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DEPOSITS OF BROWN IRON ORES (Brown Hematite) IN WESTERN NORTH CAROLINA

BY
W. S. BAYLEY

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LETTER OF TRANSMITTAL

CHAPEL HILL, N. C., February 3, 1922.

To His Excellency, HON. CAMERON MORRISON,
Governor of North Carolina.

SIR:—I herewith submit for publication as Bulletin No. 31 of the publications of the North Carolina Geological and Economic Survey a report on The Brown Iron Ores of Western North Carolina, which has been prepared by W. S. Bayley, Geologist. This investigation of these iron ores showed that there is a larger quantity of commercial ore than we had realized. This report should be of particular interest to the people of Western North Carolina and all those interested in the development of the iron ores of the State.

Yours respectfully,

JOSEPH HYDE PRATT, *Director,*
North Carolina Geological and Economic Survey.

PREFACE

This report on "The Brown Iron Ores (Brown Hematite Deposits) of Western North Carolina" represents simply part of an investigation of the iron ores of Western North Carolina which has been made by Mr. W. S. Bayley, Geologist, of the University of Illinois. It has been a coöperative investigation between the United States Geological Survey and the North Carolina Geological and Economic Survey, and the results of the investigation will be published as a series of reports, both by the State and Federal Surveys. One part of the investigation on "Magnetic Iron Ores of East Tennessee and Western North Carolina" will be published as a coöperative report between the Tennessee Geological Survey and the North Carolina Geological and Economic Survey.*

The present report describes particularly the brown iron ores of Cherokee and Clay counties, which is the district containing the largest amount of commercial ore. From the results of the investigation it is considered that this district offers a promising field for development of an iron ore industry of some considerable importance.

The deposits in Madison, McDowell, Catawba, Lincoln and Gaston counties are also examined and described, but they are not considered of any great commercial importance at the present time.

The report also gives an estimate of the amount of ore in the several districts.

JOSEPH HYDE PRATT, *Director,*
North Carolina Geological and Economic Survey.

*Has since been published as Bull. No. 32 of the North Carolina Survey and Bull. No. 29 of the Tennessee Survey.

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ILLUSTRATIONS

*Plates II, IV, and VII could not be completed from the original surveys in time to avoid delaying unduly the publication of this paper. It is planned to issue them later as a supplement.

DEPOSITS OF BROWN IRON ORES (BROWN HEMATITE) IN WESTERN NORTH CAROLINA

By W. S. Bayley

INTRODUCTION

For some years North Carolina has been supplying small quantities of brown hematite ore to the furnaces of the South. Between 1917 and 1920 the quantity reported to the U. S. Geological Survey was 126,000 tons. Most of this came from Cherokee County. Formerly a little came from near Asheville in Madison County and from near Bessemer City in Gaston County, but the mines in these counties were abandoned several years ago. There are deposits also in other counties but they have not yet been developed.

The ores occur mainly in the valley between the mountains in the western part of the State and in the Piedmont Plateau region in its central portion. The most important mountain deposits are in Madison and Cherokee counties. Less important ones are in McDowell County. The most important in the Piedmont Plateau are in Catawba, Lincoln and Gaston counties.

Character of the Ores

While it is probable that most of the brown hematites of these regions are limonite and goethite, a few of them may be composed largely of other compounds. They are all hydrated iron oxides, but some of them may contain a greater proportion of water than is usually present in limonite. A few of them have been reported to be turgite.

Limonite is commonly represented by the formula $Fe_4O_3(OH)_6$, but its analyses vary between such wide limits, that the assignment of a definite formula to represent its composition is hazardous. It is often regarded as a colloidal goethite with one or more molecules of water, de-

pending upon temperature. That it is a colloid admits of little doubt. It is never found in crystals, but always in some form that suggests its precipitation from solution. It is often found as stalactites, as globular masses or in forms that imitate the crystals of other minerals, which it has replaced. It is also often found in the shapes of leaves, twigs, etc. In these cases it is said to be a pseudomorph. The original materials have been replaced by the limonite, which has assumed their forms. In no case does it appear to have a shape which is peculiar to itself. Like other gel colloids, limonite possesses the power of absorbing compounds from their solutions, so that the mineral may in fact be a mixture of colloidal iron hydroxide and various other compounds which differ in nature in different occurrences. Limonite is brown on fresh fractures and its powder is yellowish-brown. When earthy it is often yellow, as in the case of "yellow ocher." In cases where its origin is known, the mineral is the result of the decomposition of other iron-bearing compounds by oxygenated water, or is a deposit made by the accumulation of the remains of iron secreting bacteria.[1] The ores in North Carolina have originated in the first way.

The commercial ores are hard, dark-brown, flinty mixtures of goethite and limonite and soft, yellowish-brown, sandy limonites. As furnished in carload lots they are non-Bessemer ores, containing about 45%-52% Fe, 0.25%-1.25% Mn, 0.3%-7% P, and 8%-18% SiO_2. The sulphur content is small, rarely greater than 0.1%. The variations in iron and silica depend mainly upon the care taken in preparing the ore. The variation in the manganese is due to inherent differences in the ore. In a few ores the manganese content is less than 0.25%, on some it is greater than 2.25%, and in a few cases the ore is a low grade manganese ore. The sulphur content is never large enough to be objectionable.

DEPOSITS OF BROWN IRON ORES IN THE MOUNTAIN DISTRICT

Geology of the Ores

Madison, Cherokee and McDowell counties are in the Appalachian mountain division of the Appalachian Province. (See map, fig. 1.) The rocks associated with the ores are Cambrian sediments that have

[1] Harder, E. C., Iron-depositing bacteria and their geologic relations. U. S. Geol. Survey, Prof. Paper 113, 1919.

been metamorphosed to a greater or less extent, depending upon their character, by the great movements that occurred during the Paleozoic Era and culminated soon after the close of the Carboniferous period. As one of the results of these movements the sediments which were once in approximately horizontal beds were crinkled into folds and broken by great faults. The folds are of various magnitudes. They extend in a general northeasterly direction and they are generally overturned to the northwest. Nearly all the dips on the sides of the folds are southeastward, those on their northwest sides being the steeper.

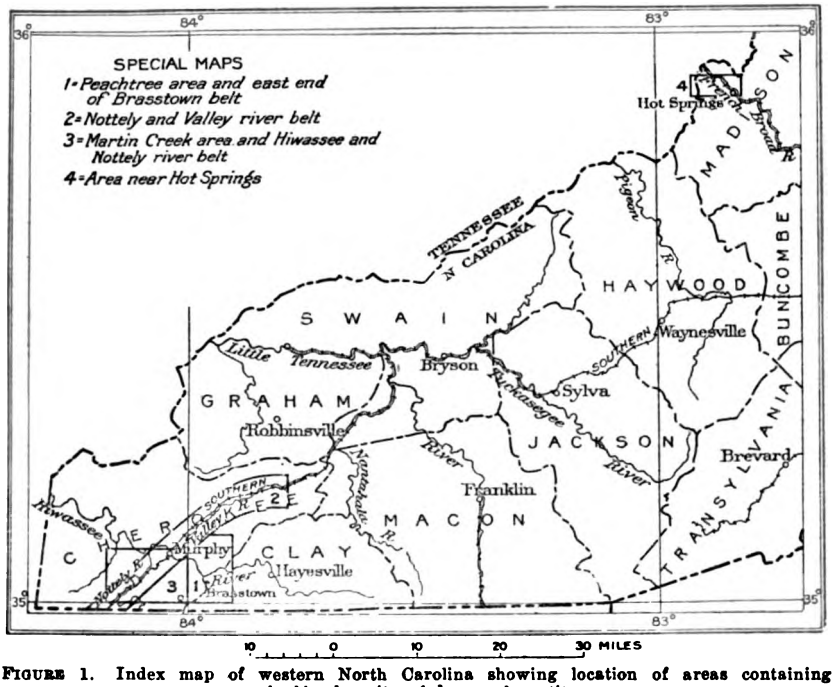


FIGURE 1. Index map of western North Carolina showing location of areas containing valuable deposits of brown hematite.

The faults usually appear on the northwestern sides of the anticlines or southeastern sides of synclines. Nearly all the fault planes dip toward the southeast and their strikes in general are parallel to the axes of the folds.

Besides the folds and faults produced by the compression of the sedimentary beds, the rocks composing these beds were broken by innumerable small cracks, and were changed in composition by the growth of many new minerals. Moreover, these new minerals were produced under conditions that caused them to grow with their long directions

in planes that are approximately at right angles to the direction of greatest pressure. This has resulted in the production of a schistosity, the strike of which is in general parallel to the strikes of the folds and faults and its dip is steep, usually 50° or more.

The sequence of the Cambrian sediments in Cherokee and Madison counties, as worked out by Keith,[1] is indicated in the following table, in which Keith's names are used. In Cherokee County metamorphism has been more pronounced than it has been in Madison County and the present character of most of the formations is different; but there is a general parallelism in them, the differences being only such as might be exhibited by rocks in any two basins separated from one another at recurring intervals or even by different portions of a single basin if differently situated with respect to old shore lines. The names of the several formations and their order of deposition in the two areas are:

TABLE OF CAMBRIAN FORMATIONS IN CHEROKEE AND MADISON COUNTIES

CHEROKEE COUNTY	MADISON COUNTY
	Knox dolomite. Light and dark magnesian limestone with chert.
	Nolichucky shale. Variegated calcareous shales and thin limestone.
Nottely quartzite. White quartzite.	Honaker limestone. Blue and gray limestone. Thin.
	Watauga shale. Purple, red and yellow shales and sandy shale.
Andrews schist. Calcareous ottrelite schist, with iron-ore beds.	Shady limestone. Gray and blue cherty limestone with marble beds near base.
Murphy marble. White and blue marble, with talc.	
Valleytown formation. Graywacke, garnet and ottrelite schist and slate.	Hesse quartzite. Chiefly white quartz.
Brasstown schist. Blue and black ottrelite schist and slate.	Murray slate. Grayish slate and shale with sandy layers.
Tusquitee quartzite. White quartz.	Nebo quartzite. Chiefly white quartz.
Natahala slate. Black slate, with garnet-staurolite schist at base.	Nichols and Nantahala slate. Grayish slate and shale with sandy layers, metamorphosed to mica schist and and ottrelite schist.
Great Smoky conglomerate. Conglomerate, coarse gray sandstone and graywacke, with many beds of black slate and schist.	Cochran and Great Smoky conglomerates. Gray conglomerate with beds of slate, metaporphosed to schists in Great Smoky conglomerate.
Hiwassee slate. Bluish-gray, banded argillaceous slate.	Hiwassee slate. Dark banded slate and schists, with layers of limestone and sandy beds.
	Snowbird formation. Light colored quartzite and sandstone with beds of slate, conglomerate and arkose.

[1] Keith, A., U. S., Geol. Survey Geol. Atlas, Asheville folio (No. 116), 1904 and Nantahala folio (No. 143), 1907.

These lie on a basement of granites, gneisses and crystalline schists that are Algonkian and Archean.

The geology of McDowell County has not yet been studied, but the rocks associated with the ores in this county are similar to those associated with the similar ores in Madison County.

The limonite deposits of greatest value are found in the residual clays of the Andrews schist and Murphy marble or their equivalents, at the contact of the marble and the schists with quartzites, along or near faults separating the limestone or calcareous schists from other formations, and at the contact of quartzites with the Valleytown and Brasstown formations in Cherokee County. The most important are those at the contact of quartzites with the marble or the calcareous schists, and those in faults.

Origin and Age of the Ores

The ores occur in veins and in residual deposits, formed by the breaking down of the rocks containing the vein material. When the rocks containing the veins are weathered much of their material is dissolved and carried away in solution. The insoluble residue consists of sand mingled with fragments of ore that remains as a covering over the undecomposed rocks. Where the underlying rocks were mineralized marble or calcareous Andrews schist the residual mantle is rich in ore fragments, because most of the rock that was originally with the ore has been carried away. In some places the ore fragments in this sandy mixture are so large and so abundant that they are gathered by hand and shipped. In most places they are small. Where sufficiently abundant the soil is washed and the ore thus separated from the sand. Most of the mines are at present obtaining their ore either from this layer of decomposed rock, or from the partly decomposed rocks beneath it.

The vein ore is found only at such places as furnish easy channels for downward traveling water; consequently it is believed that the veins received their ore from above. The source of supply of the ferruginous solutions was the great thickness of rock beds that was formerly above the Cambrian rocks in which the ore now occurs. As these were weathered the ferruginous solutions drained downward, were oxidized and made the deposits by filling the cracks through which they were flowing and replacing their walls by iron hydroxides. Because the ores are oxidized products it is probable that they are confined to shallow depths. They were formed near the surface; consequently they could not have been deposited until the surface had

reached nearly its present position, which was probably later than Tertiary time. It is believed that the greater portion of the filling of the veins was accomplished in Quaternary time.[1]

For the most part the veins follow bedding planes or fault cracks, but the smaller ones may divide and coalesce in an intricate pattern, locally crossing the rock layers, swelling and thinning, and in some places wedging out. Few of the thicker veins consist of pure ore throughout. Most of them are mixtures of iron hydroxides and sand, which in some places occur as thin alternating layers and in others as uniform mixtures. In many deposits the vein material is coarsely porous and the ore lining the openings is mammillary. Mammillary surfaces are also common on the sides of veins (Pl. V), especially those in the bedding planes of the Andrews schist, and in manganiferous ores the portions richest in manganese are the outer layers of the spheroids. Thus the North Carolina ores are like some of those in the Cartersville district of Georgia, which are described by Hayes and Eckel[2] as consisting of geodal shells containing cavities with stalactitic and botryoidal forms, which have glazed surfaces.

The veins are nowhere single. They are almost invariably grouped in stockworks, which have the same general strikes and dips as the rocks with which they are associated. Those in faults may follow the fault planes for short distances, but they feather out into the bedding planes or into joints and other fractures of the faulted rocks and so may possess very irregular shapes.

Nearly all the ore of the veins in the Andrews schist contains sand grains and the remnants of decomposed ottrelite crystals. The calcareous cement of the original rock has been replaced by the iron compounds, leaving only the micaceous decomposition products of the ottrelite and little grains of sand to represent the original schist. Such ore may preserve the schistosity of the replaced rock in the arrangement of the sand and the decomposition products of the ottrelite.

As remarked by Hayes and Eckel,[3] in discussing similar ores in the Cartersville area in Georgia, the ores appear in part to have filled open fissures and in part to have replaced schists. These authors think it probable that the veins in the Cartersville district were formed by solutions ascending from a considerable depth and that the ore may change below the water level into a mixture of iron oxides, sulphides, and perhaps carbonate. In North Carolina there is practically no evi-

[1] For further discussion of the origin of the brown iron ores in this district see: U. S. Bull. 735-F, Geol. Survey, pp. 160-163, 1922.
[2] Hayes, C. W., and Eckel, E. C., Iron Ores of the Cartersville district, Ga., U. S. Geol. Survey Bull. 213, p. 240, 1903.
[3] Op. cit., p. 240.

dence as to the character of the ore below groundwater level. None of the mines have reached to so great a depth. It is certain, however, that the veins were formed after the deformation of the rocks in which they occur, as they exhibit no signs of slickensides or of true schistosity, and it is almost equally certain that they were produced by water percolating downward. They are best developed at the contacts of replaceable rocks with impervious beds and in fault zones and are more abundant above the impervious beds than beneath them. In some places the veins are arranged as if in synclines and thus apparently follow a bed that is more easily replaced than others; but a glance at the maps (Pl. I and figs. 2, 9, 11), will show that they do not occur at any definite horizon. They may be present almost anywhere within the Andrews schist, for the rocks of this formation, because of their porous texture and pronounced schistosity, furnish abundant channels for percolating water. The veins are largest, however, at the contacts of the schists with impervious or nearly impervious beds, because these contacts furnish the best channels for the ore-depositing solutions. In rocks other than the calcareous schists deposits of brown hematite occur only at contacts or in faults.

The explanation of the existence of large deposits in the Andrews schist on the northwest side of the quartzite ridge in the Valley River belt is difficult unless it may be assumed that the foliation planes of the schists near the contact were opened by shearing when the beds were folded and, naturally, thereafter became easy conduits for descending solutions. As the folds are overturned to the northwest, the foliation of the schists and their accompanying veins dip southeasterly under the overlaying quartzite.

DEPOSITS IN MADISON COUNTY

Deposits Near Tennelina

In Madison County the only deposits that have been worked to any considerable extent are mainly limonite lumps and masses in the residual clays of the Shady limestone near Shut-in Creek at Tennelina, 3 to 4½ miles west of Hot Springs. The amount of ore in the clay varies greatly. It is most abundant at the west end of a belt of limestone, where that rock lies in a synclinal basin surrounded by ridges of conglomerate and quartzite. Keith writes (Folio 116, p. 10) "The hematite is most abundant near the contact of the limestone and the underlying quartzite, and is found here and there along the entire contact. The upper portions of the limestone contain very little ore. Its presence

in the lower layers near the quartzite appears to be due to downward concentration into these layers. The limestone itself contains little or no ferruginous material, so that the hematite is probably derived from the quartzite series, in which are found small accumulations of pyrite." The depth of the ore has been tested only by shallow pits. "It is probable that * * * the clays containing the ore are not much more than 30 feet deep."

A map and cross-section of the area showing the relation of the ores to the limestone are given in Figs. 2 and 3. They are taken from Keith's map of the Asheville quadrangle (Folio 116). The section is slightly modified, since Keith's section is east of the points at which the

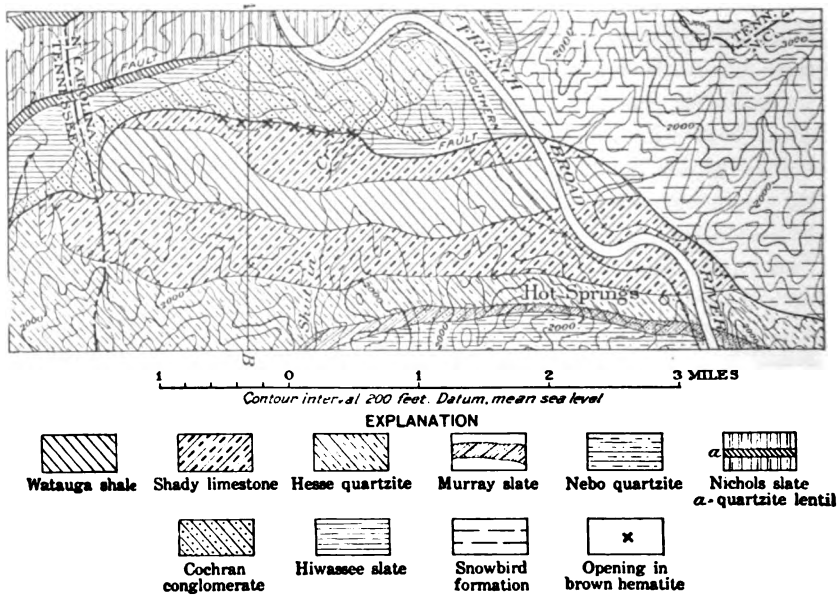


FIGURE 2. Geologic map of area containing deposits of brown hematite at Tennelina, near Hot Springs, N. C. *A-B*, Line of section, figure 3.

ores are best developed. Just west of Shut-in Creek the rocks on the upthrow (north) side of the fault are members of the Cochran conglomerate and not of the Snowbird formation as they are further east where the section was made. The ores are in or near the fault. Here weathering has been excessive because of the ease with which water could travel down the fault zone, and the limestone has been changed to sandy and clayey decomposition products to a greater depth than elsewhere.

The ore occurs nearly everywhere along the north side of the limestone. In some places it forms little streaks in the bedding planes of the

limestone; in other places it occurs as large dense masses in brecciated and massive limestone and clay and in still other places it is in veinlets cutting the limestone and to some extent the neighboring shale and conglomerate. The relations indicate that the ore is a replacement of limestone along joints, small faults and bedding cracks. As erosion proceeded the ore became shattered and scattered through the clay and formed the productive ore-mass that Keith describes.

The source of the iron in these deposits is problematic. It may have come from any one of the formations that have been eroded from above the Cochran conglomerate. Keith apparently ascribes its origin to pyrite in the Hesse quartzite; but after a careful examination of the old openings one can scarcely escape the conviction that some, at least, of the limonite came from the limestone itself.

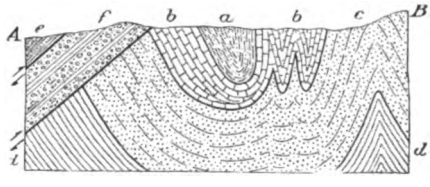


FIGURE 3. Diagrammatic north-south section through area shown in figure 2. *a*, Watauga shale; *b*, Shady limestone; *c*, Hesse quartzite; *d*, Murray slate; *e*, Nichols slate; f, Cochran conglomerate.

The mines, which are situated on or near the fault, form a line extending west from Shut-in Creek for a distance of about 1½ miles. Most of them are open pits that are now so filled with dirt that no rock can be seen in their walls. A few are tunnels in which small exposures are visible. It is said that several hundred cars of ore were shipped to Knoxville and other points when the mines were operated by A. G. Betts in 1917. Most of the ore was wash ore that yielded 1 part of commercial ore to 4 parts of material mined. In some places, however, the ore was hard and massive. In these cases it was hand picked and shipped as lump, yielding a much higher average of ore than 1:4.

The most easterly opening is a tunnel in mixed limestone, chert and other rocks. It is a comparatively small opening on the north side of a little stream, and is about ¼ mile west of the creek. The dips of the rocks penetrated by the tunnel vary from horizontal to 30° N. E. The tunnel opening goes down at an angle of about 75° N.W. following a chert-limonite streak. The strike of the beds, as nearly as could be determined, is 30° S. of W. The material removed consisted of chert, shale, and thin layers of limonite. This was washed.

Mr. John Smith, who made an examination of the district for the North Carolina Geological and Economic Survey when the mines were in operation, reports that "the ore was all worked from open cuts except the last attempt, in which the hydraulic process was used. * * * The water and ore were carried to the plant by means of an open box flume. * * * The concentration of the ore is accomplished by means of the log roller process" at the rate of 125 to 300 tons daily.

"In all, there were six mines opened on this property, from which about 30,000 tons of ore have been taken," at a cost of about $1.00 per ton.

Ore Reserves Near Tennelina

There is no means at present of estimating the quantity of ore in the belt of country along the fault trace, as all the pits are filled with sand and there are no exposures. It appears probable that the amount of ore material removed from the pits had a width of about 15 feet. If this yielded 30,000 tons of marketable ore, as has been reported, there may be as much as 100,000 tons left within about 50 feet of the surface. Since much of this would be furnished by the bowlders, etc., in the clay and sand that have resulted from the concentration near the surface of that part of the fault zone which has been worn away, the quantity of ore that might be mined profitably in the next 50 feet, if the veins extend that deep, is much less.

So far as we can judge, without systematic exploration, the supply of ore in the area discussed is not sufficiently large to warrant the erection of a plant which could handle the material effectively. Considerable ore remains that might be concentrated profitably on a small scale by log washers, but there is no promise of production on a large scale.

Other Deposits in Madison County

Deposits have been reported by Nitze[1] from two other points in the county but their descriptions are very brief and their locations not precise. He mentions, on the authority of H. L. Harris, the existence of a bed of limonite having a width of 30 feet and an unknown thickness, on the western waters of Shut-in Creek. This was said to be cellular and in places ocherous, and to be associated with a gritty metamorphic sandstone that is conglomeratic in places. The analysis of a sample gave:

[1] Nitze, H. B. C., Iron ores of North Carolina: N. C. Geol. Survey, Bull. No. 1, p. 210.

SiO_2	Fe	S	P	P ratio
11.94	45.05	.39	.53	1.176

At another point in the neighborhood the ore is said to be botryoidal and compact, and at still another point the deposit is said to consist "of a fairly solid central mass, with stringy and lumpy crusts running out from it."

All these descriptions apparently refer to the deposits on the fault at Tennelina; but other deposits are said to exist "along the southeastern slopes of the Unaka Mountains, the northwestern boundary of Mitchell County."

DEPOSITS IN CHEROKEE COUNTY

Geology of the Ores

The sequence of the formations associated with the limonites in Cherokee County has already been noted. Those that are most closely associated with the ores are the Valleytown formation, the Murphy marble, the Andrews schist, and the Nottely quartzite. All belong in the upper portion of the Cambrian. (See pl. I.)

The Valleytown formation as described by Keith in the Nantahala folio (p. 4) consists in the main of mica-schist and fine grained gneiss. "In the basin of Valley River these rocks constitute practically all of the formation. * * * The mica-schist passes downward into the Brasstown schist. * * *

"On the south side of Valley River, where metamorphism is greatest near a fault plane, the mica-schist is strongly developed and many of the gneissoid beds have received a secondary schistosity. Similar results are seen north and west of Andrews, along the border of the Murphy marble, where the folding has been excessive. The strata of the formation south of Valley River are filled with small crystals of garnets * * *. Further southwest the garnets are less common." North of the river the rocks contain both garnet and ottrelite and at some places south of the river they contain also staurolite.

All the members of the formation are closely folded and often contorted, and all of them are schistose.

Since this formation has been closely folded, in common with all the other rocks of the region, it is impossible to get accurate measurements of its thickness. It is thought, however, that the entire formation is not less than 1,000 feet thick.

The Murphy marble occupies a narrow strip of country extending southwest along the Nantahala, the Valley and the Nottely rivers, and alongside the Murphy Branch of the Southern Railway and the Murphy Branch of the Louisville and Nashville Railroad; a small crescentic area near Peachtree, and a narrow belt extending southwest from near Peachtree to near the southwest corner of the Nantahala quadrangle and then westward into the Murphy quadrangle for a mile, at which point it expands northward into the wide valley of Martins Creek. The narrow belt continues up the west branch of the creek to the head waters of Gold Branch and down this to its mouth. (See maps, pl. I and figs. 9 and 11.)

The formation consists of a fine grained white, gray, pink or blue marble, which passes downward into the Valleytown formation by interbedding with the Valleytown schists, and upward into the Andrews schist through several feet of interbedded marble and schist. Its thickness before erosion was probably 500 feet.

Where the original deposit was impure through the presence of sand or clay the metamorphic processes that changed it into marble caused also the production of a number of silicates, such as micas, tremolite, garnet and talc. The talc occurs mainly as lenses embedded in the marble near its base. At many places the talc is mined, furnishing an excellent product. Pyrite is present not only in layers in which garnet is plentiful, but also as disseminated grains through the general body of the rock.

The Andrews schist also occupies narrow belts. It flanks the Murphy marble on the east from Valleytown nearly to the State line, and also borders the marble at Peachtree on the west, south and east sides.

The formation consists of a series of beds of calcareous schists from about 200 to about 350 feet thick. The schists are composed of a matrix of marble in which are embedded sand grains and great quantities of muscovite and biotite flakes and plates of ottrelite. It is in this schist that most of the limonite deposits occur.

At its base the Andrews schist grades into the marble by interbedding. "Upward it passes into the Nottely quartzite, as the sandy material increases both in separate layers and as grains in the body of the schist."

The Nottely quartzite appears in small lenticular areas surrounded by Andrews schist between Murphy and Maltby. Farther northeast it is entirely missing, but farther southwest it occupies an almost continuous narrow belt stretching to the State line and beyond, into Georgia. Here it is on the east side of the marble, the Andrews schists being cut out by the Murphy fault.

The Nottely quartzite is composed entirely of white quartzite, consisting of quartz, a little feldspar and considerable white mica that was produced during the period of metamorphism. Where the mica is abundant the quartzite passes into a micaceous quartz schist. The thickness of the quartzite is at least 150 feet.

The region occupied in part by Cherokee County consists of a great synclinal basin with a northeast-southwest axis, complicated by minor folds with the same strike, of which one is a syncline following the Valley and Nottely rivers (map, pl. I). From Marble to the State line the syncline contains the youngest rocks of the region, but it rises rapidly toward the northeast and older beds are brought to the surface. In many cases the beds have been so compressed that the strata on each side of the axis of the fold were made practically parallel. Their dips are everywhere high and at many places, as at Andrews, the beds are nearly vertical.

Moreover the region is characterized by many faults, which like the folds have a general northeast trend. One of these, the Murphy fault, follows along the east side of the Valley River trough, bringing in contact the Valleytown formation with the overlying Nottely quartzite, the Andrews schist, or the Murphy marble through most of its course from Andrews to the State line. This is believed to be the second longest fault in the southern Appalachian Mountains, its total length being about 100 miles. Just south of Andrews the fault was probably folded after its formation, as it now outcrops in a curved Z. The dips of the Murphy fault are generally to the southeast at various angles varying between 20° and 60° in Valley River and Nottely River valleys. Its maximum throw is about one mile in the neighborhood of Andrews.

A small syncline accounts for the Brasstown and Martin Creek strips of Murphy marble (figs. 9, 10 and 11), and an anticline for the outcrops of marble and Andrews schist at Peachtree (fig. 10). The Peachtree area, moreover, is bounded by two curving faults separating it from the Valleytown formation on the north and east and from the immediately underlying Brasstown schist on the west (map, fig. 9).

Distribution of the Ores

The most important and most persistent limonite deposits in the county as well as in the State are along the belt of Murphy limestone and associated rocks that occur in a narrow zone along the Murphy Branch of the Southern Railway from Valleytown

to Murphy and its extension along the Louisville and Nashville Railway to the State line, a distance of 28 miles (map, pl. I). That portion from Valleytown to Murphy has been called the Valley River ore belt, since it lies near the Valley River, a tributary of Hiwassee River, emptying into it at Murphy. That portion southwest of Murphy is simply an extension of the portion northeast of the city. It contains the same kind of deposits as those in that portion of the belt to the northeast and they are in the same geological positions as the latter. It lies along the Nottely River, another tributary of the Hiwassee River, and may therefore be designated as a matter of convenience the Nottely River belt.

Another series of deposits surrounds the area of marble near Peachtree 6 or 7 miles west of Murphy (map, fig. 9). There has been no development of any of the deposits in this area, mainly because of their distance from the railroad. With the recent construction of the road from Andrews to Hayesville they are now more easily reached, and some of the most promising ones may be opened up.[1]

A third series lies along the border of a strip of marble that has been traced from a point a mile southeast of Peachtree, through Brasstown to the west boundary of the Nantahala quadrangle, a distance of about 6½ miles. This may be called the Brasstown belt (map, fig. 8). Here too development has been retarded by lack of cheap transportation. The belt of limestone is known to extend westward, possibly with one interruption, into the valley of Martins Creek in the Murphy quadrangle, and then southwest with some interruptions along Gold Branch to the Nottely River. It apparently expands into a broad area at Martins Creek, where it is bordered as usual by ore deposits. For convenience, this western portion of the belt is called the Martin Creek area.

A fourth series occurs between ledges of quartzite and black slate that are probably members of the Brasstown schist. It extends in a southwesterly direction from the Hiwassee River, near the mouth of Hampton Creek, 1¾ miles southeast of Murphy to near the bridge crossing Nottely River on the road between Murphy and Culberson, a distance of about 9 miles (map, fig. 11). Through this distance is a ridge of dark quartzite on the south side of which are a number of deposits, some of considerable size. Because of their distance from the railroad they have not been worked since the abandonment of the local

[1] In 1924 one of the occurrences west of Peachtree was opened but to what extent is not known.

forges. A few other deposits several hundred yards south of the northeast end of the same ridge may have had their positions determined by a thinner bed of quartzite; but the number of deposits in this series is few and the line is short.

Other deposits, some of them apparently of good promise, are on the northeast side of Hiwassee River, about on the strike of the belt of deposits last mentioned. These, too, are on the southeast side of a quartzite ridge, but whether this is the northeast extension of the belt of quartzite to the southwest is not yet known.

ORE DEPOSITS IN THE VALLEY AND NOTTELY RIVERS BELT

The Valley and Nottely rivers belt of ore banks extends from the State line northeast to Andrews as an almost continuous series of deposits. Throughout this distance, as has already been noted, is a narrow trough of Murphy marble, Andrews schist and Nottely quartzite which is a syncline overturned to the northwest, as shown by the sections (figs. 4, 8 and 11) given by Keith through Marble and Regal and by LaForge and Phalen through Culberson. The eastern side of the trough is limited by the Murphy fault with its dip to the southeast of from 20° to about 60°. Its downthrow being on the northwest side, the upper formations on this side have been preserved.

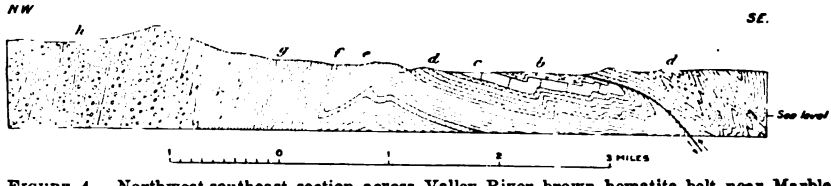


FIGURE 4. Northwest-southeast section across Valley River brown hematite belt near Marble, N. C. *b*, Andrews schist; *c*, Murphy marble; *d*, Valleytown formation; *e*, Brasstown schist; *f*, Tusquitee quartzite; *g*, Nantahala shale; *h*, Great Smoky formation.

Beyond Andrews to the northeast only an occasional deposit is known, and others are not likely to be found, since, because of the rise of the syncline in this direction, the upper formations have been almost entirely lost by erosion.

At Andrews the trough takes a sudden turn to the south for about a mile, then as suddenly, south of Valleytown, turns to the northeast and resumes its original course. On the outside of the bend are a few deposits; and these are the northeasternmost that are, at present, of economic importance.

Although limonite deposits are known to exist at short intervals all the way from the State line to Andrews, only those near Murphy and from Murphy north to Valleytown have been worked.

Where the Nottely quartzite is present there are usually two parallel belts of deposits, one on each side where it is in contact with the Andrews schist. Where the quartzite is not present the ores are usually in the center of the Andrews schist area, or in the schist near the fault that borders it on the east, or they occur at the surface in the clay and sand resulting from the decomposition of the rocks near the fault trace.

Many of the deposits are large enough to be worked with profit even by the wasteful processes that have heretofore been employed. Much of the ore shipped has been picked by hand from the surface or has been separated by hand or with a fork from the material that has been broken by pick and shovel from the walls of open pits. This is known as hard lump ore.

Where only hand picking is employed to obtain ore of shipping quality the operation is short lived and the "mine" is soon abandoned. At many places, however, the soil is so full of ore that it may be removed in its natural condition and shipped without beneficiation of any kind. The dirt is shoveled or forked into trucks or wagons and hauled to the railroad without hand picking or washing. The only selection made is in the pit, where portions of the dirt that appear poor are left behind. Mines worked in this way are also short lived, for with increasing depth the ore becomes more solid and less evenly distributed through the soft rock, and the associated rock itself also becomes harder. The cost of exacavation thus becomes more expensive and the preparation of the shipping product requires greater care. A little larger capital outlay is required and more careful supervision of the workmen. When pay dirt can no longer be forked into the carts without regard to its quality mining ceases.

Since most of the mining in the valley has been carried on in one of the two ways described, it is natural that there should be many abandoned mine sites. The first impression gained by a rapid examination of the field is that failure has followed the attempts to exploit it. As a matter of fact, most of the operations have been successful financially. Abandonment resulted only when the cream of the district had been skimmed. Most of the operators were interested in other projects and when time and attention were required to operate their mines successfully they preferred to use their capital and energy elsewhere. There are many old mine pits in the district, but unfortunately they are now tumbled in and consequently very little can be learned as to the conditions under which the ore occurs.

In the Tenth Census Report[1] only a few paragraphs are devoted to the ores of the district. Following Kerr[2] the deposits are described as being in three parallel belts. Only 5 mines were visited by the census geologists, and only a few descriptive words are devoted to each. At the Morse place, 10 miles northeast of Murphy, the ore was found to be hard and compact "with nodules filled with clay and some softer, more earthy portions." The vein was about 8 feet wide and had an east-west strike. An average sample from the entire exposed face analyzed as in I. At the Tomotla bank 3 miles southwest of the Morse opening were some shallow pits, from the old stock pile of which a sample was taken for analysis II. The belt in which the pits were sunk was thought to be at least 200 feet wide.

At a point known as Section 6 one mile north of Murphy, considerable work had been done, but only one small exposure was seen and from this sample III was collected.

A small opening at Mr. Little's place 5 miles southeast of Murphy furnished sample IV, and openings at the Monteith place 6 miles southeast of Murphy furnished sample V. At Monteith's the vein varied from 4 feet to 10 feet in thickness.

	Fe	S	P	P ratio
I	57.84		.021	.036
II	55.85		.291	.521
III	58.25	.160	.387	.664
IV	51.94		.994	1.914
V	56.46		.691	1.224

Since the appearance of the Tenth Census Report, however, the belt has been explored more vigorously than had been the case before the visit of the census geologists and a large number of small openings have been made. Mining was especially active during the war with Germany. But, as has been stated, most of the openings were superficial, and since they have now been filled with wash they reveal little information of value.

[1] Tenth Census U. S., vol. 15, pp. 827-829, 1886.
[2] Kerr, W. C., Report of the Geological Survey of North Carolina, vol. 1, pp. 160-163, Raleigh, 1875.

Fortunately, there are a few large mines in the district which have been able to work since the close of the War by the employment of efficient methods for removing material from the pits, for securing most of the ore in the material removed, and for properly preparing the product for market. These mines have furnished nearly all the information that has been obtained with respect to the manner of occurence of the ore.

MINES AND DEPOSITS IN THE VALLEY RIVER BELT

Deposits Near Murphy

All the mines in the Valley River belt, as has been stated, are either at Murphy or between that city and Valleytown.

Fain-Hitchcock Mines:—The southermost mine in the Valley River belt is the Fain-Hitchcock Mine which is about ¾ mile southwest of Murphy and therefore more properly in the Nottely River belt (see p. 14). It is described here because it is the only active mine in the southern belt and geologically its deposit is more nearly like the deposits in the northern mines than it is like those in the more southern openings. The mine is on the southwest slope of a ridge, the crest of which is occupied by the Nottely quartzite. (See map, pl. 1.) On the lower slope of the hill and to the south, as far at least as the track of the Louisville and Nashville Railroad, the surface is covered with sandy slate fragments suggesting the Andrews schist, but near the top of the low hill south of the track are outcrops and float of an ottrelite schist that is characteristic of the Valleytown formation. The ore consists of layers of hard limonite and loose bowlders of the same mineral in a mixed clay and sand matrix that appears to have been derived largely from a calcareous schist that may well have been the Andrews schist. On the surface and near it the ore is in sandy clay as loose fragments and nodules forming an excellent wash ore. At a greater depth it occurs in layers in a friable sandy schist dipping at angles to the southeast.

Such ore as can now be seen in place is in the main a mass of small and large veins cutting in a general parallel direction through much disintegrated sandy schists but often crossing the schist layers between them and uniting into a few large veins. Some of the ore is coarsely

botryoidal with dense spherical masses measuring about 3 or 4 inches in diameter. (Compare fig. 6.) Other portions are brown sandy masses that fall apart when roughly handled. Many of these contain little scaly portions that represent the decomposed ottrelite plates in the original schist, and others are simply masses of sand and limonite. The veins evidently were formed by the replacement of the calcareous cement of the schist by iron hydroxides. In open spaces and in layers that were limestone dense ore was formed. In sandy layers sandy ore resulted. It is this sandy ore and that occurring in the plexus of small veins which furnish the "wash ore." The thick veins of dense limonite and the botryoidal variety furnsh the hard or "lump ore." In this mine, as in most others in the district, the wash ore is in much greater quantity than the hard ore.

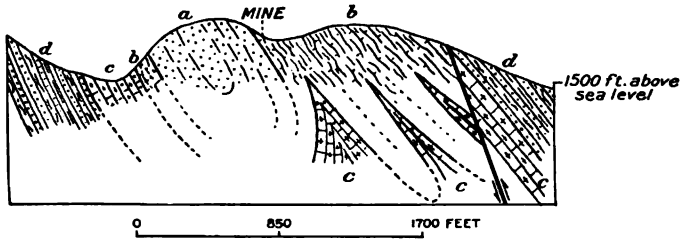


FIGURE 5. Diagrammatic cross section through Fain-Hitchcock mine, near Murphy, N. C. *a*, Nottely quartzite; *b*, Andrews schist; *c*, Murphy marble; *d*, Valleytown formation.

Since the dumps contain fragments of conglomerate and breccia, it is probable that the conditions are somewhat similar to those at Tennelina in Madison County. The breccia probably marked the position of a small fault in the pit at the contact of the schist and the quartzite. The presence of the Murphy fault south of the Andrews schist accounts for the absence of the Murphy marble from between the schist and the Valleytown formation—the position it should occupy if undisturbed by faulting (fig. 5).

Southwest of the old pits are exposures of hard ore out-cropping as rugged solid ledges for a distance of about 2,000 feet and a width of 175 feet and large bowlders of ore covering a belt that is considerably wider. To the northeast the belt can be traced by float for 800-1,000 feet.

The workings of the original mine consist of an open pit about 400 feet long trending about N. 35° E. (See pl. III.) It crosses a low hillock to the east and extends into a little depression to the west. Its maximum depth at the top of the ridge is 40 feet and in the depression 25 feet. As the bottom of the trench to the east is at the level of the top of that to the west, the total depth to which the ore has been proven is 65 feet. The width of the opening is now about 20 feet and the width of the vein between 12 and 15 feet, but the width of the layer of productive wash ore must be much wider than this. To the southwest of the old pit the ledge is now being opened by a new pit.

The ore was blasted and the loose material was loaded on cars with forks and shovels. It was carried by dump cars of 1½ tons capacity, actuated by gravity along 2,200 feet of track to a siding on the Louisville and Nashville Railroad. The ore was loaded without special screening or washing; consequently only the best of it was taken from the pit. The dumps still contain much ore that might be saved by an efficient washing plant.

It has been reported to the North Carolina Geological and Economic Survey that operations began in April, 1917, and 500 to 600 tons of ore were shipped weekly. The mine was active during 1918 but had closed down before the summer of 1919. In the early fall of the same year operations were again resumed at the west end of the old pit but were soon thereafter abandoned. In the fall of 1920, when the mine was again opened, a log washer was installed and preparations were made to ship 100 tons of washed ore daily, but legal complications ensued and the mine was idle in 1921.

The shipped ore is said to have contained from 44.75% to 49.50% Fe. Nitze (l. c. p. 198) gives an analysis of a surface sample of the best ore as follows:

SiO_2=3.82; Fe=56.56; S=.047; P=.820; P ratio=1.449

Nitze declares that on the western flank of the ridge on which the mine is situated "the parallel outcrop of the syncline is found on the west side of the quartzite, which dips 55° S. E.," and that at one time a prospect shaft was sunk into it. If ore exists on the northwest side of the quartzite, corresponding to that on its southeast side, there is on this side of the ridge a complete sequence from the Valleytown formation to the Nottely quartzite. The northwest slope of the ridge is covered by quartzite fragments, but in the valley at its base are a few

PIT OF FAIN-HITCHCOCK MINE, NEAR MURPHY. LOOKING NORTHEAST.

exposures of marble and a number of shafts from which talc has been taken. Across the valley to the south are abundant ledges of the Valleytown formation. It is evident that the ridge is synclinal. On its southeast limb, however, the Murphy marble is lacking, due no doubt to the presence of the Murphy fault, which at this place apparently intersects the Andrews schist. Nitze (l. c. p. 198) gives a section through the ridge but in it neglects to indicate the existence of the fault. An ideal section through the hill is shown in fig. 5 (p. 19).

Hall-Starbuck Mine:—The Hall Mine is about ⅓ mile north of Murphy. This and its extension for about 1,200 feet was worked in 1917 by F. R. Seeley. About 100 cars are said to have been shipped before the mine was closed. It was opened again in 1920 and was worked for the Roane Iron Company by Ben Starbuck who produced daily about 60 tons of washed ore containing from 44.5% to 58% of iron, with an average of about 48%. Two carload shipments in July analyzed:

Fe	Mn	Moisture
46.30	.29	3.90
47.70	.29	4.40

The workings consist of three or four open pits between a belt of quartzite on the northwest and ottrelite schists on the southeast. The strike of pits and rocks is about N. 35°-40° E. and the dip of the rock layers about 65° to 70° S. E. Beyond these to the northeast are other pits and trenches that indicate the extension of the ore about 1,000 feet in this direction. The main pit is about 250 feet long and about 20 feet wide. It is about 25 feet deep at the northeast end, where it exposes a ledge of ore about 12 feet thick.

West of the quartzite, at the spring on the south side of the road, are small exposures of ottrelite schist and associated with it is some limonite, and at the switch of Whiteley Lumber Company's track is a well characterized deposit of soft ore. Beyond these is a valley without exposures. This is probably underlain by the Murphy marble. These various beds represent the northwest side of a syncline at the center of which is the quartzite. Its southeast limb lacks the marble, the Andrews schist being faulted against the Valleytown formation by the Murphy fault. (See map, pl. I.)

The quantity of ore on the northwest side of the quartzite at this place is very small as compared with that on its southeast side, due no

doubt to the comparatively high dip of the beds to the southeast. The overhanging impervious quartzite on the northwest limb of the syncline protected the schist to some extent from the action of downward travelling water, while on the southeast side the quartzite has served as a basement along which the descending water was concentrated.

Dockery Mine:—Although at the Hall Mine limonite has been found in small quantity only on the northwest limb of the syncline, about ½ mile further northeast at the Dockery Mine, which was also operated by Mr. Seeley, the principal ore deposits so far as known are on the northwest limb. The quartzite here forms a ridge southeast of the mine openings and on its southeast slope ore is again encountered, but only in small quantity.

The mine is a comparatively small hole, now filled with water. North of it for a distance of 900 feet, however, there have been dug a number of pits and one shaft, and from some of these marble fragments have been taken. By a glance at the map it will be seen that the ore lies between the marble and the quartzite, in a location that would naturally be underlain by Andrews schist. No exposures of this rock are visible, either northwest or southeast of the quartzite; nor has the exact position of the Murphy fault on the southeast side of the quartzite been identified.

Section 6 Openings:—About ½ mile farther northeast from the Dockery place begin the numerous openings on "Section 6," that extend for nearly a mile on the northwest side of the quartzite ridge, thus continuing the vein system of the Dockery Mine. Some of the openings are very large, but none are deep. Some are long trenches extending from near the crest of the ridge down its west slope for 125 feet. Others are large pits near the bottom of the slope. The long trench exposes nearly throughout its length ore layers dipping 55° S. E. One of these consists of almost solid ore 30 feet wide and another of ore 15 feet wide. Besides these there are many small veins, aggregating in thickness 10 or 12 feet. On the hill above the upper end of the trench ore bowlders are scattered abundantly over the surface, so that the fair inference is that the mineralized belt is even wider than the width exposed in the trench. Moreover, pits on the slope all the way from the lower end of the trench to the road at the bottom of the slope—a distance of 500 feet—show the presence of ore in the soil, but none of them, so far as could be determined, reach solid rock. The ore on their dumps is probably all superficial material that has rolled from above.

About ½ mile farther northeast other openings well up on the northwest slope of the ridge also show a series of limonite layers from 6 inches to 2 feet thick, dipping about 45° S. E.

From the character of the ore layers seen in the few openings that reach undisturbed rock it is believed that there are here no great thick hard ore layers that can be mined without washing. On the other hand, the abundance of bowlders strewn over the northwest slope of the quartzite ridge for a distance of over a mile and the great quantity of ore fragments present in the soil and sand uncovered by the many pits that have been opened on its lower slopes indicate that this belt of country as far northeast as Marble Creek furnishes favorable prospects for an efficient washing operation.

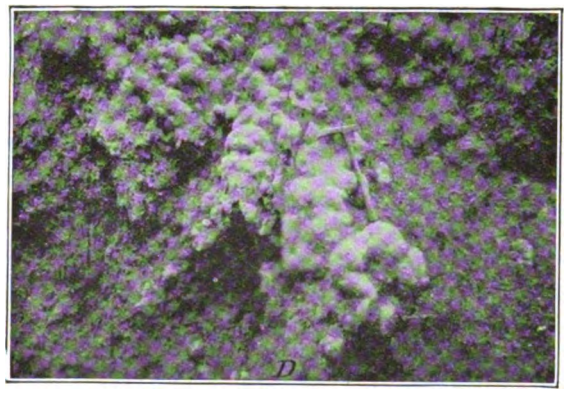


Fig. 6. Mammillary ore in Savage Bros. Mine near Murphy.

According to Nitze (l. c. p. 199) the ore contains:

Fe=58.80; S=0.161; P=0.391; P ratio=0.664

Savage Bros. Mine:—On the opposite (southeast) side of the hill from that occupied by Section 6 openings are the open cuts of the Savage Bros. Mine. The property was worked by A. G. Betts, during the first half of 1917, but later came into the possession of the Messrs. Savage of Murphy and was worked by them during the late war. The main opening, which is on the old Cooper property, is a large open pit about 500 feet long and 75 feet wide at the top, narrowing to 30 feet at the bottom. Its depth varies between 12 and 35 feet. It is well up on the slope of the quartzite ridge which separates the deposit from that on the Section 6 property. Mr. Savage states that the width of good ore was between 30 feet and 40 feet, of which 20 feet was solid black ore and 10 or 15 feet was soft ore. In its general character the ore which

dipped nearly vertical, is similar to that of the Fain-Hitchcock Mine, botryoidal, or mammillary varieties being abundant (fig. 6). Only such hard ore as it was possible to hand cob was shipped. The soft ore and small fragments were thrown on the dump. Mr. Betts shipped in all about 1,000 tons and the Savage Bros. about 4,000 tons.

Carload lots shipped by Savage Bros. analyzed:

Fe	47.08	45.10	49.54	48.81
Mn	.29	.58	.25	.49
Moisture	2.73	4.88	1.90	1.00

Nitze reports (l. c. p. 199) that the ore on the Cooper place yielded:

SiO_2	Fe	S	P	P ratio
7.76	51.94	.06	.730	1.405

An inspection of the huge dumps at this place gives abundant evidence of the great quantity of ore that has been wasted. Although, of course, no estimate has been made of the percentage of ore present in the sand and clay that make up the greater portion of the dump piles, nevertheless there would appear to be no doubt that some of the piles would warrant washing. Mr. Savage states that the width of the wash ore is at least 100 feet. If this is so, and it seems to be the case, the property deserves careful prospecting and testing with an efficient washing plant, since about 60,000 tons of ore must be available above a depth of 70 feet.

About 1,800 feet southwest of the Savage Bros. opening are exposures of ottrelite mica schists on the road. These are probably members of the Valleytown formation. Between these exposures and the mine are no outcrops. In this interval should appear the Andrews schist and a part of the Murphy marble unless faulted down by the Murphy fault which also should be situated somewhere in this interval. Since a cut in the highway, 600 feet southeast of the northeast end of the pit, is through red clay with the characteristics of clay that is known to be derived from marble, it is probable that the fault passes through the upper portion of the marble layer and very close to the road, and that here marble exists on both sides of the syncline.

Ore Reserves Near Murphy

The depth to which the ore deposits extend is not known; consequently any estimate of the total quantity of ore present in any portion of the Cherokee County area is of no conceivable value. It is certain, however, that ore persists to a depth of 75 feet in most places and to at least 100 feet in others. Even though it might extend downward for great distances, the ore below the ground water level would be unavailable under present economic conditions because of the cost of draining the openings. At present we can regard as available only the ore that can be reached by open cuts, as the individual veins are so small that they cannot be followed profitably by underground methods. In order that a deposit may prove profitable all the material in the small veins must be recovered, and this is possible only where a wide slice of rock may be raised and washed. Open pit mining with the aid of steam shovels or of hydraulic jets is the most economical method of accomplishing this result at present, consequently the only available ore is that which can be reached by open pit mining. Since most of the ore outcrops are on hill-sides well above the surface drainage level, it is probable that the bottoms of pits might be carried to 70 feet below the outcrops without meeting with any serious obstacle in the way of groundwater.

If we regard as available all ore within 70 feet of the surface and base our calculations upon the length and width of the productive belt at the surface, the quantity of ore that may be reached in that portion of the Valley River belt adjacent to Murphy is about 465,000 tons. The actual amount of ore in the area is several times greater than this, but it is so scattered in thin veins and small complexes of veins that except in a few places, it cannot supply more than a few carloads at a cost that would not be prohibitive.

Deposits Near Marble Creek

Farther northeast at Marble Creek (pl. I), two ore belts are again exposed. The creek cuts across the quartzite which dips 45° S. E. On the southeast side of the quartzite, near the mouth of the creek, ore outcrops along the highway a few feet above the level of Valley River. Its dip is 75° to 90° S. E. Because of the low altitude of the outcrop, perhaps, the ore has not been explored and consequently the thickness of the deposit is not known.

On the northwest side of the ridge the ore has been exploited on the slope of the ridge, by large open pits, both south and north of the creek. Nitze states that they were made by the Valley River Company. In recent years the openings to the southeast were worked by A. G. Betts and the pits northeast of the creek by F. R. Seeley.

Nitze (l. c. p. 200) describes the southern deposit as consisting of a "solid ore bed 8 to 12 feet in thickness, dipping 50° S. E., and underlaid by decomposed shale and clay, beneath which there are several smaller seams of siliceous ore," with the composition.

SiO_2	Fe	S	P	P ratio
17.52	48.44	.038	.295	.609

On the north side of the creek the ore was 8 feet thick and was more siliceous than that in the southern opening.

West of the openings the Murphy marble is exposed and is quarried for commercial purposes by the Regal Blue Marble Company and ½ mile further northeast is worked for talc. Keith[1] describes the section through the marble as follows:

"At the bottom are several feet of white marble with tremolite crystals; above this are 50 feet of pure white marble, 40 feet of blue marble, and 30 feet of white marble. After a small interval in which are no exposures the ottrelite-bearing Andrews schist outcrops." Then follow the ore deposits and after these about 150 feet to 200 feet of Nottely quartzite in the bed of the creek. The structure is a syncline overturned to the northwest. A reproduction of Keith's section is given in fig. 10.

The large openings immediately northeast of Marble Creek extend for about half a mile, beyond which are a number of small pits scattered on the northwest side of the quartzite for another half mile, and here and there on its southeast side is a small exposure of ore. There are no other large ore openings until Montvale is reached—a distance of about 1½ miles. Through this stretch the Nottely quartzite has been entirely eroded and with it any ore deposits that may have developed along its contacts with the Andrews schist. Here and there, as has been stated, pits in the Andrews schist have opened into small deposits, but these are very limited and of no commercial importance.

[1] Keith, Arthur, U. S. Geol. Survey Geol. Atlas, Nantahala folio (No. 143), p. 7, 1907.

ORE RESERVES NEAR MARBLE CREEK

The aggregate tonnage near Marble Creek, on the assumption that a strip 30 feet wide might be worked to a depth of 70 feet, would be about 120,000 tons.

Deposits Near Maltby

Kinsey-Betts Property:—Just above Montvale going northeast the Nottely quartzite reappears and constitutes a little ridge which extends at least as far as Morgan Creek and probably a quarter of a mile beyond.

That portion of the ridge southwest of Morgan Creek is flanked on both sides by ore deposits, but those on its northwest side have been much more thoroughly explored than those on its southeast side, although on this side are a few large, but shallow pits and several promising exposures.

The principal opening is at the northeast end of the ridge, near Morgan Creek, where active operations are now being carried on intermittently by Ben Starbuck of Murphy under lease from Mrs. Kinsey who owns the mineral rights. The main opening is about 325 feet long. Other openings on the strike of this are small and shallow, but they are so distributed as to indicate a considerable width of mineralized rock, dipping 35° S. E. The mine is equipped with a pump and log washer. Most of the product is washed, yielding an ore analyzing in carload lots about 12% SiO_2 48% to 52% Fe, 0.13% Mn and 0.04% P. The yield is about 800 lbs. of ore to the ton of rock. During the war the mine furnished several carloads of very porous ore to the naval station at Pensacola where it was used for the generation of hydrogen.

The quartzite ridge is very narrow. On its southeast side at its northeast end are exposures and strippings showing 8 or 10 feet of hard ore which it is proposed soon to work. Farther southwest are several large openings that were formerly operated by A. G. Betts. Mr. John Smith in a report to the North Carolina Geological and Economic Survey writes of the "Dockery place" at Montvale, presumably the property worked by Betts, that the ore vein is "made up of flat lenses stacked one on another and reaching a maximum of 7 layers, width 1 to 8 feet; dip about 45°. This was worked for about 3 months and produced about 3,000 tons." At the "Kinsey property," probably the southern part of this area, he writes "about 7,000 tons have been produced since the first opening of this mine some years ago, 1,200 of which were mined this year" (1918). The openings at the southwest end of the

strip of ore-bearing ground on the southeast side of the quartzite are spread over a width of about 150 feet indicating a belt of ore at least 125 feet wide.

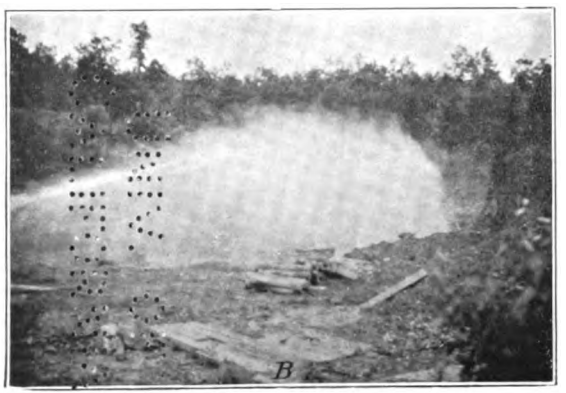
Mr. Starbuck declares that 3 engineers have estimated the reserve on both sides of the quartzite as from 1,500,000 to 2,000,000 tons, assuming a double belt of ore bodies to extend ¾ mile. He does not know the data upon which the estimates were based, but states that a shaft on neighboring property followed the ore to a depth of 85 feet. So little is known of the horizontal or vertical continuity of the veins in this locality and so vague is the information as to the proportion of ore to waste that the estimates have very little value. If the width of the strip of ore-bearing rock on the east side of the ridge is 125 feet and that on its northwest side is equally wide, and the rock can be worked profitably to the depth of 70 feet, then the quantity of concentrate that may be obtained from the two slopes of the hill within 1,800 feet of Morgan Creek is about 650,000 tons, provided the entire body of rock raised will yield 800 pounds of ore to the ton.

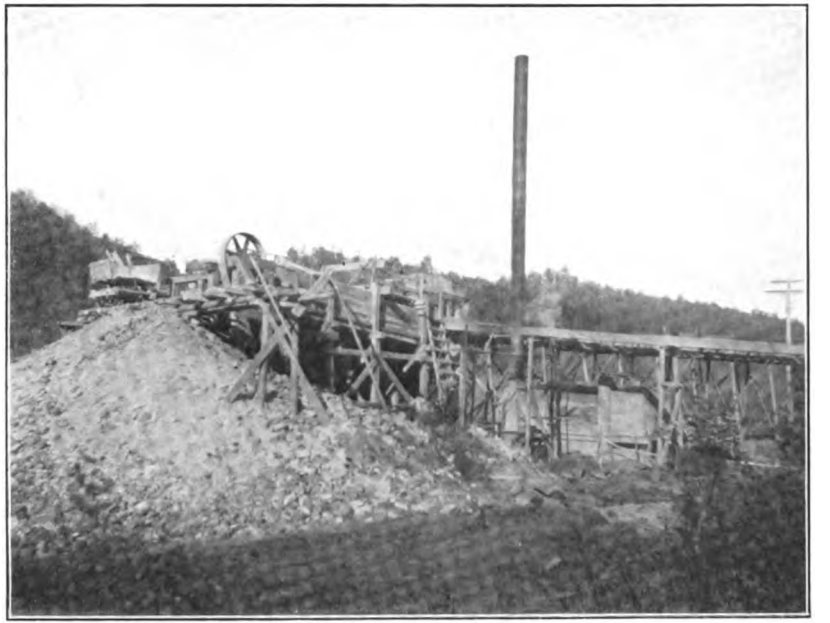
Heaton & Russell Mine:—Keith does not map the Nottely quartzite as extending to the northeast beyond Morgan Creek. There are, however, two small knobs north of the creek on which bowlders of quartzite are thickly strewn. On the northwest sides of these knobs, well up on their slopes are 4 or 5 large openings, some of which have distinctly defined quartzite to the east, while others are apparently not associated with any visible quartzite though on the strike of those further southwest which are so associated.

At the northeast end of the southern ridge, about ¼ mile from the Starbuck Mine is the large opening being worked by Messrs. Heaton and Russell. The opening shows no unusual features. (See pl. V.)

Mr. Smith writes of the "Kilpatrick property" which answers to the description of the Heaton and Russell Mine that the vein is vertical, 20 feet wide and cut into two parts by a horse. The ore is said to be more solid than it is further southwest and to have been proven for ½ mile.

The ore was originally cobbed but not washed, and consequently there was a great quantity of fine ore left on the dumps. In the summer of 1920 this was being raised by steam shovel and washed, yielding about ⅓ ton of concentrates to the cubic yard. Shipments were at the rate of about 50 tons daily. The main pit around which the dumps have accumulated is an open cut about 175 feet long, 40 feet wide and from 40 feet to 60 feet deep, with an entrance at its northeast end through a cut 150 feet long. The vein as now exposed is in ore 6 to





C

HEATON & RUSSELL MINE, NEAR MALTBY

D. Ore-vein, bottom layer, dipping away from observer.
B. Mining by hydraulic jet.
C. Washer.

10 feet wide, but ore is so thickly scattered over the surface down slope that it is believed the soil will warrant washing as far as 100 feet from the outcrop. During 1921 water was conveyed to the mine and delivered with a nozzle pressure of 100 lbs. It is intended to use it in excavating the ore.

Southwest of the main opening of the mine a continuous trench about 1,200 feet long has uncovered throughout its whole length 3 sets of veins, ranging from 2½ to 5 feet in thickness, in which are sandy partings only a few inches thick. The veins dip 45°-50° S. E., and are separated from one another by 10 to 15 feet of schist containing many small veins. To the northeast the openings of the Welch and Guy Green mines seem to prove that ore occurs beyond the visible quartzite through a distance of 1,800 feet. There is a possibility, however, that ore has not been deposited between the Welch and Green mines, in which case the northeast extension of the vein beyond the Heaton and Russell Mine is only 900 feet.

If we assume a continuous vein 2,100 feet long and a workable slice of ground 100 feet wide and 70 feet deep which will yield a concentrate of only ½ ton to the cubic yard, the available ore in this strip will approximate 270,000 tons. That the yield of ore would be as great as ½ ton per cubic yard admits of no doubt, as the yield of the waste left at the Heaton Mine after picking out the good lump ore was, as has been reported by Supt. E. C. Palmer, a little greater than ⅓ ton per cubic yard, during a week in August, 1920, when 778 cubic yards of dirt yielded 621,000 lbs. of shipping ore. As much of the material that would be removed from the strip would consist of vein ore, the yield of the entire strip would be much greater than that of the mine dumps.

Southeast of the mine there is a narrow exposure of quartzite on the top of the ridge, but so far as known there are no ores on its southeast side as is the case at the Kinsey-Betts location.

Welch and Guy Green Mines:—Northeast of the Heaton & Russell Mine the quartzite seems to disappear. It is possible that it may extend to the Welch Mine 600 feet further northeast, though no outcrops are to be seen on the hill above the opening and none are known further northeast in Cherokee County. The brown ores northeast of the Welch mine occur in relations different from those to the southwest.

At the Guy Green Mine, which is 1,000 feet northeast of the Welch Mine, the quartzite is probably absent. The mine is on comparatively low ground and there is no distinct ridge to the east. It may be that the quartzite was originally present in its usual position just over the

ores but that it has been entirely removed by erosion, which, however, has not yet cut deeply enough into the underlying Andrews schist to remove the deposits that were formed near the contact of the schist and quartzite.

The Welch Mine is a few hundred yards northeast of the Heaton and Russell Mine. It is a shallow open cut about 600 feet long with a width varying between 10 and 50 feet and a depth of from 6 to 10 feet. In 1920 it was being operated on a small scale by J. W. Welch. The opening is in flat country and is therefore difficult to work. The main ore vein is about 6 feet wide but there are other thin veins separated by thin layers of sandy schist. The ledge is broken down and the ore handled by forking. Thus nearly all the finer ore is lost. Up to September 1st, 1920, about 50 tons of ore had been shipped.

The Guy Green Mine, now known as the Green and Mehaffy Mine, consists of a large shallow pit and 5 or 6 small ones, occupying the top of a low hillock. At present nothing can be seen at the mine but a pile of mixed sand and ore. The largest pit is about 200 feet long, 25 feet wide and 15 feet deep. Southwest of this the ledge is stripped for a length of 150 feet on the vein which strikes N. 55° E. and dips 50°-55° S. E. About 200 feet further southwest is another pit 125 feet long, 10 to 15 feet wide and 6 feet deep in which the vein is again exposed. Thus the ore is exposed for nearly 700 feet on the property. The "vein" comprises for the most part a number of small veins, each about 1 foot thick, alternating with layers of sandy schist. Only the harder ore was shipped. Since the solid ledge has not yet been reached by either the Welch or the Green mines, it is impossible to predict the conditions under the mantle of decomposed rock. A clean hand specimen of the ore from the Green Mine gave 52.53% Fe and .687% P as the result of a commercial analysis.

ORE RESERVES NEAR MALTBY

On the assumption that ore exists only in those portions of the strip between the Kinsey-Betts property and the Guy Green Mine where it is exposed on the surface, and that it can be worked to a depth of 50 feet in the neighborhood of the Guy Green Mine and to a depth of 70 feet elsewhere, the aggregate available tonnage in the vicinity of Maltby is about 1,070,000 tons.

Deposits Near Marble

Puett and McHan Mines:—Beyond the Guy Green place for 2 miles no ore has been discovered. The country is low and erosion has exposed

the Murphy marble all the way to the town of Marble, where the Andrews schist reappears.

At Marble, however, begins another series of openings, some of which have developed into important mines. The series begins with the Puett openings about ⅕ mile south of Marble Station. Formerly they were worked together with the openings on the adjacent McHan property by A. G. Betts, producing about 1,500 tons, without screening or washing. The Puett property is now abandoned, and the McHan Mine has not been in operation during the past few years.

The Puett Mine consists of a number of holes, some of them large, extending in a comparatively broad band across the road from Marble up Vengeance Creek. The largest hole is about 20 feet deep and on its northeast and southeast sides shows a little hard ore. Exposures indicate a width of this ore measuring 8 or 10 feet. The dumps are so filled with fragments of ore and limonite sand as to appear to be worth washing. About 200 feet farther northeast is another large pit on a little rise. In this the vein is 7 or 8 feet wide. Several more openings indicate a vein with a strike of about N. 20° E. and a very high dip. Other openings northwest of these seem to show that the deposits are in a double belt, but they are small and not so distributed as to prove the case.

Immediately northeast of the Puett Mine and northeast of the road up Vengeance Creek is the McHan Mine. Mr. Smith writes that Mr. W. McHan began to mine here in January, 1917, at first by contract and later under his own direction. The ore was shipped without screening or washing but was separated from sand by forking. After producing about 900 tons of material averaging 45% Fe, work was discontinued in the early part of July, 1917. The ore is reported to have occurred in veins 3 to 10 feet wide. Analysis showed that some cars contained from 2% to 3% Mn. Work was again undertaken in the early part of 1918 add stopped in May of that year after the shipment of about 75 cars, some of which ran over 52% Fe. An average of analyses of 12 cars sent to the Roane Iron Co. and reported upon in August, 1918, gave:

SiO_2	Al_2O_3	Fe	Mn	P
10.86	5.30	49.90	.58	.62

The present openings on the McHan property are some very large pits uncovering a plexus of veins in a sandy schist. There is now visible no distinct massive vein, although it is currently reported that some of the veins opened were 10 feet thick, but in the northeast hole, which is about 1,500 feet from the southwesternmost pit at the road, the veins are so crowded that they form a stockwork 20 feet wide striking about N. 40° E. and dipping 35° to 40° S. E. There is no solid rock in sight. In the largest new pit which is 300 feet long, 60 feet wide and 50 feet deep, the upper 25 feet are in sand containing no ore except in bowlders lying on the surface. Beneath this is the decomposed schist with ore veins running in all directions within the belt referred to above. In the entry northwest of the main pit a little light colored clay is exposed. This may indicate the position of the southeast contact of the Murphy marble, and the material in which the pits are dug may be decomposed Andrews schist. Keith indicates the width of this belt of Andrews schist as extending from the river to the railroad, but it is possible that he has placed the contact of the schist and marble too far north, as might well be the case, since no rocks were exposed here at the time of his visit. It is only by the stripping of sand from over the ore veins that the white clay was brought to light.

Hayes-Hoblitzell Mine:—A few hundred yards farther northeast on the ridge on which are the northern openings of the McHan Mine, and across a little valley from these are the openings of the Hayes-Hoblitzell Mine (pl. VI). The principal open cut, which is at the northeast end of the hill overlooking the valley of Hyatt Creek, is about 300 feet long, about 75 feet wide and 70 feet deep at its southwest end where it is cut into the hill. The walls of the pit are sand shot through with ore, forming a stockwork 50 feet wide. No well defined solid vein was seen, though southwest of the main opening are several cross cuts that prove the ore belt to extend in that direction for more than 50 feet, and about 125 feet southeast of the main cut is another small opening showing considerable hard ore. If this is the Morse property referred to by Nitze (l. c. p. 202) there is an old shaft on it that at the time of his visit showed ore in its walls. A sample of this ore was analysed with the result shown in I. In the report of the Tenth Census (p. 327) the ore was said to be 8 feet wide, and to have the composition given in II.

	SiO_2	Fe	S	P	P ratio
I.	6.49	57.16	.036	.756	1.322
II.	----------	57.84	----------	.021	.036

B

THE HAYES & HOBLITZELL MINE, NEAR MARBLE

C. General view of pit, looking south.
B. Near view, end of pit.

The dip of the main veins is southeast as usual, but the smaller ones dip to the northwest across the bedding as though following joint cracks.

The mine is equipped with a steam shovel, a 40 foot log washer and a pump with a capacity of 200 gallons a minute.

It is reported by Mr. Hayes that there have been shipped from the present opening about 30,000 tons of ore in the past 3 years, all of which contained notable quantities of manganese. In 1920 mining was at a standstill but the old dumps were being washed, yielding 2 cars of ore daily, at the rate of 100 tons of ore to 250 yards of sand. It is estimated that in the cut the proportion of ore to sand is as 3:2.

Carload shipments during June, July and August, 1918, are represented by the four analyses of dried material following:

Fe	49.20	49.80	48.80	48.50
Mn	1.37	1.03	1.13	1.38

Cooper and Hanks Openings:—About ½ mile northwest of the Hayes Mine are numerous openings on the Cooper and Hanks places, now owned by Mr. L. L. Jenkins, that indicate a great quantity of ore that is available for washing. Although an old property that was worked extensively during the latter part of the last century, it was reopened in 1917 by A. G. Betts and worked intermittently during the war, shipping about 200 cars of ore averaging 48% to 49% of iron.

On this property are eight or nine small pits extending in a straight line about 1,500 feet and several larger ones on both sides of this line, all of which show many small veins in a mineralized zone in schists. In the southwesternmost of these the vein is 5 feet thick, and in several others it is reported to be from 7 feet to 10 feet thick, but in most of them the veins measure scarcely more than 6 or 7 inches. The mineralized zone is said to be 40 feet wide, tapering to 6 feet at the northeast opening. The ore in some of the pits is notably globular.

In the large open pit from which most of the ore was taken the lower portions of the walls show the usual plexus of small veins cutting sandy schists. Above, the veins are truncated and over their cut-off edges is a blanket of conglomerate formed of bowlders, pebbles and sand. Some of the bowlders are of ore. They may be of local origin like those on the slope of the quartzite hill at Section 6 (see p. 22), but here they are rounded and the deposit shows a rude bedding, as though worked over by water.

About 600 feet southeast of the main line of openings is another series of several shallow openings on the opposite side of the ridge. The northeasternmost one shows a vein of hard ore 7 feet wide but the others only wash ore. The ore has also been uncovered on a slope forming the west bank of Valley River. The largest opening is about 60 feet above the stream, but a smaller cut is nearer the river. The latter shows 4 to 10 feet of ore dipping about 30° N. E. Across the river on the right of way of the new railroad between Andrews and Hayesville are numerous outcrops of Andrews ottrelite schists, with which at several points are associated limonite layers.

Fortunately Nitze visited the old mines when their openings were comparatively fresh and described the conditions as he saw them at that time. He stated (l. c. p. 203) that there are two series of outcrops trending nearly east-west on parallel ridges about 600 feet apart. The northern belt was uncovered by trenches for a width of 175 feet and at one point a shaft was sunk 38 feet in ore, without reaching the bottom of the deposit.

The outcrops on the southern belt had been explored by a shaft 55 feet deep, which penetrated to its full depth alternating layers of clay and limonite averaging about 4 feet thick. Drifts from the bottom of the shaft were driven 40 feet and 20 feet south in the same mixture of materials. A few yards east of the shaft the top of the ore had been uncovered for a width of 60 feet and had been found to be 8 feet thick. Further east the ore had been again stripped and penetrated by a shaft. Here the deposit was also found to be only 8 feet thick. It lay almost horizontal as a layer 8 feet thick just under the surface. Again at the river a large outcrop was exposed over a width of 48 feet and this again was 8 to 10 feet thick.

The deposit described above as dipping 30° N. E., which is just a little steeper than the slope of the surface at this point, is probably the extension of the layer described by Nitze. It is evident that a nearly uniformly thick layer of ore exists under the surface, following its undulations rather closely. It is overlain by about 4 or 5 feet of sand and loose rock fragments, some of which are quartzite and granite bowlders and many others are ore bowlders, and is underlain by sand and clay, representing a decomposed rock. In no way is this ore layer directly related to fissures in the associated material, as is the case with the hard ore veins. Nitze (l. c. p. 205) describes the ore bed near the river as being "as a rule compact, but in places porous; again it is nodular and extremely argillaceous, changing in fact into a hard, siliceous, ferruginous clay slate." Observations by the writer revealed a layer made

up of rounded masses like bowlders, in some places tightly cemented by limonite and in others loosely embedded in a mass of sand and limonite.

Analyses of samples of ore from the two belts are as follows:

	SiO_2	Fe	S	P	P ratio
I. From shaft on northern belt	3.32	58.52	.026	.520	.888
II. From 30 foot shaft on southern belt	10.70	54.88	.072	.273	.497

It is plain that the blanket deposit which slopes with the surface has not had the same origin as the hard ore veins that are steeply inclined. The latter were evidently made in fractures in the rocks. The former is not related to fractures, but appears to be directly related in some way to the surface. The deposit seems to be a conglomerate or breccia, such as might be made by cementing together into a mass the ore fragments so thickly strewn over the surface near the outcroppings of ore veins and down slope from them. It is possible that the thick layer of clay below the ore represents decomposed marble and calcareous schist, and the ore was originally in the debris on top of these rocks before they were so thoroughly decomposed, like the ore in the clay above the marble in Madison County (p. 8) or like the conglomerate above the sandy schists in the main pit on this property. Apparently the deposit was made and cemented after the general features of the present topography had been developed, the ore having been furnished by veins outcropping near the apex of the ridge.

At present no work is being done anywhere on the property, although it furnishes a promising opportunity for the use of a steam shovel and log washer. At a few places, as on the slope to Valley River, though there are abundant bowlders of ore scattered over the surface, there are intermingled with these many equally large bowlders of granite and quartzite which it would be impossible to separate except by hand picking. However, it is probable that the cost of picking these from the washed ore would be slight. Moreover, they occur only on the surface and are not found in the layer of ore beneath the surface, so that most of the material furnished by the shovel could be delivered from the washer in shape for shipment without any further treatment.

ORE RESERVES IN THE NEIGHBORHOOD OF MARBLE

It is clearly impossible to estimate the quantity of ore in the vicinity of Marble. Small cuts southwest of the main pit of the Hayes-Hoblitzell Mine show that the ore-bearing strip extends at least 600 feet in this direction, and the openings on the McHan and Puett properties extend it at least 1,500 feet further. If the ground can be worked as deep as at the mine, there are in this strip of 2,100 feet about 160,000 tons of ore. But it is probable that mining can be carried on profitably below this depth, since the ore at the bottom of the mine is in a condition to be removed easily and, in all probability, if all the material removed were put through the washer, the yield in concentrate would be greater than it has been in the case of the material taken from the open cut. It is therefore very likely that the quantity of ore that might be taken from this strip of country south of Hyatt Creek would amount to well over 200,000 tons.

Northeast of Hyatt Creek on the Jenkins property a moderate quantity of wash ore is available from the strip of country on the northwest side of the ridge. On the southeast side of the hill is the blanket deposit which, if it is spread over this slope uniformly, will yield about 750,000 tons.

On the assumptions made the total quantity of available ore in the vicinity of Marble must be about 1,000,000 tons.

Deposits Between the Jenkins Place and Andrews

General:—At the Jenkins place the ore belt crosses the Valley River and for the rest of its course remains southeast of the river.

Small exposures on and near the Andrews-Hayesville railraod where it crosses Taylor Creek mark the course of the main veins for a mile, and other exposures and pits extend it all the way to Andrews. Other exposures and pits farther south, on and near the highway from Andrews to the mouth of Vengeance Creek, indicate the presence of other deposits near the fault trace between the Andrews schist and members of the Valleytown formation. None of the explorations on any of these deposits have yielded promising results. In some places the deposits are moderately large, but nowhere are they large enough to warrant the installation of washing plants under present normal economic conditions.

Although the ore veins on the southeast side of the river are not promising sources of ore, the case is quite different with respect to the blanket

deposits, already referred to as existing at the northeast end of the Jenkins property. From Nitze's description we are assured that the conglomeratic sheet-like layer of ore spreads over the northeast end of the hill on this property and dips down to the edge of the river. Whether it fills the river valley and the slopes on its opposite side is not known, since no exposures of it are seen for the next mile. A few rods northeast of Taylor Creek it is, however, again encountered and from this point it extends at least ⅗ mile farther northeast where it is mined by the Southern Iron Mining Company.

Taylor or George Luther Property:—The Talyor or George Luther prospect is on the little hillock between the lower portion of Taylor Creek and the river. There are two openings on the southeast slope of the hill in a very flat lying ore bed which is exposed also in the road cut a few yards to the east. The ore is said to be about 10 feet thick, overlain by a mixture of sand and ore fragments. Nitze (l. c. p. 205) reports the ore to be 40 feet wide and from 6 feet to 8 feet thick. As the ore body slopes with the surface, it is probably a sheet like that on the Jenkins Place, in which case the width exposed possesses no great significance. As a matter of fact, small pits and trenches that have merely removed the loose soil have exposed ore under a strip of country ½ mile long.

On the northwest slope of the hill are exposures along the track of the Carolina and Georgia Railroad and a few pits, which show the presence of an ore vein the size of which has not been developed. A clean sample of the ore from one of these pits yielded Fe=48.93; P=.766.

Southern Iron Mining Company's Mine:—On the next hill to the northeast the conditions are nearly the same as at the Luther place. Here the main openings of the Southern Iron Mining Co. are at the southwest end of the hill where an area at least 100 feet wide has been uncovered, showing a sheet of ore about 10 feet thick wedging to 5 feet or 6 feet toward the west and east. On the top of the hill farther east are ditches and test pits, all uncovering ore over an area 250 feet wide and nearly ¼ mile long. Within this area a shaft is reported to have penetrated ore to a depth of 38 feet. Moreover the valley to the southeast of the hill is said to have been explored by several pits now obliterated and these pits exposed 5 feet or 6 feet of ore like that on the hill. Other pits and a tunnel 750 feet west of the mine opening mark the presence of a well defined vein.

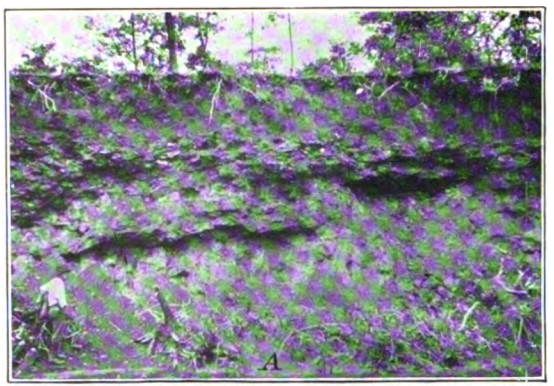
The ore sheet here has in most places a conglomeratic aspect, although so compact that it forms a continuous unbroken and quite rigid layer (pl. VIII, A). It is composed mainly of many bowlders of limonite

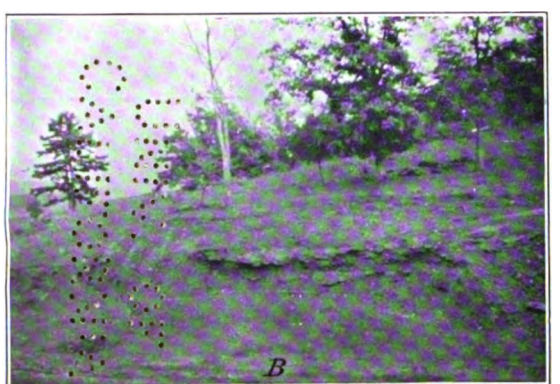
and a few of quartz and schist in a matrix of micaceous sandy limonite. In some places globular masses of ore are cemented by a dense limonite or goethite exhibiting no characteristic structure, or by crusts of fibrous goethite that were evidently deposited in open spaces between fragments. The structure of the layer is distinctly platy (pl. VIII, C), because of the fact that many of the bowlders are flat and partly because there are in it many lenses of decomposed schist, similar to that underlying the ore bed. Many of the quartz pebbles are fractured and the cracks are filled with iron hydroxides. The cement of the ore is in general very porous. Some of the pores are now completely filled with soft limonite and others are lined with fibrous goethite. The mica plates so abundant in it evidently represent the partially decomposed ottrelite plates that are so common in the Andrews schist.

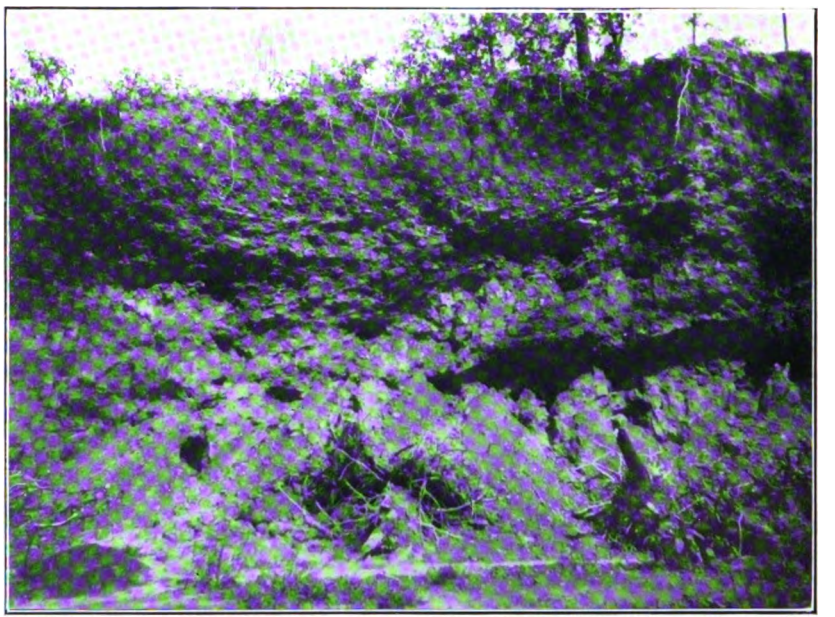
Below the ore bed is a mass of sand that represents decomposed Andrews schist. It is thinly layered like the schist, and the layers are as a rule complexly distorted. Just under the ore, however, the layers of the schist become parallel to the ore-bed and many schist streaks are interlaminated with the ore, especially at its base. This parallelism of the schist layers with the ore-bed is thought to be due to slumping occasioned by the weight of the ore. The underlying sand is almost free from ore particles. Occasionally there is a little limonite vein in the foliation planes, but there are in it no large pieces of ore.

Above the ore is a 3-foot layer of an obscurely bedded mass of mixed sand, ore fragments and pebbles of quartz. At its base, immediately over the ore, is a thin layer of pebbles and sand. This grades upward into a red sand and this into soil. Although the evidence is very weak, nevertheless it appears to indicate that the ore rests on an old erosion surface and that another old surface is just above it.

From the property, which when formerly active was known as the Lena Walker Mine, 13 cars of float ore were shipped and 65 cars of ore were taken from the opening at the east end of the hill. The mine was reopened in November, 1919, and a steam shovel and washer were installed to recover the ore in the sand above and beneath the ore sheet as well as from the ore sheet itself. Between November, 1919, and April 21st, 1921, when the mine was again closed, production was at the rate of about 70 tons of washed ore daily, containing an average of 48.5% Fe and a moisture content between 2% and 4%. The total shipments between October, 1919, and August, 1920, were about 11,000 tons. The







C

VIEWS IN MINE OF SOUTHERN IRON MINING COMPANY NEAR ANDREWS.

A. General view of ore-bed.
B. West end of ore-bed, showing parallelism with surface.
C. Detail of ore-bed, showing detrital character.

overburden of loose material above the ore-bed yielded about ¼ ton of ore to each ton of material handled and the ore bed a little less than ¾ ton (about 1,450 pounds to the ton).

In Nitze's report (l. c. p. 205) the "Sharp place" is described as being 3 miles from the point at which the ore belt crosses the river, but the description fits the Lena Walker place. If the two names refer to the same place his statement that "in one of the prospect shafts marble was found at a depth of 32 feet below the ore by means of a sounding bar," is of interest. Keith does not map any marble in this vicinity, but, since it is not exposed, it may easily have been missed, and the southeast boundary of his marble area may have been placed a trifle too far north.

If the ore layer is continuous over the area between the Luther property and the Southern Iron Mining Company's land and has as wide a spread over the last named property as seems to be indicated by the explorations that have been made on it, and the yield of merchantable ore that might be obtained from it is as great in proportion as that now being recovered at the Southern Iron Mining Company's pit, there is probably available in the vicinity of the mine about 600,000 tons of ore.

Deposits between Southern Iron Mining Co.'s Mine and Andrews:—Between the Southern Iron Mining Company's plant and Andrews, a distance of 3 miles, there are no mines. The country is mapped by Keith as being underlain by a strip of the Andrews schist about ½ mile wide all the way to Andrews. This is bounded on the south by the Murphy fault and on the north by the Murphy marble. As the country is flat and only a few exposures exist, it is probable that the mapping is only approximately correct. It is possible that the strip of schist is much narrower than mapped, as a ledge of material resembling decomposed marble was noted on the highway 1½ miles west of Andrews in the area colored for Andrews schist. No evidence of the presence of the Nottely quartzite was seen anywhere between the Lena Walker property and Andrews. At several points, however, ore has been uncovered near the highway to Andrews, but at no place has mining been undertaken seriously, though a number of carloads of ore fragments were shipped from several of the openings during the exploratory operations.

The more promising explorations are on the land of Mr. Ensley, about ⅘ of a mile northeast of the Southern Iron Mining Co.'s plant, where there are 4 shallow trenches in the hill back of Mr. Ensley's house; on the property of Mr. D. P. Adams, about ½ mile farther

northeast, where 4 or 5 cars of ore are said to have been shipped from a pit on the west side of the highway; on the farm of R. W. Luther about a mile farther northeast, where there is a large pit on the east side of the highway; near the church, ¼ mile farther northeast, where there are several old pits to the west of the highway on both sides of the road running northwest to the railroad and another on the road running east from the church, and on the property of Mr. C. M. Schlagel, ¼ mile east of the highway, on the outskirts of Andrews about ⅞ mile southwest of the Andrews railroad station.

At the Ensley place the pits show some ore but it is not in distinct veins. On the east side of the highway, however, on the northwest slope of a small hill is the outcropping of a very distinct vein which is persistent for several hundred feet. The size of the vein is not determinable but much of the float is in such large fragments that its width is probably several feet.

Near the church is a shallow pit in decomposed Andrews schist. On its walls, which are much weathered, is a breccia of schist fragments cemented by iron hydroxides and cut by small veins of limonite. Above this, and reaching to the surface, is a layer of conglomeratic ore like that farther southwest. The exposures are poor and there is nothing to show whether the opening is in a small local deposit or whether it cuts into the blanket deposit that is so prominent at the Southern Iron Mining Company's plant. The pit on the Luther place shows no blanket ore. It exposes a series of small veins.

The Schlagel occurrence is on a little hill covered with ore bowlders. On its slope are two shallow pits that reveal nothing as to the source of the bowlders. Two carloads of ore fragments taken from the holes and picked from the surface in July and August, 1918, yielded on analysis Fe 45.80% and Mn 1.18%. Since the pits are not far from the position of the Murphy fault as mapped by Keith, it is possible that the ore fragments came from a deposit in the fault fracture.

Ore Reserves Between Jenkins Place and Andrews

It is impossible to estimate the quantity of available ore in the strip of ore-bearing rocks between the Southern Iron Mining Company's land and Andrews because of lack of exposures and the scarcity of explorations. There are unquestionably some deposits in the strip that would yield a few tons of ore; but there is no evidence at present that their yield would be commensurate with that of the mines farther southwest.

DEPOSITS BETWEEN ANDREWS AND TOPTON

Northeast of Andrews the syncline of marble and Andrews schist that is so marked a feature in the Valley River Valley southwest of Andrews disappears a few miles from Andrews. Beyond it to Topton there remain only a few patches of marble that represent its bottom. Elsewhere the entire syncline has been eroded and the great Murphy fault, already referred to, separates a strip of Valleytown formation from a strip of Nantahala slate (pl. I). Along this fault are a few deposits, but none of them give promise of successful operation under present economic conditions. So far as now known they are comparatively small and are not in compact veins. There are only two points at which explorations have been made. One is on the crest of the little hill on the east side of the railroad track about 500 feet south of Rhodo Station. Here there are 3 small trenches that uncover a little ore that appears to be a horizontal vein or a thin blanket deposit like that on the Lena Walker property, south of Andrews (p. 37). The other is about 1,600 feet north of Topton on the east side of Red Marble Gap. Here the Nantahala black slate is mapped by Keith as being in contact with the Tusquitee quartzite, which lies above it. The ore occurs at this contact where the conditions are somewhat similar to those further southwest. In both cases quartzite lies above a schist and ores were deposited at their contacts. Very little is known about the Red Marble Gap occurrence. The openings have nearly been obliterated. Nitze (l. c. p. 206) states that the deposit is 20 feet thick and that it dips toward the southeast.

DEPOSITS IN THE ANDREWS AREA

General:—Attention has already been called to the fact that the Murphy fault makes a sudden turn at Andrews, running south for a mile to the mouth of Snyder Creek, then southwest for ¾ mile, where it apparently is cut off by another fault that trends northeast and continues the general fracture so prominent southwest of Andrews. Where this fault crosses Junalaska Creek it is joined by a short fault that extends for several miles in a little more northerly direction and then dies out. The triangular area enclosed by the faults west, south and southeast of Valleytown is occupied by a crescentic area of Murphy marble to the northeast and a surrounding crescent of Andrews schist to the southwest. The Andrews schist is bounded by the faults which separate it on the surface from the Brasstown and lower formations. In the

Andrews schist and along the faults that limit the area on the southeast are several mines and a number of prospects that are being seriously considered for exploitation in the near future.

Washburn Place:—Northeast of Andrews there is one deposit on the strike of the deposits in the Valley River belt to the southwest. This was described by Nitze (l. c. p. 206) as occurring on the Washburn place, ½ mile north of Valleytown, on the south side of Valley River between the mouths of Tatham and Junaluska creeks, which is not far from the position of the contact between the Murphy marble and Andrews schist as mapped by Keith. The occurrence is described as consisting of two outcrops, one of which was 75 yards a little south of east of the other. One exposed 18 feet and the other 25 feet of a compact, massive ore. This is the place later worked by J. Q. Barker and from which about 150 tons of ore were taken. There are 3 pits on the sides of a little hillock about 750 feet east of the Andrews Lumber Company's plant. The vein is said by Mr. Barker to trend northeast and then to bend to the southeast, following in general the direction of the contact between the marble and the Andrews schist as it makes its turn toward the south into the Tatham Creek area. The largest pit is about 150 feet long and its bottom is from 10 feet to 15 feet below the water level. There was no evidence that the limonite was changing to pyrite with depth, as is the case where limonite is a surface oxidation product of pyrite deposits. During the course of the operations some bowlders measuring 30x40 feet were mined, indicating the existence of a large vein somewhere in the vicinity. None of the ore was washed, only the coarse, hard material being saved.

Swan Property:—The first openings southeast of the Washburn place are two pits on the property of Mr. G. W. Swan near the junction of the road to Valleytown and that up Snyder Creek. The larger is a trench 10 feet wide and 70 feet long trending N. 15°-20° E. Its walls show a number of small veins dipping about 25° S. E. No compact ore is now visible, though it is said that some ore was shipped without washing. A second pit a few hundred yards further southeast is just east of Valleytown. It is a shallow opening 70 feet by 40 feet in a wash ore. These two pits must be near the contact of the marble with the Andrews schist, as mapped by Keith, or within the schist near the contact.

Ferebee & Young Mine:—The next openings in this direction are those of the Ferebee and Young Mine, about ¾ mile nearly east of Valleytown at the junction of the road from Valleytown to Topton

and that leading northwest from Junaluska Creek. Here are several openings, from one of which about 200 cars of ore were shipped.

One of the openings is a small pit on the side of the road leading northwest to Topton, where there is a deposit of loose ore about 8 or 9 feet thick lying under calcareous schists dipping 45° S. E.

Most of the ore that was shipped came from a large pit 150 yards from the road, near the top of a little hill, and near the fault bounding the Andrews schist on the southeast. This pit has a length of 125 feet in a direction N. 80° E., which is believed to be the trend of the vein, a maximum width of 70 feet and an average depth of 17 feet. The rocks associated with the ore appear to be contorted and crushed, as though in a fault zone. The ore-ledge in the bottom of the mine consists of many thin layers of limonite separated by sandy layers, the whole measuring about 9 feet wide, and having a high dip to the south. The mining operations followed this ledge in a general way, but the whole area of the pit was worked. In some places the material was simply scraped up and loaded into trucks without washing or even forking. In other places the material was screened and shipped. When the harder rock under the mantle of disintegrated material was reached the place was abandoned.

It is reported that near the surface about 50% of the "dirt" was iron. With greater depth the iron content diminished to 45%. At a depth of from 12 to 15 feet the material became so poor in iron that it no longer paid to ship it. A glance at the bottom of the pit reveals the fact that there is still a great quantity of ore in it, but that it will require washing before it becomes salable.

Analyses of the ore as shipped without washing or cobbing are given below. In the second series the effect of increasing depth on the quality of the ore is well shown.

	SiO_2	Fe	Mn	P	Analyst
Mar., 1917, 1 car	5.46	53.00	.78	.46	Va. I. C. & C. Co.
Oct. 3, 1917	11.90	50.40	.41	1.03	Intermont C. & I. Corp.
Mar., 1918, 17 cars	7.93–10.93	46.06	.37–.92	.35–.65	Va. I. C. & C. Co.
April, 1918, 6 cars	11.15	49.80	.49	.35	Roane Iron Co.

	Mar. 1917	Aug. 1917	Sept. 1917	Oct. 1917	Nov. 1917	Dec. 1917	Mar. 1918	Apr. 1918	June 1918
Fe	52.40	52.75	51.57	50.06	51.46	47.84	46.06	49.80	52.30
No. of cars	3	1	7	9	18	10	17	6	2

Samples of selected ore gave:

	SiO_2	Fe	Mn	P	Analyst
Road cut	12.48	46.70	3.37	1.008	Intermont C. & I. Corp.
Road cut	3.63	56.01	.00	1.22	F. P. Drane, Charlotte.
Hill opening	3.23	58.11	tr	.90	F. P. Drane, Charlotte.
Creek opening	.90	2.56	55.16	.113	F. P. Drane, Charlotte.

The last sample was taken from a small hole on the creek south of the opening on the road. It is evidently from a small vein of pyrolusite.

There are no other ore pits and no exposures of brown ore anywhere in the immediate neighborhood of the mine. It is reported, however, that trenches and pits have uncovered limonite in Ingram field, which occupies the valley extending from the Ferebee and Young Mine westward to Junaluska Creek. The ore is probably underlain by the Murphy marble and the Andrews schist, for in an old pit for manganese on the east bank of the creek where it crosses the valley, is exposed a broad expanse of contorted calcareous schist resting on a white marble that dips southeast.

About 300 yards southwest of this point, on the west side of the road up Junaluska Creek several openings and a shaft have been made in search for magnetite. Bowlders of magnetic ore were scattered over the surface and through the soil in which the pits and shaft were dug, but no ledge was encountered. A line of magnetic attraction is said to run southeast to the point of a projecting hill of Nantahala shale. The source of the ore is unknown.

Rogers Opening:—The road leading up Tatham Creek follows very closely the fault between the Valleytown formation and the Andrews schist, which forms the western boundary of the Valleytown area. Near or on this fault are some of the largest deposits in the area, one of which is now being worked by the Marvacar Mining Company. The most northerly deposit that has been uncovered in this portion of the district is about 100 yards east of the road opposite the residence of J. R. Rogers, which is about ½ mile south of the junction with the Valleytown road. Here an open cut 150 feet long and from 40 feet to 70 feet wide has exposed a series of sandy schists striking about N. 50° E. and dipping 50° S. E. These schists are traversed by a number of small veins forming a stockwork about 20 feet wide. Many of the veins are an inch or two in width but more are larger. They are so closely spaced and there are so many of them that the whole would appear to offer a promising opportunity for a washing plant.

A

B

MARVACAR LIMONITE MINE, NEAR ANDREWS

A. General view of south end of open cut.
B. Near view of vein in same cut.

Marvacar Mining Company's Property:—About a mile south of the Rogers opening is the large pit of the Marvacar Mining Company (pl. IX). This is the only operating mine in the district. It was formerly operated by Cover & Porter and later by Griffith, Middleton & Co. In September, 1920, the Marvacar Mining Company was incorporated. This company secured the mineral rights on 201 acres of land and immediately began plans to operate on a large scale.

The present workings consist of an open cut, 550 feet long by about 100 feet wide, and varying in depth from a few feet to 50 feet. The opening follows a ledge of dark compact ore striking N. 50° E. and dipping 65°-70° S. E. There is an 18-foot vein of ore of which 10 feet is hard and compact in the southeast wall and this constitutes the principal source of the shipping ore, though the whole pit is in material that furnishes a satisfactory wash ore. The foot wall of the main vein is a micaceous sandy schist and the hanging wall a red and white clay that may be a fault gouge. The overburden varies in thickness from 1 to 10 feet, and much of it contains enough ore to pay for washing.

It is said that 6 drill holes put into the bottom of the pit 30 feet northwest from the outcrop of the vein bottomed in ore. Assuming that the width of workable ore is 50 feet, there is present under the pit, for every 30 feet of depth, about 80,000 tons of merchantable ore. It is reported by the men in charge of the washing that under normal conditions the material going to the washer would yield 3 tons of washed ore containing about 50% Fe to 4 tons of ground excavated.

Sandy schists containing ore veins extend for some distance to the west of the main vein, and prospect trenches cut in the hill 500 feet west of the pit indicate that the ore-bearing zone may cover a strip of country at least this wide. The westernmost row of trenches has uncovered ledges showing several veins from 2 to 3 feet wide and a number of thinner ones closely spaced through a width of 18 feet. The soil covering the ledges is only a few feet deep, but everywhere it contains numerous fragments of ore.

About 24,000 tons were shipped from the property between April, 1917, and December, 1918. During a portion of 1919 the mine was shut down temporarily, but in 1920 it was shipping about 50 tons daily until the end of the year, when it was again shut down. During the summer of 1921 mining was suspended, but a little work was being done to prepare the mine for more economical operation. It is interesting to note the use of hydraulic methods for removing the overburden and washing the sand from the ore. Water for the system is drawn from a branch of Tatham Creek.

The ore is broken down by very light charges of dynamite, is elevated by a steam shovel and hauled by a light locomotive over a narrow gauge track 2,000 feet to the washing plant on the Andrews Manufacturing Co.'s railroad and then on this logging road 1¾ miles to Andrews. Formerly about 2 cars were loaded daily, but the property is now being equipped to load 3 or 4 cars daily.

The following analyses of carload lots represent the composition of the shipped products.

		Fe	Mn	P	SiO_2
Nov. 17, 1917	Four cars	49.00	.64	1.00	8.40
Nov. 28, 1917	Two cars	41.00	.40	.52	17.92
Nov. 28, 1917	Three cars	49.60			7.84
Dec. 17, 1917	Two cars	44.00	.26	.76	11.00
Dec. 17, 1917	Four cars	45.40	1.12	.54	10.10
Mch. 18, 1918	Nine cars	51.21			
April, 1918	Two cars	51.90			8.91
June, 1918	Thirteen cars	51.73			

J. W. Walker Property:—The J. W. Walker property is about ⅓ mile southwest of the Marvacar Mine near the junction of the two faults limiting the east and west sides of the Valleytown area.

The property is under the control of the Southern Iron Mining Co. but is not now being worked. Explorations have been made by means of trenches and pits on the crest and northeastern slope of a hill overlooking a branch of Tatham Creek. There are five large openings in

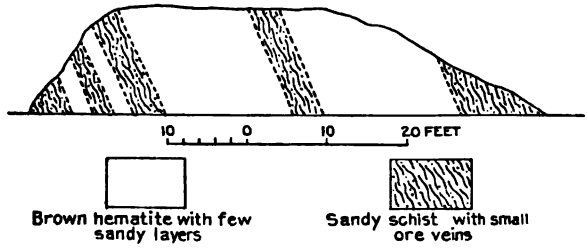


FIGURE 7. Section across end of pit on J. W. Walker property, near Andrews, N. C.

the hill and several small trenches exposing ore for a distance of 700 feet in length and several hundred feet in breadth. These openings were made for exploratory purposes, but during the explorations about 60 cars of ore were shipped. The rocks in most of the openings dip 55° S. E., but in the large pit that is farthest east the dip of the vein is nearly vertical. The loose ore was separated from the sand of the decomposed schist by hydraulicking, forking and screening. In addi-

tion hard ore was broken from the steep quarry-like faces of some of the pits and shipped without further preparation. At the large opening on the south side of the top of the hill there has been exposed a wall 60 feet long that shows about 30 feet of ore, in two veins 17 feet and 15 feet wide, separated by 3 feet of sand, and a number of smaller veins from 1½ feet to a few inches wide. Some of the ore in the wider veins could be shipped without washing, but much of it and most of that in the smaller veins and in the sand between the veins (see fig. 7) would have to be washed to become salable.

The following analyses of shipments made to the Roane Iron Co. indicate the character of the product that may be furnished without washing and without further cobbing than the rejection of sand in the pit. There is added for comparison the analysis of a sample composed of material taken from the 5 openings on the property, quartered and washed.

Analyses of carload lots of dried material, unwashed. 1918.

	July	July	Aug.	Aug.	Aug.	Sept.	Oct.	Oct.
Fe	46.50	43.30	46.70	45.90	47.90	42.80	40.50	44.10
Mn	.39	.45	.69	2.36	.98	.88	.34	.64

Analysis of 8 cars unwashed ore and sample from 5 openings. Dry.

	Fe	Mn	P	Al_2O_3	Insol.
Eight cars, Sept., 1918	44.04	1.02	.84	4.57	20.15
Sample from 5 openings	48.41	2.36	.349	--------	12.65

The Walker property appears to be well situated for working. Water can be obtained by ditch from Tatham Creek and delivered 40 feet below the main openings. It can then be pumped to the pit and utilized for carrying ore and sand to the bottom of the hill where separation can be accomplished by washing. An outlet to Andrews might be provided by building a spur of ¾ mile up Tatham Creek from a logging road already in operation.

The southwesternmost openings in this area are several pits between Tatham Creek and the road on its southeast side, some of which are on the property of Geo. Walker, about ⅛ mile from the pits just described. They are now filled. About 20 cars of ore were shipped from them before the place was abandoned. The rocks in their vicinity strike a little east of north and dip 85° E.

ORE RESERVES IN THE ANDREWS AREA

If the ore-belt is continuous from the Marvacar through the Walker property, the quantity of ore in the southwest corner of the Andrews area must be very large. Unfortunately, however, we are not yet sure that the veins extend between the two. An estimate of the ore that is available in this portion of the area, based on the explorations that have been made, indicates the existence within 70 feet of the surface of about 1,350,000 tons. Most of the ore elsewhere in the area is unavailable at present. Some of the deposits might be worked on a small scale for a short time, but so far as is now known, they could be operated only to a shallow depth, because, since the area is one of low relief, the underground water level is close to the surface except at a few places. It is probable that the deposit at the Ferebee and Young Mine might furnish considerable wash ore, but the product would have to be hauled 1½ miles to Andrews for shipment, unless a spur were built down Ingram field to the Andrews Company's logging road at Junalaska Creek.

DEPOSITS IN THE NOTTELY RIVER BELT

The extension of the Valley River ore belt to the southwest as far as the State line has been called the Nottely River belt, since it follows very closely the course of this river all the way to Georgia (pl. I). As a rule the syncline is much narrower to the southwest of Murphy than it is between this city and Andrews and the Andrews schist is not as well

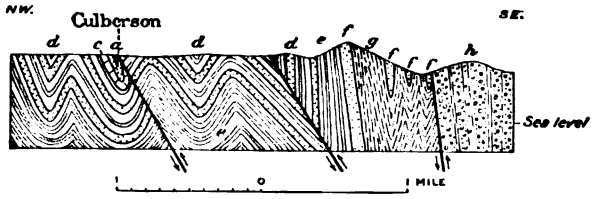


FIGURE 8. Northwest-southeast section across Nottely River belt at Culberson, N. C. *a*, Nottely quartizite; *c*, Murphy marble; *d*, Valleytown formation; *e*, Brasstown schist; *f*, Tusquitee quartizite; *g*, Nantahala shale; *h*, Great Smoky formation.

developed. The rocks are closely folded so that their dips are usually high (fig. 8). Moreover the Murphy fault traverses the fold nearly along its axis. The close folding and the position of the fault account for the narrow width of this portion of the syncline. Because the syncline is more depressed to the southwest than toward the northeast (see p. 13), and because of the close folding, the Nottely quartzite has been more completely protected from erosion in this portion of the syncline than

further northeast and has consequently been preserved as a low ridge flanking the Murphy branch of the Louisville and Nashville railroad nearly all the way to the State line. West of the quartzite is a narrow strip of the Murphy marble which at Kinsey was formerly quarried and in many places has been worked for talc. East of the quartzite is a comparatively narrow belt of the Andrews schist and east of this the trace of the Murphy fault. The fault in some places passes very near the quartzite, so that the belt of Andrews schist exposed at the surface is reduced to very narrow limits. In other places the fault passes through the Andrews schist and consequently there are at these places wider patches of the schist between the quartzite and the members of the Valleytown formation. At one point near Ranger, a very narrow strip of the Murphy marble is between the Andrews schist and the fault line, but this is the only outcropping of the marble known on the east side of the quartzite.

The ore deposits in the Nottely belt are confined mainly to the neighborhood of the fault. That is, so far as known, most of them occur only on the southeast side of the Nottely quartzite ridge. A few pits have uncovered deposits on its northwest side but they are small and unimportant. No mines have been developed, but from a few openings in the neighborhood of Culberson small shipments have been made from time to time.

On the southeast side of the quartzite ridge, on the other hand, are numerous evidences that an ore belt is nearly, if not quite, continuous all the way to the State line. Many pits and small exposures on or near the highway from Murphy to Culberson have shown the presence of deposits all the way. Only on the Fain-Hitchcock property, however, have any large explorations been attempted (see p. 18). Most of the openings are small pits that have not reached the solid ledge; consequently there is no means of learning whether the veins are large or small. Usually only soft ore was encountered and because of this the openings were abandoned. No recent attempts have been made to test the material as a source for wash ore.

One of the most promising of these deposits is the Rogers prospect near the mouth of Cane Creek where it crosses the quartzite ridge just before entering Nottely River about three miles southwest of Murphy. Here ore appears to be between the quartzite and Andrews schist. It is opened by a comparatively large pit, just east of the railroad track, exposing a yellow or yellowish-brown and sandy ore containing many little rhombohedral or cubical masses of limonite that represent decomposed ottrelite plates, indicating that the ore replaced Andrews schist. North-

east of the pit near the railroad are 5 other pits that carry the ore-bearing zone about ½ mile further in this direction. Some of them are large, and from them a great deal of ore must have been taken. It was apparently all loose ore that required washing. Much of the ore is manganiferous and some of the pits have yielded manganese ores of shipping grade. There is no means of estimating the quantity of ore in the deposits, but if the ore-belt is 20 feet wide through the entire ½ mile about 60,000 tons are present within 50 feet of the surface.

A small pit in the woods about 1,000 feet north of the pit on the railroad shows that ore is on the northwest side of the quartzite as well as on its southeast side, and exposures on the track of the Louisville and Nashville Railroad indicate that the mineralized zone extends at least 3 miles farther southwest. But the exposures are all small and the veins uncovered are all narrow, so that the quantity of ore on the northwest side of the ridge is probably inconsiderable in quantity.

On the southeast side of the ridge, farther to the southeast, are a number of pits and several fairly large exposures revealing the presence of much wider veins than those on its northwest side. Most of the exposures are on the highway between Murphy and Culberson, and the pits are near this road on either side. An exposure of manganiferous ore is at the road corner about 650 feet southwest of the bridge over Cane Creek, a cut in red ocher is on the road and a pit is just east of it on the property of W. P. Hall, about 2,000 feet farther southwest, and other exposures are at about equal intervals between the Hall property and the corner of the road to Kinsey.

Between this corner and the junction of the highway with the road to Ranger are 4 more exposures on the main road, and two pits on the west side of the road in the Andrews schist near its contact with the quartzite. Neither of the two pits shows any ore in its wall, but the dumps are so filled with small fragments of limonite as to suggest that the deposits might furnish wash ore in fair quantity.

Near the corner of the highway and the road to Ranger ore is much more abundant. About 750 feet northeast of the corner is an exposure in the stream-bed just east of the road and in a cut on the Ranger road a few yards northwest of the corner is another. On the northest bank of the cut is a small pit in the same veins as are exposed in the cut, but neither in the cut nor in the pit can the width of the mineralized zone be determined. It is reported by the residents in its vicinity that some ore was shipped from the pit. These deposits are all near the trace of the Murphy fault. On the map (pl. I), they are designated the Speed and Kirkpatrick prospects.

The largest deposit in this region is opened at the southeast side of the quartzite ridge, on the southwest side of the Ranger road just east of the railroad crossing. At this point is a pit several hundred feet long well up toward the crest of the ridge and just east of a large quartzite quarry. The pit has been abandoned for some time and therefore shows no solid ledge, but from its size it is evident that it has yielded considerable ore. Here and there are small seams of sandy ore in very much disintegrated schist. Their strike is N. 40° E. and dip about 75° S. E.

Another group of deposits is exposed by a series of trenches and a tunnel at the southwest end of the same quartzite ridge—the Carroll prospect. Like the pit at its northeast end, the trenches are on the contact of the quartzite and the Andrews schist. There are a few narrow seams of ore in the schist but most of the ore appears to consist of bowlders in its disintegrated upper portion. About 1,500 feet farther east, on the southeast side of the highway, are two other pits, likewise in loose ore, and a few yards west of them is an exposure of ore in the road. These are near the Murphy fault line. If the strip of country 500 feet wide between the various pits and exposures is everywhere as rich in ore as is indicated by the character of the material in which the pits have been sunk, it contains a large quantity of ore suitable for washing.

At this point the syncline widens and a narrow belt of the Murphy limestone lies between the Andrews schist and the Murphy fault trace. Only one distinct exposure of the marble is known to occur, and that is in the large spring north of Carroll's corner, but the east slope of the hill to the southwest is covered with the kind of white sand that is known to result from the decomposition of the marble elsewhere, so that there can be little doubt that it is underlain by the marble.

Here the highway turns south and crosses the fault line, and for the rest of its distance to Culberson runs over rocks of the Valleytown formation. Since it nowhere crosses onto the Andrews schist belt it cuts no more ore exposures.

The quartzite ridge, however, continues its southwest course and crosses the Nottely River midway between the highway and the railroad. Most of the area between the highway and the river is devoid of exposures, but the quartzite can be traced across it by trains of bowlders. Near the river are a few exposures of the quartzite and about 1,000 feet from its bank is a little ridge which is covered with quartzite fragments. On the northwest side of this is an exposure of ore in veins and above this is a thin layer of conglomeratic ore. There is no likelihood

that the ore is in large quantity. The occurrence is interesting, however, as indicating the presence of ore on the northwest side of the quartzite.

About a mile farther toward Culberson, where the railroad passes through a narrow valley between two small hills, ore is again met with. The little valley is in marble. The hill to the southeast is mainly quartzite, but on its southeast slope is a pit from which some ore has been taken. Nothing is known of the size of the deposit, but the float indicates that the ore zone extends the full length of the hill. Southeast of the pit the land is low and there are no exposures for a distance of 500 feet. Beyond this the rocks are sandy slates that are probably Valleytown. The interval between the slates and the pit may be underlain by Andrews schist, in which case the ore is on the contact of this rock and the quartzite. If the underlying rocks are Valleytown the deposit is on the Murphy fault plane.

No other deposits were seen on either side of the quartzite until Culberson was reached. This is about ½ mile from the State line. On the road running northwest from the railway station is an exposure of ore on the northwest side of the quartzite, and a little farther west, on the northwest side of the main road, are three pits near the contact of the marble with the Valleytown formation, from which it is said large quantities of ore were once taken for the use of local forges. The pit walls are now covered with weeds and nothing can be seen in them, but the old dumps still contain a great many ore fragments.

Other exposures and pits mark the position of an ore belt on the northwest side of the quartzite all the way to the State line and just across it, in Georgia, exposures and pits prove the existence of ore on both sides. Much of the ore near Culberson is highly manganiferous, and some is composed largely of pyrolusite. In no case do any of the deposits appear of commercial importance.

ORE RESERVES IN THE NOTTELY RIVER BELT

There appears to be no good reason why there should not be ore deposits in the Nottely River belt, south of the Fain-Hitchcock Mine, of the same magnitude as those farther north, since the geological conditions are the same in both portions of the ore-bearing belt. There is, however, no evidence that large deposits occur in the southern portion of the belt. There are several deposits from which a few thousand tons of ore might be obtained, but none, so far as known, that would yield a large production. The most promising deposits are those near the

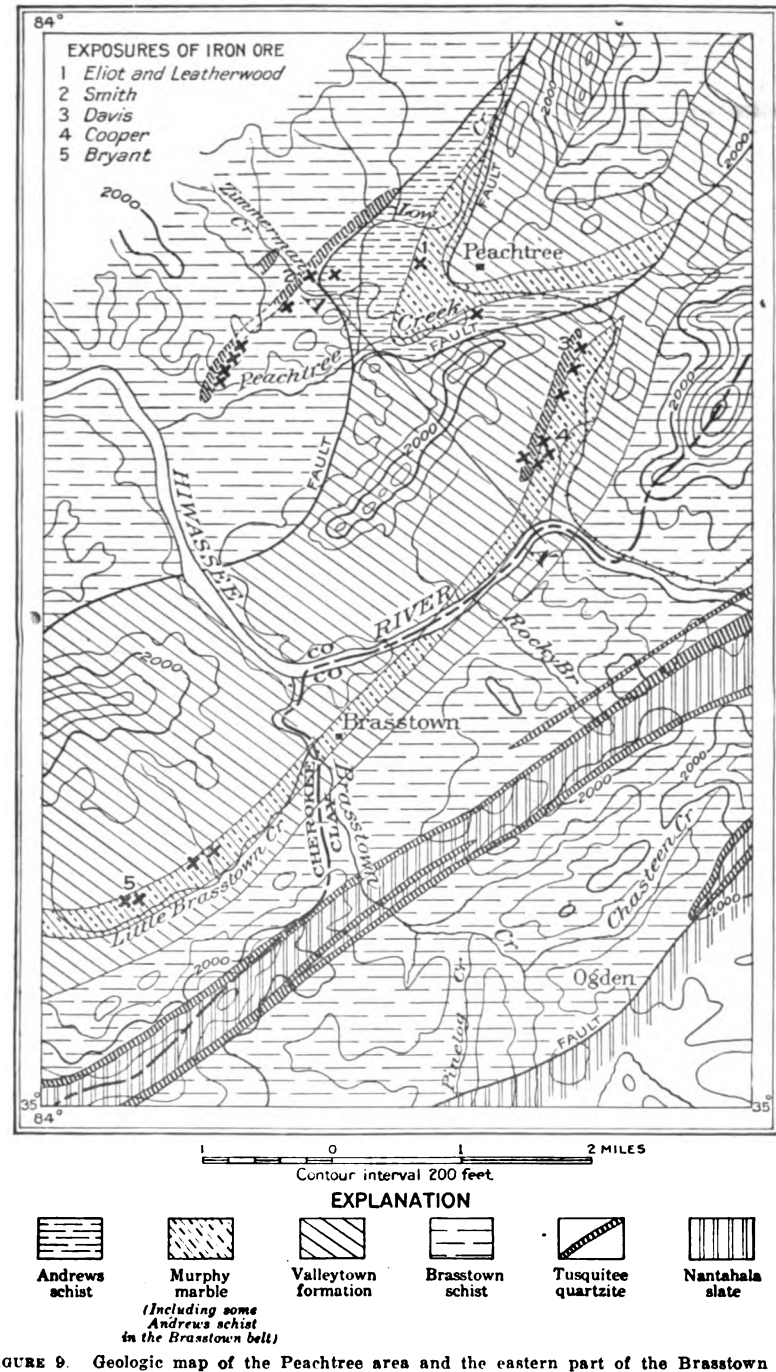


FIGURE 9. Geologic map of the Peachtree area and the eastern part of the Brasstown belt, N. C. *A-A'*, Line of right-hand portion of section, figure 9.

mouth of Cane Creek. There may be others equally as large, which explorations have not discovered, but the covering of soil is so uniformly spread over the rocks of the area that outcrops are rare and the trace of the Murphy fault is difficult to locate.

ORE DEPOSITS IN THE PEACHTREE AREA

The village of Peachtree, 6 miles east of Murphy, lies in the concavity of a crescentic-shaped area of Murphy marble and Andrews schist produced by the erosion of an anticline pitching toward the southwest (fig. 9). The fold involves only the two formations mentioned, with the Andrews schist surrounding the marble on all sides but the northeast. A fault separates the Andrews schist from the Brasstown schist on the west, and another separates it from the Valleytown formation on the south and east. Both faults are indicated by Keith as dipping at comparatively low angle to the southeast. (See fig. 10.)

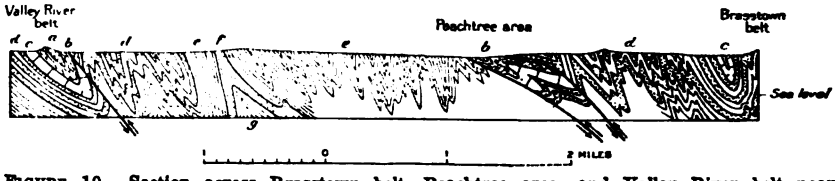


FIGURE 10.—Section across Brasstown belt, Peachtree area, and Valley River belt near Regal, N. C. *a*, Nottely quartzite; *b*, Andrews schist; *c*, Murphy marble; *d*, Valleytown formation; *e*, Brasstown schist; *f*, Tusquitee quartzite; *g*, Nantahala shale.

There have been no developments of ore deposits in the district in consequence of the lack of transportation facilities. With the opening to traffic of the Carolina and Georgia Railroad to Hayesville, it is probable that a more thorough knowledge of the resources of the district will soon be available. Because of the lack of exposures in the vicinity of the village few deposits are known to exist within the area underlain by the marble and Andrews schist, but nearly a dozen are known within a short distance of the village outside of this area.

One of the most promising looking of all the deposits is just west of Peachtree on the lands of Messrs. Eliot and Leatherwood, where two ledges about 20 feet by 35 feet rise a few feet above the general level of the valley. There are no other rocks in the neighborhood, but the position of the deposit is near that of the contact between the marble and the Andrews schist.

There has been no attempt to discover the extent of the vein, nor so far as known, has there been analysis of the ore.[1] It is clear from inspection alone that much of the vein could be shipped without washing.

[1] This exposure was opened during the Summer of 1924, but with what result is not known.

The only other evidences of ore in the area are a narrow ledge crossing the road, about half a mile north of the Eliot deposit, another crossing Peachtree Creek about ½ mile southeast of the Eliot ledge, and two openings in ocher, one near the junction of the Murphy and Zimmerman Creek roads, and the other about ½ mile north on the road running north from this junction. The exposure first mentioned appears to be near the contact of the marble and the Andrews schist, as mapped by Keith, and the second is in the Andrews schist near the fault separating it from the Valleytown formation. Neither is large enough to offer promise of affording much ore.

The first of the two openings in ocher is in a cut on the north side of the road very near the fault line. The material is a mass of red clay just west of exposures of white and pink clays that probably represent weathered calcareous layers in the Andrews schist. The second is also close to the fault, but it is also close to a ledge of quartzite which lies just west of it. It is a large pit, locally known as the Paint Mine, but it is so old that its walls have fallen in and are now hidden by a thick cover of weeds and brush.

The quartzite immediately west of the Paint Mine is not mapped by Keith as a separate formation. However, it extends southwest as a ridge which is flanked on its southeast side by ore deposits. It may be a thick bed in the lower portion of the Brasstown schists, but from its massive character it appears more likely to be a strip of the Tusquitee quartzite raised from beneath by folding.

Ore is exposed on the southeast side of the quartzite, a few rods west of the corner of the Zimmerman Creek and Murphy roads, at a few yards further south on the property of Mr. W. P. Smith, and again in a road cut 600 feet south of Mr. Smith's house.

Only one of these deposits is of more than passing interest. This is the one on Mr. Smith's property, about 200 yards north of his house. Here on a low hill are a ledge and many loose fragments of hard ore that would seem to indicate a vein 6 or 7 feet wide. It has not been explored, so no estimate of its value as a source of ore can be made.

Another and more lofty ridge of quartzite is a little further southwest. The quartzite is well exposed at the corner of the Peachtree and Murphy roads where it has been quarried for road metal. From this point it extends as a distinct ridge all the way to Zimmerman Creek, but beyond this point it has not been traced. It may be the southern extension of the belt of quartzite near the Paint Mine. All along its southeast side are exposures of ore or belts of ore float. The most notable deposits are at its southwest end, where for ½ mile from the

Murphy road exposures and heavy float ore are continuous. The largest exposure is about ⅓ mile from the road-corner, on the east side of a rough quartzite ledge which forms the crest of a little ridge near the base of the greater ridge. The exposure is a ledge of hard ore about 7 feet wide, and nearby is a small pit. There is no question of the presence of considerable ore in the belt, but it is doubtful if it is so concentrated in any one place as to constitute an important deposit.

ORE RESERVES NEAR PEACHTREE

The Peachtree area proper offers little promise for the development of large mining operations, though one or two of the deposits in it may furnish fair quantities of ore.

ORE DEPOSITS IN THE BRASSTOWN BELT AND THE MARTIN CREEK AREA

General:—Southeast of Peachtree is a second belt of quartzite, in the area mapped by Keith as being underlain by the Valleytown formation. This quartzite is not as well developed as that farther west. It is at the northeast end of the Brasstown belt of Murphy marble (see map and section, figs. 9 and 10) which begins at a point a little south of east of Peachtree as a narrow belt, nowhere more than ½ a mile wide, that has been mapped as extending for 7 miles to the western border of the Nantahala quadrangle, passing through the village of Brasstown. At the Monteith Mine on the divide between Little Brasstown and Martin creeks no evidence of the presence of marble was seen; consequently it may be assumed that the Brasstown belt terminates at this point. Another belt starts at the head waters of Martin Creek, a mile further west, spreads out over the valley of Martin Creek, and then contracts and again becomes a narrow belt running southwest to the Nottely River. This has been called the Martin Creek area.

THE BRASSTOWN BELT

General:—The marble strip passing through Brasstown is the exposure of a closely compressed syncline overturned to the northwest about 15° from the vertical. It is bordered on both sides by the rocks of the Valleytown formation. (See fig. 9.)

Ore deposits are known to occur on both sides of the marble throughout nearly its entire length, and at several points they were formerly exploited.

Deposits North of the Hiwassee River:—The most important deposits in that portion of the Brasstown belt north of the Hiwassee River are those on the west side of the marble near its contact with the quartzite already referred to above. If Keith's mapping is correct, the deposits are in the Valleytown formation between the marble and the quartzite. The topography, however, suggests that the marble or the Andrews schist may extend as far west as the ore-ledges, in which cases the deposits are in the calcareous rock at its contact with the quartzite.

At all points where observed the ore in this portion of the belt is hard and comparatively dense and is apparently in large quantity. At the J. van Davis place, about one mile southeast of Peachtree, and at the A. E. Suddeth place ¼ mile farther southeast pits have been dug and some ore has been removed.

At both of these places the ore is at the east contact of a narrow belt of quartzite, which if Keith's interpretation of the structure of the area is correct, is a bed of quartzite near the top of the Valleytown formation and overlying schistose beds of the same formation. The quartzite is persistent for several hundred yards to the northeast and appears at intervals for a mile to the southwest. The ore was not seen in place at either location, but it outcrops as narrow veins at several places in the road between them.

On the Davis property large fragments of almost pure ore occur on the slopes of a low hill in such great quantity as to suggest the presence of a wide vein near by, and at the Suddeth place is a pit with an old dump composed almost entirely of limonite gravel.

The largest and most promising ledges in this portion of the belt are on the property of J. W. Cooper about ½ mile south of the Suddeth property and west of the residence of Cyrus Witte, across a valley which is underlain by marble. There are here two ledges that are the outcrops of parallel veins about 300 feet apart. The eastern ore is exposed in a little cliff, which apparently marks the western boundary of the marble. The vein can be traced continuously for 500 feet as an almost solid ledge about 15 feet wide. It is admirably situated for mining. The western exposure is an accumulation of large fragments and rough ledges that indicate another vein about 15 feet wide at the surface. This has been traced by float for a distance of about 1,000 feet, where it disappears to the southwest under a valley filling. Between the two lines of ledges no rock is exposed, but the character of the soil indicates the presence of calcareous schists beneath.

Deposits South of the Hiwassee River:—South of the Hiwassee River ore is known to exist at Brasstown on the southeast side of the marble and at two points on its northwest side near the village. The ore on the southeast side is exposed in a small ledge just east of the post office. Northwest of the village about 400 yards east of Big Brasstown Creek, on the northwest side of the marble belt, is an old pit in an exposure that shows a closely crowded series of small veins of limonite. The ground in the vicinity is covered with fragments of ore so that neither the width nor the length of the series can be determined. The third point near the village at which ore is known to occur it about 400 yards south of that last mentioned and about the same distance west of the village. Two pits, dug many years ago, uncovered soft ore, but they are now so covered with brush that the character of the deposit cannot be seen.

Farther west there are several exposures on the road leading to Martin Creek and near the road on its southeast side are several pits and shafts from which small quantities of ore have been taken for local forges. They show that the ore belt is persistent and nearly, if not completely, continuous all the way to the Monteith Mine. South of the ore exposure marble ledges occur in some of the springs, and in the bed of Little Brasstown Creek, and a short distance south of the creek are exposures of the Valleytown formation. The best exhibit of ore is on the road near Rev. Gay Bryant's residence, about 2 miles from Brasstown. In a little cut in the road about 10 feet of ore have been uncovered, and in an old field on the opposite side of the road fragments of float ore of the same kind as that in the road are quite abundant. If ore is continuous between the two points the deposit will be worthy of careful exploration when transportation conveniences are furnished the country south of the Hiwassee River.

A little farther west near the point marked Ballew on the map of the Murphy quadrangle are several exposures on the road and in an old pit a short distance to the north but nothing of special interest is shown by them. South of the road, however, on the crest of a ridge of white sandy rock, is a large opening in a black, porous manganese ore which is composed mainly of pyrolusite. The ore is intimately associated with the white sandy rock, which in this place is probably decomposed limestone. The deposit is on the south side of the marble, probably near its contact with members of the Valleytown formation, for a short distance farther south are numerous exposures of a siliceous ottrelite schist.

All the other ore exposures in the valley of Little Brasstown Creek are of small veins cutting sandy schists lying between the marble on the

south and members of the Valleytown formation on the north. The sandy schists may represent a thin bed of siliceous limestone at the base of the Murphy marble.

A few evidences of the existence of ore are said to be present on the south side of the marble belt, but none were found except at Brasstown and near Ballew.

ORE RESERVES IN THE BRASSTOWN BELT

Until transportation facilities are provided for the country south of the Hiwassee River, it is futile to discuss the value of the deposits in this portion of the Brasstown belt. There is not in the entire belt sufficient ore to warrant the building of a railroad, and there is no deposit, so far as we now know, that is rich enough to furnish ore that could stand the cost of haulage to Murphy or to any point on the Carolina and Georgia Railroad. It is possible that at a few points mining might be prosecuted on a small scale for 2 or 3 years, but there is no likelihood that a large mine might be developed at any place.

North of the Hiwassee the case is different. The exposures on the Cooper property indicate the existence there of a comparatively large deposit, and the new Carolina and Georgia Railroad offers a convenient outlet for shipments. On the Davis property there is probably also a large, or at any rate, a fair-sized deposit. If the two deposits could be worked under one management so that the overhead charges could be distributed between them, their development might be profitable for a few years, at any rate. We have no means of knowing the depth to which the deposits extend with their surface widths, and so have no basis for estimating their value after their surficial portions have been removed.

THE MARTIN CREEK AREA

General:—The only mine in this portion of the district that was ever of importance was the old Monteith Mine about 3,500 feet west of Ballew, on the headwaters of Martin Creek about 5 miles south of Murphy. As has already been stated, the Brasstown belt of Murphy marble may end at the divide between the headwaters of Little Brasstown Creek and those of Martin Creek, and another area, beginning near the Monteith Mine, may follow down the valley of Martin Creek and up its west branch. It is possible, of course, that the two areas are continuous, since all rock between the headwaters of the two creeks is covered by sand. For the purpose of the present report the marble on Martin Creek is regarded as a separate area. (Map, fig. 11.)

The larger part of the Martin Creek area of marble occupies the valley of the main creek from near the Monteith Mine to the junction of the two roads along its sides four miles farther north. A narrow extension follows the principal western tributary to its source, then an eastern tributary of Cane Creek for a mile, and then down Gold Branch to its mouth. Few exposures of the marble are seen. The best are at the bridge crossing Martin Creek about ½ mile north of the Monteith Mine, where two low ledges show a definite strike and dip. A small exposure in a stream a few yards farther north, a ledge in Mr. Elliott's spring, occasional shallow cuts made by the tributaries of Martin Creek in which white clay is uncovered, and a few sink holes are about the only data, aside from topography, by which the main area can be outlined. The western strip extending down Cane Creek and Gold Branch is traced by sink holes east of Martin Creek Church, by an exposure in Cane Creek a few hundred feet west of Martin's Saw Mill, an exposure in the bed of Gold Branch near the crossing of the old road from Ranger to Belview, and finally by fragments of talc plowed from the fields near the mouth of the Gold Branch. According to Mr. L. E. Mauney, marble occurs also in the hill to the west of the mouth of the branch.

Limonite deposits have been discovered at the Monteith Mine, at several places along the west side of the marble area in the valley of Martin Creek and on the north side of its western extension, and in the valley of Gold Branch. At one or two points the deposits are large enough to have furnished ore to local forges, but none are thought to be worthy of exploitation at present.

The Monteith Mine:—The Monteith Mine is the best known of all the occurrences in this area. It is at its southeast corner, about 3,500 feet west of Ballew (fig. 11, No. 2). If the ledge of ottrelite schist exposed in the bed of Martin Creek, about 1,800 feet northwest of the old pits, is a member of the Andrews schist series, the mine is on the southeast side of the marble, at or near its contact with the slates of the Valleytown formation.

The old mine which is on Ham Stalcup's farm is now represented by a series of very old pits in a line striking about N. 70° E. Nitze (l. c. p. 207) states that the ore was mined for a forge 10 miles away. At the time of his visit the dimensions of the main opening were determined to be 600 feet long and 6 feet to 20 feet deep. The width of the ore was reported in the Tenth Census Report to vary between 4 and 10 feet. Its better portions were hard and flint-like, the softer being more siliceous, grading into a brown clay.

A sample taken from one of the cuts analyzed:

Fe=56.46; P=.691; P ratio=1.224

All the pits are now so overgrown that no rocks can be seen in them, nor can any ore be found on their dumps. From the great amount of work they represent, it is plain that the mine must once have been a very important one.

Other Deposits in the Martin Creek Area:—The next openings to the west were about 1,000 feet northeast of the residence of J. Martin, at the corner of the road between Martin Creek and Brasstown and that to Beaver Gap (fig. 11, No. 3). Here was a trench about 250 feet long from which it is said much ore was taken during the Civil War. Nothing can be seen as to the character of the ore, but from the material in the small dumps around the trench it is probable that it would require thorough washing before shipment. A pit about 700 feet north of the trench has also uncovered ore, the quality of which, however, is not known. About 350 feet east of the trench decomposed marble is exposed in the bed of a little stream. Between the two there are no exposures of any kind. It is probable that there is at the contact of the marble with the Valleytown formation.

Farther north, east of Mr. H. D. Elliott's house, ore is said to have been found by test pitting near the marble referred to above as exposed in the spring on Mr. Elliott's property.

No other evidences of ore are known in the main valley of the creek, but along the western extension of the area, forming the narrow strip running along the road to Ranger, are several old openings that can still be recognized as ore pits and a few depressions that are said to be the remnants of other pits that have been filled. None of them are important, although from several ore was formerly obtained. Two of these are a few hundred yards east of the Martin Creek Schoolhouse and north of the road, apparently between a narrow strip of marble to the south and a hill of slate to the north.

In the road west of the school house are exposures of decomposed marble and soft ocherous ore, but no considerable explorations have been made until the headwaters of Gold Branch are reached. The marble belt turns from the Cane Creek valley to that of the Gold Branch and follows this stream southward to the Nottely River, beyond which it has not been traced. The most westerly point in the valley of Cane Creek that is reached by the marble is about ½ mile east of the junction of the Ranger and Belview roads. It reappears as another very narrow strip at the Belview road about ½ mile southeast of the junc-

tion, runs southwest crossing the road down Price's Creek at the old sawmill and continues down Gold Branch to its mouth. A few hundred yards southwest of Mr. Suit's house on the new Belview road is a sinkhole, and just south of it is a small trench in soft ore (fig. 11, No. 6). On Gold Branch, at the bridge crossing, about ¼ mile to the southwest, is a large pit and trench on the south side of the stream, and a few feet down stream is a small exposure of brecciated talc and marble in the bed of the stream (fig. 11, No. 7). The pit, which is so old that it shows nothing in its dumps, is on the south side of the marble as at

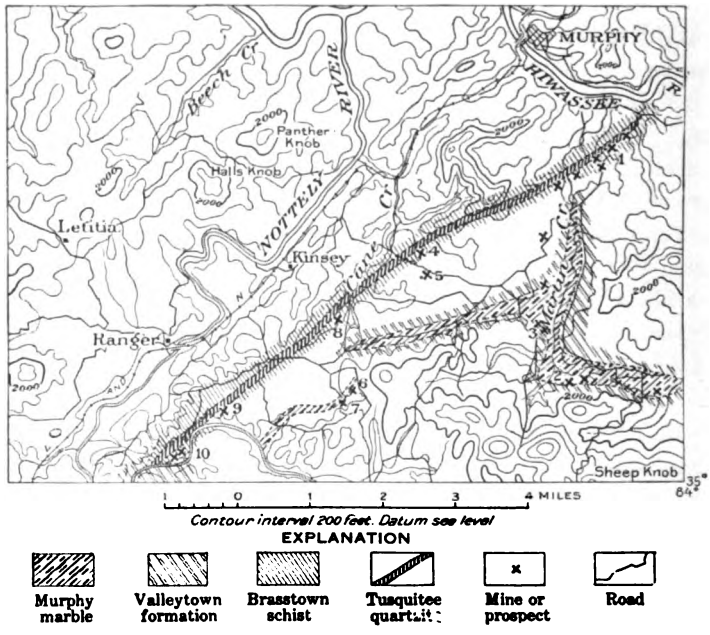


FIGURE 11. Map of Martin Creek area and Hiwassee-Nottely rivers belt, N. C., showing location of deposits of brown hematite.

Mr. Suit's house. It is reported that a number of tons of ore were removed from it and shipped to local forges, but no definite figures concerning the quantity can now be given. The farmers in the vicinity state that ore was taken from several pits in the stream valley, but, because of the fact that the whole valley has been dug over for gold, none of these could be identified.

No other evidences of the presence of ore in this belt were seen along the branch, though Mr. Mauney states that ore occurs in its channel near its mouth.

ORE DEPOSITS IN THE HIWASSEE AND NOTTELY RIVERS BELT

The fourth belt of deposits is on the southeast side of the quartzite ridge that stretches from the Hiwassee River about 2 miles above Murphy in a general direction S. 35° W. to the bridge crossing the Nottely River 1½ miles northeast of Culberson (fig. 11). The quartzite is nearly continuous through this distance, but at some places the outcrop becomes very narrow. On the road running south from Murphy, up the valley of Martin Creek, the quartzite is in contact on the south with black slates that are probably members of the Brasstown formation. It has not been determined whether the quartzite is also a bed in this formation or whether it is a narrow strip of the Tusquitee quartzite on the crest of an anticline. The series dips about 70° S. E., and the principal ore deposits are on its southeast contact with the slates. At the northeast end of the belt a second line of deposits is about 300 yards south of the main line. The ore here is also on the southeast side of a quartzose layer. In some places this quartzose layer is in contact with black slate and in others with a clay that resembles a decomposed calcareous schist. Some of the deposits on both lines were worked years ago, furnishing considerable ore; others have simply been explored. As a rule the ore is more porous and more ocherous than that in the Nottely and Valley river belts and usually much more sandy. Moreover, much of it, especially that in the more southerly line, apparently contains some hematite and much more than the usual quantity of manganese. Some of it is so rich in pyrolusite that it would pass as an ore of manganese.

The most northeasterly point at which ore is known to exist in this belt is about 1½ miles southeast of Murphy on the northeast corner of a hill overlooking the Hiwassee River. At this point is a fairly large opening on a vein about 34 feet wide dipping southeast. The hanging wall looks like a shaly limestone cut by quartz veins. The footwall was not seen, but to the northwest on the crest of the hill is quartzite. About 2,000 feet southwest of this is another opening near the crest of the quartzite ridge in which only about 10 feet of good ore are exposed. The hanging wall is a black slate. About 200 feet southeast of the eastern limonite vein is a 5 foot wide vein of hematite in red slates.

Other pits and ledges give evidence that brown hematite ore is continuous on the south side of the quartzite ridge all the way to the road leading from Murphy up Martin Creek. On and near this road, about ¼ mile south of the lower crossing of Martin Creek, on land belonging

to Mr. L. E. Mauney, are the two largest explorations in the belt (fig. 11, No. 1). This is probably the place referred to by Nitze (l. c. p. 207) as the Mooney place, ½ mile above the mouth of Martin Creek. Nitze describes the exploration as a "rectangular pit on the southeastern flank of a quartzite ridge; it shows a thickness of 18 feet of mixed ore, clay and shale; roughly estimated, over 50% of this material is ore, which is porous and ocherous. At one point of the bed the ore is solid for a thickness of four feet; the dip is 55° S. E. and the strike of the shales is N. 45° E."

A sample analyzed:

SiO_2	Fe	S	P	P ratio
15.42	48.02	.039	.201	.418

On the east side of the road is a deep trench 64 feet long with a shaft at its northeast end. According to Mr. Mauney, the owner of the property, the shaft, which is said to be 60 feet deep, was sunk in 1855. The trench is in thinly layered rocks striking N. 45° E. and dipping 45° S. E. On the road, northwest of the trench and about 100 feet distant, are road cuts in quartzite and graywacke schist and between these and the opening of the trench is an exposure of clay that seems to be a decomposed slate. No rocks but a few black slates were seen near the ore on its southeast side, but 800 feet distant in this direction is a tunnel 110 feet long, running into the slope from the northeast side of the road. The tunnel cuts about 20 feet of ore and for the rest of its length is in quartz schists. South of the ore are again black slates. About 60 feet northwest of the tunnel are other quartz schists and about 50 feet southeast is another trench. This also shows a little ore underlying a blue slate which is on its southeast side.

The relation of these ore veins is not clear. It is certain, however, that there are at least two veins of ore, each on the southeast sides of belts of quartzites and a third under slates. The latter, however, appears to be only a local development.

About ¼ mile southwest of the trench on the road, on the south side of another hill which is the extension of the hill north of the trench, is another opening. Here again the ore is at the southeast contact of the quartzite. In this opening the ore is said to be 49 feet wide, but of this width 6 feet is black clay. Its dip is 70° S. E. On the hanging wall is fissile black slate and south of this a few thin layers of quartzite which are apparently beds interstratified with the more slaty members of the

Valleytown formation. South of this quartzite are a couple of hundred feet of black fissile slates and in these are layers of ore aggregating about 10 feet. The ore exposed in the pits outcrops on an old road, at a point about 600 feet northeast of the pit.

About 200 yards southeast of the pit and about 150 feet north of the main highway from Murphy is a trench in a sandy slate that has been strongly impregnated with limonite and hematite, but in which no definite ore deposit has been made. The mineralized belt is about 10 feet wide. It represents the last exposure to the southwest on the southern line. About a mile farther southwest a small deposit of manganese ore was developed on the top of a little hill near the main highway from Murphy, and this also is on the southern edge of a ledge of quartzite, but the quartzite is a different bed from that farther northeast, or at any rate the two are not continuous on the surface, and they are at different distances south of the main quartzite belt, which is continuous.

A few pages back attention was called to the existence of a vein of hematite in slates at the northeast end of the belt. It is a matter of passing interest to note that there are other deposits of hematite in this neighborhood, some of which have been opened by trenches. None of them are of any economic importance. The most extensive is about 150 yards south of the trench on Mr. Mauney's place and near the Glade Church. Here are two veins, 5 feet and 12 feet thick. The uppermost is overlain by white stratified clay. The hematite is of two kinds—a dull red granular variety that resembles a fragmental deposit, and a dense, lustrous darker variety that looks like a direct precipitate. The latter has a reddish brown streak and may be turgite. About 75 yards southeast of these is a small limonite vein with a foot wall of red and yellow slate cut by quartz veins. The hanging wall was not seen, but in the cuts on the road slates are exposed in the position to be expected of the hanging.

The hematite and limonite in the slates are evidently of very different origin from the larger deposits of limonite that occur in the distinct and well defined belts. Although nothing definite can be made out about their relations to the rocks associated with them, they nevertheless appear to be only small deposits of local origin, occurring in the bedding of schistose planes of slates.

To return to the limonite deposits. About ¼ mile southwest of the pits last referred to and about 1,200 feet northwest of the bridge over Martin Creek is another pit in limonite on the south edge of a bluff of quartzite. Here again the ore appears to be associated with slates. It occurs in three layers having a total width of 30 feet.

Beyond this point the quartzite ridge can be followed to the southwest without interruptions for several miles, but nowhere are there any explorations for ore, until the road between Martin Creek and Cane Creek is reached. A few rods north of this road, on the farm of R. R. Owensby, are three trenches on the north side of the road that are dug at the contact of the quartzite and Brasstown schists (fig. 11, No. 4). They uncovered about 5 feet of ore which is reported to contain about 2% of manganese. The ore deposit is probably wider than 5 feet, but it is doubtful if it is of sufficient size to be of economic importance.

On the south side of the highway, a little farther east is the largest deposit of manganese ore that that has been developed anywhere in Cherokee County. It is on the land of Geo. R. Eager about ½ mile south of the main quartzite ridge in a mass of quartz, and thus is in the same position with reference to the main ridge as is the deposit 1½ miles northeast on the road between Murphy and Martin Creek (fig. 11, No. 5). At the Eager place the ore is a shattered mass of quartzite about 20 feet wide that is cemented by psilomelane and pyrolusite. There are three trenches in the ore body and from them a great deal of ore has been removed; but unless the material was crushed and washed it cannot have had much value. Other openings north of the road and about 200 yards southeast of Mr. Owensby's house also uncovered manganese ore but in what quantity is unknown.

For the next 1½ miles to the southwest the hills have been unexplored, but about ½ mile north of the residence of Mr. J. H. Headon on the Martin Creek road is a pit high up on the southeast side of a hill which is covered with quartzite bowlders (fig. 11, No. 8). The pit shows only a mass of soft brown ore that is plainly manganiferous. No ore was seen in place, as the walls of the pit are covered with loose material; consequently there is no means of learning whether or not there is any considerable body of ore uncovered. The quartzite is on the strike of that at the three trenches on the Owensby place.

There are two other points beyond this place at which explorations have been undertaken, and although they are on the south side of a quartzite belt which is on the trend of the quartzite ridges along which so many evidences of the existence of ore have been noted, nevertheless it is possible that they may be in a different belt of deposits since the ridge has not been followed continuously from the Headon place. It is more probable, however, that the two ridges are continuous and that the ores are in the same belt. This view seems all the more reasonable since the ores are manganiferous.

One of the largest of the explorations is a deep trench and small pit on a tributary of Gold Branch, about 1½ miles southeast of Ranger. The trench, which is about 25 feet long, is 200 to 250 feet south of a ledge of quartzite which outcrops on the hill slope above (fig. 11, No. 9). It uncovers a sandy slate with which are interlayered three seams of manganese ore (pyrolusite), manganiferous limonite and some hard limonite. The material in the dumps appears to be rich, but in all probability this is due to the deep color given it by the pyrolusite. By carefully washing the crude material there may be secured a highly manganiferous ore that may be a profitable product.

A little over a mile farther to the southwest, on the land of Mr. B. L. Fox and his neighbors to the northeast are three other pits and trenches, on the south side of the same quartzite ridge which is continuous all the way from Gold Branch (fig. 11, No. 10). The openings show very little of interest. The most widely separated ones are about ½ mile apart and the three are connected by a continuous line of float.

The only other deposit in this portion of the country is exposed by a pit on the southwest side of the road, about ⅗ mile southeast of Culberson, and just across the State line in Georgia. The pit is in black slates mapped as Valleytown by La Forge and Phalen. The slates strike N. 40°-60° E., and the ore seems to be a plexus of veins about 6 feet wide occurring in a fracture zone, partly as seams in the cracks and partly as replacements of the slate. It is reported that some of the material, which is a very richly manganiferous limonite, has been shipped as a manganese ore. There is no quartzite in the vicinity of the pit, nor is it near a fault line. The only explanation of the presence of the ore is that it is a local replacement deposit along a shear zone.

ORE RESERVES IN THE HIWASSEE AND NOTTELY RIVERS BELT

From the descriptions of the deposits in the Hiwassee-Nottely rivers belt it will be inferred that the explorations on this belt have as a rule been so superficial that we know almost nothing of the size of the deposits or of the quality of the ore in them. At a few places, as for instance on the Mauney property, south of Murphy, it has been shown that the deposits are reasonably large, but whether they are sufficiently large to warrant the construction of plants ample to handle their products efficiently is doubtful. Moreover, all of them are a mile or two from the nearest railroad, to which their ore would have to be hauled over hilly roads before it could be shipped. None of them give prom-

ise of profitable development in the near future, though it is possible that when the hard road is completed up Martin Creek a few of them might be worked on a small scale.

DEPOSITS IN McDOWELL COUNTY

In the north corner of McDowell County is a deep gorge-like valley extending from Linville Falls south and southwest to the North Fork of Catawba River. Its bottom is occupied by North Cove Fork for nearly its entire length. East of it is the great mass of Linville Mountain, which consists mainly of Erwin quartzite and west of it are other ridges of the Blue Ridge, composed principally of crystalline pre-Cambrian rocks with here and there small masses of the Cambrian Hampton shale, which lies under the Erwin quartzite.

Where the valley is narrow the stream flows over quartzite. In the few places where it widens the underlying rock is the Shady limestone, which is approximately equivalent to the Murphy marble in Cherokee County. About northwest of Brown Mt. it is now being quarried as an ornamental stone, and ½ mile above Ashford is being quarried and crushed by the Clinchfield Lime Company for agricultural purposes. At the quarry the limestone is a thinly bedded blue-gray rock, dipping about 30° to the southeast. A short distance farther south, between Ashford and Avery, the stream and the tracks of the Carolina, Clinchfield and Ohio Railway run over quartzite dipping 45° N. W. South of Ashford the valley widens to about ½ mile and is underlain for the most part by limestone.

On the lower slopes of Linville Mt. about ¾ mile southeast of Avery Station and about 200 feet above the railroad track are several limonite deposits in a line trending about N. E.-S. W., and higher up on the mountain to the northeast are other deposits. At all the occurrences the ore appears to lie on the quartzite, forming a veneer on the slope facing the railroad. At any rate, no exposures are to be seen between the ore layer and the track except here and there in the railroad cuts, where a decomposed sandy schist containing ore veins is occasionally encountered. The slope of the ridge, where not covered with talus, has about the same inclination as the dip of the quartzite, so that when the limestone was removed by erosion the ore, if a vein, was left as a veneer on the quartzite beds.

At only one point has the ore been opened, and at this point it has not been sufficiently uncovered to show its relations to the surrounding rocks. So far as can be judged, it occurs as a vein about 15 feet wide dipping about 35° N. W.

DEPOSITS IN THE PIEDMONT PLATEAU

Although brown hematites are known to occur at many places on the Piedmont Plateau, most of them are in small deposits, which do not offer much prospect at present for profitable exploitation. The only deposits of prospective importance are those in Catawba, Lincoln and Gaston counties, and of these only those in Gaston County have been developed.

DEPOSITS IN CATAWBA AND LINCOLN COUNTIES

The deposits in Catawba and Lincoln counties are described by Nitze (l. c. p. 87) as occurring in a belt passing 2 miles east of Lincolnton. They are said to be in mica schists, lying above a limestone, which may be of Cambrian age. Search was made for some of the old pits mentioned by Nitze, but none were found. They have been abandoned many years and are now obliterated. The belt is said to cross the Carolina and Northwestern Railway 2½ miles south of Lincolnton, but a traverse along the railroad revealed nothing but micaceous schists cut by pegmatites and fine grained quartz veins many of which contain tourmaline. No iron ores were seen but some of the schists are very red. Nitze also reports the existence of old pits on land formerly belonging to Cephas Quickel 2 miles east of Lincolnton. He states that a line of pits extends from the Seaboard Air Line Railway in a general southwesterly direction for 1¼ miles to the C. and N. W. Ry. A cut on this road, he writes, "exposes the talcose, or hydromica schists, with small seams of yellowish, saccharine quartz, having a strike of 3° to 5° east of north, very much folded; and this folded structure evidently accounts for the great width of the ore-belt, which, judging from the position of the old openings and the wide distribution of the float ore over the ground, which is comparatively level, must be ½ mile. The ore beds here are reported to vary in thickness from about 6 inches near the surface to 2 and 3 feet at a depth of 10 feet, with a general pitch toward the south, between walls of dark red to dark yellowish slate, accompanied by seams of yellow saccharine quartz. It is highly probable that the beds exist in pockets of irregular thickness and extent. * * * The formation has been traced by surface float some 4 or 5 miles each way * * * and its northeasterly extension is reported in Catawba County, where the ore was superficially worked for some old forges in former years."

A sample from the Quickel place contained:

SiO_2	Fe	S	P	P ratio
4.94	54.32	.037	.840	1.546

DEPOSITS IN GASTON COUNTY

General:—In Gaston County brown hematites are found in two belts, one in gneisses and schists immediately east of a belt of limestone, which may be the continuation of that in Lincoln County, and the other in quartzites about ¾ mile still farther east. Both belts are short and each is notable for one mine. Both mines are within a mile or a little more of Bessemer City. The Ormond, which is on the western belt, was at one time one of the best known mines in the State. The other—the Little Mountain Mine—was noted because of the fanciful forms assumed by its ore.

Mr. Nitze's idea of the geological structure of the region is given in a section, which, however, is of little value, partly because of the scarcity of exposure of the rocks involved and partly because of the indefiniteness of the rock determinations. The country has not yet been mapped geologically, and until this is done it is useless to speculate upon its structure. There are practically no exposures in the neighborhood of the Ormond Mine. At the Little Mountain Mine the only rock exposed is the quartz schist that is associated with the ore.

Ormond Mine:—The Ormond Mine is about 1½ miles west of Bessemer City in a series of talcose-quartz schists, on the northwest side of the railroad. It is not now working, but some of the shafts and many old pits are still easily discoverable, and on one of the dumps is a large quantity of fresh rock. The pits extend in a line for a distance of about ¾ mile in a direction about S. 20° W.

In the Tenth Census Report only a few words are devoted to the description of the mine. Its greatest depth at the time had been reached in the engine-shaft, which was down 80 feet. The ore is reported to lie in lenticular masses 3 feet to 8 feet in thickness, the southern end of one lying east of the northern end of the one beyond it. The dumps "contained two kinds of ore intimately associated in the same pieces; the first is very dense, hard enough to scratch glass, has a brown streak like limonite, and is distinctly magnetic; it is not at all granular, and in appearance closely resembles many of the dense homogeneous limonites. The other is dark colored, fine grained, and slightly

friable; it shows lamination, has a very dark almost black, slightly reddish streak, and is also magnetic." An analysis of a sample of the mixed ore gave: Fe=65.82, P=.092.

At the time of the visit of the Census geologists the mine had been developed to a slight extent only, but when Nitze visited it, he was able to describe it (l. c. p. 97) more in detail.

Nitze remarks that the deposits have been worked at intervals as far back as the Revolutionary War. "The country rock is a quartzitic talcose schist, argillaceous and decomposed to considerable depths, striking N. 25° to 30° E., with a dip of from 70° to nearly 90° N. W." He finds 4 types of ore: a hard black jointed ore containing generally less than 5% water, possibly to be classified as turgite; a hard black homogeneous ore, slightly magnetic; a porous limonite and a loose, pulverulent, bluish black powdery ore. The latter "may be considered a decomposed variety of manganiferous block ore" since it "is often found filling up the interstices formed by the joints and cracks in the same." The ore is declared to be in overlapping lenses with a general northwesterly dip. They are connected with each other by small stringers of ore along which there is a flow of water. The "hanging wall is usually a decomposed gneiss or slate and the foot wall a soft, black muck, which has been found to contain a considerable amount of fine black ore." The lenses varied in thickness from less than 3 to more than 28 feet, but their length and heights had not been developed. In all they occupied a belt from 50 to 100 feet wide.

On the western drifts of the lower level, 173 feet below the surface, at shaft No. 4, limestone was found, which Nitze thinks is the western boundary of the ore formation. It dips about 45° W. and shows "signs of erosion" where in contact with the ore. This limestone, of which there is "great quantity on the dump, is a thinly bedded, gray and white, very sandy variety. This is not exposed anywhere on the surface, but just west of the pits is a little ridge of very friable white sandstone." Nitze's statement, quoted above, that the hanging wall of the ore is a "decomposed gneiss or slate" must refer to individual lenses, for the hanging wall of the belt of lenses, or what Nitze calls the "ore formation", is the limestone.

At the time of Nitze's visit the mine was working in three different ore bodies. One, 30 feet south of the shaft, was a mass of solid block ore 28 feet thick. (Analysis I.) Another, 100 feet north of the shaft, was a body of similar ore 12 feet thick and at least 30 feet long. Its composition is shown in II. The third was a lens 7 feet thick lying against the limestone. The composition of a sample taken from 2

cars of mixed ore that had been prepared for shipment by crude washing in a trough is shown in III, and that of the tailings from this ore in IV. Analysis V is of a black powder ore.

	SiO_2	Fe	S	P	P ratio
I. Block ore, from 28 foot lens	-------	64.40	-------	.036	.055
II. Block ore, from 12 foot lens	-------	63.52	-------	.033	.051
III. Mixed ore, ready for shipment	9.72	52.39	.048	.079	.150
IV. Tailings from III	-------	43.50	-------	.155	.333
V. Black powder ore	1.55	65.35	-------	.007	.010

Since the shipping ore was imperfectly washed in a trough it is probable that with more careful manipulation in a log washer it might be raised to Bessemer grade. This probability seems reasonable in view of the fact that the specimens of the block ore, which must have constituted a large proportion of the shipping product, were well under the Bessemer limit.

Nitze gives several figures of sections through the mine at various places, but they are so unlike that they apparently possess little significance. In none of them is there shown any of the quartzitic talcose schist that is said to be associated with the ore bodies, nor is there anything to show that the deposits are in overlapping lenses. The impression gained from a study of the sections is that the ore bodies are very irregular masses lying in the schistose planes of foliated rocks, or at the contacts of pervious and impervious layers. The erosion of the lower contact of the limestone in No. 4 shaft suggests corrosion by water. It may signify that the origin of the ore at the Ormond Mine is analogous to that of the ore in the mines in Cherokee County, and that in the case of the Ormond Mine the source of the iron was in the limestone.

During its life the mine was a large producer. During the first eight months of 1892 about 5,000 tons of ore were shipped. The mine was then closed, refinanced, and more effectively equipped, and it produced regularly for several years thereafter.

The belt on which the Ormond Mine is situated has not been traced beyond the old mine workings in either direction. There are probably a number of lenses in the mine property that have not yet been discovered, but whether the belt extends to the northeast or southwest is not known.

Little Mountain Mine:—The Little Mountain Mine, or the Devil's Workshop, is about one mile southwest of Bessemer City Station on the crest of a little hill of quartzite or, perhaps better, quartz. On the

ridge of the hillock are outcrops of fractured quartz, cemented by quartz. In some places the quartz is broken by gashes. In others it is crossed by quartz veins. In other places sharp edged fragments of quartz lie in a quartz cement. In many places the cement is porous, or cavernous, and the walls of the holes are lined by quartz crystals. The ore is in the cracks and caverns.

Mr. Willis in the Tenth Census Report (p. 321) describes the ore as limonite altered from siderite or calcite. He writes that "portions of it are mamillary and stalactitic, but the greater number of specimens show pseudomorphs after rhombohedra. It incloses large crystals of quartz, sometimes 3 inches through, whose surfaces bear the impressions of rhombic crystals. Associated with this limonite is an earthy friable ore, which also shows pseudomorphs after rhombohedra, but has a dark-reddish streak, and it is apparently manganiferous." The ore is said to occur in a vein, 8 feet or 10 feet wide, with vertical walls of siliceous slate. Its strike was recorded as N. 30° E. Some of the ore was described as containing also large apatite crystals.

Analyses of the limonite and the manganiferous ore, taken from piles containing about 10 tons each, resulted as follows:

Limonite		Manganiferous Ore
1.63	SiO_2	5.26
.24	FeO	.29
86.75	Fe_2O_3	82.92
.25	Al_2O_3	1.33
1.00	MnO	4.11
.24	CaO	.52
.13	MgO	.16
.169	FeS_2	.211
tr	NiS	tr
tr	CoS	tr
tr	CuS	tr
.15	CO_2	.14
.023	P_2O_5	.017
.06	C in carbonaceous matter	.03
.33	H_2O-	.62
9.30	H_2O+	4.24
100.272	Total	99.868
61.00	Fe	58.37
.009	P	.005

Nitze (l. c. p. 102), who examined the mine after it had been more extensively developed repeats the statements of Mr. Willis, except that he declares the ore to be limonite, goethite and turgite, with a strike N. 37° E. and a dip of from 75° N. W. to vertical. He repeats the

statement that it is in a distinct vein between parallel walls, and that it is probably pseudomorphous after siderite or calcite. He gives no evidence corroborating his conclusions, but evidently is satisfied to follow Mr. Willis, without discussion.

He describes the vein matter as consisting of an admixture of crystalline quartz and ore in varying proportions, lean on the outcrop but becoming richer with depth, until at the bottom of the 60 foot shaft the vein material is nearly pure ore. "This ore assumes some of the most grotesque and beautiful shapes, * * * —hard, massive; porous, honeycombed; stalactitic; botryoidal; mammillary; pisolitic; reniform; soft, earthy; etc., etc."

At the time of his visit the outcrop had been explored by a trench 270 feet long, from 3 to 10 feet wide and from 3 to 20 feet deep. Two shafts had also been sunk, one at the southwest end of the trench and the other about 175 feet farther northeast. In the northeast shaft the vein matter was "profusely mixed with quartz" to a depth of 30 feet, beyond which point the proportion of quartz diminished until at its bottom the shaft was in pure ore, 10 feet wide. Drifts proved the vein to vary in thickness between 10 feet and 27 feet. At the 50 foot level a crosscut into the quartz hanging passed through 17 feet of quartz into a second vein of ore. Analysis of the ore from the bottom of this shaft (I) and from across the vein on the 50 foot level (II) are quoted below. Analysis III is of a sample taken from a stock pile of 50 tons of ore raised from the southwest shaft. Short drifts from this shaft at the 25 foot and 54 foot levels developed ore at least 8 feet wide but at no point was its extreme width established.

	SiO_2	Fe	Mn	S	P	P ratio
I	6.67	54.32	.45	.....	.017	.031
II	7.90	53.75	.....	.011	.045	.083
III	11.96	52.70	.....	.....	.022	.041

Nitze declares that the ore does not require washing, but that it may be improved by crushing and jigging. He also states that from a point 264 feet S. 40° W. from the southeast shaft a tunnel was driven 100 feet in a direction N. 10° E. but failed to strike ore.

When the writer visited the mine it had been abandoned and the trench had been partly filled, so that access to the vein was impossible. However, good exposures were found on the walls of the trench and

good outcrops on the hill near the trench. As has been said, the quartz is crushed and the fragments that resulted from the crushing are cemented by quartz. Thus the quartz is in many places crossed by quartz veins, many of which contain vugs lined with quartz crystals. On the strike of the trench and on its walls, however, the cementing quartz appears to be replaced in part by ore, and the walls of open gashes and of vugs are coated with ore material. The ore is mainly in crusts lining the walls of crevices and in botryoidal and stalactitic forms in vugs. It often encloses quartz crystals and coats them concentrically. Usually there is a mass of earthy or porous limonite next to the walls, or a mass of platy limonite in which the plates are thin and arranged parallel to the walls. Next to this and surrounding quartz crystals that penetrated the vug spaces are layers of fibrous goethite about ½ inch wide. Often the goethite does not entirely close the space, in which case its exposed mammillary surface is covered with a lustrous black enamel.

An analysis of a sample of compact ore, made by Mr. E. T. Erickson, in the U. S. Geological Survey laboratory, yielding this result:

Fe_2O_3	MnO	FeO	H_2O above 105°
81.84	.15	.00	11.81

Goethite (FeO(OH)) contains 10.1% and limonite ($Fe_4O_3(OH)_6$) contains 14.5% of water. The sample is a mixture of approximately 60% of goethite and 40% of limonite.

Another type of the ore is a cellular mass of goethite, made up of thin plates enclosing cells of rhombohedral shapes as though the iron hydroxide had developed in the cleavage cracks of some rhombohedral mineral. Where massive, rather than cellular, the mass is a reddish brown color, and it often exhibits a rhombohedral cleavage. The writer saw none of the impressions of rhombohedral crystals on the quartz as described by Willis. However, the rhombohedral cleavage of some of the massive goethite and the rhombohedral cavities in the cellular varieties suggest that some rhombohedral mineral was present in the crevices before the iron hydroxide was introduced. It is possible that this was siderite. If this is so, it was oxidized to iron hydroxides, and later supplies of iron hydroxides coated the surfaces it found, whether they were surfaces of the hydroxide that had replaced the carbonate, surfaces of quartz crystals that extended into cavities, or surfaces of cracks that had contained no carbonate.

The sequence of events seems to have been: 1, the shattering of the quartz; 2, the introduction of silica forming quartz veins and the crystals in the vugs; 3, the introduction of a carbonate; 4, the introduction of iron hydroxide that (a) replaced the carbonate and (b) formed the fibrous coatings of goethite. The iron hydroxides may have been brought from some outside source, or, if the carbonate was siderite, a part might have resulted from the oxidation of this carbonate in place and a part from the oxidation of solutions of a similar carbonate higher up in the deposit. The carbonate certainly originated elsewhere. There is no marble in the series of rocks near the Little Mountain Mine, but the layer found in the Ormond Mine, if it keeps its strike to the southwest, cannot be more than a mile distant on the surface.

The vein of the Little Mountain Mine has been traced for several miles to the southwest by its outcrop of ferruginous quartz, and two small pits about 1½ miles from the mine have uncovered conditions similar to those near the surface at the mine.

ORE RESERVES IN CATAWBA, LINCOLN AND GASTON COUNTIES

There are a few deposits of brown ore known in these three counties, other than those described above, but none of them are large enough to be considered even probable sources of ore. The Ormond and Little Mountain mines may contain fair quantities of ore, but they are so much more expensive to operate than the deposits in Cherokee County or similar deposits farther northeast in Virginia that they are not likely to be able to compete with these in the near future.