Maury, 1837.
	Silver Hill	Davidson	N. C	Genth, 1875.
	Silver Valley	Do	Do	Genth, 1875.
	Vein Mountain	McDowell	Do	This report.
	Stewart	Union	Do	Genth, 1875.
	Dorne	Abbeville	S. C	Dana, 1892.
	Parson's Mountain	Do	Do	Tuomey, 1848.
PYRRHOTITE	Asbury	Gaston	N. C	Genth, 1875.
	King's Mountain	Do	Do	Devereaux, 1881.
	Reimer	Rowan	Do	Kerr and Hanna, 1887.
	Field	Lumpkin	Ga	Shepard, 1859.
RHODOCHROSITE	Flowe	Mecklenburg	N. C	Booth and Garratt, 1866.
Scorodite	Ludwick	Cabarrus	Do	Dana, 1892.
Scheelite	Bangle	Do	Do	Genth, 1859.
	Cullen	Do	Do	Dana, 1892.
	Flowe	Mecklenburg	Do	Genth, 1859.
	Gold Hill	Rowan	Do	Shepard, 1853.
SIDERITE	Phœnix	Cabarrus	Do	This report.
	Conrad Hill	Davidson	Do	Genth, 1891.
	Silver Valley	Do	Do	This report.
	Flowe	Mecklenburg	Do	Genth, 1859.
	Rudisill	Do	Do	This report.
	Hodge's Hill	Rowan	Do	Emmons, 1856.
	Moore	Union	Do	This report.
	Barlow	Lumpkin	Ga	This report.
	Field	Do	Do	Credner, 1867.
SILVER (NATIVE)	Silver Hill	Davidson	N. C	Genth, 1875.
SPHENE	Steele	Montgomery	Do	Genth, 1859.
STOLZITE	Silver Hill	Davidson	Do	Genth, 1891.
SYLVANITE	Reynolds	Montgomery	Do	Emmons, 1856.
TELLURIUM	Tellurium	Fluvanna	Va	Credner, 1868.
TETRADYMITE	Tellurium	Do	Do	Genth, 1859.
	Boger	Cabarrus	N. C	Genth, 1875.
	Cullen	Do	Do	Genth, 1875.
	Phœnix	Do	Do	Genth, 1875.
	J. C. Mills	Burke	Do	Genth, 1875.
	Allen	Davidson	Do	Genth, 1891.
	Beck	Do	Do	Genth, 1875.
	Asbury	Gaston	Do	Genth, 1891.
	Kirksey	McDowell	Do	Genth, 1875.
	Gold Hill	Rowan	Do	Shepard, 1853.
	Field	Lumpkin	Ga	Shepard, 1859.
	Drake	Polk	Do	Little, 1874.
TETRAHEDRITE	Eldridge	Buckingham	Va	Genth, 1855.
	Ludwick	Cabarrus	N. C	Dana, 1892.
	King's Mountain	Gaston	Do	Devereaux, 1881.
TOURMALINE	United States	Spottsylvania	Va	Maury, 1837.
	Calhoun	Pickens	S. C	Tuomey, 1848.
	Hedwig	Lumpkin	Ga	This report.

Table of gangue minerals, excepting quartz and pyrite, etc.—Continued.

	Mine.	County.	State.	Authority.
VANADINITE	United States	Spottsylvania	Va	Maury, 1837.
Warellite	Silver Hill	Davidson	N. C	Genth, 1875.
Wolfram	Flowe	Mecklenburg	Do	Genth, 1859.
ZINC-BLENDE	Walton	Louisa	Va	Credner, 1869.
	United States	Spottsylvania	Do	Maury, 1837.
	Rocky River	Cabarrus	N. C	This report.
	Emmons	Davidson	Do	This report.
	Silver Hill	Do	Do	Genth, 1891.
	Silver Valley	Do	Do	Genth, 1891.
	King's Mountain	Gaston	Do	Devereaux, 1881.
	Brackett	McDowell	Do	This report.
	Vein Mountain	Do	Do	This report.
	Steele	Montgomery	Do	Genth, 1859.
	Lemmond	Union	Do	Kerr, 1875.
	Long	Do	Do	Genth, 1891.
	Moore	Do	Do	Genth, 1891.
	Smart	Do	Do	Genth, 1891.
	Stewart	Do	Do	Genth, 1891.

The tabulated data require some slight comment. A mass of a fibrous mineral carrying free gold was shown me by Mr. Richard Eames, jr., in Salisbury. This, as he assured me, came from the Parish mine. When I visited the mine almost nothing was to be seen on the grass-grown dumps, and I could find none of this peculiar ore. A slide from a specimen given me by Mr. Eames shows much beautiful fresh actinolite in a groundmass of a fibrous material which suggests anthophyllite. There is also a small amount of epidote in the slide. This strange ore may be compared with some of the ores at Ducktown, Tenn. There chalcopyrite, pyrite, pyrrhotite, and garnet occur crystallized with actinolite, but the Ducktown ores are reported as showing a mere trace of gold. Albite carrying gold from the Winter's vein, Calaveras County, Cal, is noted by Genth in the same paper quoted in the table. Mr. H. W. Turner has also described this association from the Shaw lode, 4 miles southwest of Placerville, Eldorado County, Cal.,[1] and there can be no question of the reality of this association.

Allanite and apatite have been observed in auriferous quartz, so far as I know, only by Shepard. His statement is most distinct, and he remarks on the rarity of apatite. I can not rid myself of the belief that these minerals were really fragments from the gneiss walls of the quartz vein in which they were found.—Barite has been found associated with gold in California as well as in North Carolina. At the Phœnix mine, North Carolina, heavy spar often forms a very large part of the ore.—Biotite of a greenish tinge is not uncommon in the ore of the Franklin mine. It is very possible that some of the colorless micas or micaceous minerals found in ores are colorless biotite or bleached biotite. Of this more will be said under the head of muscovite.—Bismuth compounds have been detected at four mines. Bismuthinite is also found in some of the Bolivian mines.—Calcite is noted in no less than eleven of the Southern gold mines. It is usually very subordinate to quartz

[1] Amer. Jour. Sci., vol. 47, 1894, p. 470.

and is generally less intimately associated with gold. In the King's Mountain mine the country rock is mainly limestone, and calcite is extremely abundant. Even there, however, there are stringers of auriferous quartz in the calcareous mass. Calcite is known as a gangue mineral accompanying gold in Nova Scotia and in California.—Mr. Chatard, who was at one time superintendent of the Brewer, informs me that cassiterite was most intimately associated with the gold in portions of the mine.—Pyrophyllite was also found in the mine-but not, as I understand, in immediate contact with gold.—Chalcopy, rite is, next to pyrite, the most frequent metallic gangue mineral. Its decomposition yields the sulphate of copper; for example, at the King's Mountain mine, covellite (Brewer mine), chrysocolla (Pioneer Mills), malaconite (Silver Hill), and other products.—Copper glance is naturally more rare than chalcopyrite, since all the mines contain in abundance iron sulphide, with which copper sulphide usually unites.—Covellite has not, I believe, been hitherto reported from the Brewer. A chemical examination was made to ascertain that the mineral was a sulphide of copper without arsenic.—Enargite may be regarded roughly as a mispickel without iron, and, like copper-glance, is rare, because iron is so plentiful.—Epidote as a vein mineral is unimportant, and is probably derived from the decomposition of the wall rocks during the deposition of the ores.—Fluorite is rare in gold veins proper, but common enough in lead and copper mines. In the Southern gold mines it is found only at the Kings Mountain, which is an exceptional locality for minerals.[1]

Galena occurs in the South about half as frequently as chalcopyrite, and is more often met with than mispickel or zinc blende. Anglesite and cerussite are for the most part decomposition products of galena. Galena sometimes alters to pyromorphite, but pyromorphite sometimes changes to galena. I suspect that in the cases in which pyromorphite is noted in this paper galena was the original mineral.

The occurrence of garnet as an auriferous gangue mineral near Dahlonega and Nacoochee seems to me of some importance and much interest. It was first noted by Credner at a locality which I suppose to be identical with the Field mine, on the Chestatee River, 2½ miles easterly from Dahlonega. In two of the cases tabulated the garnets are auriferous but are not found in veins. Further notes on the subject will be found in this report in the description of the region in question. It is suggestive that ore deposition and ordinary metamorphism are both sometimes attended by the formation of garnets.

Magnetite is reported at only one mine. There is also one instance of hematite and two of ilmenite. I am not prepared to admit that hematite and magnetite are primary gangue minerals in auriferous quartz veins. On the contrary, as Mr. Lindgren has pointed out to me, one of the usual effects of ore-bearing solutions on the wall rocks is to

[1] Mr. R. A. F. Penrose informs me that fluorite occurs abundantly as a gangue mineral in the auriferous quartz veins of Cripple Creek, Colorado.

destroy the magnetite. It is also well known that hematite and magnetite are ordinary secondary products. Solfataric action also causes the disappearance of ilmenite, but as ilmenite has not to my knowledge been recognized as a secondary mineral it is left in the list, with much doubt, as primary.—Marcasite has been identified at only one of the Southern mines. It occurs at a gold vein near Grass Valley, in California, and the marcasite from the Baker quicksilver mine in that State is auriferous.[1] Secondary marcasite is common in the auriferous gravels of California, yet the circumstances under which it forms must be peculiar, for it has not been reproduced artificially. It is certainly an unusual companion of gold in veins. Mispickel is about as common in the veins as is zinc blende. The occurrences are widely scattered and seem to present nothing particularly noteworthy.

Colorless mica has been observed in the ores at a number of points. In the ore of the Franklin mine and of the Barlow mine some of the mica exhibits the wide divergence of the optical axes characteristic of muscovite; and that of the Brackett mine, as seen in slides, seems to have the optical properties of muscovite. It is possible that some cases of white mica in the ores represent bleached or colorless biotite.

The tellurides, nagyagite and tetradymite, and native tellurium have a wide distribution, but fortunately are nowhere present in important quantities.

Manganese ores are uncommon in the fresh vein material, but in the decomposed zone above water level black stains, which are seemingly psilomelane or wad, are extremely common. They sometimes assume a dendritic character. The carbonate, rhodochrosite, is reported from only a single locality.—Pyrrhotite is a mineral of some interest, because it appears to form a link between the gold veins and the copper-sulphur mines, such as those of Ducktown. In the Armenius mine, in Virginia, where pyrrhotite forms a large part of the sulphur ore, there are stringers of auriferous quartz.—Siderite is not rare as a gangue mineral, and is peculiarly abundant at the Phœnix mine. I have seen a large mass of siderite ore said to have come from the Silver Valley.

Tetrahedrite is rare in the Southern gold mines. Genth believes it to exist in the ores of Silver Hill, as these sometimes give a reaction for antimony. No other antimonial mineral has been recorded from the Southern gold mines, while in Australia and the Transvaal stibnite is often found with gold.—Tourmaline is noted in a few cases only. Oral reports have reached me that the tourmaline-bearing quartz veins at the tin mine on King's Mountain are auriferous.—Zinc blende is a fairly common mineral, excepting in the north Georgian mines, from which it has not been reported.

The gold ores of the South are quartzose deposits with very subordinate admixtures of carbonates in which pyrite is always present, while chalcopyrite is common, and galena, mispickel, and zinc blende

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[1] Mon. U. S. Geol. Survey, Vol. XIII, 1888, p. 368.

are by no means rare. The long list of other minerals found in the veins is unimportant, excepting in so far as it assists in elucidating the genesis of the ores. I am unable to see that the accompanying minerals, with the one exception of pyrite, serve in any way as an indication of the value or extent of the ore bodies.

Precisely these statements would apply to almost any of the great gold regions of the world, so far as I know them; and it may therefore be asserted that the gold ores of the South are of a thoroughly typical character.

THE VEINS AND IMPREGNATIONS.

A very large part of the auriferous quartz deposits of eastern North America exhibits at least approximate conformity to the structure of the wall rocks. This fact has received different explanations from observers. In 1835 Messrs. T. G. Clemson and R. C. Taylor pronounced these quartz masses in the Virginia gold regions contemporaneous with the formations in which they occur.[1] In 1836 W. B. Rogers pointed out that, although in the main the dip and strike of the veins conform with those of the inclosing strata, the correspondence is far from being exact, and he classed them as true veins of injection.[2] In 1837 Silliman dissented from Rogers and pronounced those auriferous quartz deposits in Virginia which he had examined beds.[3] In 1854 Prof. J. D. Whitney classed the deposits of North Carolina as veins, but seemingly as "segregated" veins, and this kind of deposit he esteemed as originating in the gradual elimination of the component particles from the surrounding formation.[4] In his later works, however, this geologist regarded the similar deposits of California as what Rogers would have called veins of injection.[5] E. Emmons, in 1856, supposed the gold of the impregnated slates a sediment, and contemporaneous with the rock, but he perceived that the quartz masses are only in approximate conformity with the slates, and that they are real veins.[6] O M. Lieber, in 1859, announced that the gold is contemporaneous with the rocks, but that its segregation took place at a later time.[7] Prof. Herman Credner, in 1867, called the deposits in question "beds" and "primary deposits," "true veins," he thought, being foreign to the schists of the Southern Appalachians.[8] In 1875 W. C. Kerr wrote: "Many of these quartz veins are in reality beds, as they coincide in dip and strike with the stratification, whilst an equally great number run in every conceivable direction and dip just as irregularly."[9] In 1884 J. A. Phillips referred to these deposits as segregated veins, but he uses this term

[1] Trans. Geol. Soc. Penn., vol. 1, 1835, p. 310

[2] Rept. Geol. Recon. Va., 1836.

[3] Amer. Jour. Sci., vol. 32, 1837, p. 100.

[4] Met. Wealth U. S., 1854, pp. 129, 83, 45.

[5] Auriferous Gravels, 1880, p. 330.

[6] Geol. Midland Counties of N. C., 1856, pp. 130, 142.

[7] Proc. Amer. Assoc. Adv. Sci., vol. 12, 1859, p. 229.

[8] Neues Jahrbuch der Min., 1867, p. 442.

[9] Geol. N. C., vol. 1, 1875, p. 285.

as equivalent to bedded veins, and doubts there being any difference excepting that of position between these and so-called "true" veins.[1]

The veins of Nova Scotia have been similarly interpreted. Sterry Hunt and Professor Hind thought them sediments, while Messrs. Campbell, Selwyn, and Poole took the opposite view, as will appear later in this report.

Rogers and Campbell appear to me to have been perfectly correct in their views, and it is difficult to understand that when the evidence they offered was once known any different opinion could have been adopted by subsequent observers. It is true that a quartz seam will sometimes follow a schistose parting or a slaty cleavage quite accurately for a few feet, or even for some yards; but I have met with no reasonably large exposure in which it did not appear that the quartz breaks across at least from one cleavage to a parallel surface, and usually such evidences are abundant. Furthermore, stringers diverging from the main quartz bodies into the walls are frequent, and angular fragments of schist can generally be found completely embedded in the quartz, showing beyond a question that rupture of the country rock preceded the deposition of ore. Occasionally also comb structure is visible in conformable veins, and, where the veins pinch, as these veins do with remarkable frequency, the walls are often scored by the motion which resulted in the formation of the openings now filled with quartz.

The structure with which the quartz veins under discussion are approximately conformable is not stratification, but schistose cleavage. In most cases the rocks are of igneous origin, and although there are instances in which the material is sedimentary, it is none the less an accident when the bedding and the cleavage coincide. There is certainly nothing remarkable in the fact that a schist subjected to orogenic dislocation should very often split along its cleavage surfaces. It is this very property which gives the rock its name.

The wall rocks in the Southern Appalachians were for the most part rendered schistose by forces antedating the fissure-forming disturbances and wholly independent of them. The pressures which opened the vein fissures did not in general coincide in direction with those which had previously produced schistosity. In the Georgian belt the effect of the later disturbance was usually to split the slaty rocks along their main cleavage and to dislocate the walls. The cleavage surfaces of the rocks were not planes, but surfaces crossed by undulations of more than one system, and the result of the dislocation was to produce lens-like openings, or pipes with lens-shaped cross sections. In such openings the quartz was deposited, and the mass is often corrugated like the "barrel quartz" of Nova Scotia.

It rarely happens in any mineral region that isolated fissures are formed. In the Georgian belt the tendency to the distribution of motion over various surfaces is very marked, and, as a rule, a mine

[1] Ore Deposits, 1884, p. 90. On p. 61 he refers to his own observations in the Carolinas.

opening displays many associated small fissures, each bearing lenticular quartz masses, the whole system forming what may conveniently be called a *stringer lead*. Such leads are known in Georgia as veins, the use of this term being to a slight extent excusable because the entire lead is mined and treated as ore.[1] The undulatory character of the cleavage is so strongly marked a feature of the rock structure as to impress itself on an entire deposit or any small portion of it. One may collect hand specimens of ore showing the lenticular structure. The mine stopes show at a glance the same lenticular shape on a larger scale, and sometimes it seems that the entire workable ground of a mine is also a lens.

Very often the lenticular stringers are discontinuous. One such stringer dwindles to a thread or disappears and is replaced by another, or by others, in the foot or hanging. In many instances it can be seen that diagonal seams connect such shingling (or more scientifically, imbricating) stringers. Often no such connection is visible in the section which happens to be exposed, but it does not follow that a different exposure would not show a connecting seam. Indeed, the fact that they are often visible, together with simple considerations on the origin of the fractures, points to the conclusion that all the stringers were once united by cracks sufficiently large to permit the passage of solutions. I have formerly employed the term "linked veins" to designate similarly connected groups of veins.[2]

Besides the stringer leads, coinciding on the whole but not in detail with the chief schistose cleavage of the country, there are in the Georgian gold belt many relatively small cross fissures. These answer to joints in the country rock, originally formed as a part of the dynamic effects, among which schistose cleavage is the most prominent. In many cases these joints gaped when the schists were split to receive the ore. In a few cases it seems to me that the joints have yawned in response to later movements of the country, and have then received a somewhat different filling, usually calcite. I have not been able to ascertain that there is any characteristic difference in the tenor of the main deposits and the cross stringers when both are filled with quartz. In the Franklin mine there are cross stringers filled with calcite, carrying, I was informed, a mere trace of metal.

Throughout the South the veins are very frequently attended by impregnations of the country rock, the gold, accompanied by pyrite, permeating the walls to a depth of from a few inches to a few feet. Such impregnations occur also with veins of tin ore.[3] When the walls are rich enough, of course the rock is mined, and sometimes the walls are worth more than the vein.

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[1] *Lead* is a variant of *lode*, and means a deposit which, though not a stratum, is bounded by more or less definite walls. It is in use to some extent in Nova Scotia to denote zones of auriferous quartz seams. I understand that in Australia it is applied to a pay streak in gravel. It seems the only word indefinite enough to be applied to these groups of stringers. *Belt* would be available did it not suggest a wide zone of country, such as the gold belt of California.

[2] Mon. U. S. Geol. Survey, Vol. XIII, 1888, p. 409.

[3] J. A. Phillips, Ore Deposits, 1884, p. 96.

In the South Mountain area the veins are of an altogether different type from those of the Georgian belt. Their strike is more easterly by 30° or 40°, ranging about N. 50° E. to N. 70° E. The strike of the schistosity in this area is very irregular, but is usually to the west of north. Thus the South Mountain veins cut across the schists. They form a system of parallel fractures which is absolutely astonishing in its regularity when the heterogeneity of the country is considered. The variations in lithological character and in structure of the country seem without any sensible effect whatever on these sharply-defined fissures. The dip of the schistose surfaces is to the northeastward, while the veins dip northwestward at about 80°. Most of the veins in this area are very thin, though not so tenuous as some of the seams in the stringer belts of Georgia. Veins only half an inch in thickness are common, and, small as they are, it seems possible to follow them as far as may be worth while. Oftentimes several small veins are found within a horizontal distance of a few feet and can be worked in the soft superficial layer at the same time; more usually, however, veins thick enough to pay even the expense of trenching in the saprolite[1] are a rod or two apart.

There seems to be a tendency to regularity in the distribution of the larger veins. Thus some 5 miles north of Rutherfordton there is a group of veins of 1 or 2 feet in thickness, including those of the Idler property. To the northward of this group is another, including those of the Vein Mountain mining property, at a distance of several miles from that first mentioned. After another interval of a few miles is a third group of similar lodes, including the Neighbor's vein. Between these groups there seem to be literally innumerable veins of small size parallel to the larger ones, and equally persistent. Such relations are well worth noting for practical purposes, as well as for their theoretical bearing, but it must not be inferred that groups of larger veins will be distributed at equal distances. If there is, as I suspect, a rhythm in the distribution of the larger veins, it probably follows a complex law, like that of ocean billows.

The veins of the South Mountain region, being clean-cut fissures, are very free from horse matter, which, however, is sometimes met with. They are substantially quartz veins, with a little calcite, carrying, besides gold and pyrite, chalcopyrite, galena, and zinc blende in small quantities. There seems no reason why the larger veins should not pay if they carry over $3 per ton. The small veins can not be worked below water level unless found in groups so close as to permit of simultaneous exposure.

In this same region there are some irregular streaks of glassy quartz, coinciding in strike and dip with the schistose rocks. So far as I know, they are of small thickness and soon fade out in strike. They seem to be mere local segregations of silica and are not known to be auriferous.

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[1] *Saprolite* is used in this paper to signify thoroughly decomposed rock in place. The word is more fully explained in the section on Placers, p. 43.

No miner would think of testing this unpromising material for gold. They seem in no way related to the auriferous quartz veins or stringer belts intercalated in the schists of the other gold-bearing regions. In all the Southern gold regions there are many quartz veins which carry little or no gold, and the wide, solidly filled transverse veins are particularly apt to be barren. In almost all cases the quartz of these veins looks unpromising, being either glassy or milky. It is very possible that these veins are of a different age from those which carry gold, but they have not been carefully studied as yet.

In the Carolinian belt stringer leads entirely like those of Georgia are by no means uncommon. This area, however, possesses deposits of another kind which bear much resemblance to the *fahlbands* of Norway.[1] Extensive lens-shaped masses of rock conformable to the general schistose structure of the country are charged with disseminated pyrite and gold. In and close to these ore bodies there are quartz stringers grouped as in the stringer leads of Georgia, but these form a relatively unimportant portion of the ore. The auriferous schists also show effects of dislocation, such as grooving. At the Haile mine well-developed quartz veins appear close to the enriched rock masses, but these veins are barren. The mineralization of the auriferous masses is curiously irregular. Sometimes the gold and pyrite are accompanied by so little silica that the impregnated schists are easily cut with a knife, and occasionally gold spangles appear on cleavage planes without any visible quartz. I have not been able to satisfy myself, however, that any of the deposits are absolutely devoid of gangue quartz. This mineral is to be found in almost all cases within a few millimeters of any gold particle, even when not in contact with it, and the microscope shows a very curious association of pyrite with fibrous silica in the slate ores. Oftentimes these deposits are highly silicified, and the ore is then a hornstone-like mass. There seems to be no relation between the intensity of silicification and the value of the ore.

It seems to me that these deposits are impregnations dependent in great part upon the lithological character of the rock for their existence. The frequent occurrence in them of stringer-lead structure and evidences of dislocation indicates that the whole mass has been shaken up and its texture loosened. If in such a mass the rock itself is porous or peculiarly susceptible to chemical change, it is evident that ore-bearing solutions might easily impregnate the whole body. Now, along the Carolinian belt there are unquestionably great quantities of volcanic material, and such material, through its heterogeneity, would tend to irregular rupture. Fragmental eruptives are also commonly porous and of no great chemical stability.

In some instances it seems certain that the impregnated rock is eruptive. This is the case at the Brewer and the Haile, in South

[1] Compare M. Kjérulf's account of fahlbands as reported in Fuchs and DeLaunay, Gîtes minéreaux, vol. 2, 1893, p. 759.

Carolina, and at the Hoover Hill, in North Carolina. At the Davis and the Russell mines, in the latter State, it seems probable that the impregnated mass is eruptive. There are other cases in which only prolonged and detailed study of the localities could decide the origin of the rock.

A peculiar case is the Moratock. There is no question that the rock upon which this mine is opened is eruptive. It is a spherulitic mass showing flow structure and containing phenocrysts of quartz, labradorite, and biotite. Portions of the rock are plainly breccia. It is not greatly decomposed, but contains scattered pyrite crystals, sometimes lining minute geodes. The attempt to work this rock as ore was a failure, though I was informed that it carried a very little gold. This was probably in the pyrite. Whether the pyrite was secondary or primary I am not sure; but I could perceive no evidence that it had been introduced into the mass after solidification.

The dependence of ore deposition upon intrusive rocks is not clear or satisfactory in the Georgian belt. There are numerous granitic dikes near Nacoochee, and they appear at the Loud mine. At no great distance from the Franklin mine, also, such dikes are abundant. In the neighborhood of Dahlonega it is curiously difficult to decide whether or no there are dikes. The gneiss is there remarkably well banded, and there are places in which one suspects dikes among the bands, but I could not find any single case of a clearly marked intrusion. At the Boilston mine, in North Carolina, on the other hand, a granite dike accompanies the veins and appears closely connected with ore deposition.

The age of the dikes mentioned can hardly be greater than that of the ore bodies, for the disturbance of the country preceding the deposition of ore would have affected the dikes, and there is no evidence of their having been thus disturbed. The ore bodies, however, have not been considerably faulted; and in short there seems no evidence of any profound dislocation since the time to which both ore and dikes are referable. Nevertheless, only experience got in other regions justifies the hypothesis that a genetic relation exists between the ores and the granite dikes of the Georgian belt, excepting in the case of the Boilston mine.

In the South Mountain region there are also granite dikes, but they are few in number. They do not strike with the veins, and in one case (the Brackett mine) a dike is said to fault the vein.

In the Carolinian belt, on the other hand, the connection between volcanic phenomena and ore deposition is very clear at some points. At the Haile mine, for example, a system of heavy diabase dikes intersects the country. These dikes are somewhat decomposed in contact with the ore, but themselves carry little or no gold. The ore bodies are found along the dikes and are richest close to them. At the Howie there are both diabase and diorite dikes, but the mine being closed the exact relations to ore can not be determined. In the Ferris mine a granitic dike exists in contact with the ore. At the Reed and the Phœnix there are large quantities of porphyrite, and there is a dike at Hoover Hill in the mine workings.

Many instances of the association of dikes with gold deposits are also mentioned in the reports of Tuomey, Lieber, and Emmons as occurring in Alabama, South Carolina, and North Carolina. In considering the connection between dikes and deposits it should be remembered that (as stated in the description of rocks in this report) there were Mesozoic intrusions as well as earlier ones. The later dikes are probably far younger than the ore, and of course without influence on its genesis.

The whole subject of the relation of intrusive or eruptive rocks to ores is in a very unsatisfactory condition. Most mining geologists believe in a direct or indirect connection between vulcanism and ore deposition, but the nature of this connection has not been elucidated. I am inclined to suppose the intrusion of lava and the formation of ore-bearing solutions two distinct effects of vulcanism, which may be associated or dissociated.

A special effort was made during the reconnaissance described in this report to gather any evidence which might exist of the substitution of ore for country rock. So far as the veins were concerned, this effort was a total failure. One of the chief physical indications of replacement is the rounding of the edges and corners of unchanged kernels of the material which undergoes replacement when the process is incomplete. This is in consequence of the fact that edges and corners expose a greater surface per unit volume of the mass than do flat surfaces. It follows that fissures will be irregularly enlarged and that replacement will take place in cuspoid forms along joints intersecting main fissures. Nothing of the kind was met with in the veins, and the total absence of such phenomena is valid evidence that the auriferous veins occupy spaces opened by purely mechanical action.

With respect to the impregnations, it is more difficult to judge what has happened. That profound alteration has taken place there is no doubt. Pyrite crystals have grown to most perfect development, as if in a fluid, in spite of the pressure of the rock mass, and have even bent adjacent laminæ of slates; quartz grains, too, have developed. Whether, however, rock constituents have been dissolved as a condition of the precipitation of quartz and pyrite accompanied by gold, is uncertain. I suspect not.

The association of minerals in the veins, among them carbonates and chlorite, indicates that the ore was deposited from solutions and not from gases or vapors. It is true that there is a very close analogy between the chemical behavior of gases and dilute solutions, but the physical state of the unprecipitated ore is a matter of importance.

The character of the solutions from which the ore was deposited is still a matter of doubt. I showed in 1887 that silica, gold, pyrite, and the sulphides of arsenic, antimony, copper, zinc, and iron are soluble in a menstruum common in nature, viz, waters containing carbonates and sulphides of the alkalies. That is a satisfactory result so far as it goes, but this solvent will not dissolve galena under any conditions known to me, while galena is a common mineral in gold veins. Either, then, lead sulphide is soluble in this menstruum under conditions still unknown, or the right natural solvent has not been experimented with. The recent deposits of Steamboat Springs, Nevada, contain lead as well as copper, gold, etc., and the water flowing from the springs contains carbonates and sulpho-salts of the alkalies, chlorides of the alkalies, borax, and sodium silicate.[1] It would seem, therefore, that my solvent must have been closely analogous to that which comes in play at Steamboat. Galena has, indeed, been formed artificially in several ways from lead compounds, but the mere generation of crystals of the sulphides from other compounds in place implies only an infinitesimal solubility. To explain ore deposits one must find a probable menstruum which will hold in solution sensible quantities of lead sulphide and from which it can be precipitated under known conditions.

To discuss the origin of the gold in the South it would be needful to make very laborious analyses of large quantities of the freshest gniesses of the region. This has not been done. Should they prove auriferous, it would be reasonable to infer that the gneissic rocks are the source of the gold. The indications of the occurrences do not seem favorable to the hypothesis of such an origin, for there is no such prevalence of solfataric decomposition of the wall rocks below water line as would probably accompany a gathering together into the veins of small quantities of gold from great masses of rock.

The question of the persistency of the veins in depth is one which, in my opinion, need cause no uneasiness. For reasons stated elsewhere in this report, it is believed that the veins date chiefly from a pre-Cambrian period, and if so, the present croppings are far below the original ones. If mining could be carried to an unlimited depth, it is probable that the fissures would be found to grow smaller, for the greater the pressure of the superincumbent mass the greater must have been the tendency to close openings formed under catastrophic conditions; but the total depth of fissures measured from the original surface is most likely of the same order as their length, several miles in many cases, while no mine has ever yet reached a depth of one mile. In sinking, it should not be forgotten that veins may imbricate in a vertical as well as in a horizontal direction, and that crosscutting is, therefore, a very essential feature of development.

[1] Am. Jour. Sci., vol. 33, 1887, p. 199, and Mon. U. S. Geol. Survey, Vol. XIII, 1888, pp. 344, 349, 433.

It has been held that the precipitation of gold took place mostly near the original surface,[1] but if the veins of the Southern Appalachians are, as they seem to me, of pre-Cambrian age, this can not be strictly true, nor does it seem to me that the mining operations of the last thirty years point to such a conclusion. Doubtless some veins grow poorer in depth, while some grow richer. These variations within accessible limits of depth are probably controlled for the most part by circumstances similar to those which bring about variations in tenor from point to point on the strike of veins.

An idea is very prevalent among mine owners that veins may be expected as a rule to grow stronger and richer with depth. This is an hypothesis based on hope and with no justification in general experience.

PLACERS.

Gold is found in loose material of two very distinct kinds in the Southern Appalachians. True stream gravels carrying gold are not wanting, but much more common are auriferous accumulations of rotten rock in place. As is well known, decomposition of the bedrock in the unglaciated South often extends to a depth of from 50 to 100 feet from the surface. Where the mass was originally intersected by gold-quartz seams, perhaps accompanied by impregnation of the wall rock, the decay of the mass to soft earth takes place without sensible loss of the precious metal. Such deposits can be worked with pick and shovel or, when they are rich enough, by the hydraulic process. In such deposits, as a rule, the original structure of the rock is perceptible to within a couple of feet of the surface. The rock in decomposing may have undergone some change of volume and a trifling amount of movement, but the material is substantially in place.

There is no term in general use to designate this decomposed rock in place, although it is found almost universally in unglaciated regions, even within the arctic circle. It is by no means often possible to name a given occurrence of this kind from the original rock, because, when there are no exposures of unchanged material, it is usually doubtful which of several allied rock species is really present. The word "Geest" was long ago proposed as a general term for such material. This is a provincial German word meaning dry land as distinguished from marshy land. The name does not seem aptly chosen and has not been adopted by many writers. The German term "Gruss" has sometimes been made to serve, but this word denotes a mass consisting of angular fragments, as distingnished from the rounded pebbles of gravel, and it is constantly in use for transported material, as for example "Gruss-kohle," equivalent to slack-coal.

I propose the term *saprolite*[2] as a general name for thoroughly decomposed, earthy, but untransported rock. When the exact character of

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[1] Murchison, Siluria, 4th ed., 1867, p. 459.

[2] From σαπρός, rotten. The term *laterite*, as used in India, where it originated, has a lithological signification and applies in part to transported material.

the original rock is known it is easy to qualify this term and to speak of "granitic saprolite," and the like.

The deposits referred to above, then, are gold-bearing saprolites. In these the original quartz veins are usually but little decomposed, and can be followed at small expense. Near Brindletown the hills are scored with deep trenches thus excavated. In the Dahlonega region a system often adopted is to hydraulic the saprolite, the fine earth usually being allowed to escape after passing through sluices, while the fragments of vein quartz are thrown out by grizzlies, or equivalent devices, and passed through the stamp mill. The losses in this process, however, are very great, owing, it would seem, to the inclosure of the gold particles by films of iron oxides or other substances which prevent amalgamation.

Geologically the saprolites are of course identical with the more solid masses beneath them, yet they sometimes permit the observation of relations less well seen elsewhere. Thus in some saprolites an almost endless number of the thinnest possible quartz seams and the most perfect quartz lenses are accessible not merely in section but in three dimensions. At the Kin Mori mine one can pull out of the saprolite pieces of vein of several square inches area and scarcely thicker than writing paper. But this is not always the case; some auriferous saprolites show almost no quartz. There are instances in which the observer can scarcely believe the results of assays from carefully taken samples, so little indication is there of any gold. Now, the investigations of late years make it certain that quartz is often attacked and dissolved, or is replaced by mica, iron oxides, etc. It seems to me probable that the deceptively rich saprolites are those in which the quartz has been thus removed.

The gold found in the saprolite deposits is naturally very rough, and in some cases, as at the Loud mine, north of Dahlonega, masses of wire gold are met with. If anyone still doubts the origin of the gold in stream gravels he may readily convince himself in the South that the origin of the metal is in veins, for gold can be seen there in all stages from the roughest to the smoothest as the saprolites are followed into the waterworn gravels.[1]

It was stated above that the saprolites often extend to within a couple of feet of the surface. Above that level the soil has usually been worked over by plant roots, if by no other agency, and has thus lost the characteristic rock structure. In some cases, particularly on steep slopes, the disturbance extends to a greater depth and seems due to a different cause. The soil within a few feet of the surface is exposed to the expansive action of daily sunshine and frequent winter frost. In contracting again after expansion, it tends to settle as far down hill as possible, and this tendency is promoted by the fact that fine particles are apt to fall into any crevices which may form in the mass. Hun-

[1] See a paper by Prof. A. Liversidge on the origin of gold nuggets, Proc. R. S. New South Wales, vol. 27.

dreds or thousands of such expansions followed by contractions are nearly equivalent to a slow flow when the mass is soft, as in the case of saprolite. By such means this material is often fed into the head waters of streams, and but for this action the saprolites might be much thicker than they are. Substantially this explanation is given by Kerr, who, however, refers the expansion to the cold of the glacial epoch,[1] a reference with which I wholly disagree. He also points out that this settling process frequently affects schistose rocks when they come near the surface, and I have observed cases in which the laminæ were flexed down hill to a depth of 6 or 8 feet.[2]

Much gold has been obtained in the South from modern rivulet or "branch" gravels, and it is evident that in saprolite areas such gravels must almost inevitably be rich. The earth is removed with ease by heavy rains, while the gold and the larger pieces of quartz remain in the stream bed.

The presence of saprolite also favors the concentration of those rock-forming minerals, which offer relatively great resistance to decomposition, particularly if they happen to be denser than the average mass. Thus near Brindletown the list of rare minerals found in the sands[3] is immense, and nearly all of them no doubt came from the granitic and dioritic gneisses, or from pegmatitic lenses in these rocks.

Of these rare minerals monazite has a commercial value, selling for from 5 to 10 cents a pound, and considerable quantities of it are obtained by panning, a process in which the men, women, and children of the region are thoroughly expert. The density of monazite being about 5, this mineral is easily freed from quartz and feldspar. The magnet might be used to extract magnetite from the concentrates.

About a dozen diamonds have been found in North Carolina, always in gravels, and according to Genth, in every instance associated with gold and zircons. In no case, however, was a diamond found adhering to gold, or containing gold like the Kimberly specimen, a description of which is given at the beginning of the section on Gangue Minerals. It is difficult to guess the origin of the diamonds in a region like the South Mountains, where the rocks are acid or neutral, unless they come from the amphibole-pyroxene blebs in the prevalent country rock.

There are ancient as well as modern auriferous stream gravels in the South, and some of these have yielded much gold. In such cases the well-worn gravel is commonly covered wholly or in part by blue clay containing fragments of more or less lignitic wood. The most extensive gravel bed of this kind which I have seen is on Dukes Creek,

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[1] Trans. Am. Inst. Min. Eng., vol. 10, 1882, p. 475.

[2] See description of the Bell mine, Moore County, N. C., in the notes on the Carolinian belt.

[3] Genth mentions among others tetradymite, montanite, brookite, anatase, rutile, zircon, malacon, cyrtolite, monazite, xenotime, samarskite, columbite, fergusonite, chromite, titanite, cyanite, corundum, enstatite, tourmaline, garnet, beryl, allanite, thorite, diamond. Bull. U. S. Geol. Survey No. 74, 1891, p. 89.

near Nacoochee. There is a similar deposit on Yahoolah Creek at Dahlonega, and a small one near Brindletown. Mr. F. H. Knowlton has examined specimens of wood which I collected on Yahoolah Creek, and pronounces them Pleistocene. The conditions indicate either a period during which the streams were dammed back or one during which the slope of the stream beds was temporarily diminished. There is no evidence of temporary damming, and it would seem that the Columbia subsidence must be called upon to explain the phenomena.[1]

The deformation of the peneplains studied by Messrs. Hayes and Campbell[2] and their consequent dissection by streams is a matter of practical consequence. Had the country not been upheaved and distorted the streams would not have cut back into the country, the gold would not have been concentrated in the "branches," and there would have been no outlet for tailings from the areas of auriferous saprolite.

In the Southern Appalachians, as in every region where gold is obtained from streams, it is well known that, other things being equal, gold dust is purer or of higher grade than coarse gold, and that the exterior of waterworn nuggets is purer than the interior. Even Pliny seems to have been aware of this fact and to have had an inkling of its cause, for when speaking of the gold dust obtained from rivers he wrote: "Nor is any gold more pure, inasmuch as it is refined by the flow of the stream itself and by the attrition."[3] Oviedo, Columbus's companion, is much more explicit on this subject, and some of his remarks are so sound as to be worth literal translation, if only to correct a tendency to overestimate modern discoveries in such directions. "It may be considered certain," he says, "(judging from the results), that the greater part of the gold is born in the summits and higher portions of the mountains; but that it is created and engendered in the entrails of the earth; and so as the earth brings it forth or expels it, and because of the abundance of the material in the mountain tops, the storm waters transport it little by little and in time carry it down into the gulches and the ravines of those streams which rise in the mountains; notwithstanding which, gold is often found in the plains far from the mountains." Subsequently he remarks: "I say that when any bank of a river or of a ravine or the river itself is worked within the 'mother ranges' [madres] (as people say), it is always those miners who get the gold at a lower level (I say down stream) who find it purest; so that in proportion as some washers are lower down than others, the gold will be of more carats or of greater value and fineness, because the more the gold travels, the higher and finer the alloy. But those who

[1] Tuomey reports auriferous deposits of rounded gravel near the summit of the Blue Ridge in such positions as to preclude the possibility of the pebbles being rounded and transported by any aqueous force that could have existed since the region received its present form. (Geol. Rept. on South Carolina, 1848, p. 86.) I have not visited any so far from the existing drainage. Lieber mentions gold in connection with Tertiary pebbles. (Geol. Rept. on South Carolina, 1856, p. 77.)

[2] Nat. Geog. Mag., vol. 6, 1894, p. 63.

[3] "Nec ullum absolutius aurum est, ut cursu ipso trituque porpolitum." Hist. Nat. Lib. XXVIII, chap. 21=chap. 4 of some editions.

extract it at a greater elevation, higher up the river, go closer to the birthplace of the gold, and obtain it more often in abundance. Hence it may be inferred that the distance which it moves takes much time, many years, so as to effect the increase of carat and of purity." Again he asserts that: "On the contrary, the nearer gold is found to its vein or birthplace, once it has reached the river, the more crinkled and rough is it and of lower carat and value than it would have been if it had traveled."[1]

Oviedo seems clearly to have understood that the less valuable silver or other admixture was partially removed from the gold grains by the action of the water, and that this process was more complete as the gold grains grew smaller through attrition. The most explicit statement of this action with which I have met is by Mr. Ross E. Brown, who says that the silver and baser constituents of the nuggets when exposed to air and water are partially oxidized and dissolved, so that the surface film undergoes partial purification.[2] It seems probable that the alkaline chlorides present in almost all natural waters must play a part in this superficial refining, which is analogous to tho process of "pickling coin blanks" practiced in the mint.

DESCRIPTIVE NOTES ON THE GEORGIAN BELT.

The Georgian gold belt lies in the Piedmont region of northern Georgia and eastern Alabama, receding from the mountains to the southward. This area was baseleveled both in the Cretaceous and in the Tertiary, but the two levels do not appear distinctly separated in all cases. Above them project some monadnocks, and they have been moderately dissected. The country is well watered, sufficiently timbered, and much of it is extremely picturesque.

While a great number of mining properties which have produced more or less gold are scattered along this belt, from near Montgomery, in Alabama, to near Clayton, in north Georgia, there are several points which may be regarded as centers of interest. Such are Creighton, about 14 miles northwest of Canton, at which lies the Franklin mine, Auraria and Dahlonega (two towns only 5 miles apart), and Nacoochee.

The most instructive mine of all those on the belt is the Franklin, for it appears to be thoroughly typical. The workings extend below the 400-foot level, and the mine is in active operation. It affords the only opportunity of making a satisfactory study of the ore bodies in solid rock. At the time of my visit the mine was producing about $100 a day in gold.

The rocks at the Franklin mine are gneissoid mica-schists for the most part, the gneissic structure sometimes being very distinctly preserved. A hornblende-zoisite-schist also makes its appearance here, but does not seem to represent a different series of rocks. No dikes were found directly at the mine, though within a mile of it there are many of

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[1] Hist. Gen. y Nat. de las Indias, published 1535, edition of 1851, Lib. VI, Chap. VIII, sections 6 and 7.
[2] Eng. and Min. Jour., Feb. 2, 1895.

them, all granite, but some gray and fine-grained, while others are nearly white, with relatively coarse structure along the median surface.

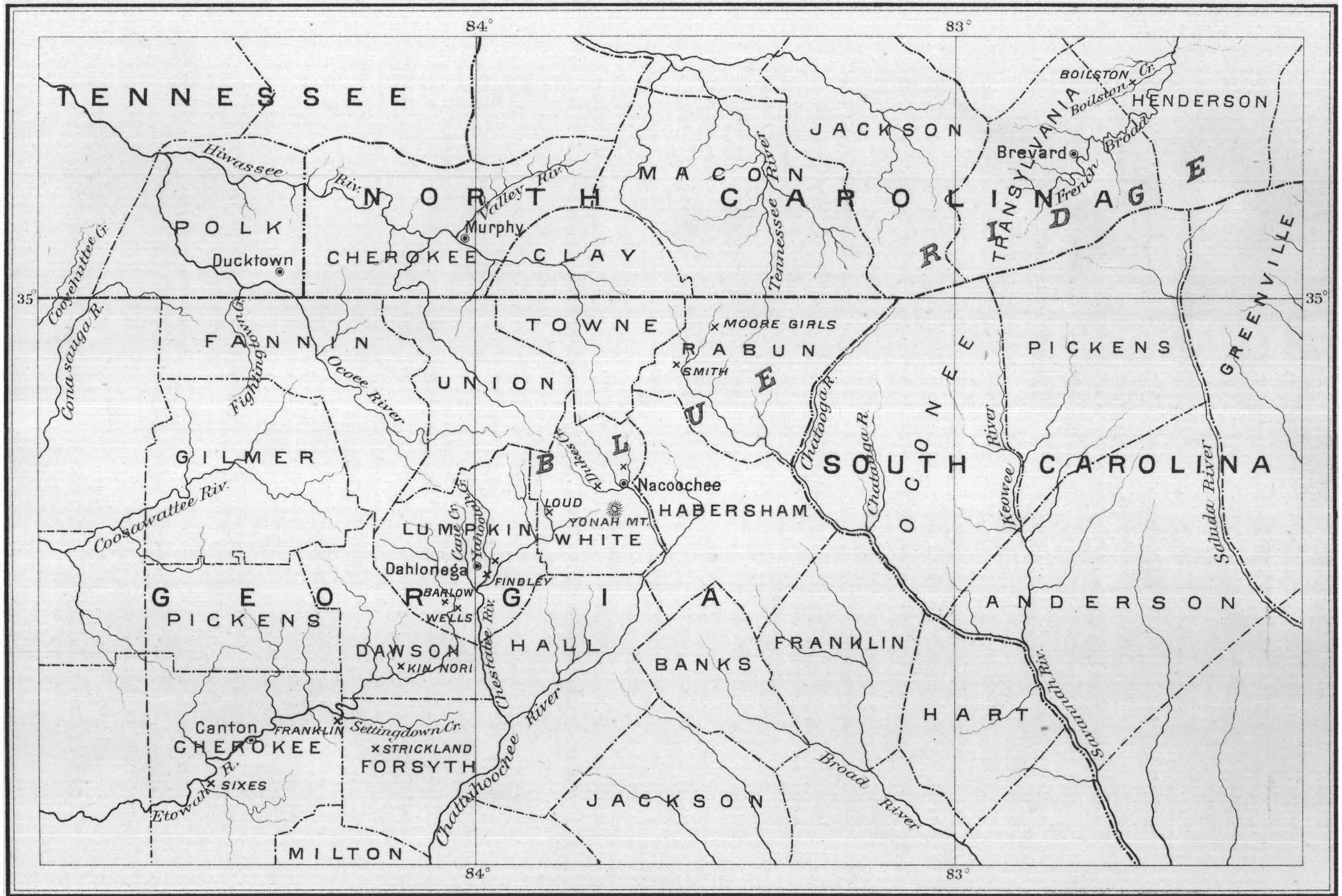
The wall rocks are chiefly undulating schists, and the vein fissures have been opened by a movement such as to produce a series of pipes with lenticular section, closely analogous to the barrel quartz of Nova Scotia, though less regular. The dislocation is marked by sharply incised grooves on the swales of the schist. The ore-bearing schists strike in an average direction N. 56° E. and dip at 41° to the southeastward. In this plane the corrugations and the pipes make an angle of about 56° with the strike of the walls, pitching northeastward. The incised grooves also pitch northeastward at an angle of about 27° less than the pipes, the angle between them being measured in the plane representing the average schistosity. Such grooves would be produced by a dislocating force in a plane at right angles to the plane of schistosity, and so oriented that the intersection of the two planes coincides with the grooves. The direction of the force would be at an angle of about 45° to the movement it produced. There are two such directions. A force in one of them would cause normal faulting, while a force in the other would cause abnormal faulting. If the faulting was normal the force producing it was in a vertical plane striking nearly N. 40° E. and pitched to the northeastward at about 50°. This force would bring about a motion the horizontal component of which is about twice the vertical component, so that the hanging wall would be shifted to the northeastward relatively to the foot wall by a distance twice as great as the slip downward to the southeast.

The dislocation which opened the ore chambers at the Franklin was a normal movement, as is shown by the fact that there are numerous stringers which show smooth walls and dip more steeply than the slate. This subject has been discussed in the section dealing with Structure.

The gangue minerals at the Franklin are quartz, with occasional calcite, a little muscovite, much pyrite, and some chalcopyrite. The pyrite is usually most abundant where the quartz is richest, and at such points, as a rule, the adjoining slates also carry numerous large, well-developed, auriferous pyrite crystals, resembling in all respects the pyrite in the quartz. Such rock is of course ore, and its occurrence in this manner throws light on the distribution of gold in saprolites.

The ore bodies are composed of innumerable quartz stringers, each a flat lens or pipe petering to a feather edge, but replaced by other similar bodies. There seems at this mine no indication of a regular shingling (or imbrication), so that a fresh stringer is as likely to appear in the foot as in the hanging. Such a body of ore is not, as a whole, a vein, and I have suggested the name "stringer lead" to describe it. The larger features of the deposits, as well as the minor details, exhibit the tendency to lenticular structure.

There can be no question that the ore in the Franklin is a deposit from aqueous solutions in interstitial spaces due to mechanical rupture.



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MAP SHOWING THE GEORGIAN BELT.

SCALE 20 MILES=1 INCH.

The ore carries fragments of a thoroughly schistose wall rock, and there is not a trace of rounding or other phenomena of solvent action.

The ore of the Franklin carries about $6 per ton. About half of this gold is saved on the battery plates. The clean sulphurets assay about $56, and the concentrates, which contain about 50 per cent of sulphurets, are treated by the wet chloridation process as modified by Mr. Adolph Thies.

The proportion of gold obtained by direct amalgamation at this mine is actually much greater than in the saprolite mines of the belt, where the sulphurets are almost totally oxidized. This is an extremely remarkable fact, and one highly encouraging to deep mining in Georgia. It also shows, I think, that in the saprolite mines much gold once free has become "rusty," or coated with films of substances which prevent amalgamation.

A second vein accompanies the Franklin at a distance of about 150 feet. It is called the McDonald, and has been prospected by shafts which are now inaccessible. The rock and the ores as seen on the dumps of the shafts appear to be nearly the same as at the Franklin, but more gneissic.

The Sixes mine, some 8 miles in a southwesterly direction from Canton, shows a mass of granite which has been reduced to schist only in part. The composition of this rock is normal. Near by in a rivulet a black schist, probably of dioritic origin, crops out. It carries actinolite and zoisite. It is said that crystallized gold has been washed out in the streams at this locality. The Sixes mine has long been abandoned and nothing is to be seen of ore or of its geological relations. At the Wilkinson and Cherokee properties, about a mile southeast of the Sixes, the wall rocks are the usual gneissoid schists of the Georgian belt with the usual strike and dip, and the ore appears to have occurred in stringer leads. The same may be said of the Strickland mine, about 4 miles a little east of south from the Franklin. At the Dr. Charles mine, which is near the junction of Dawson, Forsyth, and Cherokee counties, mispickel is abundant, and the deposits are stringer leads.

At this property, in the saprolite and in the partially decomposed rock, there are numerous slickensided surfaces stained black with manganese, probably in the form of wad. Such slickensides in such positions are abundant throughout the belt, but I have looked in vain for anything of the sort below the water level. It would seem that the slickensiding is due only to the changes in volume attending decomposition, of which also the manganese stains are a result.

The Kin Mori and McGuire properties adjoin each other and lie in Dawson County, about 4 miles southwest of Dawsonville. No work has been done on them for years. Large cuts have been made in the saprolite and some tunneling has been done on stringer leads. The more solid exposures of rock are gneissic schists and the darker schists which I suppose of dioritic origin. The strike is N. 50° E. and the dip is 50° to 65° to the southeast. Some of the schists contain garnets. A part of the rock shows undulous and carunculated cleavage surfaces, and my guide informed me that the stringer leads are best developed where one wall shows such structure and the other is characterized by flat cleavage. At one point on the Kin Mori property, near the mill, a vein is exposed which shows 4 feet of solid quartz. This is very probably on the same fissure as a heavy cropping about 8 feet in width to the southwest and on the other side of the Etowah River. Both exposures carry sulphurets, but appear to be very low grade, as are many of the thicker quartz veins of the belt.

In portions of the saprolite of the Kin Mori there are great numbers of tiny quartz veins, scarcely thicker than writing paper. At one point twenty such were counted in a mass only an inch thick. On the McGuire there is a very large amount of white float quartz full of tourmaline needles. This must come from a vein near by, but none of the rock could be found in place. Tourmaline-bearing quartz is not known to occur with the ore at this property.

Dahlonega and Auraria (formerly Knucklesville) are surrounded by mining properties forming one continuous district geologically and technologically. In this district work has been confined almost entirely to the saprolite, and exposures of rock in place are to be found only where natural erosion or hydraulic washing have laid it bare.

The rocks are hornblendic schists, gneisses, and gneissic schists. In one or two cases fragments of the darker schists or of a similar rock appeared to be included in the gneiss. The gneisses are for the most part dynamometamorphosed and schistose, but in limited areas they show only gneissic banding, and this is occasionally almost insensible, so that the rock approaches simple granite. Such an exposure appears in the bed of Yahoolah Creek below the Murray mine. Ordinarily the gneissic sheets are extremely distinct and are parallel to the schistose cleavage of the country, but in a few cases the schistosity cuts the gneissic structure. Sometimes the schists pass over into true slates.

No unquestionable dikes were found in place in this district; in some cases, however, bad exposures left it uncertain whether unusually well-marked sheets in gneiss might not be intrusions. Instances of this kind were seen near the Hand mill. Notwithstanding my failure to find well-marked dikes, I find it impossible to believe that there are none. On the dump of the Wells mine near Auraria there is a slightly schistose quartz-diorite, which probably came from a dike.

In spite of the schistose structure of the rock, weathering in some cases has produced rounded forms which are analogous to the domes of the Sierra Nevada, although on a very small scale. Instances of such rounding occur in the Yahoolah and the Barlow mines, and seem to indicate that schistose deformation was locally unaccompanied by even blind joints. Had it been otherwise the rock could not have behaved to the weather like a homogeneous mass.

The average strike of the schists is about N. 30° E. and the average dip about 40° eastward. In the Auraria end of the district the strike and dip are pretty constant, or vary slowly, but at Dahlonega the variation is great and sudden, so that it is difficult to arrive at any proper mean values.

The gangue minerals in the gold quartz are usually pyrite and more rarely chalcopyrite. In the Findley mine mispickel, galena, and calcite make their appearance. Muscovite is sometimes to be seen in the ore, for example at the Barlow, where also there is siderite in the veins. Shepard in 1859 first described a remarkable mineral locality on the Chestatee River under the name of the Field mine, which, so nearly as I can ascertain, is the same place on that river referred to by Prof. H. Credner in 1867, though he gives no name to the property. I was not aware of the existence of this deposit at the time of my visit to the region. The authorities referred to found in the gold-bearing quartz allanite, apatite, chlorite, garnet, ilmenite, pyrrhotite, and tetradymite.

In the Lockhart mine a considerable amount of garnet exists in the quartz veins. Some of this, which seemed quite free from quartz, was kindly assayed for me by Mr. Arthur Weld, superintendent of the Hand and Barlow properties. It carried no less than $10.74 per ton. On the Whim Hill property near Auraria the schist contains much garnet in well-developed crystals. Some of these of the size of nuts were also assayed by Mr. Weld, and they too were found to be auriferous, although no quartz seams appeared near them in the schist. Gold-bearing garnets have long been known in the district, though the fact has not been published, so far as I can ascertain. Professor Hanna, of Charlotte, N. C., and Mr. Adolph Thies, of the Haile mine, possess specimens of garnets from this district showing free gold. It appears, therefore, that when garnet-bearing schists are found near gold veins it is worth while to assay them.

In the Singleton mine, near the quartz veins, there is a vein of milky quartz carrying tourmaline. It is said to be barren. On the Whim Hill property there is also similar tourmaline-bearing quartz, which Mr. Weld found gold-bearing by assay.

The original deposits in this district are almost without exception stringer leads, for the most part conformable to the schistose cleavages, but not following them accurately. Spurs of quartz diverging into the country rock are frequent, and included fragments of schist are not uncommon. They are of precisely the same type as those studied at the Franklin. The wall rocks also, as at the Franklin, are often rich for a few inches from the quartz stringers.

On manuscript maps of the district belts of ore-bearing ground are sometimes shown at tolerably regular distances apart and extending for miles through the country. Assertions are also made that these belts can be identified by the character of the ores. I could see no evidence of such remarkable continuity. On the contrary, it seemed to me that this part of the Georgian gold belt may be likened to a magnified stringer lead, an aggregation of lenticular, ore-bearing masses, which, considered singly, die out in strike and are replaced to the east or west by other similar bodies. Nevertheless, it seemed to me probable that two lines across the strike and a mile from each other would intercept about the same number of auriferous masses.

The ore seems to occur more plentifully in the gneisses than in the dark dioritic schists, which also appear to be tougher than the gneiss and less subject to fissuring.

A considerable number of small faults are to be seen on the stringers in the district, and all of those observed were normal. They do not appear to have taken place after the deposition, but during the preliminary dislocation of the rock. The quartz has been deposited in interstitial spaces or in the more or less porous wall rock, and no trace of substitution was found.

The saprolites are of variable depths, reaching, it would seem, at least 100 feet in the Preacher mine. One portion of the rotten rock is distinguished as "brickbat," from its red color, and this is usually found to be barren. It appears to answer to the dark ferromagnesian schist. The saprolites show numerous quartz veins, mostly not over 2 or 3 inches in thickness. In some cases there is little or no quartz; for example, at the Hedwig property, near Auraria, although the mass assays over $2 per ton. As remarked elsewhere, I suppose in such cases that the quartz veins were minute and that they have been resolved into other minerals by solutions. It is now well known that limonite may be substituted for quartz and that large bodies of that iron ore may be formed in this way.

At the Singleton mine there are stream-bed gravels overlain by blue clay containing fragments of wood and cones. The slack water indicated by the clay deposits, judging from these plant remains, is referable to the last well-marked subsidence of the coast, answering to the Columbia formation.

On the Chestatee River is the Chestatee claim, where, at the time of my visit, preparations were being made to turn the channel and work the river bed. At this property are often found pebbles of a heavy mineral which the miners call "hovas," a word of origin unknown to me. This material is an impure corundum and should be worth saving. Being of great density, it is naturally found with gold in the gravels.

About 5 miles east of Dahlonega, on the Chestatee River, is a newly opened pyrite mine. The ore carries some chalcopyrite and, it is said, a trace of gold. I was informed that within a few hundred feet of this deposit there are intercalated stringers from which some hundreds of dollars' worth of gold have been obtained. Pyrite is reported to have been found on the strike of this body at intervals for some miles. The ore bodies are most likely flat lenses. The gneissoid schists at this mine strike N. 47° E., in fair accord with the whole region, but they dip to the northwestward at about 65°. I have discussed such anomalies under the head of Structure.

A vast amount of the saprolite ores remains to be worked in this district. This material can be handled very cheaply by hydraulicking the mass, sluicing to the mill, and crushing the quartz fragments. The coarse free gold is recovered from the sluices and a large part of the gold in the quartz is caught on the battery plates, but in the ordinary practice an immense proportion of the entire contents passes off with the tailings. Careful investigations by Mr. Arthur Weld show that this method saves only about 25 per cent of the gold, or even less. This gentleman is engaged in intelligent efforts to improve the method and has met with considerable success. It would appear that the rustiness of the gold must be overcome either by more friction, as, for example, in amalgamation pans, or by chemical means. Unless means can be devised of getting at least half the gold, surface mining in this region must, in my opinion, remain an unimportant industry, but I do not believe the problems involved at all beyond the reach of good metallurgical engineers.

The Loud mine, about 14 miles northwest of Dahlonega, is noted for its coarse gold, which is of unusually low grade, running about eight hundred thousandths fine. While some of the gold obtained here is smooth and waterworn, other specimens are very rough, and several masses of wire gold have been found. The deposit consists in part of stream gravel and in part of saprolites, which explains the various forms of the gold. The schists here are of the usual character, strike, and dip. The quartz stringers also bear the usual relations to the rock. Several light-colored, coarse granite dikes of unmistakable nature are to be seen in the open cuts.

Near the beautiful Nacoochee Valley the rocks are gneisses, mica-schists, and hornblendic schists, with numerous granitic dikes, a few fine-grained and gray, but for the most part light-colored and coarse. The schists in which gold has been found strike about N. 30° E., and dip steeply to the northwest, but to the eastward of Yonah Peak, a gneissic monadnock, they dip easterly. Work on a small scale was in progress on two properties at the time of my visit. At the Lumsden tributers were following up small veins in the saprolite. The exposures showed the usual stringer leads of the Georgian belt, but not developed in great force. Much of the schist carries garnet, and the garnets are auriferous, as I was informed by Mr. Lumsden. I cleaned, crushed, and panned a few ounces of these garnets and obtained many small grains of gold.

The property of the Yonah Land and Mining Company lies along Dukes Creek. It contains many acres of stream gravel lying about due north of Yonah Peak. The lower portion of this deposit consists of water-worn gravel, which is in part covered by blue clay. In this are found numerous semicarbonized fragments of wood and cones similar to those noted at the Singleton mine in Dahlonega. The material overlying the clay is the ordinary angular and subangular detrital gravel of the region. In past times much gold has been obtained from this deposit, and it is known that care was taken to work the richest ground. Whether much of the remainder will pay a considerable profit can be determined only by experiment. The same company has exposed a number of veins by cross-cut trenches at points on the south side of Dukes Creek, 2 to 3 miles in an air line from Nacoochee. Some of these veins are 18 or 20 inches in thickness; some of them are intercalated in the schist, while others cut it at low angles. There is no question in my mind that all of them are of the same origin and age, it being a mere accident whether the fissures follow or cut across the schistose planes of the rock. These larger veins were not sufficiently exposed to enable one to pronounce upon their continuity, but in the same rock were many lenticular stringers. This and the characteristics of the whole Georgian belt lead me to believe that the individual seams will be found to be flat lenses grouped in stringer leads. The assays are encouraging, being from about $4 to $20 per ton. With good management and the Thies process it would seem that some of this ground should pay fairly well.

Two miles south of Nacoochee an asbestus-like mineral is being mined. This, on chemical examination, proves to be fibrous serpentine, or chrysotile. The exposure was not such as to make it possible to determine the origin of this serpentine; it may have been a pyroxenic bleb, such as has been described in the South Mountain district of North Carolina.

Close to Burton is a property called Smith's mine. There are several quartz veins on it from 18 inches to 4 feet in width. They seem to strike between 30° and 40° east of north and to dip very steeply to the northwest in conformity with the schistose surfaces. They are so slightly exposed as barely to be visible. It is asserted that some fifty years ago a vein was followed in the saprolite and much gold found. There are certainly remnants of an old tunnel. Considerable cuts have been excavated in the saprolite, which shows the usual stringers of quartz. The Moore Girls' mine, 12 miles northwest of Clayton, on Persimmon Creek, is a trifling excavation exposing heavy blocks of quartz so slightly that it is not even certain whether they are in place. The quartz sometimes shows pyrite and chalcopyrite, and a little gold is said to have been obtained.

The Boilston mine, in Henderson County, N. C., is on the strike of the Georgian belt, far to the northward of the others. It lies in the easterly flank of a ridge to the west of Boilston Creek, and about 10 miles northeast of Brevard. Several veins are reported to exist on this ridge, of which one only has been worked to any extent. The country rocks on the Boilston claim are micaceous and hornblendic schists, which strike about N. 30° E. and dip to the eastward. There is also a heavy dike of granite running nearly parallel with the veins at a short distance from them. It is some yards in width, and is traceable for several thousand feet. The Boilston property shows two veins, one of which reaches 20 feet in width at certain points. It is on this vein that most of the work has been done, but in spite of the great amount of quartz, mining was unprofitable, the pay streak in the vein being narrow. This vein strikes nearly with the country rock, but dips steeply to the westward, cutting the slates. The quartz has taken a mold of the fractured edges of the slate and at first sight looks schistose, but more careful examination shows that it is fairly solid and includes thoroughly schistose masses of the country rock. Some openings have been made on the second vein, which gradually approaches the first toward the northeast. The granite dike referred to above lies between the two veins and comes almost in contact with the lower one at what is known as the Baring shaft. It can hardly be doubted in this case that the dike and the veins are genetically connected.

The gneiss here is probably Archæan, but there are also sedimentary rocks in the district, some of them carrying auriferous quartz stringers, as is mentioned in the section on rocks.

Considering the Georgian belt from an economical standpoint, it appears to me probable that the stringer leads below water level may be worked at Dahlonega and Nacoochee as well as at Creighton at a fair profit, provided that operations are conducted under vigorous and economical management; but I see no prospects of sensational returns. The present method of working the saprolites is very wasteful and yields insignificant returns. If means can be found to save the rusty gold much money may be made.

DESCRIPTIVE NOTES ON THE SOUTH MOUNTAIN MINING DISTRICT, NORTH CAROLINA.

This district extends from near Morganton to near Rutherfordton, and from the South Mountains to the west-northwest, a distance of 10 or 12 miles.

The area is peneplained, the average elevation of the surface being approximately 1,300 feet, but its height increases from the northeast toward the southwest. This peneplain seems to answer to the Tertiary baselevel of Messrs. Hayes and Campbell.[1] It is somewhat dissected in consequence of its elevation and contortion, but not sufficiently to afford good facilities for hydraulic mining on a large scale; in other words, there is a lack of fall and dumping ground. It is possible that there is a second peneplain some 500 or 600 feet above that mentioned. The contour map of the region gives some indications of such an one, but none was observed, and indeed could hardly have been detected from the level of the mines.

The region is undulating and covered with timber, mostly of second

[1] Nat. Geog. Mag., vol. 6, 1894, p. 63.

growth. It is fairly well watered, though there are few points at which a supply sufficient for hydraulic mining can be obtained.

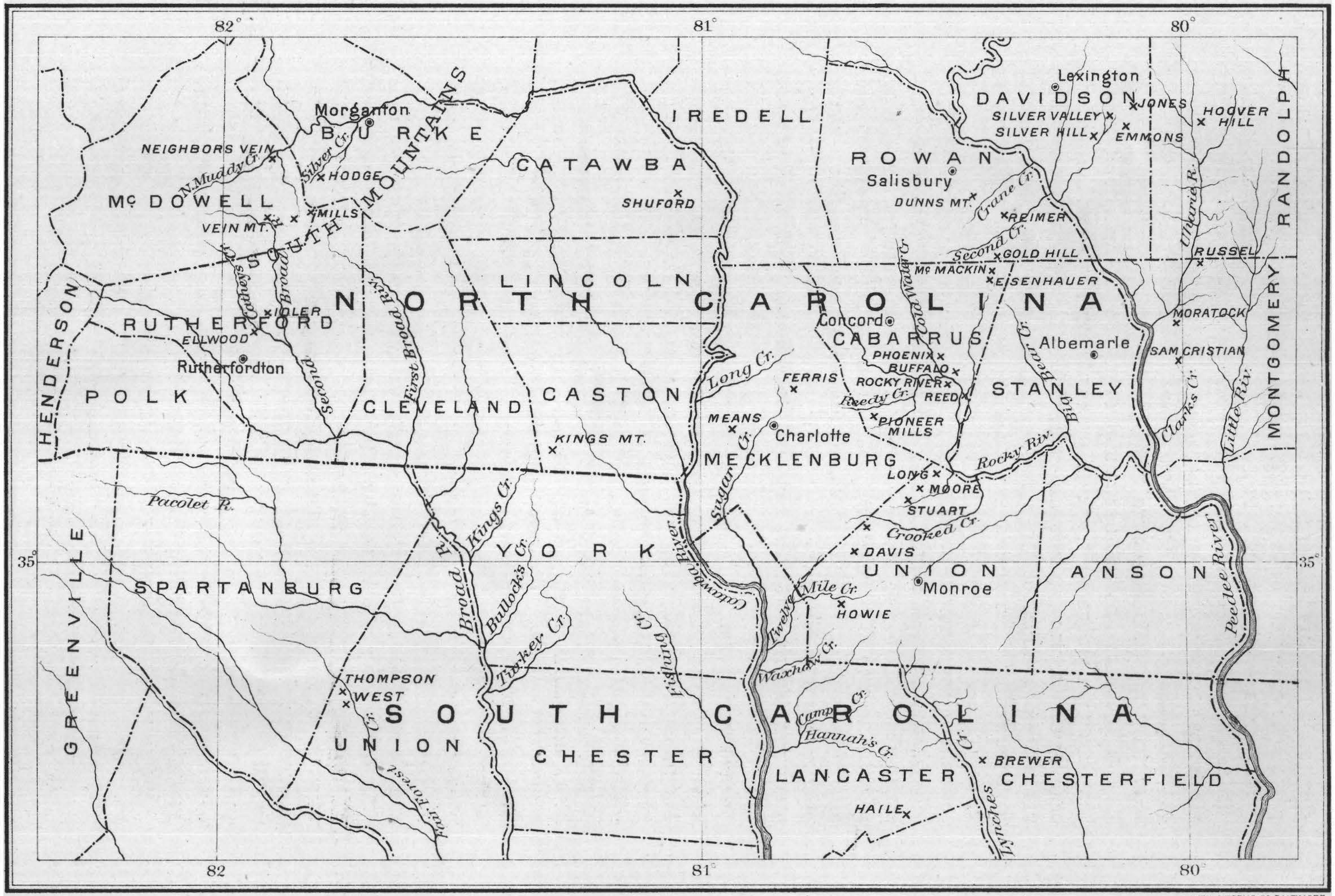
The surface rocks are decomposed, and almost everywhere to a considerable depth. Perhaps 50 feet would be a fair estimate of the thickness of the rotten layer, for which I have suggested the name saprolite, and it is only occasionally that local erosion has laid bare fresh rocks fit for microscopical study.

Gold was discovered in the district in the bed of Brindle Creek in 1828, and the search for it has been prosecuted with more or less energy and success ever since. It is said to be impossible to estimate the product with any approach to accuracy. Much gold was coined into Bechtler dollars[1] and much is supposed to have been exported in crude form.

So far as I can ascertain, only the placer deposits have been worked with much system or energy. There has been much work done in a small way on little veins in the saprolite, but since the war chiefly by men and women working singly or in small gangs, the pan being the main means of separation. Occasionally these people strike a small pocket with from $5 to $100 in it. For the rest they subsist on trifling quantities of gold and great hopes. It is said that an average of from 60 to 70 cents per day could be made by an industrious and skillful independent miner. The women, beginning in childhood, develop great acumen in selecting ore, and become very expert in panning it. Mining on the larger veins has been attempted to some extent, and a good many shafts have been sunk to about 100 feet. The ore from some of these mines looks good, and is said to assay extremely well, $15 or $20 being often asserted as an average, and much higher values being sometimes given. I am not able to verify these statements. None of the mines were producing anything worth mention at the time of my visit, and the ore in place was almost altogether inaccessible, so that no representative samples could be obtained. It would have been of no use to sample the specimens or trifling ore dumps which were to be seen. There is no question at all that fine specimens are found, and assays at the United States assay office at Charlotte show ores running above $60 per ton. On the other hand, the ores could be mined and reduced for $3 per ton, or thereabout, and it seems incredible that veins of 18 inches or more in width, *averaging* $10 or over, should be allowed to remain idle. From an economic standpoint it seems to me that the veins should be prospected with local capital. If reasonable quantities of ore with an average content of $10 can be put "in sight," i. e., exposed on three or four sides, there can be no doubt that capital from commercial centers will be forthcoming.

The main country rock of the district consists of schistose gneiss, in part micaceous and in part hornblendic; it often contains augite, and plagioclase frequently predominates over potash feldspars. Microcline

[1] This curious coinage is referred to early in this report in treating of the statistics of the region.



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MAP SHOWING THE SOUTH MOUNTAIN AREA AND A PART OF THE CAROLINIAN BELT.

SCALE 20 MILES = 1 INCH.

is abundant in some specimens. In the more hornblendic varieties quartz is sometimes nearly or quite absent. At many points in the region, for example, on the elevation a mile easterly from Capt. J. C. Mills's (whose house is indicated on the Morganton sheet), near the Marion Bullion mine, and elsewhere there are dark blebs in the gneiss. These are often flattened in the direction of the schistosity. It is evident that they offered greater resistance to dynamic action than the mass of the rock, and the schistose laminæ are often curved at the contact, more or less like the grain of wood near a knot. These blebs are in some cases highly and in some exclusively pyroxenic, and in other instances hornblendic. They seem altogether similar to the blebs common in most granite regions. Similar or analogous blebs occur also in andesites. The largest bleb seen is about half a mile easterly from the Marion Bullion or Brackett mine. It is about 100 feet in diameter. They resist decomposition somewhat better than the gneiss, and when found in the saprolite are considered "bowlders" by the mining population. They do decompose, however, in some cases to serpentine and in others to talc. There appears to be true lenticular pegmatite of local origin in the region, and Captain Mills has found tourmaline and beryl in them. There are also coarse dikes of granite, such as are often called pegmatite, the margins being much finer grained than the central portion. Such a dike, cutting one of the veins which has been worked on the Marion Bullion property, strikes north and south, and is said to throw the eastern portion of the vein 4 feet southward. At the Vein Mountain mine also a series of such dikes is observable in the saprolite. They strike N. 50° W. and dip easterly about 70°. Two of them occur a couple of feet apart and have faulted the gneiss normally, one throw being a foot and the other 9 inches. In the same neighborhood there is still another similar dike, striking N. 20° E. One dike of gray fine-grained granite was also observed crossing the road about half a mile south of Captain Mills's house. It strikes N. 23° W. and dips 80° NE. The connection of the dikes with the ore deposits is not direct or close; nevertheless, for reasons stated under the head of Structure, it is believed that their intrusion was coeval with the ore deposition and a result of the same general set of causes.

A very remarkable feature of this region is the fact that the ore-bearing veins, large and small, an almost countless number, are parallel, and strike N. 60° to 70° E., dipping to the northwest at angles of 70 or 80 degrees. According to Mr. Nitze, who has studied this district in much more detail than I have done, this rule prevails throughout, and among the many veins which I have seen no exceptions are found. This regularity is the more remarkable inasmuch as the fissures were produced in a region which had already acquired pronounced schistosity during some earlier era of disturbance. The cleavage of the gneissoid schists is much less regular than at most points in the Southern States. In the region surrounding the South Mountain district the usual strike is that of the Appalachain chain, and the dip is easterly. On the flanks of the South Mountain the schistose cleavages strike on the average N. 20° W., dipping at various angles to the northeast, and there appears to be some local cause of confusion. In the western portion of the district the strike is more nearly northeast, with a southeasterly dip, but the dip of the surfaces varies greatly and is often nearly flat. Thus the forces which opened the fissures now filled with ore acted upon a highly eolotropic mass. In this connection the reader may be reminded of the conglomerates which have been sliced up by joints; for example, the Carboniferous pudding stones of Newport Island.

As most of the veins are exposed only in the saprolite, it is impossible to study the faulting on them satisfactorily. One small vein on the Mills property was noticed, with a normal fault of an inch, and two of the small veins at the Marion Bullion are faulted, one 3 inches and one one-half inch, both normal. Since the veins manifestly form a system, and since on any system of parallel fissures the direction of faulting is uniform, these three cases may be taken as indicative of the movement of the entire district.

Faults such as these would be produced by a force acting in a vertical plane which strikes N. 20° W. and directed southward at an angle of about 50° to the horizon.

In the South Mountain district there appear to be no real veins intercalated in the slate, though there are some local segregations of glassy quartz in this position. The term "segregated vein" is sometimes applied to veins coinciding in direction with the structure of the country (whether this structure is bedding or schistosity); "true" vein being reserved for veins which cross the structure. It makes little difference what things are called, provided that the names given are not misleading, as they are in this case. Local segregations of ore-bearing gangue minerals really exist, although, in my experience, they are neither common nor important. If the term "segregated vein" is to be employed at all it should be confined to those. A true vein should be understood to be filling of a true fissure, i. e., a crack or split made in rock previously continuous. Whether this crack follows or crosses the structure is of little moment.

In the distribution of the veins in the South Mountain region there seems, from such information as I possess, to be a certain rhythm, which is suggestive and may prove of some importance. Veins of relatively large size usually occur at considerable horizontal intervals, while between the larger veins small ones are interspersed, often in very close proximity to one another. The most northerly of the large veins of which I have notes is on what is known as the Neighbor's property, on the waters of Muddy Creek, some 5 miles slightly west of north from Dysortville. At this locality there are three veins. The most northerly is sometimes called the Forney vein and is 18 inches wide, the strike being normal as far as known. Further south, at a distance of 1,200 feet, is the Neighbor's vein, 20 inches wide; its strike is N. 65° E., and the dip is 75° NW. Again to the south 500 feet is a smaller vein, 8 inches to 10 inches wide. Some miles further southwest the veins of the Vein Mountain Mining Company occur. The principal deposit here is called the Nichols vein. It strikes N. 70° E., and varies somewhat in width from 5 inches up to 3 feet, according to the statements made by the superintendent, and in part verified by observation. The average is said to be about 18 inches. Nearly on the strike of this vein is one of about the same width, one-third of a mile south of Brindletown post-office. Five or 6 miles farther south occur the veins of the Idler mine, the principal one of which is about 17 or 18 inches wide, and not far off are the veins of the Ellwood property of a similar width. Thus there appear to be three groups of strong veins at distances of several miles apart. The multiplicity of small veins is very great. For instance, on the Vein Mountain property 33 small veins have been counted in a strip of country only a quarter of a mile wide, and there is reason to believe that this large number falls short of the fact. On the Mills property, too, small veins often occur at intervals of 20 feet or less. It is to be presumed, I think, that the larger veins have in general been more thrown than the smaller ones; for if a fissure were faulted only an inch it is altogether improbable that protuberances would be brought in contact in such a way as to wedge the crack open a foot. Hence it is probable that in the rupture of the country there was a fluctuation in the intensity of the dislocating forces, which is marked by the larger veins. It is evidently much more probable that this fluctuation is rhythmical than that it is wholly without rule. In the flexure of rocks recurrent maxima may often be observed, and such cases are visible in the South Mountain district.

The filling of the veins of the district seems to present nothing unusual. The quartz is sometimes glassy, sometimes milky, and often of that intermediate appearance known among Western miners as "lively." It is in this last variety that gold is most abundant. The quartz is often saccharoidal, a mass of loosely adherent, imperfect crystals, and such quartz is frequently more than usually rich. In a great majority of cases auriferous quartz is streaked with sulphurets or their decomposition products, and of course the oxydized ores yield their gold more readily than those in which the sulphides are fresh. The accompanying minerals are usually pyrite and chalcopyrite, with occasional manganese oxide. Galena and zinc blende are also met with in some of the deposits. Above water level the sulphides are rarely fresh, and the good quartz is there rusty and cellular. I looked in vain for any evidence or replacement of country rock by ore. There seem to be no rounded angles or enlarged fissures, and in one case, at the Marion Bullion mine, a small "horse" in the vein was observed, which retained its angularity most perfectly. It was evident that if the quartz had been removed the walls and the horse could have been brought together so as to fill the space completely.

The placer deposits are of two varieties. In a majority of cases the ground washed is simply saprolite intersected by small, more or less disintegrated quartz seams, and capped by 3 or 4 feet of stony soil which has lost the rock structure by the action of vegetation and frost. Doubtless this surface layer commonly represents the residuum of a thicker layer of rock, the more soluble portions having been removed by rain and vegetable assimilation. Such placers are very conveniently worked when water can be brought to them. At a lower level, along the rivulets—or "branches" as they are called in this part of the world—there are also true secondary gravel deposits, which have been worked wherever practicable. Even in these cases the material has not been moved to any great distance, and most of the fragments are subangular. The richest portions, as is usual in alluvial deposits, are in the lower parts of the coarser streaks of gravel. Many of the placers would undoubtedly pay well if it were practicable to "pipe" them on a moderately large scale. It is said that on the Vein Mountain property the opportunity for the application of the hydraulic process is good.

The sands of the South Mountain district contain many rare minerals, whose detection is due largely to Mr. W. E. Hidden. The more important of them have been enumerated in the systematic discussion of placers.

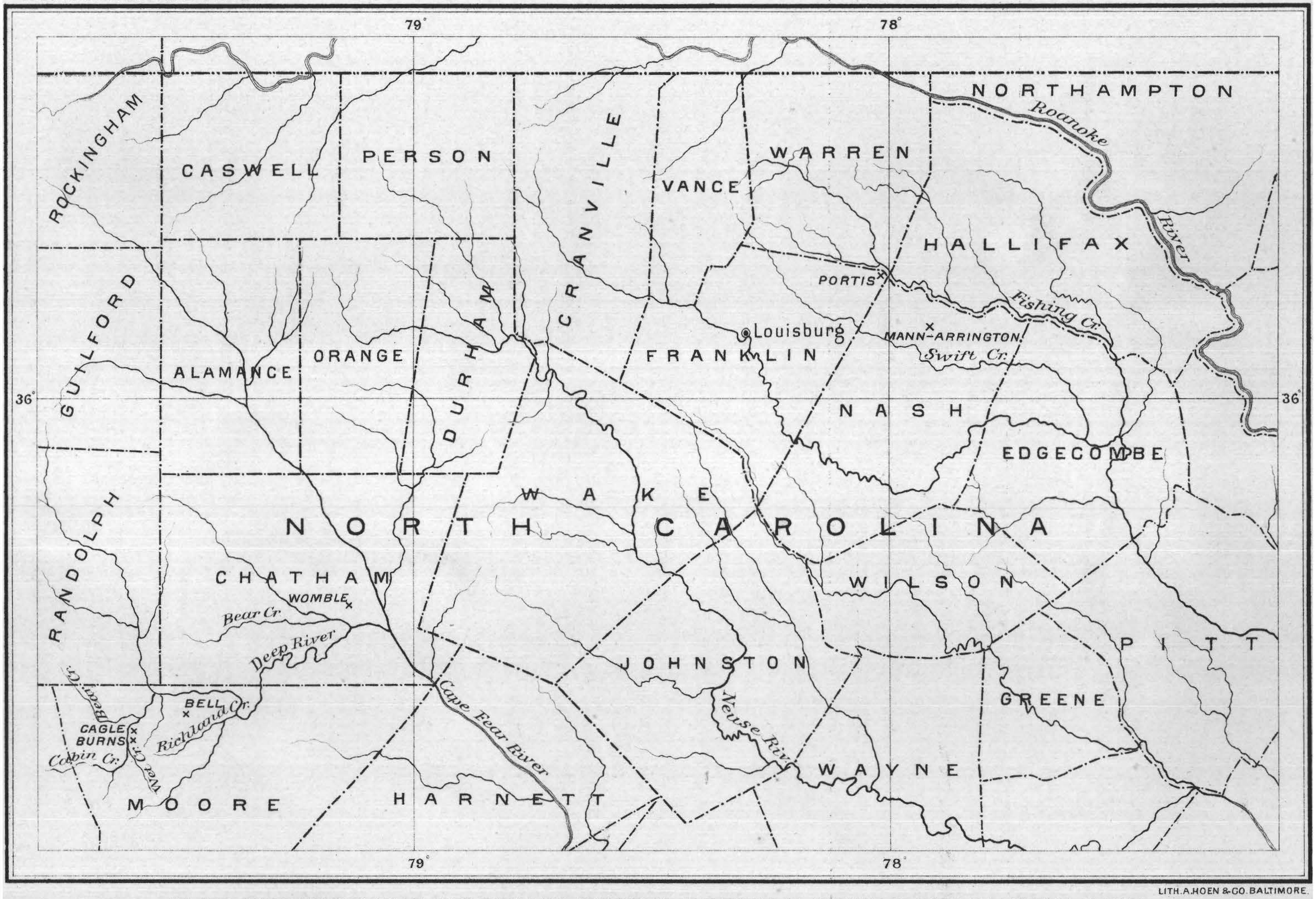
The preceding notes are extremely unsatisfactory. The only mines in the district at which any work is being done are the Hancock placer and the Marion Bullion, and little is to be seen at either. The Golden Valley is a placer which has produced gold, but is not now being worked, and I was told on good authority that there is nothing of interest to be seen there. There are many other points at which gold has been obtained in the region, but the localities mentioned are believed to be the only ones at which there has been any notable production.

More information on this district will appear in a paper by Mr. Nitze, in the Second Biennial Report of the Survey of North Carolina.

DESCRIPTIVE NOTES ON THE CAROLINIAN BELT.

Much the most important mine on the Carolinian belt is the Haile, in Lancaster County, S. C. It is extensively developed; it represents a geological type unknown in the other areas dealt with in this paper, and it is the only mine in the South which has for a considerable number of years past paid dividends. The characteristic ore of this deposit is impregnated rock, a fact which lends additional interest to the fissure system through which the impregnation has taken place.

The country rock at the Haile is for the most part more or less siliceous muscovite-schist (ordinarily spoken of as talcose schist), the schistosity striking on the average N. 50° E. and dipping 70° to the northwest. The mass of schists is intersected by a number of diabase



MAP SHOWING THE NORTHEASTERN PORTION OF THE CAROLINIAN BELT.

SCALE 20 MILES = 1 INCH.

dikes striking and dipping at various angles. At least a portion of the country rock is of volcanic origin, containing original crystals of labradorite and quartz grains now showing undulous extinctions in polarized light. Flow structure is still visible in the ground mass, and one of the quartzes contains an inclusion which seems to be glass. The slides show a large amount of muscovite in minute scales. These characteristics are visible in spite of the schistosity of the mass, and it is manifest that the eruptions antedate the period at which the country was converted into schist. This fact, together with the frequent recurrence of similar rocks from here to the South Mountain of Pennsylvania, where they are known to be pre-Cambrian, points to the Algonkian as the age of the Haile schists.

The "amount of shear" in these rocks is small, for when prismatic cleavage is found the cross sections of the prisms are very nearly rectangular. The development of schistosity was attended by the corrugation of the schists, the corrugations pitching downward steeply to the northeastward. Such is also the pitch of the ore bodies. The schists have been dislocated, this dislocation being marked by incised grooves on the schistose swales or corrugations. These grooves are finely shown in a stope between the 160 and the 200 foot level at the Cross workings. The grooves dip at an angle of only 15° and the slope downward to the southwest They indicate a dislocation with a very large horizontal component tending to bring into opposition the corrugations of the schist and to form open spaces.

The foregoing notes on structure are similar to those made at the Franklin mine in the Georgian belt, yet the results are very different. While at the Georgian mine the ore is substantially confined to the fissures, only a few inches of wall rock being impregnated, at the Haile the great mass of the ore is impregnated rock, and one might almost overlook the quartz stringers. Nevertheless, the latter exist, and indeed in lenticular form and in stringer leads though these are poorly defined. These relations make it substantially certain to my mind that impregnation has gone on in the Haile through a fissure system analogous to the fissure system of the Franklin, but that in the Carolinian mine the nature of the wall rock lent itself to more complete impregnation. It might be asked whether the composition of the ore-bearing solutions was not the determining cause of impregnation, but the character of the actual ore seems opposed to this hypothesis. The ore consists of quartz, pyrite, and gold, almost without other minerals, and the solution would seem to have been unusually simple. At other mines of the same type in the Carolinian belt there is chalcopyrite, indicating solutions indistinguishable from those which deposited ore at the Franklin. On the other hand, glassy volcanic rocks are often porous and always chemically unstable, so that there is good reason to believe that they would lend themselves to impregnation with more ease than gneissic schists.

The impregnation of the rock was attended by deposition of pyrite, usually with quartz, which often forms fibrous fringes attached to the cubes of pyrite. Some of the ores are converted into "hornstone," which, in this case, is quartz recrystallized in fine interlocking particles. Between these grains tiny scales of muscovite are visible with high magnifying powers.

While the ore bodies follow the dip of the schists and the pitch of the corrugations, they are also dependent on the diabase dikes, lying directly against them and being richest close to them. The dikes are decomposed at the contact with the ore, and I observed a little pyrite in the dike rock, but this rock is not appreciably auriferous.

The Haile includes two distinct workings at a distance of about 1,500 feet from each other, known as the Cross mine and the Bequelin mine. The ore is low grade, averaging only about $4.50 per ton, but the mine is worked with energy and economy, and ore sufficient to last several years is kept "in sight." Approximately a third of the output is said to be clear profit. About one-third of the gold is obtained by direct amalgamation; the remainder is extracted by the chloridation process as modified by the superintendent, Mr. Adolph Thies.

The Brewer mine in Chesterfield County, like the Haile, was worked very soon after the discovery of gold in South Carolina, and, as has been mentioned before, 100 or 200 men were employed there in 1830 to 1831. At the time of my visit, however, it had recently been shut down and there was no one on the ground from whom any valuable information was to be obtained. The property showed an old shallow placer of no special interest excepting that it afforded an opportunity to take the dip and strike of the somewhat confused schists, and an enormous pit something like 150 feet in depth, the walls of which are composed of highly silicified rocks. Some of this disintegrates to excessively fine white sand. A portion of the rock near the bottom of the pit is evidently brecciated. Under the microscope it appears that porphyries were present and that the hornstone is identical with that of the Haile mine. There seem also to be recent secretions of hydrous silica, such as are often observed in volcanic masses, and decomposition, possibly solfataric, extends to the bottom of the great pit. Mr. Thies informs me that near the pit there is a diabase dike.

The Brewer is famous for rare minerals, the list of which may easily be compiled from the table of gangue minerals presented earlier in this paper. The association of cassiterite with gold in this mine is peculiarly noteworthy, and may indicate the presence of now unrecognizable greisen.

The West and the Thompson mines are close together, some 3 miles in a southerly direction from Glen Springs, Union County, S. C. The rocks are micaceous and hornblendic schists similar to those of the Georgian belt, but the dip of the cleavage is steep northwesterly. Between the mines and Glen Springs, however, southeasterly dips appear. In the cuts it is evident that the quartz is deposited in what are called in this report stringer leads, in all respects analogous to those of the Georgian belt. The Thompson was being worked on a small scale at the time of my visit, the system employed being the so-called Dahlonega method of combined hydraulicking and milling.

The Kings Mountain mine, Gaston County, N. C., is a very peculiar deposit. It is said by Mr. Hanna to have yielded some $900,000, and at the time of my visit it was just being reopened under the superintendence of Mr. John A. Church. The country rock of the lower part of this mine is limestone. This seems to be a lens embedded, to some extent at least, in schists. Toward the surface it is wholly covered in by micaceous schists striking about N. 50° E. and dipping 70° to the northwest. It is said by the old miners that a granite dike occurs in an inaccessible portion of the mine, but I was not able to verify the report. A couple of miles from this mine there is a tin deposit in granitic rocks, so that the existence of such a dike would be anything but surprising.

The greater part of the gold was obtained in the upper portion of the mine where the walls were schist. There are no tolerable exposures of such ore remaining, but in recent trenches enough can be seen to show that the quartz was intercalated in stringers. The brown ore of the upper workings was probably saprolite filled with decomposed auriferous pyrite, forming selvedges to the quartz stringers. The mass at the contact with the limestone was extremely rich. The ore bodies in the limestone, which is schistose, are very noteworthy. They form lenses within the rock, striking at an angle of only 30° east of north, with a pitch to the northeast, and three such lenses are known to exist. They are mixtures of limestone, in part silicified, and quartz stringers. Graphite also makes its appearance at some points on the hanging wall. The ore contains free gold, in part in the limestone, some fluorite, biotite, pyrite, and pyrrhotite, chalcopyrite, mispickel, galena, zinc blende, tetrahedrite, and the rare minerals nagyagite, bismite, and bismutite. In such an association one might expect to find the gold heavily alloyed, but this is not the case, the fineness being reported at 0.929 by Devereaux in 1881. As a curiosity it may be noted that at one point in the mine a blue, jelly-like slime pours slowly down the walls, the blue color being due to copper sulphate. Chrysocolla occurs at an old shaft a few hundred feet from the main shaft.

I have little doubt that the peculiarities in structure are chiefly due to the presence of the limestone. But for this mass the deposit would probably have been a mere stringer lead and perhaps fewer minerals would have been precipitated. The mine will be well worthy of extended study when it is thoroughly reopened.

In the neighborhood of Charlotte, N. C., there are many points at which gold has been found, and from the prevalence of dikes in this district it is probable that there have been very interesting exposures.

With one or two exceptions, however, the mines (or prospects) are abandoned and there is no opportunity to make inspections. So far as could be ascertained from specimens and from dump heaps, all the deposits, such as the Means, Arlington, and Wilson, are stringer leads. At the Ferris mine, 5 miles northeast of Charlotte, a little work was going on. This deposit is a stringer lead striking N. 25° E. and dipping 70° to the northwest. The rocks are gneissoid schists and a granite dike, which cuts off the lead. This dike contains fragments of schist and is penetrated by stringers of quartz. The ore contains pyrite and a little chalcopyrite. The development is as yet very slight.

In the neighborhood of Monroe, N. C., there is a group of mines at no great distance from the Haile and Brewer and sharing some of their peculiarities. The Davis, Phifer, Lewis, and Hemby mines are on one belt of rocks 9 miles northwest of Monroe and 2½ miles west of south from Indian Trail. A map showing them is given in Messrs. Kerr and Hanna's Ores of North Carolina. They are all closed. The country rock is mica-schist, striking N. 20° to 40° E. and dipping westward almost vertically. The ores show pyrite, and Kerr and Hanna report some galena. The gold at the Davis is of remarkably low grade and has been known to run as low as 450 thousandths in the presence of galena. The interest of these deposits consists in the fact that they show a commingling of stringer leads and impregnations. So far as the open cuts and dumps enabled me to judge, it seemed to depend upon the character of the rock which form the deposits took, the fissure system being the same in either case. No dikes were seen, but in a field near the Phifer there are numerous large and small fragments of diabase, probably from some dike in the immediate vicinity.

The Bonny Bell and Howie mines are 9 miles west-southwest from Monroe. A portion of the rocks here are sedimentary slates, the schistosity cutting the bedding. There is also some gneissoid rock at the Bonny Bell, and some of the schist is garnetiferous. The schists strike about N. 55° E. and dip 80° or 85° to the northwest. There are dike rocks on the dumps of each mine, and at the Howie both diorite and ophitic diabase are thus found. It is reported that several such dikes were encountered in the underground workings, now inaccessible, and that they cut the schists. The ores are in part stringer belts and in part impregnations with a variable quantity of silica. In some specimens from these mines flakes of gold appear on the cleavage surfaces of the slate without visible quartz, and the slate is so soft as to be easily cut with a knife. Other ores are completely silicified, like the hornstone ores of the Haile mine. Careful inquiries were made to ascertain whether the siliceous ores were richer or poorer than those in which the silicification was insensible, but the men who had worked the mines were unaware of any difference. As miners are very keen in detecting indications which assist them in selecting ore, it may be assumed that the silicification and the impregnation with gold at these deposits are quasi independent. The ores seen are simple, pyrite being the only sulphide present in sensible quantities; there is some calcite in stringers which may be of later origin than the quartz.

At the Howie there are said to be eight leads within a width of 400 or 500 feet, and the ore is much richer than that at the Haile, large quantities milling on the average $15. The fineness of the gold is reported by Kerr and Hanna as low, between 0.700 and 0.800. Why the Howie is allowed to remain idle I can not say. At the Bonny Bell a small prospecting shaft was being sunk, and a testing mill was in operation.

Near Monroe, as has been mentioned before, a little gold has been obtained from a few weak stringers cutting the Monroe beds. This occurrence is of geological interest, but of no economical importance.

To the northeastward of Indian Trail there are several abandoned mines. Of these the Stuart is of the same type as the Davis and Phifer. The ore at the Moore mine is very peculiar, being characterized by seams, the walls of which are coated with well-crystallized quartz, while the central portion is filled with calcite containing some specks of what is probably siderite. In such veins pyrite and chalcopyrite were observed both in the calcite and in the quartz. The ores also show galena and zinc blende. It was said at this property that the gold obtained came chiefly from the calcite, but no specimens of gold in calcite were to be seen. There are highly decomposed eruptive rocks in the region of these mines.

The Reed, Phœnix, and Rocky River mines lie close together in Cabarrus County. The Reed is famous as the point at which the discovery of gold was made in the South and for the many large nuggets which it has yielded, including the largest found in the United States. This weighed 28 pounds. The Phœnix was for a long time a very prosperous mine and has a peculiar ore. The Rocky River was being worked on a small scale at the time of my visit, but the others have long been closed. At the Reed the rocks are argillaceous slates of westerly dip and a porphyrite. A very large amount of propylitic rock is supposed to belong to this porphyrite, and it is in this decomposed material that most of the quartz stringers seen are embedded. As nearly as could be judged, the contact of the porphyrite and the schist conformed to the schistose surfaces. The stringers in the porphyrite have the same general direction. Many details of this mine in earlier days are to be found in the literature. At the Phœnix not even the strike of the schists could be ascertained at the time of my visit. Most of the country rock on the dumps is a porphyrite containing both hornblende and augite. I was told that nearly all of the ore occurred in this igneous rock. The ore consists of quartz associated with a great deal of barite, siderite, and calcite, carrying iron and copper pyrites. Three or four hundred yards to the eastward of the main shaft there is a highly cupriferous vein, said to be very rich in gold, which has not been worked on account of the metallurgical difficulties involved. At the Rocky River mine the rocks exposed are muscovite-schists striking N. 20° to 30° E., and dipping 80° to the northwest. A slide of the rock seems to indicate derivation from a porphyrite. The deposits are stringer leads, and those stringers which do not conform to the schistosity almost all pitch more steeply than the cleavages. These also show regular walls. One flat stringer was found showing greatly broken walls, and these relations point to normal faulting, as explained in the section on Structure. The quartzose ore carries iron and copper pyrite and a good deal of galena and some calcite. Barite was reported by the superintendent, but not identified by me. An abandoned shaft called the Buffalo is rear the Rocky River and appears similar to it in character.

The dumps of the Pioneer Mills mine, Cabarrus County, which has not been worked since the war, are mainly interesting because they are almost wholly composed of porphyrite, in part propylitic. This rock varies rapidly in texture from coarse to aphanitic. Close by a somewhat schistose, fine-grained, microclinic granite is exposed by the roadside.

The Shuford mine, Catawba County, is more than 30 miles west of Salisbury and might be considered as altogether outside of the Carolinian belt. It is in saprolite and is said to have yielded as much as $100,000. When worked with the pan, by following up pay streaks, it yielded a profit. The attempt to work it by the hydraulic process was a failure, mainly, it seems, because the water had to be pumped—in fact, the mine is at the highest point in the neighborhood. The deposits are small veins which strike about N. 70° E., while the schists, though very irregular, trend on the average at about N. 35° E. Both schists and veins are nearly vertical. There is some intercalated quartz in the schists, but this is said to carry no gold. The veins here are too small to be worked on a considerable scale excepting by the hydraulic process.

The Reimer mine, 6 miles southeast of Salisbury, is open. The rock varies greatly in texture and is much decomposed. It appears under the microscope that the quartzes are in some cases penetrated by muscovite, as if undergoing resolution into silicates. The vein is of variable width, said to average 3½ feet, striking N. 75° W. It is nearly solid quartz, but contains some horse matter. There are also stringers of quartz in the walls. The quartz carries iron and copper sulphurets and is said to average $7 per ton, the clean sulphurets running up to $35 or $40. At the time of my visit preparations were making to treat the ore by the Thies chloridation process.

The Gold Hill mine is at the town of Gold Hill, and is not in operation. The wall rocks are argillaceous slate, not impregnated, so far as could be told from the dumps. The deposits appear to have been stringer leads in this material. The leads strike N. 30° E. and dip 70° to the northwest. Ore chimneys in them are said to pitch about 45° to the southwest. There are three principal leads, 18 inches to 3 feet in width, at intervals of 300 and 400 feet apart. They are crossed by a diabase dike some 15 feet in width striking to the west of north. The ore contains copper, but no lead or zinc, it is said, and about half of the gold is free. This mine has been more extensively developed than any other in North Carolina.

The Sam Christian is 12 miles east of Albemarle. The property is a large one, but the principal workings are at the "big cut" and at "dry hollow." These are in saprolite. In the big cut, however, a shaft has been sunk on a small quartz vein which strikes 70° W. of N. and dips 60° NE. Evidently such a vein cuts the schistose structure of the country at a large angle. The schists close to the shaft strike N. 20° E., and dip 30° to the NW. The dip is not constant in this region, however, and between the mine and Albemarle the schists were observed dipping alternately eastward and westward. Much of the rock at the mine is clearly sedimentary and shows well-marked bedding, with which the schistose cleavage coincides only in places. These bedded rocks are believed on lithological grounds to belong to the Monroe slates. The shaft, however, is sunk in a somewhat brecciated mass of ancient porphyrite containing quartz and labradorite. This rock is considerably dynamometamorphosed and the ferromagnesian silicates are gone. A part of this material is reduced to hornstone. At the time of my visit I was unfortunately unaware that there is a locality of Emmons's paleotrochis on this property.

The Moratock is an open quarry in volcanic rock 6 miles north of the Sam Christian. It has been sufficiently described in the section on veins and impregnations. This mine, together with the Sam Christian and the Russell, lies along a range of low hills called the Uharie Mountains, and the Hoover Hill lies in the northerly continuation of the same range. It is probable that ancient volcanics enter largely into the composition of these hills, which have not been studied in detail, and which may represent a very ancient range of mountains.

The Russell shows two large open cuts in slate which is in part distinctly bedded and undoubtedly sedimentary. The ore consists of impregnations, with no well-defined fissure system exposed, although stringers of quartz are sometimes visible and calcite accompanies the pyrite in some cases. Under the microscope it is seen that the pyrite is often accompanied by fringes of fibrous quartz microlites, such as were observed at the Haile. The groundmass is made up chiefly of very fine quartz grains, probably accompanied by some feldspar. There are diabase dikes within a mile of the workings, but I saw none at the mine itself.

The Hoover Hill mine, in Randolph County, is 15 miles due north of the Russell. From the dumps it would seem that the quartz formed reticulations in a shattered mass of porphyry. Messrs. Kerr and Hanna describe the deposits as persistent belts of rock abounding in seams of quartz, the distribution of rich ore in the belts being somewhat pockety. The rock is a quartz-porphyrite, seemingly in part tuffaceous; the ferromagnesian silicates have disappeared, excepting some muscovite. At a distance of 200 or 300 yards southeast of the main shaft, at another working, a pyroxene-porphyrite occurs, probably as a dike. It seems to me that the form of this deposit depends largely on the physical condition of the rock, which is not thoroughly schistose. Had it been so, the deposits would have been developed as the stringer leads, so frequent in the State. Some hornstone occurs here, and pyrite, the only sulphuret observed, is found to some extent in the rock, as well as in the quartz.

There is a group of mines in Davidson County, a few miles west of Hoover Hill, where similar rocks appear. At the Jones the rock is very schistose, and the exposures show it in a decomposed state. It seems, however, to have been the same porphyrite met at Hoover Hill. The schists dip deeply to the northwest, so far as I saw them, but E. Emmons mentions them as dipping steeply to the southeast. The rock is charged with sulphurets, and it is said to carry about $2 per ton. Under the favorable topographic conditions of the deposit such ore should pay. The sulphurets themselves are said to go as high as $22.

At the Parish mine there is nothing to be seen. The remarkable actinolite ore has been commented upon in the section on Gangue Minerals.

The Silver Hill, Silver Valley, and Emmons mines, in Davidson County, might be classed as gold, silver, lead, or zinc mines, but as the ores carried up to $10 per ton in gold they are included in this report. The Silver Hill has been more extensively worked than any other mine in the State, excepting the Gold Hill, and many particulars are given in Messrs. Kerr and Hanna's Ores of North Carolina. At the time of my visit all of these mines were abandoned. So far as could be ascertained on the ground, the deposits conform to the general structure of the country, striking to the east of north some 30° and dipping westerly at about 45°. The country rocks are slates, accompanied by eruptives similar to those of Hoover Hill. The eruptive material is highly decomposed and in part schistose, but appears to have been a porphyrite. It is associated with hornstone, such as has so often been mentioned in the description of the Carolinian belt, and at the Silver Hill by a considerable amount of actinolite, such as was found at the Parish, but no gold was seen in this fibrous hornblende. The eruptive rock and the slate both show sulphurets, and quartzose ore was found in direct contact with the porphyry. At the Silver Valley there is a considerable amount of hornstone, and in it sulphurets are distributed on seams which look like shrinkage cracks. The deposits appear to have been closely analogous to stringer leads, but less regularly lenticular than such leads in thoroughly schistose masses. The most abundant sulphuret in these ores was zinc blende, followed in quantity by galena, and the well-known difficulty of treating this mixture is partly responsible for the closure of the mine. Besides the sulphurets, the stringers carry nearly black chlorite in masses as large as a nut. Mention of other minerals will be found in the table of gangue minerals. Excepting argentite, they are all minerals which might occur in ordinary gold veins carrying trifling quantities of galena and zinc blende.

Why so much lead and zinc should have been deposited at this group of mines is a very important question, to which no answer can now be given. One is accustomed to expect these sulphides in auriferous regions where limestone makes its appearance, but only as a matter of experience for which no distinct reason can be assigned. In this locality, however, there is no known occurrence of limestone. Mining geology is still for the most part in the descriptive stage, and there are few of its phenomena for which sound reasons can be given.

The Burns, Cagle, and Bell mines form a small group in Moore County, well to the east of the Uharie Range and a few miles northwest of Carthage. The Burns shows only open cuts on a belt of auriferous muscovite-schist, which is sometimes much injected with quartz stringers and sometimes not. Sulphurets appear only in portions of the gold-bearing ground, and specimens were seen in which the gold appeared isolated in the schist. The ore is said to contain tellurides, but I saw none. The schists strike N. 20° E. and dip 55° to the northwest. The Cagle is an abandoned mine opened on schists similar to those at the Burns. The deposit was evidently a stringer lead, and a small amount of hornstone was found on the dumps. The Bell mine also is abandoned, and it was difficult to ascertain even the nature of the ore. The material in the ore bin was garnet-schist, which looks like a metamorphosed igneous rock and shows plagioclase under the microscope. According to Messrs. Kerr and Hanna, the ore was a belt of schist silicified and enriched along seams of from one-eighth of an inch to 4 inches in width, forming together a body 4 feet wide and assaying over $12 per ton on the average. At a shaft on this mine the flexure of schists by surface expansion is finely shown. The dip of the schists at the surface is about 45° to the southeastward, or uphill, while at a depth of about 8 feet the dip is 75° to the northwest. The curved laminæ are continuous from the surface of the rock, and the maximum curvature is at about 1 foot beneath the top of the slates. The slates at this point are covered only by a few inches of soil.

The Womble lies about 3 miles northwest of Moncure, in Chatham County. The interest of this excavation lies in the fact that it is in unmistakable Newark (or Juratrias) conglomerate, and that the matrix of this conglomerate is auriferous. The rock forms a portion of an extensive belt of the Newark, which is usually a red sandstone, but at this point contains pebbles as large as a man's head. The pebbles are quartz, granite, schists, and porphyrite; but, excepting the quartz, all of them are decomposed. The pit may measure 100 cubic yards, and offers irreproachable exposures on its sides. I took material from below overhanging banks and from between the large pebbles, and on panning it I found grains of gold. Of course, this result shows that gold deposition preceded the Juratrias. Just to the north of the Womble there is a mass of porphyrite similar to that of Hoover Hill.

The Portis mine is at Ransom's Bridge, 18 miles east-northeast of Louisburg, and the Mann-Arrington is some 5 miles farther eastward. They are both in an Archean area surrounded by Tertiary deposits and scarcely belong to the Carolinian belt. The schists here strike N. 50° to 60° E., but they dip to the southeastward at angles of 25° to 40°, instead of westward, as is the case with most of the schists on the Carolinian belt. Both mines are idle. The Mann-Arrington dumps show masses of diorite or dioritic gneiss and schists, and the deposit appears to have been a stringer lead of the ordinary type. Both the quartz and the wall rock showed sulphurets. The Portis mine, now called the Sturgis, is a saprolite working, and many nuggets have been found there. Most of the work has been done with nozzles. There seem to be two reticulated veins here. One of them strikes nearly east and west, dipping 25° to the southward. The other is nearly flat and is said to be very extensive. I have met with nothing resembling these reticulated veins elsewhere in the Southern Appalachians, and can only regret that the exposures were too small for satisfactory study. There is a float diabase at this mine, but no dikes were found in place.

In the Carolinian belt the impregnations seem on the whole more valuable than the stringer leads, for they are of greater width. They will be found in all probability along the areas of ancient volcanic rocks, which should therefore be mapped in detail. These impregnations can be cheaply mined, because they are large, and there is little doubt that with prudent management some of them would pay fair returns on invested capital.

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REVIEW OF THE GOLD FIELDS OF THE BRITISH MARITIME PROVINCES AND THE GREEN MOUNTAINS.

The analogies between the geology of the northern Atlantic Coast and that of the southern Atlantic States are very close. These analogies extend to the gold deposits, and for that reason a digest is here presented of the published investigations on the occurrence of gold in the eastern British possessions. Much the most important of these are in Nova Scotia, but gold has been detected in Newfoundland, New Brunswick, and Quebec, and to a small extent in the northern New England States.

In reading discussions of the age of the older rocks of the maritime provinces it is necessary to bear in mind that the term "Cambrian" is used in different senses by geologists. The United States Geological Survey has adopted the lowest Olenellus beds as the base of the Cambrian, and includes the precedent clastic series in the Algonkian. The Canadian geologists, as a rule, include in the Cambrian two groups lying below the Olenellus beds—the Animikie and the Keweenawan. Thus the lowest Cambrian of the Canadian survey is often Algonkian in the nomenclature of this Survey. In Europe, also, the usage of Cambrian has varied greatly, but in the third edition of his Geology Sir Archibald Geikie adopts the delimitation employed in the United States.

Gold was discovered in Newfoundland near Brigus, on Conception Bay, in 1880, in a group of rocks regarded by Dr. A. Murray as next beneath the St. Johns slates.[1] These latter are supposed to represent the close of the Algonkian, and the gold-bearing series is included in the same division by Professor Van Hise.[2] The rocks are "greenish, fine-grained felsite slates" of which the cleavage coincides with the bedding. The strike of the beds is almost exactly north and south (true), with a westerly dip at 45°. Joints intersect the beds, striking about northeast. This is also the strike of the belt of quartz deposits, although a large part of the veins, taken singly, follow the bedding. Smaller veins cross the beds in every direction. The pre-Cambrian rocks of the Avalon peninsula are cut in the most intricate manner by both acid and basic eruptives. It is a noteworthy fact that these eruptives do not seem to penetrate the Cambrian of the same region, for the fossiliferous Cambrian beds throughout the Atlantic Coast are remarkably free from contemporaneous intrusions.

Chlorite is frequent in the auriferous veins of Newfoundland, which also show pyrite, galena, and copper, probably as chalcopyrite.[3]

There has been no gold production in Newfoundland, and the above notes are set down only to illustrate the geological occurrence of the

[1] Geol. Surv. of Newf., 1880.
[2] Bull. U. S. Geol. Surv. No. 86, 1892, p. 251.
[3] The report says small crystals of sulphate of copper. The word sulphate is doubtless a misprint.

metal to the north before entering upon the discussion of the more interesting mines of Nova Scotia.

The Nova Scotia gold mines are distributed over an area extending along the southeast coast of the peninsula for about 40 miles southwest of Halifax, and about 100 miles to the northeast of that town. This area attains a maximum width of somewhat over 30 miles measured to the northwestward from the coast.[1] The zone thus indicated is purely geographical, the lines of structure running east and west, as will be noted below.

The main gold-bearing series of Nova Scotia was regarded as probably Lower Silurian by most writers up to 1870,[2] when Dr. A. R. C. Selwyn called attention to the resemblance between them and the Cambrian of Great Britain.[3] Since that time most writers have agreed in referring these rocks provisionally to the Cambrian.[4] Dr. Alexander Murray, however, compared them to the auriferous rocks of Newfoundland which underlie the Algonkian-Cambrian unconformability, and also underlie the Aspidella or St. Johns slates,[5] which appear to close the Algonkian. This resemblance is denied by Sir William Dawson,[6] but is regarded with approval by Mr. Walcott.

Almost the only trace of life in these rocks consists in obscure markings discovered by Dr. Selwyn and determined as Eophyton.[7] These objects are considered inorganic by Mr. Faribault,[8] but Sir William Dawson[9] thought them trails of animals, and Professor Van Hise regards them as evidences of life.[10]

So far as direct evidence goes, it appears that the gold-bearing rocks of Nova Scotia might be anywhere between the base of the Algonkian and the top of the Lower Silurian. The general facies of the rocks, however, is not such as to suggest the Silurian. Mr. Walcott has pointed out to me that if they are Cambrian the absence of fossils is remarkable, since in Newfoundland and New England the Cambrian is

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[1] The positions of the more important mines are given on the map accompanying Sir William Dawson's Acadian Geology, 2d ed., 1868. In the supplement to this work, 1878, some corrections are made. The blue tint indicating Upper Silurian is to be interpreted as including Lower Silurian, and the purple tint used for Lower Silurian is to be interpreted as Cambrian.

The gold product of Nova Scotia is given by districts in the annual report of the Geological Survey of Canada, 1890-91, paper ss., p. 137, from the discovery to 1891, inclusive. The total product is over $10,000,000 and the average yield of the ore per ton of 2,000 pounds has been $14.

[2] Dr. J. W. (Sir William) Dawson, Acadian Geology, 2d edition, 1868, p. 614. Prof. H. Y. Hind, on a gneissoid series underlying the gold-bearing rocks of Novia Scotia, Halifax, 1870, p. 8. Dr. T. S. Hunt, in Geol. Nat. Hist. Surv. Canada, Report on the gold region of Novia Scotia, 1868, p. 7, etc.

[3] Geol. Nat. Hist. Surv. Canada, Report of Progress 1870–71, p. 269.

[4] Sir William Dawson, Supplement to Acadian Geology, 1870, p. 81, and Quart. Jour. Geol. Soc. London, vol. 44, 1888, p. 804.

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E. R. Faribault, Geol. Nat. Hist. Surv. Canada, Ann. Rept., vol. 2, 1886, paper P, p. 129.

[5] Geol. Surv. of Newfoundland, Rept. for 1880.

[6] Quart. Jour. Geol. Soc., London, vol. 44, 1888, p. 805.

[7] Geol. Nat. Hist. Surv. Canada., Ann. Rept., 1870–71, p. 269.

[8] Loc. cit., p. 144.

[9] Suppl. to Acadian Geology, 1878, p. 82.

[10] Loc. cit., p. 503.

well supplied with organic remains, even when not apparently better suited to the preservation of organic forms than the beds in question. He has suggested their reference to the Algonkian,[1] and this classification is held to be more probable than any other by Professor Van Hise, who, in his map, has colored the area in which these rocks occur "Algonkian?".

Besides the main series of quartzites and slates which are noted above there is a very interesting and important occurrence of auriferous conglomerate of Lower Carboniferous age at Corbitt's Mills, 4 miles north of Gay's River, Colchester County. If this is a "fossil" placer deposit, it shows of course that the gold of the country, or at least a part of it, is older than the Carboniferous. It is reported by Sir William Dawson that in this locality the slates belong to the "gold-bearing formation, and contain small but rich auriferous quartz veins. The conglomerate is formed of the debris of these older rocks, and gold occurs in it exactly as in modern auriferous gravels, being found in the lower part of the conglomerate, and also in hollows and crevices of the underlying slate."[2] This deposit has been worked, and, "as in most gravels, the richest part of the deposit seems to be near the bed rock."[3] Mr. H. S. Poole reports that "the gold is not very fine and pieces of over a pennyweight are only occasionally found." "In the 'runs' or hollows of the slate the bed rock is removed to a depth of 3 or 4 feet for the gold contained in the backs or crevices of the slate."[4] In view of these statements there seems no reason to surmise that the gold is younger than the conglomerate.

In Cape Breton, also, gold is reported as existing in a Carboniferous conglomerate, but the occurrence has not, I believe, been described in detail.[5]

The Acadian series of Dawson, which carries most of the gold veins, is divided into a lower quartzitic group 11,000 feet thick, and an upper graphitic group 4,000 feet thick. The quartzitic rock is called "whin" by the miners, and some authors speak of it as sandstone. It is generally micaceous, and is said sometimes to become gneissic in the vicinity of granite. Slate bands are frequently intercalated in it, and these bands are more numerous near the middle of the group than elsewhere. The black slate is separated from the quartzite by a few layers of greenish slate. This group shows andalusite, staurolite, and garnet near granite contacts.[6] Mr. Fletcher describes the slates of the auriferous series as greenish and light gray, chloritic and micaceous, pearly and soapy, striped.[7] Hunt commented on the great rarity of calcareous rocks or minerals in the gold region.[8]

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[1] Bull. U. S. Geol. Surv. No. 81, 1891, p. 262.
[2] Acadian Geology 2d ed., 1868, p. 277.
[3] Supplement to the same, 1878, p. 96.
[4] Quart. Jour. Geol. Soc., London, vol. 36, 1880, p. 313.
[5] H. Y. Hind, Rept. on the Sherbrooke Gold District, etc., Halifax, 1870, p. 50.
[6] Faribault, loc. cit., p. 146.
[7] Geol. Nat. Hist. Surv. Canada, Ann. Rept. 1890–91, p. 97 P.
[8] Gold Region of Nova Scotia, 1868, p. 9.

Ancient igneous rocks of acid and basic types are abundant in Nova Scotia, but the ages of those which are of special interest here are not definitely determined. Eruptive material is particularly abundant in the Cobequid group, which adjoins the gold fields. This group is regarded as Lower Silurian by Sir William Dawson,[1] as Cambro-Silurian by Mr. Fletcher,[2] and as pre-Cambrian by Professor Van Hise.[3] During this period the area of Nova Scotia, says Sir William, "was the theater of extensive and long-continued volcanic ejections producing a series of rocks * * * in some respects resembling * * * those of the regions of Quebec and the United States lying east of the great Appalachian line of disturbance." Mr. Fletcher also describes dikes cutting the Devonian and the Carboniferous, and some of these are perhaps contemporaneous with the strata which they cut, but it appears that there was no repetition of the extreme volcanic activity of the earlier period. In the Triassic, however, great masses of diabase were poured out—for example, at Cape Blomidon.[4]

The intrusives more immediately associated with the gold deposits are described as chiefly granite, diorite, and intrusive gneisses. Massifs of granite with aureoles of metamorphism are also frequent. It is reported that toward the *center* of the masses the granite often assumes a porphyritic texture. Small dikes are apt to be finely crystalline, while wide dikes are coarse and irregular, "the feldspar often attaining 2 feet in diameter, while the mica is in large scales forming perfect hexagonal crystals." Hornblende granites are often found.[5]

In connection with the granites of Nova Scotia, I find descriptions of phenomena with which I have never met and which seem to require a detailed investigation. Dr. Selwyn, in comparing the relations of the quartz veins to the granite in Nova Scotia and Australia, says: "In one instance an auriferous quartz vein, which had been worked close up to the boundary of a large granite area, was found to pass gradually, by the addition of feldspar and mica, into granite, losing its auriferous character and becoming a vein of ordinary gray granite exactly resembling the rock of the neighboring granite mass, into which it eventually merged."[6] This strange occurrence was probably in Australia. Mr. Faribault has been good enough to inform me that he knows of no single instance in Nova Scotia to which this description would apply. At Country Harbor and at Cochran's Hill, the only places known to him at which gold veins have been worked close up to the granite, all the evidence tends to prove that the granite cuts off the veins. Mr. Faribault, however, has described pegmatites, or coarse granite dikes, spurs from which, in thinning out, pass over into quartz veins by

[1]Quart. Jour. Geol. Soc. London, vol. 44, 1888, p. 813.
[2]Geol. Nat. Hist. Surv. Canada, Ann. Rept. 1886, paper P, p. 18.
[3]Bull. U. S. Geol. Surv., No. 86, 1892, Pl. V.
[4]Acadian Geology, p. 93.
[5]The granites are described by Mr. E. R. Faribault, Geol. Nat. Hist. Surv. Canada, vol. 2, 1886, p. 131 P.
[6]Geol. Nat. Hist. Surv. Canada, Rept. for 1870-71, p. 265.

the suppression of mica and feldspar.[1] It would be interesting to know whether in slides of such dikes the mica and feldspar would not reappear under the microscope.

Gold-bearing veins are occasionally found in the dikes of crystalline rocks in Nova Scotia.[2] On the other hand, a quartz lead near the west shore of Moose Lake is capped by granite and pierced by small tongues of granite, seeming to indicate that this vein is older than this granite.[3] Sir William Dawson, after reviewing such relations, reaches the conclusion that the granite and the gold veins are "roughly contemporaneous."[4]

Mr. P. S. Hamilton in 1866, being then chief commissioner of mines, reported that "auriferous quartz has been discovered and to a slight extent mined in the trappean headlands of Partridge Island and Cape d'Or."[5] I have not succeeded in finding any other reference to these occurrences, which, if well established, would be of much interest. Dr. Hind and Professor Kennedy, who are intimately acquainted with these traps, are of the opinion that Mr. Hamilton was mistaken and that no gold has ever been found in this diabase.[6]

Prof. O. C. Marsh noted in the auriferous quartz at Tangier pyrite, mispickel often showing free gold, chalcopyrite, galena, magnetite, and hematite. He found the gold 0.9813 fine at this point and 0.9204 at Lunenburg.[7] The younger Silliman found at Tangier, besides the above, marcasite, zinc blende, native copper, malachite, calcite, in part ferriferous, and arseniosiderite. He sought in vain for bismuth or antimony. The gold is most intimately associated with mispickel and zinc blende, often inclosing or penetrating them. The pyrite also is auriferous. Free gold occurs in the adjoining slates as well as in the vein. The slate also carries auriferous mispickel.[8] A specimen from the Britannic mine shows a magnesian and ferruginous calc-spar holding gold.[9]

Prof. Henry Howe notes that argentiferous copper sulphide is sometimes observed in the Nova Scotia gold mines; he mentions native copper at Oldham and elsewhere, and sulphur and chlorite at Uniacke. The sulphide of molybdenum occurs in a quartz vein at Gabarus, Cape Breton, and albite is said to be found in auriferous quartz at Waverly.[10] Stibnite and rarely bismuth are mentioned by Dr. Selwyn, who enumerates also bitter spar and barite as gangue minerals.[11] Mr. H. S. Poole mentions mica and feldspar as gangue minerals, and remarks

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[1] Loc. cit., p. 134.
[2] Selwyn, loc. cit., p. 254.
[3] H. S. Poole, Quart. Jour. Geol. Soc. London, vol. 36, 1880, p. 312.
[4] Suppl. to Acad. Geol., 1878, p. 85.
[5] Trans. Nova Scotia Inst., vol. 1, 1866, part 4, p. 44.
[6] Communicated to me in a letter from Mr. Hugh Fletcher in Jan., 1895.
[7] Am. Jour. Sci., vol. 32, 1861, p. 397.
[8] Report on New York and Nova Scotia Gold Mining Company, 1864, p. 26.
[9] Acadian Geology, 1868, p. 630.
[10] Mineralogy of Nova Scotia, 1868, pp. 39, 61.
[11] Geol. Nat. Hist. Surv. Canada, Report for 1870-71, p. 255.

that gold is sometimes so abundant in the slate that more slate than quartz goes to the mills.[1] Of these minerals stibnite is not known to occur in the gold mines of the Southern States, and mispickel is much more abundant than in the mines of the South.

It has been recognized from the first that quartz veins occur in Nova Scotia cutting across the lamination of the slate, but such veins, although they have proved rich in some cases, are usually barren or too poor to repay working. Mr. P. S. Hamilton in 1866 mentioned cases of rich "crossleads" at the Ovens near Lunenburg Harbor and at Oldham,[2] and Mr. H. Y. Hind states that some of them are very rich though narrow, while others which are broad are poor, though perhaps not too poor to be worked.[3] Nevertheless, it is apparently true that most of the Nova Scotia gold has come from bedded leads.[4]

The character of the quartzose masses which are found between strata has been somewhat discussed. Hunt[5] and Hind[6] held these quartz deposits to be at least in part true sediments contemporaneous with the inclosing rock. Mr. J. Campbell,[7] however, described them as veins following "the planes of bedding in both their strike and dip, except when passing from one plane of bedding to another, which often occurs." Dr. Selwyn reexamined the question in 1870 and came to the conclusion that all of the deposits had been formed since the deposition and consolidation of the adjoining rocks.[8] In 1880 Mr. H. S. Poole again took the subject up and described cases at Tangier in which angular fragments of wall rock are inclosed in the quartz of the bedded leads.[9] Such observations seem to leave no room for doubt.

It has sometimes been maintained that the bed veins were formed at an earlier date than the cross courses. This is Campbell's opinion, founded on the observation that the cross courses sometimes fault the bedded veins.[10] Many of the veins are attended by impregnations in the adjoining walls,[11] consisting of auriferous mispickel and pyrite and scales of free gold, found particularly along the planes of slaty cleavage of the slate.

A frequent form of the deposit is that called "belts of veins" by Dr. Selwyn and "intercalated lodes" by Hind. In these Selwyn says the slate "is often so intimately associated and interlaminated with the

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[1] Quart. Jour. Geol. Soc. London, vol. 36, 1880, p. 310.

[2] Trans. Nova Scotia Inst., vol. 1, 1866, part 4, p. 48.

[3] Rept. on Sherbrooke Gold District, Halifax, 1870, pp. vi and 23.

[4] H. S. Poole, Quart. Jour. Geol. Soc. London, vol. 36, 1880, p. 309.

[5] Geol. Nat. Hist. Surv. Canada, Rept. on Gold Region of Nova Scotia, 1868, p. 9.

[6] Loc. cit.

[7] Rept. of 1862, quoted in A. Heatherington's Guide to the Gold Fields of Nova Scotia, 1868, p. 74. I have not seen the original report, which is rare.

[8] Loc. cit., p. 260.

[9] Quart. Jour. Geol. Soc. London, vol. 36, 1880, p. 310.

[10] Rept. of 1863, p. 7. This observation seems to me insufficient to prove the relative age. The joints may very probably have opened and faulted at the same time with the formation of the vein fissures.

[11] Silliman, Rept. on New York and Nova Scotia Gold Mining Company, 1864, p. 13. P. S. Hamilton, Trans. Nova Scotia Inst., vol. 1, 1866, part 4, p. 51. Selwyn, loc. cit., p. 267. H. S. Poole, loc. cit., p. 310.

bands, layers, and strings of quartz that the whole body of the rock, often for 20 feet in width, is taken out and milled; the gold frequently occurring in films between the slaty laminæ, as well as in the quartz and mispickel." Such belts, he remarks, occur also in Australia. They are found in California, too, and are very abundant in the Southern Appalachians. Selwyn notes that where these belts occur the planes of cleavage and of bedding usually coincide very nearly both in strike and dip and the rocks afford undoubted evidences of great pressure and of motion of one plane upon another, producing fractures and openings. The layers of quartz in these belts are generally thin, from a mere thread to a couple of feet, but probably do not average 12 inches. "They are more or less lenticular, and are sometimes seen to pass obliquely from one plane to another, in such a manner as to preclude the possibility of their having been deposited contemporaneously with the slate."[1] These are the deposits which have been termed stringer leads in the earlier portion of this report, Selwyn's "belt of veins" being rejected as applicable rather to a zone of country, such as the Georgian belt, than to a deposit a few feet in width; while the term "vein" is usually employed for something larger than the elementary seams of a stringer lead.

The corrugated quartz known as "barrel quartz" in Nova Scotia has often been described. The instance most frequently referred to is at Waverley, but in almost all the mining districts modifications of this structure have been discovered.[2] Mr. J. A. Phillips compared the exposures to a corduroy road and to a series of small casks placed side by side and end to end.[3] Mr. Campbell calls it fluted quartz. Silliman says the cross-sections of the veins resemble a chain of long links and that the surface is undulating.[4] Mr. Hind says that the surface often resembles ripple marks.[5] According to Dr. Selwyn the distance between the corrugations, as well as their size, is very irregular.[6] That the barrel quartz is vein quartz is certain from Mr. Poole's observation that at Waverley it includes angular fragments of slate, and sends offshoots and tongues of quartz into the superjacent strata.[7] But though the quartz is younger than the rock the characteristic corrugations or ripple marks are found, according to Hind, in the overlying rock and in the slates remote from the leads.

At Waverley the barrel quartz is found at the summit of an anticlinal and is nearly flat, but at Oldham, according to Hind, a barrel vein dips north at an angle of 60°. The direction of the axes of the

[1] Loc. cit., p. 261.
[2] H. Y. Hind, Rept. on Waverley Gold District, Halifax, 1869, p. 30.
[3] Quoted by Silliman, Am. Jour. Sci., vol. 38, 1864, p. 104.
[4] Rept. on Lake Loon Gold Mining Company, 1864, p. 31.
[5] Loc. cit., p. 23.
[6] Loc. cit., p. 266.
[7] Loc. cit., p. 308.

corrugations seems to coincide with that of the anticlinal axes and of the "grain" of the slate.[1]

The nature of the barrel quartz has been discussed by Dr. Selwyn. He considers the corrugation of the quartz intimately connected with and dependent on the operation of the forces which produced the slaty cleavage, to which he also ascribes the openings between the beds now filled with quartz and the great parallel foldings of the strata. The sharply corrugated veins, he finds, lie in highly cleaved, soft slates. The slaty laminæ in proximity to the quartz conform more or less to the convolutions of the latter, and the beds in which the veins lie afford abundant evidence of great pressure and of motion of one plane on another. The cleavage intersects the stratification at all angles, but is invariably at a higher angle than the bedding.[2]

Mr. J. Campbell was the first to point out some extremely significant features of the occurrence of auriferous veins in Nova Scotia. He perceived that the veins are distributed along east-and-west anticlinal axes, of which he recognized six. The number has since been increased by Mr. Faribault to eleven. Campbell found that the fiber or grain of the slate coincides in direction with that of the anticlinal axes, and that the corrugations in the slate and veins also have this direction. He ascribed the origin of the slaty cleavage to the folding force acting on a plastic mass. He recognized that the veins often pass from one plane of the rock to another, even where there is a general coincidence. These views are substantially those adopted later by Dr. Selwyn.

The descriptions of the veins cited above show that they include fragments of slaty rock and that the veins intersect the schistose cleavage at all angles from 0° to 90°. These facts seem to me wholly incompatible with the hypothesis that the fissures were opened by the same system of forces which produced the schistosity. In the case of well-developed barrel quartz the dislocation which opened the fissures must apparently have been either in the same direction as the movement which produced the cleavage or in a direction exactly opposite to it, but only a portion of the quartz is found in this form. The ordinary irregularly lenticular deposits point to a dislocating force not at right angles to the grain of the slate, and therefore not in the direction of the force to which the cleavage is due.

Unimportant quantities of placer gold have been found at several points in New Brunswick. It has also been met with in veins near St. Stephen, near Woodstock, and 17 miles south of Bathurst. At Nauwigewauk the Lower Carboniferous conglomerates are found to be slightly auriferous.[3]

[1] Selwyn says that the axes of the corrugations coincide with the *strike* of the cleavage (l. c., p. 266). This is no doubt the case where the grain of the slate is horizontal, but Campbell's discussion seems to show that the grain and the anticlinal axes dip to some extent. (Rept. of 1863, p. 2.) In Silliman's description of the Montague lode it appears that the axes of the corrugations must dip at about 45°.

[2] Loc. cit., p. 266.

[3] Geol. Nat. Hist. Surv. Canada, Ann. Rept. 1890–91, p. 146 ss.

The geology of southern New Brunswick, like that of New England, is extremely difficult and complex, and little that is definite seems to have been disentangled. The veins along the St. Croix River on both sides appear to be crystalline schists of great but uncertain age. The gold is found in them in quartz veins very similar to those at other points in the eastern part of the continent. At St. Stephen, on the New Brunswick side of the river, the wall rock of the auriferous veins is graphitic slate. At Baileyville, on the Maine side, the gold-bearing quartz is found in pyritous mica-schist.[1] There are rumors of other occurrences in Maine and New Brunswick, but such as I have met with are so vague as to be of no determinable value.

There are two districts in eastern Quebec known to be auriferous, and both are close to the United States frontier. One of these is the valley of the Chaudière, close to the Maine line and lying along the northerly continuation of the White Mountains. The other is the Little Ditton field, near the northern end of Lake Memphremagog, lying in the northern continuation of the Green Mountains. The rocks of both areas are regarded by the Canadian geologists as Lower Cambrian, and their likeness to those of the auriferous region of Nova Scotia is striking. Mr. Faribault has recently visited Little Ditton for the purpose of comparing the rocks with those of Nova Scotia. He reports that, like all who have examined both localities, he has no doubt that the auriferous rocks are of the same age. They are also lithologically similar, and at Ditton, as in Nova Scotia, the quartz veins accompany the sharp anticlinal axes along which the rocks have been folded.[2] The quartz-bearing rocks were first clearly pronounced Cambrian by Mr. R. W. Ells in 1886.[3] They are not fossiliferous, but are lower than beds determined as Cambro-Silurian, and rest unconformably upon highly metamorphic schists. They consist largely of volcanic agglomerates. This intermixture of volcanic material is not known to exist elsewhere in the Cambrian beds of the Appalachians, and for this reason Mr. Walcott thinks the rocks may be pre-Cambrian.[4] Professor Van Hise also thinks them probably Algonkian.[5] This is in part a matter of nomenclature, as indicated on an earlier page.

The likeness between the auriferous areas of the eastern townships of Quebec and Nova Scotia extends to the quartz veins, which usually follow the bedding, but sometimes cut it.

Very little work has been done on the veins of the region, development being chiefly confined to the gravels. It is interesting to note that a part of these gravels occur in old river channels beneath the present drainage system. The gold is largely coarse, and many nuggets worth from \$50 to \$200 have been found. One nugget from the Chaudière is reported to have weighed no less than 52 ounces 11

[1] Holmes and Hitchcock, 2d Ann. Rept. Geol. Maine, 1862, p. 423.
[2] Geol. Nat. Hist. Surv. Canada, Summary Report for 1891, p. 55.
[3] Geol. Nat. Hist. Surv. Canada, Ann. Rept., part J.
[4] Bull. U. S. Geol. Surv. No. 81, 1891, p. 310.
[5] Bull. U. S. Geol. Surv. No. 86, 1892, p. 501.

pennyweights, and must have been worth about $1,000.[1] A specimen from this river was found to be 0.866 fine. At Leeds, in the Chaudière Valley, to the west of the river, masses of gold of several pennyweights, with copper glance and specular iron, have been found in a vein of bitter spar.[2] A remarkable rock, apparently homogeneous and composed in great part of a white lime-alumina garnet, is found at St. Francis. Its density is about 3.4. Grains of native gold have been observed in it.[3] At St. Francis, on the Chaudière, gold has also been found in a quartz vein with galena, blende, pyrite, and mispickel.[4] The product of the Chaudière region has been very imperfectly recorded. The greatest amount reported to the mining inspector of the district was $56,661 in the year 1881.[5]

Gold has been found all along the Green Mountains in Vermont, mostly to the eastward of the crest and in a belt 10 to 20 miles wide. In nearly all cases the discoveries are of float gold, but they seem to indicate that the rocks of the range are to some extent auriferous at many points.[6] As has been mentioned, the Little Ditton gold field in Quebec is on the northerly continuation of the Green Mountains. Gold has been found in place on this belt in the two neighboring towns of Plymouth and Bridgewater. A second belt extends along the Connecticut River, passing to the westward of the White Mountains, and seems to be in the line of strike of the Chaudière region of Quebec.

The details as to occurrence in the official reports are very meager. At Plymouth gold traverses slate in feathery veins, crossing the laminæ at various angles. At some points not specified it is found in small flattened masses between the laminæ of slate. It is usually found in quartz.[7] Besides the occurrences in talcose schist, gold is found in gneiss at Bridgewater and Danby Mountain.[8] At Bridgewater there are also gold-bearing quartz veins in talcose schist. The veins vary from a few inches to several feet in thickness, and in them are also found sulphides of copper, lead, and zinc, as well as zinc gahnite. The gold of Plymouth in one case was found to be 0.969 fine,[9] and gold amalgam is reported from this locality.[10] Prof. E. Hitchcock also found gold in the porous quartz of a limonite deposit in Somerset.[11]

Prof. C. H. Hitchcock has described as the Ammonoosuc gold field the territory occupied by auriferous slates and schists along the Connecticut River, lying mostly in New Hampshire, but partly in Vermont.

[1] R. W. Ells. Geol. Nat. Hist. Surv. Canada, Ann. Rept. 1888–89, p. 65K.
[2] Geol. of Canada, 1863, p. 519.
[3] Ibid., p. 496.
[4] Ibid., p. 739.
[5] Geol. Nat. Hist. Surv. Canada, Ann. Rept. 1886, p. 33 S.
[6] Geol. Surv. of Vermont., vol. 1, 1861, p. 525. The towns here enumerated form the belt mentioned in the text.
[7] A. D. Hager, Econ. Geol. of Vermont, 1862, p. 120.
[8] Geol. of Vermont, vol. 1, 1861, p. 530.
[9] Ibid., vol. 2, 1861, pp. 844, 845.
[10] Geol. Nat. Hist. Surv. Canada, Rept. of Prog. 1863, p. 518.
[11] Am. Jour. Sci., vol. 22, 1832, p. 64.

He considers that this region extends into Maine, and may be connected with the Chaudière region.

The schistose rocks are supposed to belong to the Huronian and Cambrian systems, and are believed to be of the same age as the talcose schist and gold-bearing formations just east of the Green Mountains. So far as I can see, the reference to the Cambrian of any of the rocks of this district is entirely provisional and rests on vague resemblances.

The Dodge vein in the eastern part of Lyman, N. H., is said to have yielded $50,000 up to the end of 1877. It is a vein of a nearly constant thickness of 16 feet, dipping northeast, with chimneys of pay ore pitching to the northwest. The vein mass consists of quartz, slate fragments, and ankerite, carrying pyrite, galena, and free gold. The pyrite is almost barren. The gold is 0.917 fine. The ore runs from $3 to $19 per ton.

At the Lisbon, near the Dodge, there is also a gold-bearing quartz vein carrying pyrrhotite to the extent of 5 per cent, with some chalcopyrite and mispickel. At the Cook and Brown mine, a mile or more north of these deposits, a quartz vein 10 inches wide shows free gold and a great deal of auriferous mispickel. The wall rock for several feet was found to be auriferous. This vein is reported to have been lost at 30 feet from the surface.[1]

Gold has been found even in New York State, in Dutchess County,[2] and on Manhattan Island. Mr. N. H. Darton informs me that quartz which he assayed from Wassaic, Dutchess County, carried over $2 per ton, and quartz from the northern end of Manhattan Island over $4. The rocks in both cases were mica-schists, supposed to be post-Archean.

The age of the gold deposits of the maritime provinces and the Green Mountains is not definitely determined, but the known facts seem to point to one conclusion. All observers are agreed that the quartz veins bear an intimate genetic relation to the intrusives which accompany them both in Nova Scotia and in Quebec, and that the age of the inclosing rocks is the same in both areas, although no fossils have been found in either. In Nova Scotia it is known that the gold, or most of it, is older than the Carboniferous, so that the choice lies between the earlier Paleozoic eras and the Algonkian or Archean.

Now, the whole of the Paleozoic was a very quiet period over the greater part of the Atlantic slope, the elevation of the Green Mountains at the end of the Lower Silurian being the principal exception, and even at the time of this uplift "no volcanoes were made, and little took place in the way of eruption through fissures."[3] The upheavals of the Paleozoic were of a relatively gentle character, whereas the ore-bearing fissures were formed during a disturbance which shattered the country. No disturbance of equal violence has taken place since

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[1] Ammonoosuc Gold Field, Geol. of New Hampshire, part 5, 1878, p. 7.

[2] Dr. Pohle describes an auriferous quartz vein from the township of Rhinebeck in Amer. Jour. Mining, vol. 6, 1868, p. 370.

[3] Dana's Manual, 1895, p. 326.

the veins were formed, for although renewed movements have in some cases extended joints across the veins, the amount of dislocation they display is trifling compared with that which opened the spaces they occupy.

The Paleozoic is also abundantly supplied with fossils in every considerable known area on the Atlantic slope. Hence, if the Green Mountain gold-bearing district is Paleozoic, it is of a highly exceptional character in three respects, viz, in the presence of volcanic material, in the absence of fossils, and in the occurrence of auriferous quartz veins. On the other hand, the first two of these characteristics are usual in Algonkian areas, and the ascription of the gold-bearing series to this system accords with the phenomena in Newfoundland as well as in the Southern Appalachians. While it seems to me most reasonable, in the present condition of knowledge, to regard these deposits as in the main Algonkian, nothing would be less surprising than the discovery of some minor deposits in the fossiliferous Paleozoic. Indeed, if there is any relation between intrusives and gold deposition, it is hard to understand how a renewal of volcanic activity in a gold-bearing region can fail to be attended by fresh deposits of auriferous quartz.