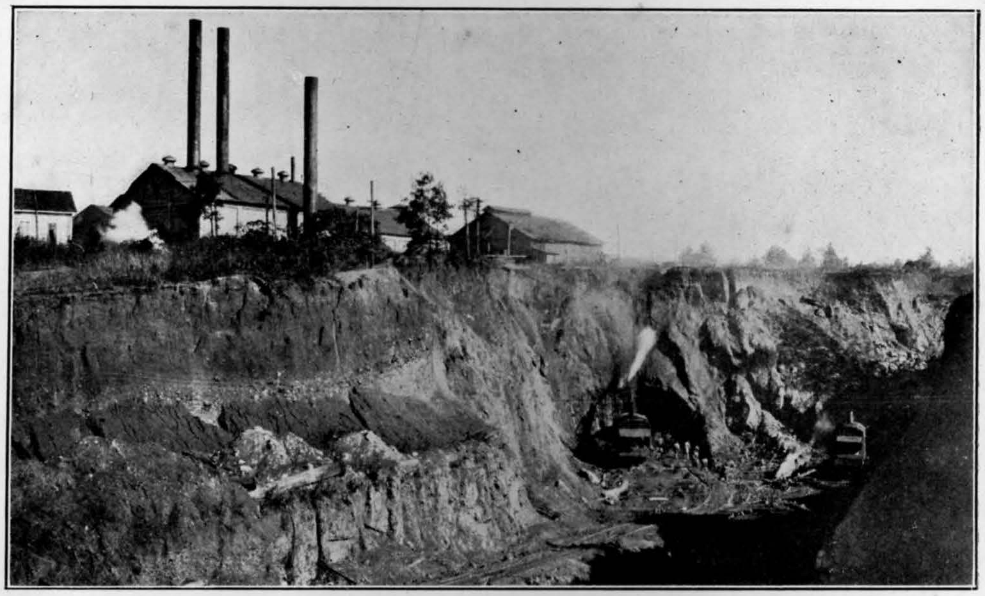

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GEOLOGICAL SURVEY OF GEORGIA
S. W. McCALLIE, State Geologist

BULLETIN NO. 35

REPORT
ON THE
MANGANESE DEPOSITS
OF
GEORGIA

(SECOND REPORT ON MANGANESE)

BY
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Assistant State Geologist

LAURENCE LA FORGE,
U. S. Geological Survey

W. R. CRANE,
U. S. Bureau of Mines

PREPARED IN COOPERATION WITH THE U. S. GEOLOGICAL SURVEY
AND THE U. S. BUREAU OF MINES

Atlanta, Ga.
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1919

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OF THE

Geological Survey of Georgia

IN THE YEAR 1919

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LETTER OF TRANSMITTAL

GEOLOGICAL SURVEY OF GEORGIA,

ATLANTA, MARCH 1, 1919.

To His Excellency, HUGH M. DORSEY, *Governor, and President of the Advisory Board of the Geological Survey of Georgia.*

SIR: I have the honor to transmit herewith the report of Mr. J. P. D. Hull, Assistant State Geologist, Dr. Laurence La Forge of the U. S. Geological Survey, and Dr. W. R. Crane of the U. S. Bureau of Mines, on the Manganese Deposits of Georgia, to be published as Bulletin No. 35, of this Survey.

Very respectfully,

S. W. MCCALLIE,

State Geologist.

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FOREWORD

This report, prepared in cooperation with the U. S. Geological Survey and the U. S. Bureau of Mines, is the second report issued by this department on the manganese deposits of the State. The first report which was prepared by Dr. Thomas L. Watson, former Assistant State Geologist, was published in 1906. The field-study forming the basis of Watson's report was begun in 1900 and completed in 1902 thus making an interval of approximately 18 years between the two reports. During this time although the manganese industry was not particularly active, nevertheless considerable new development work had been carried on, but hardly enough to justify the issuing of a second report.

The main object in the collection of data for the present report was the immediate stimulation of manganese ore production as a war measure. Last spring, when field work was first commenced, it seemed clear from what was already known about the manganese ores of the State that the output was by no means what ought to be expected. It was the opinion of the State Geological Survey concurred in by the U. S. Geological Survey and the U. S. Bureau of Mines that to get the best results in the shortest possible time men should be sent immediately into the manganese districts to assist the prospectors, the miners, and the mine operators in every way possible that would stimulate production. To avoid duplication the work under consideration was divided into three divisions, (1) the relation of the ore deposits to the structural geology, (2) the descriptions of individual properties and the mode of the occurrence of the ore, and (3) the methods of mining and cleaning the ore.

The relation of the ore deposits to the structural geology was taken up by Laurence La Forge of the U. S. Geological Survey. Dr. La Forge confined his work entirely to the Cartersville district where it was hoped that the structural relations of the Shady limestone and the Weisner quartzite would give important data in aiding the location of valuable ore bodies. The descriptions of the individual properties and the mode of occurrence of the ores, which constituted the greater part of the work was assigned to J. P. D. Hull, Assistant State Geologist, while the methods of mining and cleaning the ores were taken up by Dr. W. R. Crane of the U. S. Bureau of Mines.

Mr. Hull began field work in May and later was joined by Crane and La Forge. The field work was completed in August and the report went to press in December.

Owing to the signing of the armistice at an earlier date than was anticipated this report does not fully meet the needs for which it was intended, nevertheless, it is felt that data collected mainly as a war measure should be published, as the information is essential for the upbuilding of the industry in time of peace as well as in time of war.

All chemical analyses in this report when not otherwise stated were made in the laboratory of the State Geological Survey by Dr. Edgar Everhart, acting chemist.

S. W. McCallie,
State Geologist.

February 20, 1919.

MANGANESE DEPOSITS OF GEORGIA

MANGANESE

THE METAL

The chemical element, manganese, does not occur in the native metallic state, but as obtained by the chemist it is a grayish-white, hard, brittle substance eight times heavier than an equal volume of water. It is closely associated with iron in its chemical relation and natural occurrence, and is widely distributed in small quantities throughout the earth. Manganese constitutes 0.08 per cent of the lithosphere, thus with barium holding fifteenth place in the relative abundance of the chemical elements in all known terrestrial matter.[1] The most common compounds of manganese are silicates, oxides, and carbonates. Manganese minerals that occur in greatest abundance are pyrolusite, the dioxide (MnO_2) and psilomelane, the complex hydroxide (H_4MnO_5), in which part of the manganese is generally replaced by barium or potassium.

THE ORES

In describing the manganese production of the United States for 1916, Hewett classified manganese ore, except zinc residuum, according to manganese content as follows:[2] (1) manganese ore, containing more than 40 per cent of manganese, (2) ferruginous manganese ore containing 15 to 40 per cent of manganese, and (3) manganiferous iron ore, containing 5 to 15 per cent of manganese. Ores containing 1 to 5 per cent of manganese, previously included in manganiferous cre, are classed with the iron ores.

[1] Clarke, F. W., Data of Geochemistry, U. S. Geol. Survey Bull. 616, pp. 12-40, 1916.

[2] Hewett, D. F., Manganese and manganiferous ores: U. S. Geol. Survey Mineral Resources, 1916, pt. 1, pp. 733, 734, 1918.

MANGANESE ORES

Those ores which are classed as strictly manganese ores contain more than 40 per cent of manganese and generally less than 20 per cent of silica. Their chief use is in the manufacture of ferromanganese, but the purer forms of the minerals constituting the ore are used for chemical purposes.

PRINCIPAL MANGANESE MINERALS

Manganese ores are composed principally of oxides, partially of carbonates, and only slightly of silicates. The chief constituents are the oxides, psilomelane and pyrolusite. Of the carbonates, the most important is rhodochrosite and of the silicates, rhodonite.

Manganese is a constituent of more than one hundred minerals, but the most important ore-forming species[1] are given in the following table.

Principal Manganese Minerals

Mineral	Composition	Percentage of Manganese
Oxide		
Polianite	MnO_2	63.2
Pyrolusite	$MnO_2.nH_2O$	60–63
Psilomelane	$MnO_2.(MnKBa)O.nH_2O$	45–60
Wad	Hydrous impure mixture of manganese oxides	5–50
Manganite	$Mn_2O_3.H_2O$	62.4
Braunite	$3Mn_2O_2.MnO.SiO_2$	69
Franklinite	$(FeZnMn)O.(FeMn)_2O_3$	10–19
Carbonate		
Rhodochrosite	$MnO.CO_2$	47.56
Silicate		
Rhodonite (manganese pyroxene)	$MnO.SiO_2$	41.9
Tephroite (manganese olivine)	$2MnO.SiO_2$	54.3
Spessartite (manganese garnet)	$3MnO.Al_2O_3.3SiO_2$	33.3

[1] Hewett, D. F., op. cit., p. 732.

The four species constituting the manganese ores of Georgia are pyrolusite, psilomelane, wad, and manganite,—all oxides.

Pyrolusite.—Pyrolusite ($MnO_2.nH_2O$) is a soft black mineral that soils the fingers. It makes a black or bluish-black streak. One of its chief characteristics is its hardness of 2 to 2.5,—so soft that it can be scratched by the finger nail. The specific gravity is 4.8. Pyrolusite occurs in granular massive form and stalactitic, botryoidal, and reniform crusts or coatings. Crystals are commonly slender, bladed, fibrous, needle-like; also rectangular and tabular. They are generally less than an inch long. The occurrence of pyrolusite as a soft amorphous coating on psilomelane suggests the derivation from psilomelane. It crystallizes in the orthorhombic system but it may be pseudomorphous after manganite by dehydration. Many specimens observed, particularly in the Cartersville district have generally been termed pyrolusite, though this classification is tentative and not altogether exact, for besides having the crystal form of manganite, which feature alone would not class them as such, these specimens possess a hardness considerably greater than 2.5. On the other hand, they give the black streak of pyrolusite and lack the water required in the hydrous manganite.

Psilomelane.—Psilomelane ($MnO_2.(MnKBa)O.nH_2O$; or H_2MnO_5) is a hard, black, amorphous mineral generally occurring in botryoidal form. The color is steel-blue, or grayish-black in some specimens, and the streak is brownish-black. Its hardness is 5 to 6 (cannot be scratched with a knife), and its specific gravity is 3.7 to 4.7.

It is common in massive, botryoidal, reniform, and stalactitic forms, mixed both chemically and mechanically with pyrolusite. It generally contains considerable quantities of barium, iron, and silica.

Wad.—Wad is a hydrous impure mixture of manganese oxides, ordinarily a soft brownish-black to black, earthy substance. Though commonly soft and clayey it may have a hardness of 6 in some forms. Its specific gravity is 3 to 4.26.

Wad is amorphous. It occurs as reniform and irregular masses associated with manganiferous clay. It includes among several earthy manganese oxides the varieties bog manganese and dendrite. Having been derived supposedly from a number of more or less impure oxides, carbonates, and silicates of manganese, and deposited near the source of its material, wad and its earthy associates contain more or less distinctive quantities of silica, alumina, iron, water, copper, barium, lead, nickel, and cobalt.

Manganite.—Manganese ($Mn_2O_3.H_2O$) is black, generally crystallized, moderately hard, and characterized by a reddish-brown streak. The color is dark steel-gray to iron-black and the streak is reddish-brown to black, the reddish-brown streak distinguishing it from pyrolusite, which has the same crystal form. Its hardness is 4 (easily scratched with a knife), considerably greater than pyrolusite. Its specific gravity is 4.2 to 4.4.

Manganite crystallizes in the orthorhombic system and generally occurs in fibrous, bladed, and slender prismatic crystals, striated vertically. The crystals are commonly grouped in divergent or radiating bundles. It also occurs in massive and stalactitic form. It is associated with pyrolusite and psilomelane.

FERRUGINOUS MANGANESE ORES

The ores classed as ferruginous manganese ores contain 15 to 40 per cent of manganese. They differ from manganese ores proper only in the percentage of their metallic content, being somewhat higher in iron and silica. They are made up of the same minerals as manganese ores, but in a less pure form and more intimately mixed with iron, both hematite and limonite. The higher grade ores are used in the manufacture of ferromanganese and the lower grades are used for spiegeleisen and high-manganese pig iron. Some is used as a flux in the roasting of metalliferous ores, particularly in the West.

MANGANIFEROUS IRON ORES

Manganiferous iron ores contain 5 to 15 per cent of manganese. They occur with the higher grades of manganese ores and in much the same geologic conditions. In mining the ores, the different grades are ordinarily produced by the degree of care in concentrating. Many deposits, however, are essentially iron ore deposits with small percentages of manganese so intimately associated with the iron that it is impossible to produce high-grade manganese from them. Furthermore, silica is generally present in greater amounts in the lower grade manganese and manganiferous iron ores.

Manganiferous iron ores are used for fluxing and in the manufacture of high-grade pig iron. They are also used in making spiegeleisen when higher grade ore is added to bring up the manganese content or to lower the percentage of silica and iron. Ores containing less than 5 per cent of manganese are classed as iron ores.

MANGANIFEROUS SILVER ORES

As many manganiferous silver ores contain manganese ranging from 5 to 15 per cent they are included in manganiferous iron ores in order to indicate the relative manganese value. Because of their special character, however, they may be considered separately. These ores are intimate mixtures of iron and manganese oxides together with silver chloride and lead carbonate. Manganiferous silver ores are mined principally in Arizona, Colorado, and Nevada. They do not occur in Georgia.

MANGANIFEROUS ZINC RESIDUUM

Manganiferous zinc residuum results from the roasting of zinc ores and contains iron and manganese oxides. It is a waste product in the extraction of zinc, but is used in the manufacture of spiegeleisen. The chief manganese-bearing mineral of the zinc ore is franklinite, though rhodochrosite, rhodonite, and tephroite also occur. Manganiferous zinc residuum, classed according to manganese content, is included in manganiferous iron ores. It is produced from the New Jersey zinc ores.

THE USES[1]

The uses of manganese ores (including manganiferous ores) and manganese compounds may be grouped in three classes: metallurgical, chemical, and minor uses. The most important use for manganese and manganiferous ores is in the manufacture of the iron and manganese alloys, spiegeleisen and ferromanganese which are used in the manufacture of steel. Low-grade manganiferous ores are used in making pig iron.

Of the chemical uses, probably the most important is in the manufacture of chlorine. Manganese compounds are also used as coloring materials.

"Probably the most recent use for manganese is in a certain nonferrous mixture which is used for the production of the necessary charcoal for gas masks by the carbonization of fruit stones."[2]

METALLURGICAL USES

(Manganese and manganiferous ores)

I. Alloys with iron
   1. Ferromanganese, spiegeleisen, silicomanganese, silicospiegel
   2. Hadfield's manganese steel
   3. Quaternary manganese steels
      (1) Manganese-nickel, manganese-chromium, and manganese-silicon steel

II. Alloys with metals other than iron
   1. Cupromanganese, manganese bronze, manganese brass, silver bronze, manganese amalgam, manganese-aluminum alloys, Heusler's alloys

III. Flux
   1. Smelting of copper, lead, and silver ores

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[1] For detailed discussions of the uses of manganese and manganiferous ores, and for descriptions of the products of these ores, see Penrose, R. A. F., jr., Manganese: its uses, ores, and deposits: Geol. Survey of Arkansas, Ann. Rept. for 1890, Vol. I, pp. 1-56, 1891, and Harder, E. C., Manganese deposits of the United States: U. S. Geol. Survey Bull. 427, pp. 243-268, 1910, from whose works the uses here given are taken.

[2] Braid, Arthur F., Pure carbon-free manganese and manganese copper: Bull. American Institute of Mining Engineers, p. 1697, Nov., 1918.

CHEMICAL USES

(Manganese oxides)

I. Oxidizing agents
   1. Chlorine, bromine, and oxygen manufacture
   2. Disinfectants
      (1) Sodium permanganate
   3. Decolorizer of glass
      (1) Removes green iron impurity
   4. Dryer in varnishes and paints
   5. Leclanché cell
   6. Dry cell
   7. Explosives and bleaching
      (1) Potassium permanganate

II. Coloring materials
   1. Calico printing and dyeing
      (1) "Manganese brown"
   2. Coloring glass, pottery, door knobs, bricks, soap
      (1) Red, pink, violet, yellow, brown, black
   3. Paints
      (1) Wad for chocolate and brown
      (2) Barium manganate for "manganese green"
      (3) "Nuremberg violet"

MINOR USES

I. Mordant in fixing colors in dyeing (manganous oxide)
II. Compounds for medical, chemical, and manufacturing purposes
III. Ornamental purposes (pink rhodonite)

MANGANESE MINING INDUSTRY

HISTORY

The earliest mining of manganese in the United States was probably in the early thirties, though it is almost impossible to credit any one operation as being certainly the first.

The old Paddy's Run Mine in Frederick County, Va., was among the first to be worked, according to Haney[1], who says, "Old records

[1] Haney, Marshall, Manganese development in Virginia: Engineering and Mining Journal, Vol. 106, No. 16, p. 697, Oct. 19, 1918.

show that the property was operated in 1832, although the length of operation and production at that time are unknown."

Penrose[1] states, "The first manganese ore mined in the United States so far as the writer has been able to find out, was obtained near Whitfield, Hickman County, Tenn., in 1837. . . . The next manganese mining on record was in the Batesville region of Arkansas, between 1850-52." Manganese deposits were prospected and worked about 1859 in Georgia, Vermont, and Virginia. In 1861, small quantities of ore were obtained in Nova Scotia, Canada. In 1866 the first shipments of manganese were recorded from Georgia.[2] In 1867, the first manganese mining in California was done in San Joaquin County. In 1870, the residuum from the manganiferous zinc ores of New Jersey was used in the manufacture of the first spiegeleisen made in the United States and in 1874 the first ferromanganese that was manufactured in the United States was made in the Cartersville district of Georgia.[3]

In 1875 manganiferous iron ore was first used in this country in making spiegeleisen, at the Woodstock furnace, Anniston, Ala.[4]

IMPORTS

The following statistics of imports and production of manganese ores are taken mainly from the Mineral Resources of the United States, published by the United States Geological Survey.

During the period from 1913 to 1916, importations of manganese ore into the United States increased from 345,000 tons to 576,321 tons. In 1917, Brazil, India, Cuba, and Central America shipped about 610,000 tons to this country. During the first six months of 1918, the imports from all sources, as reported by the Bureau of Foreign and Domestic Commerce, were 244,836 tons,[5] supplied prin-

[1] Penrose, R. A. F., jr., Manganese: its uses, ores, and deposits: Geol. Survey of Arkansas, Ann. Rept. for 1890, Vol. I, p. 68, 1891.

[2] Weeks, Jos. D., Manganese: U. S. Geol. Survey Mineral Resources, 1885, p. 329, 1886.

[3] Penrose, op. cit., pp. 17, 27, 63.

[4] Weeks, Jos. D., Manganese: U. S. Geol. Survey Mineral Resources, 1895, p. 193, 1896.

[5] U. S. Geol. Survey Press Bulletin, No. 386, Nov., 1918.

cipally by the previously named countries, together with small quantities from Chile, Costa Rica, United Kingdom, Panama, Mexico, Japan, Canada, and Australia.

PRODUCTION OF THE UNITED STATES

Though manganese ore was produced in the United States as early as 1837, it was not systematically mined until about 30 years later, in 1865 or 1867. From that time until 1883 the production was rather small, but beginning with 1884 it increased rapidly to a maximum of 34,524 tons in 1887, after which it decreased to 6,308 tons in 1894. Another increase and decline followed, with a low figure of 2,825 tons in 1903. From 1913 to 1914 the yearly production was low, the highest being 6,921 tons in 1906 and the lowest being 1,544 tons in 1909. Beginning with the second year of the world war, the production of strictly manganese ore increased phenomenally from 8,708 tons in 1915 to 114,000 tons in 1917. During the first six months of 1918, the production was 136,554 tons of ore containing 35 per cent or more manganese, and the U. S. Geological Survey estimated 324,576 tons for the whole year. During the same period of six months, the country produced 314,137 tons of ore containing 10 to 35 per cent manganese, exclusive of fluxing ore from Arizona and Nevada.

The total domestic production (1838-1917) of 567,078 tons of high-grade manganese ore is less than the imports in 1917 alone, the quantity imported that year being more than 600,000 tons.

PRODUCTION OF THE STATES

The states in which occur deposits of manganese and manganiferous ores include Alabama, Arizona, Arkansas, California, Colorado, Georgia, Maryland, Michigan, Minnesota, Missouri, Montana, Nevada, New Jersey, New Mexico, North Carolina, Oklahoma, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, and Wisconsin. The states that had produced the most high-grade manganese through 1916 were, in order of quantity shipped, Virginia, Georgia, Arkansas, and California. These states produced 422,791 tons of the country's total of 453,078 tons. Virginia produced more than 54 per cent of the country's total from 1838 through 1916. Georgia produced more than 17 per cent of the country's total production of high-grade ore from 1838 through 1917.

During the first six months of 1918, Montana was the largest producer, furnishing 87,338 tons of ore containing 35 per cent or more of manganese. This quantity was more than 63 per cent of the total produced during the same period.

PRODUCTION OF GEORGIA

The first definite record of tonnage of manganese ore produced in Georgia was in 1866. From that time until 1880 the average yearly production was 1,425 tons. A decrease occurred during the next three years and in 1883 and 1884 no ore was produced. Operations were resumed in 1885 and the output rose rapidly to 9,024 tons in 1887, the maximum production of the State. The next year showed a considerable decrease and in 1890 only 749 tons were produced. After another moderate rise and fall, the production became steadier during the period of 1895 to 1902, never falling below 3,089 tons. In 1903 there was a decided drop to 500 tons and with the exception of 150 tons in 1905 no ore was produced from 1904 through 1914. The great needs of the recent war then caused a resumption of shipments, amounting to 3,168 tons in 1915. After a slump in 1916 and 1917, the shipments of manganese ore, averaging at least 40 per cent manganese, approximated 5,000 tons in 1918. Manganiferous ore, including ferruginous manganese (15 to 40 per cent of manganese) and manganiferous iron (5 to 15 per cent of manganese) amounted to about 14,000 tons shipped in 1917, and about 17,000 tons in 1918.

Almost all the strictly manganese ore is produced in the Cartersville district. Small shipments are made from the Cave Spring and Varnell-Cohutta districts. Likewise almost all the ferruginous manganese ore is produced in the Cartersville district. The largest shipments of manganiferous iron ore are made from the Cave Spring district.

The following table, showing the yearly production of manganese ore, containing more than 40 per cent of manganese, is taken from the United States Geological Survey Mineral Resources:

Manganese ore produced in Georgia, 1866-1917

Year	Long tons	Year	Long tons	Year	Long tons
1866	550	1889	5,208	1906	......
1867–73	5,000	1890	749	1907	......
1874	2,400	1891	3,575	1908	......
1875	2,400	1892	826	1900	......
1876	2,400	1893	724	1910	......
1877	2,400	1894	1,277	1911	......
1878	2,400	1895	3,856	1912	......
1879	2,400	1896	4,085	1913	......
1880	1,800	1897	3,332	1914	......
1881	1,200	1898	6,689	1915	*a* 3,168
1882	1,000	1899	3,089	1916	(*b*)
1883	.....	1900	3,447	1917	*a* 2,100
1884	.....	1901	4,047	Total	97,512+
1885	2,580	1902	3,500		
1886	6,041	1903	500		
1887	9,024	1904	.....		
1888	5,568	1905	150		

a Shipments.

b Survey not at liberty to publish.

c U. S. Geol. Survey Press Bulletin No. 381, Sept., 1918.

MANGANESE DEPOSITS IN GEORGIA

TYPES OF DEPOSITS

TYPES ACCORDING TO MANGANESE CONTENT

The types of manganese deposits as classified on the basis of manganese content in the ore and the association of manganese with other metals have already been mentioned (p. 1). Of these types there are in Georgia, manganese, ferruginous manganese, and manganiferous iron ore deposits. All these types of ore, however, may and generally do occur in the same deposit, and the grade of ore produced may depend not so much upon the deposit as upon the care used in mining and milling.

TYPES ACCORDING TO GEOLOGIC ASSOCIATION

The types of deposits may be classified according to the rocks with which they occur. Thus there are (1) deposits in semicrystalline and pre-Cambrian schists and quartzites, (2) deposits in Weisner quartzite and Shady (Beaver) limestone, (3) deposits in Knox dolomite, and (4) deposits in Holston marble and Tellico sandstone. The formations range in age from pre-Cambrian to Ordovician, inclusive. The deposits in the pre-Cambrian schists and quartzites are concentrated in pockets or lenses generally in contact with the country rock and are comparatively small deposits. The deposits in the Weisner quartzite and Shady limestone occur in various forms in the clay above the quartzite and in the lower part of the limestone residuum. They form the largest and most important deposits of the State, as at Cartersville. The deposits in the clay overlying the Knox dolomite rank second in size and are best shown in the Cave Spring district. The deposits in the residuum of the Holston marble and Tellico sandstone are not large, but they produce exceptionally rich ore.

TYPES ACCORDING TO MODE OF OCCURRENCE

The manganese deposits of Georgia may be classified according to their mode of occurrence or formation. Thus the following types are recognized together with the form of the ore in each type of deposit:

Types of manganese deposits and ores according to mode of occurrence

Deposit (*in clay and hard rock*)	Ore (*crystallized and amorphous*)
1. Residual	Bedded, concretionary, stalactitic, nodular, pellet, powder,, irregular masses
2. Replacement	Same as in 1
3. Vein- and fracture-filling	Bedded, stalactitic, irregular, coatings
4. Detrital	Part or all of 1-3, and breccia

No one of these types is exclusive; they overlap. Nor is any one deposit composed of only one type of ore; they are mixed. As a rule vein- and fracture-fillings do not form workable deposits. However, the ore bodies of the Cartersville district particularly, which have as their foot wall the Weisner quartzite and as their hanging wall the weathered clay of the Shady (Beaver) limestone, may be rightly classed as bedded veins. Thus the vein type ranks with the others in importance. The deposits of each mining district are discussed in subsequent pages.

ORIGIN

SUMMARY OF THEORIES

Since it has not been the purpose of the work which is the basis of this report to investigate thoroughly the origin of the manganese deposits, it must suffice here to state in briefest form the conclusions reached by geologists who have studied the deposits and their environment.

Penrose.[1]—In discussing the sources of manganese Penrose[2] says in part:

"The sources of manganese in the Paleozoic and later sedimentary rocks are to be found in the pre-Paleozoic and in the igneous rocks."

The source, alteration, and deposition are merely outlined by the following excerpts:[3]

"The supply of manganese in the crystalline rocks exists mostly in the manganese-bearing silicates and the less common manganese carbonates and other minerals carrying manganese as a more or less important constituent. . .

"The decay of the crystalline rocks has progressed from the earliest times to which there are means of tracing it, and by its agency a source of supply of manganese has been continually contributed to the encircling waters. It is still progressing and as in the beginning of Paleozoic times and ever since then, the manganese in solution is precipitated and gradually forms deposits of ore wherever the necessary conditions are fulfilled.

"These conditions are usually fulfilled when the waters are subjected to active oxidizing influences. . . . Such conditions exist in those bogs, lakes, coastal lagoons, or other local basins which are the receptacles of water draining from areas of manganese-bearing rocks. Precipitation under these conditions, especially in coastal lagoons and shoals, has probably been the origin of most of the workable deposits of manganese in the United States."

Concerning the association and separation of manganese and iron, Penrose[4] says:

"As both ores are derived from the same source, are taken up in solution together, and under many conditions are precipitated by the same influences, their frequent association in the ore deposits is what would be expected. Under certain circumstances, however, iron and manganese may be precipitated separately, and hence the not un-

[1] Penrose, R. A. F., jr., Manganese: its uses, ores, and deposits: Geol. Survey of Arkansas, Ann. Rept. for 1890, Vol. I, 1891.

[2] Idem, pp. 543-544.

[3] Penrose, op. cit., pp. 596-597.

[4] Op. cit., p. 600.

common occurrence of deposits of each in a state more or less free from the presence of the other. From the solution of manganese and iron the latter may be precipitated as oxide, and the manganese, on account of a difference in oxidability, may be precipitated afterwards as either oxide or carbonate.''

The original sediment in which the manganese was deposited has been largely decomposed and the ore remains as a residual deposit in the resultant clay.

Dana, J. D.[1]—In describing the brown iron ores of the Appalachian region, J. D. Dana suggested that those deposits, which are similar to manganese deposits, were formed in marshes and coastal lagoons which are supposed to have characterized the changing conditions of deposition now represented in the Cambrian formations of hydromica slate, sandstone, and limestone.

Spencer, J. W.[2]—J. W. Spencer, formerly State Geologist of Georgia, also describes the brown iron and manganese ores, particularly of the Knox dolomite formation, as having been deposited in lagoons or estuaries by streams bearing metalliferous solutions from the decay of crystalline rocks containing hornblende, garnet, pyroxene, and other manganese-bearing minerals.[3] ''The metals are generally disseminated, to a small extent, amongst all the rocks; but they are concentrated only in limited areas.''[4]

Hayes.[5]—C. W. Hayes, in his study of the brown iron ores of Georgia, recognized four types of deposits as follows: (1) gossan ores, (2) Tertiary gravel ores, (3) concentration deposits and (4) fault deposits.[6] In connection with manganese deposits, the last three types are of interest. The Tertiary gravel ores were deposited in swamps that received the drainage from adjacent regions. The concentration

[1] Dana, J. D., Amer. Jour. Sci., 3d series, Vol. XIV, p. 139, cited by Penrose, R. A. F., jr., op cit., pp. 559, 599.

[2] Spencer, J. W., The Paleozoic Group. The Geology of ten counties of northwestern Georgia, and resources: Geol. Survey of Ga., 1893.

[3] Spencer, op. cit., pp. 205-209.

[4] Idem, p. 207.

[5] Hayes, C. W., Geological relations of the iron ores in the Cartersville district, Georgia: Trans. Am. Inst. Min. Eng., Washington meeting, Feb., 1900.

[6] Hayes, op. cit., pp. 9, 10, 11, cited by McCallie, S. W., Preliminary report on a part of the iron ores of Georgia: Geol. Survey of Ga. Bull. 10-A, p. 21, 1900.

deposits illustrated in the Cartersville district, according to Hayes, "occur wherever a limestone is underlain by an insoluble and impervious stratum, such as sandstone or quartzite," a condition which occurs "at the contact of the Beaver [Shady] limestone with the underlying Weisner quartzite." The fault deposits are described as being indicated by breccia often containing considerable deposits of iron ore.

Another aspect of the fault deposits is mentioned by Hayes[1] as follows: "It appears probable that the extensive faulting of the region was accompanied by the formation of springs, doubtless thermal, which brought minerals in solution from considerable depths."

The types and occurrences of the iron ores are further described by Hayes and Eckel in Bulletin 213 of the United States Geological Survey,[2] and in the same publication, Hayes[3] refers to the occurrence and origin of the manganese in part as follows:

"It has the appearance of having been deposited by solutions percolating through the residual mantle. The original source of the manganese was probably the Beaver [Shady] limestone, although some of it may have come from the Weisner quartzite. The deposits occur with about equal frequency in the residual material derived from the two formations.

"Dr. Penrose holds the view that some at least of these deposits existed in their present form in the rocks of the region before weathering, and are therefore strictly residual. While this may be true in a few cases, the writer has found no evidence of it in the field; and the manganese ores are regarded, like the iron ores with which they are associated, as purely secondary deposits, their distribution being determined chiefly by chemical and physical conditions, rather than by the outcrop of beds especially rich in manganese."

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[1] Hayes, C. W., U. S. Geol. Survey Geol. Atlas, Rome folio (No. 78), 1902.

[2] Hayes, C. W., and Eckel, E. C., Iron ores of the Cartersville district, Georgia, Contributions to economic geology, 1902: U. S. Geol. Survey Bull. 213, pp. 233-242, 1903.

[3] Hayes, C. W., Manganese ores of the Cartersville district, Georgia, Contributions to economic geology, 1902: U. S. Geol. Survey Bull. 213, p. 232, 1903.

Watson.[1]—T. L. Watson, in his discussion of the genesis of the manganese ore deposits of Georgia, agrees in part with Penrose and in part with Hayes in recognizing both strictly residual and strictly secondary deposits, but he regards the deposits generally as secondary residual accumulations since the manganese that was formerly distributed or irregularly scattered through the limestone and quartzite has been very largely segregated and concentrated by secondary agencies during the decay of the hard rocks, and still remains in the residual clay.[2] This term "secondary residual" seems most applicable in describing the workable manganese deposits of Georgia.

MANGANESE CONTENT OF THE ROCKS

Since it is generally considered that the manganese deposits are in the main secondary in origin, that is, they have received their manganese content from solutions passing through overlying rocks and from streams draining adjacent formations, it is interesting to note the results of available chemical analyses of these contributing rocks.

PALEOZOIC FORMATIONS

Weisner quartzite.—If the deposits received their manganese content from overlying formations, it is not expected that the Weisner quartzite was a large contributing factor, because the deposits associated with it occur in its uppermost portions. Watson[3] found no manganese in samples of this rock but two samples of fresh quartzite (*Hu-339* and *Hu-349*) collected from the Cartersville district in 1917 by the writer showed an average of 0.54 per cent of manganous oxide. Sample *Hu-339* came from a barite mine and sample *Hu-349* from an ocher mine.

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, 1908.
[2] Idem, p. 151.
[3] Idem, pp. 37, 152-153.

Shady limestone.—Chemical analyses of representative and unweathered fragments showed a greater percentage of manganous oxide in the Shady (Beaver) limestone (sample *Hu-47*) than in any other formation that is in any way associated with the ore deposits. The analyses also showed, however, that the manganese is by no means uniformly distributed, and further, that some parts of the formation contain no manganese whatever (sample *Hu-40*).

The following six analyses were made of fresh unaltered rock as nearly as such samples may be collected from outcrops, and they represent both northern and southern parts of the Cartersville district.

Analyses of Shady limestone

Constituents.	*McCallie*	*Hu-40*	*Hu-414*	*Hu-16A*	*Hu-45*	*Hu-47*
Insoluble	....	......	0.40	0.27	0.50	0.21
Silica (SiO_2)	1.94	2.32	1.95	2.80	2.36	1.35
Alumina (Al_2O_3)	....	2.35	0.05	0.20	0.16	0.24
Ferric oxide (Fe_2O_3)	1.76	1.40	1.04	0.60	0.11	0.47
Ferrous oxide (FeO)	....	......	0.70	0.70	1.73	5.76
Magnesia (MgO)	20.40	19.78	20.65	20.46	19.65	17.57
Lime (CaO)	29.48	28.86	29.32	29.54	29.60	28.78
Moisture at 100°C	....	0.25	0.02	0.01	0.04	0.80
Loss on ignition	....	44.67	45.70	45.43	44.83	43.46
Sulphur trioxide (SO_3)	....	0.07	......	....	......	......
Phosphorus pentoxide (P_2O_5)	....	......	0.05	trace	0.02	0.03
Manganous oxide (MnO)	0.65	0.00	0.21	0.42	0.52	1.60
Barium sulphate ($BaSO_4$	....	......	......	....	0.55	......
Barium (Ba)	....	0.00	0.00	0.00	......	0.00
Total	54.23	99.70	100.09	100.43	100.01	100.26

McCallie.—Dr. W. B. Vaughan property, lot 317, 23d district, 2d section, Bartow County, 3 miles north-northeast of Rydal.

Hu-40.—City pumping station, 1½ miles south-southeast of Rydal.

Hu-414.—Tennessee Coal, Iron & Railroad Company, lot 902, 4th district, 3d section, Bartow.

Hu-16A.—Old limestone quarry north of Pumpkinvine Creek, 1½ miles southwest of Emerson.

Hu-45.—Paga Mining Company, lot 838, 4th district, 3d section, 1¼ miles west of Emerson.

Hu-47.—Old limestone quarry near Paga barite mines, lot 838, 4th district, 3d section, 1½ miles west of Emerson.

Cartersville formation.—A sample of feldspathic sandstone (*S-511*) collected by H. K. Shearer, Assistant State Geologist, contained 0.62 per cent of manganous oxide. The sample was taken from the Cartersville formation, next younger than the Shady limestone, and thus above it in the geologic time column. It was associated with the high-potash slates near White, Bartow County.

Conasauga shales.—Manganese oxide also occurs as small deposits in the Conasauga shale but by no means as an ore deposit.

Holston marble.—A sample of Holston marble (*Hu-394*) broken from an outcrop several hundred yards from any manganese mine showed on analysis 0.12 per cent of manganous oxide. This is a sample of the formation at whose contact with the overlying Tellico sandstone occur the manganese deposits of the Varnell-Cohutta district. It was collected from the J. W. and E. O. Eslinger property, lot 227, 11th district, 3d section, Whitfield County, a mile east of Varnell.

PRE-PALEOZOIC AND DOUBTFUL PALEOZOIC FORMATIONS

The semicrystalline and crystalline rocks east of the Cartersville fault are considered to have been important sources of the manganese deposits. Chemical analyses in which manganese has been determined are available to represent some of these rocks.

Corbin granite.—Specimens of the Corbin granite which is a few miles east of the Cartersville manganese deposits were collected by A. H. Brooks, of the United States Geological Survey and analyzed by H. N. Stokes.[1] The result showed only a trace of manganous oxide.

Ocoee.—The mica schists tentatively classed as Ocoee by Hayes and also termed metamorphosed Paleozoic lie east and southeast of the Cartersville fault. These schists are exposed through a thickness of several hundred feet in the cut of the Dixie Highway at Allatoona Pass, about 6 miles in an airline southeast of Cartersville. At this place they are full of small fractures $\frac{1}{32}$ to $\frac{1}{16}$ inch thick, both parallel to the schistosity and at right angles to it. The fracture-

[1] Clarke, F. W., Analyses of rocks from the laboratory of the United States Geological Survey 1880 to 1899: U. S. Geol. Survey Bull. 168, p. 55, 1900, cited by Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull 14, p. 42, 1908.

filling sample (*Hu-412*) is soft, brownish-black, slickensided material whose analysis showed 2.46 per cent manganese. This material characterizes the schist in the whole Pass. The fractures are a few inches to a few feet apart. No deposits of manganese ore occur here.

Great Smoky.—Micaceous and sericitic schist formations in the metamorphosed Paleozoic rocks southeast of the Cartersville fault, that have been classed with what is known as the Great Smoky formation, but may be part of the crystalline Archean rocks, since they resemble the Carolina gneiss and contain Roan gneiss (hornblende) formations, occur in the Draketown district, Haralson County. Mine water from the Tallapoosa pyrite mine, which is in gray micaceous and sericitic schist, contained manganese in the ratio of 51 parts per million.[1] Magnesian limestone contained in fragmental condition in the pyrites deposit showed no manganese upon analysis.[2] Small and unworkable surficial deposits of manganese occur half a mile southwest of the mine.

Carolina gneiss.—Quartzites in those parts of the Archean rocks grouped as the Carolina gneiss contain manganiferous minerals which are the immediate source of manganese deposits localized in the quartzite or at its contact with the mica schist. At the Douglass manganese prospects in the Draketown district, Haralson and Paulding counties, manganese occurs as the oxide in the quartzite and associated with magnetite and garnets.

At the Bell-Star pyrite mine 3.8 miles west of Woodstock in Cherokee County, manganese ore occurs in localized alteration replacement pockets in the "sandstone vein," which is composed principally of quartz, magnetite, and garnet.[3] In places the garnet is massive and is doubtless a source of the manganese ore. The ore does not occur in workable quantities. Analyses were made of specimens of grayish-pink granular and massive garnet sent to the Survey by the owner, J. G. Westerman. One specimen contained 19.28 per cent and the other 7.29 per cent of manganous oxide.

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[1] Shearer, H. K., and Hull, J. P. D., Preliminary report on the pyrites deposits of Georgia: Geol. Survey of Ga. Bull. 33, p. 76, 1918.
[2] Idem, p. 78.
[3] Idem, p. 148.

The crystalline rocks of the Piedmont Plateau area that are associated with the gold deposits of Georgia have been sampled and described by S. P. Jones[1] and analyzed by Dr. Edgar Everhart. Eight samples of granite and gneiss, including amphibolite, contained an average of 0.163 per cent of manganous oxide. Ten samples of mica schist, including hornblendic and garnetiferous phases, contained an average of 0.46 per cent of manganous oxide. The minimum found was 0.15 per cent in a quartz schist containing magnetite. The maximum was 1.48 per cent of manganous oxide in a garnetiferous quartz schist containing biotite, chlorite, and garnet, together with accessory pyrite and magnetite. Both specimens came from Dahlonega, Lumpkin County.

It is of importance to note that museum specimens of botryoidal pyrolusite were collected from the Bast gold mine[2], which is a few hundred yards southwest of the Findley gold mine, where the garnetiferous schist contained 1.48 per cent of manganous oxide. No manganese ore deposits of workable quantity occur at this place.

It is thus seen that, though some parts of the rocks most closely associated with the manganese deposits contain significant quantities of manganese oxide, other rocks not known to be directly related to the deposits contain in places an equally high percentage of the oxide. This may be explained by the fact that chemical and physical conditions favorable for the deposition of the solutions and the accumulation of the ore did not occur everywhere, even though the supply was present and adequate.

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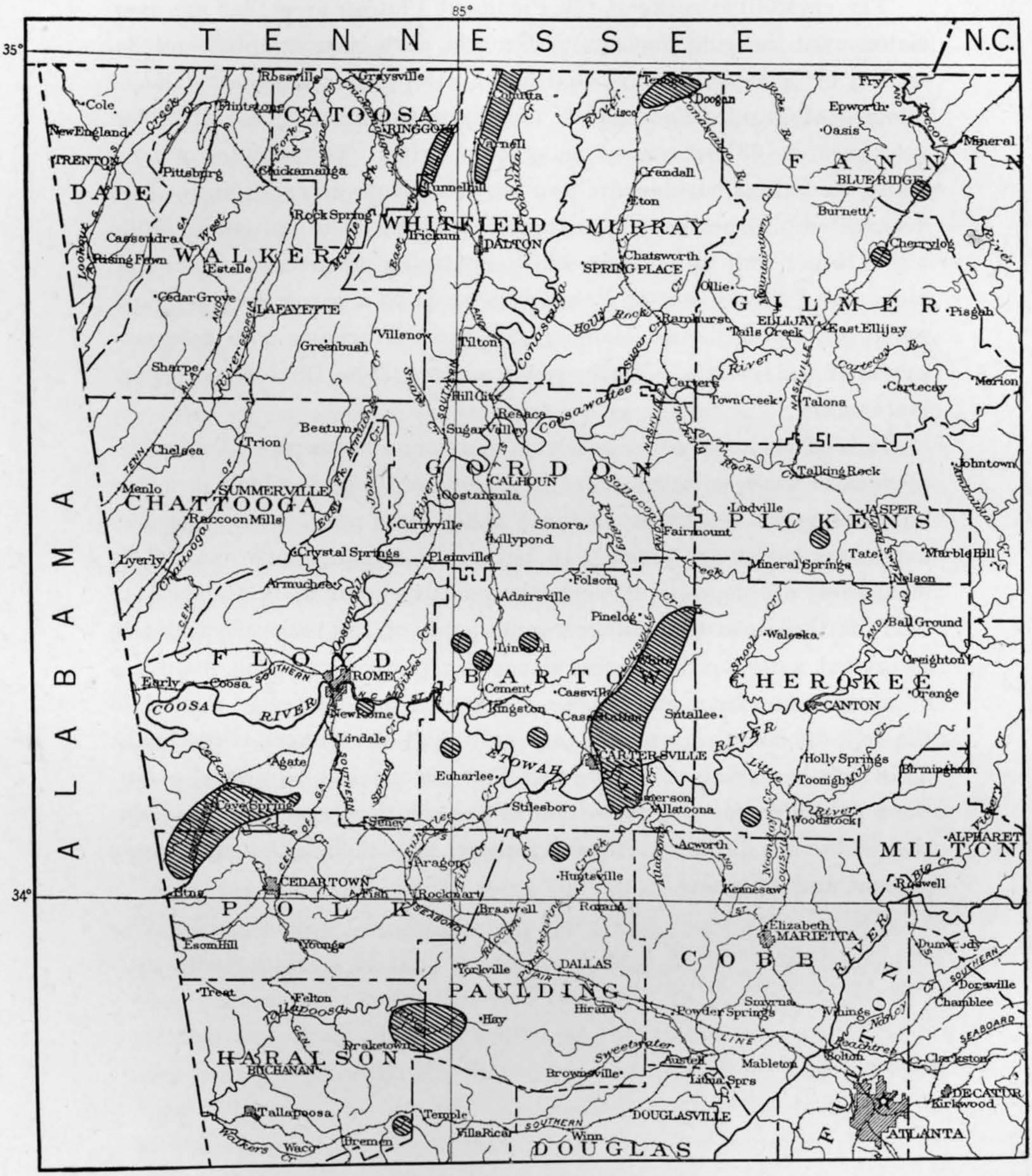
[1] Jones, S. P., Second report on the gold deposits of Georgia: Geol. Survey of Ga. Bull. 19, pp. 53-78, 1909.

[2] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, p. 165, 1908.



Map I. Index map of Northwest Georgia, showing distribution of the six manganese mining districts and the location of the principal isolated deposits. *Scale: 1 inch approximately 16 miles. Base map by the U. S. Geological Survey.*

DISTRIBUTION OF DEPOSITS

The manganese deposits of Georgia occur in the northern part of the State in the Piedmont Plateau and Appalachian Valley provinces. Their wide geographic distribution is shown by their occurrence in Lincoln County near the Georgia-South Carolina state line, in Towns County near North Carolina, in Whitfield and Catoosa counties near Tennessee, and in Polk and Haralson counties east of the Georgia-Alabama state line. The principal deposits, however, are within rather well-defined areas chiefly on the west side of, and approximately parallel to, the Cartersville fault. They may be conveniently described by mining districts. These districts have geographic and geologic features peculiar to each. The Cartersville district is the oldest mining district and the largest producer. The Cave Spring district ranks second in importance, though its production as compared with that of Cartersville has been very small. Named in the order as described in this report, the six principal mining districts are, (1) Cartersville district, (2) Cave Spring district, (3) Draketown district, (4) Tunnel Hill district, (5) Varnell-Cohutta district, and (6) Doogan Mountain district. Besides these, there are several isolated deposits.

THE CARTERSVILLE DISTRICT

GENERAL GEOLOGY

By Laurence LaForge

INTRODUCTION

GENERAL RELATIONS

The manganese ore deposits of the Cartersville district are found in a narrow belt—18 miles long and 1 to 2 miles wide—in southeastern Bartow County. The belt extends from a point 4 miles east of Pinelog southwestward past White to Aubrey and thence southward past Cartersville to Pumpkinvine Creek, south of Emerson. The city of Cartersville is situated just west of the belt, 4 miles from its southern end. Workable deposits of manganese ore are found in an area of about 30 square miles.

The manganese-bearing belt is situated in the Coosa Valley section of the Great Appalachian Valley and lies at the eastern margin of the section, at the base of and along the irregular escarpment, here formed by bold hills and low mountains, that is the western edge of the Piedmont Plateau. Geologically it lies at the southern margin of the Paleozoic Belt of Georgia, along and just west of the boundary between the Paleozoic and Crystalline belts. It is thus situated nearly in the center of that part of the Appalachian Province comprised in the states of South Carolina, Georgia, and Alabama.

GENERAL GEOGRAPHY AND GEOLOGY OF THE REGION

GEOGRAPHY

Divisions.—The southern part of the Appalachian Province comprises several main divisions, four of which—the Cumberland Plateau, the Great Appalachian Valley, the Appalachian Mountains, and the Piedmont Plateau—enter Georgia. The Cumberland Plateau barely enters the northwest corner of the State and the Appalachian Mountains terminate in the northern part, so that the greater part of Appalachian Georgia is comprised in the Great Valley and the Piedmont Plateau. The boundary between these two divisions crosses the Cartersville district from north to south.

Altitude and relief.—On its eastern and southeastern side the Great Valley in Georgia is for the most part a broad, open valley with a rolling floor that lies in general from 700 to 800 feet above sea level. In tracts remote from the larger streams the surface rises to 900 feet or more and it descends southwestward to 600 feet at the Alabama line. The valley floor is trenched to a depth of 100 to 200 feet by the valleys of the main streams, most of which are open, with gently sloping sides, but in places they assume a somewhat gorgelike character. It is also broken by a few low hills and ridges, rising to an altitude of 1100 to 1200 feet above sea level and having a trend in general parallel to that of the Great Valley itself.

The northwestern part of the Great Valley in Georgia is very different, being made up of narrow, parallel, but more or less interlocking valleys separated by steep, narrow mountain ridges. The floors of these valleys lie at about the same level as that of the open valley on the east, but the crests of the ridges separating them stand 1300 to 1600 feet above sea level.

The altitude of the general surface of the Piedmont Plateau in Georgia is much less uniform than that of the Great Valley. Northwest of Chattahoochee River it ranges between 1000 and 1400 feet above sea level and rises to more than 1600 feet about the southern end of the Appalachian Mountains. Southeast of the Chattahoochee the plateau is highest in the northeastern part of the State, where it lies about 1600 feet above sea level, and it descends gently southeastward, southward, and southwestward to an altitude of 500 to 600 feet at its southeastern margin.

Although large tracts of nearly level upland surface form the main divides between the streams, the Piedmont Plateau is trenched by valleys from 200 to 500 feet deep. In the northern and western parts its surface is also diversified by small knobs and low ridges which rise 200 to 500 feet above the general level and in northern Georgia by some larger mountains and groups of mountains, a few of which stand more than 3000 feet above sea level. These larger ranges and groups, like the Pinelog range northeast of Cartersville, are regarded by some geographers as outlying portions of the Appalachian Mountains and are included by others among the isolated mountains of the Piedmont Plateau.

Drainage.—All that part of the Great Appalachian Valley in Georgia except the northwest corner, where the streams flow to the Tennessee, lies in the drainage basin of the Coosa-Alabama system. The two main rivers—the Etowah and the Oostanaula—have their ultimate sources in the mountains on the northeast, and, flowing across the valley, unite at Rome to form the Coosa. The northwestern part of the Piedmont Plateau is drained by tributaries of these streams and of Tallapoosa River, which eventually unites with the Coosa. A narrow belt across the central part of the Plateau is drained by Chattahoochee River, which also flows to the Gulf of Mexico, and farther southeast the Plateau is drained by streams flowing directly to the Atlantic.

Climate.—The region is one of heavy rainfall, which is not uniformly distributed throughout the year, but is largely concentrated in the late Spring and early Summer. Early Autumn, on the other hand, is a nearly rainless season. These conditions have contributed both to the very great depth to which surface weathering of the rocks has proceeded and to the rapidity with which the streams cut down their channels, especially in times of flood. The abundant rainfall also aids in the leaching out and transportation downward of soluble material in the rocks, and, as the same climatic conditions have presumably prevailed in part of past geologic time, this fact has probably had an important bearing on the mode of formation of the ore deposits.

GEOLOGY

Character of rocks.—The hard rocks of the Great Valley are wholly sedimentary and of Paleozoic age and are little if at all metamorphosed. Those of the Piedmont Plateau and the Appalachian Mountains are highly metamorphosed and most of them are wholly crystalline. Part of them are sedimentary and part are igneous, part of them are of pre-Paleozoic age and part are regarded as Paleozoic. Northwest Georgia is, therefore, divided geologically between the Paleozoic Belt, comprising the Great Valley and the small part of the Cumberland Plateau included in the State, and the Crystalline Belt, comprising the Appalachian Mountains and the Piedmont Plateau. The topographic difference between the two belts is due primarily to the difference in their geology.

Geologic structure.—The rocks of all of Appalachian Georgia except the Cumberland Plateau have been greatly deformed, having been compressed laterally until the beds were thrown into close folds. In most of the region the compression was so great that the folds were overturned and, as the pressure continued, the folds broke in places where the strain was greatest and great blocks of rock were pushed westward over the rocks beneath, some of them for several miles. In some parts of the region more than one deformation occurred, so that the resulting structure is extremely complex.

The pressure in the latest great deformation, the one that gave the final form to the structure as now displayed, came from the southeast and east and the overturning and overthrusting were therefore toward the northwest and west. Consequently the prevailing dip is southeasterly or easterly throughout the region and in many places the beds and formations are inverted. In general the deformation seems to have been greatest toward the southeast and progressively less northwestward, so that the rocks of the Piedmont Plateau are more disturbed than those of the Great Valley. Furthermore, some of the earlier deformations seem to have affected only the rocks now exposed in the Piedmont Plateau and in the Appalachian Mountains, hence the rocks of those divisions are much more metamorphosed than those of the Great Valley.

Surface weathering.—The depth to which weathering has proceeded and the extent to which the rocks at the surface have been decomposed are striking features of the region. Except in the beds of streams, on very steep slopes, on the crests of narrow ridges, and on the summits of sharp peaks, the cover of thoroughly decomposed rock is many feet thick and over all but the hardest or least soluble rocks probably at least 100 feet thick. Formations or beds composed largely of soluble minerals have, throughout most of their outcrop areas, been reduced to residual clay or sand, which, in many places, retains no vestige of the original structures. Outcrops of the original rock of such formations are very rare, except in stream beds. Formations or rocks composed largely of insoluble minerals retain much of their original lithologic structures, but are so completely decomposed that they have little coherence and in places can be scooped out with a shovel to a depth of several feet. This is the form in which such rocks and formations are characteristically exposed along roadsides, in the banks of streams, and in rain gullies on slopes.

Another notable surface feature is the thick mantle of wash, composed of fragments of vein quartz, quartzite, and chert, in sandy clay, that covers the lower slopes and is several yards thick on the level bottoms, where it is interbedded with sand and clay wash from the residuum of wholly disintegrated rocks.

Outline history.—The rocks of the Great Valley were laid down on the floor of a sea that covered a large part of the region in early Paleozoic time and southeast of which lay the old continent of Appalachia. Later, as the land rose, the sea retreated westward and, toward the close of the Carboniferous period, finally disappeared from the region and the deposition of marine sediments ceased.

The uplift which finally drove the sea from the region and raised the surface several thousand feet culminated in a great deformation of the rocks and the upheaval of a mountain system. The streams at once began wearing down the surface and in time the greater part of the region was reduced to a nearly smooth lowland. Further uplift, without marked deformation, revived the erosive power of the streams and the reduction of the surface began anew and was again carried well toward completion. This seems to have happened several times, but since the latest uplift the streams have not had time to do more than to cut wide and deep valleys, hence the surface has now considerable relief, especially in the areas of more resistant rocks.

TOPOGRAPHY

RELIEF

General features.—A topographic map of part of the Cartersville quadrangle, on the scale of 1 to 125000, or practically one half inch to the mile, with the relief shown by contours at vertical intervals of 100 feet, has been used as the base of the geologic map accompanying this report. The main features of the topography are shown on this map and a study of it will give the reader a better idea than can be conveyed by a brief description.

The district lies along the boundary between the Piedmont Plateau and the Great Appalachian Valley and partly in each of the two divisions. The boundary between them crosses the district from the northeast to the southwest and is, on the whole, convex westward. The boundary is not, however, a line, but is a narrow belt lying along the irregular slope, broken by spurs, outlying knobs, and deep reentrants, by which the surface descends from the general level of the upland to that of the valley.

The northwestern part of the district lies in the Great Valley and the southeastern part in the Piedmont Plateau, the two parts being strongly contrasted in their topographic features. The western margin of the Plateau is a line of disconnected bold hills and low mountains, rising above the general level of the upland, which culminates at the northeast in the Pinelog Mountain group.

Piedmont Plateau.—The Piedmont Plateau within the district is so diversified by the mountains that occupy a large part of it and by the deep valleys that cut up nearly all the rest of it that its true character as a plateau is not very evident. The greater part of its surface consists of steep slopes and only a few small areas of fairly level upland surface are left on the main divides. Most of these lie between 1000 and 1100 feet above sea level, but, owing to the diversity in the character of the rocks, they have, as a whole, little uniformity in altitude. The deep, sinuous trench of Etowah River crosses the southern part of the district, the altitude of its floor decreasing from 860 feet, where it enters the district, to 700 feet where it leaves the Plateau, and the valleys of the main tributaries are cut down well toward river level. Hence the average relief of the Plateau is about 300 feet and the maximum relief, excluding the mountains that stand above it, is nearly 500 feet.

The valleys are, as a rule, steep-sided, with narrow bottoms, although in some places, where the streams flow along belts of easily eroded rocks, the valley bottoms are wide and flat and are floored with alluvium. The valleys of streams which, like Pumpkinvine and Allatoona creeks, flow across belts of different sorts of rock, are made up of alternate open, flat-floored stretches and narrow, gorgelike "shut-ins." The valleys of the larger streams are also conspicuous for their tortuous courses, especially in their lower portions.

Mountains.—The low mountains that line the western edge of the Plateau are the most prominent topographic features of the district. Although they stand in a row from Pinelog Mountain on the northeast to the valley of Pumpkinvine Creek on the south they can not be said to constitute a range, as the individual mountains and groups of knobs that make up the row are separated by wide gaps at the level of the upland. Their summits range from 1300 to 2300 feet above sea level, but only on Pinelog itself do any stand higher than 1700 feet. As they rise 300 to 1300 feet above the general level of the upland, these mountains are almost as conspicuous when seen from the east as when viewed from a point out in the Great Valley toward which they face.

Pinelog Mountain is one of the conspicuous features of the Piedmont Plateau of northwest Georgia. Its main summit, which stands 2400 feet above sea level, is outside the Cartersville district, but its southwest end and its foothills on that side extend into the district. Little Pinelog Mountain, which reaches an altitude of 1620 feet, stands just southwest of Pinelog and is almost a part of the same group. It is cut off on the south by the deep and wide Wolfpen Gap, beyond which a line of bold knobs, separated by broad, low gaps, extends about 5 miles southwestward, gradually decreasing in altitude in that direction. Northeast of Cartersville the line of knobs turns southeastward across the Etowah and becomes almost a range, though cut in two by the gorge of the river. The height of the summits is greater toward the river, attaining 1552 feet in Pine Mountain. In this southern area several bold hills, reaching altitudes of 1000 to 1300 feet, form two or three irregular rows, west of and parallel to the main line of mountains. Groups of similar foothills stand in front of the mountains at one or two other places also.

Appalachian Valley.—The northwestern part of the district lies in the Coosa Valley section of the Great Appalachian Valley and is characterized by a rolling surface of slight relief compared to the Piedmont Plateau. It is made up of low hills with rolling summits, broad, nearly level tracts at lower altitudes, and flat bottoms along the streams. The hilltops stand 900 to 1000 feet above sea level, being highest north of White, along the main divide, and lowest about Cartersville, near the Etowah. The intermediate flats and level bottoms lie at all altitudes from 900 feet down to 670 feet above sea level.

At first glance there appears to be no systematic arrangement of the low hills and shallow valleys that characterize this part of the district, but closer inspection reveals a tendency toward a north-northeast trend, though obscured by the courses of some of the streams, which flow in various directions. Several roughly parallel lines of hills and short ridges cross the area and give its relief an obscure but recognizable "grain." There are, however, no sharp ridges or low residual mountains that stand prominently above the general level of the valley floor, as in the area a few miles to the west.

Several streams have narrow flood plains here and there, but the only important flood plains are those of Etowah River and of Pumpkinvine Creek. The plain of the Etowah begins just above the mouth of its gorge through the Plateau and broadens gradually to a width of about three-fourths of a mile at the west side of the district. The plain of the Pumpkinvine begins south of Bartow and has a width of half a mile where it merges with that of the Etowah. The surface of these flood plains is nearly level and lies 6 to 12 feet above the streams.

Character of surface.—The character of the surface differs greatly in different situations, depending chiefly on the character of the rocks, the slope of the surface, and the relation to streams. As the general aspects of the subject have already been discussed only the local relations will be described here.

In the mountains and the Piedmont Plateau, where much of the surface has a steep slope, it is generally covered to a depth of several feet by a heterogeneous mixture of slope wash, talus debris, and residual clay and gravel, the whole constituting a stony clay, much of which is firmly compacted. In places this grades downward into the broken up and deeply weathered crust of the rock beneath; in other places, where the surface mantle is mainly wash, it is sharply separated from the underlying rock, which, though deeply weathered, may be little disturbed. Exposures of rock in place are abundant in the beds of ravines, but, outside of areas underlain by such rocks as quartzite and conglomerate, outcrops are rare except on steep slopes.

The relatively flat, not much dissected areas of the Plateau surface on the main divides are covered to a depth of a few feet with light-colored, sandy, residual clay. In some places this is practically free from stony material, in others it contains abundant small residual fragments of vein quartz. Fragments of the underlying rock are rare, but where the rock contains a considerable amount of coloring material, such as graphite or an iron oxide, the overlying residual clay is generally strongly colored. Practically all the rocks of the district, except the limestones and the hornblendic rocks, contain a great deal of sericite, much of which remains unaltered in the residual clay and gives it a peculiar sheen, especially in strong sunlight. This sheen is characteristic of the residual clays of all the rocks of the region except the limestones, as even the residual clay of the hornblendic rocks has a sheen, supposedly due to minute fibrous pseudomorphs of limonite after hornblende.

In the Great Valley portion of the district steep slopes are rare except on sandstone ridges and the cover of talus and stony clay is largely confined to such ridges. The flatter areas on the shale uplands have a thin cover of sandy clay, mixed, in some places, with residual quartz gravel or with small hard lumps of iron and manganese oxides. The shale slopes, as a rule, are barely covered with thin soil, and the weathered surface of the underlying rock is exposed in numerous rain gullies and ditches and in bare places on the slopes, but hard rock outcrops are rare except in cliffs and stream beds.

Areas underlain by limestone, which, as a rule, form bottom lands and alluvial flats, are generally covered by a thick sheet of dark red, lumpy clay, commonly mottled with white and yellow. Much of this clay is indistinguishable from the residual clay of the limestone, and it has generally been supposed to be in place, but deep cuts in several places have revealed interbedded lenses of sand and gravel, and some of the red clay itself shows evidence of deposition by water. Therefore, although presumably nearly all of it has been derived from limestone and although most of it is found in areas that are or once were underlain by limestone, much of it seems to have been transported and deposited in its present position. Another common feature of the limestone areas is the abundance in some places of residual fragments of chert, which are of all sizes up to large blocks.

In many places the lower slopes bordering the Etowah valley are mantled with coarse terrace gravel, more or less interbedded with sand and clay, and, on the whole, well stratified. Just south of Cartersville this mantle covers the entire surface and is so thick that the streams have not cut through it except in a few places.

DRAINAGE

Most of the district lies in the drainage basin of Etowah River, which flows westward across the southern part, descending 120 feet in 12 miles. Above Webster Ferry its valley is wide, has a flat floor with narrow flood plains, and is flanked by low hills. The river here has deep and shallow stretches, but is sluggish and broken by alluvial islands. From the ferry to a point south of Pine Mountain the valley is a gorge, bordered by cliffs on both sides. The stream here is broad, shallow, and swift, is dotted with rocky islands, and flows over many ledges, so that this stretch is a series of rapids and riffles. Below the mouth of the gorge the valley widens and the river is again bordered by flood plains. Here it is narrower and deeper, but sluggish, except in one or two places where it crosses ledges.

South of the river most of the district is drained by Allatoona and Pumpkinvine creeks, both of which rise outside it and, entering it from the south, flow in zigzag courses to the river. The entire basin of Allatoona Creek and almost all that of the Pumpkinvine are in the Piedmont Plateau but the Pumpkinvine leaves it south of Emerson and flows for 4 miles in an alluvial valley half a mile wide and having a grade of only 6 feet to the mile. The lower Allatoona, on the other hand, flows in a narrow, winding, steep-walled valley having a grade of 17 feet to the mile. Furthermore, although the streams rise many miles apart and reach the river at some distance from each other, a little south of Allatoona they are less than a mile apart and Allatoona Creek is about 80 feet higher than the Pumpkinvine.

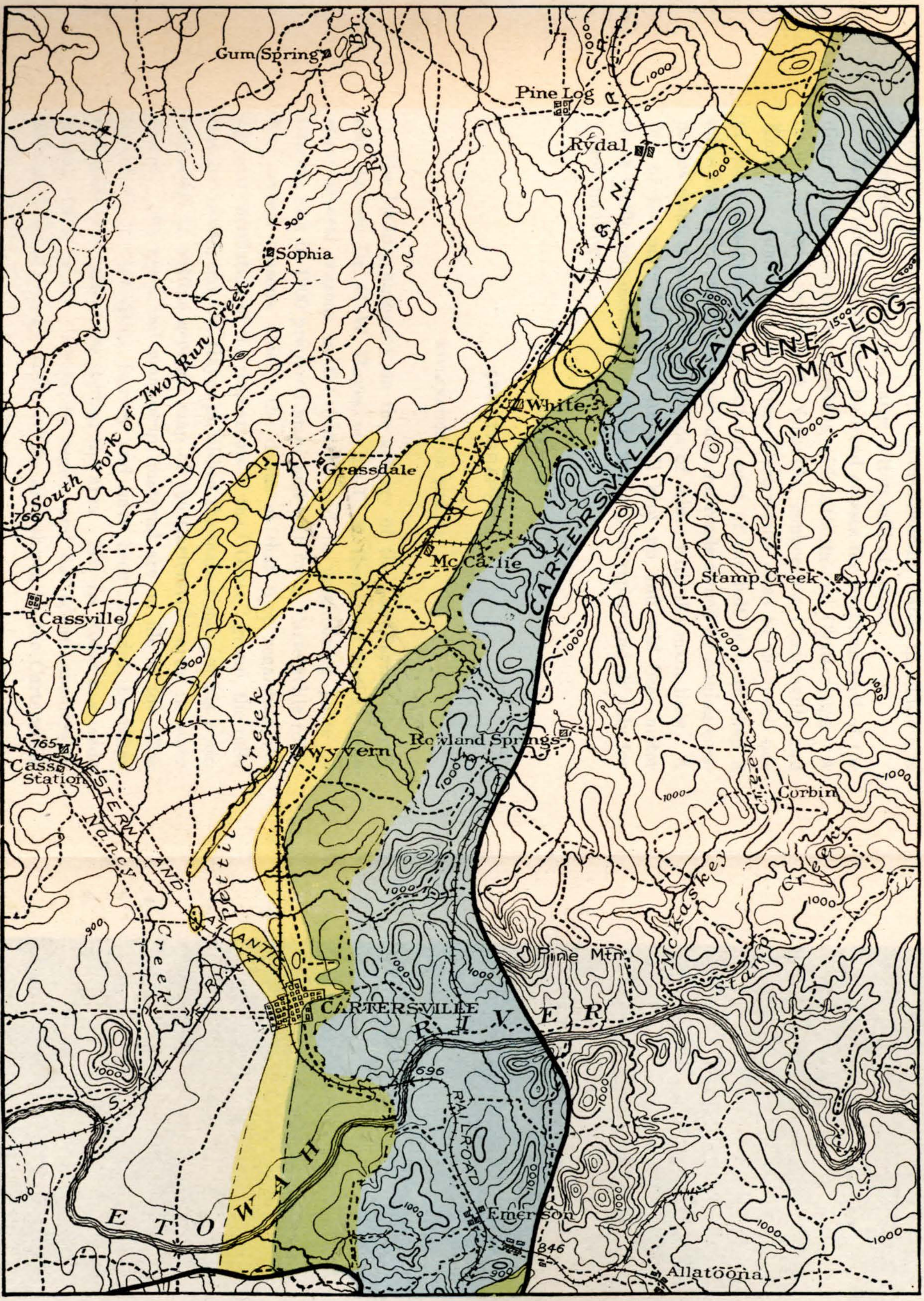
Nearly all that part of the Piedmont north of the river and inside the district is drained by Stamp Creek, the basin of which is much like that of Allatoona Creek in its general character and topographic relations. The larger part of the Appalachian Valley within the district is drained by Pettit Creek, which rises at the western base of Little Pinelog Mountain and flows southwestward past Cartersville to the Etowah. The northern part of the district is drained by several branches of Pinelog Creek, which flows northward to Coosawattee River, another member of the Coosa River system. Although a considerable part of this area is underlain by limestone the streams are fairly well adjusted to the geologic structure and there is not much underground drainage. There are one or two small cave springs and a few dry sinks, but no large stream sinks underground.

The drainage pattern has two rather striking general features. First, although there are several exceptions, the streams of the valley area show a tendency to flow south-southwest or north-northeast, parallel to the trend of the geologic structure. Second, the divide between the streams of the Piedmont Plateau and those of the Appalachian Valley runs along the line of hills and mountains at the western margin of the Plateau, and, although these mountains are separated by a number of broad, low gaps, the Etowah itself is the only stream that flows from the Plateau through the mountains and out into the Valley.

CULTURE

Cartersville, with a population of nearly 5000, is the only place of importance in the district. Emerson, White, Pinelog, Allatoona, Atco, Aubrey, and Bartow are small villages. Outside the settlements the district is rather sparsely populated and the mountainous portions are almost uninhabited. The part of the district in the Coosa Valley is generally cleared and under cultivation, with patches of woodland here and there, especially on the ridges. The Piedmont Plateau area, however, is only partly cleared and the mountains are hardly at all so. Pinelog Mountain and its southern foothills are occupied by an almost unbroken stretch of forest.

The chief occupation of the inhabitants is agriculture, particularly



Cartersville formation

Shady limestone

Weisner quartzite (Including many small in-faulted areas of Shady limestone.)

MAP OF THE CARTERSVILLE MANGANESE DISTRICT

From the Cartersville Topographic Map of the U. S. Geological Survey

Scale 1:125,000

Contour Interval 100 feet

Map II.

cotton raising. Mining is an important industry, as the district produces iron ore, ocher, barite, and potash-bearing slates, in addition to manganese ore. There is a large cotton mill at Atco.

The Western & Atlantic Railroad crosses the southern part of the district and connects Cartersville with Atlanta and Chattanooga. A branch of the Louisville & Nashville, connecting Cartersville and Knoxville, runs northward from Cartersville close to the west side of the manganese belt, so that no part of the belt is more than 3 miles from a railroad. Several short railroads owned by mining companies connect some of the groups of mines with the main lines. A few of the main highways are well kept up and will bear motor truck traffic, but most of the roads are in poor repair and fit only for wagon hauling.

GEOLOGY

STRATIGRAPHY

EXPLANATION OF THE MAP

The leading authority on the geology of the Cartersville district was the late Dr. C. W. Hayes, of the U. S. Geological Survey, who spent several seasons in the district and in neighboring parts of Georgia and in 1900 prepared maps and text for a Cartersville folio. For several reasons, chiefly the doubt at that time regarding the age and correlation of the formations of the "Ocoee" group, the folio was not issued, but Dr. Hayes published the main results of his work, including an outline geologic map of the Cartersville area, in other places.[1] His notes and manuscript material are on file in the office of the U. S. Geological Survey and have been utilized by other geologists who have since studied the area. Mr. La Forge has made several visits to the Cartersville region and has spent considerable time in detailed geologic study of the area shown on the Cartersville

[1] Hayes, C. W., Geological relations of the iron ores in the Cartersville district, Ga., Trans. Am. Inst. Min. Eng., p. 403, 1901. Hayes, C. W., and Eckel, E. C., Iron ores of the Cartersville district, Ga., U. S. Geol. Survey, Bull. 213, p. 233, 1903.

Special map. The results of this work will presumably be published eventually in a bulletin of the U. S. Geological Survey or of the Geological Survey of Georgia. Meanwhile a summary of those features that are of importance in connection with the deposits of manganese ore is given here.

When the publication of this report was decided upon and during the preparation of the text, it was expected that the Cartersville Special topographic map of the U. S. Geological Survey, as published in the first report on the manganese resources of the State, would be used as the base of the geologic map of the manganese-bearing area. The description of the Cartersville District was written with this plan in mind and the expression "Cartersville District," when used herein, meant in general the area shown in the Cartersville Special map. Owing to conditions arising from the war it was not feasible to have an edition of the Cartersville Special map, with the geology shown thereon, printed in time to be used in this report. Therefore, in the emergency, it has been necessary to use a part of the base map, modified from the old Cartersville sheet of the U. S. Geological Survey, that was used in Mr. Shearer's report on the Slate Deposits of Georgia. This base map includes an area extending several miles farther west, but not so far south, as the Cartersville Special map, and the description written with the other map in mind does not everywhere apply to this one. In order not to delay the issuing of the report it has seemed best, however, to let the description stand as it is.

No attempt has been made to show the geology of the whole area, but only the distribution of the formations with which the manganese ore deposits are associated. Owing partly to the highly complicated geologic structure, partly to the lack of exposures in many critical areas, and partly to the inadequacy of the topographic base map, it has not been possible to show the details of the distribution of the Weisner quartzite and the Shady limestone. For the same reasons no structure sections have been drawn. The area colored as Weisner on the map includes all of that formation in the district, so far as known, but it also includes many infolded or down-faulted masses of Shady limestone or of residual clay and chert of that formation, whose outlines and relations are indeterminate. Similarly the area colored as Shady limestone includes only that formation, so far as known, but not all of it. The boundary between the areas colored as Weisner and as Shady is not, therefore, strictly a formation boundary, but is rather a line that separates, roughly, the area which is dominantly Weisner from that which is, presumably, all Shady. It is, therefore, drawn as a broken line. The position of the Cartersville fault is that mapped by Hayes and is now open to some doubt, but is left until more detailed mapping can be done and the structure better worked out.

CHARACTER AND AGE OF THE ROCKS

The Great Valley and the Piedmont Plateau differ strongly in their geology. All the rocks of the Valley are sedimentary and retain most of their original textures and mineral composition. Part of the rocks of the Plateau are sedimentary and part are igneous and all are much metamorphosed, most of them having been recrystallized and having lost much or all of their original character. The contrast between the northwestern and southeastern parts of the district is therefore as great in geologic as in topographic character.

The Appalachian Valley part is occupied by strata of Cambrian age. Few fossils have been found in these rocks, but those that have been found, together with the lithology and sequence of the formations, serve to establish their stratigraphic position. The Piedmont Plateau part is occupied by crystalline rocks, some of which may be the metamorphosed equivalents of Cambrian formations of the Valley, though others are regarded as pre-Cambrian. Some of them, however, are igneous and unlike any found in the Valley. Pinelog Mountain and the chain of mountains cut through by Etowah River east of Cartersville are formed chiefly by the metamorphic rocks, but Little Pinelog Mountain and the hills for several miles south of Brushy Knob, as well as the foothills in front of the mountains, are formed by the basal Cambrian beds.

FORMATIONS OF THE PIEDMONT PLATEAU

Nearly half of the Piedmont Plateau part of the district is occupied by a crushed, sheared, and altered granite to which Hayes gave the name Corbin granite. It is typically a coarsely porphyritic augite-biotite granite, most of which has been so much sheared that it is now characteristically an augen gneiss. In places it displays a fine-grained, non-porphyritic phase which has suffered less from crushing than the porphyritic rock and in other places it has been so greatly crushed that it is altered into biotite-sericite schist without a semblance of the original rock. It is believed to be of Archean age, as it is manifestly one of the oldest formations of the region and has furnished much of the material for the overlying metamorphosed sediments.

The granite is overlain and nearly surrounded by a conglomerate gneiss that Hayes called the Pinelog conglomerate. This is a rather heterogeneous formation composed of conglomerate, arkose, quartzite, siliceous phyllite, and graphitic slate, all much sheared and largely altered to sericitic schist and gneiss. Its base is in places an arkose, composed chiefly of granitic debris of all degrees of coarseness from sand to boulders. Much of this arkose is composed wholly of granitic material and shows little evidence of transportation and sorting. In such places it is believed to be a sedentary arkose formed by the reconsolidation of the debris derived from the weathering and disintegration, without much washing about, of an anciently exposed surface of the granite.

The conglomerate is overlain, along most of its west side, by interbedded graphitic slate and sericitic schist that Hayes regarded as a distinct formation, equivalent to his Wilhite slate of Tennessee. He also believed that this slate and the conglomerate beneath are distinct from the quartzite that he regarded as the lowest Cambrian formation and are separated from that formation by a great thrust fault. More recent field work, however, has thrown doubt on the existence of a great regional fault along the contact of these formations. It now seems not improbable that the slate and conglomerate conformably underlie the quartzite and constitute the base of the Cambrian strata and that the whole section from the basal arkose to the top of the quartzite is equivalent to Safford's Chilhowee group of Tennessee.

In the southeastern and southwestern corners of the district the Plateau is occupied by several formations, part of which are sedimentary and part of which are igneous. They have not been mapped in sufficient detail to establish their sequence, and field work in surrounding areas has not progressed to the stage where it is safe to form more than purely tentative hypotheses regarding their age and correlation. Some of the sedimentary rocks may be the metamorphosed equivalents of Cambrian formations of the Valley, but the balance of opinion at the present time seems to lean toward the view that most of them are pre-Cambrian.

FORMATIONS IN THE APPALACHIAN VALLEY

General character.—The rocks of the Appalachian Valley part of the district comprise quartzite, sandstone, shale of several kinds, and limestone, as well as some conglomerate and schist. They have been divided into the following formations, named in ascending order—Weisner quartzite, Shady limestone, Cartersville formation, Conasauga formation, and Knox dolomite. Very few fossils have been found in these beds, but their correlation and age are fairly well established by their character and sequence, and the upper two formations have a wide extent outside the district and do contain fossils in other localities. All the strata are of Cambrian age and all three series of the Cambrian system are represented. The Weisner and Shady are Lower Cambrian, the Cartersville is Lower or Middle Cambrian, its age being as yet uncertain, the Conasauga comprises both Middle and Upper Cambrian strata, and the Knox ranges from Upper Cambrian into Ordovician, but only its lowermost part is found in the district. The Weisner quartzite and the Shady limestone, with possibly a few small masses of the Cartersville, are the only formations that are found in the manganese-bearing belt or that are immediately connected with the occurrence and relations of the manganese ore deposits, and only these three formations will be described in detail.

Weisner quartzite.—The Weisner quartzite was named by Hayes from Weisner Mountain, Alabama. It is found at several localities in the Appalachian Valley in western Georgia, but is not known in the eastern part of the Valley outside the Cartersville district. It is regarded as in general equivalent to the Erwin quartzite of Tennessee and Virginia and to part of the group of strata in Tennessee which Hayes called the Chilhowee series. Fossils which have confirmed its age as Lower Cambrian have been found in the formation at a point a mile north of Emerson. Some imperfect Scolithus tubes have also been found in the uppermost bed of the formation on the hill northeast of Cartersville.

The formation occurs in a narrow, irregular belt extending from the valley of Pinelog Creek in the northeast corner of the district to that of Pumpkinvine Creek in the southwest corner. It does not occupy a continuous area, but is interrupted in many places by downfolded or downthrown masses of the Shady limestone. Little Pinelog Mountain is made up chiefly of the formation, as are the many foothills that stand in front of the row of mountains along the western margin of the Piedmont Plateau. The valleys between and among these hills, however, are largely occupied by younger formations or their residual clay.

Because of the intense folding and complicated thrust faulting which has occurred in the district and because the base of the formation is not certainly known to be exposed anywhere its thickness has not been determined. It is probably much more than 1000 feet and may be 2500 to 3000 feet thick. Both Hayes and Watson estimate that the thickness is at least 2000 feet and this is probably not far from correct.

The formation consists chiefly of quartzite, in part massive and semivitreous and in part thin-bedded and generally schistose, but it includes much coarse grit and some beds of conglomerate. In places a large part of the formation consists of quartzose, feldspathic, and graphitic schists and slates, all sericitic. Some quartzite beds consist of almost pure silica, but others contain much disseminated specular hematite, magnetite, or pyrite. Not far below the top the formation is so highly aluminous for a considerable thickness that it weathers to a conspicuous, white, sandy clay which serves as a useful key horizon in working out the geologic structure. The uppermost bed of the formation is nearly everywhere massive and fairly rich in pyrite and its upper surface is characterized by a peculiar embayed or cavernous appearance, as though it had been irregularly corroded by some solution.

Analyses of several specimens collected from the formation show that as a whole it contains very little manganese and iron and a somewhat larger amount of barium. It seems probable, however, that the barite in the formation is largely, if not wholly, secondary and deposited by infiltration.

The massive siliceous beds of the formation, including the persistent uppermost bed, outcrop in many places in the bluffs along the large streams, on steep slopes, and on the crests of sharp ridges. The rock does not disintegrate readily, but it breaks up into angular pieces of all sizes. The coarse rock waste is strewn over the summits and the slopes and the finer subangular gravel has been washed out to some distance on the lower ground. The schistose and the feldspathic phases weather to sandy clay, much of which is covered by the waste of the harder beds. The characteristic surface material overlying the formation is therefore a stony, sandy clay, partly residual and partly transported, ranging in color from white through light gray to drab and light red. In a few places, where there has been a concentration of iron oxide, it is dark red, but dark red soil is not characteristic of the formation in general.

The formation is expressed topographically in steep, rugged hills covered with coarse rock waste and showing abundant ledges. The soil is generally too poor and stony for cultivation and the hills are nearly everywhere covered with brush or timber.

Shady limestone.—The Shady limestone is named from Shady

Valley, in northeastern Tennessee. It has a wide distribution in eastern Alabama, western Georgia, northeastern Tennessee, and southwestern Virginia, but it is not certainly known to occur in the eastern part of the Appalachian Valley in Georgia, except in the Cartersville district. It was named Beaver limestone by Hayes in the areas mapped by him, but that name has been abandoned, as it is now certain that the formation does not occur at the supposed type locality in Beaver Ridge, north of Knoxville, Tenn.

One specimen of a fossil sponge—Ethmophyllum—replaced wholly by barite, has been found in a barite mine which is being worked in the residual debris of the formation. This is a Lower Cambrian form which is found in the Shady limestone in Tennessee and it serves to fix the age of the limestone in this district.

The formation occurs in a narrow, irregular, but presumably continuous belt lying just west of the quartzite foothills and extending from Pinelog Creek on the northeast to Pumpkinvine Creek on the southwest. It, or its residual clay, also occupies many of the valleys among the quartzite hills and extends some distance up the slopes of some of the hills. Possibly some of the isolated areas of limestone along Pettit Creek may belong in this formation, although they have been assigned to the Conasauga formation. Hayes mapped a large area of "Beaver" limestone in the western part of the district, extending from Grassdale southwestward nearly to Cass Station, but it now seems probable that all the limestone of that area is Conasauga.

Inasmuch as the Shady is exposed in the district very sparingly, and as the details of its structure are unknown, its thickness can not be determined. From the width of the belt of red clay and the average dip of the adjacent beds Hays estimated its thickness as possibly 1500 feet.

The formation consists almost wholly of gray siliceous and earthy limestone, generally rather shaly, but in places massive. It has a peculiar lumpy or mottled structure, which apparently is original and which persists in the residual clay. The more shaly phases are interbedded with siliceous shale or slate which consists chiefly of quartz and seems free from calcareous material, but no real sandstone has been noted in the formation. The upper part is also characterized in places by thin laminae of pinkish and purplish sericitic phyllite. One of the notable features of the formation is the abundance of so-called chert. This material is not amorphous, but consists of a granular aggregate of quartz, without bedding or lamination. It is distributed irregularly through the formation, though it is apparently more abundant near the base, but this apparent greater abundance may be due to concentration as the limestone was dissolved. The chert occurs in irregular masses, some of them of enormous size, and it has been mistaken by some geologists for sandstone lenses in the limestone or for outlying patches of the Weisner quartzite. It is of considerable economic importance because of its relation to the occurrence of the ore deposits.

The Shady limestone seems to be more soluble than most limestones, as outcrops are very scarce in the area occupied by the formation and nearly everywhere all the rock has disappeared and only residual material is left. The residual clay is dark red, lumpy and mottled, slightly gritty, and very tenacious. In most places it contains fragments of chert and a few flakes of siliceous phyllite and, near the surface, debris of Weisner quartzite from the hills. It also contains most of the deposits of iron and manganese ores and of barite. This dark red clay occupies most of the area of the formation but it is not confined to that area nor is it all residual, as some dark red clay otherwise indistinguishable from the residual clay shows faint but positive evidence of transportation and redeposition and some of it is interbedded with or underlain by sand and gravel. Furthermore, what was once supposed to be the residual clay of the Shady limestone, in place, has, where cut through by streams, been found to lie in some places on the Cartersville formation, where it must have been washed. In other places, as along the west base of Little Pinelog Mountain, the belt of red clay is interrupted for some distance, at least on the surface, which is covered with waste from the Weisner quartzite of the mountain. Whether the clay is continuous under the cover of wash has not been determined. It is evident, however, that the area occupied by the dark red clay is not exactly coextensive with that occupied by the Shady limestone and that the occurrence of the red clay is not everywhere a safe guide in mapping the formation.

The characteristic topography of the Shady is the reverse of that of the Weisner. The formation occupies chiefly low ground, level or gently rolling and lying but little above the present drainage. Its outcrop belt is not a continuous lowland, however, as it is more or less interrupted by low ridges and spurs projecting from the quartzite area. It is further broken by some small but rather sharp ridges and knobs that are residual chert hills, marking portions of the original limestone where the chert was either much more abundant or in larger masses than in the formation in general.

The soil of the chert hills and of the fans of quartzite wash is poor and those areas, as a rule, are not cleared and cultivated. The dark red residual clay forms a rich soil, although one that washes badly on slopes, and most of the red clay areas are cleared and farmed. The best soils of the formation are those composed of the red clay that has, at least to some extent, been transported and redeposited and such soils are among the most fertile in the district.

Cartersville formation.—The Cartersville formation was so named by Shearer[1] from Cartersville, where it is well exposed in railroad cuts. It comprises most of the strata assigned by Hayes to the Rome formation in this area, but the olive shale forming the upper part of the Rome as defined by Hayes is now included in the Conasauga formation. The Cartersville formation appears to have the same stratigraphic position as the Rome formation elsewhere in Georgia and as part of the Watauga shale in Tennessee and it may be equivalent to them. On account of its peculiar composition, its strong lithologic differences from those formations, and the lack of positive evidence of equivalence, it has seemed best, however to give it a separate name.

[1] Shearer, H. K., Slate deposits of Georgia, Geol. Surv. of Ga., Bull 34, p. 128, 1918.

The formation occupies a narrow belt, generally less than half a mile wide, lying next west of the Shady limestone and extending from Pinelog Creek on the northeast to the bluffs south of Etowah River. About midway of its length the belt widens greatly and a branch extends westward south of Grassdale, beyond which place it splits into three belts which extend southwestward nearly to Cass Station. In the valley of Pettit Creek, between these and the main belt, are several small, apparently isolated areas of the formation. It is unknown elsewhere.

The formation is generally closely folded, but its upper and lower limits are rather well defined, and in one or two places it seems not to be repeated by folding, hence a fairly close estimate of its thickness is possible. In Cartersville it is 600 to 700 feet thick, but it may be thicker at the north.

The formation consists of gray shale and brown sandstone, in alternate zones ranging in thickness from a few inches to 10 feet. The shale has been considerably metamorphosed, with the development of abundant sericite, and different beds display all degrees of alteration, from micaceous shale through siliceous sericitic schist to rock that is almost pure sericite. The shale and schist are bluish-gray, lead-gray, or slate-gray, with here and there a slight pinkish or purplish tinge. Much of the sericite schist, when freshly exposed, has the color and almost the luster of lead. The sandstone is prevailingly thin-bedded and ranges from a hard quartzose rock to shaly sandstone and sandy shale. Its color ranges from nearly white through light gray and cream color to tan. The formation is nowhere brightly or deeply colored, but the two prevailing colors—lead-gray and tan—are in fairly strong contrast and most outcrops that display much of the formation are distinctly color-banded.

The formation is rich in potash, much of it containing 8 to 10 per cent of K_2O. The nearly pure sericitic schists contain a little more than 10 per cent and even the sandstones contain 6 per cent or more. There is a great quantity of the rock in sight, well exposed in many easily accessible places, including several long railroad cuts, and the formation may prove to be one of the most valuable mineral resources of the district.

No fossils have been found in the formation except a few obscure forms, apparently fucoids, of no stratigraphic value.

The rocks of the formation contain comparatively little soluble material and in weathering most of them merely disintegrate into saprolite and then into residual clay and sand, both the saprolite and the residuum differing little in composition from the original rock. The residual clay and sand also have much the same colors as the rocks of the zones from which they were derived, and the characteristic color-banding of the strata persists in many places even in the overlying soil. The sericitic schists weather into very tenacious clay, which absorbs a great deal of water, but retains its tenacity even when apparently saturated. The sandy shales and shaly sandstones weather into sandy clay containing many small fragments of the harder sandstone beds. The hard sandstones do not disintegrate on weathering, but break up into moderately small pieces, which, like residual fragments of chert and vein quartz, remain and accumulate throughout a long period of denudation. As a result the surface in some places is thickly strewn with sandstone fragments, whose abundance gives a wrong impression of the amount of hard sandstone in the formation, for the numerous exposed sections show that the hard sandstone beds are comparatively few and are everywhere thin.

Its peculiar lithologic character, by which it is rather sharply differentiated from the underlying and overlying formations, and its distinctive colors, which persist even in the soil, make the formation comparatively easy to trace and map.

The formation is expressed topographically by low, commonly smoothly rounded hills and gently rolling lowlands. Where the hard sandstone beds are more abundant or thicker than in the formation as a whole it makes rather sharp, steep ridges thickly strewn with sandstone waste. The soil formed by the rocks of the formation is thin and not especially fertile. Much of the surface of the more shaly areas is cleared and farmed, but the sandstone ridges are nearly everywhere covered with timber. As the potash in the rocks is in the nearly insoluble form of potasium silicate it seems to make no noticeable difference in the fertility of the soil as compared with the soil on other formations.

Younger formations.—The northwestern part of the district, west of the Cartersville formation, is occupied by the Conasauga formation, which overlies the Cartersville. The Conasauga consists of olive, brown, and yellow shale, rather free from grit, and bluish-gray oolitic limestone. It may be as much as 2000 feet thick, but, owing to the absence of distinctive beds and the possibility of repetition by thrust faulting, its thickness is quite uncertain. It occupies the stratigraphic position of the combined Rutledge limestone, Rogersville shale, Maryville limestone, and Nolichucky shale of Tennessee and presumably is equivalent to those four formations. If so, it is Middle Cambrian in its lower part and Upper Cambrian in its upper part, though no fossils have been found in it in this district to confirm this correlation. Apparently the beds of limestone are more abundant in the lower and upper parts of the formation, but they seem to be lenses and not persistent, and so far it has not been found feasible to divide the formation into members that can be correlated with the Tennessee formations.

The shale part of the Conasauga forms smoothly rounded, but in places fairly steep-sided hills. It weathers into a smooth residual clay that makes the best roads of any of the Cambrian formations, but only an indifferent soil, hence the shale hills are but partly cleared. The areas occupied by the limestone are generally flat lowlands. This limestone outcrops much more commonly than the Shady limestone and numerous ledges are found along the streams. The limestone weathers to a dark red clay, which is much like that of the Shady and forms a rich soil.

The base of the Knox dolomite enters the west side of the district 10 to 11 miles north of Cartersville. The rock is the well-known dolomite, interbedded with layers of chert, that is found throughout a wide extent of the southern part of the Great Appalachian Valley. It is not of geologic importance in this district and need not be treated further.

STRUCTURE

Attitude of beds.—The stratified rocks of the district must have been laid down nearly level, but they have since been greatly deformed and part of them have been altered. The igneous rocks that appear to be intrusive in the altered strata of the Piedmont Plateau were probably irrupted before the tilting of those strata and have been deformed and metamorphosed to about the same extent as they have. The other igneous rocks, such as the Corbin granite of Hayes, are the oldest rocks of the region and nothing is known of their original form or attitude. They have, however, been crushed and metamorphosed. The geologic structure of the district, therefore, is complex and difficult to decipher. The difficulty is rendered almost insuperable in some parts of the district by the lack of outcrops and by the almost complete obliteration of original sedimentary structures.

In the Appalachian Valley portion of the district the prevailing trend of the formations is north-northeasterly and in general the strata dip steeply southeastward, but the structure is so complex that all directions of strike and all angles of dip are found. In the Piedmont Plateau there is not much local complication, but metamorphism has gone so far that in many places it is uncertain whether the cleavage, which is the most obvious structure, coincides with the bedding. In general the formations of the Plateau trend north-northeastward, except in the central part of the district, where they trend northward. The dip is rather uniformly southeastward and fairly steep.

Folds.—The Appalachian Valley portion of the district lies on the east side of the geosyncline of the southern Appalachians and the oldest formations outcrop farthest east and are overlain toward the west by successively younger formations. Because of the close folding and overturning of the beds, however, westerly dips are comparatively rare. Quite commonly, at the contact between two formations, instead of the older dipping westward beneath the younger the relation is reversed and the younger dips eastward beneath the older. In some places this is due to overturning, in other places to thrust faulting. Nearly everywhere the width of the belt occupied by a formation is a number of times its thickness and, although much of this repetition is due to closely spaced thrust faults, complex folding can be made out in some places, especially in the Weisner quartzite and in the Cartersville formation. Most folds that have been mapped are of the closed, overturned sort. Many of them have axes oblique to the general trend of the formations and pitching toward the Valley. The district has not been mapped with sufficient minuteness, including careful plotting of dips and strikes, to warrant a more detailed treatment of the folding here.

The sequence of the formations in the Piedmont Plateau is not certainly known and the possible folding of the rocks in that area has not been worked out. The Corbin granite of Hayes is regarded as the oldest rock in the area and is nearly surrounded by younger sediments derived from it, hence its relation is in general anticlinal, but further than that nothing can be said.

Faults.—The dominant structural characteristic of the district, especially of the portion in the Appalachian Valley, is the abundance of thrust faults. In very few places is evidence of faulting seen in outcrops, but the distribution and relative position of the formations, considered in the light of their known sequence and normal relations, can hardly be explained in any other way than by the occurrence of extensive faulting. As in other parts of the southern Appalachians, the faults are of the overthrust type and the traces of most of the fault planes are nearly parallel to the strike. Where they cut across formations they do so very obliquely. As the fault planes are rarely seen in outcrops little is known of their attitude. From general structural considerations, the dip of the faulted strata, and the relation to the topography, it is concluded that they have as a rule a moderate dip to the southeast and that the overthrusting was toward the northwest as in neighboring areas.

The width of the belts occupied by the Cambrian formations as compared with their thicknesses is accounted for chiefly by repeated thrust faulting along planes oblique to the bedding, which has cut the rocks into a series of slices and has brought up the same beds several times. The Weisner quartzite, in particular, seems to be cut by a bewildering series of faults into a patchwork of blocks that almost defies interpretation. The Shady limestone, where it overlay the quartzite with a low easterly dip, has been involved in this faulting, which has, therefore, profoundly affected the accumulation, distribution, and preservation of the iron and manganese ores.

The extreme metamorphism of the formations in the Piedmont part of the district and the lack of definite knowledge of their sequence make it hardly practicable to map faults in that area at present, with one exception. Along part of the southeastern boundary of the large granite mass the arkose and conglomerate that normally overlie the granite are absent and the granite is in contact with other metamorphic formations whose relation to the conglomerate is unknown, but which are apparently younger. It seems not unlikely, therefore, that this part of the boundary of the granite is due to a thrust fault, and a few details noticed in the field point to the same conclusion.

From the Cartersville district southwestward into Alabama the escarpment bounding the Piedmont Plateau on the northwest and overlooking the Appalachian Valley marks the trace of a great thrust fault, along which the metamorphic rocks of the Plateau have been thrust, in some places for miles, upon the Paleozoic strata of the Valley. A similar great fault runs along the base of the escarpment from the Cartersville district northward as far as Tennessee and perhaps into that state. Hayes believed these to be parts of one great fault, which he named the Cartersville fault, extending from Tennessee into Alabama and continuous across the Cartersville district. In his opinion it crosses the district along the eastern boundary of the Weisner quartzite, as mapped by him, from Pinelog Creek on the north to Pumpkinvine Creek on the south. Later studies have thrown some doubt on the existence of a fault along this boundary and have made it seem not unlikely that the rocks next east of it, which Hayes regarded as older than the Weisner, are the lower part of that formation. There is no doubt of the existence of a great fault north of Pinelog Creek or of one southwest of Pumpkinvine Creek, but there is reason to suspect that the northern one swings eastward around the north side of Pinelog Mountain and that the southern one continues northeastward from the Pumpkinvine along the southeast side of the granite instead of turning northward as Hayes mapped it. The two may join to form a continuous fault around the east side of Pinelog Mountain and the granite area instead of along the west side, but this has not been determined, and the whole question of the course of the Cartersville fault across the Cartersville district is still unsettled.

Metamorphism.—Although the Cartersville formation and some beds of the Weisner quartzite are considerably metamorphosed as far as the development of new minerals and of schistose texture is concerned, the alteration has not been so great that original sedimentary structures are much obscured. This is partly due to the fact that even the most altered parts of both formations are made up of layers of different lithologic character which are manifestly original sedimentary structures. These leave no doubt, in almost any outcrop that may be found, as to the present attitude and relations of the beds. The metamorphism of the other formations of the part of the district in the Great Valley is negligible so far as its effect on structure is concerned.

The prevailing metamorphic structure of the rocks of the Piedmont Plateau part of the district is schistosity, which has been developed nearly everywhere and in all formations. Slaty cleavage has also been produced where the texture of the rocks and other conditions were favorable. Schistosity is better developed in the sedimentary formations and in the other igneous rocks than in the Corbin granite of Hayes, which is gneissic rather than schistose. The coarser and more strictly sedentary portions of the arkose that overlies the granite in places are also much less schistose than the more fine-grained and homogeneous rocks of other formations. The dip of the schistosity and of the cleavage is in general steep and is nearly everywhere toward the southeast. The strike and dip of the schistosity in the sedimentary formations appear to be the same as those of the bedding, where that structure is still discernible.

The rocks of the southwest corner of the district, south of Pumpkinvine Creek, are highly metamorphosed, being entirely recrystallized and converted into schists and slates. They, however, comprise rocks of several types interbedded and the original stratification is still fairly distinct. The same is true of the rocks, immediately surrounding the granite area, which Hayes assigned to the Pinelog conglomerate and Wilhite slate, but in the southeast corner of the district the highly metamorphosed rocks are homogeneous through considerable thicknesses and the bedding is in many places a matter of doubt.

GEOLOGIC HISTORY

Relation of geologic history to deposition of ores.—Some ore deposits are formed without relation, in position or origin, to the surface of the earth or to such surface phenomena as weathering, leaching, erosion, transportation, and deposition; others are formed in direct relation to the surface and to such phenomena. Manganese ore deposits of the kinds found in the Cartersville district are of the second sort and the history of their formation is closely connected with that of the deposition and weathering of the rocks and the development of the topography. The altitude at which the deposits lie and their relation to the surface, to the associated rocks, and to the geologic structure, are all consequences of the geologic history. In order to understand their genesis, as well as to judge of the probability or improbability of their occurrence beneath a given tract, it is necessary to learn not only the stratigraphy and structure, but also the main outlines of the geologic history, including the development of the surface features. The geologic history is, therefore, given here in some detail.

Most of what is known regarding the sedimentary, structural, and physiographic development of the southern Appalachian region has been learned through the investigations of C. W. Hayes, of A. Keith, and of M. R. Campbell, whose results have been published in a number of folios and elsewhere. Mr. LaForge's field studies in the Cartersville district and in neighboring areas have contributed to the detailed history of the district and to the interpretation of the topographic relations of the ore deposits. The general theory of the relation of the ore deposits to physiographic development and surface features is, however, due mainly to Hewett,[1] although Penrose, Watson, and Hull have each contributed something to it. The following account of the geologic history is based largely on the work of all the above-mentioned geologists.

Cambrian time.—The geologic history of the district does not, of course, begin with the story of the events of the Cambrian period, and the rocks of the Piedmont Plateau record much of its earlier history, which, however, is only partly deciphered, and as it is but remotely connected with the origin of the ore deposits it will be passed over here and the story begun with the opening of the Cambrian period. At that time the district formed part of the floor of an interior sea that occupied most of the central part of the United States. Not far away on the east and southeast lay a continent which has been called Appalachia, the rocks of which were probably not greatly different from those of the Piedmont Upland at the present time.

At the beginning of the Cambrian period Appalachia was probably a rugged land, the streams of which were vigorously wearing down its surface and carrying the waste to the sea, and its western shore may have been fringed by granitic islands which were being worn away by the waves and the debris of which was being spread along the coast. The land appears to have been slowly sinking so that eventually the islands disappeared and the sea reached farther east than at first. For a long time the streams carried out quantities of rock waste which was spread over the sea bottom in sheets of gravel,

[1] Hewett, D. F., Some manganese mines in Virginia and Maryland, U. S. Geol. Survey, Bull. 640, p. 43, 1916.

sand, and mud that are now the conglomerate, quartzite, and schist of the Weisner quartzite, and perhaps also the formations, next on the east, to which Hayes gave the names Pinelog conglomerate and Wilhite slate.

The fossils found in the Weisner quartzite prove that this part of the sea was then inhabited by invertebrate animals, but their scarcity shows that conditions must have been on the whole unfavorable for animal life. The graphitic phyllites also indicate that the neighboring land supported some plant life, the decay of which supplied carbonaceous material to those beds.

By the close of Weisner time the surface conditions of Appalachia seem to have been considerably changed and the streams were carrying comparatively little detritus to the sea. Instead a great thickness of calcareous ooze was deposited which now forms the Shady limestone. The precipitation of the calcareous material from the sea water seems to have been accompanied by that of salts of iron, manganese, and barium, presumably as constituents of the calcareous ooze. Toward the end of Shady time the sea became shallower and part of its bed probably emerged, at the same time that the neighboring land was also uplifted and the activity of the streams increased. At first they spread over the sea floor a considerable amount of clay, with beds of sand here and there in it; later the amount of sand increased until the number and thickness of the beds of it were about equal to those of clay. For some reason not yet discovered practically no ferruginous material was deposited at this time, but an uncommonly large amount of potassium salts in some form. These potash-rich beds of clay and sand now form the shale or schist and sandstone of the Cartersville formation.

By Conasauga time the streams were again bringing only clay, which now forms the shales of the Conasauga formation. The deposition of clay was interrupted from time to time by that of calcareous ooze which has become the limestone of the formation. At length the clay deposition ceased and a great thickness of calcareous ooze, interbedded with siliceous layers, was laid down and now forms the Knox dolomite with its numerous beds of chert.

Later Paleozoic time.—The sedimentary record in the district ends with the deposition of the strata now forming the Knox dolomite and the record of later Paleozoic time is missing. From the rocks of other parts of the Appalachian Valley, however, much of the later record may be read. The sea covered the region until about the end of Ordovician time, when it was driven out by an extensive uplift of southern Appalachia which probably lasted throughout much of the Silurian period. From some facts gathered elsewhere in the southern Appalachians it seems likely that this uplift was attended by some deformation of the rocks of the region, but no evidence of this has been found in this area.

Nothing in the rocks of this part of the Great Valley shows that the sea ever again invaded the area, but it must sometimes have approached closely, as Carboniferous strata are found not far to the west. The rocks of other parts of the southern Appalachians show that another extensive uplift, perhaps accompanied by local deformation, occurred in Devonian time, but again there is no record of this in the district. At last, toward the end of the Carboniferous period, another great uplift, which involved most of the eastern United States, took place, and the sea was finally driven from the Appalachian region.

During later Paleozoic time, therefore, possibly from the end of the Ordovician period on, the district was probably a land area which was being worn down by the streams that flowed across it to the sea and from which those streams were carrying sediment to form new strata on the sea bottom. All traces of the events of that time have, however, long since been eroded away.

Appalachian deformation.—The continental uplift that took place at or near the close of Carboniferous time was accompanied by intense deformation of the rocks of the eastern part of the Appalachian province and by the upheaval of a great mountain system. As has been suggested, part of the deformation which the Paleozoic rocks of the Cartersville district have undergone may have occurred earlier, but so far as has been determined from the rocks of the district it all occurred in the deformation at the end of the Carboniferous period.

The rocks were crumpled and closely folded by great lateral pressure from the southeast and most of the folds were overturned toward the northwest. The pressure being continued, the beds broke in places along the axes of the folds or in places where they were most stretched, and thrust faults were developed on the fractures. A series of long, thin slices of rocks were shoved one upon another, in some places for miles. In parts of the region the deformation continued to the point where further folding took place and the slices of rock, with the fault planes that separate them, were themselves folded. The geologic structure that has resulted from this complex process is very intricate and defies interpretation in places where outcrops are scarce. The deformation of the rocks was accompanied by some dynamic metamorphism of those of Lower Cambrian age, but not enough to obliterate original sedimentary structures.

A geographic effect of the Appalachian deformation that is not as a rule sufficiently considered was the areal shrinkage of the region due to the compression of the rocks and the resultant folding and faulting. Its extent can not be closely measured, as there are undoubtedly more faults than have been mapped and the amount of movement on most of those mapped is uncertain. An estimate can be made, however, based on the thickness of the formations, the dip of the strata, and the probable amount of movement on the known faults. Taking all things into consideration the conclusion seems reasonable that the area occupied by the rocks of the Appalachian Valley in Georgia before their compression and while they were still lying as they were deposited was at least two to five times as wide as the present valley.

It is not feasible at present to estimate the amount of similar shrinkage in the Piedmont Plateau, as it seems certain that the rocks there have been deformed more than once, but at any rate it must have been comparable to that in the Valley. The shrinkage due to thrust faulting is probably not so great as in the Valley, but that due to compression and metamorphism of the rocks is probably enough greater to make up some of the difference.

Post-Paleozoic time.—Since Carboniferous time the Cartersville district, in common with the surrounding territory, has been land and has been undergoing weathering and degradation. The total degradation has probably amounted at least to several thousand feet and the quantity of rock waste removed from the region has been enormous. Consequently all record of the events of the earlier part of the time since the end of the Paleozoic era has been eroded from the district and adjacent areas, and the story of that time can be only partly recovered from the present relations of the streams and from conditions elsewhere in the southern mountains, where the degradation has been less.

The Appalachian deformation resulted in the upheaval of a mountain system which exceeded the Appalachian Mountains of to-day in area and probably in height and ruggedness. The Cartersville district was among these mountains and it must have had some relief that was the result of the deformation. The courses of the streams must have been largely determined by the form of the surface, although perhaps the master streams—the Etowah and the Coosawattee-Oostanaula—are antecedent, that is, were flowing on approximately their present courses before the upheaval and were able to cut down their beds as rapidly as the surface was deformed, so that they were not displaced.

By long-continued degradation the surface of the region was eventually reduced nearly to base level and what is called a peneplain was formed. This plain extended from the foot of the present Appalachian Mountains to the coast, which was farther inland than now. Some small areas, for one reason or another, were not reduced to the general level and stood up as residual mountains or monadnocks, like Pinelog and Kennesaw mountains. The oldest peneplain of which traces remain in the Southern Appalachian Valley and the Piedmont Plateau is called the Cumberland Plain, from its preservation on the Cumberland Plateau. Its relation to the Cretaceous strata of the Coastal Plain shows that it dates from about the end of Jurassic time. Some topographic features of the southern Appalachian Mountains make it seem probable that other peneplains had already been formed in the region but had been destroyed by renewed degradation following uplift, so that no recognized trace of them remains outside the mountain area.

Early in Cretaceous time the southern Appalachian region was uplifted and broadly warped and the central part of the Cumberland Plain was raised considerably above base level. The streams flowing across it had for a long time been free to meander on its surface and to become adjusted to its structure and some of them were so adjusted. When the plain was raised the streams began again to develop valleys. On the more easily eroded rocks of the Appalachian Valley the Cumberland Plain was soon destroyed and nothing remains to show its former existence in that area but the narrow, even crests of some sandstone ridges. In the Piedmont Plateau the Cumberland Plain was well dissected by valleys but much of it must have remained along the interstream divides. Before long the greater part of the region had been reduced to a new peneplain, called the Highland Rim Plain, which was not so extensively developed as the Cumberland Plain, but which, like it, extended from the mountains to the sea. Like the Cumberland Plain, too, it was diversified by scattered monadnocks.

At or near the end of the Cretaceous period another broad uplift of the region raised the Highland Rim Plain in much the same manner as the Cumberland Plain had been raised and moved the coast out still nearer its present position. Again the streams, some of which had acquired new meandering courses on the Highland Rim Plain and others of which had become better adjusted to the structure than before, began to cut valleys and to reduce the surface generally. On the limestones and shales of the Appalachian Valley they developed broad valleys near the new base level, but did not have time, before the next uplift, to reduce the general surface of the area occupied by harder rocks, although such areas were well dissected. In the Valley the Highland Rim Plain was cut away and remains only in the crests of a series of sandstone and chert ridges which are lower than those that are regarded as remnants of the Cumberland Plain.

In the Piedmont Plateau much of the Righland Rim Plain remains to form the general upland surface, but the valleys of some of the principal streams have wide, flat bottoms in places, which are probably to be correlated with the Coosa Plain, the name given to the partly completed peneplain represented by the broad valleys of the southern Appalachian Valley.

Development of the present surface.—When the degradation of the region reached the stage where the streams had developed wide valleys, in which they were free to meander, along their lower courses, they began to aggrade the valley floors, because their torrential headwaters, where degradation was still vigorous, were bringing down to the lowlands more waste than the sluggish trunk streams could carry away. Undoubtedly a thin sheet of waste was spread in such manner on the surface, near the main streams, of each peneplain in turn, but, because of the later removal of most of the original surface of the older plains, only the alluvium on the Coosa Plain has been in part preserved.

Late in the Tertiary period the development of the Coosa Plain was interrupted by further slight uplift and once more the streams began again the work of carving out valleys, a task on which they are still engaged. It has progressed far enough so that some of them have widened their valleys a little and have developed narrow flood plains, on which they meander in places. Most of them, however, are still engaged in cutting down their beds and in dissecting the surface of the Coosa Plain, some of which remains untouched.

Pinelog and Little Pinelog mountains, Brushy Knob, and a few other summits in the district stand above the level of any peneplain of which remnants have been detected in this immediate region. They must have been monadnocks on the Cumberland Plain, owing their preservation chiefly to the greater hardness of their rocks. As they have steep slopes above the altitude of the Cumberland Plain they have evidently suffered much erosion during the time they have stood up as residual masses and they must have been reduced considerably in size and somewhat in height.

There seem to be no remnants of the Cumberland Plain in the district which, by themselves, could be positively recognized as such. From the residuals of it preserved in adjacent districts it is known, however, that the altitude which the Cumberland Plain should have in the Cartersville district is 1300 to 1400 feet above sea level. Probably, therefore, the summits of the mountains south of Etowah River and of the higher hills of Weisner quartzite, and perhaps some spurs of Pinelog Mountain, are residual masses which, because of their small size and their separation, have been reduced somewhat below the Cumberland Plain.

The Highland Rim Plain is well represented in the general upland surface of the Piedmont part of the district, where it lies from 1000 to 1100 feet above sea level. In the Valley part of the district there is nothing that can be definitely assigned to this plain, but elsewhere in the Valley it is represented by the crests of sandstone and chert ridges and possibly the summits of some of the lower hills of Weisner quartzite may also be residuals of it. Some hills of shale of the Conasauga formation which stand between 900 and 1000 feet above sea level, too high for the Coosa Plain, are probably residuals of the Highland Rim Plain that have been somewhat cut down.

The Coosa Plain is well developed in the Valley portion of the district on the Cartersville and Conasauga formations, where it lies at 800 feet or a little more above sea level. Like all youthful peneplains which are still in the strath stage, the altitude of its surface is less uniform and shows more relation to the geologic structure than that of the surfaces of the older and more nearly reduced peneplains. The highest remaining patches of the thin sheet of gravel which once probably covered much of the Coosa Plain are found at the level of that plain.

Since late Tertiary time the streams of the Valley have cut down a little more than 100 feet below the Coosa Plain. In the Cartersville formation and in the shales of the Conasauga formation most of the valleys are flaring, with fairly steep slopes and narrow bottoms. In limestone areas they have been more or less widened and have flat, alluvium-covered bottoms. The alluvial valleys of Etowah River and Pumpkinvine Creek are the widest. In areas that were covered with the old alluvial gravel it has been cut through, undermined, washed down the slopes, and redeposited again and again. The gravel is now arranged on the slopes in ill-defined terraces, but these are apparently neither systematic nor persistent. At present the streams are still engaged in cutting down their channels, but apparently at a reduced rate, so that where the geologic conditions are favorable the widening of the valleys is going on more rapidly than the cutting down.

Accumulation of the ore deposits.—It has been suggested by several students of the problem that the ultimate source of the manganese ores and possibly of some of the other useful minerals of the district was in the igneous rocks of the Piedmont Plateau, some of which contain manganese-bearing silicates. The material dissolved from these rocks by weathering in Cambrian time was carried by streams into the sea and may have been precipitated as part of the strata that underlie the Appalachian Valley. This hypothesis is not improbable, but it is of course incapable of proof and to go back beyond the immediate source of the manganese ore in explaining the present deposits is, for all practical purposes, unnecessary.

The ores are generally believed to have been derived from the leaching of the weathered rocks, especially the Shady limestone, although some of the younger formations may have contributed a little.

Analyses of the rocks of several of the Cambrian formations show that they contain minute quantities of manganese in one form or another. That the manganese was chiefly, if not wholly, derived from the Shady limestone is probable because no workable deposits are found in the residuum of any other limestone in the district. They are found in the residuum of the Knox dolomite in neighboring districts, but the geologic structure of this part of the Great Valley makes it probable that deposits in the residual clay of any of the other limestones, if any once existed in the district, must have been formed at the level of one of the earlier peneplains and must have long ago been removed by erosion.

In the first part of each erosion cycle, while the surface of the region was in general being dissected and the streams were still cutting down their valleys, the rocks, especially the limestones, were exposed to the vigorous action of percolating water and the soluble material was nearly all leached out and carried down to lower levels in the rocks. It is not necessary to go into the chemical reactions involved, but it will suffice to say that the field work of Hayes, Watson, and others, has shown that the salts of manganese, probably along with those of barium and iron, in whatever form they may have had in the limestone, were taken into solution by the percolating water that was dissolving the limestone itself. Upon coming into contact with silica, either the masses of chert in the lower part of the Shady or the topmost quartzite beds of the Weisner, the water precipitated part of its dissolved material upon the surface of or in crevices in the masses of siliceous rock. Much of the manganese ore is now found in such association, but in places the manganese in solution was deposited in or replaced part of the residual clay of the Shady limestone and Weisner quartzite.

The mode of precipitation of the manganese ores, iron ores, ocher, and barite may have differed somewhat, but the close association of all the minerals and their similar geologic relations show that they were accumulated under similar conditions. As material that was derived from a great thickness of limestone during a long erosion cycle became concentrated in a rather thin zone at the base of the limestone and the top of the quartzite, the minerals which had been almost negligible constituents when disseminated through the rocks from which they were derived were accumulated in deposits of considerable volume and importance.

During a great part of an erosion cycle, while the surface of an area is being worn down, the solution and precipitation of mineral deposits, as just described, is a continuous and regenerative process. If the strata are nearly level the zone of concentration, having reached the quartzite, can not move downward as the surface is lowered and the deposits that have been accumulated may be eroded away if they lie above base level. If the strata are inclined the zone of concentration will move downward as the surface goes down and also laterally in the direction of the dip, and the degree of concentration will increase as more rock is dissolved. When the surface has been planated and is no longer being appreciably lowered the rate of downward progress of the solution of the rocks and of downward movement of the zone of concentration is greatly lessened and most of the precipitated minerals become concentrated in a rather thin zone and form ore deposits of workable richness and thickness.

When such erosion cycle was closed and a new one was begun because of renewed regional uplift part of the ore deposits were removed by the renewed downcutting of the streams. Until the dissection of the surface had reached maturity and practically all of the old peneplain had been destroyed, however, some deposits remained, on the tops or the slopes of the newly formed hills, at the level of the former peneplain, as has been pointed out by Watson and by Hewett. In the new cycle part of the material removed from the old deposits was taken away by the streams and redeposited elsewhere, though in such cases it was as likely to be scattered as to be reconcentrated. Part of it was washed down the slopes as the lowering of the surface proceeded and was redeposited, as a detrital accumulation, in the general talus and surface wash, and part of it was dissolved by percolating water and reprecipitated at a lower level, either on bed rock or in surface wash. While these processes were going on the old process of solution of the rocks and concentration of the dissolved salts by precipitation had again begun and a new set of deposits was being formed in the same manner as the old ones. The whole series of events will be repeated in each erosion cycle until the degradation of the region has reached the point where all the rock from which the ores were originally derived and perhaps all the secondary deposits in which the ores were for a time accumulated, have been removed from the region, or it may be indefinitely interrupted by the subsidence of the region and the deposition over it of a new series of strata.

MINERAL RESOURCES

Minerals found.—The Cartersville district is rich in useful minerals, both in amount and in variety. Some of them have already been mentioned. Barite and manganese ores are now (1918) the principal minerals mined, and the district also produces considerable iron ore and ocher. Gold and graphite have also been mined in a small way, but not for several years. A large quarry in the Knox dolomite 2 miles southwest of Cartersville produces limestone for a variety of purposes. There is a great deal of clay shale and of residual clay loam that should be suitable for the manufacture of brick and drain tile, and the Cartersville formation is rich in potash and some day may furnish a large supply of that much-needed substance.

Association of manganese and other deposits.—The deposits of manganese ore, brown iron ore, ocher, and barite are closely associated, all being found in the same general area and in the same geologic relations, and all having probably been derived from the same formations and having been deposited in much the same manner. The association of the manganese and brown iron ores is particularly close, as most of the manganese ores contain traces of iron and all the brown ores contain traces of manganese. Nevertheless, although every gradation of manganiferous iron ore is found, the manganese ore deposits are generally distinct from the strictly iron ore deposits.

The work of Hull and others has shown that the four kinds of ores tend to be arranged on the hill slope in successive zones. In mining, the manganese ores are generally entered first and the brown iron ores, if found in the same section, are beneath the manganese ore deposits. If barite deposits are encountered in the same mine they are generally above the oxide ores, but small amounts of barite are also found filling cavities and crevices in the upper beds of the quartzite. The ocher is also in the upper beds of the Weisner, in irregular masses that clearly are replacements of the quartzite. The ocher and barite deposits are less widely distributed in the district than the iron and manganese ores, and they show some tendency to be associated in their occurrence. Possibly the ocher has been derived by solution, not from iron in the Shady limestone, but from disseminated pyrite in the quartzite.

Position of ore deposits.—The stratigraphic relations and the theory of the origin and mode of formation of the manganese ore deposits have already been given. The present topographic relations of what are regarded as deposits of the first generation accord with the theory. Not only are such deposits found at the base of the Shady limestone or at the top of the Weisner quartzite, but most of them are found on the tops or well up on the slopes of the quartzite hills and at or close beneath the level of the Highland Rim peneplain. Similar deposits were presumably formed at the level of the Cumberland Plain, but they have since been eroded away. Some deposits of the sort are found, however, at or close to the level of the Coosa Plain, on the tops of the low hills of Weisner quartzite or even on hills where no quartzite is exposed.

Another group of manganese ore deposits is regarded as of a later generation. Most of these belong in the detrital class and are found at the base of steep slopes on which deposits of the first generation are or formerly were situated. A few of them are vein or replacement deposits and these have no relation to the stratigraphy or the physiography, but were leached from overlying detrital deposits and precipitated in the upper part of the underlying rock, whatever that might be. Hence it is not feasible to predict their occurrence from the general stratigraphic and physiographic relations in any particular locality.

MANGANESE ORE DEPOSITS

GEOLOGIC OCCURRENCE

The manganese ore deposits of the Cartersville district occur in the residual and detrital clay and unconsolidated material resulting from the decay of the Weisner quartzite and the Shady limestone. A few small outlying deposits are in the clay overlying the Knox dolomite and a few commercially unimportant occurrences are in the Cartersville formation, the Conasauga formation, and the remnants of Tertiary (?) clay and gravel deposits. The workable ore bodies, however, lie in the yellow and red clays which are considered to represent the quartzite and the limestone respectively. No manganese ore has been found either in the fresh quartzite or in the fresh limestone, though chemical analysis shows manganous oxide in both.

The general "lead" of the deposits as shown by the line of mines and prospect openings follows both the strike of the rock formations and the trend of the hills. This parellelism of deposits, rocks, and hills indicates the peculiar relation of the three which is the result of the same regional force that produced the Cartersville fault and helped bring about conditions favorable for the original deposition and subsequent accumulation of the different ore bodies of the Cartersville district.

The deposits are on the west side of the great fault and for the most part occupy the lower hills and western slopes of the main range of hills. They are located principally by the presence of manganiferous "float," or detached fragments of ore, that generally occurs in the blanket of red clay loam overlying the larger body of ore. The deposits thus located and opened by mining operations, occur at elevations ranging from 700 feet to 1160 feet above sea level, or from the level of Etowah River to a height 460 feet above the river. It is not known that manganese deposits occur in places below the river level, but it is quite probable that they do, as the ore has been found below the upper level of ground water at a number of mines in the district. At the Dobbins manganese mine, high-grade ore was worked in unconsolidated material 210 feet below the surface of the ground.[1]

[1] Information from M. G. Dobbins, owner of the mine.

The deposits are generally on the hillslopes, nearer the foot than the top of the hill, but also distinctly at the foot of the slope and in small valleys or ravines between two hills. A common and rather typical occurrence of a manganese ore body is shown in fig. 8, illustrating conditions in the east end of the road-cut of the Dixie Highway near Bartow five-eighths of a mile southeast of Emerson. The manganese ore body is 7½ feet thick and overlies ocherous yellow clay containing fragments of ferruginous quartzite grading into hard quartzite stained with limonite. The beds strike typically northeast and dip southeast. Two open-cuts that clearly show the distinct manganese ore bed several feet thick lying against the steeply dipping foot wall of iron-stained quartzite are those at the Peachtree mine and the Red Mountain mine in the Wolfpen Gap district east of White.

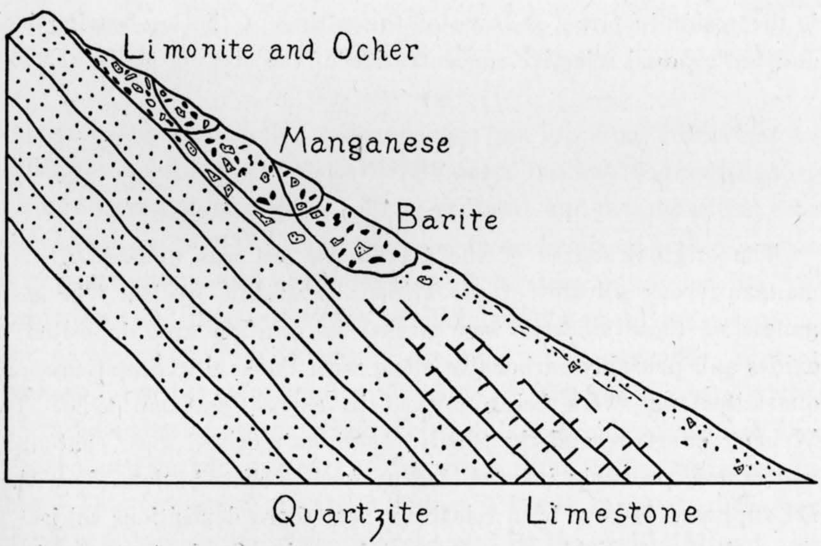


Fig. 1. Ideal section showing hillside relations of limonite, ocher, manganese, and barite accumulations according to specific gravity, as brought about by tilting of the ore-bearing beds.

Observation of all the ore deposits in the district shows the following typical stratigraphic sequence: steeply dipping Weisner quartzite foot wall overlain in turn by yellow ocher and limonite, manganese, and barite. Each of the four minerals commonly occurs in the same open-cut, but only one generally forms an ore deposit. Furthermore, the same sequence holds in a general way topographically. First below the quartzite outcrop, down the hillslipe, occur limonite and ocher mixed in the clay; farther down the slope, manganese nodules appear with the limonite; and next appear barite fragments mixed with the manganese.

It is thus seen that the hillside is marked by zones of ores down the slope from the quartzite outcrop, each lower zone occupied by an ore having a successively higher average specific gravity, that is, yellow ocher and limonite (3.8); wad, psilomelane, manganite, and pyrolusite (4.03); barite (4.8). An ideal section showing these relations is given in fig. 1. The position of the oreas shown in fig. 1 is the result in large measure of the tilting of the ore-bearing beds and the gradual selective concentration of the ores by gravity.

ORIGIN

The original source of the manganese ore was undoubtedly the manganiferous silicates of the ancient crystalline rocks. The manganese of these silicates was carried in solution and deposited as oxides and probably carbonates along with the shales, limestones, and quartzites that were being formed in early Cambrian time. The Weisner quartzite and the Shady limestone received their content of manganese, probably in none too uniform a distribution, since they are supposed to have been relatively near-shore depositions subject to the action of variable currents and irregular floods from the land. This would explain the absence of manganese in some parts of the rocks now exposed. In some places the ore-bearing solutions filled marshes or shallow basins in which the manganese oxide and carbonate were deposited with similar iron compounds. In other places the manganese was widely disseminated. As iron oxidizes more readily than manganese, it was deposited first in many places and distinct layers of iron and manganese oxide were formed. In other places where there was an alternation in supply of manganese and iron, the reverse of the order of deposition may have occurred.

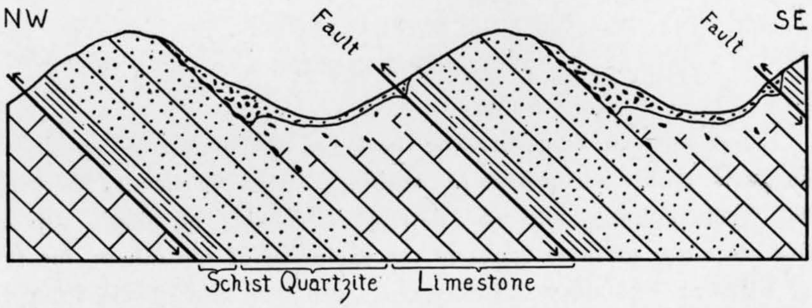


Fig. 2. Ideal section showing secondary-residual accumulation (by gravity) of manganese ore, forming hillside deposits as a result of the weathering of tilted beds. Section also shows monoclinal-thrust faulted structure as explanatory of ridge-valley topography.

After passing through many changes and receiving additional metalliferous solutions, the rocks were folded, faulted, and subjected to various conditions of erosion. Long exposure and decomposition more thoroughly oxidized the manganese and in many places caused a secondary distribution and concentration. The steep tilting of the rock formations and their alteration to clay brought about the accumulation of ore on the lower slopes of the hills. Thus secondary replacement and detrital accumulation added to the residual deposits farther down the slopes and formed workable ore bodies where none had been before and formed large ore bodies where small bodies had been before. This process of ore accumulation is shown in fig. 2. The fracturing and brecciation of the rocks caused by the continued and various movements in the region of the fault afforded many pervious zones and openings for the secondary deposition of ore. The rocks affected by the shattering and fissuring of the fault zone were also favorably situated for the deposition of additional supplies of metalliferous solutions from deep-seated sources.

Some of the largest manganese ore deposits in the district do not show the clearly defined relations of ores and foot wall previously described, for the large deposits are probably complex accumulations, and, having been produced by several secondary causes, they do not show a clear and simple mode of occurrence.

TYPES OF DEPOSITS

Based on mode of occurrence the types of manganese deposits in the Cartersville district are: (1) residual, (2) replacement, (3) vein and fracture-filling, and (4) detrital. Probably no single deposit illustrates one of these types to the exclusion of the others, for the far reaching secondary influences of a chemical and physical nature that have operated through extended periods of weathering and faulting have tended to conceal the original mode of formation and to combine several types of occurrence.

Residual.—Deposits are rare that can be recognized as strictly residual, in which the ore occurs in the form and position as originally deposited in the rock. In places the stratification of the rock is preserved in the residual clay and nodules of ore occur along the bedding planes. These occurrences indicate residual deposits, though it may be that the manganese nodules are secondary deposits from solutions following down the more or less pervious bedding planes during, and subsequent to, the decay of the rock. Watson therefore terms such deposits "secondary-residual."[1]

Penrose[2] mentions the deposit on the Bartow County Pauper Farm as one of the best illustrations of the residual type. A deposit that clearly shows a distinct bed of manganese-bearing clay several feet thick occupying a position parallel to the underlying quartzite is seen at the Red Mountain manganese mine in the Wolfpen district east of White.

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, pp. 151, 156, 1908.

[2] Penrose, R. A. F., jr., Manganese; its uses, ores, and deposits, Geol. Survey of Arkansas, Ann. Rept. for 1890, Vol. I, p. 423, 1891.

A. OPEN-CUT SHOWING UNCONSOLIDATED MANGANESE-BEARING FORMATION. NORRIS MINE, A MILE EAST OF CARTERSVILLE.

B. FRACTURED AND FOLDED STRATA IN AN ADIT ON THE SATTERFIELD-McGINNIS PROPERTY NEAR WHITE, BARTOW COUNTY. WIDTH AS SHOWN, 2⅓ FEET.

Replacement.—Replacements by manganese oxides of calcareous portions of the dolomite and argillaceous portions of the quartzite formations have occurred in almost all of the deposits. There have been replacements by chemical and physical processes along pervious zones produced in part by minor movements in the region of faulting.

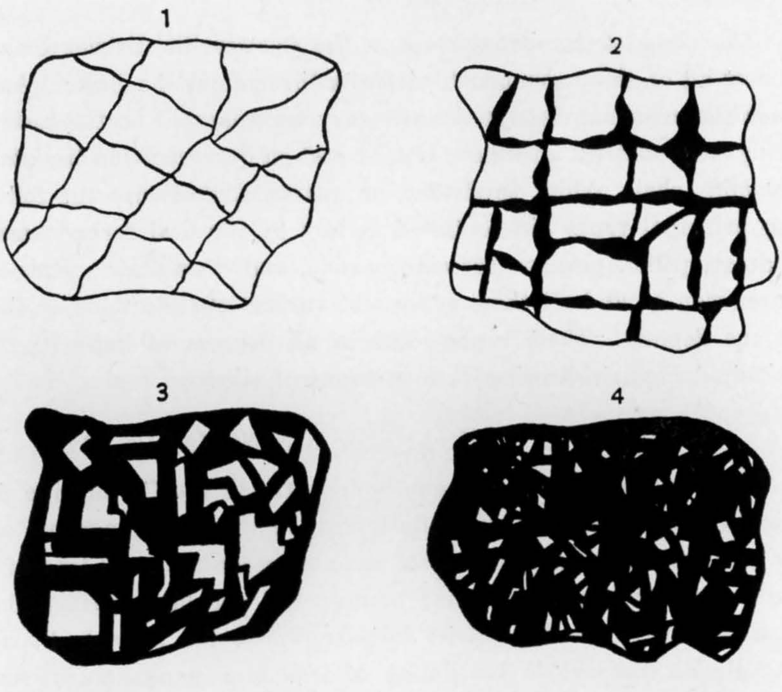


Fig. 3. Fragments of manganese breccia showing gradual replacement of chert and quartzite by manganese. *(From Watson.)*

Gradual replacement in cherty and siliceous material may be seen in the ores of the Wyvern mine and the Satterfield-McGinnis mine.

Vein- and fracture-filling.—Deposits of this type do not in themselves form workable bodies, but they are widespread in both clay and quartzite.

Detrital.—Detrital deposits, including brecciated deposits and hillside wash and debris, form a large part of the workable ore bodies.

They have in many places accumulated in combination with residual and replacement ore bodies. A good example of a detrital deposit in which manganese oxide fills the spaces between angular blocks of quartzite is shown at the Brockman-Dorn mine on the Vaughan property, 3 miles east of Rydal.

TYPES OF ORES

The types of manganese ores in the Cartersville district include almost all of those common to deposits throughout the State. Aside from those commercial types which may be separated on the basis of manganese content, and those types based on occurrence in limestone, dolomite, shale, schist, sandstone, or quartzite, there are the following principal types differentiated mainly by physical form, namely, nodular, pellet, powder, breccia, massive, and crystalline. It is not uncommon to find all these types and various modifications of them in one deposit. These types occur in all degrees of impurity, the principal impurities being various forms of silica.

HISTORY OF MANGANESE MINING INDUSTRY

The beginning of the manganese industry in the Cartersville district is obscured by the iron industry. The value of manganese and its use in the manufacture of steel was not recognized until long after the brown iron ore deposits had been opened and blast furnaces had been established in the district then known as the Etowah district. The almost inseparable association of iron and manganese in some deposits probably brought about the use of manganiferous iron ore in the furnaces. At times ore known to contain low percentages of manganese was mixed with the iron ore to produce desirable results.

Probably the first blast furnace operated in Georgia was erected on Stamp Creek about 1840.[1] In 1845, Mark A. Cooper, the pioneer in the iron industry along Etowah River, began on a large scale the establishment of manufacturing interests in this district.[2] It is re-

[1] McCallie, S. W., Preliminary report on a part of the iron ores of Georgia: Geol. Survey of Ga. Bull. 10-A, p. 27, 1900.

[2] Cooper, M. E., Notes, general and special, relating to Milam & Cooper's Keepsake Photos about Cooper's iron works, p. 2, 1892.

ported that of the iron shipped from the Cooper iron works to Liverpool, England, knives and razors were manufactured for Mr. Cooper and presented by him to the Georgia legislature.[1] It is supposed that the high grade of iron used in the manufacture of these instruments is explained by a considerable percentage of manganese in the ore.

It has been stated that the first mine in the district worked for manganese was on lot 390, 4th district, 3d section, 1¾ miles east of Cartersville.[2] The first shipments of manganese ore from the district as recorded in the Mineral Resources of the United States were in 1866. At that time the Dobbins mine was opened and it is considered the oldest mine in the district, as well as in the State.

The Cartersville district has been the principal producer of manganese in Georgia. Its periods of activity and fluctuations of output correspond to those of the State. No ore was produced in the years 1883, 1884, 1904, and 1906 to 1914 inclusive. The total production of high-grade ore is close to 100,000 tons.

The largest producing properties are those of the Bartow Mining and Manufacturing Company, the Etowah Development Company, and the Georgia Iron & Coal Company.

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[1] For much information and historical notes about the Cartersville district, the writer wishes to thank Capt. J. J. Calhoun, of Cartersville.

[2] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, p. 90, 1908.

DESCRIPTION OF INDIVIDUAL DEPOSITS

BARTOW COUNTY

RHEA PROPERTY

Lots 543 and 544, 4th district, 3d section, belong to R. R. Rhea of Cartersville. These are 40-acre lots just south of Etowah River, 3 miles east of Cartersville and 2 miles north of Emerson. In Bulletin 14[1] the manganese deposits on this tract are described as the Heath sisters' property, from which 12 to 15 carloads of ore were reported to have been shipped. Very little work was done on the property for a number of years prior to the fall of 1917. At that time a small concentrating plant was erected and a few tons of manganese shipped. During the greater part of 1918, however, no ore was produced. B. C. Sloan of the Southern Leasing Company of Cartersville holds a lease on the Rhea property.

The openings of the ore deposits on this land extend eastward from the concentrating plant on lot 544 about three-eighths of a mile along the broken ridge of Weisner quartzite which rises rather abruptly south of the river. The line of outcrop roughly parallels the westward flowing Etowah a few hundred yards south of it. The river is 700 feet above sea level and the open cuts range in height from 30 to 200 feet above the river.

The character of the ore deposit is shown in the open-cut near the log washer on the north side of lot 544. Two types of ore occur, "soft chemical" ore and nodules of pyrolusite and psilomelane. Both are in the yellow residual and colluvial clay mixed with angular and irregular fragments of partially decomposed quartzite. The yellow and reddish-yellow surface soil contains in places many water-worn quartz pebbles. The thickness of this unconsolidated ore body where exposed in the workings is 5 or 6 feet. At many places along the "lead" the manganese becomes subordinate to brown iron ore, which

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, p. 84, 1908.

commonly occurs on this and adjacent property and was at one time mined. Broken outcrops and float ore mark the length of this manganese and limonite deposit for three-eighths of a mile across the Rhea property; the depth, however, has not been prospected, so far as known, below 30 feet.

That the ore is very desirable in quality and would show high metallic manganese and low silica when carefully concentrated, is apparent from the following analyses. The analysis quoted from Bulletin 14 shows higher phosphorus than appears in the analyses of samples collected by the writer. It is not thought that the ore found on this property generally contains an objectionable amount of phosphorus.

Analyses of manganese ore from the Rhea property

Constituents	*Hu-342Ax*	*Hu-342Bx*	*Watson*
Silica (SiO_2)	......	......	32.00
Silica (SiO_2) and insoluble	28.35	29.00	......
Alumina (Al_2O_3)	1.42	1.56	......
Moisture at 100°C	0.23	0.27	......
Manganese dioxide (MnO_2)	......	44.62	......
Manganese (Mn)	38.13	36.39	33.00
Iron (Fe)	1.84	2.80	......
Phosphorus (P)	0.122	0.162	0.329
Sulphur (S)	0.08	......	......

Hu-342Ax.—Average sample of log-washed ore representing a stock pile of about 6 tons. Collected in May, 1918.

Hu-342Bx.—A typical manganese nodule 1½ inches in diameter, consisting chiefly of soft, finely granular and partly crystallized pyrolusite in concentric layers around a harder, more siliceous center.

Watson.—Analysis taken from Watson's description of the property as given in Bulletin 14, Watson, op. cit., p. 84.

In the spring of 1918, the two openings from which ore was being taken were about three-eighths of a mile apart at the east and west extremities of the outcrops on lots 543 and 544. Between these two places are a number of old cuts and pits several feet deep in, or near, the outcropping of ferruginous and manganiferous quartzite. The height of the several workings above the river increases from west to east.

The western end of the prospected deposit and that most recently worked is on the north side of lot 544, about 200 yards south of the river. A small open-cut combined with two vertical shafts opens the deposit to a depth of 30 feet. One of the shafts is newly timbered and has a short drift southeast along the local strike of the ore body.

Concentrating equipment near the shafts includes a single-log washer operated by a 15-horsepower boiler and engine. All the water needed on this property can be supplied by the river which is little more than 200 yards distant and about 25 feet lower than the log washer. A 15-horsepower boiler and pump are installed at the river.

The Rhea property is a mile northeast of the Western & Atlantic Railroad, but in order to reach a side-track for loading, the ore must be hauled to the spur at the Nulsen, Klein and Krausse Manufacturing Company's barite mine, which is about 2½ miles distant by ordinary clay road. The large supply of water, the abundance of standing timber, and the comparatively short haul to the railroad combine to make this property very favorably situated.

ETOWAH DEVELOPMENT COMPANY

The Etowah Development Company of Cartersville, O. T. Peeples, president, and R. S. Munford, general manager, owns several thousand acres of land in the 4th and 5th districts, 3d section, and in the 21st district, 2d section. The property includes extensive brown iron and manganese deposits which have ranked among the largest producers in Georgia. These deposits have been worked at different times and by different operators, and some of the mines once the most productive have for many years been idle, though not because the ore was exhausted.

A few notes on the history and the description of the property are here taken from Bulletin 14.[1] "This property has been extensively

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, pp. 54-55, 1908.

worked, from time to time since the early forties, for iron ore. It was worked continuously from the early forties until the year 1864, and again at intervals from 1864 to 1892." In 1889 the Etowah Iron Company obtained possession and mined both iron and manganese. In 1900, a northern syndicate, the Blue Ridge Mining Company, bought the property which Watson describes as including "17,-500 acres of mineral lands situated in Bartow County and the remaining 3,500 acres in Cherokee County. It is located directly on the Western & Atlantic Railroad, to the north and east of the town of Cartersville, 90 miles south of Chattanooga, and about 40 miles northwest of Atlanta. Etowah River, one of the largest streams in northwest Georgia, flows through the property, giving a river frontage of 4 miles on the two sides. The estimated fall in the river for the 4 miles is 70 feet, which is computed to develop 12,600-horsepower at the lowest stage of water. Sixteen miles of railroad have been in operation on the property, connecting with the main line of the Western & Atlantic Railroad. Ten of the 16 miles of the road are broad gage track, and the remaining 6 miles are of 36-inch gage, with full rolling stock for the 6 miles."

Several years later, this valuable tract of land passed into possession of the Etowah Development Company, a corporation formed by citizens of Cartersville. In 1918, the mining operations of the company itself were confined almost entirely to the production of brown iron ore at the Iron Hill mines, formerly known as the Allatoona[1] and Crow[2] ore banks, 1¾ miles north of Allatoona, and at the large open-cuts on lots 329 and 392, 4th district, 3d section, half a mile west of Pine Mountain. A considerable amount of manganese is being mined, however, on several parts of the property by lessees. These different operations will be described separately. Several valuable deposits of excellent manganese ore on this extensive property were not being worked in 1918 and had been non-productive for many years chiefly on account of the small demand for the ore.

[1] McCallie, S. W., Preliminary report on a part of the iron ores of Georgia: Geol. Survey of Ga. Bull. 10-A, pp. 126-128, 1900.

[2] Idem, pp. 14, 142.

In 1918 the actual mining and milling equipment in operation on the property, included 4 steam shovels, 6 double- and 2 single-log washers, and one 5-cell and two 3-cell jigs. Of this machinery, 3 shovels and 5 double-logs were owned and operated by the company. Of the remainder under operation of lessees, one shovel, one double-log, and a 5-cell jig were used in the production of barite, and only 2 single-logs and 2 jigs of 3 cells each were being used for manganese.

The company has in operation an approximate total of 4 miles of standard gage railroad, equipped with locomotives to haul cars to and from the Western & Atlantic Railroad. Two miles of this road connects with the main line at Etowah Siding just west of the railroad bridge over Etowah River, and serves the mines east of Cartersville. The other 2 miles connect the Iron Hill brown ore mines with the main line about a mile west of Allatoona. Of the extensive system of narrow gage road once operated on this property, a little more than one mile remains; this is fully equipped with small locomotives and side-dump cars together with a large repair shop. This system is used primarily in hauling brown iron ore.

Those portions of the Etowah Development Company property that contain the manganese deposits constitute a large and important part of the south half of the Cartersville district and an almost continuous strip of land extending from the property of the Tennessee Coal, Iron & Railroad Company at Bartow and Emerson, 7 miles northward to the property of the Georgia Iron & Coal Company, 3 miles south of White. This rich ore-bearing area includes more than 1200 acres of the company's property. It occupies the rolling quartzite slopes and ridges west of Signal and Pine mountains, and is crossed from east to west by Etowah River.

The different lots and mines are briefly described in general order from south to north, foot note reference being made to Bulletin 14, from which some passages are quoted.

Lots 759 and 755.[1]—These lots are in the 4th district, 3d section, half a mile northeast of Emerson. On lot 759, an old open-cut in the

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, pp. 66, 67, 1908.

western slope of a quartzite ridge exposed good manganese in residual clay. A small quantity of ore was shipped. Prospecting on lot 755 also shows conditions favorable for a manganese ore body. No work has been done at these prospects in many years.

Lot 616.[1]—Lot 616 is 1½ miles north of Emerson. Watson states that "an excellent showing of partially crystallized manganese gravel ore is exposed in the tunnel," which was driven 215 feet to work a vein of specular hematite.[2]

Lots 541, 542[3], 611, 612, 613[3], 614[3].—These lots form an area of 240 acres in the 4th district, 3d section, 2 miles northeast of Emerson. They lie south of Etowah River and for the most part immediately west of the fault contact of Weisner quartzite and schists of older age. Some manganese ore occurs on all of the lots, commonly associated with limonite. Altogether only a few hundred tons of manganese have been mined.

Stiles lease.—The Etowah Development Company has leased to Hamilton C. Stiles of Cartersville the manganese ore on lots 462, 464, 465, 473, and 474, 4th district, 3d section. This tract of 200 acres, more or less, is on the north side of Etowah River, 2 miles in an air-line east of Cartersville. Lots 465 and 473 have been probably the most productive, but in 1918 lots 464 and 473 were being worked and 465 had been idle several years.

The topography is hilly. Elevations above sea level range from 700 feet at the river to 1000 feet on lot 465 just southwest of Pine Mountain. The main drainage of the tract is southward through small branches to Etowah River, which flows westward.

The ores consist of the different soft, brecciated, and nodular types in the unconsolidated soil mantle and the more or less broken Weisner quartzite.

Lot 464.[4]—The most of the openings on lot 464 are on the northern part of the lot, half a mile north of the company's iron ore concen-

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[1] Watson, op. cit., p. 66.
[2] McCallie, S. W., Preliminary report on a part of the iron ores of Georgia: Geol. Survey of Ga. Bull. 10-A, pp. 134-136, 1900.
[3] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, pp. 56, 57, 1908.
[4] Watson, op. cit., pp. 58, 59.

trating plant at the river. An open-cut about 70 feet long, 35 feet wide, and 5 to 15 feet deep was made about 1915 when the company was mining barite. In 1918, indications at the cut seemed favorable for a workable deposit of manganese beneath a 15-foot layer of barite and quartzite fragments in yellow soil.

About 100 feet north of the old barite mine, several 15-foot pits were reopened by Stiles in the summer of 1918 and a larger open-cut was made, exposing an excellent grade and a workable deposit of manganese ore. One working face of the cut showed a rich ore body 6 feet thick composed of "soft chemical" ore and rather pure nodules in yellow gritty clay.

The ore was mined by hand methods and hauled by wagon about half a mile to Hebble Brothers' log washer. In August, however, Stiles erected a concentrating plant on lot 473, half a mile south of the deposits on lot 464.

Lot 465.[1]—Lot 465 is just east of lot 464. It contains the old Knight and Barron manganese mine which was first worked in 1900. By September of that year 1200 tons of high-grade ore had been shipped.

Analyses of manganese ore, lot 465. Etowah Development Company

Constituents	*1*	*2*
Silica (SiO_2)	6.715	2.460
Manganese (Mn)	45.041	49.749
Phosphorus (P)	0.195	0.183

1.—Average of 6 analyses furnished by Capt. John J. Calhoun, Cartersville, Ga.
2.—Booth, Garrett & Blair, Philadelphia, Pa., analyst, 1889.

Lot 473.[2]—Watson's apt description of the operations on lot 473 is applicable to the manner in which manganese mining has been carried on in a large part of the Cartersville district. It is as follows,

[1] Watson, op. cit., p. 59.
[2] Idem, pp. 57, 58.

"No systematic mining has been undertaken on this lot, though considerable work has been done over most of its surface." The lot is on the river road on the right bank of the river. As it is at the east end of the Etowah Development Company's railroad connecting with the Western & Atlantic Railroad and as on it are situated the Riverside washer for iron ore and the machine shop from which the narrow gage roads lead out to the big open-cuts, this lot may be called the mining center of the whole property north of Etowah River. The reason for this importance is its topographic and geographic situation at the river, whither all tram lines from the mines, converging along easy grades, meet at the common milling point where water supply is limited only by pumping capacity.

At this place, about on the site of the Riverside washer, the Etowah Iron Company built, in 1891, a large and well-equipped manganese mill. In 1891 and 1892[1] this company operated the Dobbins mines, which were connected with the mill by a 4-mile railroad[2]. The mill is said to have contained machinery for crushing, washing, classifying, and jigging the ore and at that time was the largest and most elaborate concentrating plant for manganese in the district.

Stiles' manganese mill is on lot 473, a few yards east of the Riverside iron ore washer. It consists of a single-log washer, screen, and two 3-cell jigs. In October, 1918, it was in steady operation, treating the ores hand-mined from open-cuts on lots 464 and 473.

The ore on lot 473 consists, to a large extent, of the usual nodular type in red and yellow colluvial and residual clay. The following analyses indicate the generally desirable quality of the ore on these lots.

[1] Information from M. G. Dobbins, Cartersville, Ga.
[2] See U. S. Geol. Survey Atlas, Cartersville topographic sheet.

Analyses of manganese ore. Stiles lease. Etowah Development Company

Constituents	*Crane–39*	*1*	*2*
Silica (SiO_2)	42.86	18.07	7.50
Alumina (Al_2O_3)	7.92	1.37	......
Moisture at 100°C	0.48	......	......
Moisture	......	4.63	......
Iron (Fe)	17.25	7.19	......
Manganese (Mn)	8.45	38.77	36.47
Phosphorus (P)	0.398	0.25	0.214

Crane–39.—Sample collected by W. R. Crane from the prospect pits and working cuts on lots 464, 465, and 473. Sample represents the ore deposit as it occurs in the formation.

1.—Average analysis of first three carloads of ore shipped from the Stiles mill during August and September, 1918. Analyses furnished by H. C. Stiles.

2.—Average of two analyses of ore from lot 473 furnished by Capt. John J. Calhoun. Taken from Geol. Survey of Ga. Bull. 14, p. 58, 1908.

The exact amount of production from the deposits included in the Stiles lease is not known. At least 1350 tons of manganese ore were shipped prior to 1918. It is altogether probable that these lots contain deposits large enough to justify the use of steam shovel methods and the repairing of tram lines on the old grades, so that particularly lots 454, 465, and 473 could be worked as a unit supplying run-of-the-mine material to a central concentrating plant of ample capacity on lot 473.

Hebble mine.—Hebble Brothers' manganese mine is on the south side of lot 391, 4th district, 3d section. It is 2 miles in a straight line east of Cartersville and three-quarters of a mile north of the Etowah Development Company Railroad at the river. In 1917 and 1918 H. M. and J. C. Hebble, of Cartersville, leased the deposits on this lot.

The Hebble mine openings are on the west slope of a partially cleared north-south quartzite ridge along whose top is the tram line of the Etowah Development Company. This ridge may be considered one of the minor foothills west of Pine Mountain. The topography is hilly, the western part of the lot being traversed from north to south by a narrow valley occupied by a small stream which furnishes water for milling purposes. Local relief is about 120 feet and the elevation at the mouth of the shaft, which was the main opening located near the top of the ridge in the summer of 1918, is about 840 feet above sea level, or a little more than 100 feet higher than the stream. The wagon road over which the ore is hauled leads southward along the east side of the valley three-quarters of a mile to the loading point on the Etowah Development Company Railroad, which is somewhat lower than the Hebble washer.

The rock outcropping at the Hebble mine and on lot 391 is early Cambrian quartzite of the Weisner formation. Exposures occur at several places and the rock has been encountered in the underground workings as the gray massive foot wall, much fractured but still hard and fresh. The yellow and reddish-yellow, soft residual material which is exposed in open-cut work is probably the decomposed remnant of the Shady limestone. This thoroughly weathered residuum and the detrital and colluvial soil contain the manganese ore, and altogether form an unconsolidated mantle overlying the quartzite to a depth known to range from almost nothing at the rock outcrops to 40 feet in the vertical shaft.

The geological structure at the Hebble mine illustrates one of the innumerable irregularities of local importance that do not conform to the general structure of the district. Observations on outcrops and relations of underground developments lead to the suggestion that the quartzite at the mine occurs as a basin tilted toward the west, or northwest, so that its lower rim is at the foot of the western slope and its upper rim near the top of the ridge. The outcrops and "float" of quartzite occur in a semicircle bounding the west, south, and east sides of the deposit, but it is impossible to determine a sufficient number of dips to prove the basin interpretation. On the west side of the deposit, the tunnel opened in 1917 passes through rather massive, fractured quartzite from the entrance to a point about 70 feet within the tunnel, but the direction of dip is only doubtfully determined as southeast. On the southwest and south sides of the deposit, distinct outcrops dip northeast and north. Lastly, on the southeast and east sides of the deposit are broken rows of quartzite "float" and no dip is determinable; at the bottom of the vertical shaft, however, the eastern limit of the ore deposit as shown in the workings of July, 1918, dips generally westward. All these dips, or probable dips, it is seen, form a semicircular floor sloping in toward a theoretical center beneath the body of manganese ore.

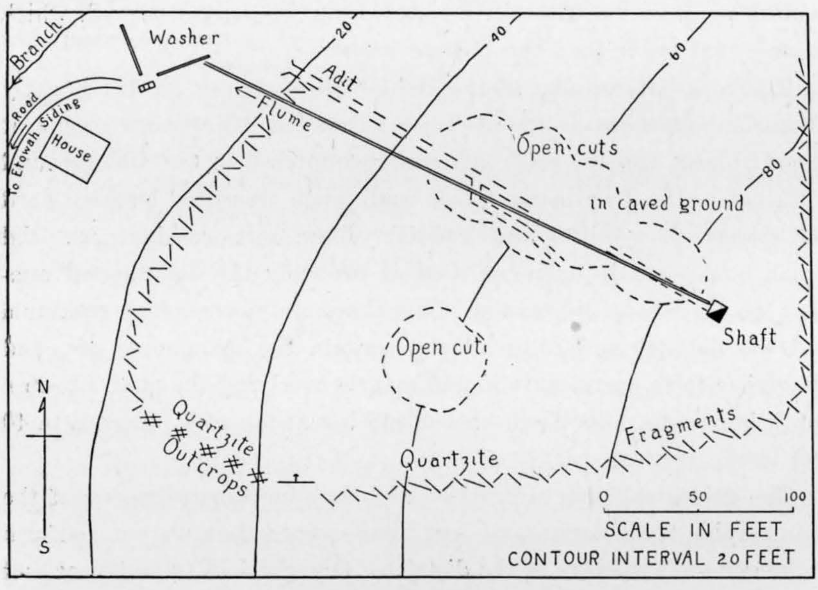

Fig. 4. Topographic sketch map of Hebble mine, lot 391, Etowah Development Company property, 2 miles east of Cartersville.

The ore deposit lies on top of the quartzite, the latter, wherever it has been observed, forming the foot wall. From the observations on the geological structure, it will be seen, therefore, if the semicircular rim of quartzite continues down the converging dips to a center beneath the mine workings, that the ore deposit forms the filling of quartzite basin. The greatest diameter of this bowl-like ore pocket is approximately 100 yards from east to west. Its depth, which is of vital importance to the operator, is not known, as the deepest mining is hardly more than 50 feet below the surface and no depth-prospecting has been done. Judging from the dips of the quartzite, it might be estimated that the bottom of the basin would be reached within 180 feet from the surface, but in such an estimate the irregularities of the quartzite foot wall are not considered.

The ore raised at the Hebble mine in the summer of 1918 was undoubtedly the richest manganese ore being mined in the Cartersville district. During June, the output of 7 carloads contained 44.94 per cent metallic manganese. The high grade of the product was due largely to a combination of rich deposit and selective mining. The only concentrating machinery used in cleaning the ore, besides the flume line from shaft to bull-pen, was a single-log washer.

Analyses of manganese ores. Hebble mine and lot 391. Etowah Development Company

Constituents	*1*	*Hu-358x*	*2*	*3*	*4*	*5*	*Crane-30*	*Crane-21*
SiO_2 and insoluble ...	....	......	......	......	......	......	......	44.36
SiO_2	2.175	17.40	10.60	5.12	......	......	37.68	......
Al_2O_3 ......}	9.135	2.24	2.02	1.31	......	......	8.60	5.82
Fe_2O_3 ......}		......	......	......	......	......	......	......
CaO	....	0.02	......	......	......	......	......	......
Moisture	....	0.54	7.43	4.20	......	......	0.93	0.38
Water and or- matter	1.015	......	......	......	......	......	......	......
MnO_2	87.600	......	......	......	......	......	......	......
BaO	....	2.89	......	......	......	......	......	......
Mn	....	......	41.97	46.99	40.91	27.24	10.50	13.02
Fe	....	12.11	6.57	4.72	......	......	17.32	18.44
P	0.065	0.28	0.36	0.28	......	......	0.162	0.229
S	0.010	0.06	......	......	......	......	......	......
Total	100.000							
Mn	54.750							

1.—"Analyses made by Prof. H. C. White of the ore from the mines opened on the Etowah property, lot No. 391, being the opening worked by Mr. Silva."[1]

Hu-358x.—Ferruginous manganese collected 1918.

2.—Analysis of a carload of ore shipped by Hebble Brothers, April 5, 1918. Analysis furnished by H. M. Hebble, Cartersville.

3.—Average analysis of two carloads of ore shipped by Hebble Brothers, June 1, 1918. Analyses by Tennessee Coal, Iron & Railroad Company, Ensley, Ala.

4.—Average analysis of several hundred tons of manganese ore shipped by Hebble Brothers in 1918. Analyses furnished by Hebble Brothers.

5.—Average analysis of the manganiferous ore shipped by Hebble Brothers in 1918. Analyses furnished by Hebble Brothers.

Crane-30.—Analysis of sample collected from the Hebble mine by W. R. Crane, June, 1918. Average sample from all workings to represent the ore deposit as it occurs in the formation.

Crane-21.—Analysis of sample collected from the Hebble mine by W. R. Crane, June, 1918. Average sample from mud pond to show amount of manganese lost.

The ore occurs as remarkably clean concretionary nodules a few inches in diameter and as larger masses of somewhat vesicular or spongy ore ranging from one to several feet in thickness. The oxides, pyrolusite and psilomelane, are the only manganese minerals noticed in the ore.

The manganese deposit at the Hebble mine has been worked by open-cut, tunnel, and shaft methods. In 1917, J. M. Knight of Cartersville produced several car loads from an open pit and later in the same year Hebble Brothers continued operations for a short time from the same opening. As indications warranted deeper explorations a few rods north of the old excavations, the Hebble tunnel or adit was driven. It led approximately S.60°E., a distance of 150 feet. The last 60 feet were in good ore developed by stopes to an upper level. The ore was in reddish-yellow clay material and rather easily worked by pick and shovel methods. Several hundred tons of ore were removed and shipped, but in the first part of 1918, the adit was abandoned.

A vertical shaft was then sunk near the top of the ridge to a depth of 36 feet. From the bottom of the shaft, levels have been

[1] Weeks, J. D., Manganese: U. S. Geol. Survey Mineral Resources, 1885, p. 331, 1886.

driven about 60 feet to the northwest and the southwest, both in high-grade ore. The heading of the northwest passage approached a point above the headings in the old adit driven southeast from the washer. All work underground was done by hand with the aid of some blasting where the large masses of ore were consolidated. Material was hoisted by bucket and mule to the surface.

During the latter part of 1918, underground work was again given up in favor of open-cut methods. Ore was mined from a pit in the caved ground above, and in the old adit workings. Equipment includes a single-log washer, a stationary steam engine, a boiler, and a pump.

Including the earliest known shipments, lot 391 has probably produced altogether about 3,000 tons of manganese and manganiferous ore, of which 300 tons are known to have been ferruginous manganese ore containing less than 35 per cent of manganese, and 2,200 tons could probably be classed as manganese ore carrying close to 40 per cent of manganese.

The future of any producing mine depends primarily, of course, on the amount of workable ore still remaining in the deposit. The ore reserve at the Hebble mine can be estimated only in a most general way because of lack of prospecting below the mine workings and because of the uncertainty of the attitude of the foot wall. If the theory of the basin, or bowl-like deposit be correct, then the ore still untouched amounts to considerably more than the total already mined, and probably continues to a depth of 180 feet. No reason is known why the quality should not remain the same as that of the ore already mined.

In that part of this bulletin devoted to mining and milling methods, mention is made of the manganese lost in tailings and slimes. It is interesting to compare, in this connection, the content of manganese found in the ore deposit as a whole at the Hebble mine and the content in the mud pond. The ore deposit represented by analysis of sample *Crane-30* showed 10.50 per cent, and the mud pond represented by analysis of sample *Crane-21* showed 13.02 per cent of manganese.

Lots 400 and 401.[1]—These lots lie southeast of the Hebble mine and somewhat more than half a mile north of Etowah River. The manganese is described as occurring in "abundant nodules of crystallized ore thickly studded in the clay."

Analyses of manganese ore. Lot 400. Etowah Development Company

Constituents	*Watson-1*	*Watson-2*
Silica (SiO_2)	5.61	13.50
Manganese (Mn)	47.25	39.02
Phosphorus (P)	0.198	0.245

Watson-1.—Analysis of sample collected from shaft on the quartzite ridge by T. L. Watson, 1900-1902.

Watson-2.—Analysis of sample collected from openings in the southwest corner of lot 400 by T. L. Watson, 1900-1902.

Lots 392 and 393.[2]—These lots are on the southwest side of Pine Mountain about a mile north of Etowah River. A considerable amount of manganiferous iron ore occurs with the extensive limonite deposits on these lots and some manganese has also been mined. Nodules of both ores are numerous on the surface of the hill slopes and on lot 392 on the west slope of the knoll between the two forks of the company's tram line, float manganese is so abundant that several openings have been made at different times to test the deposit. The ore seems to be of good quality, but there is no indication of a deposit large enough to be worked independently.

Lot 460.[3]—Lot 460 occupies the north and east slopes of a quartzite ridge 1¼ miles east of Cartersville. It is just south of the Norris manganese mine on lot 405, recently worked by the Republic Iron & Steel Company of Birmingham, Ala. It contains deposits of brown

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, pp. 59-60, 1908.
[2] Idem, p. 61.
[3] Idem, p. 62.

iron, manganese, and barite. The manganese deposit is about half way up the slope between two barite deposits, one near the foot of the hill and one near the top. In his description of the ore, Watson says: "The dumps indicate a preponderance of the gravel type of ore, admixed with some nodular and lump ore. . . The ore is usually sufficiently concentrated to be generally free from admixed clay and other foreign materials, and it requires practically little or no washing before shipping." The following analyses are taken from Watson's report:

Analyses of manganese ore. Lot 460. Etowah Development Company

Constituents	*1*	*2*	*3*	*4*
Silica (SiO_2)	4.13	......	......	0.42
Manganese (Mn) ...	40.86	48.28	15.26	49.369
Iron (Fe)	......	......	39.25	......
Phosphorus (P)	0.13	0.127	0.193	0.136

1.—Average of the analyses of two carloads of ore, furnished by Capt. John J. Calhoun, Cartersville, Ga.
2.—Analysis made and furnished by S. Albert Reed, New York City.
3.—Manganiferous iron ore. Analysis made and furnished by S. Albert Reed, New York City.
4.—Booth, Garret & Blair, Philadelphia, Pa., analyst, 1889.

It is reported that a large quantity of high-grade ore was produced from lot 460, and probably a considerable amount still remains. The ore at the Norris mine on lot 405 is undoubtedly a part of the same deposit.

Lot 330.[1]—Lot 330 is a mile north of the Etowah Development Company Railroad terminus at the washer on lot 473. In 1908, Watson reported: "Several openings on this lot have been worked about midway up a high and steeply sloping quartzite ridge. One of the cuts has been recently worked and one carload of the ore shipped."

[1] Watson, op. cit., pp. 63, 64.

Lot 260.[1]—Lot 260 is on the Rowland Spring road 2 miles northeast of Cartersville. A good grade of manganese ore is reported to have been found, in a 60-foot shaft. No recent work is known.

Lot 171.[2]—This lot, one time known as the Kennedy lot,[3] occupies part of the west slope of a prominent quartzite hill five-eighths of a mile northwest of the Rowland Spring road and 2½ miles north-northeast of Cartersville. Most of the prospecting and mining was done on the east part of the lot joining lot 172, which is being worked for manganiferous iron ore by J. M. and W. S. Knight of Cartersville.

Manganese occurs on lot 171 in close association with manganiferous iron, barite, and quartzite breccia. Most of the manganese is probably pyrolusite in the partially crystallized nodular form. Possibly as many as 15 carloads of ferruginous manganese have been shipped from the lot.[4]

Fair-sized bodies of both barite and manganiferous iron could be profitably worked on this lot though all the ores are so intimately mixed that careful sorting and comparatively small scale methods would probably be necessary.

Lot 174.[5]—Lot 174, situated on the Rowland Spring road, 3 miles northeast of Cartersville, contains manganese ore of good grade which was rather extensively mined, according to Watson, from a large open-cut and a 40-foot shaft. Some barite was found in a drill hole which encountered 30 to 40 feet of gravel manganese ore at moderate depths. Samples of the manganese ore showed more than 40 per cent manganese.

Lots 113 and 114.[6]—These lots are on the Rowland Spring road, 3¼ miles northeast of Cartersville. Some work was done on lot 114 about 1900, on the west side of the public road near a prominent outcrop of quartzite, which strikes northeast, dips about 90°, and is stained with limonite, ocher, and manganese.

[1] Watson, op. cit., p. 63.
[2] Idem, p. 67.
[3] Idem, p. 96.
[4] Information from R. S. Munford, Cartersville, 1918.
[5] Watson, op. cit., pp. 67, 68.
[6] Idem, p. 62.

Lot 113, on the east side of the road, was worked prior to 1900 by A. P. Silva who removed a large quantity of high-grade ore. This lot was crossed by the tram line of the Etowah Iron Company, built to the Dobbins mines about 1890. No work of recent date has been done on these lots.

Lots 305 and 306.[1]—Lots 305 and 306 contain 160 acres each. They are in the 5th district, 3d section, 4¼ miles northeast of Cartersville on the Rowland Spring road. High-grade manganese ore has been found in some quantity on both lots, but has been shipped from lot 306 only.

Lot 306 joins the east side of lot 271, which is part of the Dobbins property. The western part of the lot occupies the same ore-bearing ridge with the Dobbins mine and the ore mined on both properties is of a similar character. The openings are on the west side of the Rowland Spring road. Near the fork of the road a little more than a mile southwest of Rowland Spring and at the place where the old Etowah Iron Company tram line crossed the public road east of the Dobbins mines, the road cut exposes manganese ore through a distance of 50 feet. This is bluish-black, soft granular and crystallized pyrolusite and psilomelane intimately mixed with yellowish-gray clay loam. Manganese "float" of good quality is very noticeable for 100 feet or more east of the public road.

No manganese ore has been produced on lot 306 in many years, but there is in all probability a large workable amount still intact.

Analyses of manganese ore. Lot 306. Etowah Development Company

Constituents	*1*	*2*	*3*	*4*
Silica (SiO_2)	3.78	14.50	......	......
Manganese (Mn) ...	49.32	39.24	35.32	41.701
Iron (Fe)	......	......	3.11	2.628
Phosphorus (P)	0.208	0.154	0.063	0.162

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, pp. 64, 65, 1908.

1, 2.—"Analyses of 2 carloads of the ore from this lot, furnished the Survey by Capt. John J. Calhoun, of Cartersville, Ga." Watson, op. cit., p. 64.
3.—"Samples of ore from the same lot, collected by Mr. A. S. Reed, of New York City." Watson, op. cit., p. 64.
4.—Collector, Daniel G. Wiggins. Analyst, Booth, Garrett & Blair, Philadelphia, Pa.

Lots 303 and 274.[1]—These two 160-acre lots are in the 5th district, 3d section, Bartow County, 6 miles north-northeast of Cartersville. The adjoining property on the north and west belongs to the Georgia Iron & Coal Company. Lot 303 is known as the Mayburn lot.[2] As no extensive mining has been done since the nineties, the openings are caved and do not show the full relations and character of the ore deposit. Watson's description is as follows: "Much ore of superior quality has been mined on this lot. . . The larger cut and several shafts, from 30 to 40 feet in depth, from which drifts were run at different levels, comprise the mining done on this lot in 1898. Pockets of high-grade, massive and crystallized ore, similar to that mined on lot 306, were worked. Smaller prospect openings are to be found over most of the lot, with good faces of ore exposed in each."

In 1918, a small log washer, practically useless from lack of repair, stood at the small stream on the south side of the northwest-trending quartzite ridge which contains the ore deposits. This stream flows southwest 2½ miles to Pettit Creek.

The following analyses are from Watson's report:

Analyses of manganese ore. Lot 303. Etowah Development Company

Constituents	*1*	*2*	*3*
Silica (SiO_2)	8.350	......	......
Alumina (Al_2O_3) } Ferric oxide (Fe_2O_3) }	2.520	......	......

[1] Watson, op. cit., pp. 65, 66.
[2] Harder, E. C., Manganese deposits of the United States: U. S. Geol. Survey Bull. 427, pp. 82, 83, 1910.

Constituents	*1*	*2*	*3*
Water and organic matter	1.042	......	......
Manganese dioxide (MnO_2)	87.960	......	......
Manganese (Mn)	......	54.94	55.392
Iron (Fe)	......	3.62	0.876
Phosphorus (P)	0.120	0.034	0.100
Sulphur (S)	0.008	......	......
Total	100.000		
Manganese (Mn)	54.975		

1.—"Analysis of ore from this lot, made by Professor H. C. White, of State University, Athens, Ga."

2.—"Samples of manganese occurring on this lot, collected by Mr. A. S. Reed, of New York City."

3.—Collector, Daniel G. Wiggins. Analyst, Booth, Garrett & Blair.

Lot 274 is immediately west of the Mayburn lot. The ore occurs under similar conditions, but has not been so extensively mined. Lot 274 does not belong in its entirety to the Etowah Development Company, certain portions belonging to the Georgia Iron & Coal Company, Mrs. J. W. Akin, and C. J. and R. L. Smith. Two carloads of ore containing about 40 per cent of manganese are reported to have been shipped from this tract in 1916.[1] These lots are 1½ to 2 miles east of the Tennessee public road and the Louisville & Nashville Railroad, and are connected with these roads by a rather poor dirt road.

NORRIS MINE

Lot 405, 4th district, 3d section, Bartow County, is 1¼ miles east of Cartersville and at the north end of the Etowah Development Company Railroad 1¼ miles north of the Western & Atlantic Railroad. The property is described in Bulletin 14[2] as being a part of the

[1] Information from R. S. Munford, Cartersville.

[2] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, pp. 84, 85, 1908. It was described as the "Barrow lot," possibly a misprint for Barron lot, by which name it was locally known in 1917.

Parrott Spring tract. The lot contains 39 acres and is owned by J. T. Norris of Cartersville, and Mrs. L. C. Hall of Milledgeville, Ga. In March, 1917, they leased the manganese deposit to the Republic Iron & Steel Company of Birmingham, Ala., which was also operating the Dobbins mines, 4 miles northeast of Cartersville.

The recent work of 1917 and 1918 has been done at the north end of a north-south quartzite ridge and about 50 feet higher than the ore railroad which terminates 100 yards from the open cut. The general elevation of the lot above sea level is 900 feet and the narrow valley which heads on the property slopes in a south-southeast direction to Etowah River about a mile away and approximately 100 feet lower than lot 405.

The manganese ore body forms a part of the larger deposit that has been worked for manganese, brown iron, and barite on adjoining lots. All of these ores, together with ocher, occur at the Norris mine in the sequence usually found in the district, that is, the quartzite foot wall is overlain in turn by limonite and ocher, manganese, and barite,—all in yellow and reddish-yellow residual clay.

The ore occurs in pockets and streaks in the loose clay as "soft chemical" or very finely granular, black oxide ore, probably a mixture of pyrolusite and wad; as concretionary and nodular layers of pyrolusite and psilomelane rather free from mechanical impurities; and as manganiferous limonite with quartz impurities.

The analyses here given show the character of both high-grade manganese and the more abundant manganiferous iron ore.

Analyses of manganese and manganiferous iron ores. Norris mine

Constituents	*1*	*2*	*3*
Silica (SiO_2) and insoluble	......	25.00	......
Manganese (Mn)	47.23	17.00	15.13
Iron (Fe)	4.85	27.00	......
Phosphorus (P)	......	0.18	......

1.—Manganese. "A partial analysis of specimens of the ore from this lot made in Chicago[1]."

2.—Manganiferous iron ore. Approximate average analysis of shipping product, according to J. H. Burgess, superintendent of Republic Iron & Steel Company's mines at Cartersville, 1917.

3.—Manganiferous iron ore. Manganese content of 15 carloads of ore shipped in the early part of 1918, furnished by T. A. Penhallegan, superintendent at the mine, 1918. Analyses by Republic Iron & Steel Company, Birmingham, Ala.

As all of the mining on this lot has been carried on by hand methods, the mine was known for some time as the Barron dry mine.[2] Since the Republic Iron & Steel Company used the whole output in its own furnaces in Alabama, for purposes which did not require high manganese content, no effort was made to produce a concentrated ore.

A 25-horsepower boiler and a hoisting engine were used to operate the ore car in the inclined tunnel. Although there is no water supply at hand sufficient for milling purposes, the abundant supply of Etowah River is only a mile away, and a pipe line furnished all the water necessary.

In the summer of 1918, after shipping more than 3500 tons of manganiferous iron ore, the Republic Iron & Steel Company suspended operations at the Norris mine.

FREEMAN PROPERTY

Lot 313, 4th district, 3d section, Bartow County, is just outside the city limits of Cartersville, 1½ miles north-northeast of the Western & Atlantic Railroad station. The property belongs in part to Mrs. Mary J. Freeman of Dallas, Tex., in part to J. L. Smith, and in part to Mrs. Fannie L. Smith, of Cartersville. The ore deposits were

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, p. 85, 1908.

[2] The term "dry mine" is commonly applied to mines worked strictly by hand methods. The ore is dug with pick and shovel. Preparation for shipment may be made by hand sorting or by dry screening. The term usually implies a small operation, and in this sense does not refer to absence of ground water in the workings.

operated in 1918 by the Cherokee Ochre Company, J. T. Norris, treasurer and secretary, and by J. M. Knight, both of Cartersville.

The many small pits and openings are on the north side of the lot, on the north nose of a prominent hill. They are 40 or 50 feet higher than the public road and about the same height above the small stream that flows westward through the lot joining the north side of the Freeman lot. The Rowland Spring public road is a few hundred yards east of the openings.

The property has been worked at different times through a period of many years. All of the mining has been of the dry-mine type, strictly hand work, on a comparatively small scale. The openings are 30 to 40 feet deep in places and expose the underlying yellow clay. The manganese is irregularly scattered throughout the unconsolidated material as gravel, nodular, and boulder ore, together with fracture- and breccia-filling in more or less decomposed quartzite fragments.

Of the following analyses, the first, quoted from Bulletin 14[1], shows the excellent quality of the ore, and the second shows the grade of the whole ore deposit.

Analyses of manganese ore. Freeman lot

Constituents	*Watson*	*Crane–38*
Silica (SiO_2)	8.00	71.02
Alumina (Al_2O_3)	......	10.22
Moisture at 100° C.	......	0.66
Manganese (Mn)	42.40	2.40
Iron (Fe)	......	5.15
Phosphorus (P)	0.10	0.073

Watson.—High-grade manganese ore, collected by T. L. Watson, 1900.
Crane–38.—Analysis of an aggregate sample collected from all over the lot to represent the whole ore deposit. Collected by W. R. Crane, 1918.

[1] Watson, op. cit., p. 83.

Several hundred tons have been produced, and it is probable that a large quantity is still in the ground.

LOT 312

Lot 312, 4th district, 3d section, is also 1¼ miles north-northeast of Cartersville station and joins the west side of the Freeman lot. It is owned in part by Mrs. Fannie L. Smith (W. E. Smith, agent) and the estate of W. H. Howard. The south part of the lot, owned by Mrs. Smith, was worked some years ago for brown iron ore by P. F. Renfroe of Cartersville, who also holds a lease on the manganese deposit which has been prospected not more than 200 yards north-northwest of the old iron cut. The property was formerly known as the Pattillo lot.[1]

The geological conditions are similar to those on the Freeman lot, the surface formation being characterized by ferruginous red clay loam containing more or less decomposed quartzite fragments and nodules of manganese oxide.

In 1917, P. F. Renfroe had a prospect shaft sunk to a depth of 32 feet from which a level was driven 20 feet toward the east. The manganese ore body as opened by the shaft extends to a depth of 22 feet. The ore occurs as grayish and bluish-black concentric nodules made up of alternating layers of hard, dense psilomelane and soft crystalline pyrolusite. The concentric layer of pyrolusite is commonly composed of bladed, needle-like crystals, which form by their radiating structure and close growth, at the sharp contact with the next layer of psilomelane, an almost spherical surface of intricate and shimmering mosaic. Some of these concentric layers of splintery, radiate crystals are more than an inch thick. In some nodules, the pyrolusite is crystallized in tiny tabular forms which present a sparkling appearance when turned in the light.

These crystals appear to be pure mineral, yet the chemical analysis of some crystal fragments selected for their apparent purity shows as much silica, iron, and phosphorus as is contained in many average ore samples.

[1] Watson, op. cit., p. 88.

Analyses of pyrolusite crystals and manganese ore. Lot 312

Constituents	*Hu-340Bx*	*Hu-340Ax*	*1*
Silica (SiO_2) and insoluble	......	4.07	......
Silica (SiO_2)	1.23	......	2.80
Alumina (Al_2O_3)	0.10	0.46	......
Ferric oxide (Fe_2O_3)	0.70	3.51	......
Magnesia (MgO)	0.00	......	......
Lime (CaO)	0.00	......	......
Soda (Na_2O)	0.00	......	......
Potash (K_2O)	0.00	......	......
Moisture at 100°C	0.03	2.393	......
Water on ignition	0.00	......	......
Titanium dioxide (TiO_2)	0.00	......	......
Phosphorus pentoxide (P_2O_5)	0.78	0.397	......
Sulphur trioxide (SO_3)	0.00	......	......
Nickel oxide (NiO)	trace	......	......
Manganese dioxide (MnO_2)	97.22	89.17	......
Manganous oxide (MnO)*a*	0.00	......	......
Strontium oxide (SrO)	0.00	......	......
Barium oxide (BaO)	0.18	......	......
Total	100.24	100.000	
Manganese (Mn)	61.44	57.03	60.61
Iron (Fe)	0.49	2.46	1.45
Phosphorus (P)	0.340	0.173	0.052
Sulphur (S)	......	......	0.00
Cobalt (Co)	trace	......	......
Carbon (C)	0.00	......	......
Copper (Cu)	0.00	......	......
Arsenic (As)	0.00	......	......
Zinc (Zn)	0.00	......	......

a Manganese in excess of dioxide is calculated as manganous oxide (MnO).

Hu-340Bx.—Pyrolusite. Stout, tabular crystals, vertically striated. Hardness greater than 2.5. Pseudomorphous after manganite. The mineral has a black streak and lacks the water of manganite; it is therefore classed as pyrolusite.

Hu-340Ax.—Pyrolusite. Columnar, splintery, fibrous crystals about an inch long, forming one of the concentric layers in a manganese nodule. This specimen also has some characteristics of manganite, but seems to be nearer pyrolusite.

1.—Manganese ore. Analysis of select sample made by Carnegie, Phipps & Company, Pittsburgh, Pa. Taken from Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, p. 88, 1908.

C. N. SMITH PROPERTY

Lot 264, 4th district, 3d section, 1¼ miles northeast of Cartersville, includes part of the property belonging to C. N. Smith of Cartersville. This was formerly part of the Rowan property.[1] It joins the north side of the Freeman lot, previously described, and occupies the gentle westward-drained valley and adjacent slopes whose geology and ore deposits are about the same as found on the neighboring lots, 313 and 312.

In July, 1917, C. N. Smith opened a cut in the red and yellow residual clays on the hillside about 100 yards south of the little stream. The open-cut is about 80 feet long, 35 feet wide, and 20 feet deep. In 1918, after the cut was abandoned, very little ore was in sight, except as stain and fracture-filling in partially decomposed yellow gritty material, capped by 3 to 5 feet of red soil that has a gravelly contact at its base. All the mining was done by hand and the ore was concentrated by a single-log washer run by a portable steam engine and supplied with water by a small pump at the stream.

In the spring of 1918, a deposit associated with quartzite on the north side of the stream, was being worked by the Cherokee Ochre Company and W. S. Knight of Cartersville, who leased the deposits on lots 264 and 241 from the owner, C. N. Smith. An open-cut was dug 120 feet northward into the quartzite and the unconsolidated ore body farther in the hillside beyond the solid rock. Much of the ore is lean but the low manganese content of the shipping product is due largely to lack of proper concentrating machinery.

The total production of manganese ore from lot 264 is probably not more than a few hundred tons. The following analyses indicate the different grades of ore on the Smith property.

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[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, pp. 83 and 98, 1908.

Analyses of manganese and ferruginous manganese ore. Lot 264

Constituents	*Watson*	*Hu-341x*	*Crane-40*	*Crane-35*	*Crane 36*
Silica (SiO_2) and insol	.....	13.90	.....	.....	.....
Silica (SiO_2)	3.32	.....	28.40	50.76	53.78
Alumina (Al_2O_3)	.....	6.52	4.80	12.68	10.54
Moisture at 100°C	.....	1.20	1.62	1.15	1.99
Manganese (Mn)	53.20	37.72	20.06	4.21	2.49
Iron (Fe)	.....	2.46	15.78	10.30	9.07
Phosphorus (P)	0.146	0.301	0.156	0.10	0.084

Watson.—Manganese ore. Collected by T. L. Watson, 1900-1902.

Hu-341x.—Ferruginous manganese ore. One specimen representing the better part of the ore mined in 1918.

Crane-40.—Ferruginous manganese ore. Analysis of average sample representing a carload shipped in June, 1918. Sample taken by W. R. Crane.

Crane-35.—Analysis of average ore deposit sample, representing the whole deposit as it occurs. Collected by W. R. Crane, June, 1918.

Crane-36.—Analysis of average mud pond sample, showing metallic content lost in mud pond. Collected by W. R. Crane, June, 1918.

ZIEGLER PROPERTY

The William Ziegler estate, of which W. S. Champ of New York City has the management, includes 280 acres in lots 115, 175, 187, 188, 189, and 245, 4th district, 3d section, Bartow County. The property lies on both sides of the Rowland Spring road, 2½ to 3 miles northeast of Cartersville.

In 1918, W. C. Satterfield began working the rather steep east and southeast slopes on lots 245 and 188 west of the Rowland Spring road, where a considerable amount of mining had been done in former years.

This part of the property occupies the east and south sides of a prominent wooded hill which rises 440 feet higher than the public road, or 1340 feet above sea level. Along the road at the southeast foot of the hill, a small stream flows southwest. The ore deposit extends from the road, 200 feet or more up the hill slope. Farther up the hillside outcrops of hard gray Weisner quartzite strike generally northeast with the ridge-like top of the hill which extends toward the public road, and dip southeast with the slope of the hill containing the ore deposit.

The ore is high-grade pyrolusite and psilomelane, easily mined, and seems to be rather abundant for several hundred feet along the hillside. Its depth is limited by the quartzite foot wall which is probably 30 or 40 feet below the surface in many places. Besides high-grade manganese, the test pits showed the commonly associated ores of manganiferous iron and limonite.

It is planned to install a single-log washer and a 4-cell jig which will have a capacity of about 20 tons a day.

INGRAM AND EVANS PROPERTY

Lot 172, 4th district, 3d section, belongs to H. L. Ingram and W. L. Evans, of Acworth, Ga., and is operated under lease by J. M. and W. S. Knight, of Cartersville. This property was formerly known as the Franklin lot,[1] owned by Laramore, Stephens, and Daniel. It is on the west slope of a prominent quartzite hill half a mile northwest of the Rowland Spring road and 2½ miles north-northeast of Cartersville. It joins the east side of lot 171 of the Etowah Development Company and is about three-eighths of a mile northwest of the Ziegler property. The occurrence of the ore is about the same as on the neighboring properties previously described.

In 1917, Ingram and Evans operated a 24-foot shaft and two tunnels, one 27 feet long and the other 55 feet long, all starting from the bottom of an old open-cut. In the summer of 1918, J. M. and W. S. Knight reopened the same general workings.

The ore is all dry-mined, preparation for shipment being by hand sorting and screening. Hauling is done by wagon, 3 miles to Cartersville. The shipping product is manganiferous iron ore containing 8 to 20 per cent of manganese and 24 to 36 per cent of iron.[2]

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[1] Watson, op. cit., pp. 77, 78, and 96.
[2] Information from H. L. Ingram, June, 1918.

DOBBINS MINES

General statement.—Lot 271 and a small part of lot 270, 5th district, and lots 30, 31, 42, and 43, 4th district, 3d section, Bartow County, are the property of the Bartow Manganese Mining and Manufacturing Company, M. G. Dobbins, agent, Cartersville. The lessee is the Republic Iron & Steel Company, Birmingham, Ala. T. A. Penhallegan, Cartersville, is superintendent at the mines. This tract of land includes more than 325 acres,—lot 271 in the 5th district containing 160 acres and the lots in the 4th district each containing 40 acres, —mostly on the west side of the Rowland Spring road, about 4 miles northeast of Cartersville.

The Dobbins mine is the oldest manganese mine in Georgia, having been opened as early as 1866.[1] In writing of the manganese industry at Cartersville, Weeks states:[2] "Mining was begun at this locality in 1866 by the Pyrolusite Mining Company, and 550 tons of ore were mined and sold in that year." As this production of 1866 was reported in the statistics of the United States Mineral Resources as coming from the whole Cartersville district, the quantity produced in 1866 on the Dobbins property is not known.

Because of the lack of records of the earliest work, it is rather difficult to reconcile different statements, but it is undoubtedly true that the Dobbins mine is one of the very few operating mines in the United States that were producing in 1867, the first year in which any systematic attempt was made to work American manganese ores.[3]

Some of the early history of the Dobbins mine is given in the following quotation, written in 1883 or 1884[4]: "The chief rivals of the Virginia ores are those of the 'Etowah region,' Bartow County, Georgia. A Virginian named Ruckman discovered manganese at

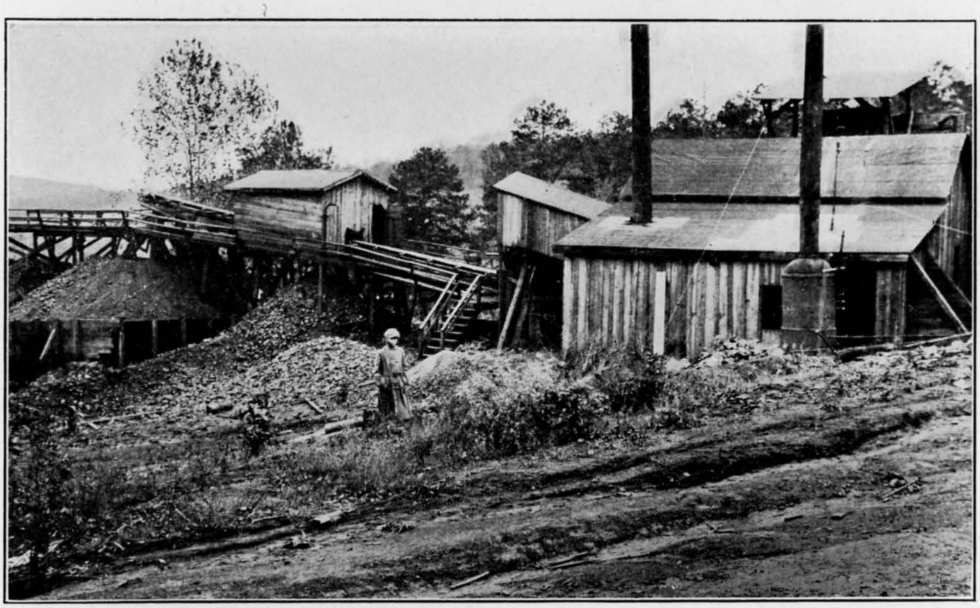
[1] M. G. Dobbins, Cartersville, has kindly furnished much information about the property.

[2] Weeks, Jos. D., Manganese: U. S. Geol. Survey Mineral Resources for 1889 and 1890, p. 133, 1892.

[3] Penrose, R. A. F., jr., Manganese: its uses, ores, and deposits: Geol. Survey of Arkansas, Ann. Rept. for 1890, Vol. I, pp. 57-61, 1891.

[4] Day, D. T., Manganese: U. S. Geol. Survey Mineral Resources, 1883 and 1884, p. 552, 1885.

A. OPEN-CUT, DOBBINS MINE, 4½ MILES NORTHEAST OF CARTERSVILLE, BARTOW COUNTY.



B CONCENTRATING PLANT, DOBBINS MINE, 4½ MILES NORTHEAST OF CARTERSVILLE, BARTOW COUNTY.

Cass Station, Bartow County, and recognized a similarity between these ores and those of Virginia. In 1867 the property was bought for mining purposes by Mr. M. G. Dobbins."[1]

E. H. Woodward, president of the Pyrolusite Mining Company, opened the Dobbins mine and worked it until about 1878. In 1891, Woodward's lease was transferred to the Etowah Iron Company of Cartersville, Ga., and Philadelphia, Pa., for a term of 5 years. Under the supervision of A. O. Granger, this company did a considerable amount of development work, extending one shaft, which M. G. Dobbins had sunk to a length of 100 feet in 1888, to a total depth of 210 feet. It hauled the ore over the 4-mile railroad built in 1891 to connect the Dobbins mine with the company's large manganese mill on Etowah River.

For almost a decade from the close of 1905 through 1914, there was no regular production of manganese on the Dobbins property nor anywhere else in the Cartersville district. In 1916, the Republic Iron & Steel Company of Birmingham leased the mine and reopened the workings. It is producing chiefly manganiferous iron, but is also shipping some manganese ore.

Topography.—The Dobbins property occupies part of the prominent and hilly divide between the valleys of Pettit Creek and McKasky Creek, whose general drainage is southward to Etowah River. Although the property is about midway between the main streams of these two tributaries, the small branches that drain its hills flow southwest and west to Pettit Creek.

The principal mine is at an elevation about 1000 feet above sea level and 3½ miles by road east of Wyvern, a siding on the Louisville & Nashville Railroad, 760 feet above sea level. Because of better shipping facilities, however, the ore has been hauled, heretofore, 4½ miles to Cartersville, where the rail elevation is about 740 feet above sea level.

Geology.—The rock underlying the area of the Dobbins property is Weisner quartzite whose structure is shown in the trend of the

[1] He was the father of M. G. Dobbins, now of Cartersville, 1918.

ridge, the general strike being N.45°E. and the dip, though rather obscure, probably ranging from almost vertical to southeast, with the slope of the hill. West of the open cuts and near the top of the ridge, but in places distinctly on the westward slope, there are discontinuous and fractured outcrops of quartzite whose attitude seems to conform to the general structure of the ridge.

Overlying the quartzite are yellow and reddish-yellow clays, representing a formation almost completely decomposed, but containing fragments of only partially decayed rock and in some places still retaining stratification planes as evidence of its residual character.[1] A large part of the loose ore-bearing clay is undoubtedly detrital material accumulated by hillside wash and talus, and in many places it is almost impossible to determine which is residual and which colluvial.

Along the east slope of the ridge and near the top, a few hundred yards southwest of the main open cuts, the red soil contains many smooth quartz pebbles, ranging from a fraction of an inch to less than a foot in thickness. They are distinctly water-worn and occur on the surface about 100 feet higher than the present stream bed.

The depth to which the decomposed mass extends depends very largely on the irregularities of the underlying hard quartzite. The deepest shaft on the property is said to have been 210 feet deep. This was sunk well up on the slope on the north side of lot 271 and no solid rock was found in its entire depth.[2]

Ore deposit and ore.—The great mass of the ore deposit is on the southeast and south slopes of the quartzite ridge. Mining development shows that the deposits are larger and more concentrated on lot 271 in the northeastern part of the property, but surface indications are abundant almost over the whole tract.

The ore deposit is in the decomposed material overlying the quartzite. It extends from the surface accumulations of ferruginous and

[1] Penrose, R. A. F., jr., Manganese: its uses, ores, and deposits, Geol. Survey of Arkansas, Ann. Rept. for 1890, Vol. I, pp. 419, 420, 1891.

Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, p. 97, 1908.

[2] Information from M. G. Dobbins, Cartersville.

manganiferous nodules to larger and more connected masses of manganese oxide at a depth of 210 feet. Along the top of the northeasterly ridge, the deposit is thinner, lying next to the quartzite, and seems to be characterized by a predominance of brown iron ore. Along the slopes, however, and at greater depths, the clay formation contains manganiferous iron deposits of the higher grade manganese.

The occurrence of the ore is in the common forms of "soft chemical," gravelly, nodular, vesicular, crystalline, and massive, as stringers and pockets in the clay.

High-grade manganese ores, consisting of intimate mixtures of pyrolusite and psilomelane, formed almost the whole output until 1916. Since that time, the operations have been concentrated on the production of manganiferous iron, this grade being the particular quality desired by the lessee.

The following analyses represent the different ores on the Dobbins property:

Analyses of manganese and manganiferous iron ores. Dobbins mines

Constituents	*1*	*2*	*3*	*Hu-346Bx*	*Hu-345x*	*4*	*Hu-344x*	*Hu-346Cx*
SiO_2 & insol.	......	......	......	13.45	8.13	25.63	64.96	49.79
SiO_2	0.60	1.32	4.30	......	......	......	......	......
Al_2O_3	0.13	......	......	......	0.16	......	3.52	1.40
Fe_2O_3	0.54	15.72	......	......	......	......	......	......
MgO	0.15	......	......	......	......	......	......	......
CaO	0.90	......	......	......	......	......	......	......
Moisture	......	......	......	0.44	0.44	......	1.66	1.66
H_2O and CO_2	17.00	1.15	......	......	......	......	......	......
P_2O_5	0.33	......	......	......	......	......	......	......
S	0.027	......	......	......	0.00	......	......	......
MnO_2	......	......	......	73.51	......	......	......	......
MnO	80.00	80.58	......	......	......	......	......	......
BaO	......	......	......	......	1.82	......	......	......
$BaSO_4$	......	......	......	......	0.00	......	......	......
C	......	1.34	......	......	......	......	......	......
Total	99.67	100.11						

Constituents	*1*	*2*	*3*	*Hu-346Bx*	*Hu-345x*	*4*	*Hu-344x*	*Hu-346Cx*
Mn	......	65.35	52.726	48.66	42.77	15.84	3.23	20.39
Fe	......	....	4.490	73.51	11.11	25.71	14.66	5.37
P	......	....	0.188	0.269	0.173	0.188	0.084	0.176
Ni	......	....	......	......	0.00	......	......	......

1.—Pyrolusite. "A sample analyzed in New York[1]."

2.—Pyrolusite. "Taken from a lot of ore shipped to England[1]."

3.—Manganese ore. Analysis of one of several carloads shipped to Carnegie Bros. & Company, limited, Pittsburgh, Pennsylvania[2].

Hu-346Bx.—"Soft chemical" ore. Selected sample from open cut on lot 31.

Hu-345x.—High-grade hard ore. Collected on site of old "sand shaft"; represents ore at depth of 210 feet[3]. Lot 271.

4.—Manganiferous iron ore. An average of 5 analyses representing 5 carloads of log-washed ore. Part of a shipment in January, 1918. Represents the ore being produced by the Republic Iron & Steel Company. Analyses by the Company.

Hu-344x.—Tailings. Sand from log washer and screens at Dobbins No. 1, lot 271.

Hu-346Cx.—Tailings. Mud from log washer at Dobbins No. 2, lot 31. This material from the mud pond is sometimes shipped.

Development.—Almost all of the mining has been done on lot 271; very little was done on the other lots until 1917 and 1918. In 1902, Watson said[4]: "It is not possible to estimate the exact amount of ore mined on this lot; but it is safe to say that it has been greater than for any other single lot in the State. Eight main cuts, averaging from 100 to 150 feet in length, 50 feet wide, and from 25 to 30 feet in depth, have been worked. Six shafts have been sunk, with the following approximate depths: 50, 80, 100, 106, 110, and 190 feet. Drifts or tunnels were run from all the shafts at different levels, for long distances and in different directions. Similar smaller openings have been dug over all parts of the lot, and manganese ore exposed in all of them."

[1] Day, D. T., Manganese: U. S. Geol. Survey Mineral Resources for 1883 and 1884, p. 552, 1885.
[2] Weeks, J. D., Manganese: U. S. Geol. Survey Mineral Resources, 1885, p. 330, 1886.
[3] Information from M. G. Dobbins.
[4] Watson, op. cit., pp. 96, 97.

The deepest shaft was the old "sand shaft" sunk by Mr. Dobbins to a depth of 100 feet in 1888, and 110 feet farther by the Etowah Iron Company, in 1891 or 1892, making a total depth of 210 feet. No hard rock formation was encountered even in the bottom. It is reported that in the bottom of the shaft, ore was mined from three drifts one above the other and each in high-grade manganese oxide ore such as sample *Hu-345x,* which was collected from the surface at the site of the old head-frame.

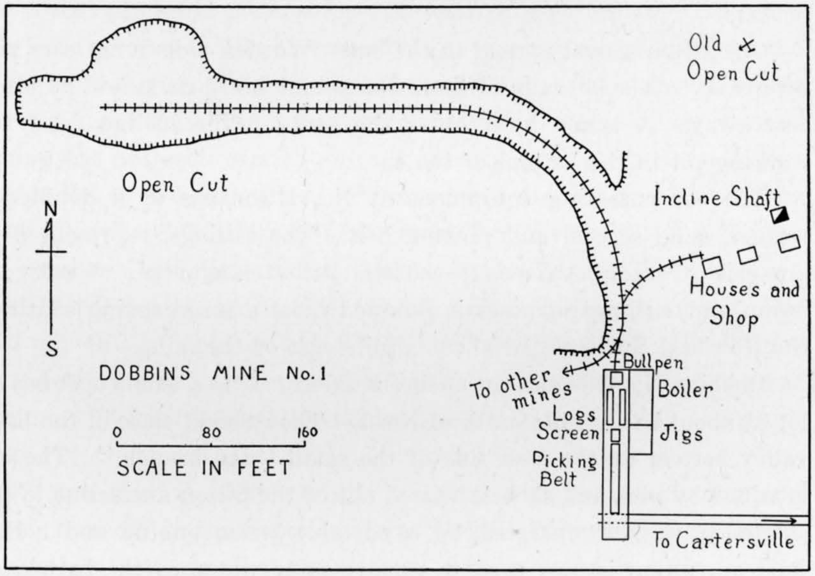


Fig. 5. Sketch map of Dobbins mine No. 1, lot 271, northeast of Cartersville.

The Republic Iron & Steel Company produces manganiferous iron ore of the grade shown in analysis *4*, by open-cut work and simple log washing and screening methods. Some manganese ore is also shipped but this is produced at various times when desired by hand sorting at the picking belt, and is not mined as such.

The company mined some manganese ore in 1916 and 1917 from an inclined shaft whose entrance is less than 100 yards northeast of the No. 1 plant. The incline extended about 200 feet northwest, at an angle of 45° approximately, beneath the open cuts. A body of good manganese ore was worked through several drifts with a total length of 100 feet.[1]

The Dobbins No. 1 mine is near the center of lot 271. This whole open cut is several hundred feet long, 100 feet wide in places, and almost 100 feet deep. It extends east and west in red and yellow clays containing broken layers and fragments of quartzite in various stages of decomposition. The ore is not uniformly abundant, but occurs as scattered nodules, irregular masses, and more or less distinct pockets.

One steam shovel is used in the cut. Wooden side-dump cars run by gravity on steel rails to both dump and bull-pen a few hundred feet away. A steam hoist hauls the cars up the incline from the working pit in the bottom of the cut.

The concentrating equipment at No. 1 consists of a double-log washer, sand screen, and picking belt. The tailings, represented in analysis of sample *Hu-344*, contain little manganese. Water for steam and milling purposes is pumped from a large spring south of the Rowland Spring road about a mile east of the mine.

Dobbins No. 2 is also an open cut mine. It is a small opening on lot 31 about half a mile south of No. 1. The excavation is in the little valley bottom on the west side of the small "dry branch." The ore is mined by pick and shovel, hoisted out of the pit on an incline to the single-log washer, operated by a portable steam engine and boiler. A steam pump is also used to remove mine water as the bottom of the open cut is several feet lower than the branch.

The ore at No. 2 occurs in the clay in the usual forms. Analysis of sample *Hu-346Bx* shows the high grade of the soft, finely divided oxide in small streaks and pockets. That a large amount of manganese is sometimes lost in the sand tailings and slimes from the log washer is shown by the analysis of sample *Hu-346Cx*. This material, containing 18 to 20 per cent of manganese, is frequently shipped as ore when the content of silica is not too high.

[1] Information from T. B. Johnston, foreman at Dobbins No. 1, 1918.

A small opening has also been made on the south side of lot 271, about a quarter of a mile south of No. 1. This cut is on a low hill across the ravine from No. 1, and is connected with the washer by a tram line. The ore is hauled 4½ miles to Cartersville by a 3-ton motor truck and 3 trailers. It is expected that the shorter route to Wyvern will soon be used.

Production.—In 1886, when it was stated[1] that the Dobbins mine was not only the oldest mine operating in the Cartersville district, but that it had produced the most ore, its total production was 6226 tons[2], or a little more than 19 per cent of the total amount produced by the whole State during the same time, from 1867 to 1886 inclusive. This ore was high-grade, containing more than 44 per cent of manganese. Mining has not been carried on continuously and several lessees have operated it at different times. Figures are not available to show how many more than 10,000 tons of manganese ore have been shipped since the property was first worked, but it is not improbable that more than 15,000 tons have been produced. Since 1916, the output has been principally manganiferous iron ore containing less than 20 per cent of manganese. It is probable that the shipments of this ore have amounted to half the total of manganese ore shipped from the property.

Future of mine.—The quantity of manganese, manganiferous, and brown iron ore in the deposits of the Dobbins property is unknown. It seems safe to say that the reserve tonnage may be estimated at least in tens of thousand tons.

The deposits are favorably situated as regards disposal of tailings, transportation of ore, and supply of timber, fuel, and water. Jigs are being installed at the Dobbins No. 1 plant.

[1] Weeks, J. D., Manganese: U. S. Geol. Survey Mineral Resources, 1885, p. 330, 1886.
[2] Weeks, op. cit., p. 330. Idem, 1886, p. 187.

LOT 272

This property has been known as the Milner-Harris property.[1] It contains 160 acres more or less, is in the 5th district, 3d section, about 5 miles north-northeast of Cartersville, and belongs in part to A. E. Milner (Watt H. Milner, agent), and in part to C. J. and R. L. Smith, all of Cartersville. The lot joins the north side of lot 271 of the Dobbins estate and occupies part of the same quartzite ridge. The ore was once mined in large quantities from the north and east slopes of the ridge a little more than a quarter of a mile west of the public road and about 1¼ miles west of Rowland Spring. The character of the ore and the deposit is similar to that of the Dobbins mines. No mining has been done for many years and nothing remains on the surface but the old tailings heaps.

LOT 273

Lot 273, 5th district, 3d section, about 7 miles by road north-northeast of Cartersville, is owned by A. E. Milner, Mrs. A. J. Pyron, and C. J. and R. L. Smith, Cartersville. The deposit being operated under lease by W. O. Houck is in a tract of 28 acres owned by C. J. and R. L. Smith.

This property constitutes an 160-acre lot occupying the north end of the same ridge on which are the Dobbins and the old Milner-Harris mines. The Houck mine is at an elevation approximately 900 feet above sea level in the northeast quarter of the lot and on the east slope of the hill considerably less than 50 feet above a small branch flowing northwest and west into Pettit Creek. It is about 100 yards west of a wagon road, three-quarters of a mile north of the main Wolfpen-Cartersville road over which the ore is hauled to Cartersville, 7 miles distant. A less used road, however, leads northwest to the Louisville & Nashville Railroad, only 2¼ miles away.

In July, 1918, W. O. Houck leased the property and resumed operations which had been suspended since the close of 1917.

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[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia Geol. Survey of Ga. Bull. 14, pp. 91-93, 1908.

Ore of high quality and promising abundance has been found by prospecting a distance of 300 yards along the east slope of the ridge. The underlying rock is quartzite, covered in places by 60 feet of unconsolidated yellow clay and yellowish-red soil containing the manganese oxides in the usual nodular and crystalline form.

In the latter part of 1918 a vertical shaft sunk 42 feet penetrated 32 feet of ore. The following analyses show the different grades of manganese ore at the Houck mine.

Analyses of manganese ores. Houck mine

Constituents	*1*	*2*	*3*	*4*
Silica (SiO_2)	9.98	5.61	12.37	66.03
Alumina (Al_2O_3)	1.48	2.53	5.06	3.04
Iron (Fe)	17.15	2.86	3.37	10.62
Manganese (Mn) ...	35.72	54.07	44.82	8.78
Phosphorus (P)	0.25	0.05	0.06	0.07

1.—Manganese ore from surface accumulation. Analysis made and furnished by the Tennessee Coal, Iron & Railroad Company, Birmingham, Ala., 1918.
2.—Manganese ore. Hard ore stock pile. Analysis as above.
3.—Manganese ore. Soft ore stock pile. Analysis as above.
4.—Tailings dump; mud pond. Analysis as above.

WYVERN MINE

The Wyvern mine is on the east side of lot 200, 5th district, 3d section, a quarter of a mile northeast of Wyvern station on the Louisville & Nashville Railroad and 4 miles north of Cartersville. The property belongs to R. Pyron and is leased by the Paga Mining Company of Cartersville.

In 1917, Wilbur A. Nelson and W. L. Torbert, of the Paga Mining Company leased the wooded hill just west of the railroad and a quarter of a mile east of the old Guyton iron mine, and together with P. C. Renfroe, of Cartersville, produced about 30 cars of ferruginous manganese ore, chiefly in the latter part of 1917. In 1916, the Paga Mining Company shipped a few carloads of ferruginous manganese ore.

The elevation of the mine is about 740 feet above sea level and only a few feet higher than the small stream flowing on the north side of the open cut, northwest to Pettit Creek, a quarter of a mile away. The open-cut is in the steep north side of a low hill rising abruptly west of the railroad.

As shown in the open-cut, the ore occurs in a more or less definite body at least 10 feet thick, striking north and dipping about 40°E. It is in partially decomposed quartzitic rock, somewhat ferruginous, and fragmental in yellow clay. A test pit sunk 25 feet in the bottom of the cut encountered limestone.

Limestone of the Conasauga formation outcrops rather markedly along the old Iron Belt Railroad at the Guyton mine a quarter of a mile west of the Wyvern mine. These outcrops generally show a north or slightly northeast strike and a sharp east or southeast dip. McCallie[1] in his description of the Guyton iron mine, gives a geologic section showing the position of the limestone beneath the brown iron ore.

The Wyvern mine is an open-cut about 80 feet long, 70 feet wide, and 15 to 25 feet deep. The deposit is worked as a dry mine. Three principal types of ore are produced, brown iron ore, soft ferruginous manganese ore, and hard lump ferruginous manganese ore. The hard lump manganiferous ore composes the bulk of the production and shipments. This contains manganese ranging from 15 to 30 per cent with low iron and high silica (sample *Hu-361Bx*). The peculiarity of the ore is the high silica content caused by the abundance of angular cherty fragments throughout the ore body.

Although the massive and amorphous types of manganese ore are most abundant at the Wyvern mine, some crystallized pyrolusite occurs together with good mineralogical specimens of psilomelane (sample *Hu-361Ax*).

This mine is exceptionally well situated as regards shipping facilities and water supply, being a quarter of a mile from Wyvern station and the same distance from Pettit Creek. A smaller stream flows within a few yards of the open cut.

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[1] McCallie, S. W., Preliminary report on a part of the iron ores of Georgia: Geol. Survey of Ga. Bull. 10-A, p. 147, 1900.

Analyses of psilomelane and ferruginous manganese ore. Wyvern mine

Constituents	*Hu-361Ax*	*Hu-361Bx*
Silica (SiO_2)	0.20	40.42
Alumina (Al_2O_3)	1.00	7.56
Ferric oxide (Fe_2O_3)	3.28	......
Magnesia (MgO)	0.00	......
Lime (CaO)	0.00	......
Soda (Na_2O)	0.00	....
Potash (K_2O)	0.00	......
Moisture at 100°C	0.74	......
Water on ignition	6.27	......
Titanium dioxide (TiO_2)	trace	......
Phosphorus pentoxide (P_2O_5)	0.58	......
Sulphur trioxide (SO_3)	0.11	......
Nickel oxide (NiO)	0.44	......
Manganese dioxide (MnO_2)	67.42	......
Manganous oxide (MnO)[a]	6.75	......
Strontium oxide (SrO)	0.08	......
Barium oxide (BaO)	14.03	......
Total	100.90	
Manganese (Mn)	47.82	24.95
Iron (Fe)	2.29	2.69
Phosphorus (P)	0.288	0.144
Nickel (Ni)	0.34	......
Cobalt (Co)	trace	......
Strontium (Sr)	0.06	......
Carbon (C)	0.00	......
Copper (Cu)	0.00	......
Arsenic (As)	0.00	......
Zinc (Zn)	0.00	......

a Manganese in excess of dioxide is calculated to manganous dioxide (MnO_2).

Hu-361Ax.—Psilomelane. Specially selected fragements of the hard dense mineral showing conchoidal fracture.

Hu-361Bx.—Analysis representing about 20 tons of hard lump ore in stock, May, 1918.

GEORGIA IRON & COAL COMPANY

General statement.—The Georgia Iron & Coal Company, of which Joel Hurt, Atlanta, is president, owns more than 12,000 acres of land in the 4th and 5th district, 3d section and in the 22d district, 2d section, Bartow County. The main office of the company is in Atlanta but the postoffice at the mines is White on the Louisville & Nashville Railroad, about a mile north of Aubrey, the mining and operating center. The Iron Belt Railroad connects the mines with the main railroad at McCallie, a station a mile and half southwest of Aubrey. Aubrey is 8 miles by the Tennessee road north-northeast of Cartersville.

This property includes both brown iron and manganese deposits, but in 1918 the company was producing only manganese and had not mined iron for several years. The main part of the property extends from the central part of the county north of Cartersville about 12 miles northeast, following the general trend of Little Pinelog and Pinelog mountains to the Bartow-Cherokee county line. It is in the northern part of the Cartersville mining district.

The early history[1] of manganese mining on the property now belonging to the Georgia Iron & Coal Company is bound up with the exploitation of iron properties in Bartow County and coal properties in Dade and Walker Counties. Part of the property was first worked by the Pyrolusite Manganese Company.[2] This was before 1880.[3] It is probable that manganese was mined on the property in the early seventies to be used in the manufacture of the first ferromanganese produced in the United States.[4] In 1874, Willard P. Ward, using local ores at the Diamond Furnace on Stamp Creek, on the

[1] The few historical notes here given are condensed from information furnished mainly by Joel Hurt, President of the Georgia Iron & Coal Company and by S. W. McCallie, State Geologist, unless otherwise credited.

[2] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, p. 71, 1908.

[3] Willis, Bailey, Notes on the samples of manganese ore collected in Georgia: Tenth Census of the U. S., 1880, Vol. XV, pp. 379-382, 1886.

[4] Penrose, R. A. F., jr., Manganese, its uses, ores, and deposits: Geol. Survey of Arkansas, Ann. Rept. for 1890, Vol. I, pp. 17, 18, 1890.

Wolfpen road 4 miles southeast of White, made the first ferromanganese, and for some time held patents on its manufacture. This first product contained more than 55 per cent of manganese.[1] In 1880 ex-Governor Joseph E. Brown built a branch railroad from the Guyton brown ore mine to Rogers station on the Western & Atlantic Railroad, a distance of 2¾ miles. This branch formed a part of what was later known as the Iron Belt Railroad, which was finally extended to the Sugar Hill brown iron ore mines about 1898,[2] through the efforts of the Hon. John W. Akin and L. S. Munford, of Cartersville, who were widely interested in mineral lands and owned some of the most important parts of the property later acquired by the Georgia Iron & Coal Company.

Beginning in 1885 and for several years thereafter, the Dade Coal Company mined and shipped thousands of tons of high-grade manganese ore from the mines owned by the Southern Mining Company, John W. Akin, and others.

As president of the Southern Mining Company, Joel Hurt, of Atlanta, directed the reorganization of large holdings in northwest Georgia, and finally acquired the Georgia Iron & Coal Company, of which he became president.

Topography.—The manganese ore-bearing property of the Georgia Iron & Coal Company is about 12 miles long and 3½ miles wide. It lies between Pettit Creek on the west and Stamp Creek on the east. Both streams flow generally southward to Etowah River, which flows westward about 5 miles south of the property. The northern part of the tract is drained northwestward by branches of Pinelog Creek, which flow into Sallacoa Creek and join Coosawattee River.

The topography is hilly, the chief feature being the northeasterly trend of the ridges, increasing in height from a maximum of 820 feet at the Guyton mine to a maximum of 2000 feet above sea level at the Bartow-Cherokee county line a mile and a half east of Sugar

[1] Penrose, op. cit., referring to Ward, Willard P., Ferromanganese: its uses and the facilities for its manufacture in the United States, p. 7, 1786.
[2] Op. cit., p. 156.

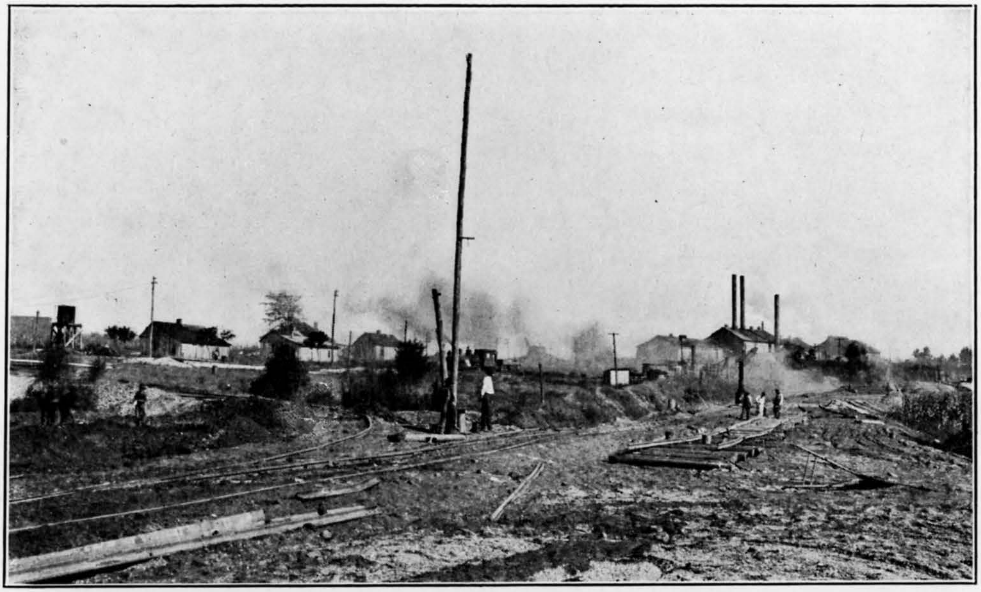
Hill. The lowest point is at Pettit Creek near the Guyton mine, where the elevation is about 740 feet. About 6 miles from either end, the tract is cut by Wolfpen Gap, which is drained northwestward by a branch of Pettit Creek. The highest point in the Wolfpen is 1134 feet above sea level. Near the Sugar Hill iron mines Little Pinelog Mountain rises about 500 feet and Pinelog rises about 900 feet above the surrounding country.

Plentiful water supply is generally near most of the mines, or within easy piping distance. Springs are numerous. A remarkable stream-head called Big Spring, less than a mile east of the Aubrey mill, furnishes a large supply for drinking and milling purposes, although the increased development of recent years has required the pumping of additional water from Pettit Creek, three-quarters of a mile west of the main plant.

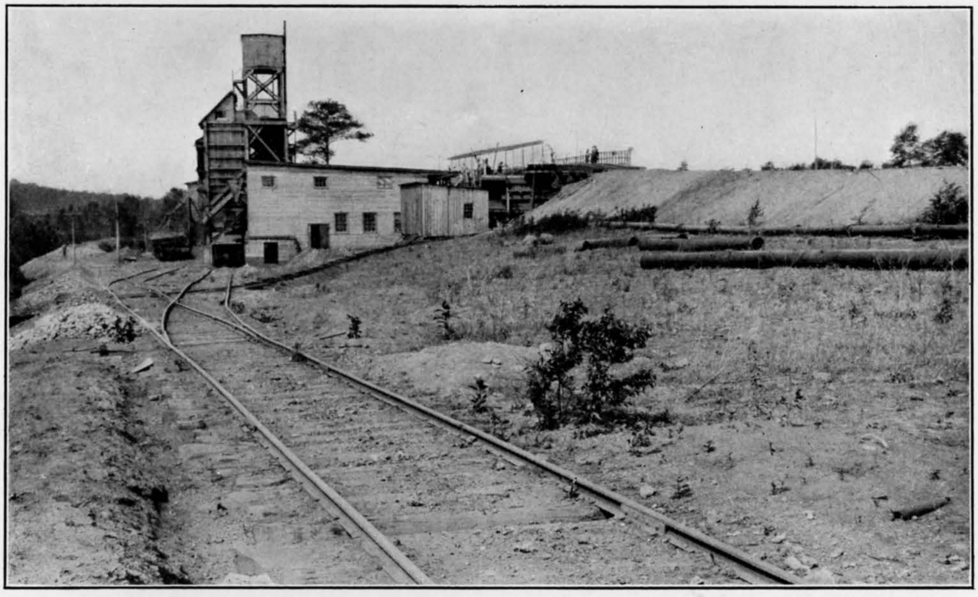
Aubrey, the mining, milling, and business center of the property, is a little more than half a mile east of the Tennessee road, and the same distance east of the Louisville & Nashville Railroad, which, together with Pettit Creek, approximately parallels the west side of the property.

Geology.—The geology of the Georgia Iron & Coal Company property is common to that of the whole district along the Cartersville fault. The great overthrust movement from the southeast has brought about a generally northeast strike and a southeast dip, but lithologic differences in the formations and inequalities of the regional pressure naturally caused innumerable irregularities of structure, as shown in the many contradictory attitudes of the outcrops. The highest knobs and the prominent ridges constituting Pinelog Mountain and its extensions are composed of Pinelog conglomerate and Weisner quartzite respectively on the east and west sides of the fault. The valley of Pettit Creek is made up of Shady limestone, Cartersville shale, and Conasauga shales and limestones.

Ore deposit.—The manganese ore deposits are generally in the Weisner quartzite and Shady limestone formations, where the almost completely eroded limestone has left the ore it once contained at or



A. VIEW OF CENTRAL POWER PLANT AT AUBREY. GEORGIA IRON & COAL COMPANY, NEAR WHITE, BARTOW COUNTY.



B THE AUBREY MANGANESE MILL OF THE GEORGIA IRON & COAL COMPANY NEAR WHITE, BARTOW COUNTY.

near the contact of the quartzite. The usual location of the deposit is on the lower part of a slope where hillside wash or colluvial debris has added to the accumulation of residual ore. As a result, however, of variations in the ore deposition, irregularities in earth movement, and differential erosion, many of the largest deposits are what may be termed abnormal in their position and occupy the valley floors with a relatively thick overburden. The ore in the large open cuts being worked by the company in 1918, lies beneath such level surfaces and is therefore less readily mined than the ore in the hillside deposits.

The size of the manganese ore deposit on the property as a whole is very large. With the exception of relatively short intervals of unworkable and lean ore, the deposit extends about 6 miles from the old Bishop mine a mile south of Aubrey to the vicinity of the Sugar Hill iron mines. The deposits that development work has proved to be the largest are generally on the western slopes of the main range of hills, although in the vicinity of Pinelog and Little Pinelog, manganese ore occurs on both east and west sides of the mountains.

Character of ore.—The quality of the ore is generally high-grade. It occurs in all of the forms found in the district and in each of the several modes of occurrence. Some of the ores of Wolfpen Gap contain more phosphorus than those from other parts of the property, and this impurity doubtless worked largely against the continuation of mining in previous years at the Moccasin, Red Mountain, and Peachtree mines.

A feature of the ores being produced from the Aubrey mines, including the Stevenson, Aubrey, and Bufford open cuts, is the high percentage of barium oxide. It is not known that this peculiar quality increases the value of the ore but the producers suggest that the effect of it may be of advantage in the fluxing processes. It is not recognized in the standard schedule[1] of prices either as a desirable or an undesirable element. The high barium content seems to be satisfactorily explained by the fact that the ores are made up largely

[1] See appendix for schedule issued by the War Industries Board to take effect May 29, 1918.

of psilomelane of which barium is a characteristic constituent, the formula being $MnO_2.(MnKBa)O.nH_2O$. Since psilomelane contains less metallic manganese than pyrolusite, manganite, and braunite which are more valuable as sources of metallic manganese, and since psilomelane is a less pure oxide than pyrolusite, which is the most desirable of all manganese oxides for oxidizing purposes, it does not seem probable that the value of these Aubrey ores is enhanced by the presence of barium oxide.

In the following table is given a rather complete analysis of shipping ores together with several average analyses showing the difference in phosphorus content between the Aubrey ores and some of the Wolfpen Gap ores; also comparing the ores shipped in earlier years with those of recent shipments.

Analyses of manganese and ferruginous manganese ores
Georgia Iron & Coal Company

Constituents	*1*	*2*	*3*	*4*
Insoluble	......	......	......	8.38
Silica (SiO_2)	17.16	24.78	12.73	7.80
Alumina (Al_2O_3)	2.30	1.72	......	1.18
Ferric oxide (Fe_2O_3)	5.16	......	......	......
Magnesia (MgO)	0.00	......	......	......
Lime (CaO)	0.00	......	......	......
Soda (Na_2O)	0.05	......	......	......
Potash (K_2O)	0.08	......	......	......
Moisture at 100°C	0.17	0.22	......	4.56
Water on ignition	3.53	......	......	......
Titanium dioxide (TiO_2)	0.00	......	......	......
Phosphorus pentoxide (P_2O_5) .	0.44	......	......	......
Sulphur trioxide (SO_3)	0.00	......	......	......
Nickel oxide (NiO)	0.52	......	......	......
Manganese dioxide (MnO_2) ..	56.55	......	......	......
Manganous oxide (MnO)*a* ...	6.19	......	......	......
Strontium oxide (SrO)	0.16	......	......	......
Barium oxide (BaO)	7.93	0.16*a*	......	13.20*c*
Total	100.24			

Constituents	1	2	3	4
Manganese (Mn)	40.52	37.35	38.46	42.06
Iron (Fe)	3.61	6.38	11.26	......
Phosphorus (P)	0.192	0.455	0.131	1.21
Nickel (Ni)	0.40	......	......	......
Cobalt (Co)	trace	......	......	......
Strontium (Sr)	0.13	......	......	......
Carbon (C)	0.00	......	......	......
Copper (Cu)	0.00	......	......	......
Arsenic (As)	0.00	......	......	......

a.—Manganese in excess of dioxide is calculated as manganous oxide (MnO).
b.—Average of *Hu–363x* and *Hu–370x.* Barium not determined in *Hu–364x.*
c.—Approximate.
1.—Manganese ore composed largely of psilomelane. Complete analysis of carload shipment of 48 tons to the Southern Manganese Corporation, Anniston, Ala., Oct. 25, 1918. Ore from Aubrey open-cut (lot 299). Sample by Wilkinson and Christian. Analyzed by Dr. Edgar Everhart.
2.—Ferruginous manganese ore. Average of samples *Hu–636x,* Moccasin mine; *Hu–364x,* Red Mountain mine; and *Hu–370x,* Peachtree mine. Shows high phosphorus content of these Wolfpen Gap ores. Collected May, 1918.
3.—Ferruginous manganese ore. Average of 11 analyses of ore mined in 1886 by the Dade Coal Company from Chumley Hill (lot 144); the Bufford, now Stevenson, lot (No. 314); and from the White, now Satterfield-McGinnis, lot (No. 315). The mine on the last named lot does not belong to the Georgia Iron & Coal Company. Analyses from Watson, T. L., Geol. Survey of Ga. Bull. 14, p. 70, 1908, quoting U. S. Geol. Survey Mineral Resources for 1886, p. 186.
4.—Manganese ore. Average of all ore shipped by the Georgia Iron & Coal Company from January through September, 1918. Ore from Stevenson cut (lot 314), Aubrey cut (lot 299), Bufford No. 1 cut (lot 300), and Bufford Mountain cuts (lot 301). Analyses furnished by the company, J. F. Wilkinson, analyst.

Development and equipment.—The mining operations on this large property have been carried on by different companies and individuals using several different methods of mining and cleaning the ore. On the surface, open cuts have been made by pick and shovel, grab bucket and hoist, and steam shovel. Underground development work and mining has been done by the use of both shafts and adits with the necessary stopes and drifts. Manganese has been mined from at least a dozen important open-cuts, of which the three largest most recently worked are the Stevenson, Aubrey, and Bufford cuts at Aubrey. Another large cut, and one of the most productive, is the Chumley Hill mine, which has been idle a number of years. The size of the largest of these openings is more than 100 yards long, less than 100 yards wide, and less than 75 feet deep. Shafts have been sunk to a depth of 149 feet beneath the surface and it is said that prospect borings were made as deep as 360 feet.[1]

The mining equipment now on the property includes 9 steam shovels, of which 3 are not used. There are about 10 miles of standard gage railroad from McCallie on the Louisville & Nashville Railroad to the Sugar Hill iron mines, together with several spurs to the open cuts. The last 4 miles of the track to Sugar Hill have not been used during the several years since iron mining was stopped and this part of the road is not in repair. The rolling stock for this railroad consists of 2 small locomotives and 5 dinkeys together with a number of 6-yard and 12-yard side-dump cars.

The milling equipment for concentrating the ore is also ample, having a capacity to treat almost any quantity of ore the large mining equipment can produce. The Aubrey washer, however, is the only plant in operation. Another large mill, known as the Bufford washer, though now idle and only equipped to handle about half the quantity of the Aubrey washer, is provided with space for the same amount of machinery. Besides these large plants there are two small washers at the Wolfpen Gap mines. They are partially dismantled.

The company manufactures its own electric light and power. Three boilers furnish an aggregate of about 1000-horsepower. Part of the water supply for the washer is piped from Big Spring and the sources of Big Spring Creek about a mile east of Aubrey, and part is pumped from Pettit Creek about a mile west of the Aubrey washer.

The large Aubrey concentrating mill contains machinery for thorough cleaning of the ore. The flow sheet is given elsewhere in this report. Test runs made with 3 of the 4-cell jigs have demonstrated that they can produce in 3 hours 44 tons of ore containing 40 per cent of manganese, but the 4 double-logs cannot supply the ore fast

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, p. 95, 1908.

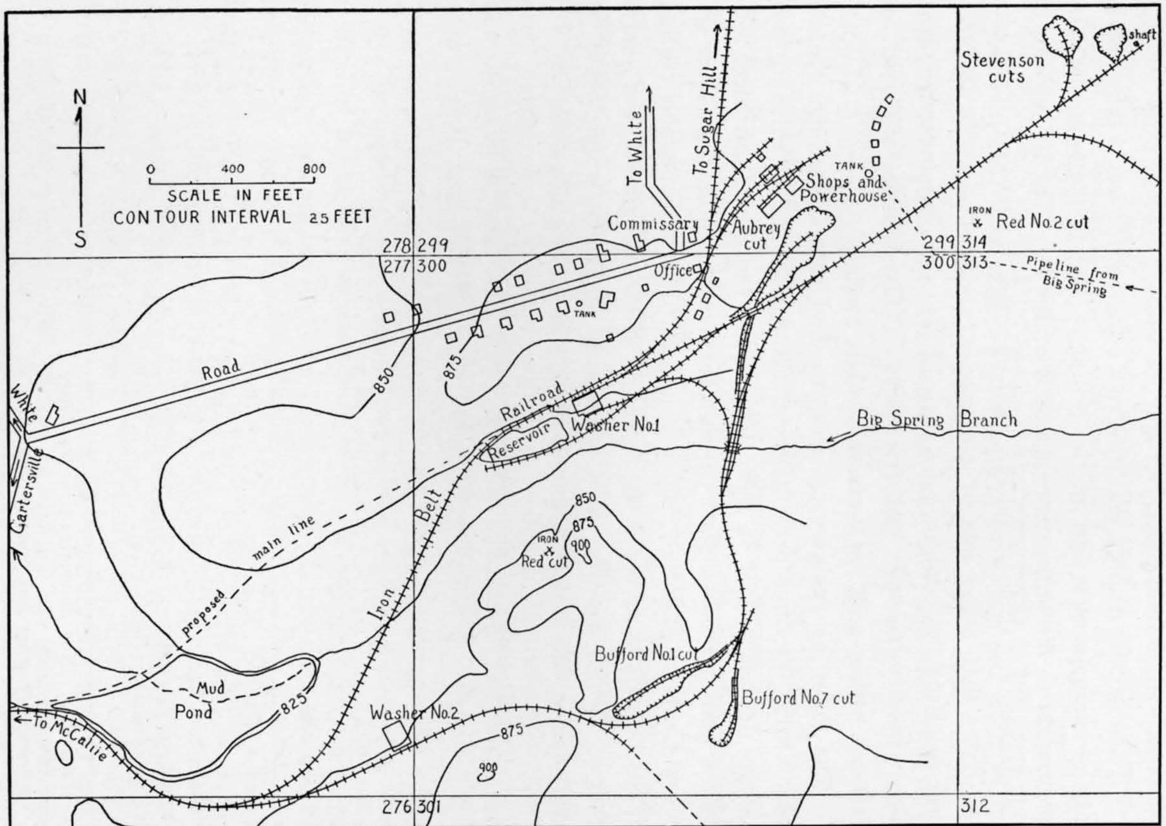


Fig. 6. Map showing a part of the property of the Georgia Iron & Coal Company at Aubrey.
From map by G. N. Mitcham, C. E.

enough to make this a continuous operation.[1] The capacity output of the mill is 50 tons a day.

Although the Aubrey mill produces a high-grade ore, a large quantity of manganese is lost in the tailings. Run-of-the-mine material as brought to the bull-pens probably contains less than 10 per cent of manganese, but slimes from the logs, collected in the mud pond, contain more than 8 per cent of manganese (sample *Crane-23*) and tailinsg from the jigs contain more than 12 per cent of manganese (samples *Crane-1*, *Hu-349x* and *Hu-350Dx*). The tailings are used for railroad ballast and for surfacing public roads.

The following analyses are given to show that the tailings contain very nearly the same percentages of manganese and of silica as does the ore deposit itself. In fact, the tailings, which are discarded, contain a considerably higher percentage of manganese than does the run-of-the-mine material,[2] which is milled. The objectionable feature of the tailings as an ore is the retention of the manganese in a quartz gangue. This, however, is a mechanical difficulty which could be overcome by fine crushing and rejigging or tabling methods.

Analyses of manganese ore deposits and tailings.
Georgia Iron & Coal Company

Constituents	*1*	*2*	*Crane–23*
Silica (SiO_2)	54.44	56.72	......
Silica (SiO_2) and insoluble	......	......	69.00
Alumina (Al_2O_3)	8.37	3.55	5.02
Iron (Fe)	8.43	9.48	7.66
Moisture at 100°C	0.62	0.22	0.28
Manganese (Mn)	11.46	13.81	8.95
Phosphorus (P)	0.138	0.086	0.100
Barium oxide (BaO)	1.21	*a*3.78	1.86
Barium sulphate ($BaSO_4$)	0.00	0.00	0.00
Sulphur (S)	0.00	0.00	0.00

a.—*Hu–350Dx*. Not determined in *Hu–349x*.

[1] Information from Joel Hurt, jr., manager.

[2] The term **ore deposit**, as used here and elsewhere in this report in describing samples that have been chemically analyzed, refers to the deposit of the ore as it occurs in the clay, or other matrix. It includes the associated and adhering gangue material, but does not include barren masses between streaks and bodies of ore. The term **run-of-the-mine material** is used to mean all the material mined and received at the washer. It includes much barren clay and rock that cannot be separated by steam shovel methods.

1.—Manganese ore deposit. Average analysis of samples *Crane–32*, Bufford cut (lot 300); *Crane–33*, Aubrey cut (lot 299); and *Crane–34*, Stevenson cut (lot 314), representing the ore deposits as they occur in the clay. Collected by W. R. Crane, June, 1918.

2.—Manganese tailings. Average analysis of samples *Hu–349x*, Tennessee road at McCallie; *Hu–350Dx*, Aubrey washer, representing tailings from the Aubrey concentrating plant. Collected by J. P. D. Hull and W. R. Crane, May and June, 1918.

Crane–23.—Mud pond. Analysis of material from mud pond, showing manganese lost in slimes from logs. Aubrey washer. Collected by W. R. Crane, June, 1918.

Production and future of mine.—The mines on the property of the Georgia Iron & Coal Company have been large producers of high-grade manganese ore and in recent years the company has shipped considerably more than half of the State's output. The capacity output of the Aubrey washer is about 50 tons a day. Under favorable conditions and with the other plants repaired and in operation, it is probable that 100 tons of ore could be shipped each day. The company already has equipment sufficient to double its present output. The property is large and very favorably situated as regards water supply, fuel, and rail transportation. The company owns the old Iron Belt Railroad extending almost the whole length of the property. Enough work has been done in the earlier prospecting and mining of manganese to make sure of an output for many years at the present rate of production. No opening has yet been abandoned because the ore was exhausted. Old underground workings, opened from several of the deeper cuts, entered large bodies of high-grade ore. There are at least half a dozen lots where openings have been made of sufficient extent and ore has been mined in sufficient quantity to prove the existence of workable reserves of high quality. In spite of this, a number of mines have been idle many years and at some of them valuable mining and milling equipment has gone to ruin by disuse and neglect. Such a deplorable condition has been caused largely by changes in title to the property and by prolonged litigation during which there was small incentive for efficient operation.

Two of the difficulties hampering capacity production in the past few years have been shortage of labor and the uncertainty of the coal supply. About 225 men are employed on the property. As regards manganese reserves, this property has one of the most promising futures in the State. It is safe to say that the reserves of high-grade manganese may be reckoned in many tens of thousand tons.

Some of the principal lots and mines of the property are here described briefly and separately, frequent reference being made to former descriptions and additional information in other bulletins. They are named in general from the southern to the northern part of the property.

Bishop bank.[1]—Lot 275, 5th district, 3d section, is about 1½ miles south-southwest of Aubrey and almost a mile east of the Louisville & Nashville Railroad. The open cut was made about 1895 for brown iron ore. Manganese is associated with the limonite. No mining has been done here for a number of years.

Bufford Mountain.—Lot 301, 5th district, 3d section, is half a mile south of Aubrey and less than a mile east of the railroad. Several open-cuts have been made on the northwestern slope of the hill. The cut worked in the early part of 1918 is connected with the main line of the Iron Belt Railroad by a spur track about three-eighths of a mile long. The manganese was mined by steam shovel and taken to the Aubrey washer.

Lot 300.—Lot 300, 5th district, 3d section, is just south of Aubrey, in fact the north line of the lot passes between the store and the company office at Aubrey, south of the power plant.

This, together with lot 299 north of it, is the operating center of the whole Georgia Iron & Coal Company property. The Iron Belt Railroad crosses it from southwest to northeast and Big Spring Creek flows almost through its center from east to west. The Aubrey washer is on the north side of the creek. It was designed and built by George F. Hurt in 1916 and has been in operation since that time.

[1] McCallie, S. W., Preliminary report on a part of the iron ores of Georgia: Geol. Survey of Ga. Bull. 10-A, p. 150, 1900.

It represents an outlay of more than $110,000 and is the largest and most complete manganese mill south of Virginia. The equipment and a flow sheet of the mill are given elsewhere in this report.

The Bufford washer is also on the Iron Belt Railroad in the southeast corner of the adjoining lot (No. 277). It has not been operated since 1916, though it has deteriorated only slightly by disuse and could be put in running condition at comparatively small expense. It was evidently designed to contain 4 double-log steel washers, 4 cylindrical sand screens, 2 picking belts and 4 sets of jigs. Half of this equipment is in place. This mill was also operated by electric power from the large central plant at Aubrey.

The Bufford open-cut is in the south part of lot 300. A 3-foot bed of water-worn quartzite gravel is exposed in the west wall near the entrance at the north end of the cut. The gravel is overlain by reddish-brown surface soil 2 or 3 feet thick and underlain by red and yellowish-brown clay that does not show evidence of bedding. Manganese nodules, pellets, and soft ore occur throughout all this unconsolidated mass.

The cut extends southwest for a length of 250 feet, is 80-100 feet wide, and 40 feet deep. It is worked by a steam shovel on a standard gage track which connects the cut with the Aubrey washer.

Aubrey cut.—The Aubrey cut is in the southeast corner of lot 299, 5th district, 3d section. It extends north-northwest somewhat less than 100 yards, is as wide as 150 feet in places, and about 60 feet deep. In the latter part of 1918 it was the chief producing mine. It is worked by two steam shovels operating from inclined tracks up which the ore cars are hauled by small locomotives to the Aubrey washer a few hundred yards to the southwest.

Analysis of an average ore deposit sample (*Crane-33*) collected from all parts of the cut by W. R. Crane in June, 1918, showed 15.75 per cent of manganese.

Stevenson cut.—The Stevenson open-cut is in the western part of lot 314, 5th district, 3d section, about a quarter of a mile northeast of the power house. Like the Bufford and Aubrey cuts it is in unconsolidated red and yellow clays which form a very gently rolling surface at an elevation of 900-940 feet above sea level. It is a large opening similar to the other two previously described. It is said that 2000 tons of ore were mined here in 1915. The mine was worked during the first half of 1918 by steam shovel. On the northeast side of the cut a vertical shaft has been sunk to a depth of 110 feet, and it is said to show a 20-foot face of ore in the bottom. The ore in the cut is the usual soft, gravelly, and nodular ore in pocket-like bodies.

Analysis of an average ore deposit sample (*Crane-34*) collected from all parts of the cut by W. R. Crane in June, 1918, showed 11.61 per cent of manganese.

Big Spring lot.[1]—Lot 109, 22d district, 2d section, is known as Big Spring lot. It is about three-quarters of a mile east-southeast of Aubrey. Watson says: "It has been worked to some extent for manganese ore in the southeast corner. One small cut, 50 feet long and 100 feet deep, was opened on the southeast side of a quartzite ridge, and a low grade of earthy oxide and fine gravel ore mined. Less than a dozen carloads of this ore were shipped."

Chumley Hill.[2]—The Chumley Hill mines are on lot 144, 22d district, 2d section, 1¼ miles east-northeast of Aubrey and 1½ miles southeast of White. Old Chumley is a large open-cut in the northeast part of the lot just south of the Wolfpen Gap road. The entrance to the cut is at an elevation about 1000 feet above sea level and 20 feet higher than the small stream flowing northwest between it and the road.

The entrance to the cut is about 250 feet long and 50 to 80 feet wide, leading southward into the hill. The main part of the open-cut is more than 100 yards wide in places at the top and 60-70 feet deep. It has not been worked since 1903, or about that time, and the bottom is partially filled with water and debris from slides. Thousands of tons of high-grade ore have been mined here.

In 1902, George F. Hurt worked the deposit on a large scale, using a grab bucket on a cable 500 feet long stretched from one side of the cut to the other. Underground work was done through vertical shafts, one of which was 149 feet from the top of the hill, in

[1] Watson, op. cit., p. 74.
[2] Idem, pp. 71-73.

which ore was found all the way, and through a long drift with numerous cross cuts into the ore body. This underground work was abandoned and the passages are entirely filled and obliterated. A large quantity of good manganese ore still remains in the deposit.

The ore still shows in all walls of the open-cut. The east side in particular indicates the attitude of the ore body as striking N.50°E. and dipping almost 90°.

A log washer was used at the small stream south of the public road and at the entrance of the open-cut. It has long since been removed, together with the ore railroad which once extended 1¼ miles southeastward from the Iron Belt Railroad near White.

Analysis of manganese ore and ore deposit. Chumley Hill, lot 144 Georgia Iron & Coal Company

Constituents	*Hu–362x*	*Crane–27*
Silica (SiO_2)	15.50	29.30
Alumina (Al_2O_3)	1.19	7.08
Iron (Fe)	4.39	18.25
Lime (CaO)	0.00	......
Moisture at 100°C	0.02	0.70
Manganese (Mn)	46.75	19.99
Phosphorus (P)	0.167	0.201
Barium oxide (BaO)	......	0.89
Barium sulphate (BaSO)	......	0.00
Sulphur (S)	......	0.00

Hu–362x.—Manganese. Samples of nodular ore from walls of open-cut. Collected June, 1918.

Crane–27.—Manganese ore deposit. Represents the ore deposit as it occurs in the whole open-cut. Collected by W. R. Crane, June, 1918.

The New Chumley mine near the center of lot 144 is described by Watson as "an open cut, from 40 to 50 feet long, 20 feet wide, and 20 feet deep, with a 40-foot shaft sunk from the bottom of the cut. Most of the ore was taken from the cut, and only a small quantity came from the shaft. The ore body was in the form of a pocket which pinched out at only a slight depth from the surface."

Moccasin mine.[1]—The Moccasin mine is in the northeast quarter of lot 143, 22d district, 2d section. It is on the south side of the Wolfpen Gap, 1¾ miles southeast of White and 1½ miles east of Aubrey. Old open-cuts and pits abandoned years ago and since somewhat hidden by vegetation are in the narrow gap through which pass both stream and public road. The elevation above sea level is about 1040 feet. The openings are of moderate dimensions, but it is reported that the main open cut was once 50 feet deep with a vertical shaft 40 feet deeper than the bottom of the cut. It is said that 1000 tons of ore were shipped from this lot. The ore is generally nodular in yellow clay and contains a high percentage of manganese, but the phosphorus content is also high, making it considerably less desirable than the Chumley Hill and Aubrey ores.

Analysis of manganese ore. Moccasin mine, lot 143. Georgia Iron & Coal Company

	Hu-363x
Silica (SiO_2)	5.80
Alumina (Al_2O_3)	2.08
Iron (Fe)	11.42
Lime (CaO)	0.00
Moisture at 100°C	0.28
Manganese (Mn)	44.60
Phosphorus (P)	0.478
Barium oxide (BaO)	0.00
Barium sulphate ($BaSO_4$)	0.00
Sulphur (S)	0.00

Red Mountain mine.[2]—The Red Mountain mine is in the southeast quarter of lot 146, 22d district, 2d section, almost 2 miles southeast of White and 1½ miles east of Aubrey. The open-cuts are on the north side of the Wolfpen Gap road, opposite the old Moccasin openings. One cut is at the foot of the hill at an elevation approximately 1030 feet above sea level and the other main cuts are near the top of the hill about 1150 feet above sea level. The openings are very nearly the same size; the cut on the hill is 70 feet long, 15 feet wide,

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, p. 72, 1908.
[2] Idem, pp. 73, 74.

and 15 feet deep. It exposes a manganese ore-bearing body about 20 feet thick in yellow ocherous clay overlying Weisner quartzite and striking and dipping with the quartzite N.70°E. and 55°SE., respectively. The ore occurs as fine "soft chemical" ore, irregular particles, and larger nodules. Chemically it is the same as the Moccasin ore.

There seems to be a considerable quantity of ore still remaining in the deposit, which extends several hundred yards northeastward into the Allison lot (No. 147).

The log washing plant, now partially dismantled, stands at the foot of the hill near the small stream. It was equipped with a grizzly, a double-log washer, and a 3-cell jig. An old pump, boiler, and hoist in bad state of repair are nearby and several hundred feet of light steel rail are still on the property. The upper open-cut is connected with the washer by about 500 feet of iron-lined flume.

Watson states that some 300 tons of ore are reported to have been shipped.

Peachtree mine.[1]—The Peachtree lot is No. 148, 22d district, 2d section, 2½ miles east-southeast of White and the same distance north-northeast of Aubrey. The open-cut is half a mile northeast of the old Wolfpen Gap court house and the public road. It is a few hundred feet east of a small southward-flowing branch of Stamp Creek, at an elevation of 1100 feet above sea level and about 20 feet higher than the stream.

The open cut is 125 feet long, 50 feet wide, and 15-20 feet deep. Both "soft chemical" material and nodules, more or less mixed with quartzite particles and broken masses, occur throughout the red clay loam topsoil and underlying yellow clay. The ore body as exposed is about 6 feet thick, strikes N.70-75°E., and dips 25°SE. In places massive ore seems to constitute 40 per cent of the 6-foot body. Several carloads of ore were shipped from this lot.

Prospects seem favorable for a workable deposit of considerable size, but the ore has the high phosphorus content so frequently found in the Wolfpen Gap ores. The analysis of a sample (*Hu-370x*)

[1] Watson, op. cit., p. 74.

taken across the 6-foot face of the ore body exposed in the open-cut showed 27.02 per cent of manganese, 2.57 per cent of iron, 0.436 per cent of phosphorus, and 46.56 per cent of silica.

The equipment used at the mine some years ago and still standing in a partially dismantled condition consists of a single-log washer, a 3-cell jig, a small hoist, and about 100 feet of steel-rail tram line.

Lots 185 and 186.—Lots 185 and 186, 22d district, 2d section, are about 3 miles in a airline east of White. They lie in the upper part of the narrow little valley of Gudder Creek between Hanging Mountain and Little Pinelog Mountain. Manganese ore of good quality has been prospected to some extent on both sides of the creek. McCallie[1] mentions manganese at the Black ore-bank in the vicinity of these lots.

Wofford mine.—Lot 182, 22d district, 2d section, is on the Iron Belt Railroad a mile and a half northeast of White. It is on the west slope of Little Pinelog Mountain. The elevation is about 1000 feet above sea level or 600 feet lower than the top of the ridge of Little Pinelog half a mile east of the openings. The deposit and the ore on this lot are a part of the distinct ore belt that extends along the slope of Little Pinelog, near its western base. This belt is paralleled by the Iron Belt Railroad and includes the Poor Farm mines, the Collins lot, and several promising but little worked deposits along the railroad to Sugar Hill.

The manganese ores on the Wofford lot were mined in the nineties and several carloads of high-grade ore were shipped, but in recent years little work has been done. One cut is about 100 feet long, 80 feet wide, and 15 to 25 feet deep.

In 1918, the Georgia Iron & Coal Company was reopening the deposit in preparation for mining the high-grade ore and carrying it over the Iron Belt Railroad to the Aubrey washer about 2 miles southwest.

Collins lot.[2]—Lot 214, 22d district, 2d section, is about 2¼ miles

[1] McCallie, S. W., Preliminary report on a part of the iron ores of Georgia: Geol. Survey of Ga. Bull. 10-A, p. 168, 1900.
[2] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, pp. 74, 75, 1908.

northeast of White. It joins the east side of the Poor Farm property, lot 215, at the foot of Little Pinelog Mountain. Prospecting has been done rather extensively on this lot and a high quality and a workable quantity of manganese ore are reported. About 1900, Watson reported an open-cut 200 feet long and 50 to 75 feet wide east of the Iron Belt Railroad. No mining has been done in a number of years.

The Hogpen lot (No. 219), just north of the *Collins lot,* and lot 260, just east of the Sugar Hill brown iron ore mines, are two among a large number of other lots belonging to the Georgia Iron & Coal Company that give good promise of workable amounts of high-grade manganese ore.

SATTERFIELD-McGINNIS PROPERTY

Lot 315, 5th district, 3d section, Bartow County, is owned by W. C. and J. R. Satterfield and Robert H. McGinnis of Cartersville. Forty acros of this 160-acre lot belong to the Georgia Iron & Coal Company, but this part is agricultural land. The property is leased and the manganese deposits are worked by the Paga Mining Company of Cartersville.

Lot 315 is locally known as the White lot and was described by Watson[1] as part of the Akin property.

In the latter part of 1917 and the early part of 1918, some of the old and extensive workings were reopened and operated by Wilbur A. Nelson, W. L. Torbert, and P. C. Renfroe of Cartersville, who erected a single-log washer, one 3-cell jig and one 2-cell jig. Later in 1918, Thompson-Weinman & Co., Cartersville, took over the lease and began to open the deeper underground workings that had become choked.

The several openings are at an elevation approximately 950 feet above sea level on the northwestern nose of a hill that rises more than 1100 feet above sea level. They are on the south side of the

[1] Watson, op. cit., pp. 93, 94, 1908.

White-Wolfpen Gap road, three-quarters of a mile southeast of White, a station on the Louisville & Nashville Railroad, 842 feet above sea level. A small branch of Pettit Creek flows northwest within a few hundred yards north of the mine and furnishes the water supply.

The geological structure at the Satterfield-McGinnis property is not at all clear in all of the shafts. Detrital clay accumulations, stratified residual clays, and cherty and quartzitic rock, commonly distorted and fractured, have been cut in the underground development work. In a small open-cut on top of the ridge southeast of the washer, one working face at the end of a short drift shows in the 4-foot vertical section of the heading, a greatly disturbed portion of the stratified clay which is an illustration in miniature of the effect of the regional disturbance that caused the Cartersville thrust fault and its attendant metamorphism. The layers of decomposed clay material are a fraction of an inch thick. Most of them are continuous but intensely folded and contorted. Some of them, however, evidently brittle and more siliceous, have been broken out of the continuous layer and the gap closed by one side being forced to overlap the other. See Plate II. B. When such highly contorted and shattered sections are observed and when it is considered that such a disturbance, magnified from inches to miles, is what occurred in the whole Cartersville mining section, it is easy to realize the difficulty of attempting to determine the location and continuation of ore-bearing horizons by means of structural and stratigraphic methods.

The ore on the Satterfield-McGinnis property is not essentially different from that at other mines; its form includes soft, gravelly, nodular, and brecciated types; its quality ranges from excellent high-grade manganese to brown iron ore; and its quantity, though unknown, is generally promising.

The following analyses indicate the quality of mineral specimens and the high percentage of manganese that characterizes the deposit opened in the underground development work.

Analyses of psilomelane and the manganese ore deposit Satterfield-McGinnis property

Constituents	*Hu–351Bx*	*Crane–26*
Silica (SiO_2)	1.75	43.58
Alumina (Al_2O_3)	......	6.12
Iron (Fe)	1.12	4.39
Moisture at 100°C	0.28	0.40
Manganese dioxide (MnO_2)	78.84	......
Manganese (Mn)	55.71	22.38
Phosphorus (P)	0.38	0.245
Barium oxide (BaO)	1.68	1.51
Barium Sulphate ($BaSO_4$)	trace	0.00
Sulphur (S)	0.00	0.00

Hu–351Bx.—Psilomelane. Small hard nodule a fraction of an inch thick, composed of thin concentric layers.

Crane–26.—Manganese ore deposit. Analysis is of an average sample collected from underground and surface to represent the whole deposit. Collected by W. R. Crane, June, 1918.

The equipment in 1918 consisted of a log washer, a 3-cell jig, 2 steam engines, a pump, and 3 boilers. A steam hoist was used at the deepest shaft.

Development work underground included, besides several vertical shafts that had been useless many years, a 100-foot vertical shaft, a 100-foot incline, a 200-foot horizontal adit with 120 feet of ramifying side entries and a 40-foot vertical shaft. The greater part of the work was done by former operators and these openings have not yet been connected underground.

The 100-foot vertical shaft was reopened in 1918. It is on a northern slope of the hill east of the horizontal adit entrance. It was cleaned out and a drift was being driven to strike a body of ore known to have been left when mining was suspended some years ago.[1]

The mine is conveniently situated for easy transportation of ore to the Louisville & Nashville Railroad at White, three-quarters of a

[1] Information from P. F. Renfroe, Cartersville, 1918.

mile from the mine, for ample water supply from branches of Pettit Creek a few hundred yards away, and for fuel or mine timber growing on, or near, the property.

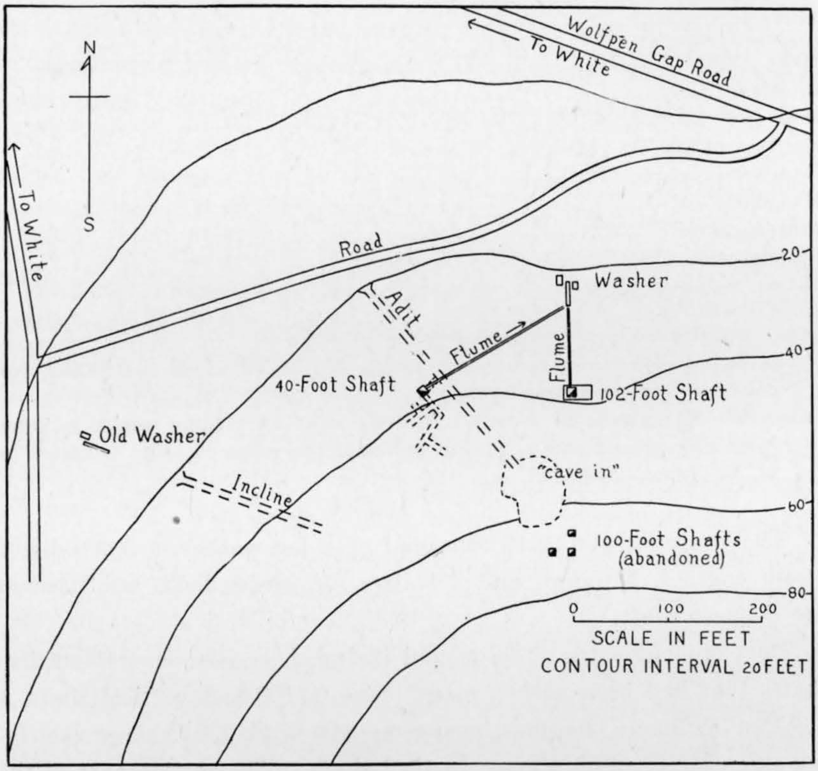


Fig. 7. Topographic sketch map of a part of the Satterfield-McGinnis property near White.

ALLISON LOT.[1]

Lot 147, 22d district, 2d section, Bartow County, belongs to J. F. Allison, of Calhoun, L. H. Crawford of Dalton, and J. M. McCandless of Atlanta. The Allison lot contains 160 acres in the Wolfpen dis-

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, p. 74, 1908.

trict about 2 miles southeast of the Louisville & Nashville Railroad at White. It lies just east of the Red Mountain manganese deposit on lot 146 of the Georgia Iron & Coal Company property and west of the Peachtree lot (N°.148). The greater part of the property is on the north side of the Wolfpen road, occupying the steep ridges that range in height from less than 1100 feet to more than 1200 feet above sea level.

Along the top of the ridge east of the Red Mountain open cuts, quartzite outcrops are more or less continuous for a distance of several hundred yards, striking N.70°E. and dipping 50-60° SE.

Manganese occurs in the common nodular form in the unconsolidated red and yellow loam and clay overlying the quartzite. The quartzite footwall is stained with limonite,—in places so richly that the brown iron ore is more abundant than the manganese ore. The relation of quartzite footwall, limonite, and manganese can be clearly seen in the order named. Several small pits were dug years ago, but evidently very little ore was shipped. The deposit is a continuation of the Red Mountain deposit and doubtless contains a workable amount of good ore.

On the east side of the lot about a quarter of a mile northeast of the old Wolfpen court house and west of a small branch flowing southeast to Stamp Creek, several open cuts of moderate dimensions were made some time ago and still show nodular manganese ore in the yellow clay.

The following analysis of several nodules picked from the small stock piles shows a rather high phosphorus and silica content.

Analysis of ferruginous manganese ore. Allison lot

	Hu–369x
Silica (SiO_2)	32.66
Alumina (Al_2O_3)	4.38
Iron (Fe)	3.47
Moisture at 100°C	0.20
Manganese (Mn)	32.23
Phosphorus (P)	0.312

The quantity of ore shipped from the whole lot has been small. Much of the ore is intimately mixed with limonite and grains of sand. The exposures do not indicate very large amounts of workable ore. No work has been done for a number of years.

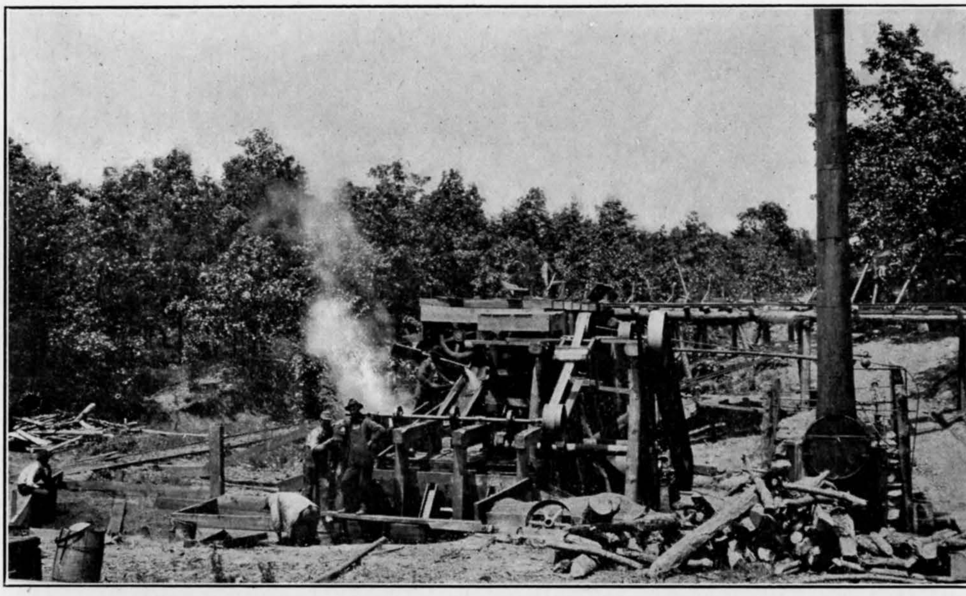
BARTOW COUNTY PAUPER FARM

General statement.—The Bartow County Pauper Farm includes two 160-acre lots, 215 and 216, 22d district, 2d section, in the northeastern portion of the county, about 12 miles by road northeast of Cartersville. This property is in charge of the Bartow County Commissioners, who have leased the mineral rights to J. W. Brockman and Phil Dorn, of Birmingham, Ala. The property is crossed on its western side by the Louisville & Nashville Railroad, and on its eastern side by the Iron Belt Railroad of the Georgia Iron & Coal Company, but the shipping point is at White, on the Louisville & Nashville Railroad, about 2¼ miles by road southwest of the mine.

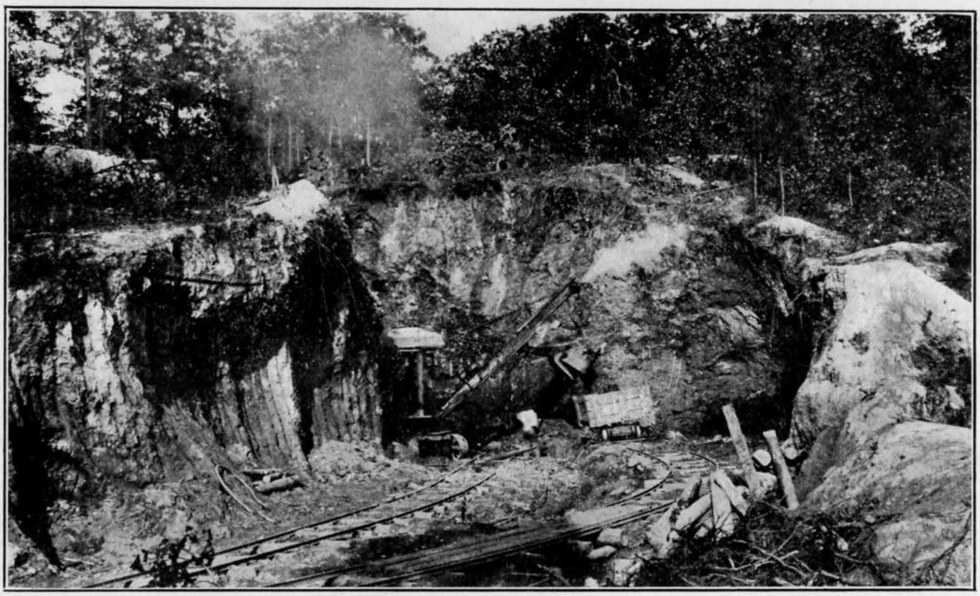
The property is locally known as the Cartersville Poor Farm. It has been prospected and worked for manganese several times,—a few years ago by Dr. Robert Wilson of Cartersville, and in 1917 by the Republic Iron & Steel Company, Birmingham, Ala. The ore was hand mined and log washed. During 1918, the mine has been operated rather steadily by the Carribee Mining Company, directed by J. W. Brockman and Phil Dorn of Birmingham, Ala.

Topography.—The Pauper Farm property has a rolling, hilly topography ranging in elevation from 880 feet in the western part to more than 1100 feet above sea level in the eastern part, which is the steep western slope of Little Pinelog Mountain. No large streams flow near lot 215 where the deposits occur, but springs are numerous and they supply water for log washing a large part of the year.

Geology.—The rocks with which the manganese is associated are hard gray quartzite, soft yellow clay, schist, and gray slate. These are Cambrian formations common to the Cartersville district. They are much folded and faulted and their structure is not altogether clear. The general attitude of the rocks where the ore is found,



A LOG WASHER AND JIGS AT THE BARTOW COUNTY PAUPER FARM NEAR WHITE.



B. OPEN-CUT, SHOWING STEAM SHOVEL METHOD OF MINING ON THE BARTOW COUNTY PAUPER FARM NEAR WHITE.

however, shows a north strike and an east dip into the hill at an angle of about 40°.

Ore deposit and ore.—The manganese occurs as soft, finely-granular material and hard concretionary masses generally not more than 5 inches in diameter. Both pyrolusite and psilomelane occur in unconsolidated clay and are relatively free from adhering iron and quartz impurities, so that the log washer and jigs produce a high-grade shipping ore containing about 40 per cent of metallic manganese.

Some of the deposits seem to be isolated and may be found here and there in a belt a few hundred feet wide and five-eighths of a mile long.

In the cuts already worked the ore is not known to have definitely disappeared within a depth of 50 feet and it is probably that it continues much deeper.

The following analyses show only the general character of the ore and ore deposit. Analyses of sample *Hu-371x* is given only to show the freedom from accessory elements and impurities sometimes found in other deposits. It does not represent the regular shipping product which is strictly high-grade manganese ore.

Analyses of ferruginous manganese ore and deposits. Bartow County Pauper Farm

Constituents	*Hu-371x*	*Crane-28*	*Crane-22*
Silica (SiO_2) and insoluble	......	......	63.29
Silica (SiO_2)	33.47	46.58	......
Iron (Fe)	13.77	5.60	11.56
Alumina (Al_2O_3)	4.34	5.54	8.52
Lime (CaO)	0.00	......	......
Moisture at 100°C	0.28	2.80	0.28
Manganese (Mn)	32.08	17.41	8.62
Phosphorus (P)	0.233	0.40	0.144
Sulphur (S)	0.00	......	......
Barium (Ba)	0.00	......	......
Titanium dioxide (TiO_2)	0.00	......	......

Hu-371x.—Analysis of some of the lower grade ore. This is not representative of the shipping ore.

Crane–28.—Analysis of average sample representing the ore deposit on lot 215. Collected from surface and all workings by W. R. Crane, June, 1918.

Crane–22.—Analysis of sample representing mud pond, showing loss from washer. Collected by W. R. Crane, June, 1918.

Development and equipment.—All of the work for manganese has been on lot 215, in the eastern part, along the old Iron Belt Railroad. Five open-cuts have been made in the western slope of Little Pinelog Mountain, ranging in size from 60 to 100 feet long, 20 to 80 feet wide, and 10 to 30 feet deep, and have produced several hundred tons of high-grade manganese. Many test wells have also been dug near the open cuts, and underground passages go into the hill in different directions.

The equipment consists of a steam shovel, a double-log washer, one 3-cell step jig, steam engine and boiler, about 600 feet of steel rail tram line connecting the underground workings and the washing plant, wooden tram cars, and a 2-ton Selden motor truck.

Production and future of mine.—Several hundred tons of ore have been produced from lot 215 in 1917 and 1918. The Republic Iron & Steel Company shipped manganiferous iron ore and the Carribee Mining Company shipped manganese ore.

This property contains a good, readily workable deposit of ore.

VAUGHAN PROPERTY

General statement.—This tract of land includes 1430 acres in the following 160-acre lots: 280, 281, 282, 297, 23rd district; and lots 296, 297, 316, and 317, 22d district, 2d section, Bartow County; also lot 298, 22d district, 2d section, Cherokee County. The greater part of this property is in northeastern Bartow County, about 3 miles east of the Louisville & Nashville Railroad. It is owned by Dr. W. B. Vaughan, White, Ga., and the mineral rights are leased by J. W. Brockman and Phil Dorn, Birmingham, Ala. Cartersville is 17 or 18 miles southwest of the property.

The property was first prospected for manganese and manganiferous ore in 1917. All prospecting before that time was extremely superficial in character. Deposits of both manganese and manganiferous iron ore were opened by the Markstein-Dorn Mining Company.

Topography.—The property lies in the rough foothills of Pinelog Mountain, 2 miles northeast of Little Pinelog Mountain, and just west of Pinelog Mountain, which rises to an elevation of 2276 feet. The general trend of these steep wooden ridges is northeast, though the rugged hills of the Vaughan property are somewhat isolated from the main mass of the mountains and exhibit many irregularities in form. The central part of this tract is occupied by a wooded hill whose summit is 1120 feet above sea level. The northern part is drained westward and northwestward by Pinelog Creek, where the elevation is about 855 feet, and the southern part is drained in the same directions by Little Pinelog Creek, whose lowest point on the property is about 880 feet above sea level.

The distance from the mine to the Louisville & Nashville Railroad at Rydal, the nearest shipping point, is 3½ miles over ordinary clay road. The manganese deposit is south of the public road from Pinelog to Canton and at least 200 feet higher than the road.

Geology.—Two distinct formations outcrop on the Vaughan property,—Weisner quartzite and Shady limestone.

The quartzite crops out most typically on the ridges and its angular fragments form many talus slopes. Argillaceous and siliceous schists, in places slaty, occur underneath the quartzite, but do not form prominent outcrops.

The limestone occurs on the northeast slope of the hill down the slope from the manganese deposit and not far from the log washer on lot 317, 23d district.

Ore deposits and ore.—The deposit of the manganese ore is indicated on the surface by the occurrence of small particles of manganiferous limonite and some fragments of manganese in a red soil mantle covering an area of 2 or 3 acres, on a distinct bench in the hillside about 200 feet above the public road. The greatest extent of the ore body as shown by underground testing is 15 to 20 feet below the surface and it extends about 100 feet in a northeast direction through a width of 50 feet, more or less. The mantle of red soil with ore particles ranging in thickness from a fraction of an inch to several inches, is only a few feet thick. Below it lies a mass of broken angular blocks of white crumbly quartzite. The irregular spaces between these blocks are filled with yellowish gritty clay and both soft and gritty manganese. As no solid rock has been encountered in the test wells, and as the nearest outcrops of rock give no clear evidence regarding regular structure at this place, the size of the deposit is an uncertainty.

Three types of ore occur in the deposit. The smooth "soft chemical" ore, specially collected from the spaces between the "sand rock" or quartzite is shown in sample *Hu-366Bx*. Another type is the fine "gravelly" ore shown in sample *Hu-366Ax*. It is probably all pyrolusite and wad. No nodular concretionary manganese has been found. The third type of ore is manganiferous limonite as given in analysis of sample *Hu-360x*. This sample was collected from the material taken out of a pit 60 to 70 feet deep.

Analyses of manganese ores. Lot 317, 23d district. Vaughan property

Constituents	*Hu–366Bx*	*Hu–366Ax*	*Hu–360x*	*Crane–31*
Silica (SiO_2)	0.50	12.71	2.70	46.98
Alumina (Al_2O_3) ...	3.20	1.90	2.22	6.34
Iron (Fe)	1.45	11.53	52.08	7.61
Lime (CaO)	0.10	0.10	0.00	......
Moisture at 100°C ..	0.52	0.19	0.40	0.63
Manganese (Mn) ...	46.31	35.40	5.36	15.09
Phosphorus (P)	0.14	0.324	0.654	0.176

Hu-366Bx.—Manganese. "Soft chemical" ore from 15–20 feet below the surface.

Hu-366Ax.—Ferruginous manganese. Fine "gravelly" ore from 15–20 feet below the surface.

Hu-360x.—Manganiferous iron ore from a 60–foot test pit.

Crane–31.—Analysis of average sample representing the whole manganese deposit. Collected by W. R. Crane, June, 1918.

Development and equipment.—The manganese deposit on lot 317, 23d district, has been prospected by a dozen test wells, ranging in depth from 5 to 70 feet and aggregating about 400 feet of vertical openings within an area of two acres. From the bottom of a 15-foot shaft, there are 180 feet of almost horizontal underground passages, cutting ore at depths of 15 to 20 feet below the surface. The ore is mined by steam shovel. A concentrating plant has been installed to produce high-grade manganese ore. The equipment consists of a double-log washer, two 3-cell jigs, a 35-horsepower boiler and a 15-horsepower engine, a steam shovel, and several wooden tram cars. There are also several thousand feet of cypress piping laid from Pinelog Creek, where the water is pumped to the washer about 230 feet above the stream. A motor truck is used for hauling supplies and ore.

MINOR PROSPECTS

Besides the principal mines and deposits of the Cartersville district just described, there are many other properties that have been prospected for manganese with encouraging results, but they have produced comparatively little ore. Some of the most important of these minor properties are here briefly described.

Stephens property.[1]—Lot 981, 4th district, 3d section, Bartow County, belongs to J. A. Stephens of Cartersville. It is a mile and a half southwest of Emerson.

In 1917, J. L. Waite of Cartersville leased the property and prospected the north and northwest side of the quartzite ridge at an elevation of 800 feet or more above sea level and 100 feet higher than Pumpkinvine Creek. About 10 tons of ore containing 30 per cent of manganese and about 100 tons of manganiferous dirt and hard ore were mined, but the prospects were not considered favorable enough for the erection of a washer.

Puckett property.—Lot 1037, 4th district, 3d section, a mile and a half southwest of Emerson, belongs to Freeman Puckett of Cartersville. Manganiferous iron ore occurs in the brecciated quartzite exposed on the ridge north of Pumpkinvine Creek. A few carloads of

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, pp. 88, 89, 1908.

ore have been produced, containing 45.66 per cent of iron, 8.54 per cent of manganese, and 0.949 per cent of phosphorus (sample *Hu-357x*).

Pittsburg-Georgia Mining Company (Stegall property).[1]—This company owns a number of acres of land half a mile south of Emerson. The Southern Leasing Company, B. C. Sloan, Cartersville, has leased the property east of the railroad spur that leads south from the Western & Atlantic Railroad at Emerson, and has done some prospecting for manganese on lots 905 and 906, 4th district, 3d section. Old openings made many years ago to a depth of 20 to 30 feet are now badly fallen in, but good manganese nodules in the red surface soil indicates a workable deposit still untouched.

Tennessee Coal, Iron & Railroad Company (Bartow Iron & Furnace Co.)[2]—The Tennessee Coal, Iron & Railroad Company of Birmingham, owns more than 1500 acres in the 4th district, 3d section and in the 21st district, 2d section, Bartow County. The Southern Leasing Company, B. C. Sloan, Cartersville, leases several lots and produces brown iron ore at Bartow, on the Western & Atlantic Railroad, 4½ miles southeast of Cartersville.

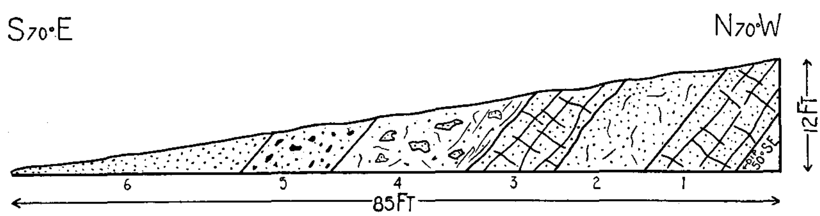


Fig. 8. Section along the Dixie Highway, lot 903, near Bartow, showing sequence of (1) quartzite, (2) decomposed clay schist, (3) ferruginous quartzite, (4) ferruginous quartzite fragments in ocherous clay, (5) soft and nodular manganese in yellow clay, and (6) manganiferous loam.

Manganese ore has been prospected and mined to some extent on lots 903, 831, 830, 827, and 758. In 1918, B. C. Sloan had some prospecting done on the north side of lot 903, a few feet south of the Dixie Highway. The size of the ore deposit is small. About a carload

[1] Watson, op. cit., pp. 69-70.
[2] Idem, pp. 68, 69.

of nodular ore has been mined. The structure and geologic relations of the formations in which the deposit occurs are well shown in the east end of the public road cut a few feet north of the prospect pit. (See fig. 8.) The sequence of he comparatively fresh Weisner quartzite foot wall grading upward into partially decomposed ferruginous and ocherous quartzite which is overlain by the manganese-bearing clay is typical of the ore deposits of the Cartersville district. The strike is N.30°E. and the dip 50°SE.

Other recent openings have been made on lot 830 half a mile north of Bartow. A 50-foot adit into the hillside cuts through a formation of manganese-bearing clay 6 feet thick. The ore includes "soft chemical" and nodular types. The ore body lies with the slope of the hill, striking about N.25°W. and dipping 55-60°NE. The openings are about 20 feet higher than the dry branch nearby and 900 feet above sea level. A few carloads of high-grade manganese ore were shipped in 1918.

J. E. and W. C. Satterfield property (Stegall property).[1]—J. E. Satterfield, Macon, and W. C. Satterfield, Cartersville, own a number of lots in the 4th district, 3d section, near Emerson. Among them, lot 895 was once worked for manganese and several carloads of ore were shipped. The workable deposit is probably exhausted. From 1915 to 1918, the Big Tom Barytes Company mined barite on this lot.

Lot 826 (Stegall property).[2]—Lot 826, 4th district, 3d section, belongs in part to J. W. L. Brown and in part to Abromson Brothers. It is half a mile northeast of Emerson. Manganese was first mined on this lot in 1892. Several carloads have been shipped since then, but no recent work has been done.

Dobbs estate.[3]—Lot 760, 4th district, 3d section, less than a mile north of Emerson, belongs to the estate of John Dobbs. In 1918, W. S. Peebles, of Cartersville, prospected part of the Dobbs property with a total of 218 feet of test holes at many places along the ridge.

[1] Watson, op. cit., pp. 69, 70.
[2] Idem, p. 70.
[3] Idem, p. 89.

At least one carload of high-grade manganese ore was shipped in 1918.

Lot 690.—This lot belongs to A. Abromson, of Adairsville. It is a mile north-northwest of Emerson and occupies part of a conical hill east of the Western & Atlantic Railroad. Some nodular and soft manganese together with limonite occurs in the red soil near several old openings on the hillside east of the railroad cut. Water-worn quartz pebbles occur in the red and reddish-yellow clay near the surface. The elevation is about 800 feet above sea level and 100 feet higher than Etowah River. This lot is leased by P. F. Renfroe of Cartersville.

Laramore property.[1]—Mrs. F. L. Laramore, of Montezuma, Ga., whose agent is W. P. Laramore, Cartersville, owns 95 acres in lots 471, 472, 537, and 538, 4th district, 3d section, 2½ miles east of Cartersville. The property is on the north side of Etowah River and east of the Etowah Development Company's Riverside washer. The following analyses taken from Watson's description of the property indicate the high grade of the ore.

Analyses of manganese ore. Laramore property

Constituents	*1*	*2*
Silica (SiO_2)	5.43	0.89
Manganese (Mn)	48.21	55.00
Iron (Fe)	3.77	1.29
Phosphorus (P)	0.143	0.156

1.—Average of four analyses of samples collected by W. P. Laramore and analyzed by the Illinois Steel Company at Chicago, some time prior to 1902.

2.—Average of two analyses of specimens of ore from lot 472. Analyses by the Tennessee Coal Iron & Railroad Company, some time prior to 1902.

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia. Geol. Survey of Ga. Bull. 14, pp. 76, 77, 1908.

Some prospecting done in 1918 on the west side of lot 472 showed the usual "soft chemical" and nodular high-grade manganese ore in red clay loam.

Blue Ridge Ocher Company.[1]—The Blue Ridge Ocher Company, H. G. Cope, agent, Cartersville, owns lot 390, 4th district, 3d section, 1¾ miles east-northeast of Cartersville, and ¼ of a mile north of Etowah River. Watson describes the property in part as follows: "Lot 390 . . ., was first worked for manganese ore in 1859 . . and is said to have produced the first manganese in the State. Work was again resumed in 1866 after the Civil War, by Mr. A. P. Silva, when a large amount of the ore was shipped."

A few tons of ore were mined in 1918 but no regular mining was carried on. The ocher plant has been idle a number of years.

Lot 333 (Morris property).[2]—Lot 333, 4th district, 3d section, belongs to Mrs. L. C. Hall, of Milledgeville. It is leased by the Cherokee Ochre Company and W. S. Knight of Cartersville. This lot is 1½ miles northeast of Cartersville and half a mile up the ravine northwest from the Blue Ridge Ocher Company's plant. In 1918 a few cars of manganiferous iron ore had been mined from an adit which extends 130 feet N.80°E. into the hill. The ore contains less than 20 per cent of manganese.

R. B. Satterfield property.[3]—R. B. Satterfield of Cartersville owns 87 acres in lots 318, 259, and 245, 4th district, 3d section, Bartow County. The mining of manganese was done on lots 318 and 259. These lots are southeast of the Rowland Spring road 2 miles northeast of Cartersville.

In 1917, George H. Woodrow of Cartersville shipped a carload of ore containing about 33 per cent of manganese and 15 per cent of iron. This ore was taken out while the deposit was being worked for barite, which occurs in close association with the manganese deposit. No mining was done in 1918.

Felton property.—About 27 acres of lot 53, 4th district, 3d sec-

[1] Watson, op. cit., p. 90.
[2] Idem, p. 93.
[3] Idem, pp. 78-80.

tion, belongs to Mrs. W. H. Felton of Cartersville. This property is between Pettit Creek and the Louisville & Nashville Railroad, 1¼ miles southwest of Wyvern and 3 miles north of Cartersville. No prospecting has been done on this lot, but nodules and fragments of high-grade manganese ore occur in the surface red clay loam.

Lot 48, also of the 4th district, is part of Mrs. Felton's property. This 40-acre lot is 1¼ miles south-southeast of Wyvern and 3 miles north of Cartersville. About 1855 or 1856, Joseph Slocum sank a vertical shaft 100 feet deep in search of copper.[1] Indications for copper were unfavorable but some good nodular manganese was encountered. Nodular manganese of good quality also occurs in the red soil on the eastern part of lot 48.

Lot 26, just northeast of lot 48, belongs to Dr. Howard E. Felton. Indications seem more favorable for manganiferous iron than for manganese ore on this lot. Several small openings are still to be seen a few yards northeast of the old Canton road where it is said Mark A. Cooper once mined ore to use in his furnaces at Etowah River.

T. S. Bishop property (Smith property).[2]—Lot 234, 5th district, 3d section, contains 160 acres and belongs to T. S. Bishop. The property is 2 miles north of Cartersville and a mile southeast of Wyvern. It occupies a low conical hill 880 feet above sea level on the north side of the old Canton road. In 1918, the Southern Manganese Corporation of Birmingham, leased 25 acres of this lot and put down about 10 prospect pits, 5 to 10 feet deep. The red soil carries both manganese and brown iron ore nodules. The finely granular manganiferous material seems to predominate in many of the prospects. No mining has been done in recent years.

H. L. and P. F. Smith property (Guyton lot).[3]—Lot 235, 5th district, 3d section, is immediately east of the Bishop lot and on the same low hill. H. L. and P. F. Smith, of Cartersville, own 50 acres in the southwest part of the lot. In 1918, an old open-cut about 75 feet

[1] Information from Mrs. W. H. Felton, Cartersville, 1918.
[2] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, p. 86, 1908.
[3] Idem, p. 85.

long, 40 feet wide, and 10 feet deep was being reopened. In July about a carload of manganiferous iron ore was awaiting shipment. The following analysis represents the average content.

Analysis of manganiferous iron ore. H. L. and P. F. Smith property

	Hu-391
Silica (SiO_2	39.06
Alumina (Al_2O_3)	2.66
Iron (Fe)	21.66
Moisture at 100°C	0.44
Manganese (Mn)	12.22
Phosphorus (P)	0.129

OTHER PROSPECTS IN BARTOW COUNTY

Outside the Cartersville district a number of properties in different parts of Bartow County have shown indications of manganese ore deposits and a few have produced ore. Several of these prospects are here briefly described.

C. C. Brown property.—Lot 220, 4th district, 3d section, Bartow County, belongs to C. C. Brown of Cartersville. This property is 5 miles west-northwest of Cartersville, in a gently rolling area underlain by Knox dolomite. The soil is reddish-brown and commonly contains ferruginous and manganiferous particles.

In the southeast quarter of lot 220 on the north side of the public road, some manganese nodules were found in digging a well 20 feet deep, but a test pit sunk to the same depth and within 45 feet of the well showed no manganese. Water-worn quartz pebbles are not commonly found in the ferruginous red soil. The general elevation above sea level is between 800 and 850 feet.

Samples of ore from lot 220 contain 25.28 per cent of manganese, 3.44 per cent of iron, and 0.085 per cent of phosphorus. It is quite improbable that ore occurs at this place in workable quantity.

Pitman property.—A. H. and O. A. Pitman, Cartersville, own property 5 miles west-northwest of Cartersville. Lot 221, joining the east side of lot 220 previously mentioned, contains a sort of bog manganiferous iron deposit in a ravine about a quarter of a mile north of the Pitman residence. It is improbable that it could be profitably worked.

Calhoun and Locke property.—Lot 222, 4th district, 3d section, Bartow County, is about 4½ miles west-northwest of Cartersville. This is part of the property belonging to A. B. Calhoun and Lois Locke. In 1918 A. W. Farrer of Rockmart held an option on this and adjoining lots.

A few hundred yards north of the public road and near the center of the lot, several small test pits were dug in 1917 in the red soil and yellow subsoil. Numerous fragments of high-grade manganese ore were found in the red clay loam, together with fragments of chert from the underlying Knox dolomite.

Virginia Iron, Coal & Coke Company.—The Virginia Iron, Coal & Coke Company of Roanoke, Va., J. L. Waite, Cartersville, agent, owns about 100 acres along the Euharlee-Rome road in the vicinity of Ligon in the western part of Bartow County. Its property comprises extensive deposits of brown iron ore which have been prospected in places to a depth of 40 or 50 feet. Lot 422,[1] 17th district, 3d section, contains a considerable amount of manganese scattered as pellets, nodules, and fragments in the ferruginous red clay loam overlying the Knox dolomite. Lots 368 and 369[1] also contain manganese in the surface soil. This property is 12 miles in an airline west of Cartersville and 5 miles southwest of Kingston. The manganese does not appear to occur in workable quantities.

Strickland property.—Lot 373, 17th district, 3d section, western part of Bartow County, is part of the property belonging to E. Strickland, of Cartersville. It is in the Ligon district 4 miles west of Euharlee and about 12 miles west of Cartersville. This was once known as the Jacobs lot.[2] Where the Euharlee-Rome road passes through the lot, it exposes soft manganese oxide mixed with yellowish-gray chert fragments and clay weathering from the Knox dolomite. The manganese occurs as coatings on chert fragments and as small

[1] Watson, op. cit., p. 130.
[2] Idem, p. 129.

stalactitic masses. The indications in the road cut are not favorable for a workable amount.

The following analysis was made of a sample of manganese ore sent to the Survey by Mr. Strickland from lot 420, which joins the south side of lot 373:

Analysis of manganese specimen. Lot 420

Silica (SiO_2) and insoluble	4.14
Iron (Fe)	0.68
Moisture at 100°C	1.00
Manganese (Mn)	40.20
Phosphorus (P)	0.42
Nickel (Ni)	1.88
Cobalt (Co)	trace

Vincent property.—Mrs. L. M. Vincent of Kingston owns lots 346, 374, 375, 418, 419, 420, 446, and 447, 17th district, 3d section, western part of Bartow County, about 5 miles southwest of Kingston and 12 miles in a straight line west of Cartersville. This property includes parts of what were once the French, Tarver, and Dodd properties.[1] Manganese and manganiferous iron ore occur, particularly on lots 346, 347, and 375. The usual form of pellet and soft manganese occurs, but the deposit is strictly one of brown iron with some manganiferous iron. The red soil surface shows an especially rich accumulation of this ore near a small cemetery a few yards north of the Euharlee-Rome road. An analysis of an average surface sample (*Hu-400*) collected from an area of several acres showed 4.08 per cent of manganese.

Greenfield property.—A. D. Greenfield, of Atlanta, owns several hundred acres near Kingston, in the western part of Bartow County. Lot 218, 16th district, 3d section, three-quarters of a mile west of Kingston, was being worked in 1918 for brown iron ore, which occurs in considerable quantity in the Knox dolomite formation. Manganese occurs in places closely associated with the limonite, and has been prospected to a depth of 7 feet on the hillside at an elevation of 750

[1] Watson, op. cit., pp. 129, 130.

feet above sea level and about 100 feet higher than Connesena Creek. Some of the nodules probably contain as much as 40 per cent of manganese, but the size of the manganese deposit is doubtful.

Lot 159, about 2½ miles north of Kingston, part of which belongs to the Greenfield property, contains some manganese chert breccia as fragments in the red soil. The content of metallic manganese in these fragments is generally not more than 25 per cent.

Holcombe property.—Lot 158, 16th district, 3d section, Bartow County, is part of the property of Mrs. R. E. Holcombe, Kingston. This lot is west of the Western & Atlantic Railroad at a point 2½ miles north of Kingston. Manganese occurs in small quantity along the slopes of a Knox dolomite ridge west of Connesena Creek. Several shallow prospect pits have exposed nodules of hard manganese oxide in the yellowish-gray soil. An analysis of an average sample (*Hu-384A*) taken from the small quantity of ore removed from a 4-foot pit showed 18.15 per cent of manganese, 2.91 per cent of iron, 0.056 per cent of phosphorus, 1.14 per cent of barium oxide, and 48.34 per cent silica.

Joseph E. Brown property.—Lot 8, 5th district, 3d section, northwest of the central part of Bartow County, is owned by the Joseph E. Brown estate, E. A. Brown, agent, Atlanta. This 160-acre lot is 3 miles east of Halls Station, or Linwood, on the Western & Atlantic Railroad and about 11 miles northwest of Cartersville. Old pitts, mostly of small dimensions, on the western part of the lot show manganiferous iron ore in the red soil overlying irregular chert masses. Within an area of a few acres near these pits, the red soil contains numerous vesicular masses of high-grade manganese ore, some as large as 1½ feet in diameter and rather free from iron and silica. This deposit is on top of a Knox dolomite ridge about 900 feet above sea level.

Kerr property.—J. C. Kerr, Adairsville, owns 312 acres in lots 99 and 100, 16th district, 3d section, western part of Bartow County. Connesena Creek flows southward through the property three-quarters of a mile west of Halls Station, or Linwood Postoffice, on the Western & Atlantic Railroad. Lot 100[1] was worked for brown iron in 1887, and manganese is reported to have occurred associated with the ore.

Lot 99, on the west side of Connesena Creek, has been prospected for brown iron and manganese. A small pit on the north side of the Linwood-Barnsley public road has exposed a little high-grade vesicular manganese ore.

Saylor property.—Mrs. A. B. Saylor, Adairsville, owns 2000 acres of a tract known as Barnsley Garden, in the northwestern part of Bartow County, 6 miles northwest of Kingston. This is in the area underlain by Knox dolomite where manganese, brown iron, and bauxite have been mined. Manganese occurs on lots 84, 94, 95, 116, and several others in the 16th district, 3d section.

In 1917 the Paga Mining Company, of Cartersville, shipped some manganese or manganiferous ore from lot 94. An open cut 50 feet long, 20 feet wide, and 10 feet deep was dry-mined and the vicinity prospected to some extent by 6-foot pits. There is still left a minable quantity of soft ore and some high-grade lump ore.

The following analyses show the grade of the ore on the Saylor property:

Analyses of manganese ore. Saylor property

Constituents	*1*	*Hu-385A*
Silica (SiO_2)	3.53	42.26
Alumina (Al_2O_3)	......	17.94
Iron (Fe)	1.01	8.06
Moisture at 100°C	......	1.66
Manganese (Mn)	43.73	12.60
Phosphorus (P)	0.129	0.062

1.—Manganese ore "from the Barnsley estate at Woodlands." Analysis made by the Pittsburg Testing Company. See Spencer, J. W., Paleozoic Group, Geol. Survey of Ga., p. 194, 1893.

Hu-385A.—Manganese ore deposit. Average of a 6-foot face in the open-cut on lot 94. Collected July, 1918.

[1] McCallie, S. W., Preliminary report on a part of the iron ores of Georgia: Geol. Survey of Ga. Bull. 10-A, p. 173, 1900.

Sherman property.—C. B. Sherman, Adairsville, owns the south half of lot 63, 16th district, 3d section, northwestern part of Bartow County. About a mile northwest of Barnsley, a few small pits produced one or two carloads of manganese ore sometime in the nineties. The ore remaining near the openings is highly siliceous, though some excellent ore occurs in the reddish-yellow soil.

CAVE SPRING DISTRICT

The Cave Spring manganese district is 12 miles long and 4 miles wide. It extends from the vicinity of Priors in northwestern Polk County northeastward through Cave Spring in Floyd County. The topography of the district is featured by alternating ridges and valleys extending north-northeast. The long narrow ridges rise in places more than 300 feet above the adjacent valleys. The altitudes of the district range from 648 feet at Big Cedar Creek north of Cave Spring to 1600 feet above sea level on Indian Mountain west of Oredell and Priors. Cave Spring is 665 feet above sea level. The district is drained by small streams flowing generally northeastward until they break through the longitudinal ridges to join the northwestward drainage of Big Cedar Creek.

The Rome, Selma, and Meridian line of the Southern Railway passes southwest through the western part of the district and the Chattanooga, Cedartown, and Griffin division of the Central of Georgia Railway passes southward just east of the district.

The geology of the Cave Spring district has been described by Hayes[1] and by Watson.[2] The rocks are similar to those of the Cartersville district, including quartzite, limestone, and shale, ranging in age from lower Cambrian to Ordovician. The formations represented are as follows:

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[1] Hayes, C. W., U. S. Geol. Survey Geol. Atlas, Rome folio (No. 78), 1902.

[2] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, pp. 102-111, 1908.

Geologic formations in the Cave Spring district

II. Cambrian and Ordovician
    5. Knox dolomite
I. Cambrian
    4. Conasauga shale
    3. Rome formation
    2. Shady limestone
    1. Weisner quartzite

The dominant structure of the district is shown by the alternating ridges and valleys, the latter occurring where less resistant shales were eroded along several parallel faults.

The occurrence of the ore deposits and the types of ore are similar to those of the Cartersville district, except that in the Cave Spring district, the ores occur more generally in the residual decay of the Knox dolomite. The deposits are smaller and less extensive than in the Cartersville district and there seems to be a predominance of chert breccia ore. The four main types of deposits with their several modifications are represented, namely: (1) residual, (2) replacement, (3) vein- and fracture-filling, and (4) detrital.

Some manganese was probably mined in the eighties. There was a period of activity about 1890 to 1891 and shipments were again made in 1901 and 1902. In 1902 the district had the most elaborately equipped concentrating mill in the State. Since that time very little work was done until 1917 when the Alabama Company began mining manganiferous iron ore. In 1918 a few carloads of high-grade manganese ore were also shipped. The principal operators are the Alabama Company and Pruitt and Conway. The district has produced altogether at least 15,000 tons of manganiferous iron ore and possibly 1,000 tons of strictly manganese ore.

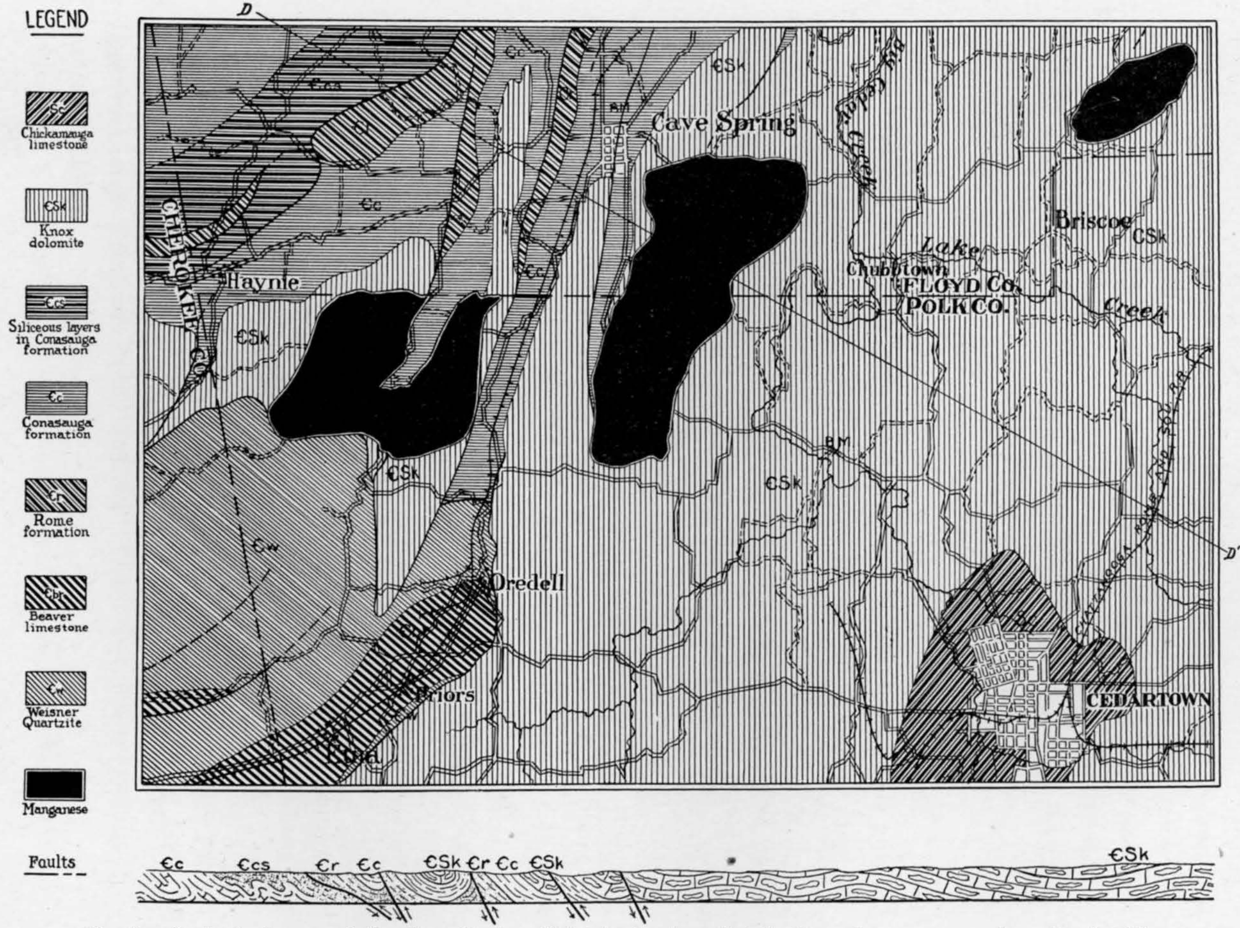


Fig. 9. Geological map of the Cave Spring district, showing distribution of manganese deposits, by Thomas L. Watson. *Based on the Rome folio, U. S. Geological Survey.*

DESCRIPTION OF INDIVIDUAL DEPOSITS

POLK COUNTY

THE ALABAMA COMPANY

General statement.—The Alabama Company of Birmingham, Ala., owns a large tract of mineral land near Hematite and Oredell, in the northwestern part of Polk County. The property includes about 1900 acres of which the greater part lies west of the Rome, Selma, and Meridian line of the Southern Railway. That part of the tract owned in fee simple consists of 40½ lots of 40 acres each, namely: lots 3 to 6, half of 64, 65 to 70, 76 to 80, 136 to 140, 149 to 153, 209 to 211, 223, 224, 263, and 264, 17th district, 4th section; and lots 4 to 6, 67, 68, 78, 139, and 149, 2d district, 4th section. That part of which only the mineral rights are owned consists of 8 lots of 40 acres each, namely: lots 81 to 85, 88, 128, and 133, 17th district, 4th section. The main operations are on lots 138, 139, 150, and 151, 17th district. A tram line connects the mine and mill with Hematite, the shipping point on the Southern Railway, about 1½ miles east.

A large part of this tract was formerly owned by the Alabama Consolidated Iron, Coal & Coke Company and operated for brown iron ore by the Hematite Mining Company. Most of this work was done since 1897, although some mining was carried on in 1874. The property was formerly known as the Hematite property.[1] In 1917, the Alabama Company, the present owner, opened the deposits of manganiferous ore, and since that time has been shipping on a rather extensive scale.

Topography.—The maximum local relief of the Alabama Company property is about 800 feet, as the elevation above sea level ranges from less than 800 feet along the forks of Little Cedar Creek to more than 1600 feet on parts of Indian Mountain, near the Georgia-Alabama state line. The topography has the general features of the ridge-valley type, which characterizes the Cave Spring district. The major

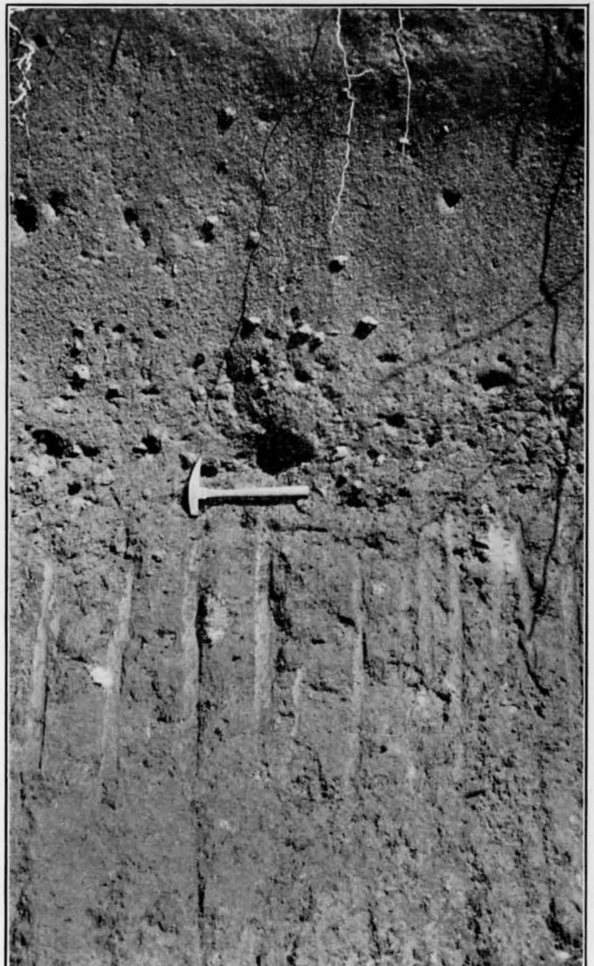
[1] McCallie, S. W., Preliminary report on a part of the iron ores of Georgia: Geol. Survey of Ga. Bull. 10-A, pp. 95-98, 1900.

trend of the ridges is northeastward. The manganiferous deposits being worked in 1918 are at an elevation approximately 1100 feet above sea level and the open cut on lot 138 is 115 feet higher than the small branch which is one of the sources of Little Cedar Creek.

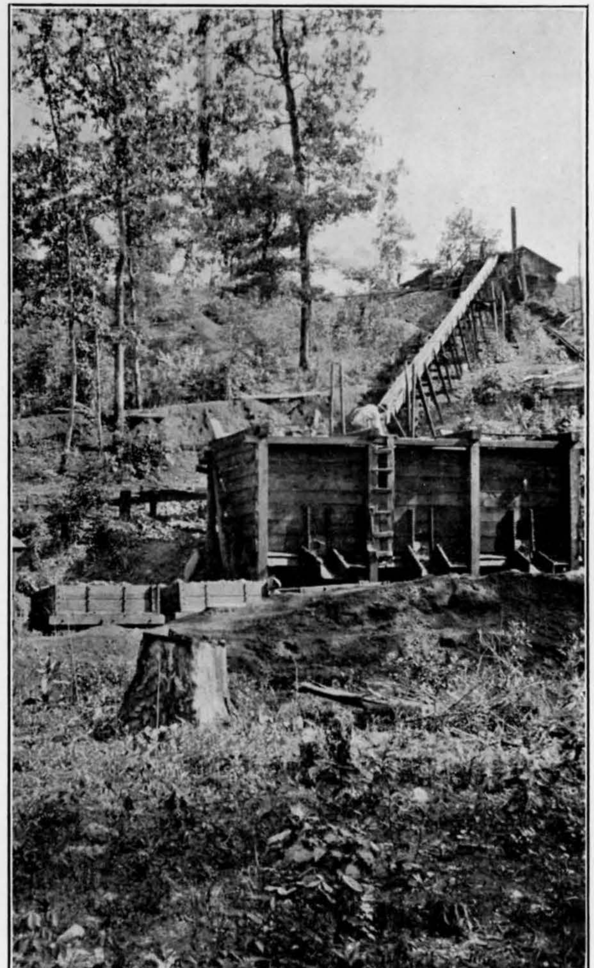
Geology.—The geological formations represented on this property are Weisner quartzite, Shady limestone, Conasauga shale, and Knox dolomite, all Cambrian and Cambro-Ordovician rocks. Outcrops showing definite strike and dip are scarce where the mining is being done on lot 138. The strike is northeast and the dip southeast,—the degree of each changing sharply within a few feet. The rocks most commonly found as fragments or partially decomposed formations in the surficial material that is being worked in the open-cuts are quartzite and chert. The quartzite is rather friable and consists of small, loosely-cemented grains of quartz which are in places distinctly rounded (water-worn). The chert is also more or less fragmental, but seems to constitute a large part of the mass, being encountered as the steam shovel goes deeper into the bottom of the cut.

Ore deposit and ore.—The ore deposit now being worked has the characteristics of a surficial accumulation. The ore occurs as small, irregular fragments and nodules with quartzite and chert fragments in no particular order throughout the dark red soil. This unconsolidated manganiferous ore body is rather extensive as the weathered product of the underlying formations. At a depth ranging from about 5 to 15 feet, this surface accumulation is in contact with yellow clay containing chert particles and grading downward into less weathered rock which is probably a chert or dolomitic formation. This residual clay contains some definite bodies of ore more concentrated than that in the surface material. One of these deposits is 3 or 4 feet thick and seems to be as rich as the manganiferous surface accumulation.

The ore being mined from these deposits is manganiferous iron ore. The larger part of the manganese is present in close chemical and mechanical association with iron oxide in amounts just sufficient to produce a manganiferous iron ore. The chief impurity is silica in the form of chert particles and small rounded quartz grains.



A. MANGANESE NODULES IN CLAY. HAMMER SHOWS CONTACT OF RED SOIL ABOVE AND YELLOW RESIDUUM FROM DOLOMITE BELOW.



B. CONCENTRATING PLANT AND SHIPPING BINS OF THE ALABAMA COMPANY NEAR HEMATITE, POLK COUNTY.

The grade of ore shipped is shown by the following analyses of 4 carload lots and their average, representing the ore shipped during the months of February, March, April, and May, 1918:

Analyses of manganiferous iron ore from the Alabama Company property[1]

Constituents	February	March	April	May	Average
Iron (Fe)	46.10	48.00	42.00	40.20	44.07
Insoluble	14.80	10.20	14.80	18.00	14.45
Phosphorus (P)	0.43	0.30	0.30	0.26	0.322
Manganese (Mn)	3.60	5.10	8.80	5.50	5.67

Development.—Manganiferous iron ore has been prospected in a number of places on the company's land, but the deposit being worked is on lot 138, about a quarter of a mile west of the public road. The ore is being taken out of an open-cut near the top of a steep ridge about 115 feet higher than the stream. This opening is more than 200 feet long, almost as wide, and in several places at least 30 feet deep.

The material is mined by steam shovel. A gravity tram line carries the ore to a bull-pen, from which the ore is flumed with water a short distance to a double-log washer. The washed ore then falls by gravity down a flume to storage bins in the bottom of the ravine. The storage bins open by chutes into 2-yard dump cars which are hauled by dinky engine along the narrow gage tram line to Hematite, about 1½ miles distant. Additional equipment consists of a steam pump, boiler, engine, and 24 dump cars, each with a capacity of 2 cubic yards.

Production and future of mine.—Aside from the extensive deposits of limonite on this property, the areas underlain by manganiferous ore of the quality being shipped in 1918 are undoubtedly large. The monthly production in the summer of 1918 was about 900 tons.

[1] Analyses made and furnished by the Alabama Company.

It is expected that the efficiency of the concentrating equipment will be increased by the installation of a jaw crusher, classifying screens, and another log washer.

The comparative simplicity of the actual mining problem, the abundance of fuel and building supplies, the presence of water, and proximity to rail facilities, make the future of the Alabama Company's property particularly bright.

McCOLLUM PROSPECTS

W. D. McCollum of Cave Spring, Floyd County, owns 160 acres composed of the following 4 lots of 40 acres each,—lots 145, 146, 215, and 216, 17th district, 4th section, northwestern part of Polk County. In the summer of 1918, the Southern Manganese Corporation of Birmingham, Ala., held an option on the property and did a considerable amount of prospecting. The manganese deposits have been opened about a quarter of a mile west of the western Cave Spring-Priors road 5 miles southwest of Cave Spring. The property is a mile south of the Polk-Floyd county line and a mile east of the Georgia-Alabama state line. Lot 215 is part of the property described by Watson[1] as the Wharton estate.

The ore deposit, as opened by the main prospect pits, is on the steep south slope of a partially cleared ridge about 60 feet higher than the bed of the intermittent stream which is one of the sources of Spring Creek. Both ridge and drainage at this place have a northeast direction. The elevation of the property ranges from 800 feet to approximately 1000 feet above sea level.

The rock containing the manganese deposit is the ordinary gray chert of the Knox dolomite formation. Although there are no well-defined outcrops showing the structure, the northeast strike and southeast dip may be inferred from the trend of the ridge and position of the deposit.

Prospect pits along the steep southern slope of the ridge on lot 216 show a more or less definite "lead" of manganiferous clay and

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, p. 119, 1908.

hard manganiferous chert about 6 feet thick, carrying some pockets and streaks of almost pure manganese oxide. The size of the ore body and the character of the ore change along the strike. The manganese as exposed in some of the western pits on lot 216 is in the form of pellets less than half an inch in diameter, loosely embedded in red clay loam. This is called gravel ore and in places seems rich enough to be profitably concentrated by washing and screening.

Less than 100 yards N.60°E., several pits not more than 20 feet deep expose slightly bluish-black manganese ore containing small and large angular fragments of chert. An average sample (*Crane-43*) of the ore taken out of these pits in the work of prospecting was collected by W. R. Crane.

On lot 145, a few hundred yards farther northeast and on the same general strike, a shallow test pit has been dug in loosely consolidated manganiferous material made up of small, roughly concentric nodules, rounded quartz grains, and rusty-yellow gritty material having a bauxitic appearance. Its content of alumina, however, is lower than that of the high-grade manganese ore (see samples *Hu-354x* and *Crane-43*).

The following chemical analyses represent two types of manganese deposits on lots 216 and 145. Much of the chert breccia ore which constitutes the large mass of the deposit and whose general average is shown in sample *Crane-43*, contains very little siliceous impurity and a much higher content of manganese.

Analyses of ferruginous manganese and manganiferous ores from the McCollum property

Constituents	*Crane–43*	*Hu–354x*
Silica (SiO_2)	37.94	47.16
Alumina (Al_2O_3)	10.90	10.00
Lime (CaO)	......	0.00
Moisture at 100°C	0.29	2.15
Manganese (Mn)	19.73	5.84
Iron (Fe)	1.79	12.54
Phosphorus (P)	0.134	0.078

Crane–43.—Ferruginous manganese ore, representing average of the breccia ore raised in prospecting.

Hu–354x.—Manganiferous semi-consolidated gravelly deposit with bauxitic appearance.

On lot 215, somewhat more than a quarter of a mile south of the prospects on lot 216, recent work shows numerous nodules of first quality pyrolusite and psilomelane together with chert fragments scattered in the yellow clay.

In 1918, there was no mining nor milling equipment on the McCollum property, and no manganese ore had been shipped. The amount of prospecting already done shows a deposit of good manganese ore more or less continuous, but of changing quality, along a distance of a quarter of a mile. There are excellent indications of a workable deposit of milling ore.

CAMPBELL PROPERTY

Lots 1160, 1161, 1216, and 1217, 3d district, 4th section, in the northwestern part of Polk County, 2 miles south of Cave Spring, are part of the property belonging to Mrs. C. H. Campbell (J. K. McDonald, agent, Trust Company, Atlanta). J. B. Pruitt and T. C. Conway of Atlanta hold a lease on the mineral rights. These 40-acre lots are half a mile east of the main public road between Cave Spring and Cedartown. Lots 1160 and 1161 lie just south of the Polk-Floyd county line and lots 1216 and 1217 join them on the south. The main openings are along the line between 1216 and 1217.

This property is described by Watson[1] as the Lopez property. The deposits were not worked for a long time prior to 1918. In the first part of that year, Sidney Simmons of Cave Spring shipped a few carloads of high-grade ore and during the latter part, Pruitt and Conway have been prospecting on a larger scale and have produced a considerable amount of excellent manganese and manganiferous ore.

The topography on these lots is a modified ridge-valley type with

[1] Op. cit., pp. 112-114.

a general north and northeast trend. The rock containing the deposits is Knox dolomite which underlies large areas in the Cave Spring district. Hard rock does not occur in place in the mine workings, but at the head of the small ravine immediately east of the main open cut an outcrop of chert indicates the general north-northeast strike and southeast dip of the formation.

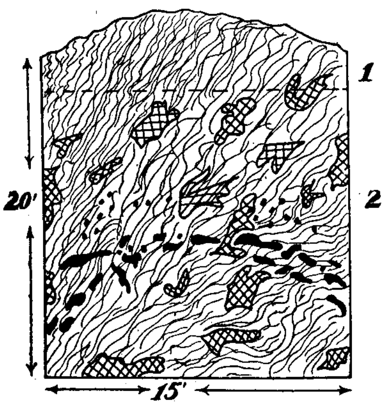


Fig. 10. Section of a pit on the Compbell property, showing occurrence of manganese ore in the clay. Cross-hatched areas indicate fragments of chert. Black areas and dots indicate manganese ore. 1. Deep red clay. 2. Red, mottled clay filled with chert fragments. *From Watson.*

The largest of the two or three open-cuts is about 150 feet long, 100 feet wide, and 15 to 25 feet deep. At the time the property was visited in the summer of 1918, the old ore faces and headings of short entrances in the unconsolidated red soil and stratified yellow clay contained many nodules and fragments of manganese, manganiferous, and limonite ore, with the last two predominant in all directions except down the dip, which is about 30°SE. Judging from conditions observed here, it seems probable that the ore occurred in a lens-like deposit, which contained high-grade manganese at its center and manganiferous ore and limonite in the outer portions, thinning out into the decomposed rock.

The manganese ore is made up of the oxides, chief of which is pyrolusite, though no small amount of psilomelane and wad are intimately associated. Crystalline pyrolusite constitutes the mass of the nodules. Some are commonly coated with a layer of limonite mixed with fragments of chert. These limonitic outer portions occur both as gradations passing into the pure manganese oxide and as distinct shells which are readily broken off.

The high grade of the manganese shipping ore is shown in the following analyses:

Analyses of manganese ore. Campbell property

Constituents	*Hu–352Cx*	*Simmons*
Silica (SiO_2)	17.08	12.04
Alumina (Al_2O_3)	2.78	......
Moisture at 100°C	0.63	......
Manganese (Mn)	42.28	49.00
Iron (Fe)	5.00	......
Phosphorus (P)	0.084	0.07

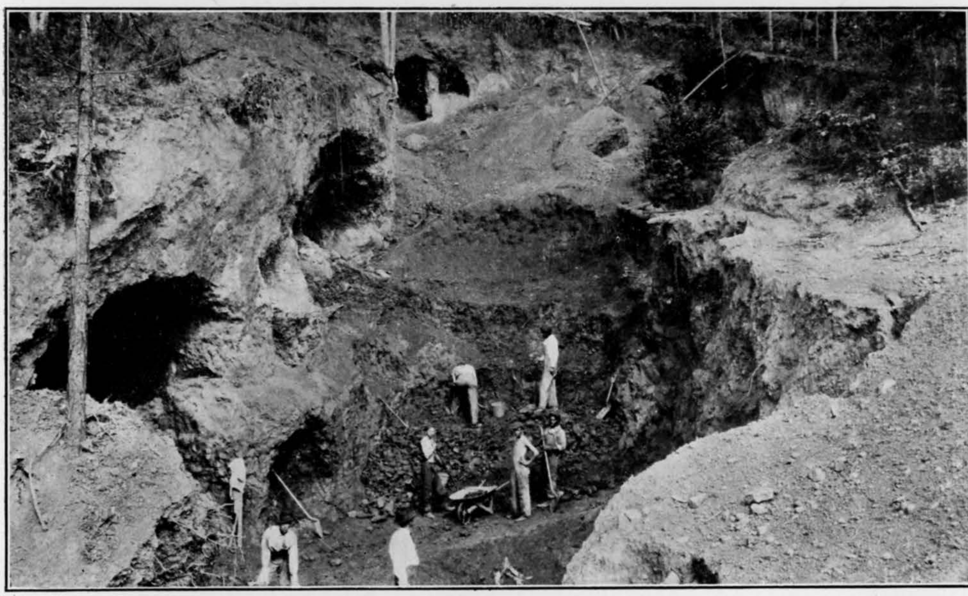
Hu–352Cx.—Average sample of a carload of hand-washed and sorted ore, shipped in May, 1918, by Sidney Simmons, Cave Spring.

Simmons.—Sample of carload shipment by Sidney Simmons, Analyst, Frank Maddox, Rome.

During July, 1918, when the property was visited, Pruitt and Conway had a force of about 30 men reopening the old pits. Besides the hard manganese and manganiferous ore in these deposits, there is a considerable amount of soft ferruginous and manganiferous clay which would undoubtedly yield a profitable amount of ore if treated by a simple method of washing and classifying in settling basins.

The total output of manganese ore from this property has not been large, considerably less than 1000 tons. Although the best grade of ore can be produced by dry mining methods, a very large part of equally good quality could be saved if a log washer and a set of jigs were in use. The only source of water near the openings is a spring which was previously used to supply a log washer, and this supply might again be used to advantage.

A. OPEN-CUT OF THE ALABAMA COMPANY NEAR HEMATITE, POLK COUNTY.



B. OPEN-CUT ON THE CAMPBELL PROPERTY IN POLK COUNTY, 2 MILES SOUTH OF CAVE SPRING.

MINOR PROSPECTS

Besides the properties already described, there are many others in the Cave Spring district in Polk County. Almost every lot of land in the northwestern part of the county contains some indication of a manganese, manganiferous, or limonite deposit.

Most of the following properties were described by Watson[1] as belonging to persons, no longer the owners in 1918. Some ore occurs on each property. In order to facilitate reference to the earlier descriptions, therefore, these properties are briefly mentioned together with the name of the former owner as given in Bulletin No. 14.

Bader property (Watts property).[2]—Herman P. Bader owns 70 acres in lots 147 and 214, 17th district, 4th section, 5 miles southwest of Cave Spring.

Hopper property (Leake, Wright, and Peterson property).[3]—Joe Hopper owns lots 143, 144, and part of 214, 17th district, and 109, 16th district, 4th section, 4 to 5 miles southwest of Cave Spring.

Shaw property.[4]—Lots 2, 71, 72, 73, and 74, 17th district, 4th section, 4 miles southwest of Cave Spring, belong to Mrs. L. B. Shaw (Joe Hopper, agent).

Southerlin property.[5]—Lafayette Southerlin owns lot 1296, 3d district, lot 36, 16th district, and lot 1, 17th district, 4th section, about 3½ miles southwest of Cave Spring.

Scarbaugh lot.[6]—"The Scarbaugh lot" as described by Watson, is lot 180, 16th district, 4th section, about 3½ miles southwest of Cave Spring.

Carver property (Youngblood property).[7]—Wm. D. Carver owns lot 105, 16th district, 4th section, 3 miles southwest of Cave Spring.

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[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, pp. 112-119, 1908.

[2] Idem, p. 116.

[3] Idem.

[4] Idem, p. 117.

[5] Idem, pp. 117, 118.

[6] Idem, pp. 115, 116.

[7] Idem, p. 115.

Dempsey property (Prior property).[1]—Mrs. T. J. Dempsey owns lot 16, 2d section, 4th district, half a mile southeast of Priors station.

Ach property (Dempsey tract).[2]—Samuel N. Ach owns lot 351, 2d district, 4th section, about 2½ miles east of Oredell.

Hampton property.[3]—Lot 148 is owned by George Hampton (A. A. Hampton, agent), and lot 214 is owned by the D. N. Hampton estate (L. Southerlin, agent). These 40-acre lots are in the 2d district, 4th section, 4 miles south of Cave Spring.

Sanders property (Lopez property in part).[4]—Mrs. Mary S. Sanders owns lot 1288, 3d district, 4th section, 3 miles south of Cave Spring.

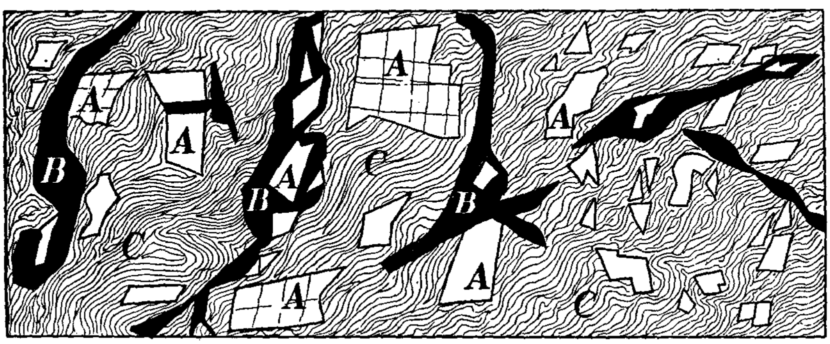

Fig. 11. Section in an opening on the Callahan property, showing occurrence of manganese ore in cherty residual clay. A. Chert fragments. B. Manganese ore. C. Residual clay. *From Watson.*

Callahan property (W. B. Lowe property).[5]—J. E. Callahan (colored) owns 204 acres in lots 1162, 1163, 1164, 1212, 1213, and 1214, 3d district, 4th section, 2½ miles south-southeast of Cave Spring. In Bulletin 14, the manganese deposits on this property are described as being on lot 1142, Floyd County, but the owners claim the work was done on lot 1163, immediately south of it in Polk County. In the summer of 1918, the old workings had been abandoned for many years

[1] Watson, op. cit., p. 117.
[2] Idem, p. 115.
[3] Idem, pp. 118, 119.
[4] Idem, pp. 114, 115.
[5] Idem, pp. 125-127.

and the pits and shafts were partly fallen in. No buildings nor machinery of any sort remained on the property to indicate the existence of what was described in 1902 as "the most elaborately equipped manganese plant in the State," having "all modern machinery and appliances, including a motor plant, for generating electricity for lighting and other purposes, and for tram cars. . . The cost of the machinery and its installation must have been large; but the amount of ore contained on the property will not begin to equal the expenditure above ground."

FLOYD COUNTY

REEVES PROPERTY

(ASBURY PROPERTY IN PART[1])

J. R. Reeves, of Cloverdale Farm, 3 miles north of Cave Spring, owns lot 923, 3d district, 4th section, 2 miles east of Cave Spring. J. B. Pruitt and T. C. Conway of Atlanta leased this property in 1918 and carried on a considerable amount of prospecting in the residual red soil mantle on an easterly slope northwest of the public road. The red soil contains numerous pellets of manganese and some bluish-black vesicular lumps of high-grade ore composed largely of pyrolusite. In the bottom of the large cut there was exposed a body of lean manganese and manganiferous ore about 3 feet thick, but containing much red clay. On lot 750 of the Asbury property, joining lot 923 on the south, an old limonite open cut contains a good supply of water fed by springs in the bottom of the opening. This supply was being used in October, 1918, by Pruitt and Conway to operate a single-log washer on the Reeves lot.

WOOD AND REYNOLDS PROPERTY

Mrs. Nelle N. Wood owns about 190 acres of land recently owned by William Reynolds, Cedartown. It constitutes two-thirds of lots

[1] Watson, op. cit., pp. 123, 124.

822, 823, and 824, half of lot 832, all of lot 833, and five-eighths of lots 834 and 835, 3d district, 4th section, southern part of Floyd County, 6 miles in an airline east of Cave Spring. The estate of Lewis Reynolds owns 30 acres or three-eighths of the south part of lots 834 and 835. This entire tract of 220 acres is on Reynolds Mountain and its manganese deposits are described under that name in Bulletin 14.[1] The 30-acre tract which is on record as the estate of L. Reynolds, is also referred to as the Hackett property in the deed records. As the rights to the mineral of this property are in litigation, the work of reopening the deposits, just being undertaken in July, 1918, was later discontinued.

Almost all of the mining operations have been on lots 822 and 835 on the western part of this property, along the top of the ridge about half a mile east of New Prospect Church on the public road to Sixmile and the same distance west of the Cedartown-Sixmile road. The openings are 2 miles west of Boody, a station on the Chattanooga, Cedartown, and Griffin division of the Central of Georgia Railway and 5 miles south of Sixmile, a station on the Rome, Selma, and Meridian division of the Southern Railway.

Reynolds Mountain is a narrow ridge whose average width between valleys is less than a mile. It extends N.30°E. several miles toward Rome and S.30°W. into Polk County, about a mile from the Wood-Reynolds tract. The elevation above sea level ranges from 800 to more than 1100 feet, and the approximate elevation at the mines is less than 1000 feet, or 150 to 200 feet higher than the southwesterly drainage into Lake Creek and Big Cedar Creek.

The rock formation containing the manganese deposits is Knox dolomite represented on the surface and in the partially decomposed material exposed in the open cuts by many irregular fragments and masses of gray chert in red soil underlain by yellow and gray residuum. A few miles north of the openings, this cherty limestone ridge is flanked by softer shale formations, in which the narrow valleys

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, pp. 119-122, 1908.

were eroded. The faulted character of this ridge-valley topography and structure is shown by Hayes in the Rome folio.[1]

Some of the ore contains finely crystallized pyrolusite in a matrix of chert breccia, and a considerable amount of pure nodular ore made up of botryoidal psilomelane and pyrolusite, but the bulk of the ore is a mixture of these oxides cementing thoroughly brecciated chert.

When the property was visited in 1918, very little work had been done since the original operations, although Major J. M. Couper of Atlanta had some prospecting done in 1902 and a little work was begun in the early part of 1918, before legal disputes arose. There are approximately 15 tons of low-grade manganese ore of the hard brecciated character stored in heaps at the old open-cuts. An analysis of this ore is given below.

Analysis of manganese ore. Wood and Reynolds property (Hu-406)

Silica (SiO_2)	27.38
Alumina (Al_2O_3)	1.95
Moisture at 100°C	0.40
Manganese (Mn)	37.53
Iron (Fe)	1.67
Phosphorus (P)	0.082

It is seen that the chief objectionable part of this ore is silica, and this impurity can be readily eliminated by the use of simple crushing and jigging treatment, while the finer and softer material could be saved by settling classifiers. The ore analyzed does not represent the richest ore but undoubtedly does represent the largest part of the deposit.

MINOR PROSPECTS

A number of other properties in the Cave Spring district of Floyd County, here described, have been prospected for manganese ore, but as yet they are not important producers.

Miller property.—The Miller estate, owned by Miss Maud Miller and Mrs. Alice M. Miller, of Rome, and Claude Miller, of Cave Spring, includes the following 9 lots of 40 acres each,—a total of 540 acres:

[1] Hayes, C. W., U. S. Geol. Survey Geol. Atlas, Rome folio (No. 78), 1902.

lots 794, 795, 796, 861, 862, 863, 867, 868, 3d district, 4th section, southwestern part of Floyd County, one mile west of Cave Spring. In July, 1918, H. M. Hebble of Cartersville held a lease on the mineral rights, but no prospecting had been done, except a small pit dug many years ago on lot 795 and a shallow opening made in 1917 on lot 794.

The pits are on a Knox dolomite ridge at an elevation of 800 feet or more above sea level, and about half a mile west of the public road. Some surface indications of manganese and limonite are noticeable on this property for more than half a mile southward along the ridge.

Thompson property.—Lot 790, 3d district, 4th section, a mile west of Cave Spring, joins the north side of part of the Miller estate and is on the same chert ridge characterized by a red ferruginous soil mantle and manganiferous chert masses on the surface.

McHenry property.—J. C. McHenry (colored) owns lots 1141, 1142, and 1143, 3d district, 4th section, in the southern part of Floyd County, 2 miles south of Cave Spring. Lot 1142 lies immediately north of the old W. B. Lowe mine on the Callahan property and lot 1143 is northeast of the former D. H. Lopez property, both in Polk County. The presence of both the hard and soft manganese oxides is shown by exposures in road cuts and gullies.

Hughes property (Hancock tract, Lopez property).[1]—Lot 998, 3d district, 4th section, 1¼ miles southeast of Cave Spring, belongs to Anna Hughes (colored) and together with lot 927, which is a quarter of a mile north-northeast, forms the old Hancock tract, formerly owned and worked by Major J. M. Couper of Atlanta and D. H. Lopez of Buford, S. C. No work has been done here in many years. Watson describes the ore as being of the chert breccia type, similar to the other manganese ore of the district.

Jennings lot (Lopez property, in part.)[2]—The deposits on lot 926, 3d district, 4th section, are similar to those on the adjoining lot (927), consisting of manganese and limonite chert breccia.

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, p. 122, 1908.
[2] Idem, pp. 122, 123.

Simmons lot.[1]—Sidney Simmons of Cave Spring owns lot 924, 3d district, 4th section, 1½ miles east of Cave Spring. A few shallow prospect pits in residual and colluvial red clay loam show breccia and nodular manganese and manganiferous ore rather high in silica.

Asbury property.[2]—Float manganese of rich vesicular and brecciated types is common on the T. W. Asbury property, comprising lots 922, 950, and 951, 3d district, 4th section, about 1¾ miles east of Cave Spring.

Spence property.—A. J. Spence, of Cave Spring, owns 405 acres in the 3d district, 4th section, 2 miles north of Cave Spring. Lot 662 of this tract is about half a mile west of the Cave Spring-Rome road, and on the steep ridge just west of the Spence residence. In the summer of 1918, J. B. Pruitt and T. C. Conway of Atlanta prospected the southeastern part of this lot, but very little manganese ore was found. Iron ore occurs in the red and yellow soil, residual from the Knox dolomite, both as brown ore, limonite, and as goethite. Adjoining properties on this same chert ridge show surface indications of brown ore deposits, but little promise of workable manganese.

McGinnis property.—W. C. McGinnis of Cave Spring owns lots 667, 668, 669, 701, 702, 738, and 739, 3d district, 4th section, 3 miles northeast of Cave Spring. J. B. Pruitt and T. C. Conway of Atlanta held a lease on this tract in the summer of 1918, and had about 20 men prospecting on lot 738 on a gentle slope south of Big Cedar Creek and about 30 feet higher than the stream. The cut was approximately 75 feet long, 15 feet wide, and 6 feet deep. It showed an ore body of the same dimensions lying against an outcropping chert foot wall and dipping northward toward the creek. Several tons of ore were produced by dry mining and hand cobbing. The ore is a massive, vesicular, and brecciated mixture of psilomelane, pyrolusite, limonite, and chert, carrying 33.82 per cent of manganese, 17.36 per cent of iron, 0.251 per cent of phosphorus, and 7.70 per cent of silica, as shown in the analysis of a sample representing about 5 tons of ore, collected by W. R. Crane, 1918.

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[1] Watson, op. cit., p. 123.
[2] Idem.

Harper tract.[1]—Miss Joy Harper, of Rome, owns 158 acres in lots 761, 762, 763, and the north parts of lots 822, 823, and 824, 3d district, 4th section, southern part of Floyd County, 10 miles south of Rome, and 5 miles southeast of Cunningham, a station on the Rome, Selma, and Meridian division of the Southern Railway. J. B. Pruitt and T. C. Conway hold a lease on the property, but scarcely any mining has been done since the nineties when, it is reported, 29 carloads of ore were shipped from the surface accumulations.

This property is a part of the Reynolds Mountain deposits and joins the Wood-Reynolds tract on the north. Many acres of red ferruginous soil contain a large quantity of brown iron ore as loose masses or nodules in the unconsolidated residual material which overlies the weathered chert of the Knox dolomite formation. Much of this ore is manganiferous, containing 5.88 per cent of manganese and 40.32 per cent of iron.

OTHER PROSPECTS IN FLOYD COUNTY

Manganese deposits occur in several places in Floyd County outside of the Cave Spring district. The following brief descriptions include the most important of these isolated prospects.

Lot 44, 22d district (Couper property or Briscoe place).[2]—Lot 44 is described by Watson as being a mile south of Lindale and 4½ miles south of Rome. It has one of the few manganese deposits in the area near Rome which have been at all productive. About 4 carloads of nodular ore were shipped from a number of pits opened in 1901. The predominating ore is of the breccia type.

Hillyer property.[3]—This property is described in Bulletin 14 as the former Bonsack estate, about 7 miles south of Rome. "Several small openings have been made; but as yet the developments are entirely too inadequate for one to judge of the extent and character of the ore."

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, pp. 120-122, 1908.
[2] Idem, pp. 132-135.
[3] Idem, p. 135.

Pattillo property.—R. M. Pattillo, Rome, owns several 160-acre lots at Freeman Ferry, in the eastern part of Floyd County, 4 miles in an airline east of Rome. The lots on which manganese has been prospected are lots 331 and 349, 23d district, 3d section. Etowah River flows along the north side of this property, and the Western & Atlantic Railroad follows the north or right bank of the river.

The most extensive prospecting for manganese on the property has been done on the east side of lot 349 less than a mile south of the Pattillo residence. The openings are on the north slope of a Knox dolomite ridge having a northward trend. They are about 800 feet above sea level and 200 feet higher than the river. One pit is about 20 feet long, 15 feet wide, and 10 feet deep in red and yellow cherty clay soil containing somewhat nodular pyrolusite and psilomelane.

Analyses of manganese ore and deposit. Pattillo property

Constituents	*1*	*2*	*Hu-403A*
Silica (SiO_2) and insoluble	8.76	9.97	......
Silica (SiO_2)	......	......	42.08
Alumina (Al_2O_3)	......	......	10.72
Moisture at 100°C	0.50	1.85	0.72
Manganese (Mn)	40.57	36.72	13.12
Iron (Fe)	4.00	......	8.32
Phosphorus (P)	0.078	......	0.072
Barium oxide (BaO)	......	......	0.26
Barium sulphate ($BaSO_4$)	......	......	0.00
Sulphur (S)	......	......	0.00

1, 2.—Manganese and ferruginous manganese ores. Analyses of samples sent the Survey from the Pattillo property.

Hu-403A.—Manganese ore deposit. Analysis of average sample representing the ore deposit as it is exposed in the pit on lot 349.

The deposit seems to be limited in size, although fragments of manganiferous and manganese ore occur on the surface for a couple of hundred yards along the east side of the lot.

In the western part of lot 331 about half a mile south of the river, an excellent quality of manganese ore is exposed in a gully along an old road. The ore is somewhat vesicular, and contains red clay as interstitial matter. Many masses of ore less than one foot in diameter show very little silica and probably contain 40 per cent of manganese. This ore occurs in a red clay body about 3 feet thick.

Nannie.[1]—In Bulletin 14, manganese deposits are mentioned near Nannie in the northeastern part of Floyd County, about 11 miles northeast of Rome. Indications of ore are more or less continuous from this place southeast about 9 miles to the Barnsley deposits in Bartow County.

Big Texas Valley.[2]—Manganese deposits of rather superficial character have been prospected in a small way in Big Texas Valley, 12 miles northwest of Rome. Watson mentions lot 94, 4th district, as containing the typical occurrence. "No workable deposits of manganese seem to have been found, but indications are said to be favorable for brown iron ore in large amounts."

DRAKETOWN DISTRICT

The Draketown manganese district is about 6 miles long and less than 2 miles wide. It extends from the vicinity of the Tallapoosa pyrite mine in Haralson County, 3 miles northwest of Draketown, eastward along Tallapoosa River, north of Draketown, to the vicinity of Embry, in Paulding County, 3 miles northeast of Draketown. The principal deposits as prospected are in the middle of the district less than 2 miles north of Draketown, in both counties. Draketown is about 7 miles north of Temple, a station on the Southern Railway.

The district has the rolling topography of the Piedmont Plateau province, with altitudes ranging from 1100 feet to more than 1250 feet above sea level. It is in the valley of Tallapoosa River, which flows westward.

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, p. 137, 1908.
[2] Idem, pp. 135, 136.

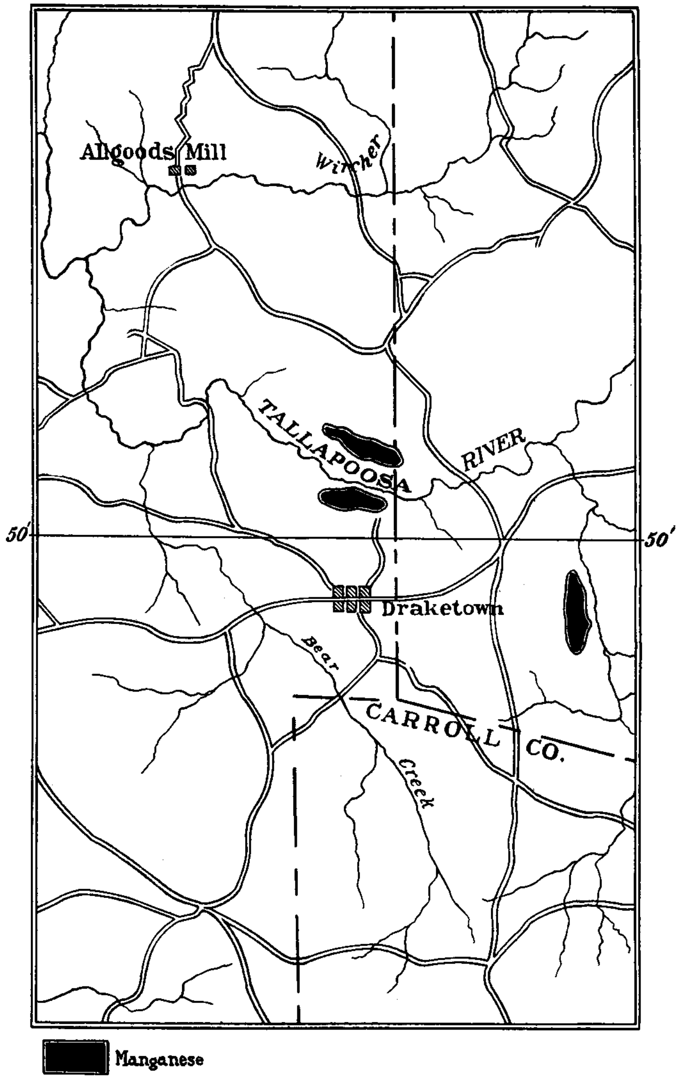


Fig. 12. Sketch map of the Draketown district, showing partial distribution of the manganese deposits, by Thomas L. Watson. *Based on the Tallapoosa topographic sheet, U. S. Geological Survey.*

The rocks of the Draketown district belong in part to the metamorphosed Paleozoic formations and in part to the ancient schists and gneisses of Archean time. The country rock is made up principally of gray micaceous schist, which may be differentiated into hornblendic and garnetiferous phases. These schists enclose ore-bearing formations of pyrites, magnetic iron, and manganese, all striking northeast and dipping southeast corresponding with the country rock.

The manganese and iron deposits are closely associated and occur in banded magnetitic quartzite which outcrops in two "leads" locally known as the "east vein" and the "west vein" about a mile and a half apart. The ore is a replacement deposit along the quartzite-schist contact. The source of the ore is to be found in the manganese oxide particles, the manganiferous magnetite, and to some degree in the garnets, all occurring in the quartzite.

The deposits on the Douglass property were prospected in the nineties, and have produced altogether only a few carloads of ore. The district has long been inactive with only intermittent prospecting going on in places.

DESCRIPTION OF INDIVIDUAL DEPOSITS

HARALSON COUNTY

DOUGLASS PROSPECTS

The Douglass manganese prospects are on lot 981, 19th district, 3d section, in the eastern part of Haralson County, 2 miles north of Draketown. This property is described by Watson[1] in his description of the Draketown Mining Company prospects. Other openings for manganese, also known as the Douglass prospects, which are included in this report in the properties of Paulding County, were described by Watson[2] as the Statham property.

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, pp. 184, 185, 1908.
[2] Idem, pp. 187-189.

The Douglass property in Haralson County is composed of the mineral rights on lots 978, 979, 980, east half of lot 981, and lots 982 and 983, owned by Capt. J. W. Douglass, Temple, Ga. The agricultural rights included by these lots are owned by several people. Lot 981, where all of the pits and shafts have been sunk, is owned by the estate of W. F. Goldin and by G. C. Goldin, J. E. Singleton, and B. F. Eaves. This property of 230 acres, including 5½ land lots of 40 acres each, is bounded on the east by Paulding County. The Buchanan-Dallas public road approaches it within a quarter of a mile on the north and the Draketown-Rockmart road forms its boundary on the east. Although Draketown, the center of the mining district, is only 2 miles to the south, the nearest point of rail transportation is Morgan Siding, a few miles west of Temple, on the Southern Railway. This necessitates, therefore, a haul of 8 or 9 miles from the mine over ordinary country roads.

The first work of opening the manganese deposits on lot 981 was probably done by James Tear,[1] who, together with several others, prospected the property under the name of the Draketown Mining Company. In 1896 or 1897, the company sank an incline and three vertical shafts, ranging in depth from 55 feet to 96 feet. Only eight tons of ore were shipped from the incline which followed the dip of the ore body, and the shafts were not much more productive. The Draketown Mining Company was succeeded in possession of the mineral rights by Maurice A. Stevens, of Lynn, Mass., and J. W. Douglass, the latter becoming sole owner in 1918.

The Douglass property in Haralson County has a rolling topography. The general elevation above sea level is about 1200 feet. Surface water drains southward a quarter of a mile to Tallapoosa River which follows a well-defined northwesterly course less than 100 feet lower than the prospects. The public roads are about half a mile to the north and east.

The country rock is decomposed at the surface, but exposures

[1] Capt. Douglass has kindly given the history of developments in this vicinity and has supplied information about the underground work, which was inaccessible in 1918.

made in prospecting on lot 981 show it to be a light-colored micaceous schist. The schist contains beds of dark gray quartzite, ranging in thickness from 4 to 10 feet, and corresponding in strike and dip to the country rock which is generally northeast and steeply southeast, respectively.

The quartzite, being comparatively fresh and resistant, forms distinct outcrops which serve as a guide in prospecting, since the ore occurs at the contact of quartzite and schist.

Three vertical shafts have been sunk, one on each of the three ore-bearing quartzites. What may be termed shaft No. 1 is farthest northwest. It is 96 feet deep, partially timbered, but filled with water and debris. It is reported that the ore deposit occurs with quartzite and vein quartz in a body 12 feet thick, extending from a depth of 56 feet to the bottom of the workings.

Two other openings were made southeast of No. 1. Shaft No. 2 is about 200 yards distant, was originally 40 feet deep, and still exposes the second quartzite formation, which also is shown in an outcrop nearby. The manganiferous iron deposit in the upper part of the shaft is 2 feet thick and underlies the quartzite. The strike is N.40°-50°E. and the dip ranges from 80°SE. to vertical.

Shaft No. 3 was 25 feet deep in the third quartzite outcrop, which is a couple of hundred yards east of the second lead. The ore at this opening is similar to that at No. 2, but leaner than at No. 1. The strike is N.25°E. and the dip 75°SE. to vertical.

The mineralogical character of the manganese at the Douglass prospects is not altogether distinct on account of the confusing gradations into manganiferous iron ore and the intimate mixture of siliceous impurities. The ore shows such differences in structure as finely granular, massive, compact, botryoidal, and globular. Very little crystallized manganese was observed. The greater part of the manganese is probably a mixture of pyrolusite and psilomelane.

The best grade of this ore seems to be very desirable, containing high manganese, little iron, and low silica, as shown by the analysis of the selected sample *Hu-122*. An average sample (*Crane-25*) collected by W. R. Crane from about 8 tons of ore in stock piles at shaft No. 1 shows low phosphorus, but high silica.

Analyses of manganese and manganiferous ore. Douglass prospects, Haralson County

Constituents	*Hu-122*	*Crane-25*
Silica (SiO_2) and insoluble	5.30	22.34
Alumina (Al_2O_3)	......	6.74
Moisture at 100°C	2.20	1.64
Manganese (Mn)	53.70	32.58
Iron (Fe)	1.23	6.27
Phosphorus (P)	......	0.056
Barium oxide (BaO)	......	1.51
Barium sulphate ($BaSO_4$)	......	0.00
Sulphur (S)	......	0.00

These analyses indicate a good grade of manganese ore, but the great mass of the deposit is so high in silica and so intimately mixed with it that thorough crushing and jigging would be necessary for the production of a shipping ore that would escape the penalties placed on high silica ore.

In the latter part of 1918, preparations for reopening the deposits were being made by the Expert Prospecting and Development Company, W. F. Aldrich, president, Birmingham, Ala. Ample water supply and plenty of standing timber are available. Tallapoosa River is about three-eighths of a mile distant.

MINOR PROSPECTS

A few other occurrences of manganese in the Draketown district and in different parts of Haralson County are here mentioned as being of some interest, but of little economic importance.

W. M. Raburn property.—W. M. Raburn owns lot 220, 7th district, 5th section, 2½ miles southwest of Temple.

Westbrook property.—W. A. Westbrook owns lot 189, 7th district, 5th section, about 2½ miles southwest of Temple.

Gober property.—F. T. Gober owns lot 995, 20th district, 3d section, 2 miles northwest of Draketown. This prospect, together with lot 997, is described by Watson[1] as the J. C. Westbrook property.

King property.—Lot 852, 20th district, 3d section, 2½ miles north of Draketown, is the property of T. R. King.

PAULDING COUNTY

DOUGLASS PROSPECTS

The Douglass manganese prospects of Paulding County are on lot 915, 19th district, 3d section, in the western part of the county, 2 miles north of Draketown.

In Bulletin No. 14[2] this property is described as the Statham property. The mineral rights on lot 915 and on half of lot 906 were acquired in 1918 by J. W. Douglass, Temple, Ga. The land, amounting to 60 acres, more or less, belongs to Edward Statham, whose residence is just west of the shafts. The prospects are on the north side of the public road a distance of 8 or 9 miles, by the way of Draketown, to the Southern Railway at Morgan, a siding a few miles west of Temple.

The surface in the vicinity of the Douglass prospects slopes gently northeast to a southward-flowing branch of Tallapoosa River. The elevation above sea level is about 1200 feet.

The geological formations are similar to those of the manganese deposits in Haralson County, just across the county line. Banded magnetitic quartzite appears as resistant outcrops in weathered mica schist which constitutes the mass of the country rock. The quartzite contains pyrite and garnet, and the schist is garnetiferous in places. The strike of both quartzite and schist is N.48°E., and the dip, 55°SE.

The ore deposit is at the contact of the quartzite and the mica

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, pp. 185-187, 1908.
[2] Idem, pp. 187-188, 1908.

schist. The quartzite forms the foot wall, dipping sharply southeast, and itself carries a considerable amount of iron and manganese.

The size of the deposit on the Statham property is known by the quartzite outcrops and the extent of the prospecting to be about 150 yards long, 8 to 12 feet thick, and at least 50 feet deep. The quality of the ore within these dimensions has a wide range of value, from magnetitic quartzite through manganiferous iron to high-grade manganese.

The ore from the original Statham shaft carries a markedly high percentage of manganese (see analysis of sample *Hu-126A*) and would require but little treatment before shipping, but the generally high content of intimately mixed silica which seems peculiar to the Draketown deposits would necessitate fine crushing and jigging for the greater part of the Douglass manganese ores. Besides the partially crystalline and massive types of manganese, there occur small lenses of ore, called "kidneys." They are commonly several inches thick in the center and a foot or more long. Their exterior is a shell-like layer, half an inch to 3 inches thick, composed of hard siliceous limonite. The inner mass of these "kidneys" is less compact, but much richer in manganese, being composed of bluish-black pyrolusite and impure psilomelane.

Several analyses of specimens from the Douglass prospects are given in the following table:

Analysis of manganese ore and specimens from the Douglass prospects, Statham property

Constituents	*Hu-128*	*Hu-129*	*Crane-24*	*Hu-126A*	*Hu-129A*	*Hu-129B*
SiO_2	....	....	....	5.54	9.96	trace
SiO_2 and insoluble	44.00	44.10	23.76	....	....	....
Al_2O_3	....	....	12.22	....	....	....
Fe_2O_3	....	....	....	....	....	97.78
FeO	....	....	....	....	....	1.43

Constituents	*Hu-128*	*Hu-129*	*Crane-24*	*Hu-126A*	*Hu-129A*	*Hu-129B*
Moisture	0.75	0.82	1.14	0.99	1.20	....
TiO_2	....	....	....	0.02	none	0.72
Mn	24.85	5.55	32.08	49.74	15.83	....
Fe	3.13	29.12	2.80	1.60	16.68	....
P	....	0.094	0.113	0.06	0.084	....
Cu	0.106	....	....	....	....	....

Hu-128.—Cross section through a ''kidney'' of ore as it occurs in the ''clay'' overlying the quartzite at the Oak shaft. Sample taken from stock pile, July 30, 1917.

Hu-129.—Manganiferous quartzite as it is reported to occur at depth of 50 feet in Oak shaft. Sample from dump, July 30, 1917.

Crane-24.—Average sample of all stock piles on lot 915, collected by W. R. Crane, June 14, 1918.

Hu-126A.—Sample of manganese ore collected March, 1918, by L. S. Rakestraw, R. F. D., Temple, Ga. Represents thickness of 3½ feet near Statham shaft.

Hu-129A.—Manganiferous ore collected by L. S. Rakestraw, to represent thickness of 7½ feet in prospect pit dug by him in February and March, 1917. From pit 10-12 feet deep northeast of Oak shaft.

Hu-129B.—Hematite laminae in vein quartz, collected by L. S. Rakestraw.

All of the development work done at the Douglass prospects has been within a distance of about 200 yards along the northeast strike of the quartzite, extending from the road at Edward Statham's house to the northeast part of lot 915. Within this distance seven shafts and pits have been dug to depths ranging from 12 to 50 feet. These openings have produced seven or eight carloads of ore, six of which were shipped in 1896 or 1897. In the latter part of 1918, preparations for reopening the deposits were being made by the Expert Prospecting and Development Company, W. F. Aldrich, president, Birmingham, Ala.

MINOR PROSPECTS

Besides the Douglass prospects, there are several properties in the Draketown district, in Paulding County, which are known to have manganese deposits. A few of these are here mentioned.

Kirk property.—In lots 913, 914, and 977, 19th district, 3d section, 2 miles north of Draketown, W. L. Kirk owns 80 acres near the Douglass prospects.

Allgood property.—C. D. Allgood owns lot 905, 19th district, 3d section, about 2½ miles north of Draketown.

Crowley property.—James L. Crowley owns lot 966, 19th district, 3d section, half a mile north of Embry.

OTHER PROSPECTS IN PAULDING COUNTY

Outside of the Draketown district there are few manganese prospects of importance in Paulding County. The two principal properties are briefly described in the following pages.

Cochran property.—W. L. Cochran, jr., owns lot 300, 3d district, about 2 miles north of Huntsville on Burnt Hickory Ridge in the northern part of Paulding County. The locality is 10 miles south of the Cartersville mining district and about 12 miles north of Dallas, the county seat of Paulding. The deposits are less than a quarter of a mile south of Cochran's house and the public road.

As opened in June, 1918, the workable ore seemed to be deposited in irregular bodies or pockets several feet long in the quartzite or at its contact with vein quartz. These replacement masses may be continuous and workable for a length of 50 or 100 feet along the strike of the quartzite, but this has not yet been demonstrated. At some places, magnetite is predominant over manganese, and much of the ore contains a large amount of silica so closely mixed with manganese that careful crushing and jigging would be necessary to produce a shipping ore. At the four prospect pits on lot 300, a carload of fair-grade manganese ore is in sight and in all probability many tons of first class ore are on the property.

An average sample of several tons of ore raised during the prospect work was collected by W. R. Crane and the following analysis shows the quality of ore that may be obtained without concentrating. Many of the better specimens contain more than 40 per cent of manganese.

Analysis of ferruginous manganese ore, W. L. Cochran property. Average stock pile sample. (Crane-37)

Silica (SiO_2)	19.74
Alumina (Al_2O_3)	7.21
Moisture at 100°C	3.07
Manganese (Mn)	33.57
Iron (Fe)	5.26
Phosphorus (P)	0.089
Barium oxide (BaO)	1.56
Barium sulphate ($BaSO_4$)	0.00
Sulphur (S)	0.00

The general geological conditions on the Cochran property are somewhat similar to those in the Draketown district in so far as the ore occurs in association with a narrow magnetitic quartzite formation in an area of more or less decomposed micaceous schist. The strike is N.75°E. and the dip 70°SE., in conformity with the highly metamorphosed country rock.

Four pits not more than 6 feet deep expose the ore-bearing formation in an open field on the northwest side of a small stream which flows southwest into Dry Creek, which in turn flows northwest to Raccoon Creek, a tributary of Etowah River. The average elevation above sea level is about 950 feet. Less than a quarter of a mile northeast of the four pits, another small opening shows the continuation of the "lead." Quartzitic float contains radiate clusters of a rather decomposed mineral, probably actinolite. The rock in the pit is largely hornblendic and the occurrence of manganese is limited to fracture-filling and stain along slipping planes. Microscopic examination of a thin section of this hornblendic rock (*Hu-379*) reveals an abundance of tiny pale-colored garnets intimately scattered alike through the shattered blade-like crystals of partially decomposed hornblende, and the finely crystalline quartzite.

Estes property.—Lot 611, 19th district, 3d section, about 3 miles north-northeast of Embry, belonging to C. D. Estes, was not visited by the writer. The deposit is described as the Folsom property by Watson.[1]

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, pp. 89-90, 1908.

TUNNEL HILL DISTRICT

The Tunnel Hill district, including the station of Tunnel Hill, on the Western & Atlantic Railroad, which is south of the principal deposits, is 4 miles long and half a mile wide. It extends from Tunnel Hill in the northwestern part of Whitfield County, north-northeastward along the eastern part of Catoosa County. The topography and geology are similar to those features of the Cave Spring district. They are discussed in the description of the Fox and Dowler property, which is almost co-extensive with the Tunnel Hill district.

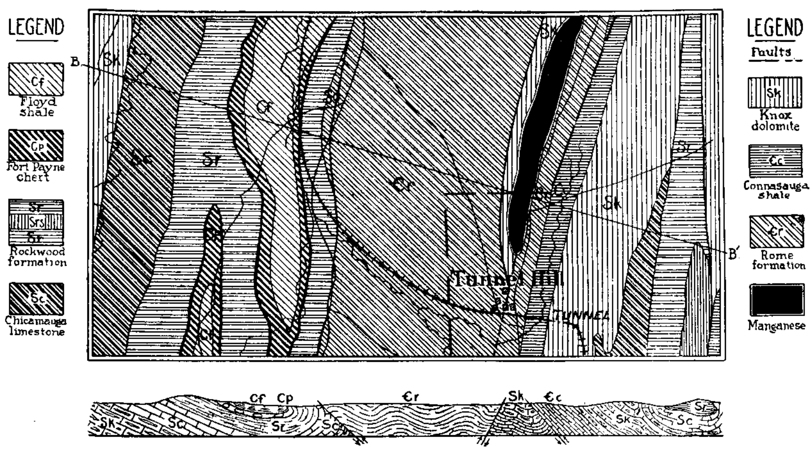


Fig. 13. Geological map of the Tunnel Hill district, showing distribution of the manganese deposits, by Thomas L. Watson. *Based on the Ringgold folio, U. S. Geological Survey.*

The district was worked for manganese from 1890 to 1893, and the mines were reopened in 1918. Probably little more than 100 tons of manganese and manganiferous ore have been shipped from the whole district. The principal mines are those on the Fox and Dowler property.

CATOOSA COUNTY

FOX AND DOWLER PROPERTY

W. H. Fox and F. H. Dowler, of Chattanooga, Tenn., own 730 acres in the following 160-acre lots: 215, 218, 251, 254, 289, and 290, and the mineral interest in lots 286 and 287, all in the 11th district, 3d section, Catoosa County. In 1918 the property was being prospected by R. E. Holley, 4021 Prairie Avenue, Chicago, Ill. The main openings are 2 and 3 miles respectively north-northeast of Tunnel Hill, a station on the Western & Atlantic Railroad in Whitfield County.

The Fox and Dowler property was owned and worked by the Catoosa Mining Company[1] from 1889 to 1893. In describing the property and the early work Watson says in part: "Less than 30 cars of manganese and manganiferous iron ores were shipped from this property, which represented the total shipment of manganiferous ores from the entire district. . . The Catoosa Mining Company has made a large number of extensive openings which extend over a distance of about 2 miles in a northeast direction. A manganese plant, equipped with the necessary modern machinery, was built and several miles of railroad laid to the openings for conveying the ores to the mill."

The topography of the property is the ridge-valley type, in which the local relief is about 150 feet. The ridges trend north-northeast and rise to elevations of more than 1000 feet above sea level. The drainage of the valleys is both northeastward and southwestward to Chickamauga Creek and East Chickamauga Creek respectively, which cut through the northeasterly ridges and flow generally northwest to form South Chickamauga Creek.

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia. Geol. Survey of Ga. Bull. 14, pp. 140-143, 1908.

The formation in which the ore deposits occur is the Knox dolomite, which has weathered deeply and formed a residual mantle of reddish-yellow and gray clays containing many fragments of chert. In places the chert is near the surface in a much fractured and fragmental condition; in others the depth of decay has been found as great as 210 feet.

The ore deposits are along a zone of fault contact between the Knox dolomite and the Rome formation, though the debris and unconsolidated ore-bearing material seem to come predominantly from the cherty dolomite. The ores resemble those of the Cartersville district, including "soft chemical," granular, gravelly, nodular, and vesicular types containing manganese oxide in different degrees of purity.

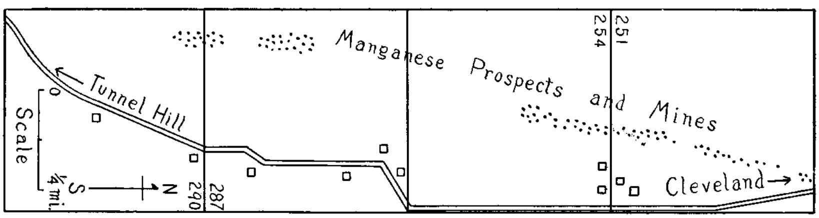


Fig. 14. Sketch map of a part of the Fox and Dowler property near Tunnel Hill. *From blue print loaned by R. H. Fox.*

In the summer of 1918, prospecting and mining work was being done on lots 254 and 290. On lot 254, on the ridge about a quarter of a mile west of the public road, an adit was driven many years ago into the chert formation. It extends about 160 feet S.50°W., almost the whole distance in barren yellow clay and shattered chert. At the entrance of the adit there is an open cut 80 feet long, 10 to 20 feet wide and 10 feet deep. This opening contains a good showing of manganese oxide, though a considerable part of it is mixed with clay and chert breccia. This siliceous ore was being dry mined in 1918 and some of it was shipped. Low-grade cherty ore seems to predominate. Crushing and jigging would be necessary to produce high-grade ore from this material.

The following analysis represents an average sample collected from a 6-foot working face near the entrance of the old adit on lot 254. It includes everything from top to bottom of the cut,—clay, chert, and ore.

Analysis of manganese ore deposit. Average of 6-foot face. Fox and Dowler property

	Hu-390A
Silica (SiO_2)	46.23
Alumina (Al_2O_3)	3.46
Iron (Fe)	5.04
Moisture at 100°C	0.83
Manganese (Mn)	23.54
Phosphorus (P)	0.50
Barium oxide (BaO)	1.02
Barium sulphate ($BaSO_4$)	0.37
Sulphur (S)	0.00

On the west side of lot 287, which is just south of lot 254 and on the same ridge, are a number of old pits and shafts that represent some of the most extensive development work done by the Catoosa Mining Company about 1892. The deepest of these former workings is said to have been 225 feet deep.[1] This was a vertical shaft with three levels extending eastward to the ore body,—at 75 feet, 150 feet, and 225 feet. The first level extended about 70 feet east to the ore body; the second level extended at least 100 feet east to the ore body; and the third level extended east and was about 300 feet long, including drifts northeast and southwest in the ore. The work indicates that the ore body dips 40° to 50° with the general east-southeast slope of the ridge. The mouth of the shaft, in the bottom of a small open cut, is filled but it is said that the workings were timbered and the shaft was sealed at the first level. High-grade manganese ore is reported to have been mined at this place.

In the northwest corner of lot 290 and in the southwest part of

[1] Information about this work of the Catoosa Mining Company was kindly furnished by Col. G. W. Head, Tunnel Hill, 1918. Colonel Head examined the underground work when it was being done about 1892.

lot 287, open-cut dry mining was being carried on in a small way in 1918. Several old pits, trenches, and shafts still remain in a caved condition from former operations. Fragments remaining from old dump and stock piles indicate a deposit of mixed high-grade manganese and manganiferous iron ore in a fractured chert formation. Some nodules contain as much as 40 per cent of manganese, but much lower grades predominate. Manganese nodules grading outward to a limonite rim are common. Such samples (*Hu-398B*) evidently represent replacement of the dolomite by manganiferous solutions. Other ore fragments (sample *Hu-398A*) clearly show rather pure manganese oxide as vein- or fracture-filling, having been deposited as finely stalactitic psilomelane growing from both walls and meeting in the middle of a fracture about three-quarters of an inch wide.

The few tons of manganiferous ore shipped from lot 290 in 1918 were rather high in silica and low in manganese, but contained a fair percentage of iron.

The ores on the Fox and Dowler property, as they appear in the surface workings, will require crushing and jigging to separate the large quantity of chert that is mixed with both manganese and manganiferous iron ores.

VARNELL-COHUTTA DISTRICT

The Varnell-Cohutta manganese district is about 9 miles long and a mile wide. It extends from a point between Waring and Varnell northward, east of Cohutta, to the Georgia-Tennessee state line east of Red Clay. The district is in the northwestern part of Whitfield County. North-northeastward across the state line the same formations and deposits continue into Bradley County, Tenn.

Although the topographic feature of this district is the north-northeasterly ridge of low hills, the major drainage is southeastward across the trend of the ridge to Coahulla Creek. The elevation of the principal ridge ranges from 900 feet to 1000 feet above sea level and from 100 to 200 feet higher than the level of the adjacent valleys.

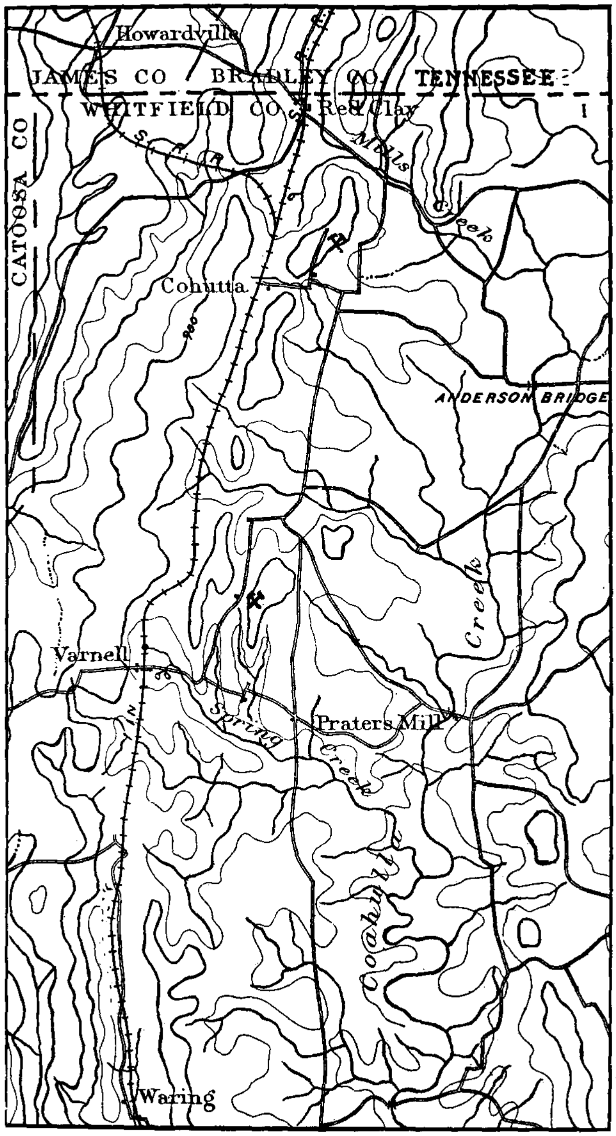


Fig. 15. Map of the Varnell-Cohutta district, showing location of the two principal manganese mines. *From the Dalton topographic sheet, U. S. Geological Survey. Contour interval 100 feet.*

The Southern Railway follows the west side of the ore-bearing ridge.

The rocks of the district are Cambrian and Ordovician formations, including the Knox dolomite, Holston marble, and Tellico sandstone, named in ascending order. The Holston marble outcrops in the valleys and the Tellico sandstone forms the low broken hills mantled with red soil. The general strike is north-northeast parallel to the folding and faulting. The Tellico formation contains red calcareous sandstone and siliceous limestone. It unconformably overlies the Holston marble. Both formations contain pelmatozoans, bryozoans, and other Paleozoic fossils.

The ores are massive hematite and psilomelane probably formed in more or less connected beds or replacement deposits concentrated in the lower calcareous layers of the Tellico formation. No fresh samples of the sandstone were secured, but the Holston marble showed, on analysis, 0.12 per cent of manganous oxide.

The occurrence of iron and manganese ore was known in the Varnell-Cohutta district many years ago, but no extensive prospecting and mining was undertaken until 1918. Small shipments of unusually high-grade manganese ore have been made from Varnell and Cohutta.

WHITFIELD COUNTY

LANSKI PROPERTY

Samuel Lanski, 110 S. Dearborn Street, Chicago, Ill., owns 1,065 acres in lots 169, 170, 172, 189, 190, and 191, 11th district, 3d section, northwestern Whitfield County. The property was formerly known as the Williams-Segers land and lot 191 was locally known as the Joseph Spann lot. In the summer of 1918 G. M. McKinney had charge of the prospecting and mining on the Lanski property. The principal work was being done on lot 191, a mile and a half northeast of Varnell on the Southern Railway (Chattanooga, Cleveland, and Brunswick division).

The chief features of the topography are the long, somewhat broken ridges trending north-northeast and rising to an elevation of more than 1000 feet above sea level and 100 to 200 feet above the valleys. The property is drained south and southeast through Spring Creek and other small streams to Coahulla Creek, which flows south to Conasauga River.

The higher ridges are made up of chert mantled by yellow and gray soils, but the lower manganese ore-bearing ridge is characterized by a deep-red surface soil underlain by calcareous sandstone and marble. The ore deposit is in the ferruginous red soil produced by the weathering of the calcareous portions of the Tellico sandstone overlying the Holston marble.

On the east side of lot 191 and on the west slope of the hill a few hundred yards east of the public road, an open-cut has been made in the red soil at least 18 feet deep. The ore occurs as irregular masses and blocks, in places several feet thick. Two kinds of ore are mined from the same deposit: (1) red iron ore, hematite, and (2) manganese ore, mostly psilomelane. Each is exceptionally pure, being free from both chemical and mechanical impurities. The following analyses indicate the high grade of these ores.

Analyses of manganese and iron ores. Lanski property

Constituents	*Hu-386A*	*Hu-386B*
Silica (SiO_2)	6.97	4.77
Alumina (Al_2O_3)	1.36	1.47
Iron (Fe)	9.74	61.22
Lime (CaO)	......	0.03
Moisture at 100°C	0.72	0.34
Manganese (Mn)	43.11	1.24
Phosphorus (P)	0.062	0.123
Barium oxide (BaO)	5.19	......
Barium sulphate ($BaSO_4$)	0.00	......
Sulphur (S)	0.00	......

A. OPEN-CUT AND MANGANESE ORE IN PILE AT SIDE OF CUT. LANSKI MINE NEAR VARNELL, WHITFIELD COUNTY.

B. OPEN-CUT EXPOSING MARBLE AT THE COHUTTA NO. 2 MINE OF THE GEORGIA-TENNESSEE COAL & OIL COMPANY NEAR COHUTTA, WHITFIELD COUNTY.

Hu–386A.—Manganese ore. Hard lump psilomelane. Average sample of about 10 tons in stock pile, July, 1918.
Hu–386B.—Iron ore. Hard lump hematite. Average sample of about 10 tons in stock pile, July, 1918.

It is reported that some specimens of manganese ore from this lot contain 57.50 per cent of manganese.

In July, 1918, the open-cut work had not reached the underlying rock, but outcrops of marble in the vicinity show a strike N.20°E. and a dip 45°SE. All the work done was of the dry mining type, as washing methods are quite unnecessary to clean the ore for shipment.

As the occurrence of the ore is rather irregular and scattering in the unconsolidated red soil, a large quantity of overburden and enclosing dirt has to be removed.

The depth to which the ore extends depends largely on the depth to the Holston marble, which generally forms the floor of the deposit. In some places it outcrops in the red soil, in other places it is 30 or 40 feet deep.

CHICAGO-TENNESSEE COAL & OIL COMPANY

The Chicago-Tennessee Coal & Oil Company, 805 Steger Building, Chicago, Ill., owns a 210-acre tract of land containing manganese and iron ore deposits at Cohutta about 3 miles south of the Georgia-Tennessee state line. The manganese deposit was being worked in 1918 on lot 60, 11th district, 3d section, Whitfield County. The prospecting and development work was in charge of J. W. Flannery.

The open-cut manganese mine on the north side of lot 60 is known as Cohutta No. 2, the No. 1 mine being an opening for brown iron ore on lot 81 about a mile west of Cohutta. Cohutta No. 2 is on the east side of a public road a mile northeast of Cohutta. The main highway between Dalton, Ga., and Cleveland, Tenn., is a few hundred yards east of the mine, but the entrance is from the road passing west of the mine. The property formerly belonged to W. M. Rogers, Cohutta, and is locally known as the Rogers place. Cohutta is a station on the Southern Railway (Chattanooga, Cleveland, and Brunswick Division) about 12 miles north of Dalton.

The north-northeast trending ridge that contains the ore deposits is about 100 feet higher than the adjacent valleys, but, as its slopes are generally gentle and partially cultivated, it presents a rolling topography of the low ridge-valley type. Drainage is northeastward to Mills Creek, which flows southeastward across the trend of the hills to Coahulla Creek.

The geologic formations represented on lot 60 are typical of the Varnell-Cohutta manganese district. The ore-bearing ridge is composed in the main of Holston marble overlain by the red ore-bearing soil representing the decay of the calcareous portions of the Tellico sandstone formation. The strike is N.20°E. and the dip 45°SE.

The ore occurs as irregular fragments and slabs of hematite and massive psilomelane ranging from a few inches to a few feet in thickness. Both kinds of ore show bedding planes and not uncommonly contain fragmental fossil imprints. The loose ore-bearing material is 5 to 10 feet deep and grades downward into more or less stratified dark red to brownish-black unconsolidated material overlying the marble. It is interstratified in places with thin yellow clay-shale layers. It is highly ferruginous (see analysis of sample *Hu-387B*) and is shipped as manganiferous iron ore, being locally known as "soft ore," "black dirt," or "black sand." The richest part of the "black dirt" is 4 or 5 feet thick.

The red hematite ore is almost as abundant as the manganese and its quality is the same high grade as that found everywhere along the manganese belt of the Varnell-Cohutta district. The following analyses show the grade of two types of ore being mined at Cohutta No. 2:

Analyses of manganese and iron ore. Cohutta No. 2 Chicago-Tennessee Coal & Oil Company

Constituents	*Hu-387A*	*Hu-387B*
Silica (SiO_2)	6.52	17.13
Alumina (Al_2O_3)	2.70	8.46

Constituents	*Hu–387A*	*Hu–387B*
Iron (Fe)	5.60	42.56
Moisture at 100°C	1.10	1.00
Manganese (Mn)	44.76	4.31
Phosphorus (P)	0.145	0.313

Hu–387A.—Manganese ore. Hard lump psilomelane. Average sample of about 7 tons in the stock pile, July, 1918.

Hu–387B.—Iron ore. ''Black dirt.'' Sample from several places in the open-cut, July, 1918.

In July, 1918, ore was being mined from an open-cut 150 feet long, 40 feet wide, and 20 feet deep. Dry mining methods were used, the overburden being removed by teams with scrapers after the soil was loosened by plowing. The cut extends eastward into the hillside and exposes the marble about 50 feet thick dipping 45°SE.

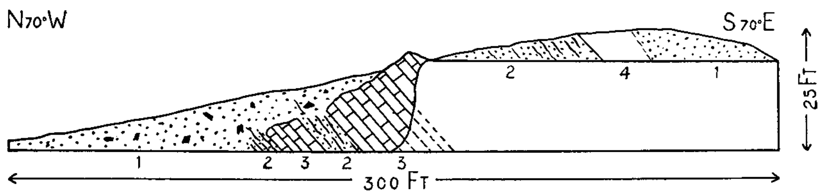


Fig. 16. Section in Cohutta No. 2 manganese open-cut, showing (1) red, ore-bearing clay, (2) interbedded ferruginous sandy clay and yellow clay-shale, (3) marble, and (4) yellow clay.

The hard ore needs no washing to clean it for shipment. The soft ''black dirt'' occurs in a rather distinct body overlying the marble and can be removed as a unit by stripping. The hard manganese ore may constitute about half of the ore in the deposit. It is exceptionally high grade but on account of its occurrence in blocks scattered throughout the formation, a large quantity of loose red soil overburden has to be handled.

A few carloads of both hard manganese ore and soft manganiferous ore have been shipped. The ore is hauled in motor trucks to the railroad at Cohutta.

MINOR PROSPECTS

Ferruginous soil and ore fragments occur throughout the length of the Varnell-Cohutta district and the presence of manganese ore is probable at all places in the "iron limestone" strip of the Holston marble and Tellico sandstone, though it is not always shown by fragments on the surface.

Eslinger property.—Lot 242 and part of lot 227, 11th district, 3d section, owned by J. W. and E. O. Eslinger, and part of lot 243, 11th district, 3d section, Whitfield County, owned by J. W. Eslinger, have indications of ore. Pellets and nodules of manganese oxide occur in the ferruginous red soil, together with fragments of fossiliferous red hematite. This property is about a mile east of Varnell.

Bare property.—Lot 206, 11th district, 3d section, Whitfield County, is part of the property owned by W. D. Bare of Varnell. Lot 206 is on the "iron limestone" ridge a mile east of Varnell and joins the south side of lot 191, where the Lanski manganese mine was opened.

A sample of the hematite ore (*Hu-389*) contained 53.87 per cent of iron and .032 per cent of phosphorus. On the west side of the lot, manganese oxide fragments in the road cut showed upon analysis (sample *Hu-395*) 13.22 per cent of manganese, 40.17 per cent of silica, 7.76 per cent of iron, and 0.168 per cent of phosphorus. No prospecting has been done.

DOOGAN MOUNTAIN DISTRICT

The Doogan Mountain manganese district comprises the area occupied by Doogan Mountain in the northern part of Murray County south of the Georgia-Tennessee state line. Its greatest length is about 5 miles, extending from the vicinity of Cisco on the Louisville & Nashville Railroad northeastward to Iron Mountain. Conasauga River bounds the district on the southeast, east, and north and its branches also drain the south and west portions of the area. The highest part of Doogan Mountain is 2125 feet above sea level, or approximately 1100 feet higher than the lowest point on Conasauga River in the district.

The rock with which the ore deposits are associated is quartzite similar to the Weisner quartzite of the Cartersville district. Outcrops generally correspond in strike to the trend of the main ridges, northeast. The dip is southeast as a rule. The ore deposits occur in residual yellow clay overlying quartzite which is commonly stained and permeated with limonite. Several types of ore are found, but manganiferous iron ore and the brecciated types of ferruginous manganese constitute a large part of the deposits.

Both iron and manganese ores were long ago prospected in the Doogan Mountain district, but very little ore has been mined and shipped. In 1918 the Southern Manganese Corporation of Birmingham, Ala., was mining on the Green property north of Doogan Postoffice.

MURRAY COUNTY

GREEN PROPERTY

A. H. Green, of Doogan, owns lots 163, 165, and 196, 27th district, 2d section, northern Murray County. The manganese ore deposits that were being worked in 1918 are on lot 196 about half a mile in an air line north of Doogan Postoffice. The deposits on this 160-acre lot are leased to the Southern Manganese Corporation, of Birmingham, Ala.

The elevation of the mine is about 1300 feet above sea level and 350 feet higher than Conasauga River, in the Alaculsy Valley, half a mile southeast of the mine. The opening is in the western part of a gap which drains west and northeast and is about 100 feet lower than the top of the hill north of it. The mine is connected with the valley by a road which leads generally eastward down the mountain a mile or more to Conasauga River, where a lumber railroad follows the river 11½ miles to Conasauga, Tenn., on the Louisville & Nashville Railroad.

The deposit is in yellow clay, which covers the hillside and contains fragments of quartzite. No outcrops of rock occur near the mine, but quartzite exposed in places northeast over the hill possesses features not unlike the quartzite of the Cartersville district. The ore body occupies a position corresponding in general to the slope of the hill and strikes about N.65°E. and dips steeply southeast.

The ore is largely manganiferous iron ore though some high-grade manganese oxide nodules and fragments occur in the yellow clay. The ore contains both high iron and phosphorus as shown by the following analyses:

Analyses of manganiferous iron ore. Green property

Constituents	*Crane–44*	*Hu–383*
Silica (SiO_2)	36.20	11.84
Alumina (Al_2O_3)	14.70	10.76
Iron (Fe)	18.34	23.87
Moisture at 100°C	0.49	0.77
Manganese (Mn)	4.39	17.07
Phosphorus (P)	0.738	1.245
Barium oxide (BaO)	......	0.49
Barium sulphate ($BaSO_4$)	......	0.00
Sulphur (S)	......	0.00

Crane–44.—Manganiferous ore deposit. Analysis of average sample collected from all parts of the open cut. Collected by W. R. Crane, July, 1918.

Hu–383.—Ferruginous manganese ore. Analysis of average sample representing about 30 tons of ore after hand sluicing and ready for shipment. Collected July, 1918.

In July, 1918, the open-cut extended 50 feet northwest into the hill; then 50 feet southwest. It was about 8 feet wide and 15 feet deep. It has since been considerably enlarged and several hundred tons of ore removed. Then or twelve test pits and trenches within an area of two or three acres show limonite and manganiferous iron ore in fair quantity.

POWELL PROPERTY

F. A. Powell of Atlanta owns lots 236 and 237, 27th district, 2d section, Murray County. This property extends along the ridges and steep narrow valleys from a point about a mile northeast of Doogan Mountain to a point half a mile south of the Georgia-Tennessee state line. The ore deposits have been opened on the steep slopes and on the top of a quartzite ridge that is 1750 feet above sea level. Drainage is northward to Conasauga River.

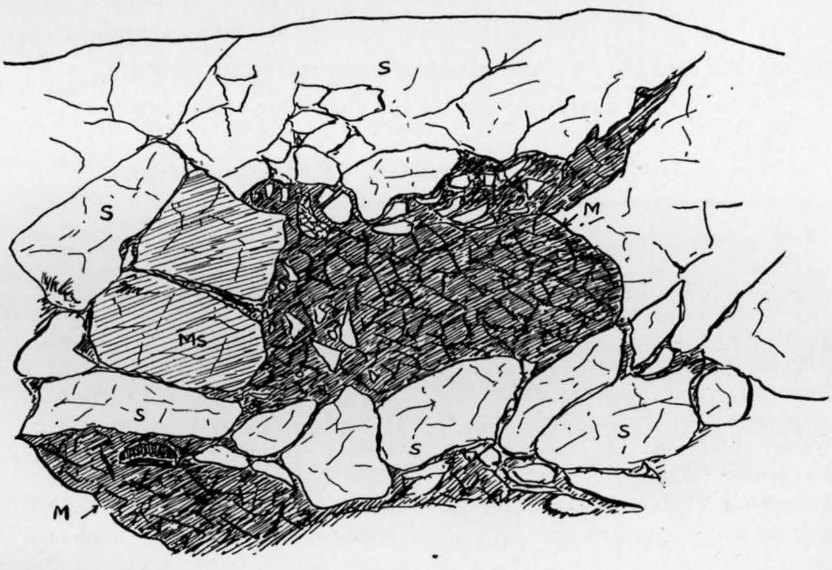


Fig. 17. Face of open-cut showing occurrence of the breccia ore. M is manganese. Ms is manganese stain. S is quartzite. Powell property, Doogan Mountain. *Sketch by W. R. Crane.*

The rock is quartzite, generally much fractured and permeated with iron and manganese oxides. It is exposed on the ridges and shows various strikes and dips. The slopes are covered with yellow and reddish siliceous clay which contains small accumulations of brown iron and manganese ore mixed with numerous quartzite fragments.

The most recent work was done on lot 237 on the divide between the north and the south drainage, where a part of the ridge extends east and west about a quarter of a mile.

Several open-cuts penetrate the soil mantle to the ore-bearing clay and quartzite. One of these cuts is 35 feet long, 20 feet wide, and 8 feet deep. It exposes a working face in broken and fractured quartzite in which manganese occurs as soft, partially crystallized pyrolusite filling irregular fractures in places a foot thick. The ore is also in the form of a thin crust on angular quartzite blocks and as massive fragments in the loose soil. Stalactitic manganese also permeates the decayed quartzite. Brown iron ore, however, is more abundant than manganese and the two are mixed as manganiferous iron ore.

The following analyses indicate the character of the ore.

Analyses of manganese ore. Powell property

Constituents	*1*	*2*	*Hu-392A*
Silica (SiO_2)	1.21	4.20	9.84
Alumina (Al_2O_3)	trace	0.38	11.36
Iron (Fe)	0.84	54.54	21.88
Moisture at 100°C	......	......	1.47
Water (combined)	4.86	18.62	......
Manganese (Mn)	54.36	5.91	22.92
Phosphorus (P)	0.76	0.45	0.502
Sulphur (S)	none	0.92	......

1, 2.—Manganese ore and manganiferous iron ore, respectively. Analyses made in 1896 by William H. Bowron and furnished the Survey by F. A. Powell.

Hu-392A.—Manganese ore deposit. Analysis of average sample representing a 5-foot ore face, collected in two places 5 feet apart. Sample did not include fragments of barren quartzite occurring in the working face. Collected from open cut on lot 237, July, 1918.

An efficient working of the deposits would require blasting, crushing, and jigging, operations which would be too expensive in view of the rather limited size of the ore body and somewhat inaccessible situation of the property. The lumber railroad and Conasauga River, however, are only a mile and a half north of the deposit here described and 900 feet lower.

MINOR PROSPECTS

Silver property.—W. J. Silver owns 80 acres in the east half of lot 301, 27th district, 2d section, Murray County. The property is north of the Cisco-Doogan public road, 1¾ miles east of Cisco. Some limonite and manganiferous iron occur as small fragments and fracture-filling associated with yellowish-brown sandy shale and gray quartzite on the mountain slope at an elevation approximately 1200 feet above sea level and 150 feet or more higher than the road and the small stream. The indications for a workable deposit of either iron or manganese are not favorable. The quartzite strikes N.80°E. and stands on end, though variations occur.

White property.[1]—Lot 276, 27th district, 3d section, Murray County, known as the Henry White property, joins the east side of the Silver lot. According to the records, the Murray County Mining Company, A. A. Raught, Chattanooga ,Tenn., has possession of this property. The indications for manganese ore are unfavorable, the conditions being similar to those on the Silver lot.

Head property.[2]—James W. Head owns 320 acres in lots 266 and 275, 27th district, 2d section, Murray County. This property is on the same quartzite ridges of Doogan Mountain as are the Silver and White lots. Some prospecting has been done, but there is little probability of workable manganese ore being found.

Miller property.—Lot 267, 27th district, 2d section, known as the Lynch lot, is north of the east Head lot (No. 266). It belongs to Miller Brothers, of Chattanooga, Tenn. This property has an elevation about 1500 feet above sea level, three-quarters of a mile east of the highest peak of Doogan Mountain. Some outcrops of limonitic quartzite and low-grade manganiferous iron ore have been prospected on the south part of the lot.

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, pp. 177, 178, 1908.
[2] Idem, p. 178.

ISOLATED DEPOSITS

In addition to the deposits grouped in distinct mining districts, or situated in the same county with a district, as described in the preceding pages, there are a number of manganese deposits that occupy more or less isolated and scattered places throughout the Appalachian Valley and the Piedmont Plateau provinces.

Small deposits that occur near Sweetgum and Blue Ridge, Fannin County, near Cherrylog, Whitepath, and Ellijay, Gilmer County, and west of Jasper, Pickens County, may be classed together as localized manganiferous deposits associated with micaceous schists along the western border of the crystalline rocks of the Piedmont Plateau.

The isolated deposit near Hiwassee, Towns County, is probably genetically related to the hornblendic rocks.

The occurrences of ore near Mount Airy, Habersham County, and near Bowersville, Hart County, are probably the result of local concentration from manganese-bearing minerals in the mica schist.

Near Lincolnton, Lincoln County, and near Union Point, Greene County, manganese deposits of workable size doubtless owe their origin in part to the alteration of rocks bearing manganiferous garnets and other original manganese-silicate minerals.

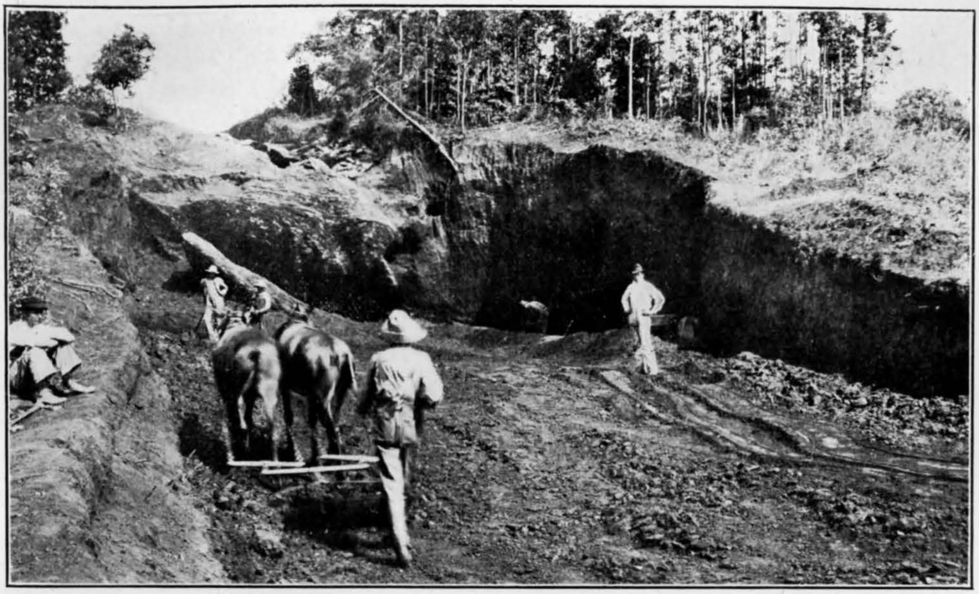
FANNIN COUNTY

Manganese in Fannin County is not abundant as an ore, but it occurs in association with brown iron ore, or limonite, at many places along faults in the metamorphosed Paleozoic formations which extend in a northeasterly direction through the central part of the county. Manganese deposits have been worked near Blue Ridge and Sweetgum.

McKINNEY PROPERTY (BLUE RIDGE PROPERTY)[1]

The McKinney property is in the southern part of the town of

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, pp. 179-181, 1908.
This property was not visited by the writer, but it was examined in September, 1918, by S. W. McCallie, State Geologist, whose notes were used in this description.



A. MANGANESE-BEARING RESIDUUM OVERLYING MARBLE AT THE CHICAGO-TENNESSEE COAL & OIL COMPANY'S COHUTTA NO. 2 MINE NEAR COHUTTA, WHITFIELD COUNTY.

B. OPEN-CUT OF THE CHEROKEE MINING COMPANY'S MINE NEAR BLUE RIDGE, FANNIN COUNTY.

Blue Ridge, on the Louisville & Nashville Railroad. The deposits of brown iron ore were worked many years ago and it is said that large shipments were made. In the spring of 1918, the Cherokee Mining Company of Salisbury, N. C., E. L. Hertzog, president, and F. W. Padgett, local manager, began producing manganese ore at the old open-cuts.

Blue Ridge is on a low divide separating the northeast drainage to Toccoa River from the southwest drainage to Ellijay River. The elevation above sea level is 1751 feet, about the same as that at the mines. The topographic feature is the northeast-southwest trend of the ridges and valleys. The rocks are Cambrian sediments generally striking N.25-30° E. and dipping steeply southeast.

The extent of the ore deposit is probably rather limited. Watson[1] states that the zone of manganese-bearing clay does not exceed 20 feet in width as a rule, but that the jaspery quartz overlying the deposit is traced for a considerable distance north of the open cuts through the town of Blue Ridge. In September, 1918, the deepest excavations were about 50 feet deep.

The ore is mostly of the "gravelly" type with some concretionary and stalactitic forms. It occurs as pockets and veins in the clay, schist and slate. The foot wall is sandstone or quartzite striking N.25°E. and dipping 50-90°E. One small shaft is equipped with hand windlass and bucket. Altogether about 20 men are employed.

Since March, 1918, several carloads of ore containing about 34 per cent of manganese have been shipped. An analysis of a selected specimen is here given.

Analysis of manganese ore. McKinney property

Silica (SiO_2)	27.43
Iron (Fe)	0.99
Moisture at 100°C	0.14
Manganese (Mn)	44.14
Phosphorus (P)	0.212

[1] Watson, op. cit., pp. 180-181, 1908.

Immediately south of the holdings of the Cherokee Mining Company, A. W. Ellis has sunk three prospect shafts, 15, 20, and 25 feet deep, respectively, and has made a number of open cuts. The ore found is limited in quantity and probably contains a high percentage of phosphorus.

Polk Patterson property.—A few tons of manganese are reported to have been shipped from the property of Colonel J. H. Moore, of Dahlonega, Ga. The property is northeast of Sweetgum near the Georgia-Tennessee state line. It was worked in 1902.

GILMER COUNTY

The manganese deposits of Gilmer County are similar to those of Fannin County in that they are associated with limonite in the slates and mica schists of the Valleytown formation and the Tusquitee quartzite. They are of little commercial importance except as they may increase the value of the brown iron ore deposits. The ore-bearing formations extend northeast through the central part of the county and are paralleled by the Louisville & Nashville Railroad.

Brown iron ore deposits which contain manganese oxide in quantities sufficient to constitute manganiferous iron ore occur near Cherrylog and Whitepath, and brown iron ores occur at East Ellijay and Talona. These deposits are described by Phalen in the Ellijay folio of the U. S. Geological Survey.[1]

Searcy property.—W. H. Searcy owns lots 214, 215, and 219, 7th district, 2d section, Gilmer County. The property is a short distance southwest of Cherrylog, a station on the Louisville & Nashville Railroad. Openings have been made to a depth of 15 feet in the iron and manganese oxides deposited in the schist of the Valleytown formation, but at that depth the ore seems to pinch out.[2] Selected samples of the manganese ore probably contain as much as 40 per cent of manganese, but the greater part of the ore, not limonite, is manganif-

[1] LaForge, Laurence, and Phalen, W. C., U. S. Geol. Survey Geol. Atlas, Ellijay folio (No. 187), p. 14, 1913.
[2] Information from field notes made in November, 1917, by H. K. Shearer, Assistant State Geologist.

erous iron containing 18 per cent of manganese, 10.55 per cent of iron, 0.224 per cent of phosphorus, and 37.03 per cent of silica and insoluble matter.

Davis prospects.[1]—W. A. Davis has done a considerable amount of prospecting and has mined some manganese ore on lot 251, 7th district, less than a mile north-northeast of Whitepath. The altitude where the deposits have been prospected is about 1600 feet above sea level. The general drainage is west and southwest through Ellijay River.

Open pits and shafts have been dug to a depth of 30 feet or more west of the public road and some openings are in the highway itself. The ore is composed of psilomelane and pyrolusite. Hard fragments of high-grade ore and soft manganese dirt occur in the more or less decomposed micaceous schists which strike N.25-30°E. and dip 55-60°E. Several hundred pounds of manganese ore of different grades have been mined at the Davis prospects. The size of the deposit is comparatively small.

The following analyses indicate the grades of manganese ore on lot 251.

Analyses of manganese ore. Davis prospects

Constituents	*1*	*2*	*3*
Silica (SiO_2) and insoluble	2.81	31.83	15.28
Iron (Fe)	0.76	3.84	4.37
Moisture at 100°C	3.65	15.43	16.04
Manganese (Mn)	55.40	24.81	32.33
Phosphorus (P)	0.082	0.163	0.082
Barium oxide B(aO)	0.26	......	......
Barium sulphate ($BaSO_4$)	0.00	......	......
Sulphur (S)	0.00	......	......

1.—Manganese, high-grade. Fragments of hard ore from opening 18 feet below the surface. Collected by W. A. Davis, October, 1918.

[1] Information about the Davis prospects was furnished by S. W. McCallie, State Geologist, who examined the deposits and collected samples of the ore in the summer of 1918.

2.—Manganese, low-grade. Yellow, gritty, and micaceous dirt containing soft manganese oxide from 18 feet below the surface. Collected by W. A. Davis, October, 1918.

3.—Manganese, low-grade. Soft slick manganese oxide in decayed mica schist, from 18 feet below the surface. Collected by W. A. Davis, October, 1918.

PICKENS COUNTY

Richards property.—Will Richards of Jasper owns parts of lots 97 and 98, 13th district, Pickens County, 5½ miles by road southwest of Jasper and about 2 miles by road northwest of Mineral Springs. Manganese occurs south of the public road, on the top and on the west slope of a ridge made up largely of quartzite covered by a reddish-yellow soil mantle. The manganese is in the form of the oxide, probably a mixture of pyrolusite and psilomelane, as a breccia-filling in quartzite and as coatings on quartz grains. It is closely associated with siliceous limonite and contains both high iron and silica. Some fragments may contain as much as 20 per cent of manganese. No prospecting has been done and the indications for a good deposit are not favorable.

Burrell property.—G. A. Burrell's property on lot 82 is immediately northwest of the Richards property and east of Sharp Mountain. A little stalactitic and amorphous manganese oxide is associated with a low grade of siliceous brown iron ore. This occurs in a much weathered outcropping of rather coarse quartzite. No ore is indicated in commercial quantities.

CHEROKEE COUNTY

Manganese ore has been reported from several places in the western part of Cherokee County, east of the Cartersville district, but very little prospecting has been done. The occurrence of manganese is not uncommon in association with a formation of quartzite which parallels in many places the belt of pyrite deposits crossing the county from southwest to northeast, passing west of Woodstock, east of Canton, and through Creighton. One location of such a deposit is in the southwestern part of Cherokee County at the Bell-Star mine.

Bell-Star pyrite mine.[1]—John G. Westerman, Woodstock, Ga., owns the mineral rights on lots 829, 900, and 901, 21st district, 2d section, Cherokee County. The pyrite mine is 2.8 miles west of Woodstock, a station on the Louisville & Nashville Railroad and 6.7 miles north of Kennesaw, a station on the Western & Atlantic Railroad, air-line measurements. The mine is about 1100 feet above sea level. The country rock is light-colored mica gneiss of the Carolina series with minor bands of hornblende or Roan gneiss.

The following quotation is taken from Shearer's[2] description of that part of the geology relating to the manganese deposits.

"A conspicuous feature of the geology of the area is the bed of rock called the 'sandstone vein' in the gold mining period.

"The 'sandstone' is manganiferous. Some of the manganese may occur in the garnet, but is also probable that a part of the magnetic mineral is jacobsite, a variety of magnetite containing manganese and magnesium, or franklinite without zinc. Locally near the surface the iron and manganese have been concentrated as pocket deposits, probably small, but some of them may be workable. . ."

The manganese deposits on the Westerman property are somewhat similar to those on the Douglass property in Haralson and Paulding Counties and on the Cochran property in Paulding County, in that they occur in a quartzitic formation adjacent and parallel to pyrite deposits in micaceous schists and gneisses with which is associated hornblende gneiss.

Analyses of manganese ores. Westerman property

Constituents	*1*	*S-364*	*2*	*Crane-41*	*3*	*4*
Silica (SiO_2)	....	....	....	30.47	....	....
Silica (SiO_2) and insol..	15.11	25.73	32.05	....	....	39.76
Alumina (Al_2O_3)	....	....	....	12.36	....	....

[1] Shearer, H. K., and Hull, J. P. D., Preliminary report on a part of the pyrites deposits of Georgia: Geol. Survey of Ga. Bull. 33, pp. 146, 153, 1918.
[2] Idem, pp. 148, 149.

Constituents	*1*	*S–364*	*2*	*Crane–41*	*3*	*4*
Iron (Fe)	....	3.55	3.08	13.77	48.59	36.94
Moisture at 100°C	1.79	3.77	2.22	3.06	0.42	0.21
Manganese (Mn)	46.03	28.35	24.25	14.72	4.52	0.15
Phosphorus (P)	0.067	0.078	0.089	0.296	....	0.048
Barium oxide (BaO) ...	....	....	....	0.00	....	....
Barium sulphate ($BaSO_4$)	....	....	....	0.00	....	....
Sulphur (S)	....	....	....	0.00	....	....

1, 2, 3, 4.—Manganese, ferruginous manganese and iron ore samples collected by J. G. Westerman.

S–364.—Ferruginous manganese ore, low-grade, from a shallow pit a mile southwest of the pyrite mine. Collected in 1917 by H. K. Shearer, Assistant State Geologist.

Crane–41.—Manganiferous iron ore from "sandstone vein" on lot 900, about 100 yards northwest of the pyrite mine. Collected by W. R. Crane, July, 1918.

LUMPKIN COUNTY

Manganese is not known to occur in Lumpkin County in commercial quantity, though here as elsewhere throughout the state it has a wide occurrence in the minerals and as a product of oxidation from the decay of the rocks. The following is quoted from Bulletin 14:[1] "In Lumpkin County, associated with a gold-bearing quartz vein in the Bast mine near Dahlonega, pyrolusite, in botryoidal masses, 2 or 3 inches thick, and several feet in length, was secured in 1896 by the State Geologist, Prof. W. S. Yeates, for use as specimens for the State Museum."

TOWNS COUNTY

McConnell estate.[2]—W. R. McConnell some years ago opened a small manganese deposit about 2 miles west-northwest of Hiwassee, in

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, p. 165, 1908.

[2] Information from field notes made in November, 1917, by H. K. Shearer, Assistant State Geologist.

the northern part of Towns County. The ore was taken from shallow pits in a hollow at the head of a small branch flowing east-northeast to Hiwassee River a mile and a half away. The elevation is about 2100 feet above sea level or 200 feet higher than the river. At the time visited, the pits were full of water and the mode of occurrence could not be determined. Hornblende gneiss float was observed nearby but no exposures of rock in place. The ore was shipped from Hiwassee in barrels. The following analysis represents an average sample of several hundred pounds of ore still remaining near the pits, collected by H. K. Shearer in November, 1917.

Analyses of manganese ore. McConnell estate

	S–345
Silica (SiO_2)	3.21
Iron (Fe)	16.70
Moisture at 100°C	0.80
Manganese (Mn)	43.55
Phosphorus (P)	0.056

The manganese ore of the McConnell prospect is probably made up of the oxides psilomelane and pyrolusite, though the carbonate, rhodochrosite, has been observed in this vicinity by Watson, who says:[1] "Rhodochrosite is found in Towns County, 2 miles west of Hiwassee, associated with the oxides of manganese and iron in hornblendic rocks of the corundum belt. . ." It occurs "lining the cavities of some of the more porous masses of impure manganese and manganiferous iron ores. . ."

HABERSHAM COUNTY

Fort property.[2]—The only place in Habersham County, where manganese may be found in commercial quantity is, so far as known, the John P. Fort property, lot 177, 10th district, 2 miles northeast of Mount Airy in the southern part of the county. The occurrence

[1] Watson, T. L., Preliminary report on the manganese deposits of Georgia: Geol. Survey of Ga. Bull. 14, pp. 160, 161, and 165, 1908.
[2] Idem, pp. 169-171.

of the deposit is on the southeast side of the Southern Railway in mica schist which is cut by quartz veins and dioritic dikes. The location is on Chattahoochee Ridge at an elevation approximately 1550 feet above sea level overlooking the valley of Broad River at its source.

In 1898 or 1899 openings were made at several places on the lot. One vertical shaft on the quartz vein was sunk to a depth of 60 feet but no workable ore was found. The manganese in the quartz rock consists of small quantities of breccia ore filling the fractures of the schist. This residual material yielded the workable ore. The deposit is described by Watson in part as follows: "The manganese at these openings is distinctly a secondary accumulation, derived from the mica, and concentrated in the siliceous clays of the schist."

Not more than a carload of ore has been shipped from the Fort property. The following analysis shows that some high-grade ore occurs in the deposit. The analysis, furnished the Survey by John P. Fort about 1900, was made by W. J. Rattle, of Cleveland, Ohio, May, 1899.

Analysis of manganese ore. Fort property

Silica (SiO_2)	3.73
Iron (Fe)	1.32
Manganese (Mn)	54.16
Phosphorus (P)	0.092

HART COUNTY

Brown property.[1]—though manganese occurs in minor quantities in several places in Hart County, the ore has been shipped from but one property, the J. R. Brown place, a mile and a half east of Bowersville, in the western part of the county. Bowersville is on the Toccoa-Elberton branch of the Southern Railway. Its altitude is 934 feet above sea level, about the same elevation as that of the Brown property. Drainage from the locality of the manganese prospects is generally northward to Tugaloo River on the Georgia-South Carolina state line.

[1] Watson, op. cit., pp. 173, 174.

The occurrence of the ore in mica schist and red residual clay of the schist is similar to that of the deposit at Mount Airy, Habersham County. The ore occurs as a massive deposit, averaging from 3 to 6 feet in thickness and lying several feet below the surface.

LINCOLN COUNTY

COLLEY MINE[1]

The property consisting of 80 acres, known as the old Aaron Hardy property, is 3¼ miles east of Lincolnton, in the east-central part of Lincoln County. J. D. Colley and J. H. Boykin owns the mineral rights and lease them to J. R. Whitman, Healey Building, Atlanta. J. H. Burgess is superintendent at the mine. Lincolnton, the county seat, is the terminus of the Washington & Lincolnton Railway. It is about 500 feet above sea level and somewhat higher than the mine. It is on a divide between small branches flowing generally northeastward to Savannah River.

Several open-cuts are being worked in the yellow and reddish-brown clays to a depth of 15 feet, more or less. The manganese occurs as nodular ore with clay and sand impurities and as massive ore remarkably free from mechanical impurities such as clay and quartz particles.

The analysis here given represent an average sample of the ore deposit as collected by W. R. Crane in July, 1918.

Analysis of manganese ore deposit. Colley mine

	Crane–45
Silica (SiO_2)	14.95
Alumina (Al_2O_3)	9.57
Iron (Fe)	3.28
Moisture at 100°C	1.53
Manganese (Mn)	32.80
Phosphorus (P)	0.061
Barium sulphate ($BaSO_4$)	3.59
Barium oxide (BaO)	3.40

[1] Information about the Colley mine was furnished by W. R. Crane, who visited the property in July, 1918.

Equipment at the mine includes a 20-horsepower hoisting engine for hauling the ore up the incline from the open-cut, and a 2-ton motor truck for hauling ore to the single-log washer which is at the creek a mile from the mine and for hauling the washed product 3½ miles to the railroad at Lincolnton. The production this year has been a few hundred tons shipped to the Southern Manganese Corporation at Anniston, Ala. The ore is of good quality, is readily cleaned, and the deposit is of fair size.

GREENE AND TALIAFERRO COUNTIES

GEORGIA MANGANESE COMPANY[1]

The property of which the Georgia Manganese Company, James Weisel, president, 1720 12th Avenue, South, Birmingham, Ala., controls the mining rights, contains 1150 acres along the Greene-Taliaferro county line about 8 miles northeast of Union Point, Greene County and 4 miles north of Robinson, Taliaferro County. This includes the mineral interests owned by the late Judge John C. Hart of Atlanta and J. O. Mathewson of Ashland, Ky. The whole property is held in lease by John E. Hill, Birmingham, Ala.

The topography of this part of the Piedmont Plateau is gently rolling. The elevation in the vicinity of the manganese prospects ranges from about 450 feet to 626 feet above sea level. The drainage is generally eastward through South Fork to Little River.

The country rock is micaceous schist covered for the most part by a deep residual soil mantle. The schist contains veins of quartz and pegmatitic material. The manganese deposit is the result of the alteration of a mineralized formation containing quartz, garnet, magnetite, and pyroxenite. This "vein" outcrops 50 feet east of one of the mine shafts and strikes N.62°E. and dips 63°NW. with the schistosity of the country rock. The ore body is northwest of, or strati-

[1] Information about this property was obtained from the field notes of J. E. Brantly, former Assistant State Geologist, who examined the deposits in March, 1916; from a private report made for the Georgia Manganese Company by T. H. Aldrich and Gaston Scott; and from the late Judge John C. Hart, Atlanta, 1918.

graphically above, the garnetiferous quartz formation, though separated from it in places by micaceous schist. At the surface the quartz vein is 3 to 4 feet thick and the ore body is 3 feet thick.

The ore occurs in two parallel bodies which may be termed "bedded veins," striking and dipping with the country rock. The "vein" that has been prospected the most can be traced more than half a mile by broken outcrops. Two openings were made on this deposit many years ago. About half a mile southeast of the main outcropping is the less-prospected "vein."

In 1916 or 1917 a vertical shaft was sunk on the main "vein" to a depth of 80 feet. At a depth of 70 feet a drift was extended 30 feet northeast and another 28 feet southeast. The northeast heading, according to Brantly, showed hard and soft non-crystallized ore 23 inches between a hanging wall of yellow micaceous schist and a foot wall of quartz, kaolin, and a little mica. Analysis of sample *B-6* represents the average manganese content of this ore face as 18.82 per cent of manganese.

The following analyses show the character of the ore.

Analyses of manganese ores, Georgia Manganese Company

Constituents	*B–4*	*B–5*	*B–6*	*1*	*2*	*3*	*4*
SiO_2 and insol.	....	....	....	0.66	....	....	....
SiO_2	35.24	19.16	....	....	9.67	1.43	18.02
Al_2O_3	....	....	....	....	6.37	1.45	6.94
Fe	5.26	11.87	....	1.87	2.82	5.67	21.06
Mn	25.11	27.20	18.82	42.00	41.72	48.36	25.26
P	0.03	0.12	....	0.03	0.12	0.058	0.16
S	0.00	0.00	....	0.04	0.00	0.00	....
BaO	....	....	....	....	6.90	....	2.65

B–4.—Manganese ore body. Average sample representing a section 12 inches thick in an excavation southeast of the main shaft. Collected by J. E. Brantly, former Assistant State Geologist, March, 1916.

B–5.—Manganese ore body. Average sample representing a section 24 inches thick in the excavation as above.

B–6.—Manganese ore body. Average sample representing the ore body in the southeast heading of main saft 70 feet below the surface. Collected as above.

1.—Manganese ore. High-grade selected sample.

2.—Manganese ore. High-grade. Analysis by Tennessee Coal, Iron & Railroad Company, Birmingham, Ala., taken from report of T. H. Aldrich and Gaston Scott.

3.—Manganese ore. As above.

4.—Ferruginous manganese ore. Analysis by Tennessee Coal, Iron & Railroad Company as above.

It is seen from the analyses that the ore is high-grade. It is reported that the ore is readily separated from its impurities by simple mechanical means and that the prospect for a workable deposit is favorable. In 1916, the equipment at the mine included a 12-horsepower hoisting engine and a 12-horsepower portable engine and boiler. The haul to Robinson, a station on the main line of the Georgia Railroad, is 4 miles.

METHODS OF MINING AND CLEANING MANGANESE ORE IN THE CARTERSVILLE DISTRICT

By W. R. Crane

INTRODUCTION

As the methods of mining and cleaning or concentration of ores depend largely upon their occurrence, it is both desirable and necessary to discuss briefly the conditions affecting such operations, but such discussion will of necessity leave much to be said regarding the origin and occurrence of the minerals concerned, which are discussed elsewhere in this report. The slight repetition necessary for such discussion will hardly detract from the value of the report, as it will serve to fix the geological relations more firmly in the mind of the reader.

As has been previously pointed out in this report, there are certain well-defined geologic relations existing in the district, which while not always apparent even after careful investigation due to the extensive weathering of the associated rocks, yet undoubtedly exist, and can be employed to decided advantage in the search for ore deposits.

GEOLOGIC OCCURRENCE OF ORE

The relationship referred to and that which alone concerns us in this connection is the sequence of formations directly associated with the occurrence of ore. The bed rock, commonly spoken of as the foot wall, beyond which ore is rarely ever found, is the Weisner quartzite; directly above the Weisner quartzite is the Shady limestone. These two formations were probably the source of the manganese after its deposition, and have been badly folded and broken by earth movements, which may reasonably be assumed to have taken place prior to the formation of the deposits.

While the formations bearing the ore deposits occasionally lie almost horizontally, yet as a rule they stand at high angles and often show reverse dips. Canoe-shaped basins formed by synclines are not of infrequent occurrence and in several instances have contained rich bodies of ore. Faults of considerable magnitude occur, but little definite information can be obtained regarding their strike, dip, and displacement, owing to the exceedingly heavy mantle of clay overlying the solid rock.

As indicated above, the disintegration and decay of the Weisner quartzite and Shady limestone have been so extensive and have progressed so far that much information ordinarily obtainable regarding the occurrence of ore deposits is largely lacking, thus rendering the various phases of mining, such as prospecting and development, both difficult and uncertain.

The decay of the formation containing the manganese has proceeded downward forming a mantle of relatively soft materials having a thickness varying from a few feet up to 300 feet or more, and an average depth of 75 to 100 feet. Naturally the decay of the limestone has been more rapid and complete than that of the quartzite, with the result that only in a few places in the district has the former been encountered in the mining operations, showing that it lies at considerable depth below the present surface of the country, while the quartzite outcrops form, in many instances, the backbone of the ridges of the hills and mountains. Further, when the quartzite does not occur in well-defined outcrops, many fragments and large boulders cover the slopes and serve as a guide to the location of the deposits.

The mantle of disintegrated limestone and quartzite is composed of various colored clays, usually highly siliceous, and many fragments of quartzite. The mantle may be separated more or less roughly into two parts, namely: the upper and lower, or the superficial or secondary deposit and that in place, the residual, or the primary deposit. The former is largely red clay, which extends to the surface and gives the surface soil its characteristic dark-red color. This portion of the mantle shows no pronounced structure except that due to creep, and as the materials contained in it have probably travelled considerable distances from their original position, they are badly broken up and often very irregularly distributed. The lower portion of the mantle is usually in place, which is more or less evident from the occurrence of definite lines of stratification and by stringers of quartz still occupying the same position as in the original bedded formation. One of the most striking evidences of the undisturbed condition of the deeper lying portions of the mantle is the occurrence of bodies of manganese, that show no evidence of having been broken up or disturbed; a condition rarely ever observed in the uppermost portion of the mantle. The loss of lime and other elements of the original formations by solution would, of course, cause a shrinkage, which though relatively slight might be responsible for the distortion and breaking up of the continuity of the remaining signs and evidences of bedded formations.

It is probable that the dark-red clay is a product of the decay of the Shady limestone and as it is one of the best indications of the presence of manganese, it would appear that the Shady limestone was the main source of the manganese deposits.

From conditions outlined above we are probably correct in the assumption that the bodies of manganese found in the clays and sands were originally deposited in the limestone and quartzite and that on the decay of these formations the manganese was freed from the enclosing rock, but not disturbed to any great extent as to position, except in the upper portions, which have moved down the slopes of mountains and hills under the action of creep.

The deposits of manganese may then be expected to be found above the Weisner quartzite and in many instances occupying considerable portions of the upper part of that formation. It is evident, also, that the bottom or floor of the deposits must be extremely irregular, being composed of bosses and pinnacles of limestone and quartzite, the ore occurring above and on all sides of the irregularities of the floor. This condition of affairs is responsible for the fact that ore may be found both above and below the quartzite bed, even in the same property, which if otherwise interpreted would be very misleading and confusing. (See fig. 18.)

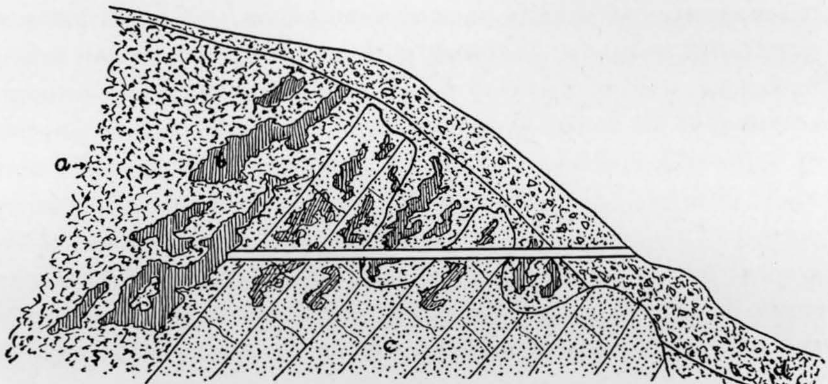


Fig. 18. Vertical section through hill, showing pinnacles of quartzite and occurrence of manganese. *a*, clay from decay of Shady limestone; *b*, bodies of manganese; *c*, quartzite.

Aside from the general geological conditions affecting the occurrence of manganese in the district, there are certain forms of deposits which are interesting and at the same time instructive from the standpoint of mining and concentration of the ores. These typical occurrences are discussed as types of ore deposits, which concern the work discussed in this report.

TYPES OF DEPOSITS

The characteristic forms of ore deposits in the Cartersville district may be outlined as follows:

1. *Dornick and pebble deposits.*—Manganese in this form is of common occurrence and is widely distributed. It is found on the surface and extends throughout the zone of disintegrated materials, often occurring in sufficiently large quantities to render its cleansing by washing readily accomplished. Occasionally this ore may be found

in irregular bodies extending for considerable distances both horizontally and vertically. As a rule the dornick and nodular ore is high-grade, probably averaging higher in manganese than the other forms common to the district. While nodular and kidney ores are high-grade if composed wholly of manganese, yet may be misleading in that manganiferous iron usually assumes the same forms. The botryoidal form of kidney ore is especially to be examined with care, as that form is commonly assumed by limonite or the so-called brown ore.

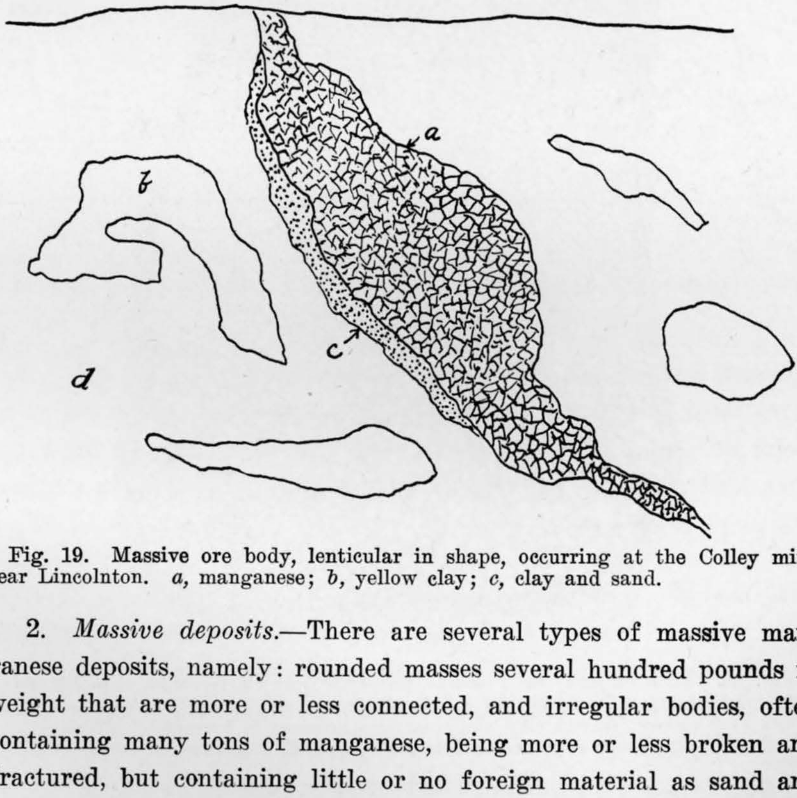


Fig. 19. Massive ore body, lenticular in shape, occurring at the Colley mine near Lincolnton. *a*, manganese; *b*, yellow clay; *c*, clay and sand.

2. *Massive deposits.*—There are several types of massive manganese deposits, namely: rounded masses several hundred pounds in weight that are more or less connected, and irregular bodies, often containing many tons of manganese, being more or less broken and fractured, but containing little or no foreign material as sand and clay. Such large masses may be very porous and pitted, and are commonly spoken of as "honeycombed" ore, the cavities being filled with clay. (See fig. 19.)

3. *Brecciated deposits.*—The brecciated ore bodies consist of badly broken quartzite, the fragments being cemented together by manganese. Large boulders of such breccia occur in sand and clay, and

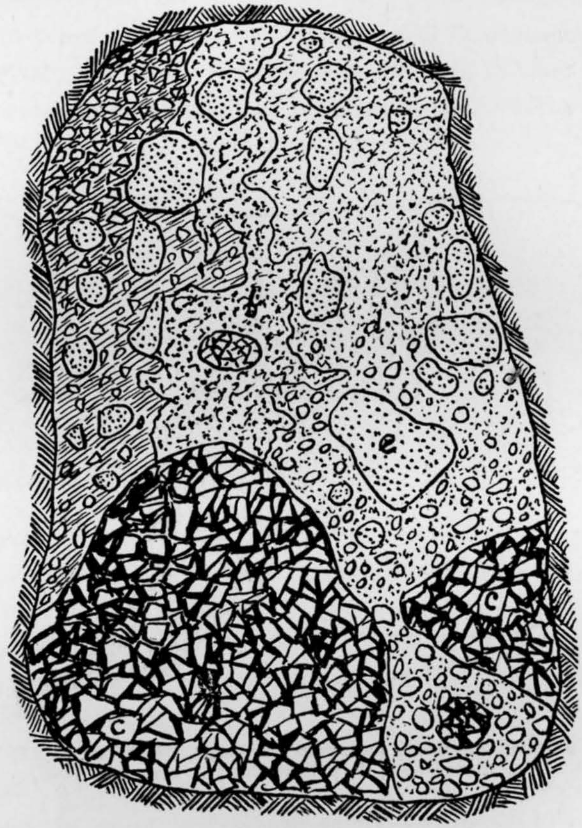


Fig. 20. Face of drift on Freeman property near Cartersville, showing occurrence of breccia ore. *a,* light brown clay carrying manganese and quartzite fragments and masses; *b,* red clay and quartzite masses; *c,* breccia of quartzite and manganese; *d,* yellow clay and quartzite; *e,* quartzite masses.

beneath them similar brecciated material occurs in place in the undisturbed bed of quartzite. This ore is usually very siliceous. (See fig. 20.)

4. *Granular and sandy deposits.*—Much granular and sandy manganese occurs as very irregular deposits in sand and clay. There is apparently no order to deposits of this type, nor is there any evidence of continuity; they are therefore difficult to follow. The percentage of manganese in the deposit may be as variable as is the shape; clay, sand, and fragments of decayed quartzite occurring in an indiscriminate mixture. (See fig. 21.)

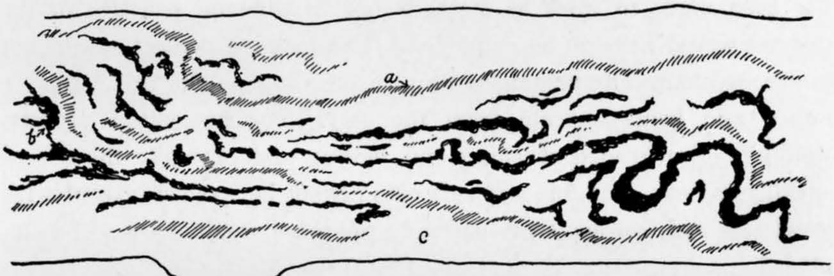


Fig. 21. Section of deposit showing granular and sandy deposit. *a*, band of dark brown ferruginous clay; *b*, manganese; *c*, brown clay. Occurrence of manganese on Freeman property near Cartersville.

5. *Soft or wad ore deposits.*—The soft ore occurs in a manner similar to the granular and sandy forms, but is usually more compact, being found in masses of 10 to 100 pounds, practically free from foreign materials. As much as 35 to 50 per cent of the ore of certain properties is composed of this ore and owing to its softness and fineness is difficult to save in the usual method of cleaning. This fine ore is often called "chemical ore," owing to its pureness. It is largely psilomelane, although usually containing other oxides.

6. *Bedded and banded deposits.*—These deposits are usually designated as veins, but might more appropriately be called zones. The manganese occurs in bands alternating with bands of magnetite, mica schist, and quartz lenses. The zone of manganiferous material is enclosed in shattered quartz, quartzite, mica schist, and gneiss formations.

The ore deposits described above are more or less distinct types, but merge into one another, forming complex bodies, increasing the difficulties experienced in prospecting, mining, and concentration. Could each form of deposit be considered by itself, the mining operations would be materially simplified as methods of mining and cleaning could be adopted particularly suited to each, but that is often impossible.

Of the forms of deposits outlined, there are several that no attempt has been made to work as methods not in common practice in the district would have to be employed. The massive deposit would not under ordinary circumstances require cleaning as the ore could be mined and kept separate from the clay. The brecciated deposits would require graded crushing and jigging and probably the use of shaking tables. The fine and soft ores cannot be washed, except with great loss and, consequently, special apparatus would have to be employed.

With the general conditions of occurrence in mind, it is possible to discuss more intelligently the various operations connected with mining and cleaning of the ores.

METHODS OF MINING THE ORE

The methods of prospecting for and extracting ores, and transferring them from the mines to the washers or concentrating plants may be divided into the following operations, namely: prospecting, mining of the ore, support of workings, ventilation, drainage, lighting, and handling of ore and waste.

Owing to the great depth of overburden often encountered, and its uncertain character, being composed of clay, sand, fragments of rock, etc., the removal of the ore either by open-cut or underground work is rendered difficult with depth, and practically impossible under certain conditions. However, with reasonable care and by the adoption of systematic methods, there is no reason why the deposits of this district cannot be mined readily and economically. Only in a few localities is it necessary to mine in solid ground, that is, in rock, as the majority of the deposits are in the disintegrated materials. It is evident then that the thickness of the deposits is limited and the work of mining, however carried on, must be at shallow depths.

PROSPECTING FOR ORE

The usual method of prospecting in the district is by test-pits, which practice is common to similar work with iron ores. However, before testing by pits is begun a favorable location is selected by careful examination of surface indications. Signs of manganese are most usually found in dark red soil and consist of large and small rounded masses, also nodules and fragments of manganese. Upon a surface with such a showing of ore, shallow holes are first sunk and if the excavated material also contains a fair amount of manganese, test-pits are put down. Should a reasonable amount of manganese be found or a deposit be encountered, other pits are sunk at intervals of 25 to 50 feet.

The placing of test-pits is usually done in a very irregular and haphazard manner and often without any regard to the probable geological occurrence of the surrounding formations. It is not always easy to secure any definite information from an examination of the existing rocks, as no outcrop may be present and the surface accumulations may be wholly foreign to the immediate neighborhood.

If, however, it is possible to locate an outcrop of the Weisner quartzite or a mass of "blossom rock," chert included in the Shady limestone, and to determine the dip of the quartzite, a reasonable assumption as to where to place the pits may be made. Pits on the upper or dip-side of the quartzite or in the neighborhood of the blossom rock would be properly placed, unless perchance the quartzite has by excessive folding had its dip reversed, when the proper place to look for the ore would be on the lower or under-dip side. If, however, the blossom rock should be present, its relation to the quartzite would be indicative of which side of the outcrop to search for ore. Once properly located with regard to the quartzite ledge, the test-pits should be placed parallel to it, changing in direction with the outcrop.

While it is not desirable to expend too great a sum in sinking test-pits, yet it is much better to go to considerable expense in order to find out that there is no ore present, or that there is too small a quantity to work, rather than to put considerable money into equipment only to discover later that there is no ore upon which the plant can operate.

In order to give an idea as to the expense necessary to test a property the following calculations have been made. An acre of ground is approximately 200 feet square, and if holes are spaced 50 feet apart there would be, not considering the placing of pits on the limits of the acre lot, nine holes required to prospect the lot if placed at the intersection of 50-foot squares. If considered more desirable to place the holes in an irregular manner and at approximately 50-foot intervals, ten or twelve holes would be required. The reason for a larger number being required in the latter case is due to the fact that the outer holes would, in a number of places, be closer to the boundaries of the lots.

The cost of testing an acre lot, with holes sunk to 10, 20, 30, up to 60 feet in depth, is given in the following table.

Depth of holes	Footage of holes arranged systematically	Footage of holes arranged irregularly	Cost of systematically arranged holes	Cost of irregularly arranged holes
10 feet	90 feet	120 feet	$ 45	$ 60
20 "	180 "	240 "	90	120
30 "	270 "	360 "	135	180
40 "	360 "	480 "	180	240
50 "	450 "	600 "	225	300
60 "	540 "	720 "	270	360

The cost of the work as given above is based on the contract price of 50 cents per foot; test-pit work is often contracted for 40 cents per foot, and occasionally pits are sunk in especially easily worked ground for 25 cents, men working at a wage of $2.50 per day.

Testing a lot having an area of several acres would require a larger number of holes than would a single acre lot, otherwise there would be spaces between the holes of the various acre lots of 50 feet between the boundaries.

It might be desirable with certain properties to space the holes at shorter intervals than 50 feet, which would not, however, be permissible if the overburden proved to be of considerable depth. In such cases the same results could be obtained by spacing the holes 50 feet apart and running drifts at the desired levels, as on showings of ore, thus proving the ground to within 25 feet or shorter intervals. While testing carried on in this manner would be more difficult due to narrow work, yet the results would be more satisfactory and considerably less expensive than sinking holes to considerable depths.

Test holes, pits or wells are from 30 to 36 inches in diameter, if round in section. When square or rectangular holes are employed they vary from 4 by 4 feet, to 5 by 5 feet in section. The rectangular forms are usually called shafts and are ordinarily sunk by day labor, while the round holes are more commonly contracted for 40 to 50 cents per foot, the latter price being the usual rate in the Cartersville district.

No attempt is made to support the walls of test-pits, as they have served their purpose as soon as the desired depth has been reached. The square or rectagular forms are, however, often employed in subsequent development and mining work, and when so used are usually made somewhat larger and are lined by timber frames and lagging. A limited amount of testing has been done by bore holes of 5 to 8 inches in diameter. Holes are drilled by churn drills of the self-contained form, that is, the drilling outfit or rig is complete in itself, being provided with a boiler, engine and actuating mechanism for operating the drill. Holes can readily be put down to depths of 50 to 200 feet in a few hours, particularly if nothing but clay is encountered; if boulders are struck much more time would be required and under difficult conditions the hole might have to be abandoned. No lining or casing of the holes is required for support as the clay walls in small openings are self-supporting.

The principal disadvantage in the use of drills for testing for manganese is the inability to secure accurate and reliable results. Frequent withdrawals of the drill from the hole and cleaning out the loosened material are necessary, which while it consumes but little time must be done carefully otherwise very inaccurate and untrustworthy results will be obtained. Extensive experience in such work in similar and even more difficult deposits has demonstrated the fact that only by the use of casing carried close to the end of the hole, can satisfactory results be obtained.

As manganese occurs very irregularly, a hole drilled through a stringer or mass of ore, though small, might readily give very erroneous results, particularly if the drill was allowed to continue to cut and rub on the exposed part of the ore, thus distributing liberal portions of the ore throughout the cuttings for many feet of the hole below the portion of deposit passed through. By the use of casing this could be prevented by covering the ore as cut with the protecting walls of the pipe or tube, thus giving an accurate record of formation passed through.

Should ore bodies of workable size fail to be discovered by test-pits and shafts, it would be better to abandon the property, although failure to locate workable deposits may result from too shallow work; however, with a careful consideration of surface signs and geological formations usually associated with manganese, combined with the results of test-pit work the chance of failure to get positive information is reduced to a minimum.

Failure to interpret properly the information secured in testing by pits often leads to useless expense and disappointing results. It is, therefore, both necessary and desirable to employ experienced men for such work and those who are particularly familiar with the usual occurrence of ore-bearing formations.

Trenches are frequently employed in the search for deposits of manganese and when used should be run at right angles with the outcrop of beds of quartzite occurring on the property or as determined by examination of adjoining properties. Trenches are especially useful as they make a complete section of deposits crossed, and while ore bodies may not be cut other information fully as useful may be obtained which may point just as conclusively to the presence or absence of ore as the actual finding or the failure to find ore would.

As trenches are usually dug by day labor the cost will vary with the wage paid and depth of cut made. It is, therefore, difficult to give costs.

DEVELOPMENT OF DEPOSITS

By development is meant the opening of a deposit by cuts, drifts, tunnels or shafts in order that ore may be mined. Extraction of ore is the ultimate aim of mining, but before that can be attempted a means of reaching the ore must be provided. Owing to the relatively small size of the deposits of manganese and their extreme irregularity, the methods of development usually employed in the district are simple, very limited, and unsystematic.

Long narrow cuts are made on the hill or mountain slopes, the bottoms of which are practically horizontal to permit haulage by wheelbarrows or hand-operated cars, also to keep the open-cuts free from water.

The cuts may be run in any direction and like other development openings, usually follow the ore bodies closely; consequently, are very irregular. Further, the bottom of open-cuts may have reverse grades, that is, slope downward into the deposit, in which case both water and excavated material will have to be removed by power. The principal objection to the use of cuts is that considerable material must be handled in forming and keeping them open to the surface, but they are permissible wherever the overburden can be handled to advantage and profitably in the subsequent mining operations.

Drifts and tunnels are used in connection with underground work, although in some instances it may be desirable to employ them in the development of open-cuts, in which case, however, they are often driven at an angle with the horizontal, forming slopes rather than drifts or tunnels.

Drifts and tunnels are similar in practically all respects except in direction driven, and that distinction is largely lost in working manganese deposits. In the case of veins or beds when the material worked lies between well-defined walls, or top and bottom rock, a passage driven from the surface, that is, on the outcrop, and following the deposit horizontally, is a drift; a tunnel, on the other hand, is not begun on the outcrop, but usually at some distance from it and cuts across the formations practically at right angles with the deposit. It is evident then that a drift is usually more readily driven and being in the deposit gives a much better idea of its character and value, than would a passage through the rock. The cost of a drift is usually much less per foot than of a tunnel of equal cross section.

Slopes and shafts are also commonly employed as forms of openings for the development of deposits of manganese. They are used much less frequently than drifts and tunnels, probably due to the almost universal occurrence of manganese deposits on slopes of considerable inclination. However, wherever the deposits are thick, or the overburden is heavy it is both necessary and desirable to employ shafts or slopes as development openings.

In ordinary mining work slopes are usually of greater length than shafts, but in working on sloping ground that is not necessarily true. Slopes of moderate grade are easier and cheaper to excavate than are shafts, and handling of material in them is also more readily accomplished. On the other hand shafts are more readily connected with the underground workings as the drifts are often driven from one or all four sides of the shafts, if not at the same, at various levels.

Development for underground work may be divided into two separate operations, namely: connecting the deposits with the surface, and opening up the deposit by passages so that ready access may be had to the working places. Owing to the small scale operations usual with manganese mining these two operations are merged and the development within the deposit is simply a continuation of the preliminary operation of connecting the deposit with the surface by means of one or more suitable passages.

The position of a deposit having been determined and the form of development opening decided upon, the work of connecting the deposit with the surface is begun. The deposit having been reached, the work of mining is begun at once by running a drift in the ore body. As the ore bodies are extremely variable both with respect to horizontal and vertical limits the drifts are of necessity very irregular with respect to direction. Further, the drifts are usually short, seldom exceeding 100 feet in length and probably the majority are under 25 feet. There may be, however, a number of drifts driven on off-shoots from the main deposit, which form short auxiliary openings within the deposit.

When shafts are employed it is not unusual to have them sufficiently close together that they can readily be connected by drifts. The deposits are thus rendered more accessible and what is of the greatest importance, a good circulation of air is obtained by natural means.

The methods employed in extracting the manganese ore from the ground or enclosing clay masses are necessarily limited as the deposits are superficial, occurring as they do within the zone of rock disintegration. While the thickness of the clays and other products of decomposition is known to be 350 feet in places, yet the average is much less than that and probably does not exceed 100 feet. The overburden is probably 8 feet thick on an average and does not, therefore, materially effect the work of mining, either in open-cuts or underground operations.

OPEN-CUT METHODS.

Removal of ore may be accomplished by open-cut or by underground work, the former being by far the most common method. The one essential thing in open-cut work is to keep the bottom of the cut level or nearly so in order that water can not accumulate and interfere with the handling of ore and waste. Probably the most difficult part of the operation is the removal of the overburden, which is usually allowed to cave in and is then removed. It is probable that in the majority of cases that method of procedure is as satisfactory and economical as any other means except that a certain amount of ore may be lost by mixing with the waste. However, in large scale work, as with steam shovels, the stripping of the overburden should always precede the removal of the ore.

Should the deposit worked extend downward below the bottom of the open-cut, the bottom of the cut is lifted by deepening the entrance or approach. Occasionally it is not found possible nor desirable to deepen the entrance, in which case the approach is turned into a slope, when the ore has to be hauled out by power.

The advantages of open-cut work are numerous and varied, such as ease and economy in removal of ore, self-draining, plenty of air and light, and an opportunity to sort the ore and to remove only that part which is worth handling.

UNDERGROUND METHODS

There are deposits of manganese in the State that are of such a size as to warrant systematic development and working, but no serious attempt has been made up to this time to produce large tonnages at low cost by systematizing the methods. The usual method of procedure in underground work is to run drifts in the ore body, and as the deposits are not large it is possible to remove the entire width of the deposit by one drift. It is evident then that all work is done at the face of the drifts and is called breast stoping. Should the ore body extend upward and pass above the face of the drift, it is reached and excavated by running a second drift above the first, the posts of the second drift standing upon the lagging of the first. If it is found necessary and desirable, other drifts may be driven one above the other to a height of five to seven sets. In fairly firm ground this method of procedure could be carried to a height of ten sets, but ordinarily five and seven sets are all that are considered safe.

In ground that stands well, little lagging need be employed either on the tops or sides of sets; in fact instances have been noted where no lagging was employed, but set upon set was built as the various drifts were run, the caps of the lower being used as sills for the upper and consequently being notched both above and below to properly space the tops and bottoms of the sets. The sets of the last and uppermost drift driven are lagged and the sides are also lagged if found necessary.

Flooring or bottom boards are placed on the sills of each drift as it is driven in order to provide a platform for the miners to stand upon, but if thought desirable the dirt as excavated may be allowed to fall to the floor of the first of the series of drifts driven, from which place it is loaded into buckets, transferred to the shaft, and raised.

Occasionally a deposit is encountered that is too wide to be worked by one drift, in which case side or "skirting" drifts are run and timbered by the so-called "jamb-sets," that is, sets standing close together, the adjacent posts being vertical instead of having a batter. As in the case of the superimposed sets, side or jamb sets to the number of five or six can be used safely and satisfactorily if the ground is firm and care is taken in placing them. Practically all deposits worked by the multiplication of sets, as described above, have been exhausted before any serious trouble due to caving has occurred, but it is doubtful whether large deposits could be worked for a number of years without collapse of the timbers through movement in the clay walls. For the ordinary small deposit the method of following the ore body by a single drift or by superimposed and side drifts, has proved satisfactory and is about as good and economical a method as could be expected under existing conditions.

A combination method of mining is commonly employed where the preliminary work is done by open-cut, which is carried to the point where the thickness of overburden becomes excessive. Further work by open-cut is abandoned and the removal of ore is accomplished by underground work. Drifts are run into the face of the ore body as exposed and the work of mining is carried on as previously described, they have to be driven from the surface or from the foot of shafts. Holes driven into the face of open-cuts are commonly called "nigger holes," while the driving of drifts in the ore bodies and gouging out the ore is called "hogging." (See fig. 22.)

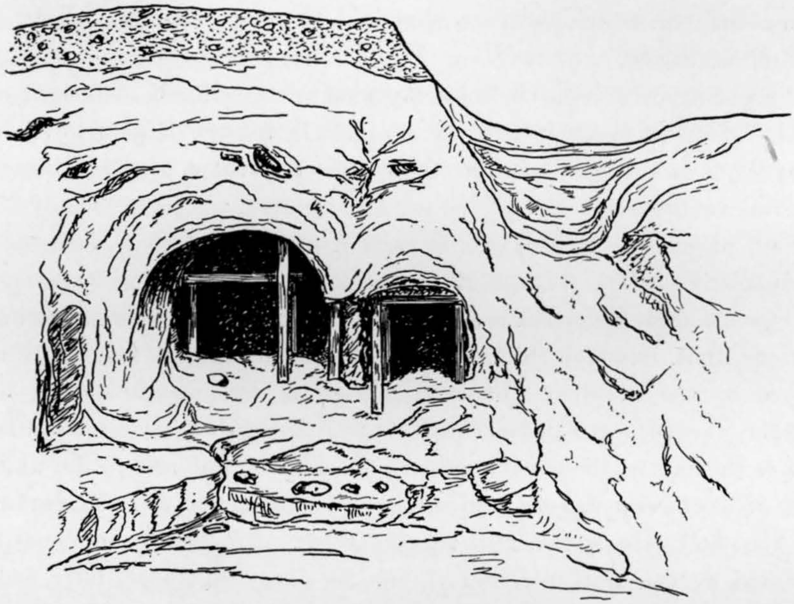


Fig. 22. Method of removing manganese-bearing clays by drifting on face of open-cut after bank becomes too high for safe working.

The working of deposits of manganese occurring on steep slopes or in open-cuts where excessive thickness of overburden has developed, may be readily accomplished by drifts driven into the face of the cut on the exposed surfaces of the deposit. Should the deposit be of considerable size and more or less continuous, it could best be worked by spacing the drifts at 15- to 25-foot intervals and driving them parallel with each other. The drifts should be well supported by sets. Cross-drifts or passages should then be run at similar and equal intervals along the series of drifts opened on the face of the cut, which would connect them and divide the deposit into blocks.

The bulk of the ore would by this method of procedure be removed by the two series of drifts run normal to one another, and at the same time ample support for the bank would be provided. Further, the extent of the workable area of wash-dirt would be definitely known, and only those portions of the blocks or pillars left standing between the drifts that contain ore need be removed.

In order that the above method may be carried on to advantage it is necessary to maintain the parallelism of the drifts, even though some barren ground be worked; the proper support of the bank can only be insured by systematic work in the driving of drifts and forming of pillars.

When the limits of the ore deposit have been reached and no workable ore remains above or below the level worked, the pillars should be removed systematically from within outward to the open-cut, temporarily supporting the working by props if found desirable or necessary. Should the deposit extend upward above the level of the ground worked a second level may be opened above the first and so continued for a number of sets in height, the upper set standing upon the lagging of those below. The removal of that part of the deposit that might extend downward below the level first opened is a difficult task and should hardly be attempted unless skilled miners are available, due to danger of serious caving. Rather than attempt to mine underground, care should be taken before work is begun to open the first level at the bottom of the deposit, when all subsequent work would be overhead, which can be carried on with comparative safety.

The principal advantage in underground work is that a minimum amount of waste has to be handled with the ore, which is a great advantage when the ore is washed, and more so when screening is the only treatment the ore receives to make it a finished product.

Where large deposits of ore occur under a covering of 50 feet or more, necessitating underground mining, some systematic method should be employed. The weak and treacherous walls of clay that would enclose the openings made by the removal of the ore could hardly be supported for any considerable length of time, so that it is doubtful whether methods requiring support could be used to advantage, nor would filling methods be applicable. Caving methods in clays which become "quick" and run when saturated with water could hardly be employed. With no stable footing for timbering the use of posts and sets, even with sills and lagging for the latter, would be limited, consequently some method would have to be resorted to, which on the one hand permits the removal of large quantities of ore, and on the other requires a minimum amount of timber for support.

A method that has been employed rather extensively in deposits difficult to mine and support might be applied to advantage in the mining of manganese, but would only be applicable to large-size deposits of ore uniformly distributed and large portions workable.

The method consists in driving a passage of triangular cross section longitudinally with the deposit and supporting the sloping walls above by timbers and lagging put together in a manner similar to the construction of the roof of a house. The main supporting timbers are called A-frames and consist of two heavy timbers fitting together at the tops and standing on sills placed longitudinally along the sides and bottom of the passage. No connecting cross-pieces are necessary as the timbers are held together by their own weight and that of the roof above.

A passage once formed and timbered as described can be maintained with very little work and expense for considerable time and permits work to be done within and beneath the protecting timbers in comparative safety. At fixed intervals along the passage, holes are sunk to and connecting with a second passage driven directly below and in line with that above. This second passage need not be larger than five by seven feet and may be timbered with ordinary sets. At the points where the holes connect with the lower drift, gates are built into the timbers of the sets, and control the discharge of all materials passing through the holes, which are nothing less than ore chutes. This preliminary work is wholly development and prepares the mine for the excavation and handling of the ore. The distance between the ore chutes should be at least twice the width of the upper passage in order that pillars of unmined ground may stand between the excavations formed around the ore chutes.

Beginning at the tops of the chutes the floor of the passage is loosened and shoved into the ore chutes, which is continued until round or square openings are made in the floor of the passage, definitely marking out the size of the rooms and pillars between. The ore excavated around the chutes falls to the gates below and may be drawn off at will, the entire operation of mining and handling of the ore being accomplished largely by gravity.

When two or more adjacent rooms have been worked out and examination of the walls show the necessity of providing support, timbers are placed in the rooms transversely with the passages above and below, following which the intermediate pillars are removed by pick and shovel, the ore falling into the adjacent rooms and being handled through the chutes previously employed in handling the ore in the rooms that have been worked out.

It is obvious that not only is the ore handled by gravity, but also that no water can accumulate in the workings as it is drawn off through the chutes and lower drifts to conveniently placed sumps, from which it can readily be ejected from the mine. Further, there can be little difficulty experienced from bad air in a mine so developed and worked, as certain of the chutes can readily be kept free from ore, thus permitting a natural movement of air.

SLUICING

Superficial deposits only a few feet in depth cannot, of course, be worked by underground methods, and had best be worked by sluicing, provided sufficient water is available. Even with a limited amount of water, sluicing can be done, but care should be taken to prevent undue wastage. As is well known, the amount of water required to move clays and gravels is small provided it is properly applied and the means of conveying the materials moved does not present an undue amount of resistance.

On slopes of 15° or more large quantities of clay can be moved in sluices made of boards or formed in the clay bed of the deposit, in fact the latter method involves less expense and though the clay bed is not as flexible as wood sluices, it offers less resistance and the expense of upkeep does not have to be considered. A more or less even slope on a hillside can be worked to advantage by sluicing, but the conditions that lend themselves particularly well to sluicing are the head of a run which slopes to a common center, and a fairly steep grade at the lower part of the slope. With such more or less ideal lay of ground it is possible to erect a plant on the steeper portion of the slope and form ditches or sluices on the slopes above the plant bringing a number to a common point where they are united and enter the plant through one main sluiceway.

At various distance on the slope roads or runways should be built crossing the sluices on bridges. Upon these runways, scrapers can operate, taking their loads at the ends or at any point along their line and delivering the excavated material to the sluices through holes in the bridges. The ditches should be cut to the clay underlying the ore-bearing formation in order that no further work need be done upon them once the work of sluicing has begun. The distance between sluices should not be too small, otherwise difficulty might be experienced in conveniently loosening and removing the wash-dirt; nor should the distance be too great, otherwise the number of sluices would be limited. Six sluices can conveniently be operated on a practically uniform slope, while on a concave slope, as at the head of a small run, a much larger number could be employed to advantage.

The sluices and runways having been constructed, the next thing in order is the bringing of water to the sluices, which can best be done by running pipe lines up the slope to points, above the uppermost runway. To the ends of the pipe lines sufficient lengths of hose are attached to permit the free ends to be placed in at least two adjacent sluices. Probably the best arrangement is when a pipe line is laid along the middle one of three sluices with a length of hose that will reach the sluices on either side. Two pipe lines will then readily serve six sluices and minimum length of hose be required.

Should the deposit be extensive both in lateral extent and depth, considerable time would be required to exhaust the ore-bearing clays adjacent to one section of sluices; consequently one pipe line might serve for the whole operation, which could readily be shifted as might be found necessary to develop and work new ground.

Where the amount of workable ground is limited either in area or thickness a box sluice can be employed to advantage, which can be moved as found convenient, but its range of movement will also be limited to the means employed in furnishing water to it. Square box sluices with or without metal linings are often used when handwork is done, in which case the pipe line usually follows the sluice box and delivers water directly to it, the wash-dirt being brought to the sluice in wheel-barrows. Often the available supply of wash-dirt immediately adjacent to the sluice may be exhausted, when it is customary to operate the washer at intervals only, thus permitting an accumulation of wash-dirt which will insure a day's wash. Runways are made for wheel-barrows by which banks of dirt can be formed along the line of the sluices convenient to be fed in by shovel.

Hand fed sluices are much more satisfactorily operated than are those fed by slips or scrapers as a constant feed can be maintained, which permits the washing apparatus to do much more satisfactory work. When sluices are fed by scrapers or cars, even when dumped on grizzlies, there is usually a rush of dirt that completely chokes the sluices unless steep grades and much water are employed. Water is dammed back by clogged-up sluices, thus temporarily cutting off the supply for a period, then when the jam is broken a rush of water and dirt overwhelms the washer. Such irregularity of feed is often responsible for much poor work that is done.

STEAM SHOVEL AND DRAG-LINE WORK

Occasionally a large deposit of manganese is discovered of considerable extent both laterally and vertically, or a series of more or less connected deposits may occur in such a position as to permit working together. Under such conditions large-scale work is both necessary and desirable, and should be done with minimum expenditure for equipment and the lowest possible working cost.

Of the two general methods of procedure with large deposits, the one chosen depends largely on the previous experience of the operator or the most available equipment. Steam shovels have probably been most extensively employed for large-scale work, but there is little doubt that the drag-line scraper can be operated just as readily and cheaply and often more advantageously than a steam shovel. (See plate V., B.).

When steam shovels are employed care should be taken to establish the working-level and not to excavate below it, otherwise water will accumulate, to say nothing of the trouble and expense of hauling loaded cars out of the working pit. Should it be found necessary to lift the bottom of the cut, much more satisfactory results can be obtained by beginning at the entrance to the cut and establishing a new level, thus maintaining the proper grade of the cut. Should the washer have been built on a level with the cut as first formed, lifting the bottom of a cut will require elevating the cars to the washer level. Such difficulty is not experienced with a drag-line scraper, as the scraper can be elevated to any height desired to discharge its load.

The arrangement of tracks in open-cuts, for the movement of cars handling both waste and wash-dirt, is of the greatest importance, but judging from the examination of various steam shovel operations is usually given very little consideration. When an ore body pitches downward it is the usual practice to deepen the pit in an effort to get the last ton, apparently with the expectation that it will not go much deeper. However, it often happens that there is no alternative other than to work on the down grade in advancing the cut, for to do otherwise would require a large amount of dead work which might not be warrantable.

Aside from the grade of the track serving the shovel, its position with respect to the bank and the shovel is of much importance and depends upon a number of considerations such as: character of truck upon which shovel is mounted; width of face of cut carried; and somewhat upon character of material being excavated. If the shovel is mounted upon a truck designed to operate upon a standard gage track, the movement of the shovel is much more restricted than if it was mounted on a truck with flat-faced wheels. With single width of face equal to the reach or radius of the boom of the dipper, only one line for cars can be maintained, which with short hauls may be all that is necessary, but with long hauls the percentage of idle time of shovel is high. With width of face of cut equal to swing of boom, two lines of track for cars can be provided with the advantage that the shovel's period of idleness is materially reduced. The character of the material excavated often determines the width of cut, as the shovel will have to be protected against falls. A shovel operating so close to the bank that there is barely room in which to make the turn to dump, is almost sure to be buried should a fall occur. Width of cut, whether single or double, depends largely upon size of ore deposit; with small or narrow deposits a narrow cut would be employed even though it is not desirable from the standpoint of handling cars; large deposits permit any arrangement that may be considered desirable or necessary.

When exploratory cuts are made or small bodies of ore are to be removed from the bottom of old cuts, it may be permissible to form a cut or less than single width, in which case the track for the serving cars may follow immediately behind the shovel, but would require a swing in loading cars of more than 180° for part of the work at least.

Banks exceeding 50 feet in height should be worked in benches, but it rarely happens that cuts formed in the mining of manganese reach that depth. The usual practice is to begin at the surface and work downward after exhausting the deposit laterally, but with a shifting of the deposit to one wall with depth it may become necessary to remove one side of the cut in benches or resort to underground methods of mining. The latter method would undoubtedly prove most satisfactory, especially if the cut is deep. (See frontispiece.)

Overburdens that exceed 25 feet in depth can hardly be stripped to advantage, or those of less thickness that are composed of hard material, such as beds of shale or chert. While manganese deposits in Georgia occur almost universally in clay, yet the clay may be considered a primary deposit in that it has not been moved from its original position, and may be overlain by extensive accumulations of debris. Steam shovel work in manganese deposits under such conditions is hardly warrantable and it will be necessary to employ shafts and drifts or tunnels to develop and work the deposits.

While drag-line scrapers have not been used to any considerable extent in mining manganese in Georgia, yet they have been successfully employed in other districts, and under much more difficult conditions than exist in the Cartersville district.

The drag-line scraper consists of two standards, usually 35 to 50 feet high, which are held firmly in place by ropes. A track cable connects the tops of the towers upon which moves a carrying device, which working in conjunction with the cable operating the scraper, permits not only the filling of the scraper but its conveyance to any point between the towers. The scraper is transferred to the cut where a load is taken, and it is then elevated and carried to the point of discharge. While in some respects the drag-line is not as flexible as is a steam shovel, yet in other respects it is more so and has a decided advantage in being able to take a load and discharge it at considerable distance in one operation. Further, stripping and excavating ore can be done with equal facility and without the necessity of going to the expense and trouble of laying track from the cut to the plant or washer and the waste bank.

The larger dimension of a deposit having been determined the towers are erected at such points as will give as great a length of cut as possible and yet permit the ends of the carrying rope to be level or nearly so, which may mean that one of the towers will be somewhat higher than the other. The operating engines are placed near the foot of one of the towers, and control the movement of the carrying rope and drag-line and through them the scraper. Stripped material may be dumped at any point desired, but preferably near one end of the line, the wash-dirt being delivered to wagons or hopper, feeding the mill preferably at the end opposite the dump.

When excavating wash-dirt, which is more or less free from rock, the scraper could be discharged in a hopper containing the grizzly, the dirt all being washed through the bars except the coarse ore, by a jet of water playing upon it. Much of the lump or dornick ore could be cleaned in this manner, unless it was more or less porous and contained considerable clay when it would have to be broken up and more thoroughly washed by passing through a log washer. The discharge hopper and grizzly could then be placed at some distance from the washer, the wash-dirt being sluiced to the washer. After excavating a strip of ground a rod or more wide, a shifting of the end of the carrying rope opposite the operating end permits the excavation of another area of approximately equal size.

The particular advantages of the drag-line scraper are: no heavy machinery has to be moved to the mine; no excavating nor grading for track is required; there is no danger of having equipment buried by falls; and the work of excavating and conveying wash-dirt from cut to washer can usually be done in one operation.

SUPPORT OF EXCAVATIONS

The support of excavation in manganese mines is as simple as are the methods of mining. In fact, aside from the lining of shafts there are but two forms of timbering employed, namely: posts or props and sets. The prop is occasionally used, but the most common support is the set, which in solid and firm ground may be the three-piece set, that is, cap and two posts or legs; while in weaker ground the four-piece or full set is usually employed.

Sets are made of 6 or 8 inches round timber with the bark on, being roughly notched in cap and sill to hold the posts in position. Lagging of round sticks 2 to 3 inches in diameter is common, often being placed two layers deep across the tops of several adjacent sets. Where timber for sets is bought it is customary to use 3 and 4 inch sticks for lagging, which on being split make two pieces each per stick of standard length. The cost of mine timber for sets is 15 cents per stick regardless of the size, lagging and set timber costing the same. Three standard length sticks, split, make six pieces, which with four pieces in a set constitute a complete set of seven pieces. The cost per set is then $1.05, which added to the cost of placing, increases the cost to about $1.50. Should lagging be required for the sides of the sets, and the timber purchased, an additional cost of 90 cents per set would make the cost of a set $2.40; however, if timber is on the property and the only cost is that of cutting and forming, the cost would hardly exceed $1.00 per set. When more elaborate systems of timbering are employed, as when top and jamb sets are placed in the excavations, more time is consumed in placing the supports and consequently the cost is proportionately higher.

Test-pits are rarely ever lined, as their usefulness is past once they have reached and proven the deposit. Shafts are, however, more permanent in character, as they are intended not only for development but for working the deposit in which they are sunk. If the indications are not favorable for a large tonnage to be handled in a shaft and the clay gives evidence of being solid and not readily decomposed by weathering, no lining is placed, but under ordinary conditions it is desirable to line a shaft as soon as it is completed, thus insuring it against caving in wet weather.

Shafts are usually lined or cribbed with round poles built up in pig-sty fashion, being notched somewhat to hold them together, or instead of notching, strips of board are often nailed in the corners, thus binding the sticks together. More permanently constructed linings of sawed timbers are employed consisting of 4 by 6 inch or 6 by 8 inch material, which is notched a fractional part, up to one-half the width, depending upon whether open or closed cribbing is desired. The four timbers comprising a set differ from a drift set in that there are two long and two short timbers of equal length for the sides and ends of the shaft excavation. The long timbers are called "wall-plates," the short members "end-pieces," and when put together constitute a "frame." The cost of a frame which is the unit upon which cost of shaft cribbing is based, depends entirely upon the cost of sawed timber, and can readily be calculated once the price of the particular size of timber used is known. Shafts are often lined with boards or split poles placed longitudinally in the shaft and held in place by frames of round timber, often roughly hewn, which are placed from 4 to 5 feet apart vertically. The frames are spaced and held in position by planks and boards placed in the corner and nailed to the frames.

Cribbing may be built up from the bottom of a completed shaft or begun at any point as desired. No support for the cribbing is needed in the former instance, while some means of temporarily holding up the cribbing will have to be provided if lining of the shaft is carried on during the sinking operations. When a shaft lining is built in sections, work of placing timber is begun at the point desired and the cribbing built upward. In order to support the timbers a "bearing-frame" is first placed which consists of long timbers serving as wall-plates, being properly spaced by end-pieces similar to those ordinarily used. The ends of the long timbers are set into the walls of the shaft where the cribbing is to begin and when properly spaced by end pieces and leveled by wedging, the work of building up the lining is begun and carried to the surface, but it should be carefully wedged in place against the shaft excavation in order to take the weight off the bearing-frame. Sections of 25 to 30 feet can be placed in this manner, but with clay walls there is more danger of slipping and breaking down of the lining than when similar work is done in rock.

When closed cribbing is used it may be built downward from the previously-placed timbers above, by the use of short pieces of plank, usually 2 by 4 inches, which are nailed to the cribbing above and to the individual frames as placed below. The short lengths of plank are called "dogs" and take the place of iron hooks similarly used in the support of 4 to 6 feet of cribbing while being built up, especially in lining large shafts. The wooden dogs are removed when the cribbing has been permanently placed and wedged so that it cannot move. The cost of round pole cribbing when timber can be obtained on the property is largely a matter of time in cutting and placing, but should not exceed $1.50 per foot for ordinary size of shafts. When timber must be bought the cost of round sticks alone amounts to 90 cents per foot, while the labor of placing brings the price up to approximately $2.00.

If the frames are not set close together it is necessary to nail boards vertically up and down on the inside of the cribbing, otherwise the clay when wet will run through the spaces between the timbers. These vertically placed boards are commonly called "lacing boards" and besides making a close lining, prevent the bucket from catching on the timbers of the cribbing. In wet shafts, especially when lined with round sticks, lacing boards are absolutely necessary.

VENTILATION

The general impression among those interested in and operating manganese mines is that the ventilation of the workings is of little or no importance, consequently slight effort is made to provide for a supply of fresh air. This lack of consideration for the health of the men working underground is not only responsible for much ill health, but also for the disinclination and inability of the men to make an adequate return for the wage paid. It is a well-known fact, demonstrated time without end, that foul air is enervating and materially reduces the effective effort of the laborer.

It is not an uncommon occurrence to see men apparently suffering from over-exertion who are not doing an average man's work. This is a symptom of an atmosphere deficient in oxygen combined with excessive moisture. Further, men not infrequently are forced to leave the workings for short periods and seek fresh air in order to do any work at all. There is therefore a double loss—loss in time and loss in efficiency.

Ordinarily it is a simple matter to provide an ample amount of fresh air and that too in most cases by natural means and consequently without any great expense. Drifts or tunnels driven into the face of open-cuts or hill-side slopes can readily be ventilated by connecting with test-pits or shafts. This is commonly done, but is the result of accident, or for the purpose of removing bodies of ore encountered by the vertical openings, rather than to furnish fresh air to the workings. Probably the greatest difficulty in securing adequate ventilation is experienced in shaft workings, especially when drifts are run some distance from the foot of the shafts. The simple and obvious solution of this problem is to connect two or more shafts by drifts or to connect a shaft with drifts driven from points lower down on the slope. There is seldom any difficulty experienced in making such connections, and in fact it is the practical thing to do irrespective of ventilation, as such openings and connections permit ready access to the workings; men coming and going through the connecting passages rather than being raised and lowered by bucket and windlass.

When not convenient nor possible to make connection between shafts or to the surface through drifts, it is necessary to force air into the workings by artificial means. There are few shaft mines with drift workings of such a length that sufficient fresh air cannot be supplied to the workings by the use of a "sail," which is simply a long sheet of muslin or other strong cloth attached to a stick at its upper end and supported at a height of 10 to 12 feet above the ground, the lower end being sewed into a cylinder beginning at the ground level. The cylinder or tube of cloth may extend into the workings or be attached to a sheet metal tube which is carried down into the shaft and extended to or near the end of the longest drift. By keeping the surface end of the tube presented to the breeze or wind by adjusting the supporting stick, considerable volume of air can be forced into the workings, which while not under much pressure is ordinarily sufficient to deliver a considerable volume of air to a distance of one hundred feet or more, provided a sufficiently large tube be provided, otherwise the resistance to the movement of the air will be too great and the supply will be correspondingly small.

Should a sail prove unsatisfactory, it is probable that some more positive means will have to be employed. Furnaces are occasionally used and fairly satisfactory results obtained. A common form of furnace and one that can be erected and operated at small cost, consists of a metal pipe inserted in a bore hole put down so as to connect the workings at such a point as to create a movement of air from and through the shaft and the workings and thence up the pipe-lined bore hole to the surface. In order to create and maintain a movement of air the pipe must ordinarily be extended to a height of 10 or 15 feet above the surface; a motive column is thus formed, but owing to the size of the pipe it is practically impossible to start a circulation of air without producing a still greater difference in weight of the two columns of air connecting with the workings. This is accomplished by connecting a furnace with the stand-pipe, the draft set up in the pipe then acts as an injector, dragging the air upward from the workings below through the pipe, and to replace the air displaced an equivalent volume of fresh air must flow into the mine through the lower opening of the shaft.

When the shaft is the only opening to the underground workings, the ventilating flue or pipe may be placed in the corner of the shaft, the lower end being extended as far into the workings as is desirable, while the upper end is run above the mouth of the shaft and thence to the furnace, which may be built upon the surface or excavated in a clay bank if one is conveniently located. The previously described method of ventilating workings by connecting shafts and drifts is by natural means, the movement of air being down the deeper opening and out of the shallower during the summer, and the reverse of that during the winter time. (See fig. 23.)

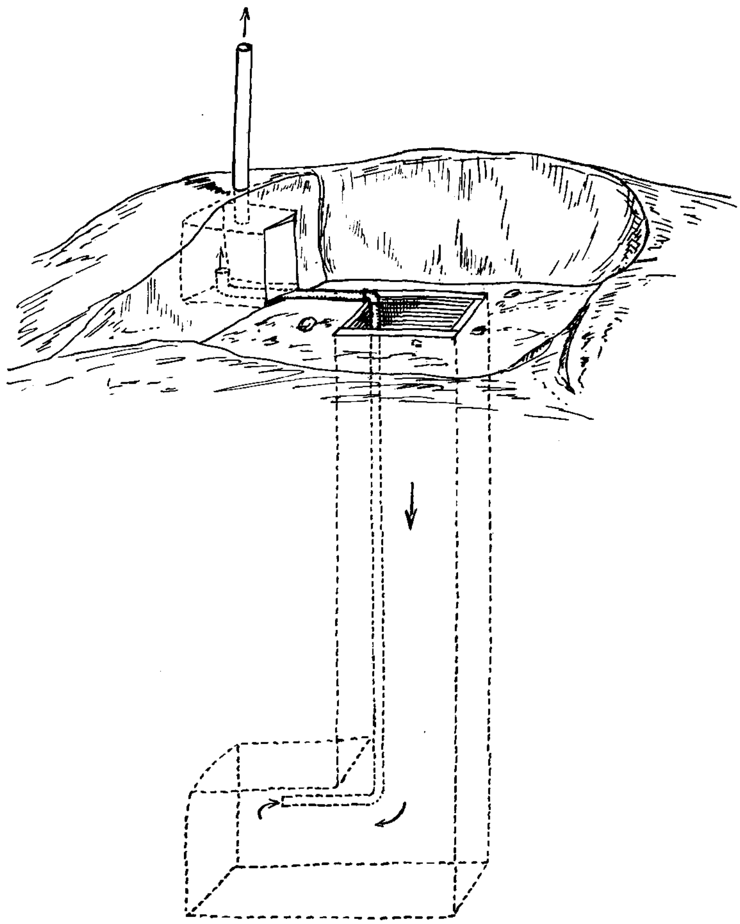


Fig. 23. Method of ventilating workings by furnace.

A still more positive means of ventilating workings is the use of small rotary blowers such as are used in forges, etc., but they cannot be employed to advantage except where there is some means of driving them, which is usually impossible about manganese mines as few mines employ hoisting engines, and it is only where washers are operated that means of driving the blowers are available.

DRAINAGE

Ordinarily shallow openings are troubled more or less by accumulations of water, which is particularly true when the openings are wholly within superficial deposits of clay resulting from the decay of limestone and quartzite. While ordinarily clays are highly impervious to water, yet their occurrence in this district is in primary deposits rather than secondary, that is, the clays occupy the same position as the formations from which they were derived and retain to a certain extent the lines of weakness and porosity, such as bedding planes, solution cavities, etc., and at the same time due to shrinkage from loss of lime have developed pronounced joints and slips, all of which permit water to pass readily through their mass.

Water is occasionally found in open-cuts where the bottoms have been puddled through the operations of mining and handling of the wash-dirt,, but even under such conditions, permanent accumulations of water are seldom ever found in them. Underground workings may become soft at times, but water rarely ever accumulates and consequently no provision need be made for its removal. Occasionally wet mines are opened and a limited amount of water enters the workings, which may have to be removed by bucket or pump. Springs that develop in mines often follow deposits of manganese, which fact has led to the prevailing impression that wet ground is especially favorable to the occurrence of bodies of manganese.

There are a few localities in the district where considerable quantities of water have been encountered, one of the most conspicuous instances being the Chumley Hill property. Several men lost their lives in a tunnel being driven to open up the deposit, which had previously been worked by an incline or slope. The tunnel broke through into the incline which stood partly full of water, the outrush of which overwhelmed the men and they were drowned.

When water is encountered in shafts, drifts and other underground workings, provision should be made for its removal by means adequate to the amount of water encountered. Ordinarily surplus water can be disposed of when encountered in drifts or shafts by making connection with workings at a lower level, or by conducting the water to the surface through drifts, which is readily accomplished when the workings are situated on hill or mountain-side slopes of steep or moderate inclination.

Much of the water entering open-cuts comes from surface drainage and can consequently be best handled by conducting it around the openings by intercepting ditches cut on the slopes above.

Accumulations of water in open-cuts can be handled to the best advantage by steam pumps, but unless installations of power are required for other purposes, the expense of operating pumps may be prohibitive. It would, therefore, be a choice of cutting a drainage ditch to the level of the bottom of the cut or the employment of a hand or horse-driven pump. The horse-driven pump, such as are extensively employed in strip-pits in coal mining would provide a convenient and economical solution of the problem of open-cut drainage.

LIGHTING

One of the principal advantages of open-cut mining is having an abundance of light, which is to be particularly desired when selection between parts of the materials excavated is made. Sorting of ore, and especially the picking out of the lump or dornick ore is always done except when steam shovels are employed, and even then when the masses of manganese are large, it may be desirable to separate them from the wash-dirt. In open-cuts worked entirely by hand, no attempt is made to employ artificial illumination, but in large-scale operations where steam shovels are operated it is necessary to provide light for night work. As a rule this means a fairly extensive and well-equipped mine, otherwise there would be no power plant nor other source of electricity. The large open-cuts of the Georgia Iron and Coal Company are well lighted by incandescent lights of high candle-power and there is no difficulty experienced in carrying on the work at night. In order that the lights may be properly placed, wires are stretched across the cuts, the lights being moved along them as desired by means of ropes. Acetylene flare-lights can be used to advantage.

In underground work any form of illumination such as candles, oil lamps, etc., may be employed, but by far the best, the most economical, and probably most widely used method is the regular miners' acetylene cap lamp. Candles are occasionally used, but as miners' metal candlesticks are not employed, it is difficult to place and hold the candle in the most advantageous position with respect to the work being done. No oil lamps were observed in the manganese mines.

HANDLING OF ORE OR WASH-DIRT

In the discussion of mining methods it has been necessary to refer in a general way to the handling of excavated materials in the open-cuts and underground workings, but owing to the importance of that part of the work it is desirable to discuss the matter in considerable detail.

Owing to the limited scale of operations in manganese mining and the small equipment and consequent small investment, it is obviously necessary to employ the simplest and least expensive methods possible. In hand mining, therefore, which comprises the bulk of the work, wheel-barrows are employed in transferring the ore and waste from the working-face to the dump, where the final sorting takes place. Occasionally the bottom of the cut is lower than the entrance and it is necessary to push the wheel-barrows up an incline in order to get the excavated materials out of the cut. Under such conditions it is not uncommon to employ two men, one going ahead and pulling by means of a rope, the other pushing from behind. Plank runways are usually provided that the track for the wheel-barrow may be both solid and free from inequalities, so that the movement of the wheel-barrow may be rendered as easy as possible.

Drag scrapers or slips are often used in the initial operation of moving the dirt from the cut to the stockpile or washer. When slips are employed they are commonly used in conjunction with bridges having small square openings, across which parallel bars or gratings are placed to keep large pieces of ore or rock from passing through. The bridges are placed over sluiceways or cuts in which cars operate. The next step in the operation of moving excavated material is handling in sluices or by cars. When sluices are employed water is introduced into the sluice box or ditch above the point where the wash-dirt enters and carries the dirt to the end of the sluice or point of discharge, which is usually the washing plant. The general arrangement and operation of such a plant is described under open-cut mining. There is probably no means of breaking up clays and putting them more effectively into solution than the employment of sluices, especially when a certain amount of fairly coarse material is present to assist in the disintegration. With particularly hard and tenaceous clays that resist disintegration and solution, the plunging grizzly can be used to advantage. The plunging grizzly consists of a grizzly placed at the end of a sluice-way, but so arranged that the clay and water fall or plunge through several feet to the grizzly below. While certain clays resist breaking up even under such conditions, such an arrangement usually proves to be efficient as a carrying and disintegrating device.

Cars may receive their load through the medium of slips and bridges and operate between the loading points and the washer or dump. On steep slopes it is often desirable to dump the cars, filled at the bridge, and load other cars at a lower level rather than to operate a gravity plane. The cars may be dumped into a chute of any desired length, which discharges into other cars operating on a track leading to washer; or the cars operating on level of open-cut may be discharged on a dump which in turn feeds into chutes in the top of a tunnel, the cars operating on washer level receiving their loads in the tunnel through the chutes.

In large-scale work as when steam shovels are employed in excavating the wash-dirt and waste, and in loading the cars, it is customary to move the cars from the cuts by mules or by dinky locomotives. With short hauls and an ample supply of cars, mules may prove satisfactory, but with moderately long hauls too much time is lost by the shovels in waiting for the removal of filled and the placing of empty cars. It is not uncommon to observe a steam shovel standing idle from 30 to 50 per cent of the time waiting for the going and coming of cars to and from the washer when mules are employed and a similar loss was noted in one instance at least, when the cars were moved by locomotives.

It is questionable whether locomotives or dinkies can be used to such good advantage as engine planes in handling cars between the cuts and washer or waste bank. Where large tonnages are handled in stripping, inclines or engine planes can be employed to advantage not only in moving the cars, but in disposal of the waste on the spoils bank. The engine operating the plane should be situated at the extreme end of the spoils bank in order to have a direct haul, which even though the engine may need to be shifted occasionally, has the advantage of less length of rope, also eliminates the need of guide pullies, which are a constant source of trouble. However, as the direction of the face of the cut may change from time to time, it may be necessary to employ a deflecting pulley in order to give direct pull on cars and particularly to prevent the movement of rope over considerable surface of waste bank.

Occasionally engine planes are employed in delivering care to washer level, particularly when the cut has been carried to a much lower level than that of the washer, and the grade is too steep for cars to be hauled out by locomotives. Further, gravity planes may prove particularly serviceable in transferring wash-dirt or ore from a mine or cut on a high and steep slope to the washer or loading chutes on the railroad below.

When a number of operations, such as shaft workings and open-cuts, are on the same property it is desirable that they should not only be connected together and with the washer, but that considerable storage track be provided; with such arrangements there is little danger of accidents or other causes of stoppage or delay, interfering to close down the mine and reduce the output, except it be occasioned by the mill itself.

The handling of wash-dirt in underground workings is usually accomplished by wheelbarrows and buckets, the buckets being filled at the working face and moved to the foot of the shaft by wheel-barrow. While this method of procedure seems crude and with heavy buckets a rather uncertain method, yet there is no need of trucks and tracks for wheel-barrows to operate upon, a piece of plank or board being sufficient.

LABOR AND WAGES

The labor situation in the manganese mines of Georgia is without doubt the most serious problem confronting the operators and unless some means of relieving the situation is definitely worked out, the production of manganese will be materially curtailed. Labor is scarce owing to the large number of men who volunteered and were drafted into the army. A still further reduction was experienced due to the demand for labor at high wages in government and private work. Furthermore, Cartersville is primarily a farming community and not a mining camp, although various minerals have been mined there for many years and in large quantities. Farm labor is far from satisfactory for mining as well as any other industry for the simple reason that it is seasonal and uncertain at best. The farmer is first of all concerned with his crops, and when he has laid them by or cannot work in the field he may be willing to put in some time in the mines. The supply of labor is, therefore, constantly fluctuating; two-thirds enough to-day and none to-morrow.

The disadvantage arises largely from having to employ unskilled labor, but that is an unfortunate condition arising from location of the district and relatively small-scale operations; there is, however, another difficulty that is inherent with all labor regardless of situation, namely, the question of wage and adequate return for wages paid. Two years ago the wage for common labor was $1.25 per 10 hour day; a year ago it was $1.75, while at the present time it is $2.75 per 8 hour day, although in many localities the regular wage is 25 cents per hour or $2.50 for a 10 hour day. To add to the difficulty certain operators in mining work, if not manganese mining, are offering $3.00 for a 10 hour day.

Had the efficiency of labor increased somewhat or even remained at the none too high standard of a year or two ago, there would be little or no complaint, but what has actually happened is, the efficiency of the laborer has fallen off in a surprising manner; according to the report of the operators less time is put in, less work is done and less manganese is consequently mined per man.

Both whites and blacks work together and at present a surprisingly large percentage of boys under 18 years of age are regularly employed about the mine and usually with as good results as with the older men.

The scale of wage for the Cartersville and adjacent districts is as follows:

Steam shovel driver	$3.75 to $6.00
Steam shovel helper	$2.75 to $4.50
Miners, in open-cuts and underground	$2.50 to $4.00
Common labor	$2.50 to $3.00
Labor for hand picking	$2.50 to $2.75
Dinky driver	$3.25 to $4.00
Washer man	$3.00
Fireman	$2.50 to $2.75
Repair man	$3.25

Contract work does not seem to be looked upon very favorably in the manganese mining operations, which if it could be applied to much of the work as test-pit work, shaft sinking, and mining, would materially improve both character and amount of work done.

The small size of workings and their wide distribution is largely responsible for poor quality and quantity of work done, for it is next to impossible to keep a foreman at each opening and consequently the men are without supervision, with its attendant evils. Short hours are made shorter, delays are magnified and a general carelessness and lack of interest results.

Contract work stimulates effort, for the laborer is first to feel the result of poor and ill-directed effort; supervision, while desirable, is not so necessary. The contract price for test-pit work ranges from 40 to 50 cents per foot. Shaft sinking is usually done by day labor. Drifting is often contracted for at the rate of $2.00 per foot, which includes the placing of timbers. Open-cut work is occasionally contracted at $7.00 per ton for lump ore; the wash-dirt is treated free of charge and the finished ore is paid for at the same rate as the lump. In all contract work supplies are furnished.

LEASES AND ROYALTIES

Options are often given for leases and sale of mineral land, the option usually being without consideration and void at the expiration of the date set. Leases are contracts covering the operation of the property with certain limitations regarding the period allowed for the equipment of the property, which under certain conditions may be extended. In a similar manner options are granted, often with considerations, covering damage to property, and insuring good faith by permitting the testing of property contingent upon purchase.

In order to ensure operation of properties it is customary to have a minimum royalty clause in leases, which requires the payment of a certain sum as $25 to $100 per month, if the property is not operated. Occasionally a fixed sum is demanded on the signing of the lease, covering the royalties at the rate named in the lease for the period of a year. This payment or royalty is reduced by application of the royalty upon tonnage of ore produced. This method is obviously unfair as it throws all the risk of operation and consequent production upon the lessee.

The usual royalty formerly asked in the manganese districts of Georgia and still the practice in certain localities, is 10%; however, during the past few years the rate has increased somewhat, 12½% and 15% being asked. The highest royalty paid to our knowledge is 20%.

20% or less of manganese	$0.50	per	ton	royalty
20 to 30% of manganese	1.00	"	"	"
30 to 40% of manganese	1.50	"	"	"
40% and over of manganese	2.00	"	"	"

It is common to have a sliding-scale of royalties based upon the grade of ore produced; the following scale may be used as an example:

A minimum royalty of $25 per month to apply for each month of the term of the lease to commence —— and to become due on the 10th day of ——.

There is a large percentage of the manganese land of the Southern States that is being held for sale and cannot be leased under any consideration. This is a short-sighted policy for an operating property is always more attractive than a non-operating one, because the nature of the deposit and the character of the ore can readily be seen, and the plant, though incomplete and inefficient, gives some idea of a possible method of treatment. An untested and undeveloped property, especially with manganese, is a very uncertain quantity. The risk is far too great for one to take without some assurance that he will receive some return for money invested. "Buying a pig in a poke" does not appeal to the average business man.

It is evident from this discussion of occurrence of manganese and its exploration and working that there can be no centralization of equipment and operation, except as under exceptional condition a number of properties can be operated under one management. As carried on to-day manganese mining is a poor man's business, although that it can be expanded into a large and prosperous operation with large investment in mining and concentrating equipment, is evident on examination of a number of the large properties in Georgia and Virginia. Lack of definite practice in the mining operations and a great scarcity of labor, particularly skilled labor, are largely responsible for the inefficient and unprofitable work often observed.

METHODS OF CLEANING THE ORE

In speaking of methods of mining the expression dry-mining is commonly employed, and is used to distinguish between mines, the ores from which are marketed without treatment other than simple screening, and those which receive more or less extensive treatment as in washers. The designation dry-mining does not refer, therefore, to a method of mining, but rather to a method of treatment or preparation. It is evident then that there are various methods employed in the preparation of ores, and were it not for the limited scale of the deposits of manganese, which has bred a pronounced conservatism and reluctance toward the adoption of changes in methods, there might be added to the list several more very important methods of treating ores for the purpose of increasing their value.

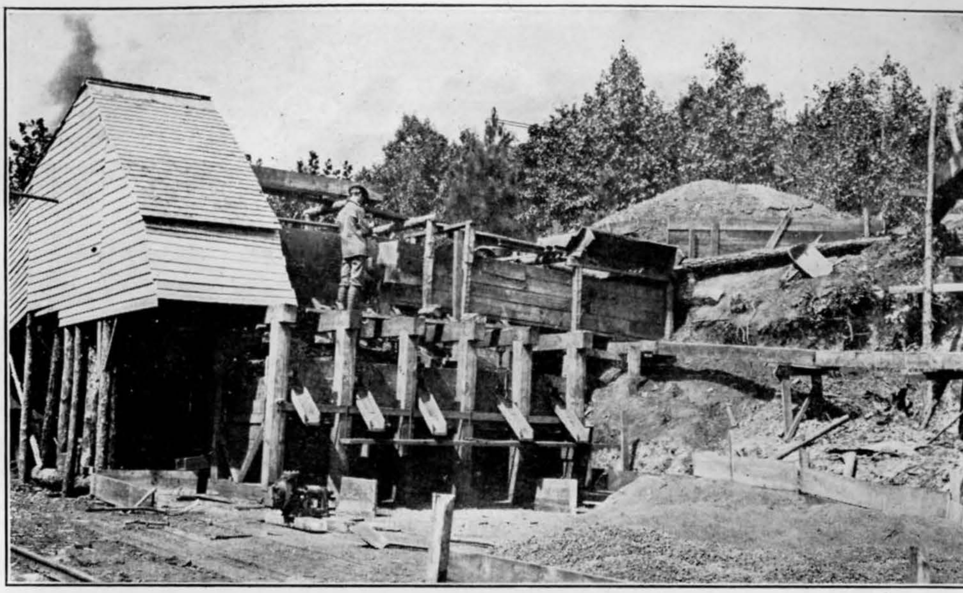
It is proposed, in this connection, not only to discuss the methods in common use, but to outline and describe certain important changes that could be made to advantage. Under this heading, then, will be discussed present practice and suggested changes.

DRY-MINING

The simplest method employed in the preparation of manganese ore for use in furnaces is dry-mining, which consists in passing the ore or wash-dirt as mined over a screen, the undersize or material passing through the screen being discarded, for the time being at least, and that remaining upon the screen being a finished product.

This method of procedure is both simple and crude, but lends itself conveniently to small scale operations, where the only capital that the miner has is his muscle. Further, the method is also employed in the earlier stages of development and working of large deposits before a washing plant has been erected and indeed before a definite method of treatment has been decided upon. Dry-mining may, however, be a matter of necessity rather than choice, as when the property is at considerable distance from water and the expense, especially during the war, of pipe lines is prohibitive. Again the deposit worked may be very rich, yet too small to warrant any great expenditure of money in equipment. There are deposits of manganese, however, that can be treated to advantage by dry-mining or screening such as occurrences of ore of great uniformity in size and of such a size as to permit the bulk of the clay or waste to pass through the screen, the manganese remaining upon it or at least failing to pass and consequently being separated from the waste. Superficial deposits of manganese of both fragmentary and nodular form and occurring in the surface soil, or at no great distance below the surface, are largely quite uniform in size. The "pebble," "button" and "kidney" forms are of the type last mentioned. Granular ore consisting of loosely-connected or broken masses or dornicks can often be separated by screening, although care must be taken not to attempt to pass all such material found over a screen, otherwise considerable loss may result from the presence of too much fine ore and particularly soft ore, as certain occurrences of pyrolusite.

Considerable loss of fine ore always results from the screening of the mine dirt and the rejection of the clay and fine mineral passing through the screen. Numerous waste banks are to be found in the various manganese districts of the state that could be worked with profit, if washing apparatus was available. From tests made on several such waste banks fully one-fifth of the original ore-content remains in the dirt and could be readily saved by washing. Dry-mining is, therefore, a very wasteful process of cleaning ores and should not be employed except where conditions or circumstances do not allow more careful work to be done, but if found desirable or necessary as a temporary expedient, the discarded fines should be placed in a bank separate from the waste from stripping and removal of masses of barren clay as are commonly associated with deposits of manganese. Could a test be made on the ores of different properties it would be possible to determine the proper size of screens that should be used in dry-mining, in order to save the largest amount of ore and yet separate out the waste. Averages of the results from



A. CONCENTRATING MILL SHOWING ARRANGEMENT OF LOG WASHER, SCREEN, AND JIGS AT THE STILES MINE, ETOWAH DEVELOPMENT COMPANY PROPERTY, 2 MILES EAST OF CARTERSVILLE, BARTOW COUNTY.

B. CONCENTRATING PLANT AT THE BROCKMAN-DORN MINE ON THE VAUGHAN PROPERTY, 3 MILES EAST OF RYDAL, BARTOW COUNTY.

a number of typical deposits would give a size of screen that would be generally applicable to such work in the district. Further, should two screens of different size openings or mesh be employed, the undersize from the first being passed over the second, a very great improvement in results could be obtained, and the loss in fine ore would be materially reduced. It is particularly in the use of two screens that a screen-test or analysis could be worked out to advantage.

The ores secured by dry-mining while having considerable clay adhering to them, may be high-grade, particularly if the clay is not highly siliceous, but as all clays are fairly high in silica, it is desirable that the clay in the ore should be reduced to the smallest quantity possible with a reasonable amount of labor. The character of the clay in which the manganese is found has much to do with the ease or difficulty experienced in cleaning the ores; if dry and granular, breaking up readily and in fairly small sizes, its separation can be easily accomplished; if moist and plastic the separation can not be readily effected.

Dry-mining should not be undertaken as a permanent enterprise, except as such may be found necessary due to conditions and circumstances that are beyond control; when employed much can be gained by a careful determination of size of screen to be used, and if possible two screens can be employed to advantage, the material that fails to pass through the screens being the finished product. Often the products formed by the two screens may vary sufficiently in grade to warrant keeping separate, having distinctly different values.

The amount of manganese in the clay worked may be very much smaller with dry-mining than when washing is done. The proportion of manganese to clay and sand should not be below 1 to 30 or 35 for wash-dirt, while with dry-mining the proportion of 1 to 50 has proven profitable. The most satisfactory work can be done with wash-dirt having from 12 to 20 per cent of manganese. (See plate X., B.)

WASHING AND WET CONCENTRATION

Throughout all of the operations of mining and preparation of manganese ores the size and extent of the deposits have a controlling influence in scale of work undertaken. While this condition affecting operations has been previously stated, it is necessary to keep the matter in mind by repetition in connection with the different phases of the work, otherwise a misconception may be obtained regarding the reasons for present practice. It is only with large deposits of known value that a more or less elaborate scheme of treatment and extensive equipment are allowable; as the majority of the manganese deposits are limited in size, it is obvious that the method of treatment is simple and often lacking in essential details, and the equipment is often incomplete, poorly constructed and poorly operated. The idea being to spend as little and to make as much in as short a time as possible. It is doubtful whether such a policy is sound and whether it has proven satisfactory in most cases where applied.

EQUIPMENT

The preparation of manganese ore as usually practised is by log washers with certain accessory equipment, which may or may not be essential, depending upon existing conditions. It is desirable, however, in this connection, to outline and discuss a standard log washing plant, and by reference to practice point out how and where such equipment may be modified to suit certain conditions.

A standard log washing plant consists of the following parts:

1. A grizzly for separating the rock and lump ore from the wash-dirt.

2. A log washer for removing the bulk of the clay, fine sand, and other wastes from the ore.

3. A revolving screen or trommel for separating the larger pieces of ore and waste from the smaller sizes for subsequent treatment.

4. A picking belt for assisting in sorting the waste rock from ore, permitting it to be done conveniently and rapidly.

5. One or more jigs for completing the cleansing of the ores and making a further separation of waste from the manganese.

6. Settling and mud ponds for removing the clay resulting from washing the ore, in order that it be not allowed to enter the streams and that it may be used over again in the plant.

7. The last part of the equipment, which is a very important adjunct to the plant, is the water supply. Water is furnished by pump and pipe line, often from considerable distance, or as is frequently done by flume from source of supply somewhat higher than the plant.

With these essential parts of the plant in mind, a brief description of the construction and operation of each is given, following which the operation of a plant as a whole is discussed, thus showing the relation of each part of the equipment to the other and the relative importance of each in the preparation of the finished ore.

The grizzly.—The grizzly as used with log washers consists of a number of railroad rails spaced from 2 to 4 inches apart, depending upon the size of the ore in the wash-dirt. The grating of bars is somewhat longer than wide, the usual size being 3 by 5 feet, the larger the area of the grating the more readily is the dirt discharged through the grizzly. The weight of rails used varies considerably, but 60 and 90 pounds are common; heavy rails being required as the large masses of ore are broken upon them. The rails are given a solid support by heavy timbers spaced about 2 feet apart transversely with the rails, or with small grizzlies, at the ends and middle of the rails. The grating is finally enclosed by a strongly-built box or hopper of plank which receives the wash-dirt from the mine.

The position of the grizzly is usually directly above the log at the overflow end, although it is not uncommon to see the grizzly placed at the one-third or one-half point from the overflow of the log; the position depending somewhat upon the grade or slope given to the log.

The log washer.—A log washer consists of one or two long timbers or logs octagonal in section and mounted in bearings at the end of the washer box. The washer box or trough is constructed of heavy planks; all parts as sides, ends, and bottom were formerly made of wood, but many of the more recent washers have cast iron ends. The cast iron ends support the bearings for the logs and are in two parts, an upper and lower, the division being made on the line of the bearing or bearings, which permits the logs to be readily placed in the trough without interfering with its construction. Bearings for the logs are separate from the end-castings, being bolted to them and are so made to permit replacing should they wear out or break. The side and bottom planks are also bolted to the end-castings, thus simplifying the construction and erection of the trough. The trough is built within a series of timber frames regularly spaced, is supported by heavy timbers or bents, and is given a slope so that all water run into it will move positively by gravity down the slope. The slope or grade of the box varies between narrow limits, as ¾ to 1½ inches to the foot, depending upon the character of the material treated. There are two openings in the trough; the upper or discharge and the lower or overflow. It is customary for the openings to be made in the ends of the box, but occasionally both are placed in the sides except the discharge opening in double log washers, which arrangement will be referred to when the operation of the logs is discussed.

There are two types of log washers, namely, single and double, depending upon the number of logs to the box or unit. Single washers have but one log; double, two logs; in other respects the construction of the washers is similar, except for the drive of the logs. The log in a single log washer is driven by a gear consisting of a spur wheel and a pinion, the pinion shaft being driven by belt, the spur wheel driving the log direct; with a double log, the cogs of the spur wheels attached to the logs engage, causing the logs to rotate toward one another or in opposite directions. Upon the surface of the logs are bolted blades set at an angle of 30° to 45° and arranged in screw-form so that when the log revolves there is a propelling action toward the upper end of the log box; further, the blades stir and agitate the ore, which together with the wash water tend to loosen the clay and clean the ore.

In order that the blades of both logs of a double log washer may act together in propelling the material in the log box up the slope to the discharge end, those on one log must be placed in a reverse order from those on the other, that is, the blades must be arranged in order of right- and left-hand screws. The direction of the right-hand log is clock-wise, that of the left-hand log counter clock-wise; therefore the blades in the right-hand log should be left-hand, those on the left-hand log should be right-hand.

To complete the log construction it is necessary to mount a water pipe several feet above the box and parallel with its longitudinal center line. The pipe is provided with holes on its under side in order that numerous streams of water may be introduced into the trough and either directly upon the ore at one side of the log if a single log is employed or between the logs if a double log is used. As the thrust of the blades is toward the lower or overflow end of the box, which is increased by the weight of the mass of the logs, there must be large gudgeons or bearing plates at the lower end in order to hold the logs in place and permit them to run smoothly. Further, owing to the great weight thrown upon the bearings it is necessary to make them large to prevent undue wear.

The trommel.—A large revolving screen or trommel receives the ore and boulders discharged from the log washer. It is usually cylindrical in form, although one end may be somewhat larger than the other, forming a conical surface. The screening may be punched metal or woven wire or rod, which is supported on cast iron wheels, being bolted to them. The size of perforations is usually the same for the whole surface, although variations from this practice are becoming rather common, and range from $\frac{1}{2}$ inch to $1\frac{1}{4}$ inch for those screens having but one size of openings; and from $\frac{3}{16}$ to $1\frac{1}{4}$ inch for screens having sections with different size openings. Equivalent sizes of mesh for woven wire screens are used. The matter of opening or mesh of screens is taken up under the discussion of operation of washing plant.

The wheels or spiders supporting the screening surface are mounted upon and keyed to a shaft which is supported by bearings at the ends and driven by gearing or belt from the log drive. With cylindrical screens the supporting shaft must be slightly inclined in order to permit a positive movement of material fed to the screen; the usual inclination of cylindrical screens is from 10° to 15°; the diameters of the ends of conical screen are 36 and 48 inches for screens 6 feet in length.

The picking belt.—Picking belts follow the revolving screens in order and receive the material passing through them. They are made of over-lapping metal plates and rubber-faced canvas belts, the latter being in much more common use and have proven very satisfactory. There is considerable range in practice regarding length and width of picking belts, varying from 30 feet by 18 inches to 50 feet by 30 inches. The slope of picking belts is also a variable quantity, the probable range being from level to 30°. The length of picking belts is not total length of belt, but effective length as between bearings of supporting and drive pulleys, both length and width depending upon the amount of material handled and therefore upon available room for pickers and the disposal of the materials sorted. Somewhat similar conditions affect the slope of the picking belt, but probably the disposal of material remaining upon the belt and discharged at the end, is the controlling factor. If waste is removed by the pickers the ore remaining upon the belt would be discharged into a bin, while if ore is picked from belt waste would remain and be discharged onto dump or into cars which carry it to the dump. In either case the discharge end of belt must be such as to permit the proper disposal of the material carried by the belt.

The jigs.—While jigs are not always employed in washing plants, yet they constitute one of the more important parts of such a plant and a serious mistake is made when they are not included in the equipment. Jigs are not washing apparatus in the same sense that log washers are, as they treat materials that have already been largely freed from clay by previous treatment. They are washing apparatus, however, in that they remove from the manganese, through the action of water, such foreign matter as remains after the preliminary treatment in the log washer. The addition of considerable quantities of fresh water to the materials treated by the jigs, together with a very complete agitation of the material in the jig bed, does assist very materially in the further cleansing of the ore from any attached particles of clay ,but the principal function of a jig is to separate minerals of different specific gravity.

The principal separation made by jigging is the removal of sand and small fragments of quartzite and chert from the manganese minerals; however, iron ores as limonite and hematite cannot be separated owing to the slight difference in specific gravity between them and manganese, nor can barite be readily removed from manganese by jigging, which is no serious disadvantage as barite seldom occurs in any considerable quantity in deposits of manganese.

A Harz jig, the type commonly used, consists of a strongly constructed tank divided into a number of compartments by transverse partitions, which are in turn partially subdivided by a longitudinal partition. The longitudinal partition does not completely subdivide the compartments, as it extends downward from the top to about one-half the depth of the tank. The compartments are, therefore, formed into roughly U-shaped passages, any one of which may be considered a complete jig, and when a number are grouped together the combination is called a multiple-cell jig. Jigs as employed in manganese washers seldom have more than 4 cells, 2 and 3 cell jigs being most common. As multiple-cell jigs are made up of single-cell jigs, a single-cell jig can best be described, after which the relation of a number grouped together may be considered. (See plate X., A.)

The jig box partially sub-divided by partition into a U-shaped passage, has a screen or grating placed several inches below the top of one of the parts or compartments formed by the partition, while in the other compartment is placed a plunger, which is caused to move up and down by means of an eccentric on a shaft mounted in bearings supported by the frame work containing the jig box and binding it together. The level of the plunger is below the level of the screen in order that when the jig box is filled with water the plunger is always covered with water. Any movement of the plunger causes a corresponding but opposite movement of the water in the screen compartment. The bottom of the jig box not being sub-divided by partition, is formed into a hopper by sloping partitions or false-bottoms, the object of which is to collect all material settling in the box so that it can be discharged at one point as through a pipe.

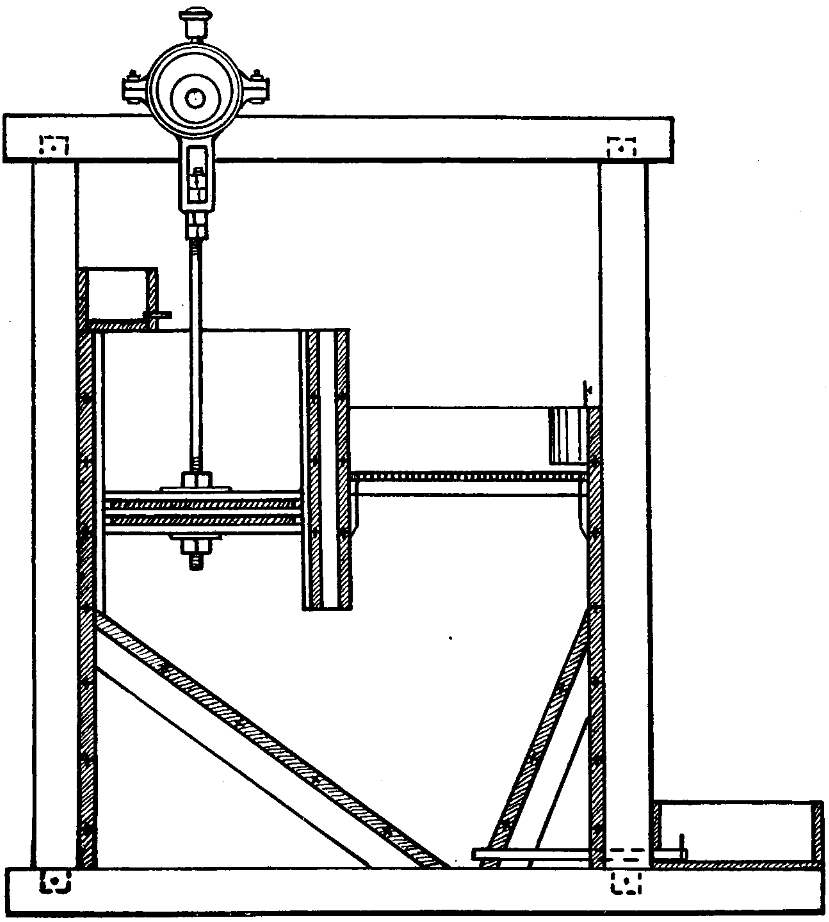


Fig. 24. Transverse section through jig box showing position of plunger and screen.

The screen compartment receives the mineral fed to the jig, having sufficient water added to make it flow readily, being brought to the jig in a trough or launder. In order that there may be a continuous flow through or over the screen compartment, where the jigging action takes place, one side of the enclosing walls must be lower than the others. The height of this discharge side is provided with a board that can be raised or lowered at will, and therefore serves as a dam or tail-board; by means of the dam the depth of the bed of mineral on the screen is determined and regulated. Aside from the feed water entering the jig box with the mineral, provision should be made for introducing water into the plunger compartment. Discharge for material passing through the screen is provided for by a gate opening and closing the pipe connecting with the lowest point of the hopper-shaped bottom. Another discharge opening is provided on one of the sides of the screen compartment, which is furnished with a gate and permits the withdrawal of accumulation of mineral a certain distance above the screen. (See fig. 24.)

A number of such individual jigs placed side by side or rather end to end, the ends of the driving shaft being considered the ends of the jig irrespective of number of cells, constitute a multiple-cell jig, but in order that there may be a continuous flow from one screen compartment to the other, each screen receiving flow from the one immediately preceding, must be at a lower level. This arrangement of screens requires a corresponding lowering of the plungers, each screen and plunger occurring at a lower level than the preceding one gives the screen compartments a stepped appearance, which is responsible for the name "stepped" jig. In a multiple-cell jig the transverse partitions subdividing the main box into individual jig boxes, form the dams controlling the flow of water and mineral from one screen compartment to the next following, and so on through the jig. The discharge openings for coarse concentrates are then placed on the front or screen side of the jig box, where they can be conveniently reached and the discharged products readily handled.

The driving shaft, operating the plungers, runs the full length of the jig, being mounted in bearings, supported by heavy timbers framed about the jig box. The bearings are at the ends of the jig box and at points between the cells or compartments, thus giving firm support and preventing vibration. The eccentrics attached to the drive shaft, by which the movement of the plunger is produced, should be adjustible in order that the length of stroke of plungers can be regulated. The double eccentric form is preferable. (See fig. 25.)

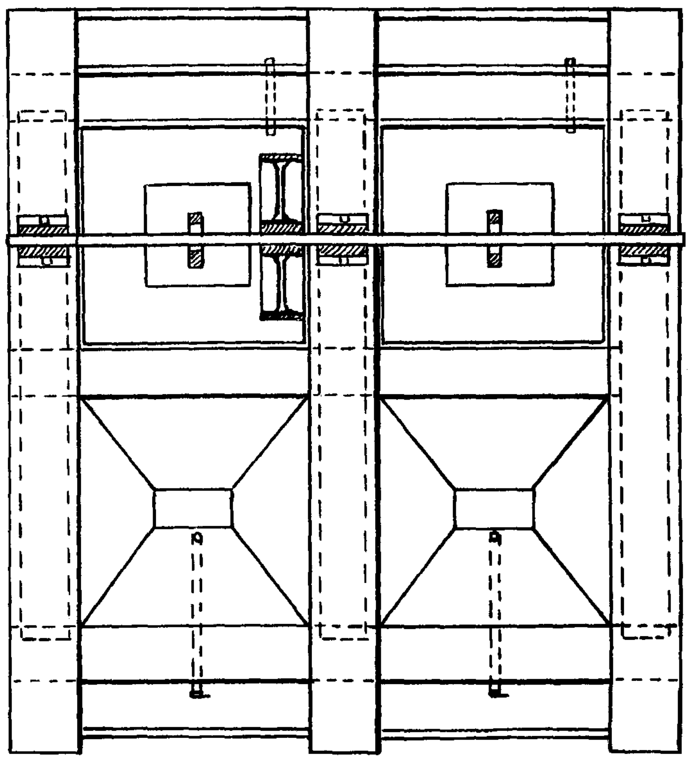


Fig. 25. Plan of 2-cell jig, showing arrangement of plunger and screen cells, position of drive shaft and eccentrics.

The screen or sieve upon which the jigging action takes place and cleaned minerals accumulate must of necessity be firmly supported that its level may be maintained. This is accomplished by employing cast iron gratings and woven wire screens; the former is self supporting; the latter is usually laid upon a wooden grating and nailed or wired to it. The wooden grating is preverably made with 4 inch spaces, or cross-bars may be used, forming 4 inch square openings, and do not materially reduce the area of the screen surface. The space between gratings or mesh of screen should vary with each compartment from the feed to the discharge end, the usual sizes for first or rougher jig being: first cell $\frac{1}{4}$ inch, second cell $\frac{1}{4}$ inch, third cell $\frac{3}{16}$ inch, fourth cell $\frac{3}{16}$ inch, and fifth cell $\frac{3}{16}$ inch. With wire screens a similar variation in size is employed. The meshes for the different screens in a cleaner jig are: first cell $\frac{3}{16}$ inch, second cell $\frac{3}{16}$ inch, third cell $\frac{1}{8}$ inch, and fourth cell $\frac{1}{8}$ inch. When a sand jig is employed it has the same size of screens as the cleaner jig.

Plungers should fit fairly closely in their compartments, but allowance should be made for swelling of wood with consequent reduction of clearance. With too large clearance the effective action of the plunger is lost, as water flows around the plunger instead of moving with it. Valves are occasionally formed by providing a wide clearance and attaching rubber belting to the plunger in such a manner that on the down-stroke there is a positive movement of the water below it, but on the up-stroke the valves open permitting the return of the plunger without positive movement of water, as it can flow by the plunger.

SETTLING AND MUD PONDS

The employment of settling ponds or basins is largely a matter of necessity rather than of choice, as they are required by law and often found necessary owing to lack of water. While it is common practice to settle fine clay and sand from the water coming from washers, yet it is commonly held to be impracticable by those not accustomed to such work. That the clearing of waters carrying a heavy burden of clay is readily accomplished is demonstrated by the practice in the brown iron ore mines of the South, also in similar operations in the manganese districts. Often the scarcity of water alone may be sufficient reason for impounding the water used by washing plants, consequently dams built for collecting and storing the water serve a double purpose in that the water may be clarified and at the same time stored for further use.

Water when moving rapidly has a high carrying capacity and will support and transport a large load of mineral matter. The amount of material carried as well as the size of the individual particles depends upon both the volume of the water and the rate of its flow. However, the volume, if unrestricted with respect to depth of channel, has but slight influence on the carrying capacity. It is, therefore, obvious that if water, heavily laden with clay and sand, as it escapes from a washer could be conducted to a basin, the points of entrance and discharge of which are of practically the same elevation, the movement would be so slow that the burden of waste must of necessity be thrown down, thus clearing it.

Water passing through a settling pond can be forced to flow so slowly that even with fairly large volumes it will spread out in a wide stream of only a fraction of an inch in depth, and having a very slow rate of flow wanders or meanders about traversing a round-about course to go a short distance. Further, the distance traveled can readily be increased or diminished at will by obstructing the flow; logs and brush are used, and often all that is necessary is to form a shallow channel by dragging a log through the accumulated muck, the current following any course, however slight, that presents less resistance.

Settling ponds are made by constructing dams of dirt across shallow runs, by digging the surface dirt off of a limited area and forming an encircling bank of the excavated material, or if a side-hill slope must be used, crescent-shaped dams may be built, forming fair sized basins of which there may be a number arranged in series, each receiving the discharge from the preceding and higher one. As a pond becomes filled by accumulations of clay and sand, it is necessary either to shift the flow from the washer to a new pond or to raise the dam on the one used. This is readily accomplished by scraping some of the accumulated material from the pond upon the top of the dam, which although wet soon dries and forms a solid wall. Dams are built up to heights of 8 to 12 feet by such a method of procedure.

When the water is to be returned to the mill for use in the washing operations, it is taken from a point in the pond most distant from the intake, where the water is free from sediment. A box is set into the pond in which is placed the suction of the pump employed in returning the water to the washer; the top of the box is open, the inflowing water entering at the top and is drawn off at the bottom. The box must be made adjustable in height in order to vary and maintain any desired level.

Probably the most satisfactory arrangement of settling slimes from wash-water is to employ a series of basins, the flow being from the higher to the lower of the series; the control of the movement of the water is also more readily accomplished. Old strip pits or open-cuts are also occasionally employed and often have the advantage over other arrangements in that no dams are required or if so they are limited in extent. Large ponds of an area of several acres are often used in connection with large operations, in which case natural depressions in fields are made use of, a low bank of dirt forming the retaining wall.

WATER SUPPLY

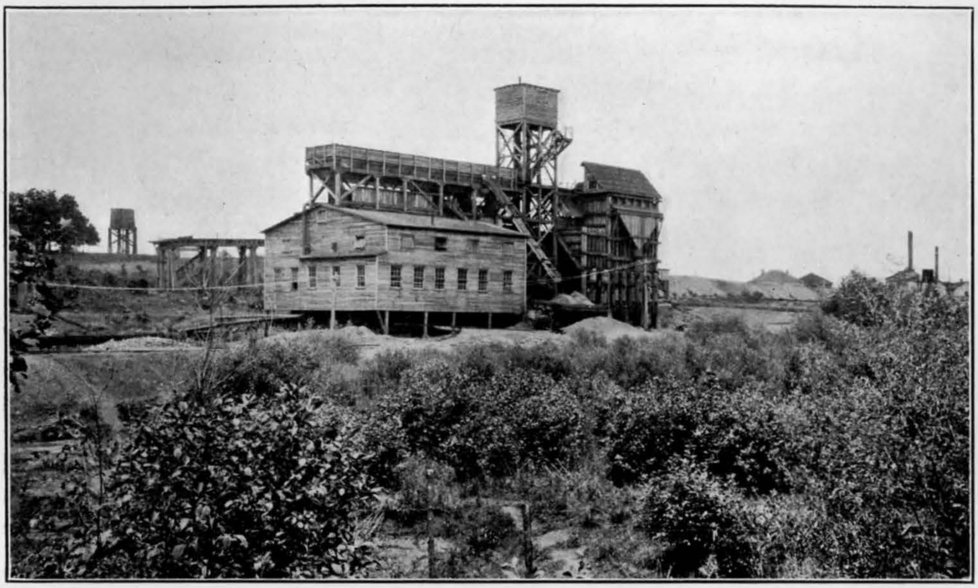
The water supply for washing plants is probably second in importance to no other part of the plants and is often the determining factor in choice of location. In fact scarcity of water, an inadequate or too distant supply, may render the washing of ores prohibitive in certain localities. The source of the supply of water is also important, although where there is an ample supply the source is of no consequence. Rivers, creeks, springs, and large bodies of water as reservoirs, even though fed by small springs, are the main sources of supply and are given in order of importance.

Pumping plants are installed at the source of the supply and should be protected against high water by having the suction enclosed in a box provided with a grating to keep out sticks and other debris.

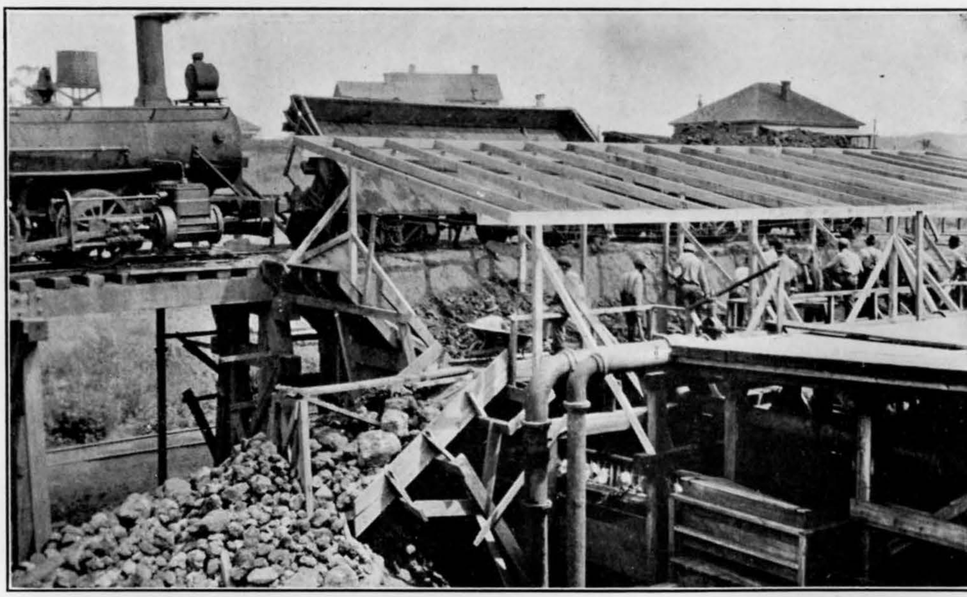
Steam pumps have been extensively used in the past, but owing to the scarcity of coal and the cost of having wood cut, gasoline and oil engines are now being used to drive the pumps. With the use of gasoline and oil engines the direct-acting plunger pumps are being replaced by centrifugal pumps, usually of the single stage type, although multiple stage pumps are used when the head is high. Pipe lines must be run, connecting the pump with the washer and are usually 3 or 4 inches in diameter, although in several installations noted a 1-inch pipe supplied water to a single log washer. The size of the pipe line depends, of course, upon the quantity of water required by the washer supplied; for a single log 50 gallons per minute are sufficient, while a double log requires fully 75 gallons per minute. It is much better to have a larger amount of water than is needed, rather than to have too little; the former condition permits an increase in capacity of plant if desired or a change in character of material treated requires more thorough washing, while the latter condition limits the quality of work done.

ARRANGEMENT AND OPERATION

The types of apparatus or machines employed in washing plants have been described, but it remains to be shown how they may be arranged to give the best results, the relation of each machine to the others preceding and following it, and under what conditions the respective machines do the best and most satisfactory work. Every machine is designed to do a particular kind of work and unless it does that work well it should not be employed; however, failure to perform the work for which a machine was designed and constructed may not be due to any defect in the machine itself, but rather to failure on the part of those operating it to understand how it must be adjusted and operated to give satisfactory results. The so-called theory upon which the operation of a machine is based is but another name for practice resulting from experience, and without experience neither theory nor practice would avail much.



A. VIEW OF THE MANGANESE CONCENTRATING PLANT AT AUBREY. GEORGIA IRON & COAL COMPANY, WHITE, BARTOW COUNTY.



B VIEW SHOWING MANGANESE ORE BEING DUMPED ONTO THE GRIZZLIES AT THE AUBREY PLANT OF THE GEORGIA IRON & COAL COMPANY, WHITE, BARTOW COUNTY.

While practice varies considerably in the washing and preparation of manganese ores, yet there is what may be considered standard practice and while the apparatus employed may differ somewhat in the various plants and the arrangement may be varied, yet about the same order is followed regardless of size of plant. However, in many of the smaller plants that are equipped at small expense, the equipment employed is often contracted to the irreducible minimum; namely, the log washer, and usually a single log at that. While with certain occurrences of ore, especially of the large dornick form and of high-grade, it is possible to make a fairly clean product, often running as high as 45 per cent, with nothing but a single log, yet even under such favorable circumstances much better results would be obtained could logs, screens, and jigs be employed. It does not always seem to be apparent that an investment which will produce a saving of 4 to 6 per cent would not only return the money expended on the equipment, but may even pay all operating expenses of the plant. There is often too much of the "penny wise and pound foolish" idea regarding manganese mining and preparation.

A standard plant as described and discussed consists of the various forms of apparatus as previously outlined, which are considered in order of progress of material through the plant.

The wash-dirt is brought to the grizzly, commonly called the "bull-pen," where it is loosened by pick until it passes through the bars, the larger pieces of manganese being also reduced to a size to pass the grizzly. The first hand picking or sorting is done at the grizzly, the large fragments and boulders of rock being rejected. The grizzly is so situated with respect to the log that the material passing through it falls into the log at the lower or overflow end, seldom entering the log at a point higher up than one-third the length of the log. (See plate XI., B.)

The size of the grizzly depends upon amount of wash-dirt to be handled by it, also upon spaces between bars, and to a less extent upon character of material handled. A grizzly that is entirely covered by dirt, when material is dumped upon it, is difficult to clear and feeding is irregular; a portion of the surface should always remain clear, at which place the work of forcing dirt through the bars can begin. The space between bars depends somewhat upon character of material, subsequent treatment and capacity of plant. Wash-dirt containing small fragments of rock and nodular or pebble ore does not require wide spaces between bars; in fact, the smaller the openings the better, as the clay can be broken up to better advantage. With large masses or dornicks of ore, which have to be reduced by hand on the grizzly, too small spaces between bars are objectionable, as reduction by hand is expensive and consumes too much time, thus reducing the capacity of plant.

On entering the log the wash-dirt is quickly mixed with the water in the log box and with that falling upon it from the wash-water pipe. In a single log the dirt is forced around by the blades until it is between the side of the box and the upward rising side of the log, while in a double log the dirt falls between the two logs and is largely held there by the action of the logs, that are both lifting and stirring and forcing forward. The action of the logs is, therefore, rubbing and forcing the dirt forward up the sloping bottom of the log box and against a downward flowing stream of water.

The slope of the bottom of the log depends upon the character of dirt treated; if the dirt is easily cleaned the slope may be low; if difficult to clean the slope should be higher. The average slope of logs in washers of the United States is 4° or .84 inches to the foot. The practice in the plants treating manganese ore is from 1 to 1½ inches to the foot, being more or less arbitrarily chosen and is high to insure complete washing; however, too high slopes may result in excessive losses in overflow from logs. Steep slope of logs, unless provided against, permits too prompt discharge of wash-water with clay and sands, and in many instances of a high percentage of fine manganese. It should be borne in mind that there is a close relationship between slope of log box and height of overflow opening; too great care cannot be taken in making proper adjustment of one should it be found necessary to vary the other.

As water is the most important agency in cleaning the ore, a sufficient quantity should be employed. Depth of water in log box means more or less complete submergence of ore and consequently more thorough washing. Submerged logs may therefore be especially advantageous in the treatment of certain ores. In the upper portion of the log box effective cleansing of the partially washed ore may be effected by jets of water from the wash-water pipe placed above and running parallel with the logs, as the ore comes in direct contact with water under pressure.

Length of log box is also an important consideration, but is largely a matter of haphazard choice. Cost of irons for logs is often more of a determining factor in deciding upon length of log than is the character of the work to be done. The length of logs and slope given to them and the log box are intimately related; it is rarely ever possible to secure the same results with short logs and high slopes as with long logs with low slopes. The use of long logs with proper adjustment as to slope to suit material treated is much more satisfactory practice. The length of logs varies from 20 to 36 feet, while 25 and 30 feet logs are more common.

The amount of water employed in logs varies considerably in the practice of different districts and even in the same locality, and depends somewhat upon the quantity of water available. An excess supply is preferable, rather than possibly limiting the output of a plant by having a too small supply due to miscalculation in the equipment. The usual amount of water used in single log is 50 gallons per minute, with double logs 75 gallons per minute.

A double log should wash from 40 to 50 tons per day of 10 hours and require 20 to 25 horse power to drive it.

Screens should be employed in connection with logs to remove the smaller sizes, thus reducing the amount of material that must be hand picked. In the description of screens no mention was made of flat screens for the reason that the revolving form is in more common use, although no more satisfactory nor efficient than shaking flat screens. If the screen is employed simply as a means of separating the coarser sizes from the smaller for hand-picking purposes, one size of opening may prove satisfactory, but should jigs be employed as in the scheme of treatment given a number of sizes of screen openings should be used. As is pointed out later on, under the discussion of the operation of jigs, the material that goes to the jigs must be sized between fairly close limits if satisfactory work is to be expected. With but a single screen it is difficult to make satisfactorily more than two or three sizes, owing to length of screen involved. For an ordinary washer with one single or double log and two jigs, it is not desirable to have more than two sizes of screening surfaces on the revolving screen frame. There would be, therefore, three sizes made, namely, two passing through the screen as undersizes, which would go to jigs, and the oversize passing over the screen to picking belt.

Washers without jigs usually have $\frac{1}{4}$ to $\frac{1}{2}$ inch openings for screen, the undersize going to fine materials dump to be retreated at some future time or to bin to be sold as low-grade product if of sufficient value. When jigs are employed the usual size of screen openings is $\frac{1}{2}$ to 1 inch, all undersize going to a rougher jig; however, the most satisfactory practice would be an arrangement giving at least two sizes for treatment on jigs; openings of $\frac{3}{16}$ and $\frac{1}{2}$ inch for revolving screen give good results. The screen should revolve at a rate of 15 to 20 per minute, which with a slope of 10° to 15° give the desired capacity.

The oversize material from the screen goes to a picking belt, which may be of metal strips overlapping and connected in such a fashion as to make an endless belt, or rubber belts may be employed. The wear of the metal picking belts is great and there is considerable loss of fine mineral, which escapes between the plates. The rubber belt is much more satisfactory as it runs smoothly, does not lose mineral and has a long life. Further, owing to the ability of such belts to elevate mineral on steeper slopes, their range of usefulness is much greater than the metal forms.

The materials picked from the belt depend upon the relative amount of ore or waste; if there is more ore than waste, the waste is sorted out, while if there is more waste than ore, the waste remains on the belt and the ore is sorted out. The sorted materials are thrown in boxes, which in turn are connected with chutes through which the sorted product is conducted to bins or cars for final disposal.

The belt should be flat, but due to the necessity of disposing of the material at various levels, it is often necessary to elevate the belt more or less to assist in the handling of the discharged material. The width of the belt depends largely upon the capacity of the plant and the relative amount of large size ore and rocks occurring in wash-dirt, also upon the number of persons employed at the belt. The common sizes of belts are 30 feet long by 18 inches wide and 50 feet long by 30 inches wide. The travel of the belts is 50 to 60 feet per minute.

No washing plant is complete without two or more jigs and for continuous operation three jigs are necessary. Jigs receive their feed from screens, which in turn size materials coming from the logs. The more uniform the size of feed the more satisfactory are the products made by the jigs. As previously pointed out the screen following the logs makes two undersizes, namely, 0 to $\frac{3}{16}$ inch and $\frac{3}{16}$ to $\frac{1}{2}$ inch. The latter product goes to the rougher jig having four compartments with the following meshes of screen in the beds: 1st and 2d cells, $\frac{1}{4}$ inch; 3d and 4th cells, $\frac{3}{16}$ inch. The product of smaller size goes to the sand jig having the following sizes of bed screens: 1st and 2d cells, $\frac{3}{16}$ inch; 3d and 4th cells, $\frac{1}{8}$ inch mesh. The third or cleaner jig treats material passing through the beds of the rougher jig and should have screens of size similar to those in the sand jig.

The feed of jigs should be as regular and uniform as possible, which is not always easily done, as they receive materials coming from logs. Logs owing to their large capacity act somewhat as regulators so that if fed at fairly regular periods with wash-dirt from the mine would deliver a fairly uniform supply of mineral to the screen, which in turn tends to equalize the feed. With the mineral entering the jig should be sufficient water to move it readily, but in order to have the proper amount of feed water it is customary to add more, either in the trommel or the trough connecting the trommel with the jig. Further, water may and should be fed to the plunger compartments or cells in order to maintain the proper level between the plunger and screen cells.

The depth of the bed of mineral resting on the screens depends upon the height of the dams between cells, but should not exceed 4½ inches, the range in good practice is between 3½ and 4½ inches, the latter for the coarser material. The length of the stroke of the plunger should be sufficient to readily raise the mineral on the bed, but not so violent as to stir and agitate it and disturb the arrangement of minerals being separated into layers by the jigging action. In order that the particles of mineral in the bed may seek their proper position, the whole mass of mineral forming the bed must be perfectly free and mobile when raised by the current produced by the down-stroke of the plunger. On the up-stroke of the plunger the movement of the water is reversed and the mineral on the bed settles, but the small particles of heavy mineral move faster than the larger particles of light mineral, which when acted on by the rising current move faster than the particles of heavy mineral, thus bringing about a separation on both strokes of the plunger into layers of minerals of different specific gravity. Continued repetition of the rising and falling currents of water causes a separation of all materials entering the screen compartments and as the incoming material is separated the particles of the lighter minerals rise to the surface and float off, while the particles of the heavier minerals settle and remain upon the bed until removed, or if of such a size as to permit them to pass through the screen, fall to the bottom of the jig box. (See fig. 26.)

It is impossible to remove from the surface of the jig bed the accumulation of large size particles while the jig is in action as the layers of mineral separating out would be disturbed, but it is possible to draw such material off by a gate placed on the front of the jig. A metal box projecting into the jig bed prevents the upper and lighter layers of mineral from being disturbed while the heavier particles below are drawn off as they collect, being discharged through an opening in the front of the screen compartment.

It is evident then that in order to secure a clean product careful adjustment of the length of stroke of the plungers is necessary, which combined with the speed of rotation of the drive shaft give the required velocity of rising current to cause a separation of the material treated. It is further obvious that a large particle requires a greater velocity of rising current than a small one, consequently each jig must be adjusted to treat the particular sizes fed to it. In fact, the

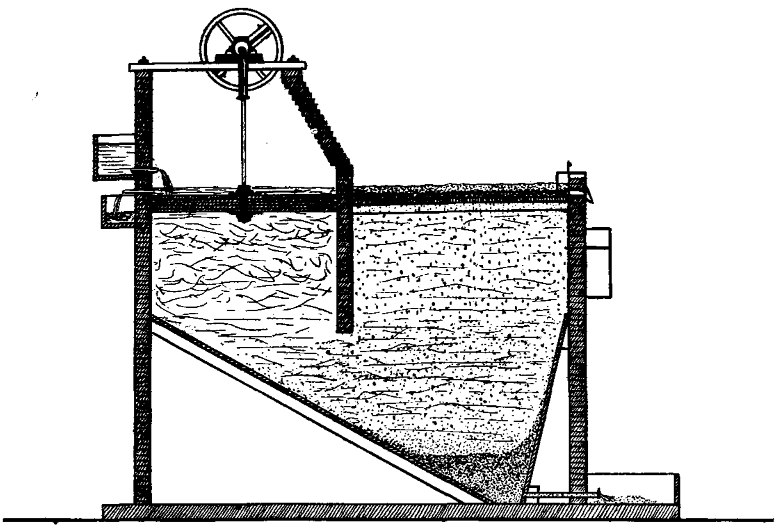


Fig. 26. Vertical cross section showing in a graphical way the action of a Harz jig.

best practice requires that each screen compartment of a jig should have a certain size of mineral fed to it and that the velocity of rising current acting upon the mineral should be carefully determined in order that the speed and length of stroke of the plunger may be definitely known and the jig set to run accordingly. A multiple-cell jig would under such conditions be made up of a number of individually acting jigs, but to simplify matters, only one drive shaft is used, the length of plunger's stroke being set to meet the special requirements of velocity of rising currents in the separate screen compartments.

The size of plungers for jigs is usually somewhat less in area than the screens, due to the effective area being reduced by screen support. The effective area of screens being known the size of plungers can be determined and made to fit the plunger compartment by nailing "rubbing" boards on the sides of the compartment. The size of screen compartments is: width, 20 to 24 inches; length, 30 to 38 inches; size of plunger compartments: width, 18 to 22 inches; length, 30 to 38 inches.

In order to insure proper separation of mineral on the screen bed it is desirable to have a layer of heavy mineral on the screen, which is called the "filter-bed." The filter-bed may be placed on the screen, or allowed to accumulate; in the former case cast iron balls may be used or pure manganese ore, while in the latter case manganese or a mixture of manganese and iron ore will collect, provided iron is present. The size of the mineral composing the filter-bed should be several times the size of the openings or mesh of the screen. The depth of the filter-bed naturally increases as mineral accumulates in jigging and is kept at the proper height by the gate discharge. Accumulation of mineral on the screen bed is therefore regulated by a more or less constant discharge at a definite height above the screen, thus maintaining a uniform depth of filter-bed and clean mineral, above which and the surface of the bed is a layer of mineral of deficient specific gravity in which separation is taking place, the heavier settling while the lighter is washed off.

That part of the mineral treated which passes through the coarse mineral of the filter-bed and the screen, falls to the hopper shaped bottom of the jig box, where it accumulates until it is drawn off through a gate provided, usually at the back of the jig. Locally the material passing the jig screens is called "flushings," but is more properly designated as "hutch" or "hutch-work." Clean mineral may be obtained from both gate discharge and hutch, but careful sizing is necessary if clean and finished products are obtained, which is particularly true of the hutch. As jigs are usually operated clean hutch is obtained from the first cell of the rougher jig, the hutches from the other cells being more or less mixed with waste and must be rerun on a second or cleaner jog. The cleaner jig operating on partially cleaned products can more readily make a clean product, but even then it must be carefully adjusted and fed a fairly closely sized material.

In the operation of jigs in connection with log washers in manganese washing plants, properly sized material from the screens following the logs, enters two jigs; the coarser sizes going to the first or rougher jig, the finer sizes to the second or sand jig. Hutch from all cells of the rougher except the first and from the last two at least of the sand jig should go to a third jig, similar in operation and adjustment to the second jig, and is therefore a cleaner. While there are two jigs of similar adjustment, one handles the finer sizes from the screen and therefore only sized products, the other treats hutch, which is partially cleaned product. As it is not desirable to mix the smaller undersize from the screen with the hutches of the rougher, it is necessary to employ three jigs in a plant, otherwise one of the products treated on the cleaner jig would have to accumulate until such time as it could be run separately, which in practice would prevent continuous operation of plant on all products made and require rehandling of considerable quantities of the accumulated material.

All water passing through a washing plant is conducted to the settling pond, where the bulk of the clay and sand is deposited. It is then returned to the logs, but is rarely ever employed in jigs as it is not considered sufficiently clean for such purposes. The wastage in a washing plant probably does not exceed 20 per cent if the plant is well constructed and not too old; however 25 per cent is a very reasonable estimate and gives a fair idea of the quantity of water that must be added to the supply. It is evident then that there are two sources of water supply for washing plants; namely, the settling and impounding pond and a stream or spring. The former is a stagnant, the latter a living supply; further, the former is contaminated with clay and sand in limited amounts and is not suitable for jig work, the later is clear, fresh water and is suitable for any of the operations of cleaning the ores as well as for boiler use.

The conservation of water by passing it through a settling and impounding pond may solve the problem of water supply where the quantity of living water is limited. Once a plant has been put in operation, the addition of 25 per cent of the total consumption would not only make up for the loss due to wastage, but would furnish the required amount of fresh water for those parts of the operations requiring clean water. By such arrangement of the water supply it is possible to operate properties that could not otherwise be developed.

In brief, then, the operation of washing manganese ores consists in passing the ore-bearing clays through a grizzly by which the boulders of rock are separated and the larger masses of ore are reduced to a size that will pass through the logs. The overflow from the logs goes to the mud pond while the material being discharged by the logs goes to a large revolving screen where at least three separations are made, namely, oversize going to the picking belt; coarse undersize to rougher jig; and fine undersize to sand jig. Clean ore is obtained from gate discharges of screens of all jigs and the hutches of the first cells of the rougher and sand jigs and all cells of the cleaner jigs. The hutches from the remaining cells of the rougher and sand jigs go to the cleaner jig. Coarse ore is cleaned by hand picking on belt, thus completing the separation of waste from ore in a standard washing plant.

PRACTICE IN CLEANING MANGANESE ORES

Owing to the small size of ore deposits and the consequent limited equipment usually employed in washing and preparing the ores for market it is not possible nor desirable to say much regarding the practice in the manganese districts of Georgia. The practice of washing ores in a standard plant as outlined above is approached in a number of operations especially in the Cartersville district, a flow-sheet of which is here given.

Wash dirt to 1.

1. Grizzly, 2 to 4 inch openinge between bars: oversize to 2; undersize to 3.
2. Rock dump.
3. Log washer, single or double log, 20 to 30 feet long: overflow to 4; discharge to 5.
4. Mud or settling pond.
5. Revolving screen, cylindrical or conical, perforations or mesh ½ and $\frac{3}{16}$ inch: oversize, everything above ½ inch to 6; undersize, ½ to $\frac{3}{16}$ inch to 7, $\frac{3}{16}$ to 0 inch to 8.
6. Picking belt: rock to 2; manganese to 9.
7. Rougher jig, 4 cells: gate discharges to 9; hutches, first to 9, second, third, and fourth to 10.
8. Sand jig, 3 cells: gate discharges to 9; hutches to 9 or 11.
9. Finished ore bin.
10. Cleaner jig, 3 cells: gate discharges to 9; hutches to 9 or 11.
11. Shaking table: finished product to 9; overflow to 4.

There are seldom more than two jigs employed in the washers of this district, and in many plants only one is used. Flat screens are also often used in place of the revolving forms, and when the latter are employed there is usually but one size of openings which range from ¾ to 1 inch. It is evident that the wide range of sizes coming from a ¾ to 1 inch screen, if fed to a jig renders good or fair separation impossible. Often the gate discharges are the only finished product made, the hutch products either being discarded or saved to be rerun at some future time. Other plants use two jigs, the second being employed to treat the hutch from the first or rougher jig.

The flow-sheet of the concentrating plant of the Georgia Iron & Coal Company is given, as it represents the best practice and most extensive operations in the district.

The capacity of this plant is 50 tons of finished manganese ore per day of 10 hours. It is connected with three large cuts in which six steam shovels operate, all being connected with tracks so that the strippings as well as wash-dirt can be handled with equal facility. While there are certain portions of the plant that might have been arranged to better advantage, yet taken as a whole the design and arrangement are good.

Wash dirt to 1.
1. Grizzlies (4 sets, 5 Ry. rails, 4 spaces, 4 inches, length 7 feet 3 inches; oversize rock to 2; manganese after being broken by sledge to 3; undersize to 3.
2. Rock dump.
3. Log washers (4 double logs, 30 feet long): discharge to 4; overflow to 5.
4. Screen (perforated metal, openings 1 by 2 inches): oversize to 6; undersize to 7.
5. Mud or settling pond.
6. Picking belts: rock to 2; manganese and attached rock to 8.
7. Belt conveyors to 9.
8. Crusher reducing to ½ inch to 9.
9. Ore bins by elevator to 10.
10. Revolving screens for jigs, Nos. 3, 4, and 5: for jig No. 3, $\frac{3}{16}$ inch, ¼ inch and ½ inch perforations; for jig No. 4, $\frac{3}{16}$ inch, ¼ inch and ⅜ inch perforations; for jig No. 5, ½ inch, ¼ inch and ⅜ inch perforations, products from these to 11.
11. Jigs Nos. 3, 4 and 5 (4 single cells): gate discharges to 12; hutches to 13; overflow to 14.
12. Concentrates bin to 17.
13. Flat screen, ¼ inch perforations for jig No. 1: oversize to 15; undersize to 15.
14. Revolving screen for jig No. 2, ⅛ inch, $\frac{3}{16}$ inch and ½ to 16.
15. Jig No. 1 (2 cells): gate discharges to 12; hutches to 12; overflow to 5.
16. Jig No. 2 (4 cells): gate discharges to 12; hutches to 12; overflow to 5.
17. Hand picking table, where ore is sorted by girls, who pick out iron and other impurities. The iron is sold as manganiferous iron.

Aside from the ores usually occurring in the Cartersville district there are a number of other types that are undoubtedly of commercial importance and will probably be mined and concentrated in the future. Probably the most available of such deposits is the breccia ore, being a broken quartzite cemented together by manganese. There are a number of such deposits that promise to have a fairly large tonnage, which if proved by testing, would warrant the erection of plants suitable for their proper treatment. A flow-sheet for the treatment of such ore is given below:

Mine-run ore: nodular ore mixed with clay and sand to 1; hard ore to 2.
1. Grizzly bars spaced 2 inches: boulders to 3; undersize to 4.
2. Blake crusher, reducing to 1 inch to 5.
3. Rock dump.
4. Log washer (double): discharge to 6; overflow to 7.
5. Revolving screen, ½ inch openings: oversize to 2; undersize to 6.
6. Revolving screen, ½ inch and ¼ inch openings: oversize to 9; undersizes to ½ to ¼ inch to 8, ¼ to 0 inch to 15.
7. Revolving screen, $\frac{1}{32}$ inch openings: oversize to 10; undersize to 11.
8. Jig (5 cell): gate discharges, cell No. 1 to 12, cells Nos. 2, 3, 4 and 5 to 13; hutches, cell No. 1 to 12; cells Nos. 2, 3, 4 and 5 to 13; overflow to 18.
9. Picking belt: rock to 3; manganese to 12; mixed mineral to 2.
10. Rolls reducing to $\frac{1}{32}$ inch to 7.
11. Cone classifier: spigot product to 16; overflow to 17.

12. Finished ore bin.
13. Rolls reducing to ¼ inch to 18.
14. Jig (4 cells): gate discharges to 12; hutches to 12; overflow to 17.
15. Jig (4 cells): gate discharges to 12; hutches to 12; overflow to 17.
16. Shaking table: finished product to 12; overflow to 17.
17. Mud or settling pond.
18. Revolving screen, ¼ inch openings: oversize to 10; undersize to 14.
19. Sand jig (3 cells): gate discharge to 12; hutches to 16.

The scheme of treatment outlined above is given as a suggestion of a tentative method and would undoubtedly have to be modified to suit conditions existing in a given deposit.

Another occurrence of ore that is very common and forms an important part of the ore deposits of all sections of the country, is the soft or "wad" ore. While much of such ore is low-grade, averaging 10 per cent probably, yet there is much of considerably higher grade, all of which should be sufficiently high in manganese to warrant extensive investigation looking toward its utilization. The quantity of such soft ores that are available would make their treatment attractive and profitable should a suitable method of treatment be found. Owing to the importance of this type of manganiferous material and the lack of means of treating it, a mill test on 1000 pounds was made at the Bureau of Mines station at Minneapolis, Minnesota, with the expectation that some information might be obtained regarding a suitable method of treatment. The result of the test is given below:

Amount of dirt treated, 1000 pounds.

Range of sizes in material: 41.37% was larger than ¾ inch, while 24% would pass through a 200 mesh screen.

The manganese content of dirt treated was 23.34%; silica, 31.47%.

Method of treatment: Dirt to revolving screen with 1¼ inch holes, water being added to feed; oversize being hand picked; undersize to log washer; overflow of log to classifier or settling box. The material settling in classifier, or spigot product, was fed to slime table.

Result of test:

Oversize from screen, hand picked	43.92% Mn.
Log washer concentrates	32.92
Table concentrates	26.44
Average content of concentrates	34.48

A low-grade ore would therefore be produced in treating such material which would analyze about 35% manganese and 18% silica.

A low grade ore would therefore be produced in treating such material which would analyze about 35% manganese and 18% silica. While the results obtained are not as satisfactory as was expected, it is evident that the value of such low grade wad can be materially improved and when the percentage of sand is not high, it is possible to make a marketable product. It is further possible to work out a scheme of treatment with an equipment differing but little from that of an ordinary washing plant that would yield fair results; however, it is evident that in such work classifiers and slime tables must occupy an important place.

The loss of fine manganese, occurring either as wad or resulting from breaking up and wear of the larger pieces of manganese, while passing through the logs and jigs is considerable, often amounting to as much as 8 to 15 per cent. Any saving of such material provided it does not involve too great an expenditure, would add materially to the returns obtained from the treatment of practically all types of manganese ores. However, as much of the fine material in many deposits is high in iron, careful investigation should be made before an attempt is made to save it by the erection of a more or less elaborate plant.

COST OF CONCENTRATION OF MANGANESE ORES

No costs of treating manganese ore are available that would be representative; certain costs of actual operations being very low due to favorable conditions, other costs being very high due to unfavorable conditions. The unfortunately extreme variableness in practice renders any estimate little better than guess work and therefore of no particular value in this connection.

APPENDIX

SCHEDULE OF PRICES

In 1918 a schedule of prices on manganese ores produced in the United States was agreed to by the American Iron & Steel Institute and was approved by the War Industries Board, to become effective May 29. The following statement was authorized by the Board:[1]

The following schedule gives domestic metallurgical manganese ore prices per unit of metallic manganese per ton of 2,240 pounds for manganese ore produced and shipped from all points in the United States west of South Chicago, Ill. This schedule does not include chemical ores as used for dry batteries, etc. The prices are on the basis of delivery f. o. b. cars South Chicago, and are on the basis of all-rail shipments. When shipped to other destination than Chicago, the freight rate per gross ton from shipping point to South Chicago, Ill., is to be deducted to give the price f. o. b. shipping point.

Schedule for metallic manganese ore containing when dried at 212°F.:

Per Cent	*Per Unit*
35 to 35.99, inclusive	$ 0.86
36 to 36.99, inclusive	.90
37 to 37.99, inclusive	.94
38 to 38.99, inclusive	.98
39 to 39.99, inclusive	1.00
40 to 40.99, inclusive	1.02
41 to 41.99, inclusive	1.04
42 to 42.99, inclusive	1.06
43 to 43.99, inclusive	1.08
44 to 44.99, inclusive	1.10
45 to 45.99, inclusive	1.12
46 to 46.99, inclusive	1.14
47 to 47.99, inclusive	1.16
48 to 48.99 ,inclusive	1.18
49 to 49.99, inclusive	1.20
50 to 50.99, inclusive	1.22
51 to 51.99, inclusive	1.24
52 to 52.99, inclusive	1.26
53 to 53.99, inclusive	1.28
54 and over	1.30

[1] Committee on public information: Official Bulletin, Washington, D. C., May 29, 1918.

For manganese ore produced in the United States and shipped from points in the United States east of South Chicago, 15 cents per unit of metallic manganese per ton shall be added to above unit prices. Above prices are based on ore containing not more than 8 per cent silica and not more than 0.25 per cent phosphorus, and are subject to:

Silica premiums and penalties—For each 1 per cent of silica under 8 per cent down to and including 5 per cent premium at rate of 50 cents per ton. Below 5 per cent silica, premium at rate of $1 per ton for each 1 per cent.

For each 1 per cent in excess of 8 per cent and up to and including 15 per cent silica there shall be a penalty of 50 cents per ton; for each 1 per cent in excess of 15 per cent, and up to and including 20 per cent silica there shall be a penalty of 75 cents per ton.

For ore containing in excess of 20 per cent silica a limited tonnage can be used, but for each 1 per cent of silica in excess of 20 per cent and up to and including 25 per cent silica there shall be a penalty of $1 per ton.

Ore containing over 25 per cent silica subject to acceptance or refusal at buyer's option, but if accepted shall be paid for at the above schedule with the penalty of $1 per ton for each extra unit of silica.

All premiums and penalties figured to fractions.

Phosphorus penalty.—For each .01 per cent in excess of .25 per cent phosphorus there shall be a penalty against unit price paid for manganese of one-half cent per unit, figured to fractions.

In view of existing conditions, and for the purpose of stimulating production of domestic manganese ores, there will be no penalty for phosphorus so long as the ore shipped can be used to advantage by the buyer. The buyer reserves the right to penalize excess phosphorus as above by giving 60 days' notice to the shipper.

The above prices to be net to the producer; any expense, such as salary or commission to buyer's agent, to be paid by the buyer.

Settlements to be based on analysis of ore sample dried at 212°F.

The percentage of moisture in ore sample as taken to be deducted from the weight.

Payments.—Eighty per cent of the estimated value of the ore (less moisture and freight from shipping point) based on actual railroad-scale weights to be payable against railroad bill lading, with attached certificates of sampling and analysis of an approved independent sampling chemist. Balance on receipt of ore by buyer. Actual railroad-scale weights to govern in final settlement. Cost of sampling and analysis to be equally divided between buyer and seller.

PRINCIPAL SHIPPERS OF MANGANESE AND MANGANIFEROUS ORE IN GEORGIA, 1918

(a) manganese ore (40 per cent manganese or more)
(b) ferruginous manganese ore (15 to 40 per cent manganese)
(c) manganiferous iron ore (5 to 15 per cent)

1. (*c*) The Alabama Company, Birmingham, Ala. Mines, Hematite, Ga.
2. (*a, b*) Carribee Mining Company, White, Ga.
3. (*a, b, c*) Cherokee Ochre Company, Cartersville, Ga.
4. (*a*) Chicago-Tennessee Coal & Oil Company, 805 Steger Bldg., Chicago, Ill. Mines, Cohutta, Ga.
5. (*a, b, c*) T. C. Conway, Candler Building, Atlanta, Ga. Mines, Cave Spring, Ga.
6. (*a, b*) Georgia Iron & Coal Company, Hurt Bldg., Atlanta, Ga. Mines, White, Ga.
7. (*a, b*) Hebble Brothers, Cartersville, Ga.
8. (*b, c*) R. E. Holley, 4021 Prairie Avenue, Chicago, Ill. Mines, Tunnel Hill, Ga.
9. (*a, b, c*) W. O. Houck, Cartersville, Ga.
10. (*a, b, c*) J. M. and W. S. Knight, Cartersville, Ga.
11. (*a*) Samuel Lanski, 110 S. Dearborn Street, Chicago, Ill. Mines, Varnell, Ga.
12. (*b, c*) Markstein-Dorn Mining Company, White, Ga.
13. (*b, c*) Paga Mining Company, Cartersville, Ga.

14. (*a, b, c*) J. B. Pruitt, Cave Spring, Ga.
15. (*b, c*) Republic Iron & Steel Company, Birmingham, Ala. Mines, Cartersville, Ga.
16. (*a, b*) Sidney Simmons, Cave Spring, Ga.
17. (*a, b, c*) Southern Leasing Company, Cartersville, Ga. Mines, Bartow, Ga.
18. (*b, c*) Southern Manganese Corporation, Brown-Marx Bldg., Birmingham, Ala. Mines, Doogan, Ga.
19. (*a, b*) H. C. Stiles, Cartersville, Ga.
20. (*a, b*) J. R. Whitman, Healey Bldg., Atlanta, Ga. Mines, Lincolnton, Ga.

SOME RECENT CONSUMERS OF GEORGIA MANGANESE AND MANGANIFEROUS ORES

1. Iroquois Iron Company, South Chicago, Ill.
2. Miami Metals Co., Peoples Gas Bldg., Chicago, Ill.
3. Republic Iron & Steel Company, Birmingham, Ala.
4. Sloss-Sheffield Steel & Iron Company, Birmingham, Ala.
5. Southeastern Iron Corporation, Goshen, Va.
6. Southern Manganese Corporation, Birmingham, Ala.
7. Tennessee Coal, Iron & Railroad Company, Birmingham, Ala.

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