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MANGANESE DEPOSITS OF EAST TENNESSEE

BY

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Prepared in cooperation with the
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ILLUSTRATIONS.

MANGANESE DEPOSITS OF EAST TENNESSEE.

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SCOPE OF THE REPORT.

The area described in this report was surveyed under a cooperative agreement between the United States Geological Survey and the Geological Survey of Tennessee. Most of the field work was done in the summer of 1918. Arthur C. McFarlan, representing the State Geological Survey, examined some of the prospects, and his notes on these properties are embodied in the report under his name. A preliminary report on the area by the authors has been published by the State Geological Survey.[1]

All the operating mines and nearly all the prospects and known occurrences of manganese ore in this part of the State were visited, and the ore deposits were studied to determine their relation to the underlying rocks and to the surface features. The report comprises outlines of the topography and geology of the area, descriptions of the several types of ore deposits and of their relations to the topography and geology, and brief descriptions of the mines and prospects. In the detailed descriptions places where conditions are regarded as favorable for further prospecting are pointed out, and undeveloped tracts which seem worthy of careful testing by boring or test pits are described. A tabular summary of the known deposits in the area is appended for ready reference.

ACKNOWLEDGMENTS.

When visiting the manganese deposits the writers were courteously received by the owners and operators, who gave them every possible assistance in their study of the mines and properties. At many places the writers were accompanied by men familiar with the properties, a courtesy that greatly facilitated the work. Special mention should be made of the Southern Manganese Corporation, Birmingham, Ala.,

[1] Resources of Tennessee, vol. 8, Nos. 3 and 4, 1918.

whose president, Mr. Theodore Swann, arranged to have a representative act as guide at each mine and prospect from Mountain City on the north to Sweetwater on the south. Mr. H. V. Maxwell, of Hampton, was especially helpful in the examination of deposits near that town and in Shady Valley. This cooperation by the mine owners is regarded not only as inspired by a desire to help the Government in its effort to increase the production of domestic manganese at a time when it was greatly needed for war purposes, but also as an expression of appreciation of the helpfulness of Government geologists, who freely gave their opinion as to the nature and relations of the ore bodies and offered advice as to further prospecting and methods of mining and handling the ore.

Much helpful inspiration was given by D. F. Hewett, who initiated the present study of the manganese deposits of the Southern States and who formulated the theory of secondary deposition of the ore during peneplanation, published in reports on Virginia.[1a]

The geology of most of this area is mapped in geologic folios published by the United States Geological Survey, which were of great aid to the writers. The general relation of the ore deposits to the rock formations was readily determined from these maps and those in folios not yet published, but many details of geology had to be worked out in the field. The folios and the manuscript geologic maps used in this work are as follows, beginning at the north: Abingdon (manuscript map), Briceville, Maynardville, Morristown, Greeneville, Roan Mountain, Cranberry, Kingston, Loudon, Knoxville, Mount Guyot (manuscript map), Asheville, Chattanooga, Cleveland, Murphy (manuscript map), and Dalton (manuscript map). Most of these folios and maps were prepared by Arthur Keith, but several on the more southern areas were prepared by C. W. Hayes. The geology of the whole area, as generalized from these maps and somewhat revised by the authors, is shown in Plate XVI.

PREVIOUS WORK.

The occurrence of manganese ore in east Tennessee has been known for many years. Troost,[2] in a report published as early as 1840, refers to its occurrence in Cocke County; Safford,[3] in his report published in 1869, refers to its occurrence at several localities; and Killibrew and Safford,[4] in a report published in 1874, refer specifically to deposits in Greene County. Bailey Willis,[5] in the United States Census report for 1880, gives analyses of samples of ore from

[1a] U. S. Geol. Survey Bull. 640, pp. 37–71, 1916; Bull. 660, pp. 271–296, 1918.
[2] Troost, Gerard, Fifth geological report on the State of Tennessee, pp. 22–23, 1840.
[3] Safford, J. M., Geology of Tennessee, pp. 224 and 505, 1869.
[4] The resources of Tennessee, pp. 268, 400, Tennessee State Board Agr., 1874.
[5] Tenth Census Rept., vol. 15, Mining industries, pp. 336, 345, 1886.

Sevier and Carter counties. Penrose,[6] in his general report on manganese, describes the deposits known in the State of Tennessee in 1890, and Harder,[7] in a report on manganese in the United States, brings the information for the State up to 1910. Burchard,[8] in a report on the iron ores, refers to the occurrence of manganese with the iron ores of Monroe County. Nelson,[9] in volume 1 of the Resources of Tennessee, calls attention to a newly discovered manganese deposit in this State. Purdue,[10] in the same publication for 1916, reviews the known deposits of the State and in the volume for 1918 describes another deposit in Bradley County. The present authors have made use of these earlier reports and also of reports describing similar deposits in Virginia (cited above) and have quoted from them where data were not available from personal investigation. A preliminary report was published in July and October, 1918, by the State Geological Survey,[11] and a brief summary of results was incorporated in a paper on manganese ores of the Southern States by the senior author, published in 1920.[11a]

GEOGRAPHY OF THE REGION.

SURFACE FORMS.

East Tennessee is partly lowland, partly mountain. The lowland is the Great Valley of east Tennessee, a flat-bottomed valley 40 miles wide, a part of the Appalachian Valley, which lies between the Appalachian Mountains on the southeast and the Cumberland escarpment, which is the eastern edge of the Cumberland Plateau, on the northwest. (See Pl. I and fig. 1.) The floor of this valley is, in general, flat and stands at about the same level throughout. Its streams flow in relatively narrow valleys cut into the main valley floor 100 feet or more, and the remnants of the valley floor appear as benches along the stream valleys.

Most of the Tennessee-North Carolina boundary follows the crest of one or another of the highest ranges of the Appalachian Mountains in a general west-southwest direction. These crests form parts of the watershed between the Atlantic and the Gulf drainage, but many of the larger tributaries of Tennessee River head in North

[6] Penrose, R. A. F., Manganese—its uses, ores, and deposits: Arkansas Geol. Survey Ann. Rept. for 1890, vol. 1, pp. 414–416, 1891.

[7] Harder, E. C., Manganese deposits of the United States: U. S. Geol. Survey Bull. 427, pp. 72–76, 1910.

[8] Burchard, E. F., The red iron ores of east Tennessee: Tennessee Geol. Survey Bull. 16, pp. 52–54, 1913.

[9] Nelson, W. A., A new manganese deposit in Tennessee: Resources of Tennessee, vol. 1, No. 6, pp. 220–228, 1911.

[10] Purdue, A. H., Notes on manganese in east Tennessee: Resources of Tennessee, vol. 6, No. 2, pp. 111–123, 1916; vol. 8, No. 1, pp. 46–47, 1918.

[11] Stose, G. W., and Schrader, F. C., Manganese deposits of east Tennessee: Resources of Tennessee, vol. 8, Nos. 3 and 4, pp. 154–324, 1918.

[11a] Stose, G. W., Eng. and Min. Jour., vol. 110, pp. 256–262, 1920.

Carolina and flow westward through deep gorges in the mountains. The Applachian Mountains in this region are made up of several high, more or less parallel ranges, which are not equally continuous. Generally the northwestern ridges die down one by one southwestward, so that they overlap, and deep reentrant valleys behind them open southward into the Great Valley. A few high knobs and some linear ridges, which also trend west-southwest, lie out in the Great Valley and divide it longitudinally.

Holston Mountain, which at the Virginia State line is the westernmost ridge of the Appalachian Mountains, is a prominent mountain ridge more than 4,000 feet high that extends from Virginia into Tennessee for 25 miles to its rather abrupt termination north of Elizabethton. The long, narrow arm of the Appalachian Valley that lies back of it is drained chiefly southwestward by Stony Creek, but the upper part, called Shady Valley, drains northeastward into Virginia. East of Stony Creek and Shady Valley is a prominent ridge called Iron Mountain, which also trends southwestward. It extends into Tennessee about 40 miles, but its southwestern part is lower and consists of detached small narrow ridges, two of which are called Gap Creek Mountain and Little Mountain.

The main mass of the Appalachian Mountains lies still farther east and has several local names. Its main crest, Stone Mountain, which stands a little south of the Virginia State line, is the eastern boundary of Tennessee to the gorge of Watauga River. South of Doe River the highest range, more than 6,000 feet in altitude, is known as Roan Mountain. The State boundary here turns westward, following the crest of this range and another range, locally called Iron Mountain, beyond which it resumes its southwesterly course, running along the crest of Unaka Mountain to the gorge of Nolichucky River. Beyond the Nolichucky the main ridge, which has a general altitude of about 4,500 feet and is called the Bald Mountains, has an irregular trend. Beyond the point where it bends sharply southwestward it forms the mountain front in Greene County, and for a short distance the State line, which follows its crest, is not more than 3 miles from the Great Valley. The low, irregular mountains that extend northeast from the sharp bend in the Bald Mountains merge south of Johnson City into two distinct outlying ridges called Cherokee Mountain and Buffalo Mountain, which together correspond to Holston Mountain, the outlying ridge northeast of Johnson City. An arm of the Great Valley, similar to the valley of Stony Creek, extends southwestward between Buffalo Mountain and Unaka Mountain and terminates near Erwin on Nolichucky River, where the mountains close in.

Southwest of French Broad River the State boundary line follows the crest of the Great Smoky Mountains, a massive range that

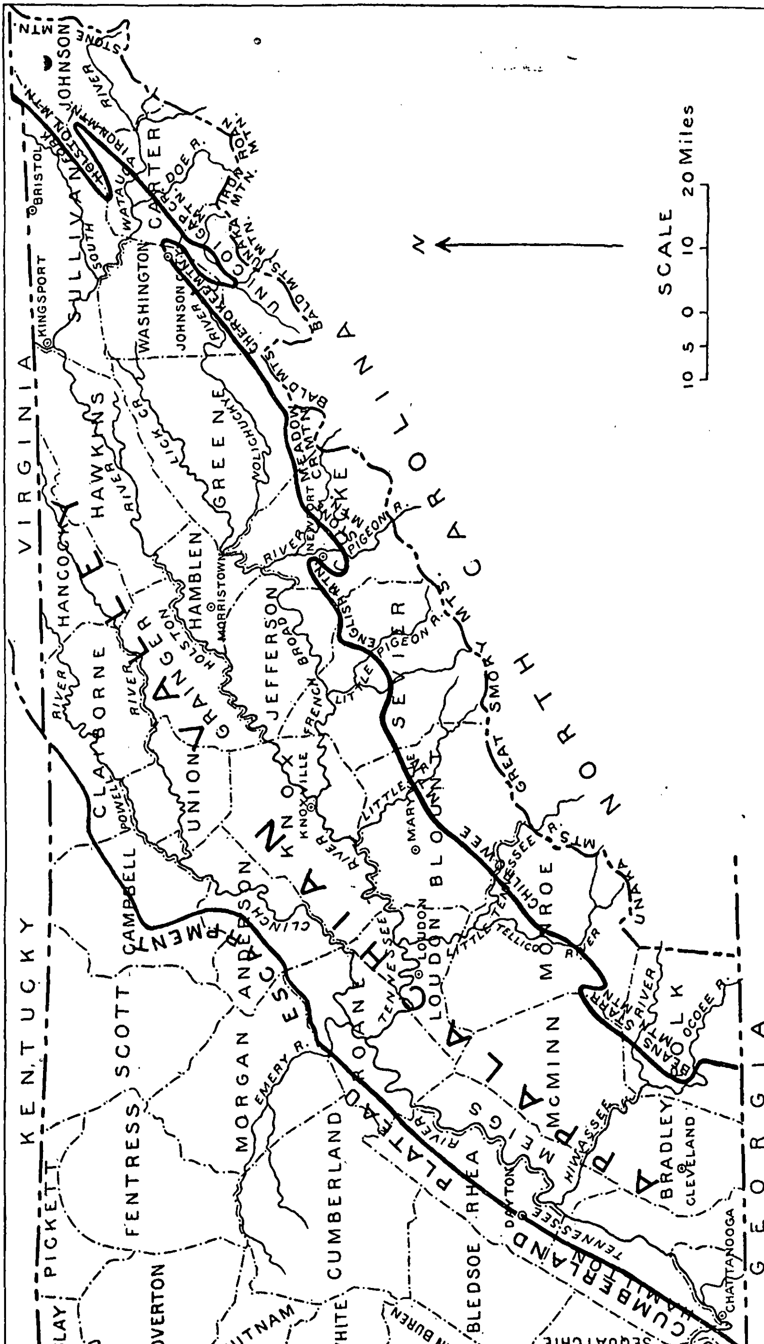


FIGURE 1.—Outline map of east Tennessee showing drainage system, boundaries of the Appalachian Valley, and names of the principal mountain ranges along the Appalachian Mountain front.

rises to an altitude above 6,000 feet. Southwest of Little Tennessee River the continuation of this great mountain range is generally known as the Unaka Mountains, but on the earliest maps of the region the names Unaka and Great Smoky were applied indiscriminately to all these higher ranges of the Appalachian Mountains and were synonymous. Where the high mountains break down at Hiwassee River the State line bends southward toward the Georgia State line. Northwest of the Great Smoky and Unaka mountains there is a mountainous tract, 10 to 20 miles wide, composed mostly of irregular ridges having local names. Of these English Mountain, southwest of Newport, and Stone, Neddy, and Meadow Creek mountains, east of Newport, form a chain of frontal or outlying ridges that is in general similar to Holston Mountain, but there are no well-defined valley arms behind them. Chilhowee Mountain is a similar though less prominent outlying ridge extending from Little Pigeon River to the Little Tennessee south of Knoxville, and Starr and Beans mountains are other outlying ridges near the southern boundary of the State.

DRAINAGE.

Practically the whole of east Tennessee is drained by Tennessee River. (See fig. 1.) A very small part of Polk County, in the extreme southeast corner, drains southward through Conasauga River into the Gulf of Mexico. The small part of the northeast corner that drains northward into Virginia is in the drainage system of Holston River, a branch of the Tennessee. Although the name Tennessee is applied only to the river below Knoxville, where the Holston and the French Broad unite, that name might appropriately be applied also to the Holston, for it is the direct continuation of the main stream and flows in the same southwesterly course. Holston River heads in Virginia, and its two main branches unite at Kingsport, just over the State line in Tennessee. Its North Fork therefore lies almost wholly in Virginia. Its South Fork, which enters Tennessee 10 miles east of Bristol, is joined from the east by Watauga River 25 miles from the State line. The latter river and one of its main tributaries, Elk Creek, head in the midst of the Appalachian Mountains, in North Carolina; with Doe River, another main tributary, which heads on the northwest slope of the mountains, they drain most of Carter and Johnson counties.

French Broad River heads at the eastern edge of the Appalachian Mountains in North Carolina and flows westward. It is first joined from the south by Pigeon River, a large stream which also heads in North Carolina and flows northward across Cocke County. It is next joined from the north by Nolichucky River at a point where the French Broad makes a sharp bend to the southwest. In fact the lower parts of Nolichucky River and of its main tributary, Lick

Creek, are a direct continuation of the main southwestward-flowing part of the French Broad and lie entirely within the Great Valley. The Nolichucky heads in North Carolina and flows in a general westerly direction across Unicoi, Washington, and Greene counties. The French Broad is next joined from the south by Little Pigeon River, which heads on the northwest slope of the Great Smokies within Tennessee and flows northwestward across Sevier County.

About 10 miles below Knoxville Tennessee River is joined from the south by Little River, which heads on the northwest slope of the Great Smoky Mountains, in Sevier County, and flows across Blount County. In Loudon County the Tennessee is augmented by the Little Tennessee, another large stream, which heads far back in the mountains of North Carolina, and its deep gorge through this high range marks the dividing line between the Great Smoky and Unaka mountains. Its main branch, Tellico River, heads on the northwest slope of the Unaka Mountains and flows westward and then northward through the center of Monroe County, joining the Little Tennessee near Morganton.

Hiwassee River is the main branch of the Tennessee in the southern part of the State. It heads in the mountains of North Carolina, and its main tributary, Ocoee River, heads in Georgia; together they drain most of Polk County, the southeasternmost county of the State. Below its junction with the Ocoee the Hiwassee forms the boundary between McMinn and Bradley counties.

Just above Chattanooga the Tennessee is joined from the south by Chickamauga Creek, which heads in Georgia and drains a small part of Hamilton County in Tennessee.

All the above-described tributaries of the Tennessee enter it from the southeast and receive the run-off from the Appalachian Mountains, where the annual rainfall is about 65 inches. The streams are therefore large and generally full of water throughout the year, and as their gradients are steep they have great potential water power. Some of this power is now being converted through great hydroelectric power plants into electricity, which is conveyed by transmission lines to distant parts of the State, where it supplies many of the larger cities and industries with light and power. A new industrial South awaits the further development of the latent powers of these waters.

The only large stream that enters the Tennessee on its northwest side is Clinch River. It heads in the Appalachian Valley ridges of Virginia and flows southwestward in the Great Valley of east Tennessee, nearly parallel with the Holston and the Tennessee, and joins the Tennessee at the big bend near Kingston. In fact Tennessee River below Kingston is a direct southward continuation of Clinch River. Powell and Emery rivers join Clinch River from the north.

THE MANGANESE DEPOSITS.

Most of the known manganese deposits of east Tennessee consist of heavy, black, hard minerals, which somewhat resemble iron ore in appearance and occurrence and are therefore often called "black iron ore" or "steel ore" by farmers. These minerals are oxides of manganese and occur most commonly in small masses in the soil and underlying clay, from which they are turned up in plowing, or they are seen in road cuts or are scattered over the fields as "float." In the clay they appear as scattered irregular masses, ranging from minute particles to lumps as large as a bushel basket or larger. Most of the pieces have botryoidal surfaces and form what is called nodular ore. The ore composed of small rounded nodules is called "nut" ore. The nodules are more generally united into clusters resembling bunches of grapes and then constitute "grape" ore or "kidney" ore. (See Pl. II.)

The ore that is scattered through the clay must be washed in a log washer or other suitable device to remove the clay and other impurities and is generally spoken of as "wash" ore. At and near the surface pebbles and fragments of rocks, usually quartzite and sandstone from the mountains, are mixed with the ore in the clay and must be either washed away with the clay or removed by hand picking after washing. Some of the masses of manganese oxide are large and clean enough to be hand picked when mined and are shipped without washing. Such ore is known as "lump" ore. Other masses fill crevices in sandstone and chert and can be recovered only by crushing the rock and separating the rock and ore by a log washer, jig, table, or similar device and by hand picking.

Only one deposit of manganese ore that is not an oxide is known in the region. This ore, which is a carbonate, is a light-gray to brown rock, part of which is crystalline and part is fine grained or amorphous. The crystalline portion resembles coarse dolomite in appearance but is heavier than that mineral. The amorphous part is finely banded. (See Pl. X.) Fresh surfaces of both kinds of the carbonate ore quickly darken on exposure, becoming coated with a thin film of black oxide. This ore occurs only in solid bedrock, where it forms layers or lenses between beds of dolomite and slate.

MANGANESE MINERALS.

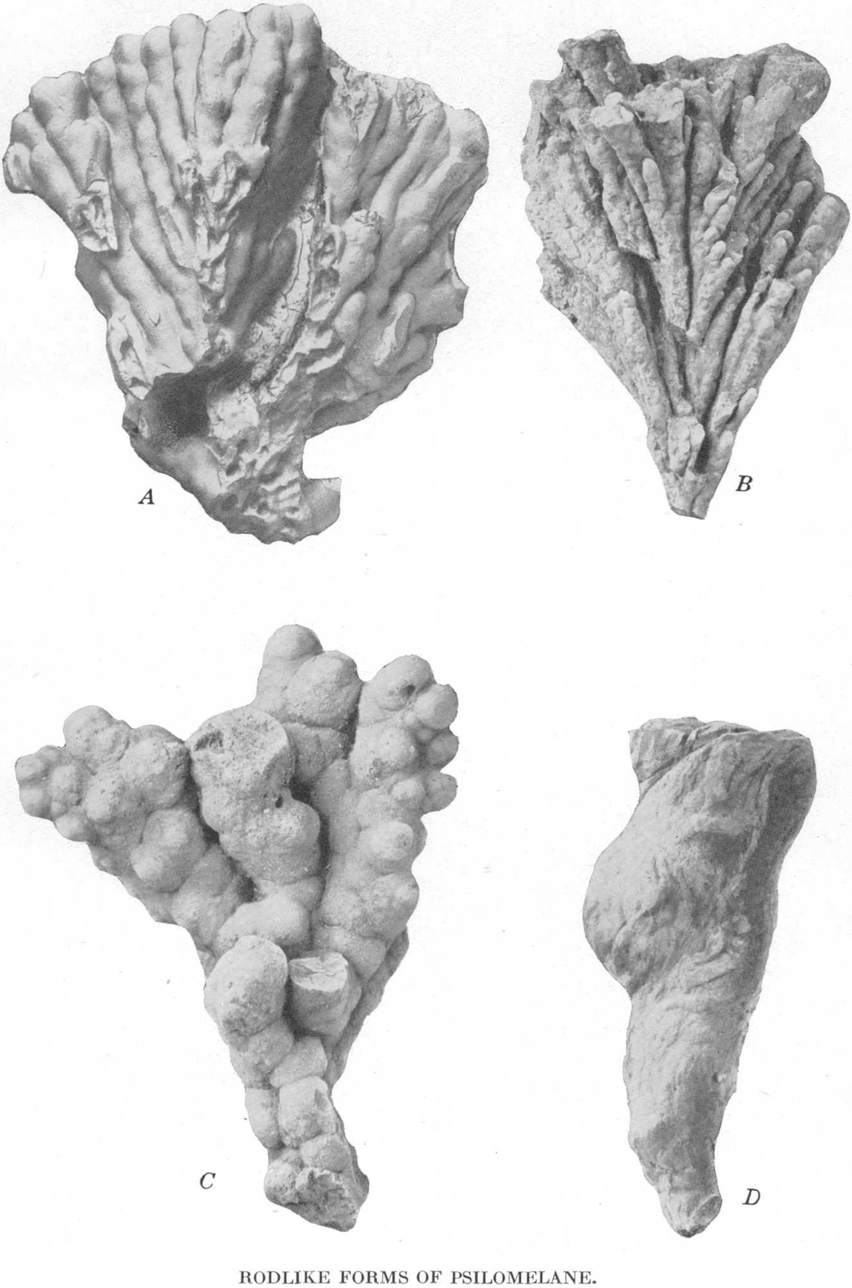
Manganese oxides closely resemble iron oxides, and the two are frequently mistaken for each other. A simple way to distinguish manganese oxide ores from iron oxide ores in the field is to scratch a piece of white chert or quartzite with the ore to be determined, so as to get the color of its streak. Manganese oxide makes a very dark brown to black streak. Iron oxide in the form of hematite makes

RELIEF MAP OF EAST TENNESSEE AND ADJACENT PART OF NORTH CAROLINA.

Photograph of part of a relief model of the southern Appalachian Valley region by Edwin E. Howell. The boundaries of the Appalachian Valley are shown in figure 1.

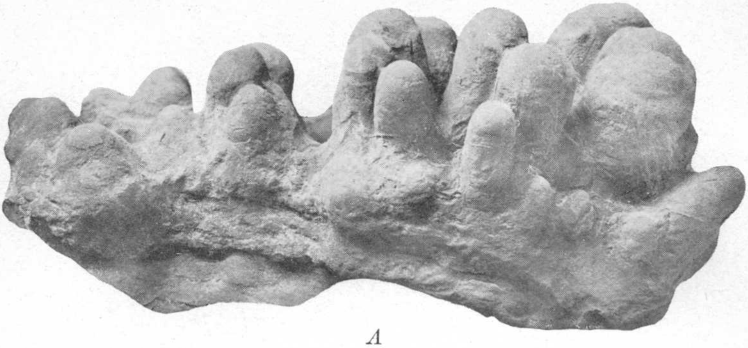
NODULAR PSILOMELANE IN BOTRYOIDAL CLUSTERS.

A, large elongate cluster, called "grape ore," from Shouns prospect, near Mountain City, Tenn.; *B*, small rounded cluster from Mineral Ridge mine, near Zepp, Va. Both natural size.



RODLIKE FORMS OF PSILOMELANE.

A, Radiate cluster of smooth rods, some of which are hollow, from Dry Run mine, Tenn., natural size; *B*, radiate cluster of solid rods from Sellers mine, Va., × 2; *C*, irregular branching cluster from Mount Torry mine, Va., × 2; *D*, single tapering rod resembling a stalactite, from Mount Torry mine, Va., × 2.



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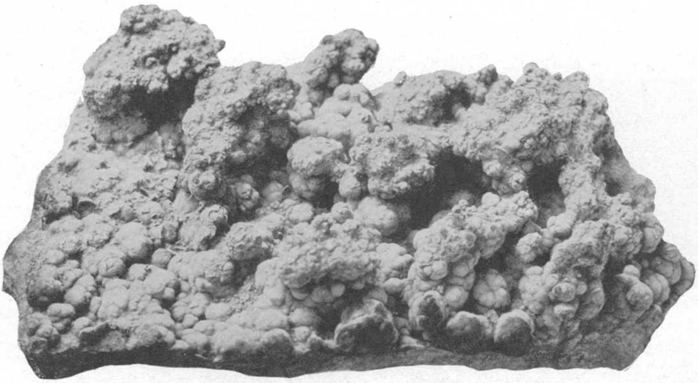

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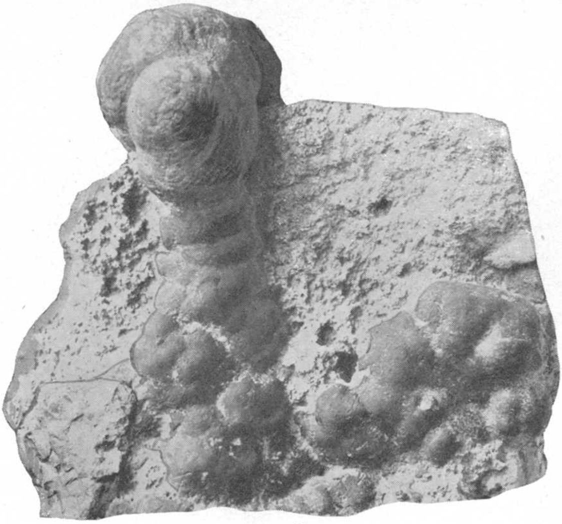


C

NODULAR PSILOMELANE ATTACHED AT BASE TO A THIN PLATE OF ORE.

A, Nipple-shaped forms from Bell mine, near Newcastle, Va.; *B*, cauliflowerlike forms, which grew by replacement of the wall rock from the crevice in which the plate was formed, from Mount Torry mine, near Basic, Va.; *C*, psilomelane nodules coated with brilliant red iron oxide inclosed in chert of Knox dolomite, which it has in part replaced, from Rutledge mine, Tenn. All natural size.

a red to reddish-brown streak and in the form of limonite a yellowish-brown streak. Iron ore containing some manganese generally makes a brownish-black mark.

The ores of the eastern United States that contain manganese oxides fall into three general groups—manganese ores, ferruginous manganese ores, and manganiferous iron ores. All of these occur in the Appalachian region of east Tennessee. The manganese ores are of much greater value than the ferruginous manganese and manganiferous iron ores and therefore in the past have been chiefly sought, but the greatly increased consumption of domestic manganese during the war caused a large demand for manganiferous iron ore as well as for manganese ores, and both have recently been mined at many places in east Tennessee.

Most of the manganese ores in this region are oxides, four of which are commonly found in the deposits and another one has been provisionally identified. These five belong to the group of brown to black oxides and hydrous oxides, several of which can not be positively distinguished without chemical analyses. For tentative identification a hard black or dark-gray amorphous manganese mineral is classed as psilomelane. One that is crystalline is classed as manganite if fairly hard but is classed as pyrolusite if soft. One that is soft and granular and shows no sign of the crystalline texture of pyrolusite nor of the compact, firm, amorphous texture of psilomelane is classed as wad. These manganese minerals and a few others will be described in detail.

Psilomelane.—Psilomelane is the commonest manganese mineral in the Appalachian deposits. It is a bluish-black to grayish-black amorphous mineral of uncertain formula (about $Mn_2O_3.H_2O+Ba$ and K). Its luster is submetallic and its streak brownish-black. It is dense, has a conchoidal fracture, and its fractured surface resembles that of steel. It usually has a concentric and somewhat radiate structure and a rounded or mammillary surface. This rounded form is due to the tendency of the mineral to grow by concentric accretion. It also tends to grow in a plumose or dendritic form, and in consequence some of the rounded forms are elongated and are arranged in clusters like bunches of grapes (see Pl. II) or in rodlike radiate clusters (Pl. III). None of these odd shapes have been developed in open spaces; they have all been formed in clay, sandstone, or other rock, where they grew by the gradual replacement or partial absorption of the inclosing material. Where the manganese solution permeated the whole rock the nodules are more or less isolated and may be attached to one another by only a small projection or stem. Where the solution came more freely along a joint or crevice in the rock the botryoidal forms grew into the wall rock

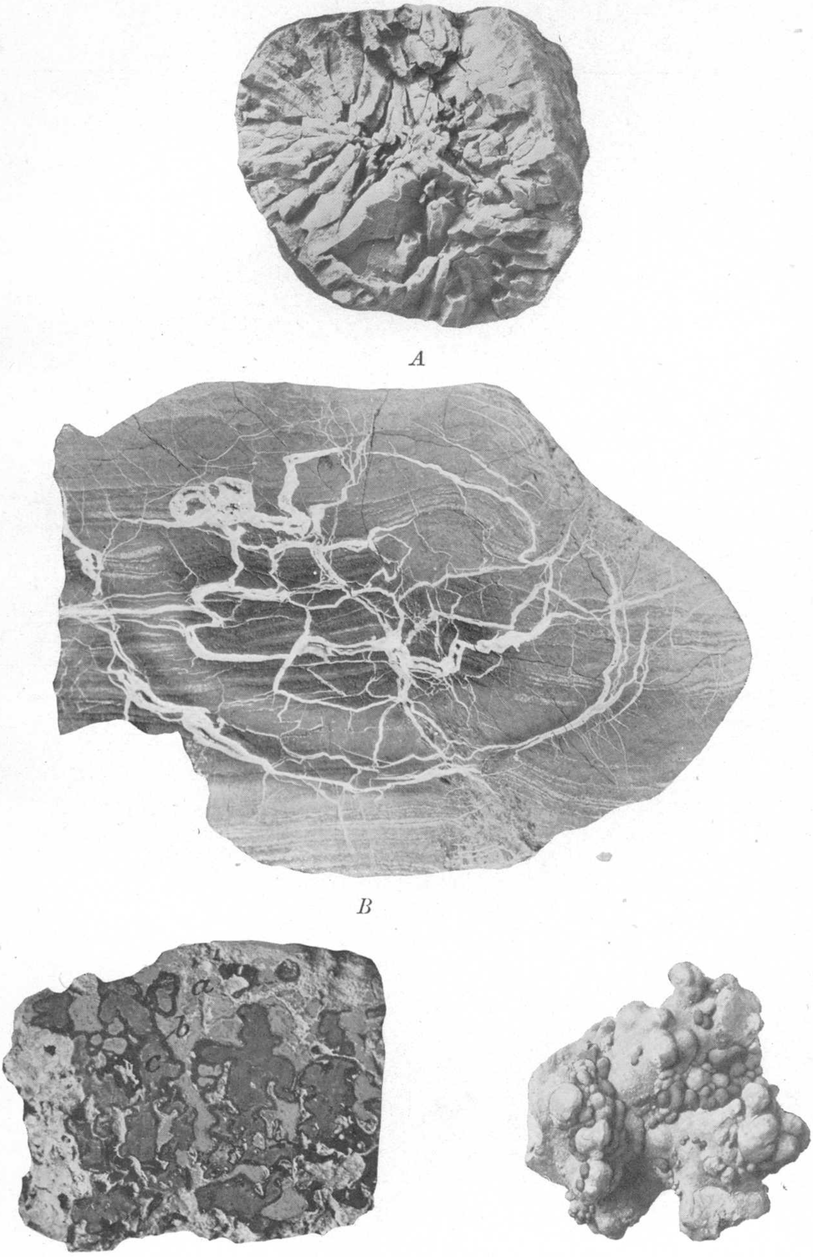
PLATE V.

A, Section of a nodule of psilomelane the interior of which has been broken into polygonal pyramids by radial shrinkage cracks. From Mount Torry mine, near Basic, Va. Natural size.

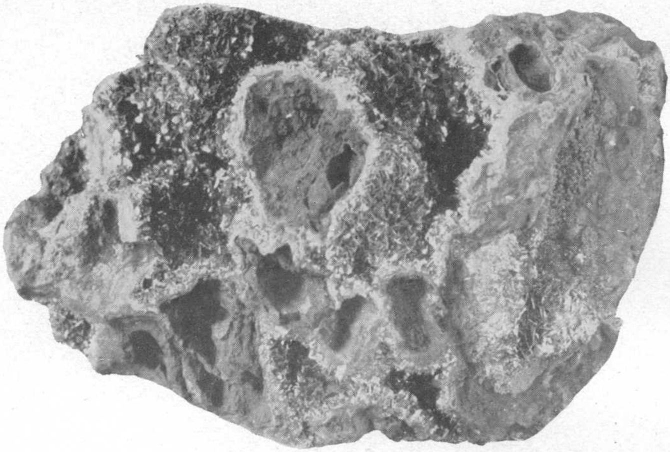
B, Polished section of a nodule of psilomelane showing irregular radial and concentric shrinkage cracks that have been filled by the deposition of harder, finer-grained psilomelane having a highly polished surface (white in photograph). The lamination of the original rock is preserved by impure bands in the psilomelane which replaced it. From Bell mine, near Newcastle, Va. × 2.

C, Two varieties of psilomelane in ore replacing chert, shown on polished surface. From Groundhog Mountain prospect, Tenn. Natural size. *a*, Brown, iron-stained chert; *b*, band of highly polished hard dense psilomelane (black in photograph); *c*, slightly softer, less homogeneous gray psilomelane.

D, Ferruginous manganese ore, a mixture of nodular psilomelane (darker parts) and rust-coated manganiferous iron. From Mount Torry mine, Va. Natural size.



MANGANESE ORES.



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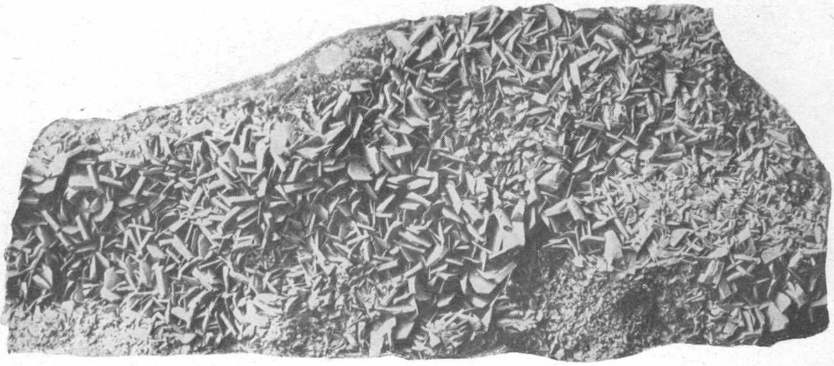

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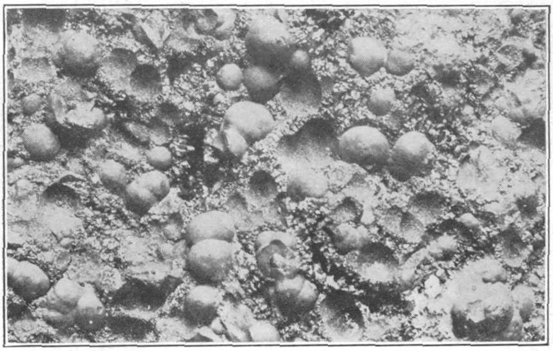
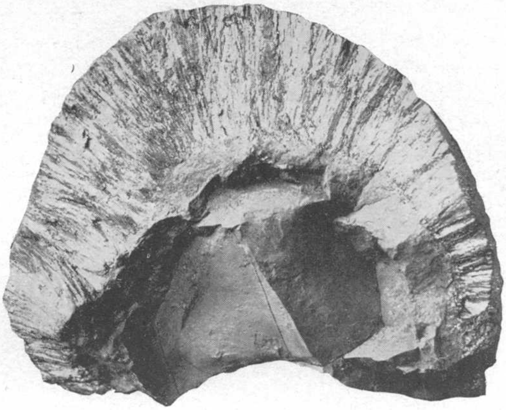


C

CRYSTALLINE MANGANITE AND PYROLUSITE.

A, Crystalline manganite lining cavities in pitted psilomelane, from Bishop mine, near Sugar Grove, Va., × 2; *B*, bladed tabular orthorhombic crystals of pyrolusite, from Powells Fort mine, near Woodstock, Va., × 3; *C*, globular psilomelane nodules inclosed by crystalline manganite in which open cavities are lined with manganite crystals, from Powells Fort mine, Va., × 2.

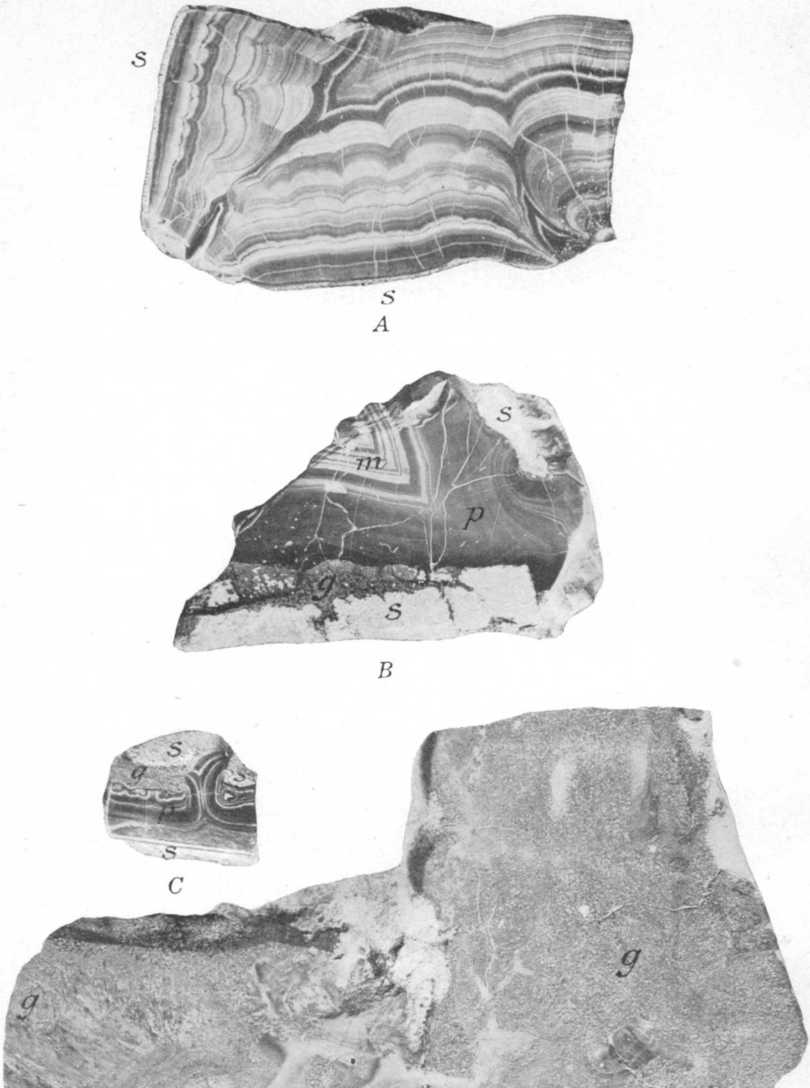


A

B

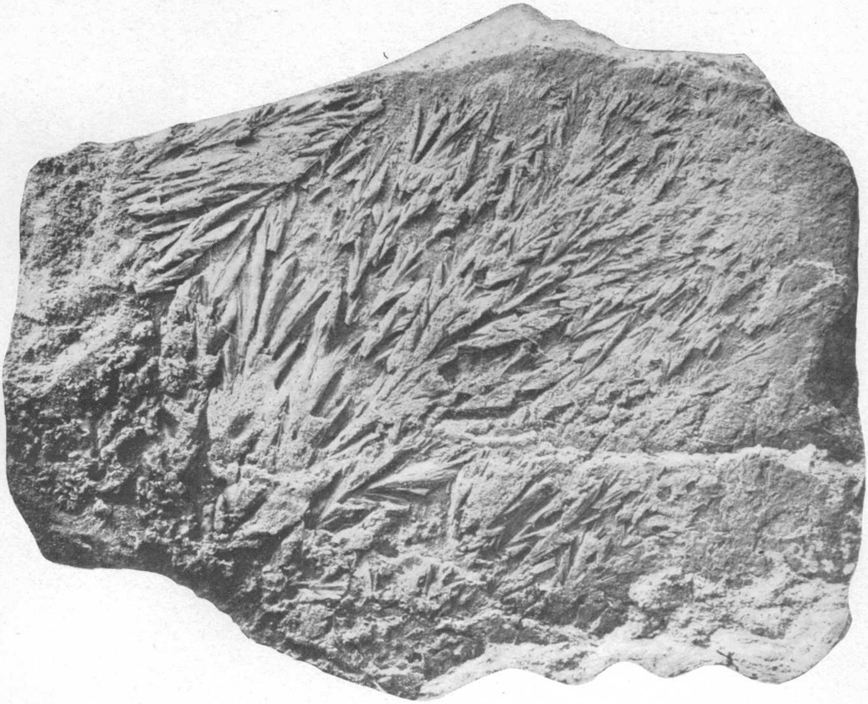
MANGANITE AND PSILOMELANE.

A, Radiate lustrous fibrous manganite, commonly called "needle ore," surrounding a core of dense psilomelane, from Embree mine, Tenn., natural size; *B*, polished surface of concentrically banded dense psilomelane and associated crystalline manganite; soft structureless cores of pyrolusite or wad are surrounded by banded psilomelane, the inner layers of which are highly crinkled and in cavities and crevices of which there is crystalline manganite (*m*), from Cook mine, near Walnut Grove, Ala., × 3.



PSILOMELANE AND MANGANITE.

Concentric layers of dense psilomelane (dark bands) and finely laminated lustrous manganite (lighter bands) shown on polished surfaces of four specimens from Compton mine, near Compton, Va. *s*, Sandstone; *m*, manganite; *p*, psilomelane. In *A* the banding is in general parallel to the sandstone walls of the original crevices; crenulations are convex away from the walls and increase in size in this direction, indicating the direction and mode of accretion. Two channels through which the solutions flowed connect the inner layers with the open crevice. In *B* the fact that the dense psilomelane between the portion banded by manganite and the sandstone walls is a replacement of the sandstone is shown by inclosed quartz grains only partly replaced at its borders, as at *g*. In *C* replacement of both sandstone walls of a crevice by psilomelane is shown by quartz grains only partly replaced at *g*. *D* shows dense concentrically banded psilomelane developing in psilomelane made granular by inclosure of numerous quartz grains (*g*) and some angular fragments of unaltered sandstone (*s*). *A*-*C*, natural size; *D*, × 2.



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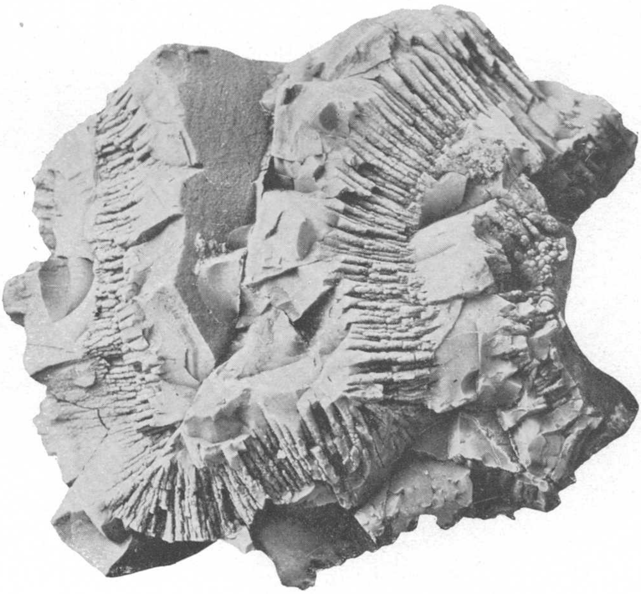

B

PYROLUSITE AND WAD.

A, Pyrolusite crystallized in plumose form in a narrow crevice in sandstone, from Mineral Ridge mine, near Zepp, Va., natural size; *B*, earthy compact wad traversed by a sigmoid band that is of similar composition but has a rodlike comb structure and radiate arrangement (the wad apparently is in the process of changing to compact and rodlike psilomelane similar to that shown in Plate XII), from Doe Valley mine, Tenn., natural size.

A

B

MANGANESE CARBONATE ORE.

A, Polished surface showing white crystalline mass with some separate rhombic carbonate crystals and dark concentrically banded carbonate ore, also a thin layer of black oxide having a somewhat brassy metallic luster at or near the contact of the two rocks, from East Fork mine, east of Sevierville, Tenn., × 2; *B*, photomicrograph showing concentric zonal structure in rhombic crystals, in which the white marginal portions seem to contain less manganese than the dark centers and to be chiefly dolomite, from East Fork mine, Tenn., × 10.

perpendicular to the crevice and are attached at their base to a plate of ore which formed in the crevice. Some of these appendages have a rounded nipple shape and others are cauliflower-like. (See Pl. IV.)

Psilomelane has a hardness of about 6 and normally can not be scratched by a knife blade or needle. Some specimens of psilomelane that can be slightly scratched are probably either impure or weathered. The mineral is heavy, its specific gravity being 3.7 to 4.7. Its composition is complex and apparently not definite. It always contains water, the quantity of which ranges from 2.5 to 6 per cent, and it generally contains considerable barium and some potassium, 17 per cent of barium and 5 per cent of potassium being the maximum recorded in analyses of the mineral. These two elements are believed by some to be mechanically admixed and by others to be chemically combined with the manganese and other elements. The percentage of manganese ranges from 50 to 57. Some nodules are composed of two or more varieties of the mineral, the original mineral composing the nodules having shrunken, probably by the loss of some of its water, and radial and concentric cracks which formed in the interior of the nodules have been filled with a similar mineral of somewhat greater hardness and finer texture. Such nodules closely resemble calcareous septaria. (See Pl. V.)

Hausmannite.—Hausmannite (Mn_3O_4) is a dark steel-gray mineral with a chestnut-brown or reddish-brown streak and submetallic luster. It is generally crystalline and has a pronounced cleavage which helps to distinguish it from most other manganese ores. It has a hardness of 5.5 and specific gravity of 4.8. Chemically pure hausmannite contains 72 per cent of manganese, which is more than is found in any other important ore-forming mineral. It is generally so intimately mixed with psilomelane or other manganese minerals that a pure sample can be obtained only with difficulty.

Hausmannite closely resembles braunite. A crystalline mineral associated with psilomelane at several mines in the Cleveland and Sweetwater districts, also at a prospect in the Washburn district, was tentatively identified by the authors[12] as braunite, but as this mineral has in general a browner streak than that of braunite, which contains silica, it was tested in the laboratory by H. D. Miser for silica. No silica was precipitated, so it is concluded that most if not all of this crystalline mineral is hausmannite.

Mr. Miser similarly found that much of the so-called braunite from the Batesville (Ark.) district was hausmannite.[13]

Braunite.—Braunite ($3Mn_2O_3.MnSiO_2$) is a heavy, nearly black, generally massive crystalline mineral. Its streak is brownish black,

[12] Stose, G. W., and Schrader, F. C., op. cit., pp. 231, 290, 306. 309.
[13] Washington Acad. Sci. Jour., vol. 10, No. 1, pp. 1–8, 1920.

its hardness 6 to 6.5 (about the same as that of psilomelane), and its specific gravity 4.75. It is generally so intimately mixed with psilomelane that it is not observed, but it may be distinguished from psilomelane by its cleavage faces on freshly broken surfaces and by its browner streak. Psilomelane, however, when weathered or impure may have a somewhat brownish streak and may be softer than the typical mineral, so that these two minerals can not always be easily distinguished. Manganite, which is also crystalline, is readily distinguished from braunite, for it is considerably softer and has a nearly black streak. Hausmannite is less easily distinguished from braunite without chemical analysis, for it closely resembles braunite in most particulars. As braunite contains silica and hausmannite does not, the two minerals can be easily distinguished in the laboratory.

Braunite has not been identified with certainty in the minerals from east Tennessee. A mineral with bright cleavage faces in dense bluish-black psilomelane from several places in southern Tennessee was tentatively identified as braunite, but the samples tested in the laboratory proved to contain no silica and are therefore regarded as hausmannite. Some portions of the specimens whose streak more closely resembles that of braunite may prove to be that mineral.

Manganite.—Manganite ($Mn_2O_3.H_2O$) is a heavy grayish-black to black, generally crystalline mineral. It has a hardness of 4 (moderately hard; can not be scratched with a brass pin) and a specific gravity of 4.2 to 4.4. On fresh fracture it is grayish black, and its streak is dark reddish brown or nearly black. It crystallizes in druses in the orthorhombic form, generally in bladed or wedge-shaped crystals. (See Pl. VI.) The crystal faces are black and have a brilliant metallic luster, but they may be tarnished to a brassy color. It also forms spherical masses of "needle ore," which when broken show glistening needle-like crystals arranged radially. (See Pl. VII.) In other "needle ore" the fibrous crystals are parallel and some are more than 2½ inches long. The mineral contains theoretically 62.4 per cent of manganese and 10.3 per cent of water. It is frequently associated with psilomelane in the Appalachian deposits, generally lining small cavities in the psilomelane ore. In some ores these two minerals are concentrically deposited in minute laminae. (See Pl. VIII.) The presence of manganite is generally regarded as an indication of high-grade ore.

Pyrolusite.—Pyrolusite (MnO_2, generally with a little H_2O) is a grayish-black to steel-gray mineral with crystalline or granular structure. It is decidedly soft, having a hardness of 2 to 2.5 (can be scratched by the finger nail and readily soils the finger), and its specific gravity is 4.8. Its color on fresh fracture is steel-gray, as distinct from the grayish black or black of manganite. Its luster is generally nonmetallic and its streak black. Some of the ore classed as pyrolusite has a porous texture and falls to a soft, powdery graphite-like mass whose specific gravity can not be readily determined. It sometimes crystallizes in plumose forms. (See Pl. IX.) Pyrolusite is the dioxide of manganese and contains theoretically 63.2 per cent of manganese. It is generally believed that most pyrolusite was derived from manganite by oxidation and loss of water, the material retaining the crystalline form or fibrous radiate structure of manganite but becoming soft, somewhat porous, and therefore light in weight, and steel-gray or dull gray in color. However, from recent studies of crystalline pyrolusite from Virginia (see Pl. VI), Watson[14] has concluded that the mineral was originally pyrolusite and is not pseudomorphic after manganite. Some of the mineral that was earlier identified as pyrolusite in the Appalachian region has the crystalline form and hardness of manganite but chemically appears to range between the two minerals.

Wad.—Wad is a dark, soft, earthy mineral and is an indefinite mixture of manganese oxides with water and other impurities such as clay and oxides of barium and iron. It is generally a dry, loosely coherent brown or brownish-black powder, not sharply distinguished except by its darker color from the slightly manganiferous clay with which it is usually associated. One specimen is compact, apparently approaching psilomelane in hardness and form, and is cut by a curved band having a comblike structure and radial arrangement, apparently in the process of assuming the form and character of pyrolusite or manganite. (See Pl. IX.) Wad contains from 30 to 42 per cent of manganese and 7 to 10 per cent of water, whereas manganiferous clay carries only 5 to 10 per cent of manganese. Wad generally contains considerable barium, sometimes as much as 20 per cent.

Ferruginous manganese and manganiferous iron ores.—The ores of manganese and iron are mixtures of manganese oxides with iron oxides in various proportions. The iron oxide is generally limonite ($Fe_2O_3+H_2O$), or brown ore, in which the quantity of water is variable. The manganese is generally psilomelane, although manganite is present in some ores. The iron and manganese oxides occur generally as a mixture of the two minerals in which each is readily distinguishable in the hand specimen (see Pl. V), but also as a mixture or compound in which the minerals are so intimately mingled that it is impossible to tell whether the substance is a mechanical mixture or a chemical combination. The amount of manganese in these mixed ores ranges from 1 to more than 40 per cent. Iron ore

[14] Watson, T. L., and Wherry, E. T., Pyrolusite from Virginia: Washington Acad. Sci. Jour., vol. 8, pp. 550–560, 1918.

that contains less than 10 per cent of manganese is called manganiferous iron ore, and ore that contains from 10 to 35 per cent of manganese is called ferruginous manganese ore. The higher grades are generally used in the manufacture of spiegeleisen, but in some steel plants they are mixed with higher-grade manganese ores for making ferromanganese. The lower grades of ore down to those containing only 3 per cent of manganese are used in making high-manganese pig iron.

Rhodochrosite.—Rhodochrosite ($MnCO_3$) is a pink, translucent vitreous mineral, generally crystalline and with a marked rhombohedral cleavage like that of calcite, but is heavier than that mineral. It has a specific gravity of 3.6, a hardness of 4, and when pure contains 48 per cent of manganese.

A crystalline manganiferous carbonate mineral that resembles rhodochrosite in many respects has been found in one of the manganese deposits in east Tennessee. In its typical form it is a white crystalline mass closely resembling marble. Analyses of this mineral follow:

Partial analyses of crystalline manganiferous carbonate ore from East Fork, Tenn.

[George Steiger, analyst.]

	A	B
SiO_2	9.53	4.68
Al_2O_3	4.02	2.07
Fe_2O_3	2.28	
MgO	11.63	12.63
CaO	22.10	19.47
MnO	11.98	22.20
	(Mn 9.3)	(Mn 17.2)

A. Select sample from a large fragment of pure white crystalline material.
B. Small crushed crystalline fragments, not so homogeneous as A.

Small separate rhombic crystals of the mineral occur in a fine-grained matrix adjacent to the massive mineral. (See Pl. X.) The rhombs have cloudy phantoms, which may carry most of the manganese, for the clearer outer portions are apparently nearly pure dolomite.

With the crystalline rock is an amorphous light-gray and brown banded carbonate rock in which are thin layers of a black metallic oxide, probably psilomelane. (See Pl. X.) It is evident from the distribution of these materials that the banded rock was deposited later than the crystalline mass. Analyses of the banded rock show from 26 to 40 per cent of manganese, as follows:

Partial analyses of amorphous carbonate ore from East Fork, Tenn.

[George Steiger, analyst.]

	A	B
SiO_2	15.54	17.10
Al_2O_3	2.42	1.06 (Al_2O_3 and Fe_2O_3 together)
Fe_2O_3	1.50	
MgO	3	3.08
CaO	11.58	2.40
MnO	33.98 (Mn 26.3)	52.53 (Mn 40.7)

A. Select sample of banded ore free from black oxide.
B. General sample of banded ore, probably including considerable oxide.

The banded material is probably not a definite mineral compound but a mixture composed largely of calcium-manganese carbonate and silica. It is difficult to get clean samples of either of these two varieties of carbonate ores, and none of the analyses quoted may properly represent a new mineral.

Mineral association.—In many of the deposits of the Appalachian region psilomelane nodules are inclosed in wad and appear to have been formed from it by concentration through the partial loss of its water. In such case the wad would be the original mineral deposited and the psilomelane secondary. A similar change from wad to psilomelane is suggested in the specimens shown in Plate IX. Many nodules and masses of psilomelane are shown on polished sections to be composed of alternate thin layers of hard psilomelane and a softer ore, generally manganite. (See Pl. VIII.) Manganite also lines cavities and fills sharply defined veinlets in psilomelane and surrounds nodules of psilomelane (see Pls. VI and VII) and is here clearly later in origin than the psilomelane. As manganite is more hydrous than psilomelane there is evidently no uniform order of deposition from the more hydrous to the less hydrous or vice versa. However, the apparent alteration of manganite to pyrolusite and of wad to psilomelane, if correctly interpreted, indicates progressive dehydration after their formation.

The clay in which most of the manganese ores occur is generally highly colored—yellow to deep red—by iron oxide, but some is gray to black from included manganese oxide where it merges into wad. Stiff, barren clay associated with the ore, generally of a chocolate-brown to dark-buff color but in places light buff to cream-colored, is referred to by the miners as "buck fat." Limonite and manganiferous iron ore are often intimately mixed with the purer manganese ores, but they are generally more plentiful or predominate in the surficial layers of the deposits associated with sand and gravel wash. The iron ores are therefore apt to be siliceous, and some are highly siliceous. Sericite, a common constituent of the metamorphosed shales in certain bedrocks, is present in some clay associated with the ores.

Grains of quartz residual from the decomposition of quartzose rocks are common in the ore-bearing clay and in some ore, and secondary quartz also occurs in the ore-bearing clay. Quartz also occurs in some deposits as minute doubly terminated needle-shaped crystals, containing rounded nuclei of calcite, according to Hewett.

Bauxite is associated with the ore-bearing clays in a few places. Small quantities of barite and wavellite occur in some of the oxide ores, and pyrite and an anthracite carbon accompany the carbonate ores.

USES OF MANGANESE.

Manganese is used chiefly in the manufacture of steel. A very small quantity of manganese, generally less than 1 per cent, alloyed with steel gives it the hardness and toughness essential for most uses. The manganese required for this purpose is extracted from the ore as an alloy with iron, with which it is generally associated in the ore. It is made into either a low-manganese alloy called spiegeleisen or a high-manganese alloy called ferromanganese. Spiegeleisen, which contains from 18 to 25 per cent of manganese, 75 per cent of iron, and 4 or 5 per cent of carbon, is used in making steel by the Bessemer process. Ferromanganese, which generally contains 80 per cent of manganese, 12 per cent of iron, and 6 to 7 per cent of carbon, is used in the open-hearth process. Manganiferous pig iron, made from iron ore that contains from 1 to 10 per cent of manganese, is used as pig iron and has no increased value because of its content of manganese.

Manganese oxides are used also in dry batteries and in the manufacture of flint glass and speckled brick. For dry batteries ore that contains a high percentage of pyrolusite, or manganese dioxide (MnO_2), is essential, as its usefulness for this purpose depends on its oxidizing properties.

ROCKS WITH WHICH THE ORES ARE ASSOCIATED.

The manganese deposits are associated with different groups of rocks in different parts of the State, and the determination of the relation of the deposits to these rocks is of much importance, especially in giving advice for prospecting or mining. As nine modes of occurrence of the manganese ore, based chiefly on the groups of rocks with which they are associated, have been recognized in east Tennessee, the rocks that occur in this region will here be briefly described. Their distribution at the surface is shown on the map of east Tennessee (Pl. XVI, p. 34).

The rocks of the region are chiefly limestone, sandstone, and shale, which occur in layers one upon the other and are tilted at various angles. They are called sedimentary rocks, because they were originally sediments, such as sand, mud, and calcareous silt, deposited from water. As the uppermost beds were deposited later than those normally below them, the relative ages of most of them can be determined. The sedimentary rocks accordingly have been classified by arranging them successively one above the other in the order in which they are found in the rock exposures, which is also according to their ages, the oldest at the bottom. The oldest rocks will therefore be described first.

The oldest rocks in east Tennessee are ancient crystalline rocks on which the sedimentary rocks rest. These crystalline rocks include granite and allied rocks of igneous origin and schists, some of which were once lavas and others sediments. They occur only in the Appalachian Mountains, on the eastern border of the State. Although some manganese deposits have been found in crystalline rocks in Virginia, North Carolina, and South Carolina, none are known to occur in such rocks in Tennessee.

Overlying the crystalline rocks is a thick series of hard siliceous rocks, chiefly sandstone, quartzite, and conglomerate, and moderately hard, finer-grained siliceous and argillaceous rocks, such as slate and shale. A few thin layers of impure limestone and dolomite occur with the slates. Most of these rocks are more resistant to erosion and solution than purer limestones and soft shales, and they form much of the Appalachian Mountains in the extreme eastern part of the State, where they have been highly tilted and folded and uplifted. Many formations have been distinguished in this series of siliceous rocks, but it is not necessary to describe them here or give their names. They are listed and briefly described in the generalized tables of formations on pages 20 and 21. Attention is called, however, to the uppermost formation of the series—a white quartzite called the Erwin quartzite in some places and the Hesse quartzite in others—because two of the kinds of manganese deposits to be described are closely associated with it.

Overlying these quartzites and slates is a great thickness of limestones in which are interbedded some shales and soft limestones.

These beds are relatively soft or soluble and have been worn away faster than the resistant sandy rocks previously described, so that they occupy the lowlands which lie northwest of the Appalachian Mountains and form parts of the valley of east Tennessee. A magnesian limestone or dolomite at the base of this series, the Shady dolomite, is a coarse open-textured rock that is readily soluble in the carbonated surface waters and is generally deeply weathered to soft, plastic yellow clay, a residuum of its impurities. One of the kinds of manganese deposits is closely associated with the residual clay of this formation. The formation next above, called the Watauga shale, is composed of hard purple shale, calcareous shale, and calcareous sandstone. Because of the greater resistance of these rocks to weathering they form low, rounded hills above the adjacent limestone lowlands. This formation also carries manganese deposits in certain parts of the State.

A thick series of limestones lie directly above the Watauga shale, and some of them contain much chert or flint. As chert is relatively insoluble, masses of it abound in the soil and clay derived from the limestones and give rise to rounded hills. The chert masses of one of the formations, called the Knox dolomite, are in many places seamed with manganese oxide, and fragments of manganese ore occur in the residual soil and form deposits that have been widely prospected.

In east Tennessee the upper beds of this limestone series are generally a gray to reddish crystalline limestone with some interbedded soft calcareous shale. Some of the beds have the texture of marble and constitute the noted Tennessee marble, which is quarried chiefly in the vicinity of Knoxville. This crystalline limestone and the associated limestone beds, some of which are shaly, argillaceous, and nodular and others blue, dense, pure limestone, have been called the Chickamauga limestone, and the marble layers in it are called Holston marble. Some of the best deposits of manganese ore in the State occur at the contact of the marble with overlying red sandy limestone, which weathers to a porous red granular sandstone known as the Tellico sandstone. The Chickamauga limestone that underlies the Holston marble in this part of the State is a well-recognized bed of middle Stones River age and represents the beds called Lenoir limestone by Safford and Ulrich, from the town of Lenoir, in this area.

The Tellico sandstone, which is more calcareous and much thinner in the southeast corner of the State, where the manganese deposits occur, than in the region around Knoxville and northeastward, represents a marked change in the character of the sediments by the influx into the sea of red ferruginous sands from lands which lay to the southeast. Although there may be no great break in sedimentation at its base, the abrupt and marked change in character of the sediment and the irregularity of its basal beds, which have discordant cross-bedding and fill channels between bryozoan reefs (see Pls. XXV and XXVI), are regarded as evidence of unconformable relations. The shales that here overlie the Tellico and are called the Sevier shale in the geologic folios include yellow shale, shaly and oolitic limestone, and white sandy marble. These beds have been described by E. O. Ulrich[15] as the Ottosee shale of Chazyan age. The so-called Tellico sandstone in the Red Hills area south of Cleveland, Bradley County, is apparently a red sandy calcareous bed at the base of the Sevier, for it contains fossils and interbedded yellow shales similar to those in the Ottosee of Ulrich. The Sevier therefore apparently rests unconformably on the Holston marble in Bradley County.

In the southern part of east Tennessee, where manganese ores occur in some higher beds, the Sevier shale is overlain by sandstone and shale which carry some high-grade iron ore. Above these is a thin but persistent and conspicuous black shale overlain by white chert or cherty limestone. The latter, called the Fort Payne chert, contains in places manganese deposits, some of which are of high grade and have been extensively worked in Alabama.

In the following table the various formations are given in their proper order beginning at the top, and the character of each is briefly stated. The general age to which the rocks are assigned is given in the column at the left.

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[15] Geol. Soc. America Bull., vol. 22, chart on page 608, 1911.

Generalized table of geologic formations for areas where manganese deposits occur in east Tennessee.

	Age.	Formation.		Character of rocks.
	Carboniferous.	Fort Payne chert.		Thin-bedded chert or cherty limestone.
	Devonian or Carboniferous.	Chattanooga shale.[a]		Black carbonaceous shale.
	Silurian.	"Rockwood" formation.[a]		Sandstone and shale.
		Sevier shale.[b]		Yellow argillaceous shale, shaly limestone, and oolitic marble.
		Tellico sandstone.		Red sandstone and sandy granular limestone or marble.
Chiefly southeast Tennessee (Hamilton and Bradley counties).	Ordovician.	Athens shale (in northern part only).		Fissile gray shale.
		Holston marble (in Chickamauga limestone).		Pinkish-buff and white marble.
		Chickamauga limestone.[c]		Light-blue to light-gray limestone and shaly argillaceous limestone.
		Knox dolomite.		Massive dolomite and limestone containing layers and nodules of chert.
		Nolichucky shale.		Shaly and platy limestone with thin argillaceous layers.
		Honaker limestone.	Maryville limestone.	Limestone, dolomite, and shale.
			Rogersville shale.	
			Rutledge limestone.	
		Watauga shale.		Purple sandy shale, sandstone, and impure limestone.
East Tennessee in general.	Cambrian.	Shady dolomite.		Massive light-gray dolomite, much of it coarsely granular, and impure argillaceous beds, with some chert at base.
		Erwin quartzite.	Hesse quartzite.	Hard white to buff quartzite containing scolithus tubes and some shale.
		Hampton shale.	Murray slate.	Dark shale, banded slate, and massive quartzite.
			Nebo quartzite.	
			Nichols slate.	
		Unicoi formation.	Cochran conglomerate.	Coarse arkosic sandstone, quartzite, conglomerate, and slate.
			Hiwassee slate.	
			Snowbird formation.	
	Pre-Cambrian.			Granite and schist.

[a] In northeastern Tennessee other formations of Silurian, Devonian, and Carboniferous ages lie above the Sevier shale, but they are not referred to in this report, as no manganese ores are associated with them.
[b] In this area equivalent to Ottosee shale of Ulrich.
[c] In this area equivalent to Lenoir limestone (of middle Stones River age) of Safford.

Detailed section of Ordovician beds associated with manganese deposits of Monroe County.[a]

[Chiefly from exposures at the McGuire mine.]

Formation.	Character of rocks.	Thickness.
		Feet.
Sevier shale (Ottosee shale of Ulrich).	Soft reddish porous sandstone, calcareous where unweathered, carrying a small amount of hematite of no economic value, and prospected for iron at one place to the southeast [b]	10
	Siliceous gray oolitic marble, reddish in part	20
	Shaly gray limestone	40±
	White marble, mostly coarse granular, some fine saccharoidal. Reddish blotched and pink beds in lower part. Somewhat fossiliferous throughout	60
	Gray to greenish shaly limestone, very fossiliferous	40±
	Soft greenish calcareous shale, weathered yellow, and some very fossiliferous shaly limestone at the base. The basal beds fill depressions and solution channels 20 feet or more deep in the upper surface of the underlying marble, representing a marked unconformity	50±
Unconformity		
Tellico sandstone. [a]	Coarse granular crinoidal red marble with Bryozoa and coral reefs in the upper part	90±
	Pink crinoidal granular siliceous marble with cross-bedded sandy and ferruginous banding and layers containing small shiny hematite-colored pebbles. The ferruginous layers are workable beds of hematite and manganese ore in places, especially where the ore is concentrated at the base of weathered zones and in residual clayey sands filling solution pockets in the underlying marble. Toward the southwest yellow shale at one or more horizons is present in considerable quantity. Mottled red calcareous nonbedded rock, resembling reworked disintegrated marble, forms the basal beds in places	50
Unconformity		
Holston marble.	Thick-bedded pink marble with deep black stylolitic markings	30
	White marble, in part light greenish, mostly coarse granular but in part fine grained	10
Chickamauga limestone (Lenoir limestone of Safford).	Thin-bedded blue limestone with wavy partings. Thins toward the south to 20 feet or less at the Georgia State line	100±
Knox dolomite.	Fine-grained, even-bedded light-gray dolomite and magnesian limestone with beds of white chert.	

[a] In the Red Hills area near Cleveland, Bradley County, ferruginous banded Holston marble is overlain in places by 30 feet of yellow shale and thin red calcareous sandstone which carries fossils similar to those in the Ottosee shale of Ulrich, so that the so-called Tellico sandstone in that district is probably a sandy bed in the Sevier shale.

[b] In the Red Hills area near Cleveland the sandstone is overlain by thick soft yellow shale belonging to the Ottosee of Ulrich.

TYPES OF ORE DEPOSITS.

All the deposits of manganese ore in east Tennessee except those of one form are oxide ores in residual clay or clayey sand derived from the weathering of sedimentary rocks. The exceptional form of deposit is a carbonate ore that replaced limestone and shale. Most of the oxide ores may be classed as replacement deposits, some of them replacing the rock in place, but most of them replacing clay and sand, residual from rock decay, which still retain the rock structure. None of them except small amounts of ore associated with other deposits are believed to be strictly residual detrital deposits concentrated by gravity.

Practically all the deposits are on benches above the stream valleys. This is an important fact to consider in determining the genesis of the ore, for the general valley floor of which these benches are remnants was once the flat bottom of a valley across which streams slowly meandered. This plain had been worn down to a nearly level lowland by long-continued erosion by rain, wind, and streams, and the rocks beneath its surface were deeply weathered to soil. It was during this period of deep weathering that most of the ore deposits were formed, the manganese set free by the weathering of the rocks being largely precipitated from solution at the bottom of the weathered zone, where the ore was concentrated. The process is believed to have taken place twice in Tertiary time, probably first in the early Tertiary and again in the late Tertiary, for the benches are not all remnants of the same plain but more probably represent two plains less than 100 feet apart. A more recent elevation of the land caused the streams to cut down their channels, which are now 100 feet or more below the old valley floor.

The oxide replacement deposits occur in many different modes, the chief distinguishing features of which are the geologic formations with which the deposits are associated. This association of a deposit with a certain formation is believed to be due to its derivation from certain sedimentary beds in which manganese minerals originally occurred in somewhat greater abundance than in ordinary sediments, the concentration of the manganese from these beds by solution and redeposition as oxide having localized the deposits in residual clays and sands near these beds. A few deposits occur in terraced stream gravels, and some are replacements along fault zones. The nine modes of occurrence thus recognized in east Tennessee and to be described in this report in stratigraphic order are as follows:

1. Carbonate ores in older Cambrian dolomite.
2. Oxide ores in Erwin quartzite.
3. Oxide ores in Shady dolomite.
4. Oxide ores in Watauga shale.
5. Oxide ores in Knox dolomite.
6. Oxide ores in Tellico sandstone and Holston marble.
7. Oxide ores in Fort Payne chert.
8. Oxide ores along fault planes.
9. Oxide ores in terraced stream gravels.

The distribution of the geologic formations at the surface in east Tennessee is shown on Plate XVI, on which also is shown the location of manganese mines and prospects. Areas where most of the formations above referred to have been found to be manganiferous are shown in figure 2. The different modes of occurrence will be described in order, beginning with the oldest associated rocks.

CARBONATE ORES IN OLDER CAMBRIAN DOLOMITE.

Carbonate of manganese, calcium, and magnesium has been found in dolomite and slate in the old quartzite series of the Appalachian

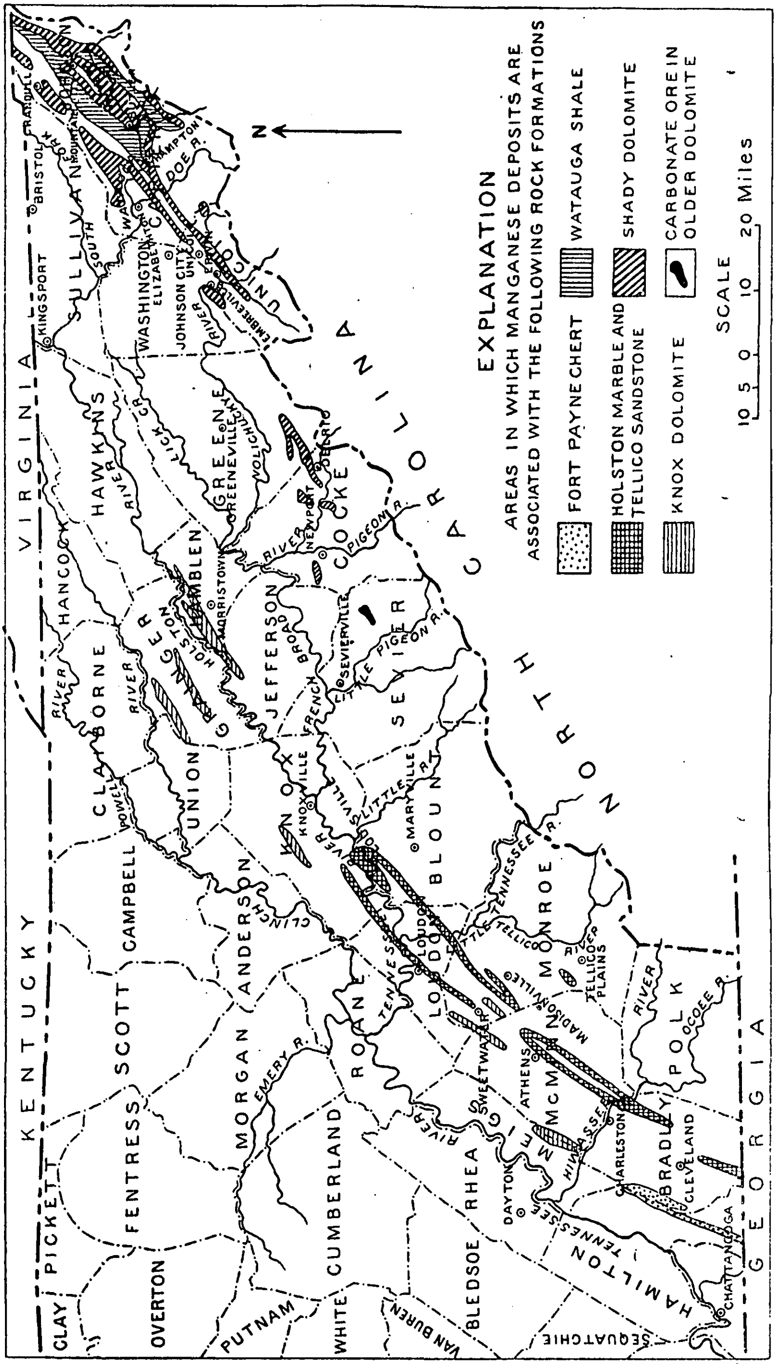


FIGURE 2.—Outline map of east Tennessee showing areas in which manganese deposits are associated with certain rock formations.

Mountains at one place in east Tennessee and may occur elsewhere under similar conditions. It occurs in lenticular beds at the contact of the dolomite and slate and is a replacement of calcareous rock along this zone. Manganese minerals were apparently originally disseminated in the dolomite, for the associated unaltered dolomite in the face of the mine responds to chemical tests for manganese and weathers on exposure to a porous brown manganiferous network inclosing rhombohedral molds of carbonate crystals. The ore was concentrated by waters that circulated along fracture planes at the contact while the rocks were still below the zone of surface oxidation. The beds now stand vertical, and the outcrops of the ore layers are altered to psilomelane and manganiferous iron oxide in manganiferous clay. These oxide ores at the surface were first prospected, and only after mining to a depth of 6 to 10 feet was the carbonate ore discovered. This ore looks like a coarse dolomite or limestone (see Pl. X) and is distinguished only by its greater weight and by its discoloration on exposure at the surface, a thin film of dark-gray to black oxide quickly coating it. It contains about 35 per cent or less of manganese, but as it is a carbonate it acts somewhat as a flux in the smelting process, and when it is mixed with oxide ores the amount of limestone necessary to the charge is reduced. It should therefore command a higher price at smelters than the manganese content alone would indicate.

The carbonate ore has been found at only one place in east Tennessee, which is near East Fork post office, on the East Fork of Little Pigeon River, in Sevier County, 13 miles east of Sevierville. The outcrop has been traced along the strike for nearly a mile and has a maximum width of 10 feet. Similar bodies of carbonate ore may be found at other places in the heart of the Appalachian Mountains where these older slates carry beds of dolomite.

OXIDE ORES IN ERWIN QUARTZITE.

In places along the front quartzite ridge of the Appalachian Mountains the Erwin quartzite carries deposits of manganese ore. The ore is dense banded psilomelane and fills crevices between the fragments of brecciated quartzite and replaces some of the quartzite. (See Pl. VIII, p. 10.) The ore as mined is consequently very siliceous and requires concentration to convert it into a commercial product. As these deposits occur chiefly where the quartzite is extensively broken up and brecciated, they may occur anywhere along the outcrop of the Erwin quartzite on the west side of the mountains In Tennessee they are chiefly developed near French Broad River east of Newport, associated with deposits in the Shady dolomite. The mineral is believed to have been derived from the basal beds of the Shady dolomite similarly to the deposits next to be described.

OXIDE ORES IN SHADY DOLOMITE.

Throughout the Appalachian Valley in Virginia and in parts of eastern Tennessee manganese ores occur in the clays which are residual from impure limestones near the base of the Shady dolomite. The deposits of this kind in Virginia have been recently described in several reports.[16] Between the typical massive dolomite of the Shady and the uppermost white quartzite beds of the underlying Erwin are transition beds of various kinds, which, because they are pervious and partly soluble, readily weather to clay and soil and are generally classed with the Shady dolomite, which also usually weathers to clay. These transition beds are exposed in few places, but in the valley of Stony Creek and in Shady Valley, in northeastern Tennessee, also in parts of southwestern Virginia, their character is well shown. They are there about 100 feet thick and embrace yellow finely laminated clays, which evidently were originally calcareous shale, and soft mealy arkosic sandstones, some stained red and purple with iron, others of a greenish color, due to contained glauconite grains. At the top are coarse grits of rounded quartz grains, from which the former calcareous cement has generally been dissolved, leaving a very porous layer or a loosely coherent mass, in many places stained black with manganese oxide or rusty with iron oxide. These unusual sediments were evidently derived from residual products of the weathering of rocks on an old land mass and were deposited in coastal lagoons. They are closely associated with the manganese deposits in the Shady dolomite and are believed to have been the source of the manganese minerals.

The manganese ores are composed largely of separate small pieces of psilomelane scattered through the residual clay. Some of these masses are of irregular shape, but many are nodular and have mammillary surfaces. Nodules resembling bunches of grapes and irregular stalactites (Pls. II and III) are common. Some are cauliflower-like forms attached to a thin plate of ore. (See Pl. IV.) These are growths into the bedrock walls from crevices along which the ore solutions moved. In some places cavities left in the psilomelane by the later solution of inclosed rock fragments are lined with crystalline manganite. More rarely the manganite forms distinct balls or rounded masses having a radiate fibrous structure and called "needle ore," surrounding a center of psilomelane. (See Pls. VI and VII.) Nearly all the ore must be washed to free it from the sticky clay. The ore that occurs in wash overlying the residual clay is usually ferruginous and highly siliceous from grains and small

[16] Hewett, D. F., Some manganese mines in Virginia and Maryland: U. S. Geol. Survey Bull. 640, pp. 37–71, 1916. Hewett, D. F., Stose, G. W., Katz, F. J., and Miser, H. D., Possibilities for manganese ore on certain undeveloped tracts in Shenandoah Valley, Va.: U. S. Geol. Survey Bull. 660, pp. 271–296, 1918; Manganese deposits along the west foot of the Blue Ridge in Virginia: Virginia Geol. Survey Bull. 17, 1919.

pebbles of quartz that it contains. These impurities can not readily be removed by ordinary washing processes, and such ore is therefore rejected as of too low grade.

The manganese deposits usually lie in yellow clay derived from impure laminated limestones in or directly overlying the transition beds at the base of the Shady dolomite. The manganese is believed to have originally been in these basal beds in a soluble form, probably carbonate, and to have been dissolved by the circulating meteoric waters that also dissolved the limestone. It was redeposited as oxide in the adjacent residual clays which it replaced. Some of the manganese solutions followed more porous layers in the clay, and the oxide gradually replaced the adjacent walls; others permeated the porous clay, and the oxide was segregated in isolated spots, which later developed into nodules. (See Pl. XI.)

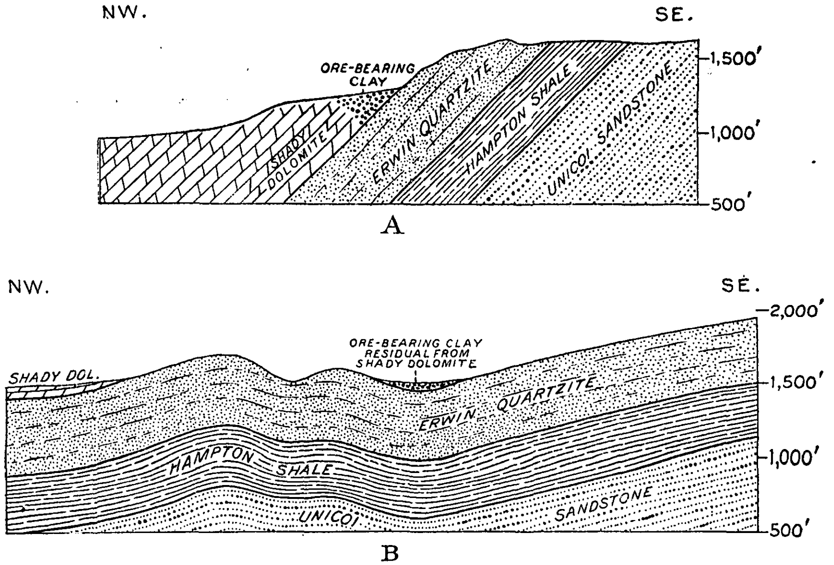


FIGURE 3.—Sketch sections along the Appalachian Mountain front showing ideal structural relations where the Shady dolomite is ore bearing. A, Monoclinal structure, which prevails in most places; B, synclinal structure, which is less common but is present in most reentrant valleys.

In most places the ore accumulated on the weathered outcropping beveled edges of the inclined beds of the Shady dolomite at the foot of ridges composed of the underlying Erwin quartzite uplifted in a monocline. (See fig. 3, A.) Where these rocks are gently folded so that a syncline at the surface incloses the Shady dolomite the descending ore-forming solutions following down the more pervious layers at the base of the Shady were concentrated along the bottom of the syncline, and the resulting ore deposits are generally thicker and of greater value. (See fig. 3, B.) This is the condition at the Crimora mine, near Basic, Va., the largest producing manganese mine in the Appalachians.

Manganese deposits in the Shady dolomite occur at many places along the west foot of the Appalachian Mountains in east Tennessee, where the Shady dolomite lies at the foot of steep slopes of the Erwin quartzite ridges in the position just described, and on both sides of limestone coves and reentrant valleys within the mountains where the Shady has been infolded in synclines. The deposits are naturally not continuous along this dolomite-quartzite contact, as their accumulation depends on the quantity of the manganese minerals originally present in the adjacent rocks, on the steepness of dip of the rocks, on the extent of decay of the bedrock, on the slope of the surface of the bedrock or its residual clay, and on the cover of wash on the bedrock surface through which the ore-bearing solutions can percolate slowly, for the ore is apparently deposited more freely where the solutions move slowly. Deposits are of course not to be expected where the rocks have been faulted so that the Shady dolomite is absent at the surface. The places referred to in the following paragraphs are shown in figures 4, 11, 16, 18, and 24.

The valley of Beaverdam Creek, in Johnson County, at the north border of the State, is a syncline, and the Erwin quartzite dips gently into it from both Holston Mountain on the west and Iron Mountain on the east. In Shady Valley and at a point farther north near Sutherland the syncline is depressed sufficiently to inclose Shady dolomite at the level of the valley floor. The conditions are thus favorable to the occurrence of deposits of manganese ore, and several have been prospected and mined. The dips are more gentle and therefore the conditions more favorable for the deposition of ore on the western side. The Shady Valley basin is terminated at the north and south by the gentle rise of the strata in these directions. Minor longitudinal folding at the north end of the basin divides it into two shallow troughs in the vicinity of Crandull. At these rising ends of the trough synclinal conditions are still more favorable for the occurrence of commercial deposits, of which the high-grade ore of the Davis mine is an example. Northeast of Shady Valley, near the Virginia State line, where the Beaverdam syncline is depressed sufficiently to infold the Shady dolomite, commercial manganese deposits have also been opened.

Southwest of Shady Valley the valley of Stony Creek, Carter County, also lies in a syncline between Holston and Iron mountains, and similar geologic conditions prevail. The manganese deposits discovered there, however, have not proved so rich as those in Shady Valley. The ore-bearing formation extends to Keenburg on the west side of the valley and to Blue Spring on the east side of the valley. Beyond this the eastern belt of the Shady dolomite follows along the northwest foot of Iron Mountain to Valley Forge and thence along the foot of Gap Creek Mountain and Little Mountain, the southwestward continuation of Iron Mountain, nearly to Unicoi, where it is terminated by a fault.

On the northwest side of Stone Mountain and on the lower slopes of outlying anticlinal ridges of Erwin quartzite in Johnson County favorable geologic relations occur at many places, but most of the deposits of this type that have been explored there are small. Southwestward the deposits along this belt increase in value and have been mined at several places at the northwest foot of Stone Mountain, in Carter and Unicoi counties, from Cardens Bluff to Unicoi, beyond which the Shady dolomite and Erwin quartzite are much disturbed by faulting.

Owing to great faulting along the northwest front of the Appalachian Mountains from Erwin southwest to the State boundary the Shady dolomite and Erwin quartzite do not generally occur in their normal relations at the foot of the mountains. In Bumpass Cove, a faulted synclinal limestone valley shut in by mountains southwest of Unicoi, the geologic relations are favorable for ore deposition only along the northwest side, where the Erwin quartzite dips gently southeast under the Shady dolomite of the cove. On the south side of Meadow Creek Mountain, in the southern part of Cocke and Greene counties, these formations locally outcrop in their normal monoclinal relations, and geologic conditions are there favorable for the occurrence of manganese ore, but the few deposits that have been prospected there and at the east end of Meadow Creek Mountain have proved to be small and scattered and of little commercial value. Similarly on the north end of English Mountain, in Cocke County, the Shady and Erwin formations locally have their normal relations and manganese deposits are being mined at the base of the Shady dolomite.

OXIDE ORES IN WATAUGA SHALE.

In the extreme northeastern part of Tennessee as in the adjoining southwestern part of Virginia deposits of manganese ore occur in the soft disintegrated beds of Watauga shale. Such deposits have been worked in Johnson County northeast of Mountain City and in Doe Valley, southwest of Mountain City, and have been prospected and mined on a small scale in both Johnson and Carter counties near Butler. (See figs. 6 and 11.) The ore is largely psilomelane, but much of it is fine needle ore composed of pyrolusite. It fills pockets in the yellow sandy clay and replaces porous, disintegrated yellow sandstone. The solutions followed bedding and joint planes and penetrated the walls, in which tubules perpendicular to the crevices were formed by replacement of the sandstone, giving rise to a miter-comb structure. The resulting ore appears like a cemented sandstone breccia. (See Pl. XII.)

The deposits that have been worked lie in the middle of belts of Watauga shale and seem to be in broad basins or troughs in the shale. Therefore, if structural relations have any bearing on the occurrence of the deposits the central part of Doe Valley, which is a broad syncline, and the region south and west of Butler, where several synclinal or trough-shaped folds occur, are the most favorable places to search for deposits of this kind. Manganese ore has been found in commercial quantities in both these places. The horizon in the Watauga with which the ore is associated, if it is restricted to any particular beds, has not been determined. The ore seems to have been concentrated only at the level of the old valley-floor peneplain, 100 to 150 feet above the stream bottoms, and peneplain conditions seem to have been the chief controlling influence in its accumulation.

OXIDE ORES IN KNOX DOLOMITE.

Chert in the Knox dolomite, which is stained black by manganese oxide at many places, is sometimes so impregnated with the oxide as to form a manganese ore. Chert masses which have been broken into small fragments are cemented together by manganese oxide and in part replaced by it, so that some large masses of ore are formed in this manner. The chert and ore are set free by the weathering of the limestone and are found in the residual clay soil on the slopes of chert hills. Most of the ore in the chert is hard psilomelane, and some of the residual masses are exceptionally pure ore with some crystalline pyrolusite in crevices. Nodular psilomelane in the forms of nut and grape ore replaces the chert (see Pl. IV, *C*) and occurs as loose fragments in the clay derived from the Knox. Managanese does not seem to be restricted to any particular horizon of chert in the Knox.

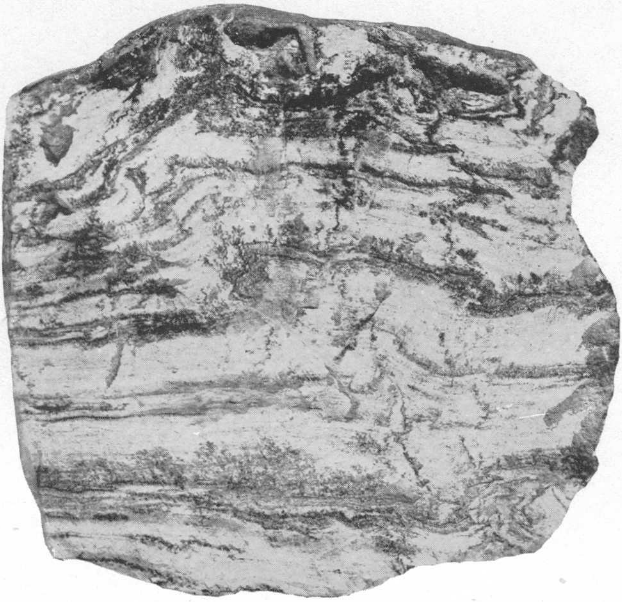
Ore in the residual clay and chert of the Knox dolomite has been found throughout the valley of east Tennessee and has been prospected at many places. On finding one or two large chunks of high-grade ore one is likely to conclude that they indicate a workable deposit, but few promising deposits have been opened in ore of this type, and such as have been mined, as that at the Rutledge mine, are at the contact of the Knox dolomite and an underlying shale, where the conditions are somewhat more favorable for the accumulation of ore, because the ore solutions tend to follow the contact with the impervious shale.

OXIDE ORES IN TELLICO SANDSTONE AND HOLSTON MARBLE.

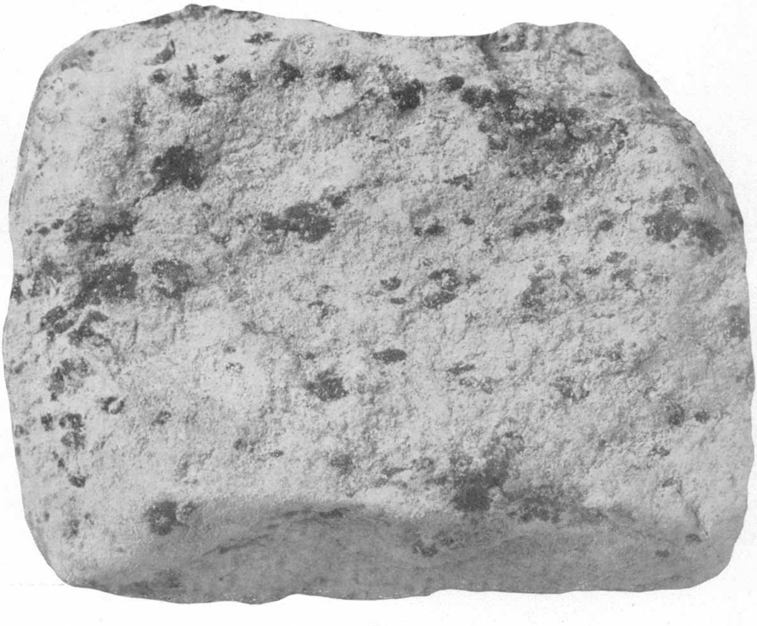
Marble beds, the Tennessee marble of commerce but referred to in geologic literature as the Holston marble, occur in the Chickamauga limestone at many places in east Tennessee. Where the marble is thin and overlain by red sandy marble or calcareous sandstone, called Tellico sandstone, high-grade iron and manganese ores generally occur. The contact of the sandstone on the marble is in many places irregular (Pls. XIII, XXV, XXVI), owing to a sudden change in deposition from lime silt to red sand, during a part of which this area was probably dry land. Such an irregular contact indicating a break in sedimentation is called an unconformity, and such a change is generally accompanied by the deposition of unusual material, the waste from the weathering of older rocks that formed the old land surface. Manganese minerals were probably among these unusual materials and became disseminated in the basal Tellico sediments. When the Tellico sandstone weathered at the surface and the soluble lime carbonate was dissolved out of it the manganese and associated iron were concentrated by solution and redeposition and formed layers and lenses of ore in the basal part of the Tellico. These deposits are generally found at the bottom of the disintegrated sandy rock, in contact with or close to the underlying unweathered Holston marble. Some of these layers of ore interbedded with the sedimentary rock contain impressions of fossils that were in the original rock and are now preserved in the ore. (See Pl. XIV.) Most of the ore mined, however, is in loose residual masses in sandy clay derived from the weathered Tellico and resting on the unweathered marble. This manganese ore is a mixture of psilomelane and a crystalline mineral, probably hausmannite, and most of it is so clean that it can be hand picked and shipped without washing. The associated iron ore is a high-grade red hematite, including both fossil ore and fine shiny-pebble ore. (See Pls. XIV, XV.)

In the Cleveland Red Hills area, near the south border of the State, the so-called Tellico sandstone contains fossils similar to those in the Ottosee shale of Ulrich and is interbedded with yellow shale of Sevier type, so it is probably a sandy bed at the base of the Sevier, at the unconformable contact with the Holston marble.

The only known occurrences of manganese ore in the Tellico sandstone and Holston marble are in the southern part of the State in the vicinity of Sweetwater, Cleveland, and Louisville. Several belts of marble overlain by the Tellico sandstone occur east and south of Knoxville, and small pieces of manganese ore have been found in the overlying soil, but only in a few places have deposits of commercial value thus far been developed. In Monroe County, between Philadelphia and Sweetwater, several deposits of high-grade ore have been mined. This Sweetwater belt is cut off by a fault at Sweetwater but reappears 6 miles south of Cleveland, where it is



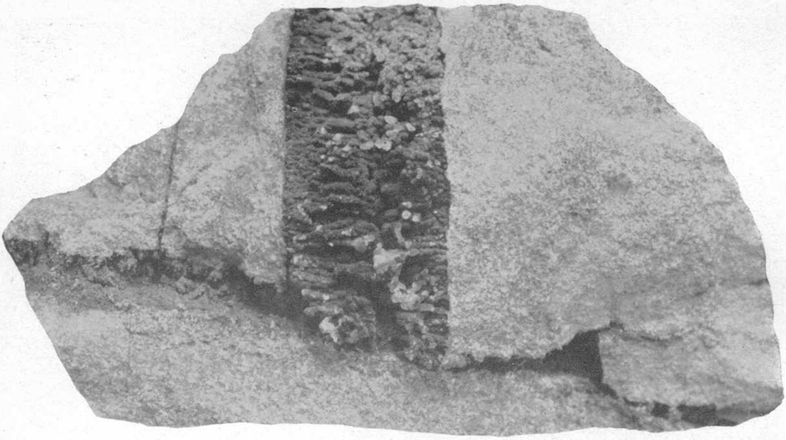
A



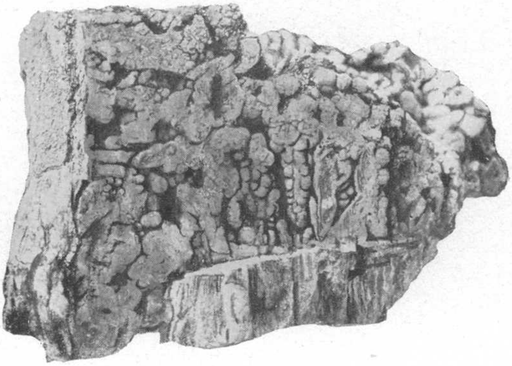
B

RESIDUAL CLAY CONTAINING MANGANESE OXIDE.

A, Residual clay of Shady dolomite banded by incipient impregnation of manganese oxide along thin crenulated porous layers, also showing dendritic incipient replacement of the clay bordering these layers, from Winter mine, Tenn., natural size; *B*, manganese oxide segregated into dark specks and incipient nodules of psilomelane, replacing residual clay of Knox dolomite, from Rutledge mine, near Rutledge, Tenn., × 3.



A



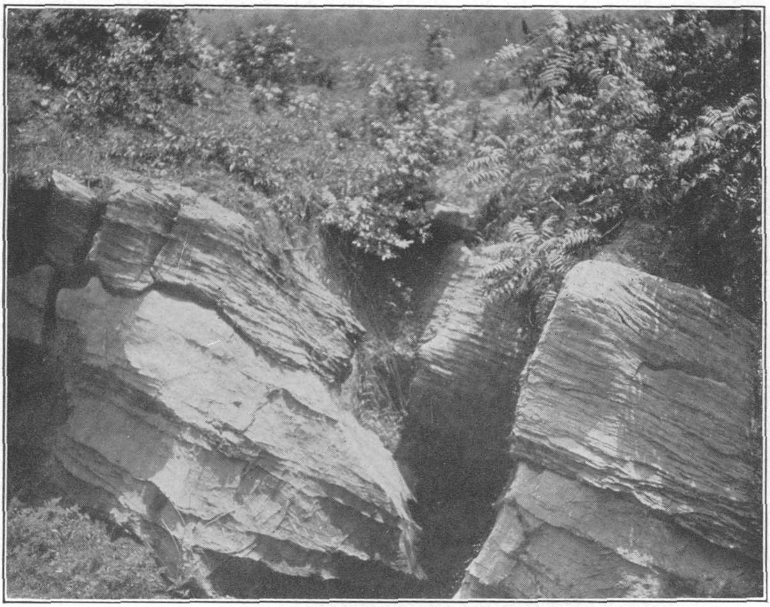
B

C

PSILOMELANE REPLACEMENT OF SANDSTONE.

The rounded knobby rods in part replace the sandstone walls. From Doe Valley mine, in Watauga shale, Johnson County, Tenn. *A*, Rods arranged in comb structure perpendicular to the walls of the crevice, × 2; *B*, rods arranged in miter form at the junction of the bedding plane of the sandstone and a perpendicular joint, natural size; *C*, partial replacement of sandstone resembling cemented breccia, × 1½.

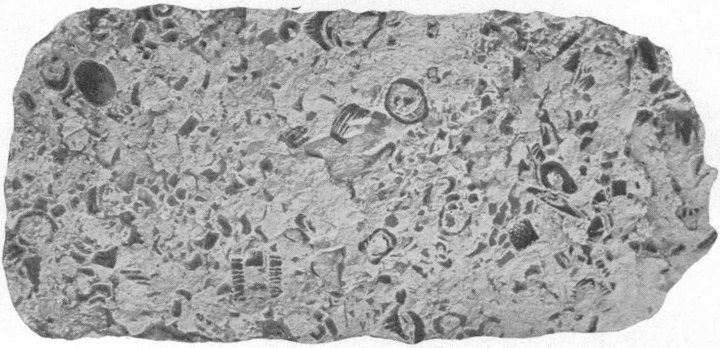
A



B

UNCONFORMITY BETWEEN CROSS-BEDDED CRYSTALLINE SANDY LIMESTONE OF THE "TELLICO" AND UNDERLYING HOLSTON MARBLE IN PITS OF D. A. M. MINE, BRADLEY COUNTY, TENN.

A, Sandy layers in the "Tellico," brought out in relief by weathering, and thin bed of psilomelane (*p*) in marble just below the unconformity; *B*, solution cavities in the marble from which ore has been mined.



A

B

CASTS AND MOLDS OF FOSSILS IN IRON ORE ASSOCIATED WITH THE MANGANESE ORE THAT HAS REPLACED FOSSILIFEROUS SILICEOUS LIMESTONE BEDS IN THE "TELLICO SANDSTONE."

From Hambright mine, southeast of Cleveland, Tenn., × 2. *A*, Fracture surface showing longitudinal and cross sections of crinoid stems and Bryozoa; *B*, weathered bedding surface, showing numerous fragments of Bryozoa and a few brachiopod shells.

also ore bearing, and several mines have there been operated. This ore belt continues into Georgia, where, however, the deposits are apparently not so rich. Another belt, 6 miles east of the Sweetwater belt, has been worked in Monroe and Loudon counties. Further search along these zones of contact of the Holston marble and Tellico sandstone is likely to result in the finding of other similar deposits.

OXIDE ORES IN FORT PAYNE CHERT.

The Fort Payne chert occurs only in the southern part of the State, where it makes low chert ridges. The chert has been in places impregnated with manganese oxide, which has filled cracks and crevices in the chert and has locally replaced the chert itself, forming large masses of ore. The slopes of the ridges, particularly the dip slopes, are covered with fragments of chert and masses and fragments of manganese ore that have been set free from the chert by weathering. Some of the manganese oxide also has been redeposited in the residual clay and wash on the slope. The ore in the chert ledges is compact, bright psilomelane, but as mined it is so siliceous that it can hardly be concentrated to a commercial product at a profit. Most of the ore in the residual clay is also psilomelane, in part nodular, and some of these deposits are of workable size. At Walnut Grove, Ala., not far south of the Tennessee line, very rich needle ore and powdery pyrolusite ore has been mined in these residual clays, but no ore of this character has thus far been observed in Tennessee. The manganese was apparently dissolved from limestone associated with or immediately overlying the Fort Payne chert when the limestone weathered and was redeposited as concentrated oxide in the underlying brecciated chert and residual clay, or in the surface wash.

Deposits in the Fort Payne chert have been mined on a small scale in White Oak Mountain, west of Cleveland, and have been prospected farther south along the southeast side of this mountain, where the same geologic conditions continue into Georgia. Other deposits may be discovered in the intervening undeveloped territory, but unless the ore is better than that which has been mined in Tennessee the deposits will hardly be of commercial value.

DEPOSITS ALONG FAULT PLANES.

Iron and manganese ores are deposited in the rocks adjacent to some of the fault planes. Minerals that are scattered through the rocks are dissolved by waters circulating along joints, bedding planes, and crevices, forming solutions that may rise along fault planes and deposit ores in brecciated zones, porous strata, or residual clays at or near the surface. Many of the deposits in the ore-bearing zones already described may have been in part concentrated from such solutions circulating along fault or joint planes, but only the deposits whose location has been determined largely by this process are here referred to. The character of the ore is controlled chiefly by the formation with which it is associated.

There are many overthrust or strike faults in east Tennessee whose outcrops follow the general trend of outcrop of the strata, and many of the larger of these faults are marked at the surface by belts of residual siliceous iron ore and iron-stained chert. Deposits of iron ore along faults have been mined at several places, but only a few deposits of manganese ore along faults have been prospected. The only worked deposit of manganese ore in east Tennessee that lies along a fault, the location of which has been determined largely by the fault itself, is at Taylor Valley, northeast of Mountain City. Here a fault breccia, altered to yellow clay containing fragments of purple schist, is in part replaced by ore along a flat overthrust fault plane. Similar deposits of workable ore may exist along some others of the numerous faults in the area.

OXIDE ORES IN TERRACED STREAM GRAVELS.

Nearly every manganese deposit in Tennessee includes in its upper part a layer of surficial clay and mountain wash in which some ore occurs. The ore was deposited in this porous material from solutions which permeated it and is in no sense a mechanical concentration of residual fragments of ore. Such deposits are therefore not included under this head in this report. Only those deposits are included which occur in gravels and sand of stream origin and which do not continue down into the underlying bedrock or its residual clays to a material extent. This type of ore is generally highly siliceous, including fragments and grains of quartz. Some is also highly ferruginous.

The only known manganese ore deposited in stream gravel in east Tennessee is at Silver Lake, northeast of Mountain City, where it occurs in old stream gravel and sand on a bench 50 feet above the present streams. (See Pl. XVII.) Such deposits must be derived from a near-by source of ore solutions and may be looked for in stream gravels in old terraces near known deposits of other types.

METHOD OF MINING.

Practically all the oxide ore deposits in east Tennessee are mined by open cut. The carbonate ore deposit is mined by drift and shaft, and a little drifting has been done on some of the oxide deposits.

The general mode of working the oxide deposits is to drive a trench into the hill across the strike and below the supposed zone of outcrop

After the ore-bearing zone is exposed it is worked out on either side of the trench in wide funnel-shaped cuts where the ground is soft and slumps badly, or is followed by narrow trenches where the material will stand in steep walls. The pick and wheelbarrow are used in most small mines. Horse-drawn scrapers, some mounted on wheels, are in use in several mines, and various forms of drag-line scrapers are used in others where the overburden is heavy. A derrick with either horsepower or steam hoist is used in a few of the deeper mines.

Most of the ore that is associated with clay must be thoroughly washed before it can be shipped. This work is done in log washers from 18 to 25 feet long, usually mounted in pairs. The paddles are of iron, generally bolted to a wooden log, but the logs in use at some mines are made of iron. The ore is generally hauled to the washer in wagons or tramcars, but at a few places it is carried by water in wooden flumes down steep slopes and thus washed. In some plants a stream of water from a nozzle is used to break up the lumps of earth before washing, and one deposit is actually hydraulicked by this means.

Some of the ore is dry mined and shipped without washing, being either hand picked, if it occurs in large lumps, or screened and hand picked. The washed ore is also hand picked, usually from a slowly moving belt, generally by women or children.

Most of the mining rights are acquired by lease, but some mines are owned by the operators. The mining rights may be held under option pending the result of development. A royalty ranging usually from 25 cents to $1 a ton is paid to the owner of the land for all ore extracted, a minimum sum to be paid each year, whether mining is done or not, being generally specified in the agreement. The rate of royalty depends on the grade of ore obtained and the cost of mining. The high-grade, easily accessible lump ore of Bradley and Monroe counties commands the highest royalty, as much as $4 a ton having been paid on it.

MINES AND PROSPECTS.

The manganese mines and prospects of east Tennessee, 130 or more in number, lie chiefly in a narrow northeastward-trending belt about 220 miles long, which extends diagonally across the State near its eastern boundary. A few unimportant deposits in Grainger County lie outside the belt, on the northwest. The location of the mines and prospects and their relation to the geologic formations are shown on the accompanying map (Pl. XVI). Iron, lead, and zinc ores, pyrite, barite, marble, bauxite, kaolin, fluorite, limestone for fertilizer, ballast, and flux, and phosphate are also mined in the belt, most of them on a small scale, however. A comprehensive tabular list of all the manganese mines and prospects, including the location, owner, operator, distance from railroad, and type of deposit of each, is given at the end of this report.

The mines and prospects are here described by counties in geographic order, beginning with Johnson County, at the Virginia State line, in the northeast corner of the State. Manganese ore is known to occur in minable quantities in the following 17 counties, which are given in the same order: Johnson, Carter, Unicoi, Washington, Greene, Cocke, Grainger, Hamblen, Jefferson, Sevier, Knox, Anderson, Blount, Loudon, Monroe, McMinn, and Bradley.

Under each county the mines are grouped into districts, which in general are named after some central point from which the mines are most accessible.

The descriptions of the mines are based chiefly on the examination of the deposits by Stose and Schrader made during April, May, June, and October, 1918, and by Stose in October, 1917. Mr. McFarlan visited some prospects, and his description of them is embodied in the report under his name. He also made the detailed maps of the Sweetwater and Cleveland districts (Pls. XXIV and XXVII, pp. 116 and 130), the geologic boundaries of which have been interpreted and modified by Stose in the field. Most of the descriptions include the location of the deposit, the occurrence, character, association, and geologic relations of the ore, and the development and equipment of the mine. The probable extent of the deposit and suggestions for further prospecting are also given if the information in hand warrants.

The deposits as a whole are conservatively estimated to contain 85,000 tons of ore available for mining under recently prevailing conditions, of which 75,000 tons is classed as manganese ore but includes some ferruginous manganese ore and 10,000 tons as manganiferous iron ore. These figures are the result of an estimate made at each mine and prospect of the ore proved by prospecting and geologic relations to be present and fairly accessible. Many of the deposits may prove to be larger, and the total reserve available in time of extreme need may be several times greater than here estimated.

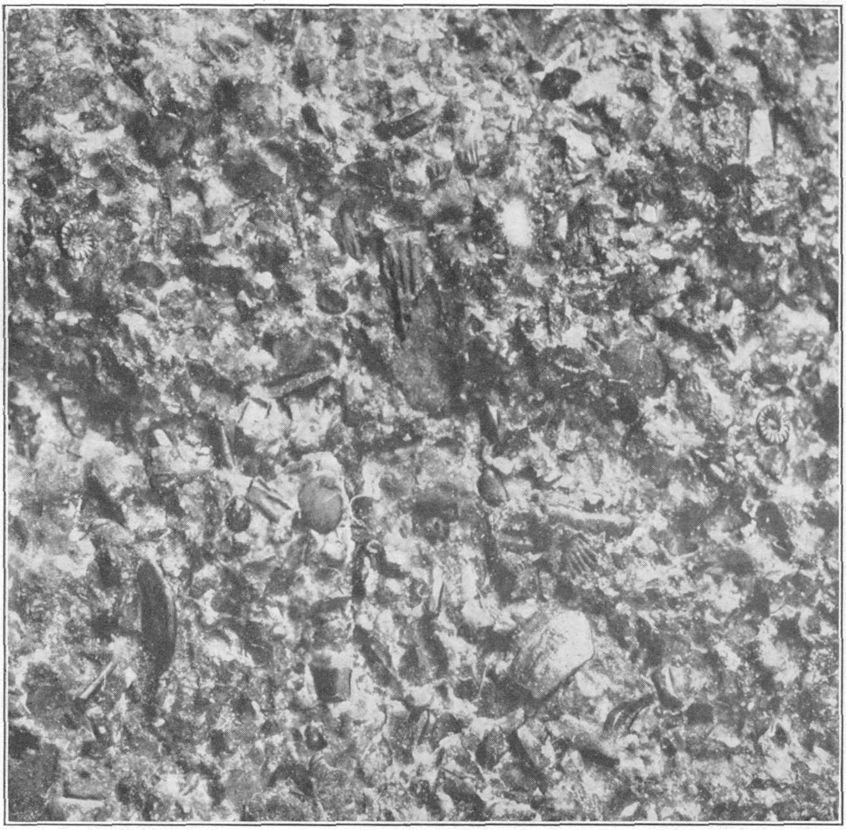
PRODUCTION.

By the term manganese ore is meant ore that contains 35 per cent or more of metallic manganese. Ferruginous manganese ore contains from 10 to 35 per cent of manganese and a percentage of iron commonly ranging from 10 to 40. Iron ore that contains less than 10 per cent and more than 1 per cent of manganese is termed manganiferous iron ore.

The production and sale of manganese ore in east Tennessee from 1886 to 1918 is given in the following table:

A. "BIRDSHOT" PEBBLE ORE, CONSISTING OF SHINY BLACK PELLETS OF MANGANESE OXIDE IN CLAY.

From Louisville mine, Tenn. Natural size.



B. FERRUGINOUS PEBBLE BED IN FOSSILIFEROUS CRYSTALLINE LIMESTONE NEAR THE TOP OF THE HOLSTON MARBLE.

Showing pebbles composed largely of fragments of fossils partly replaced by iron and having a highly polished surface. From Heiskell mine, Tenn. $\times$ 9.

MINES AND PROSPECTS.

Shady Valley district.
1. Reynolds mine, Johnson County.
2. Neely mine, Johnson County
3. Sutherland prospect, Johnson County.
4. Hogback mine, Johnson County
5. Davis mine, Johnson County.
6. M. E. King prospect, Johnson County.
7. Maxwell mine, Johnson County.
8. Wright mine, Johnson County.
9. Osborn prospect, Johnson County.
10. Hooper prospect, Johnson County.

Mountain City district.
11. Taylor Valley mine, Johnson County.
12. Silver Lake mine, Johnson County.
13. Wills mine and Silver Lake and Wills prospects, Johnson County.
14. Newton and Mary Cornett prospects, Johnson County.
15. Wright prospect, Johnson County.
16. Nelson King prospect, Johnson County.
17. Shouns prospect, Johnson County.
18. Doe Valley mine, Johnson County.

Butler district.
*19. Proffit prospect, Johnson County.
20. Wilson Hill mine, Johnson County.
21. Wagner prospect, Johnson County.
22. Dry Run mine, Johnson County.
23. Watauga River mine, Johnson County.
24. Cable prospect, Johnson County.
25. Goss mine, Johnson County.
26. Moody prospect, Johnson County.
27. Elk mine, Carter County.
28. Dubault prospect, Carter County.
29. Younce prospect, Carter County.
30. Cobb Creek prospect, Carter County.

Stony Creek district.
31. Blevins mine, Carter County.
32. Hatcher prospect, Carter County.
33. Grindstaff prospect, Carter County.
34. Blue Springs mine, Carter County.
35. Keenburg prospect, Carter County.

Hampton district.
36. Cardens Bluff mine, Carter County.
37. Teaster and Ray prospect, Carter County.
38. Cedar Hill mine, Carter County.
39. Valley Forge mine, Carter County.
40. Jenkins prospect, Carter County.
41. E. J. and Oscar Hyder prospects, Carter County.
42. Marion Hyder prospect, Carter County.
43. Winter mine, Carter County.
44. Patton mine, Carter County.
45. Treadway prospect, Carter County.
46. Hodge prospect, Carter County.

Unicoi district.
47. T. J. Brummett mine, Carter County.
48. Susan Brummett mine, Unicoi County.
49. Britt mine, Unicoi County
50. Unicoi prospects, Unicoi County.

Bumpass Cove district.
51. Embree prospect, Unicoi County.

Haysville district.
52. Haysville prospect, Greene County.
53. Sylvia prospect, Greene County.
54. Lamb prospect, Greene County.
*55. Payne prospect, Greene County.

Del Rio district.
56. Wood mine, Cocke County.
57. Adams mine, Cocke County.
58. Blanchard mine, Cocke County.
59. Waddell mine, Cocke County.
60. Huff prospect, Cocke County
61. Long Creek prospect, Cocke County.

Newport district.
62. Newport mine, Cocke County.
63. Jones & McMahon prospect, Cocke County.
64. Raines mine, Cocke County.

Boatmen Ridge district.
65. Curry prospect, Hamblen County.
66. Noeton prospect, Hamblen County.
67. Lotspeich prospect, Hamblen County.
68. Mays and Ivy prospects, Hamblen County.

Rutledge district.
69. Harmon prospect, Grainger County.
70. Rutledge mine, Grainger County.
71. Young prospect, Grainger County.
72. Swann prospect, Grainger County.

Washburn district.
73. Wallen prospect, Grainger County.
74. Frye prospect, Grainger County.

Jefferson district.
*75. Currens prospect, Jefferson County.

East Fork district.
76. East Fork mine, Sevier County.

Tuckaleeche Cove district.
77. Townsend prospect, Blount County.

Chilhowee Mountain district.
78. Miller prospect, Blount County.
79. Sellers prospect, Blount County.
80. McMurray prospect, Blount County.

Greenback district.
81. Aiken prospect, Blount County.
82. Curtis prospect, Blount County.
83. Williams prospect, Blount County.

Louisville district.
84. Louisville mine, Blount County.
85. Louisville prospect, Blount County.

Knoxville district.
86. Giezentanner prospect, Knox County.
87. Green prospect, Knox County.

Copper Ridge district.
88. Haworth prospect, Knox County.

Pine Ridge district.
89. Bright & Howell prospect, Anderson County.
*90. Wallace prospect, Anderson County.

Loudon district.
91. Cates prospect, Loudon County.

Fork Creek Knobs district.
92. Galbraith mine, Loudon County.
93. Mills prospect, Monroe County

Sweetwater district.
94. McGuire mine, Monroe County.
95. Preston prospect, Monroe County.
96. Vida mine, Monroe County
97. Ewing mine, Monroe County.
98. Heiskell mine, Monroe County.
*99. Dickey prospect, Monroe County.
100. Hansard prospect, McMinn County.
101. McDonald prospect, Monroe County.

Madisonville district.
*102. Kimbrough prospect, Monroe County.

Tellico Plains district
103. Ervin prospect, Monroe County.
104. Groundhog Mountain prospect, Monroe County.
105. Beaty prospect, Monroe County.
*106. Kilby prospect, Monroe County

Athens district.
107. Gilbert and J. H. Jones prospects, McMinn County.

McMinn Ridge district.
108. Pierce prospect, McMinn County.
109. Reed and Webb prospects, McMinn County.

Charleston district
110. Bishop and associated prospects, McMinn County.
111 Underwood mine, Bradley County.

Cleveland district.
112. Hambright mine, Bradley County.
113 M. V. Jones prospect, Bradley County.
114. Sloan prospect, Bradley County.
115. D. A. M. mine, Bradley County.
116. Lord mine, Bradley County.
117. Snyder prospect. Bradley County.
118. Hannah prospect, Bradley County.
119. Gee prospect, Bradley County.

White Oak Mountain district.
120. White Oak Mountain mine, Bradley County.
121. Brown prospect, Bradley County.

* Exact location doubtful.

GEOLOGIC MAP OF EASTERN TENNESSEE, SHOWING LOCATION OF MANGANESE MINES AND PROSPECTS AND THEIR RELATION TO THE GEOLOGIC FORMATIONS

Geology compiled chiefly from folios of the Geologic Atlas of the United States, with minor changes by G. W. Stose

Manganese ores produced and marketed in east Tennessee from 1886 to 1918, in long tons.

	Manganese ore.	Ferruginous manganese ore.
1886 to 1914	a 2,680	....
1915	250	....
1916	529	....
1917	1,996	83
1918	4,210	b 2,075

a Approximate.
b Includes 76 tons of manganiferous iron ore.

The following table shows the production of manganese in the various districts of east Tennessee in 1917 and 1918:

Manganese ore produced in east Tennessee in 1917 and 1918, by counties and districts, in long tons.

1917 District.	1917 Manganese ore.
Johnson County:	
Shady Valley district	a 935 (Shady Valley, Mountain City, Butler districts)
Mountain City district	
Butler district	
Carter County:	
Butler district	414 (Carter County: Butler, Hampton districts; Cocke County: Newport district)
Hampton district	
Cocke County:	
Newport district	
Loudon County:	
Fork Creek Knobs district	b 730 (Fork Creek Knobs district; Cleveland district)
Bradley County:	
Cleveland district	
State total	2,079

1918 District.	Manganese ore.	Ferruginous manganese ore.	Total.
Johnson County:			
Shady Valley district	468	c 311	779
Mountain City district	1,301	1,266	2,567
Butler district d	364	....	364
Johnson County total	2,133	1,577	3,710
Carter County:			
Stony Creek district; Hampton district	666	....	666
Unicoi County:			
Unicoi district	....	140	140
Cocke County:			
Del Rio district; Newport district; Grainger County: Rutledge district	312	229	541
Loudon County:			
Loudon district; Fork Creek Knobs district; Bradley County: Cleveland district	559	e 94	653
Monroe County:			
Fork Creek Knobs district; Sweetwater district	540	35	575
State total	4,210	2,075	6,285

a Includes 83 tons of ferruginous manganese ore. The principal producers were the Dry Run mine, in the Butler district, and the Taylor Valley mine, in the Mountain City district.
b The principal producer was the Lord mine, in the Cleveland district.
c Includes 25 tons of manganiferous iron ore.
d Includes a small area extending into Carter County.
e Includes 51 tons of manganiferous iron ore.

The schedule of market prices of manganese ores in the United States fixed by the War Industries Board and the American Iron and

Steel Institute[17] in June, 1918, and in effect until November 11, 1918, was as follows:

Schedule of prices for manganese ore. (Dried at 212° F.)

Metallic manganese content (per cent).	Price per unit f. o. b. South Chicago.		Average price per ton (2,240 pounds.).	
	Mined east of South Chicago.	Mined west of South Chicago.	Mined east of South Chicago.	Mined west of South Chicago.
35 to 35.99	$1.01	$0.86	$35.85	$30.53
36 to 36.99	1.05	0.90	38.32	32.85
37 to 37.99	1.09	0.94	40.87	35.25
38 to 38.99	1.13	0.98	43.50	37.71
39 to 39.99	1.15	1.00	45.42	39.50
40 to 40.99	1.17	1.02	47.38	41.31
41 to 41.99	1.19	1.04	49.38	43.16
42 to 42.99	1.21	1.06	51.42	45.05
43 to 43.99	1.23	1.08	53.50	46.98
44 to 44.99	1.25	1.10	55.62	48.95
45 to 45.99	1.27	1.12	57.78	50.96
46 to 46.99	1.29	1.14	59.98	53.01
47 to 47.99	1.31	1.16	62.22	55.10
48 to 48.99	1.33	1.18	64.50	57.23
49 to 49.99	1.35	1.20	66.82	59.40
50 to 50.99	1.37	1.22	69.18	61.61
51 to 51.99	1.39	1.24	71.58	63.86
52 to 52.99	1.41	1.26	74.02	66.15
53 to 53.99	1.43	1.28	76.50	68.48
54 and over	1.45	1.30	78.30+	70.20+

Prices were based on ore containing not more than 8 per cent of silica and not more than 0.25 per cent of phosphorus. A premium of 50 cents per ton was allowed for each 1 per cent of silica under 8 per cent down to 5 per cent, and of $1 per ton for each 1 per cent of silica under 5 per cent; also a penalty of 50 cents per ton for each 1 per cent of silica in excess of 8 per cent up to 15 per cent, of 75 cents per ton for each 1 per cent of silica in excess of 15 per cent up to 20 per cent, and of $1 per ton for each 1 per cent of silica in excess of 20 per cent up to 25 per cent. Ore containing more than 0.25 per cent of phosphorus was subject to penalty and bought at the option of the buyer.

JOHNSON COUNTY.

Johnson County, the northeasternmost county of the State, is largely mountainous, and its county seat is fittingly named Mountain City. Doe, Dry Run, and Iron mountains and smaller ridges and spurs divide the county into several longitudinal northeastward-trending valleys, in which manganese deposits occur. Descriptions of the 30 known manganese mines in the county follow.

[17] Eng. and Min. Jour., vol. 105, No. 23, p. 1053, June 8, 1918.

SHADY VALLEY DISTRICT.[18]

The Shady Valley district lies in the northwestern part of Johnson County and consists mainly of Shady Valley and its bounding mountain slopes. (See fig. 4.) Shady Valley is the flat-bottomed valley between Holston and Iron mountains, which is drained northward by Beaverdam Creek, in the northwestern part of the county. Although the open valley ends a mile or so north of Crandull, where the stream enters a rocky gorge, the few mines and prospects farther down the creek, near Sutherland, are here included in the district. Nearly all the deposits occur in residual clay of the lower part of the Shady dolomite.

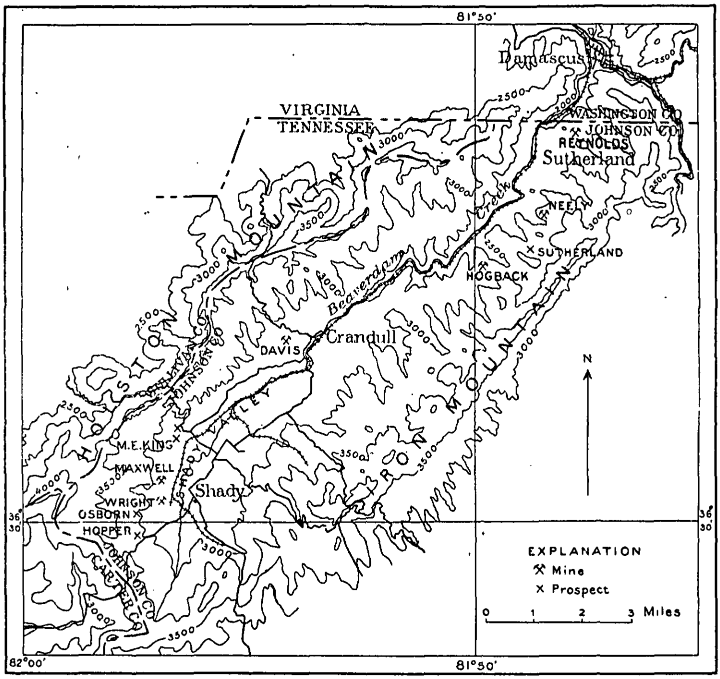


FIGURE 4.—Topographic map of Shady Valley district, showing location of mines and prospects.

Reynolds mine.—The Reynolds mine is 1½ miles south of Damascus, Va., just south of the Virginia State line, and three-fourths of a mile northeast of Sutherland. It is owned by A. D. Reynolds, of Bristol. Manganiferous iron ore was mined at the north end of the property many years ago. At the time of the writer's visit the Lehigh Valley Manganese Ore Co., of Bethlehem, Pa., and Damascus, Va., had leased the property, and it began development in June,

[18] Descriptions of the Reynolds, Neely, and Hogback mines and Sutherland prospect were written by F. C. Schrader after his visit in October, 1918. Descriptions of all other mines and prospects in Shady Valley were written by G. W. Stose.

1918. By October 100 tons of ore had been mined, about half of which had been shipped. The ore is reported to be about half manganese ore, averaging 40 per cent manganese and 13 per cent silica, and half ferruginous manganese ore. More than half of the ore is fines.

The mine is on a terraced spur on the northwest slope of Iron Mountain, at an elevation of 2,400 feet, or 450 feet above the creek. It is in red and yellow clay, believed to be residual from the Shady dolomite, resting on Erwin quartzite. The structure seems to be locally synclinal, as the quartzite in the gulch to the north dips 40° S.

The deposit is opened to a depth of 10 feet by several cuts, which extend through a vertical range of 50 feet on the slope. Most of them show nodular psilomelane wash ore in the clay, chiefly in the upper layers. Most of the ore is scattered, but irregular streaks and lenses also occur and show evidence of disturbance and creep down the slope. A bed of soft ore about a foot in thickness was observed near the north end of the property. The indications are on the whole unfavorable for profitable mining.

The ore is sledded down the steep slope to the washer, 230 feet below the mine, and the washed ore is hauled by wagon to the railroad.

Neely mine.—The Neely mine is 1 mile south of Sutherland, on the east side of Beaverdam Creek, in the Unaka National Forest. The deposit was first opened by J. A. Neely, of Damascus, Va. It was worked about 1898 for iron ore. At the time of the writer's visit it was being operated by the Laurel Mining Co., of Mountain City, and 27 tons of manganese ore, mostly from the old dumps, had been shipped, and about 4 tons lay on the dump. The ore was dry screened, and the shipped ore was reported to have run about 45 per cent manganese and 4 per cent silica. It was hauled down the steep slope from the mine to the railroad on sleds, but the company intended to build a wagon road.

The mine is on a bench on the northwest slope of Iron Mountain, 2,800 feet in elevation, or 600 feet above the creek. It is in reddish-brown clay, probably residual from the Shady dolomite, which rests on Erwin quartzite and apparently dips northwestward into the Beaverdam syncline. The main opening, which is the original working reopened and the source of the ore first shipped, is a 50-foot cut running into the ridge and following an ore bed about 8 feet thick which dips 20° NNW. The cut is 20 feet wide and 15 feet high at the face. The ore is mainly hard psilomelane in nodules and irregular mammillary fragments, the largest a foot in diameter, but it includes some wad and soft pyrolusite.

About 250 feet northeast of the main cut another old working was being reopened and showed considerable scattered ore. It has been reported since the visit made by the writer that a solid body of ore was found in this working. The prospects were bright for an active mine. In 1918 the shipments reported from the mine were 79 tons of manganese ore.

Sutherland prospect.—The Sutherland prospect is 1¾ miles southwest of Sutherland, in the Unaka National Forest. It has been prospected under lease from the Government by Wiley Sutherland and J. F. Sutherland, who report exceptionally favorable indications. The geologic conditions are believed to be the same as at the Neely mine.

Hogback mine.—The Hogback mine is 2½ miles south-southwest of Sutherland, in the Unaka National Forest. It was first opened in 1883 by David Blevins, of Shady Valley, for William McGovern, of Pennsylvania. It has only recently been developed by the Lehigh Valley Manganese Ore Co., of Bethlehem, Pa., which has an office at Damascus, Va. This company began operations early in 1918 and shipped 100 tons of manganese ore. The ore is hand picked and dry screened at the mine, and it is in part washed at the railroad by a hose gravity jet. It is reported to run 42 per cent manganese, 8 per cent iron, and 12 per cent silica.

The mine is on a bench on the northwest slope of Iron Mountain at an altitude of 2,900 feet, or 650 feet above the creek. The deposit is in brownish and red clay, in part wash and in part residual from Shady dolomite, resting on Erwin quartzite, which apparently dips northwest into the Beaverdam syncline. It is opened to a depth of 10 feet by several cuts, which extend through a vertical range of 100 feet on the slope, and all show ore, the best exposure being in a cut 60 feet long. The ore is largely psilomelane, which occurs in nodular botryoidal forms, most of it arranged in bands or layers several inches thick, but some sporadically. It contains also some wad and pyrolusite. None of the ore is very hard. The upper part of the clay is banded parallel with the surface, the banding indicating creep and surface deposition. Float ore occurs on the surface of the adjoining slope below the mine and laterally at its level. The indications were regarded as favorable to successful mining.

A few hundred yards up the slope, east of the mine, a ferruginous ledge, which outcrops and seems to be rather extensive, was prospected in early days, probably for iron ore, for which it looks promising.

Davis mine.—The Davis mine, called also the Parker or Crandull mine, is just west of Crandull at the lower end of Shady Valley. The openings are on a flat-topped spur on the west side of the valley, 100 to 200 feet above the valley bottom and adjacent to the site of the old Heberlin mine. The property was developed by George E. Davis, of Bristol, Va., who opened several pits and shipped a carload of ore. which is reported to have run about 43 per cent manganese. The property was later leased to the Southern Manganese Corporation, by which mining operations on a larger scale were begun.

The lower openings on the outer edge of a terrace about 100 feet above the valley bottom are on E. N. Martin's land. (See fig. 5.)

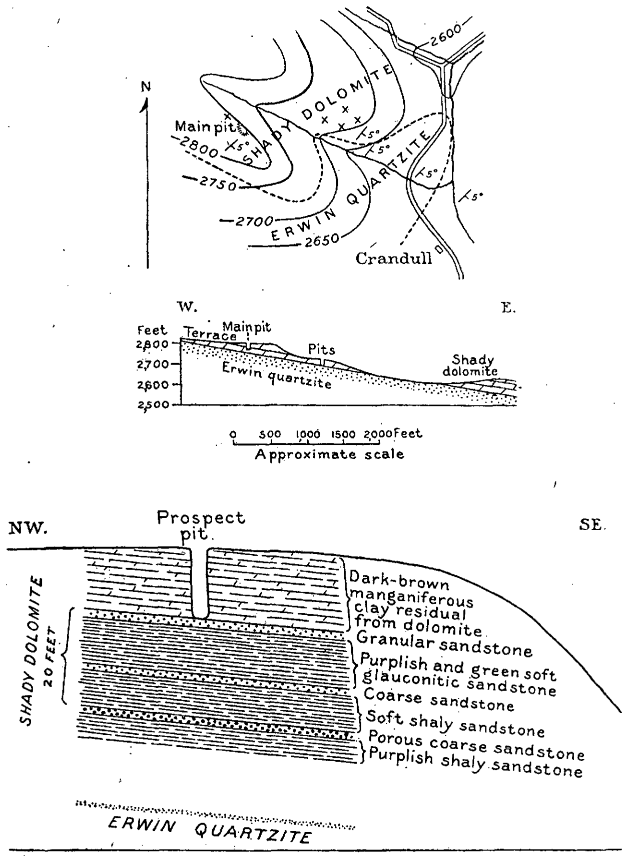


Figure 5.—Sketch map of the vicinity of the Davis mine, geologic section through the mine, and detailed section showing relation of the ore-bearing clay to the basal arkosic and glauconitic beds of the Shady dolomite.

They are shallow pits in yellow clay and dark manganiferous clay, showing considerable high-grade crystalline manganese ore, seemingly manganite, and some iron ore. Most of the manganite is cellular and forms the partitions of the cells. The clay is residual from impure calcareous beds of the Shady dolomite lying just above soft red and green glauconitic sandstones and about 20 feet above the coarse sandstone of rounded quartz grains near the base of the Shady which outcrops on the slope below in a nearly horizontal position. (See fig. 5.) The face of one small pit was almost solid ore, and although considerable of the ore is iron the quantity of high-grade manganese ore taken from the pit looked very promising. Float ore and dark-brown soil above the pits indicate the probable extension of the deposit beneath the surface of most of the terrace.

The higher openings are a short distance farther back on the terrace, beyond a small ravine, on W. J. Parker's land. In June, 1918, this part of the property was leased to the Southern Manganese Corporation, which soon equipped it with machinery and began active mining. This tract includes the pits of the old Heberlin mine, from which 800 tons of manganese ore was reported [19] to have been taken years ago. Its old waste dump contained sufficient nodular psilomelane to be profitably reworked. The new pits are dug into the side of the ravine about 20 feet below the top of the terrace and showed excellent ore, largely psilomelane in stalactitic form, with crystalline manganite lining cavities and covering stalactites. The best exposure showed the ore inclosed in wad and dark manganiferous clay, capped by a nearly horizontal layer of hard manganiferous brown iron ore.

At the time of visit, in October, 1917, several tons of high-grade lump ore in large masses lay on the dump of this small pit, and the face of the pit was still in ore. Several small pits farther up the ravine showed the ore to extend 100 feet or more back on the terrace. Analysis of a carload of the better-grade ore shipped during 1917 ran 44.18 per cent manganese, 9.77 per cent iron, and 6.27 per cent silica. A carload of ferruginous manganese ore from the cap rock, also shipped in 1917, ran 20.17 per cent manganese, 27.10 per cent iron, and 13.94 per cent silica.

By October, 1918, at the time of a second visit, the mine was producing 16 tons of washed ore a day, and equipment was being completed which was expected to increase the production to 40 tons a day by using a force of 80 men working day and night in two shifts. The "wash dirt" was removed from the pit by mule plows and scrapers, dumped through a trap hopper into tramcars, and conveyed by gravity over a double-track trestle to the 25-foot double-log washer, 60 feet from the lower end of the mine. The washed ore was hauled by wagon to the railroad at Crandull. The pumping plant is at Crandull, on Beaverdam Creek, and has a capacity of 300 gallons a minute.

The face of the working was 30 feet high and showed good ore throughout, except about 12 feet of lean overburden and barren clay, which was being removed by scrapers into the gulch below. The "run-of-mine dirt" concentrates 12 into 1. As much of the ore is brittle crystalline manganite about 40 per cent of the ore is fine, and

[19] Harder, E. C., Manganese deposits of the United States: U. S. Geol. Survey Bull. 427, p. 74, 1910.

tables were to be installed to reduce the quantity of silica, although this refining is generally done at the company's plant in Anniston. The ore shipped was reported to run 41 per cent manganese, 10 per cent iron, and 8 per cent silica. The development work had been well planned by the company's engineers, and if the deposit proved as large as was hoped a steam shovel was to be installed and the plant further enlarged.

The mine is near the end of a gentle minor syncline on the side of the larger Shady Valley syncline. As shown in the section in figure 5, the rocks lie nearly flat, and the geologic conditions are unusually favorable for the accumulation of ore, especially on the terrace representing the old valley floor. The large quantity and high grade of the ore in the mine and prospects accord with this view. These favorable conditions seem to extend northeastward on the terraced spurs, where some prospecting has been done, also southwestward, where there has been no prospecting so far as known. The thick layer of wash from the mountain slope, which covers most of the terraced spurs, makes prospecting difficult.

M. E. King prospect.—The M. E. King prospect, owned by Miss M. E. King, of Danville, Va., is in the upper part of Shady Valley, northwest of Shady village, where several old abandoned ore banks remain. It is on a terrace about 20 feet above the valley floor and apparently in a minor gentle syncline within the Shady Valley syncline, as the coarse porous sandstone layers at the base of the Shady dolomite outcrop in the axis of a small anticlinal fold about half a mile to the south. At the time of visit the openings seen at the south end of the property were several small slumped and abandoned pits dug in residual clay of the dolomite beds of the Shady and at the north end of the property, on what is called the 5-acre tract, a larger pit, which exposes dolomite in its lower part. Psilomelane nodules occurred here sparingly in dark manganiferous clay beneath a 2-foot layer of brown iron ore, which was mined for iron many years ago. The amount of manganese ore appeared to be insufficient to be mined profitably.

Since the time of the writer's visit it is reported that 10 shafts have been sunk at the south end of the property, disclosing abundant ore which contains an average of 49.80 per cent of manganese and commands a premium because of its small content of silica. Good-sized chunks of clean, solid ore from the openings, which were sent to the writer, were composed largely of crystalline manganite. It is said that the Southern Manganese Corporation had examined the property and was so favorably impressed that it would have taken over the mine if the Beaverdam Railroad had not been dismantled.

Maxwell mine.—The Maxwell mine is 1 mile northwest of Shady village, in the upper part of Shady Valley, on a tract of land of which the mineral right is owned by the Maxwell Manganese Mining Co., of Elizabethton, Tenn. H. V. Maxwell, the president of the company, was personally directing the development of the tract at the time of visit, and a test carload of washed ore was nearly ready for shipment. Considerable manganiferous iron ore had also been taken out, but the cost of transportation was so high that it could not be shipped with profit. Iron ore was mined on the property for a local forge many years ago by Mr. Scott.

The property was developed chiefly by two shallow trenches in a small stream bottom on the west side of the valley, but unfortunately the workings were subject to flooding by water from the stream and had to be abandoned. The deposit is largely in clay and sand that was washed from the adjacent hillside and that overlies residual clay of the Shady dolomite. Considerable ore was seen in pockets in the face of the trenches. The ore is chiefly psilomelane, some of which is stalactitic. It occurs in irregular pockets in the yellow clay beneath a capping of manganiferous iron ore. One specimen contained transparent rhombohedral crystals of siderite in cavities in the psilomelane. The ore was being washed by hand in a sluice box in the stream, and the fines were therefore rather siliceous.

Several prospect pits were also being opened just north of the mine and 100 feet above it, on the top of a terrace which was part of the old valley floor but is now deeply incised by the present streams. These pits are in clay residual from the Shady dolomite, which directly overlies the coarse sandstone, and in purplish and greenish glauconitic shaly sandstone of the basal part of the Shady. The rocks dip about 5° SE., toward the valley on the west side of the flat Shady Valley syncline. At the time of visit the pits exposed much dark manganiferous clay and some soft ore, but not sufficient ore to indicate that the deposits are workable. Some of the ore is soft nodular pyrolusite of very light weight, which closely resembles plumbago in its softness, shiny streak, and greasy feel. These soft nodules were apparently derived from nodules of manganite by the loss of water, and although they are a high-grade ore they are too much scattered to be saved.

Wright mine.—Half a mile south of the Maxwell mine is the old Wright bank, where 150 tons of manganese ore is reported to have been mined some years ago.[20] At the time of visit it had recently been reopened by the Maxwell Manganese Mining Co., which shipped two carloads of ore in 1917. The mine has not since been operated.

The deposit was opened by a pit about 20 feet square, extending into the face of a terrace 100 feet above the valley bottom. It consists of an irregular bed of manganiferous iron ore at the base of 5

[20] Harder, E. C., op. cit., p. 74.

feet of surface wash, which rests on pink to white and yellow plastic clay, apparently residual from Shady dolomite, in which no ore was found, although it was tested to a depth of 25 feet. The ore is manganiferous brown iron ore and is so seamed and veined with psilomclane and crystalline manganite as to resemble breccia. It runs about 48 per cent iron and 10 per cent manganese. A carload of the ore, hand-cobbed from the old ore dump, is reported to have run 30.8 per cent manganese, 6.18 per cent silica, and iron undetermined. Although the ore bed is 6 feet thick in places, it probably can not be profitably worked because of its general low manganese content and the pockety occurrence of the better-grade ore.

Osborn and Hopper prospects.—The Osborn and Hopper prospects are about half a mile south of the Wright bank. On Aleck Osborn's property psilomelane ore is exposed in a steep stream bank on the edge of a wash-covered bench well up on the west side of the valley. Little ore is exposed, but some fragments had been dug out of the black manganiferous clay in the bank.

A short distance farther south, on the Hopper property, adjacent to an old iron bank mined years ago and close to the old manganese pit of Alexander Cole, openings had been more recently made by George E. Davis, of Bristol. Considerable good ore was thrown out, but the pit had since caved in.

Both of these prospects are underlain by clay residual from the lower part of the Shady dolomite, but whether the ore lies in this clay or in the surficial wash was not determinable owing to the poor exposures.

MOUNTAIN CITY DISTRICT.

The Mountain City district is in the eastern part of Johnson County. It embraces the low country around Mountain City, including the valley between Iron and Stone mountains north of the town. which is followed by the Laurel Railroad, and the upper parts of the valleys of Roane Creek and Doe Creek. (See fig. 6.) Seven of the developed deposits in the district are in Shady dolomite, four in Watauga shale, one on a fault plane, and one in terraced stream gravel.

Taylor Valley mine.—The Taylor Valley mine is in the northeastern part of the district, at Matney, 10 miles north-northeast of Mountain City and 2 miles east of Dollars station, on the Laurel Railroad. It is on the I. H. Reece property and is operated by the East Tennessee Mining Co., of Mountain City. At the time it was visited, in July, 1918, 142 tons of ore had been shipped and about 100 tons was in the bins at the mine. During the autumn of 1918 the mine produced 60 tons of ore a month and employed about 100 men. According to Maxwell[21] 116 tons of ore was shipped to the Southern Manganese Corporation in 1917, and 550 tons in 1918. Recent shipments were made to both the Tennessee Coal, Iron & Railroad Co., of Birmingham, Ala., and to the Southern Manganese Corporation, at Anniston, Ala. The ore is reported to have averaged about 36 per cent manganese and to have contained considerable silica, some shipments running as high as 25 per cent.

The deposits occur in brecciated sandstone beds at the base of the Watauga shale and in associated residual clay of the underlying Shady dolomite at a fault contact with older rocks. (See fig. 7.) Pre-

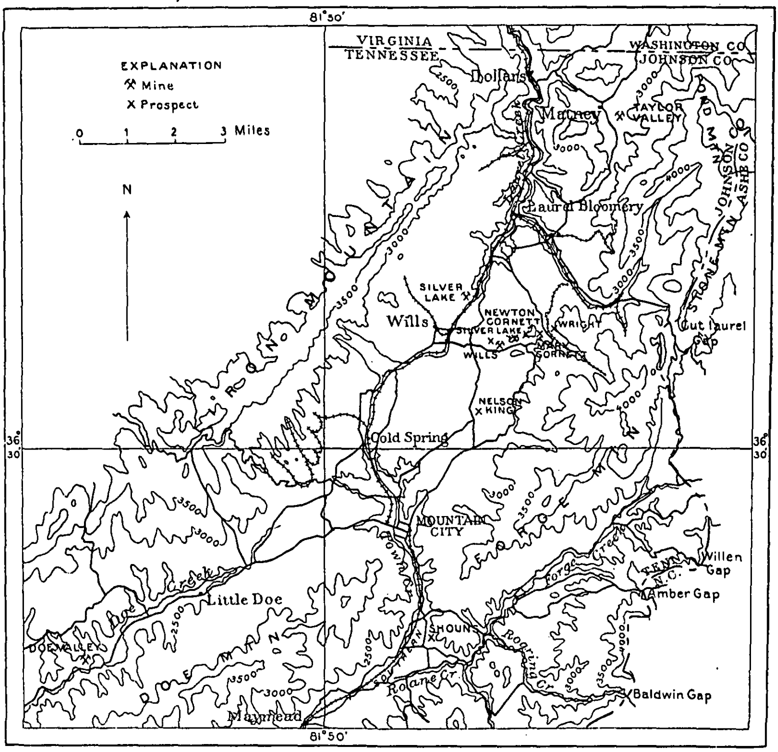


FIGURE 6.—Topographic map of Mountain City district, showing location of mines and prospects.

Cambrian volcanic rocks have been thrust westward upon the sandstone and dolomite. The pre-Cambrian rocks are chiefly a purple schist, which is an altered amygdaloidal lava, locally known as red mountain rock. On the lower slope of the spur northwest of the mine massive blue Shady dolomite outcrops, dipping southward at various low angles. Northwest of Matney the dolomite is overlain by purple Watauga shale. At the mine horizontal dolomite outcrops below the

[21] Maxwell, H. V., Manganese ore of east Tennessee: Eng. and Min. Jour., vol. 107, No. 3, p. 149, Jan. 18, 1919.

lower trench, and yellow clay and sandstone beds in the main mine pit are probably the basal beds of the Watauga. A thin overburden of 3 or 4 feet of clay and soil contains a little ore.

The mine is on the southwest slope of a spur from Pond Mountain, on the east side of Owens Branch. It is at an elevation of about 2,900 feet, or about 200 feet above the creek and washer and 100 feet below the crest of the spur. It is worked chiefly by plows and scrapers, and the dirt is thrown into tramcars from which it is dumped into a flume that descends the hill slope to the double-log washer. Much of the washed ore is of low grade and carries considerable silica. The fines also contain much silica, which is removed by further washing or jigging.

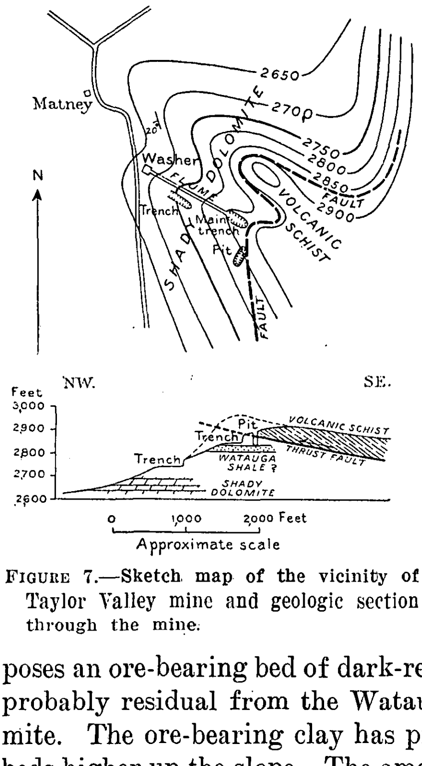


FIGURE 7.—Sketch map of the vicinity of Taylor Valley mine and geologic section through the mine.

The ore consists chiefly of nodules of black, impure psilomelane and of aggregates of pea-sized nodules with concentric structure, some of which are very pure psilomelane. Much of the ore contains embedded sand grains and fragments of chert.

Many of the fragments and some of the nodules have a metallic slickensided surface, indicating movement since their formation.

The mine is opened by several trenches and pits. The lowest opening is a small trench that exposes an ore-bearing bed of dark-red clay lying on barren yellow clay, probably residual from the Watauga shale, which overlies the dolomite. The ore-bearing clay has probably been washed from the ore beds higher up the slope. The amount of ore showing in the face was small, although much good float ore is scattered over the adjacent hill slope.

The main trench is about 100 feet higher on the spur, at the head of the flume that leads to the washer, and runs southwestward into the hill. At the time of visit it was 80 feet long, 20 feet wide, and 15 feet deep. (See fig. 7.) Beneath 3 feet of chocolate-colored overburden clay, horizontally streaked with ore in its lower part, the trench exposed 6 feet of yellow clay horizontally seamed with thin streaks of manganese oxide, next 1 foot of dark, stiff buck fat, and at the bottom 3 feet of yellow clay containing a considerable amount of ore of good grade. The floor was a soft brecciated sandstone cemented and partly replaced by ore. The clay in the southeastern part of the pit was bluish but contained the same kind of ore. Much of the ore was gritty with sand grains, and the nodules of ore, up to 4 inches in diameter, contained much silica in their central parts. This trench lies in the Watauga shale, which here forms the footwall of the fault. The trench had not quite reached the fault at the time of visit, and it was predicted that the ore would be found to improve as the fault was approached.

The east pit, which was then 50 feet long, 25 feet wide, and about 30 feet deep, trends northeastward toward the upper end of the main trench. This is an older working, in which an excellent ore body had been encountered and was abandoned because of caving with depth. The lower part of the walls was badly caved at the time of visit. The west or foot wall was composed of bedded yellow clay residual from Watauga shale and dark manganese-stained clay with a little ore. The east or hanging wall was composed largely of a mixture of fragments of purple schist and white sandstone in bluish sand. At its western edge are many slickensided surfaces on steep joint planes. The ore occurs in a zone 20 feet wide, composed chiefly of dark stiff clay, much jointed and slickensided in various directions, and some sand. The ore belt strikes N. 20° W. and dips 75° NE. The ore seen in the end of the pit occurs as pockets of wad in the clay and is said to have been found throughout the length and depth of the pit, more abundantly on its eastern side. This is undoubtedly a zone of fault breccia. Even the ore and black manganiferous clay is slickensided, showing relatively recent earth movement along the old fault plane.

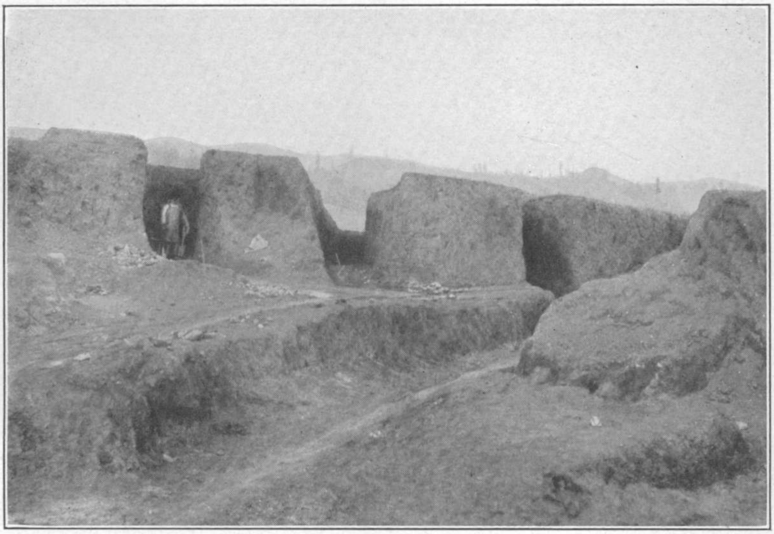
Since the time of visit a new pit has been opened on the north-northeast side of the spur, at about the same elevation as the old workings. This opening runs southward toward the old deep pit and was reported to have exposed an ore body 12 feet thick for a length of 50 feet, which ran one-third ore carrying 40 per cent manganese. The discovery of this ore body promptly increased the production of the mine to 60 tons a month. This ore body also lies along the fault plane and probably is continuous through the spur to the old workings. The new pit was opened upon advice based on this inference offered by the writers at the time of visit. The deposition of the ore seems to have been chiefly controlled by the circulation of ore-bearing solutions along the fault plane, and is regarded as a typical example of this mode of occurrence. This mine is believed to contain a considerable reserve of fair-grade manganese ore.

Silver Lake mine.—The Silver Lake mine is at Silver Lake station, on the Laurel Railroad, in the north-central part of Johnson County, 5 miles northeast of Mountain City. It is only a few hundred feet from the railroad and is 80 feet above it. The property is owned by Wiley Sutherland, of Mountain City, who managed the mine for the Silver Lake Mining Co. The company began operations early in 1918 and from February 1 to May 23, the date of visit, had shipped about 6 tons of ore a day, or a total of about 600 tons. The ore was shipped mostly to the Southern Manganese Corporation, at Anniston, Ala., and is said to have run from 42 to 45 per cent manganese, 6 to 7 per cent iron, and 3 to 8 per cent silica. Eighty tons of similar high-grade ore and 120 tons of fines averaging 35 per cent of manganese were in the bins ready for shipment. Shipments of lower-grade fines ran 25 per cent manganese, 18 per cent iron, and 14 per cent silica. It was planned to supplement the washer with jigs to improve the grade of the finer ore. About 40 tons of picked iron ore which came from an earlier surficial part of the working was on the dump. At the time of visit 14 men were at work, 7 each at the mine and washer. Late in 1918 the deposit was reported to have been worked out and the mine abandoned.

The mine is in an open part of the valley of Laurel Creek on the top of a small round, flat-topped hill that rises 80 feet above the creek which flows near its base. The hill is composed of Watauga shale and is capped by terraced stream gravel 6 to 15 feet thick. The beds of shale in general lie flat, but in minor folds they dip 35° SE. The shale is in part hard, unweathered, and purple and in part weathered to soft yellow clay shale. Low ridges on the harder beds trend northeastward. The stream deposit consists largely of red, yellowish, and brownish sand or sandy clay, the upper part of which contains many waterworn pebbles, cobbles, and some boulders of quartzite a foot or more in diameter. These deposits were laid down by Laurel Creek when the valley floor was at this level and the stream flowed across what is now the top of the hill.

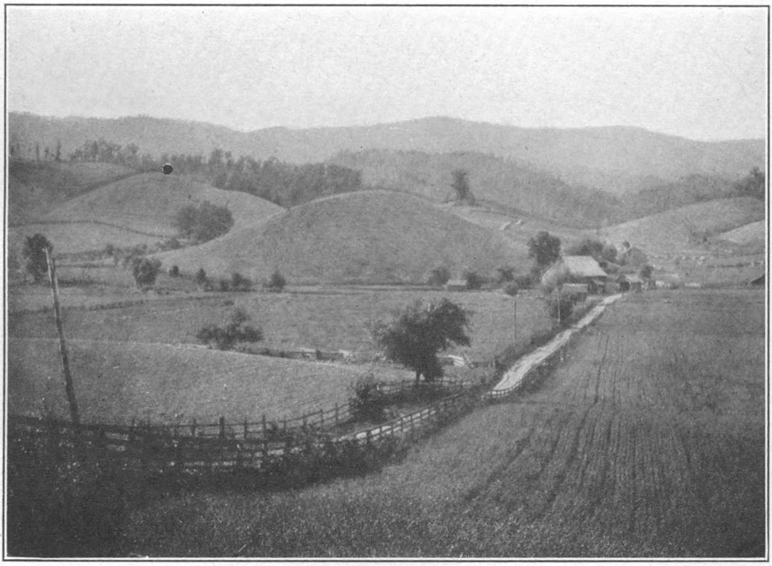
The ore occurs in the terraced stream gravel, mostly in the red sand near the base of the gravel, but some occurs in the upper part of the deposit. It appears to be more plentiful in the troughs between the ridges of shale, where the gravel is deeper than on the ridges. The pebbles, however, are mostly clean and not even stained by manganese. A small amount of ore is recovered from the clayey layers beneath the stream deposit, which seems to be residual clay derived from the bedrock. The ore is distributed chiefly in nearly horizontal zones 1 to 2 inches thick, but rich pockets of nearly solid ore are also found.

The ore is mined from a large open cut about 100 feet across and 15 feet deep, from which trenches run irregularly, following the richer streaks. (See Pl. XVII.) A test shaft was sunk 20 feet into the shales beneath the stream gravels, but they were found to be barren. The ore consists almost wholly of nodules of psilomelane, the



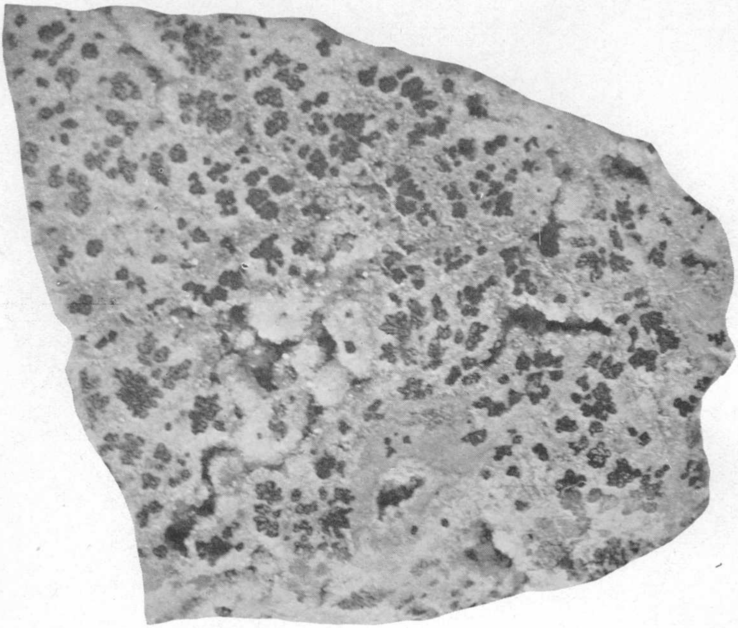
A. PIT OF SILVER LAKE MINE, JOHNSON COUNTY, TENN., IN TERRACED STREAM GRAVEL.

Large cobbles and boulders taken from the gravel are heaped in piles on the floor of the pit.



B. HILLS COMPOSED OF WATAUGA SHALE.

The hills rise to uniform height, and their flat tops form parts of an elevated old valley floor in Doe Valley, Tenn. Iron Mountain in the distance. View northwestward from a point on the road 1 mile north of Doe Valley mine.



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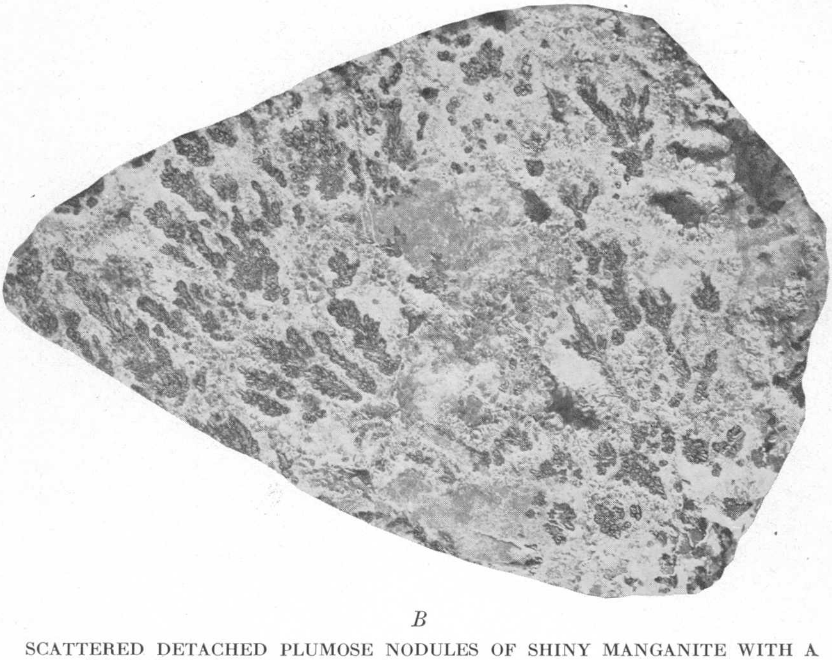


B

SCATTERED DETACHED PLUMOSE NODULES OF SHINY MANGANITE WITH A CORE OF SOFT PYROLUSITE, EMBEDDED IN CRYSTALLINE QUARTZ.

Shown on polished surfaces. From shaft of Wilson Hill mine, near Neva, Tenn. × 2. *A*, Rounded cross sections of nodules; *B*, longitudinal sections showing dendritic or plumose structure.

larger ones measuring 2½ feet in diameter. Although the ore occurs chiefly in the lower part of the surficial gravel deposit, enough ore is distributed through the upper part to warrant treating all the ground removed in the double-log washer, which stands at the foot of the hill.

Wills mine.—The Wills mine is near the north-central part of Johnson County, 1 mile east of Wills station, on the Laurel Railroad, and 4 miles northeast of Mountain City. At the time of visit it was owned by Oscar Wills and was being worked by the Laurel Mining Co., of Mountain City. The company began operations April 10, 1918, and by June had shipped several carloads of ore averaging about 40 per cent of manganese and 15 per cent of iron. In August the mine was sold to the American Minerals Co., of Cincinnati.

The mine is at the west end of a low flat-topped hill or terrace, probably a remnant of an old valley floor. The hill is composed of Shady dolomite, which in general dips northward away from a small high hill of Cambrian quartzite southeast of the mine, but on the slope just below the mine it is horizontal. (See fig. 8.) The deposit is chiefly in surface wash but extends down to some extent into the underlying residual clay of the Shady dolomite. It is opened by several pits to a maximum depth of 20 feet, but the two main pits on opposite sides of the hilltop indicate the trend of the deposit to be N. 35° W.

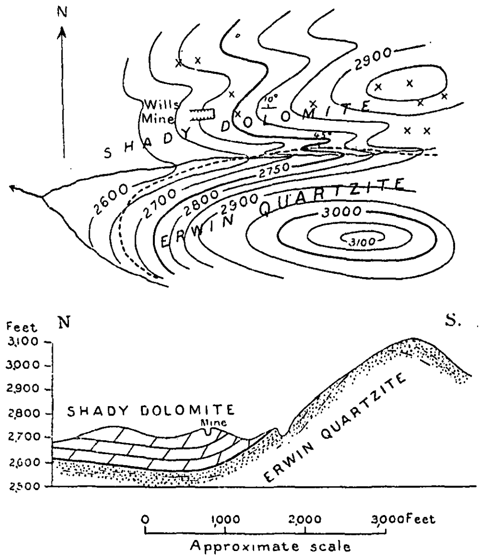


FIGURE 8.—Sketch map of vicinity of Wills mine and geologic section through the mine and adjacent quartzite knob.

The walls of the pits expose a thickness of 5 to 15 feet of surface wash, consisting of reddish-brown clay and quartzite fragments overlying yellow to brownish-buff and blackish residual clay. The ore lies chiefly in the lower part of the wash and in the residual clay just beneath. It is chiefly psilomelane, which occurs sporadically in nodules and lumps, some of large size, embedded in the clay and wash. One lump 2½ feet in diameter was seen by the writer, and another lump is reported to have yielded a ton of good-grade ore.

The ore was treated in a double-log washer at the foot of the hill and was sorted into several grades and sizes, of which the best grade, or lump ore, contained about 45 per cent manganese, a medium grade 35 per cent, and the screenings were so sandy that they needed further treatment before shipment. Some nodules that have a thin coating of red iron oxide and other ferruginous manganese minerals that are present contain about 25 per cent manganese and 25 per cent iron. The average production was about 4 tons of ore a day, derived from 40 tons of run-of-mine dirt put through the washer, a concentration of 10 into 1.

Silver Lake and Wills prospects.—Several prospects have been opened on the Oscar Wills farm. The Silver Lake Mining Co. has three shallow pits on a low terrace a few hundred yards northwest of the Wills mine, just across a small ravine. The pits are in surface wash containing some rather siliceous manganese ore, which may improve in quality with depth if the ore continues into the underlying residual clay of the Shady dolomite. The pits cover a length of more than 100 feet along the terrace front, but the deposits are not yet proved to be workable.

The Wills prospect is about one-fourth of a mile east of the Wills mine, on the top of a flat-topped hill which is about 300 feet higher than the terrace at the mine and which seems to represent an older valley floor. The rocks are deeply weathered, and the development pits are in residual clay and chert of the Shady dolomite, which here dips northward away from the high hill of Cambrian quartzite. The pits are about 6 feet deep and are scattered over the hill with a vertical range of 60 feet. A little good nodular ore was found in some of the pits, but others were barren. The indications did not seem favorable for a workable deposit.

Cornett prospects.—The Laurel Mining Co. has prospected the Cornett tracts near the Wills mine and obtained encouraging results. One opening is half a mile east-northeast of the Wills mine, on the farm of Newton Cornett, of Mountain City. Several pits were sunk to depths of about 12 feet on the upper south slope of a low ridge, which is the northeastward extension of the Wills mine hill, but about 300 feet higher and at the same general level as the Wills prospect. They disclose good nodular ore sporadically embedded in dull mottled residual clay of the Shady dolomite. Most of the ore is psilomelane, but it includes a little manganite.

Three-fourths of a mile east-northeast of the Wills mine a prospect has been opened on the Mary Cornett farm. It is on the lower part of the north slope of the same ridge on which the Newton Cornett prospect lies, about 50 feet below the general level of the hilltops. It is in residual clay of the Shady dolomite and is opened by a narrow cut, 40 feet long and 7 feet in maximum depth, showing practically throughout its extent good ore embedded in the clay. The ore is mostly psilomelane. At the time of visit about a ton of ore from the cut lay on the dump.

Wright prospect.—Half a mile east of the Mary Cornett prospect, across a small valley, manganese ore has been reported to occur on the old Ward Iron Co. tract. The property has been bought by W. C. Wright, of Mountain City, who is reported to have prospected it with favorable results.

Nelson King prospect.—On the south side of the anticline adjacent to the Wills mine, especially on the farm of Nelson King, 2 miles south-southwest of the mine, the surface of the cultivated fields carries float of nodular and lump manganese ore among the chert fragments derived from the Shady dolomite. Some of the ore fragments are of good grade, but many are manganiferous iron. Some of the road cuts in this vicinity also show dark manganiferous clay streaks with a little ore in yellow residual clay, but the surface indications are not promising for a workable deposit.

Shouns prospect.—The Shouns prospect is 2½ miles south of Mountain City and a mile south of Shouns station, on the Southern Railway. It is on the south end of a low hill which is on a large tract owned by the Virginia Iron, Coal & Coke Co., of Birmingham, Ala. It is developed only by old openings made for iron ore many years ago, one 60 feet above the valley bottom and others near the top of the hill, 100 feet higher. Here a shaft 20 feet deep has been sunk in a massive, blocky yellow glistening chert ledge, stained and slightly seamed by iron ore, which apparently forms the base of the Watauga shale in this region.

Manganese float ore is plentifully scattered over the surface and in the sandy soil for about 100 feet up the front slope of the hill, below the chert talus, although this ore is chiefly nodular and botryoidal psilomelane. It is rather impure and of dull luster. Some of it replaces chert breccia, which is derived by weathering from the Watauga shale. An unusually good example of the so-called grape ore from this place is illustrated in Plate II.

Doe Valley mine.—The Doe Valley mine, also called the Fritz mine, is in the southwestern part of the district, 7 miles southwest of Mountain City and about the same distance north of Doe, a station on the Tennessee division of the Southern Railway. It is on the farm of E. C. Fritz, of Mountain City, and was operated by the East Tennessee Mining Co., of the same place.

Sixty-two tons of high-grade manganese ore, averaging more than 50 per cent in manganese, was shipped in 1917 to the Southern Manganese Corporation at Anniston, Ala., and in 1918, up to May 24, 200 tons of similar ore had been shipped and 40 tons more had been mined and made ready for shipment. Late in 1918 it was reported that the current production was 60 tons of ore a month and that a recent shipment ran 53 per cent manganese, 4 per cent iron, and 6 per cent silica.

The mine is on a hill on the northwest side of Doe Valley, 150 feet above Doe Creek. The hill is part of a dissected upland plain which forms an upper valley floor, about 2,500 feet in altitude, into which the present stream valleys are sunk. (See Pl. XVII.) The ore is removed from the mine by a short tram running to the head of a flume which leads to a double-log washer at the foot of the hill, where it is treated and the products sorted into bins.

The deposits occur in decomposed Watauga shale, the ore largely replacing jointed sandstone and soft weathered calcareous shale or yellow laminated clay still in place. (See fig. 10.) The overburden is about 3 feet of red clay and dark soil. The ore occurs largely in

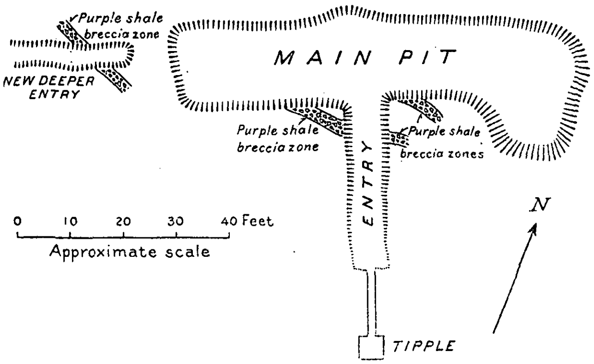


FIGURE 9.—Sketch plan of Doe Valley mine, showing purple shale breccia zones which are cut by the pit.

irregular zones or bands more or less conformable with the bedding of the rocks, which dip 40°–70° SE. Abrupt changes in dip, minor folding and puckering, and slickensiding along the bedding planes indicate that the rocks have been strongly compressed.

The deposits are opened by a main pit near the top of the hill, which trends N. 70° E., parallel with the strike of the rocks, and is 120 feet long and 30 feet wide. The height of the face is about 30 feet. A deep narrow trench running northwestward was the entry at the time of visit. (See fig. 9.) A new entry about 70 feet long and 15 feet or more deep at the face was driven in from the west at a lower level to tap the ore deposit below the floor of the main pit. In this entry, 50 feet below the surface and 20 feet below the floor of the main pit, the best body of ore opened in the mine was reported to have been found in October, 1918. The pit exposes chiefly soft yellowish laminated clay, or weathered calcareous shale, in which are interbedded layers of light-brown porous sandstone 1 to 3 feet thick generally much broken by joints and largely disintegrated. The ore has followed along the joints and bedding planes of the rock and has replaced much of the sandstone, thus giving the material the appearance of a breccia. (See Pl. XII.) Cutting across the bedding

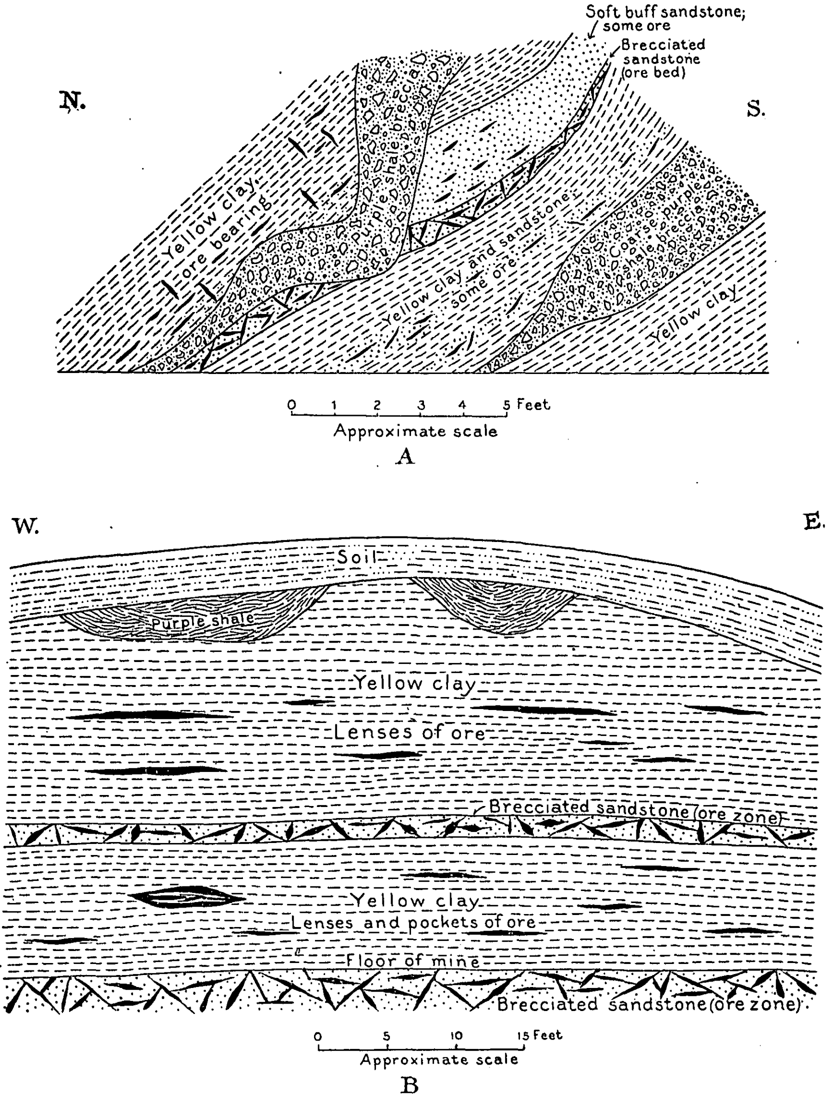


FIGURE 10.—Sketches of walls of pit of Doe Valley mine. A, Right wall of entry to pit, showing ore replacing sandstone beds in Watauga shale adjacent to brecciated zones of hard purple shale fragments filling old channels; B, face of mine pit, showing ore replacing sandstone beds in Watauga shale.

nearly at right angles are several zones a foot or two wide, which resemble subterranean channel fillings. They are composed of breccia made up largely of hard purple shale fragments in a yellow clay matrix. (See fig. 10.) They are of irregular shape, and in depth they bend so as to follow the bedding planes between laminated clay and porous sandstone layers. They seem to represent subterranean solution channels which connected with channels in the porous sandstone beds. The breaking up of the sandstone and the irregular folding and puckering of the laminated shale were probably caused by the settling and partial caving in of the rocks above the channels. The penetration of the surface waters to these and greater depths, the deep weathering of the rocks, and this development of subterranean channels occurred long ago, when the tops of this hill and of the neighboring flat-topped hills were part of the general floor of the valley and before the existing streams cut their channels to their present positions, 150 feet below that surface.

The ore consists chiefly of psilomelane and wad. A little manganite and pyrolusite also are apparently present. The ore is distributed through the rocks from near the surface to the bottom of the cut at least, and perhaps farther downward. It favors, however, the arenaceous layers or zones interbedded in the clayey shale, and most of it is contained in four such beds or zones, each from 1 to 3 feet thick, in which it is irregularly distributed. It forms seams, some as much as 3 inches in thickness, which follow both the bedding planes of the rocks and the joints at right angles to them. (See Pl. XII.) The ore solutions penetrated and replaced the sandstone walls, forming rodlike or comblike structures perpendicular to the crevices. Some of the rods or "stalactitic" forms are several inches long, and many of them are coated with a brown velvety film, which is probably wad. At the junction of two planes at right angles the comb structures miter into each other, showing that the tubes, although they closely resemble stalactites, are perpendicular to the walls and were not formed as pendants from a roof. (See Pl. XII.) Some of the ore masses are aggregates of alternate layers of "stalactitic" psilomelane and dark-brown dense, amorphous wad of porous texture and light weight. (See Pl. IX, *B*.) In some specimens even the "stalactitic" material is dull and soft like wad and disintegrates into light powdery fragments. Some surfaces of the psilomelane are studded with elongated mammillary or nipple-shaped forms, which are jet-black and have a bright metallic luster.

Much of the ore is "lump ore," in pieces more than 3 inches thick, but the fines also are saved. It is estimated that the ratio of ore saved to material washed is about 1 to 15 or 20. The material excavated, taken as a whole, is said to yield a ton of washed ore for each 50 cubic yards of ground excavated. As prospect pits along the trend of the ore body on the top of the hill indicate a total length of the deposit in that direction of at least 350 feet and a width of about 150 feet, and the known depth to the bottom of the deepest workings is about 60 feet, a considerable body of ore-bearing ground is still available as an ore reserve.

BUTLER DISTRICT.

The Butler district includes the area around Butler, on the Southern Railway, in the western part of the county. It extends up the valleys northeastward between Doe Mountain, Dry Run and Little Dry Run mountains, and Stone Mountain, southward up Elk Creek, and westward down Watauga River and up Cobb Creek. Several mines and prospects are in a part of the district that lies in Carter County and are described under that heading. (See fig. 11.)

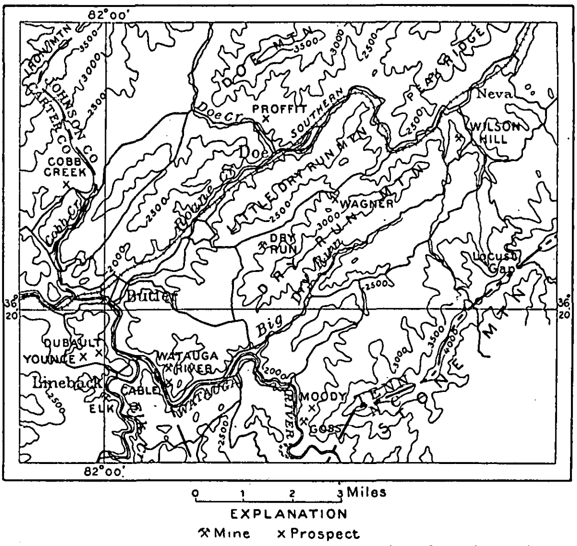


FIGURE 11.—Topographic map of Butler district, showing location of manganese mines and prospects.

Proffit prospect.—A prospect is said to have been opened by H. V. Maxwell on the Stacy Proffit property, 1½ miles northwest of Doe station, on the Southern Railway, and 5 miles north-northeast of Butler, but was not visited. The Erwin quartzite, which is brought to the surface in a sharp anticlinal fold at the southwest end of Doe Mountain and probably is faulted there, is reported to be crushed and broken at the prospect and to be recemented into a breccia and partly replaced by manganese oxide. The ore may prove to be of milling grade, but the high cost of crushing the quartzite and the loss of fines in the process make it doubtful whether or not the project will prove profitable.

Wilson Hill mine.—The Wilson Hill mine, also called the Superior mine, is in the south-central part of the county, 8 miles southwest of Mountain City and 1 mile south of Neva, on the Southern Railway. It is owned and operated by the Superior Manganese Corporation, of Elizabethton. The company commenced work early in 1918 and by May 25 had done considerable prospecting and

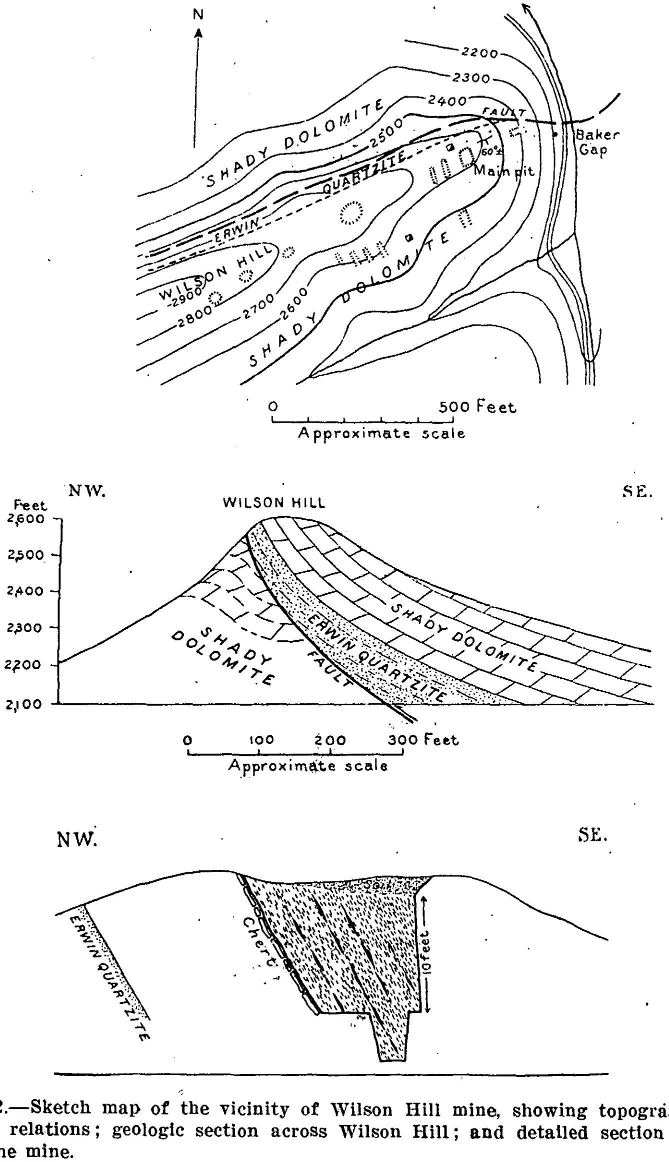


FIGURE 12.—Sketch map of the vicinity of Wilson Hill mine, showing topographic and geologic relations; geologic section across Wilson Hill; and detailed section of main pit of the mine.

developing and had taken out more than 80 tons of manganese ore. In July it was reported that a pumping plant and a 40-ton double-log washer had been installed on Mill Creek, at the southeast foot of the hill, to which the ore is flumed from the mine.

The mine is on top of Wilson Hill, a high outlying ridge at the northeast end of Dry Run Mountain, just west of the small settlement called Baker Gap. The ridge is about a mile long and rises steeply 600 to 800 feet above the adjacent valley bottoms. The deposit occurs on the upper part of the southeastern slope of the ridge, between elevations of 2,600 and 2,800 feet. (See fig. 12.) This slope is somewhat less steep than the northwestern slope and is covered with chert fragments in yellow clay apparently derived from Shady dolomite. Large masses and ledges of chert, in part brecciated, outcrop along the crest of the ridge. Just below the crest on the northwest side a quartzite, believed to be the Erwin quartzite, outcrops. As thus interpreted the quartzite is brought up on a sharp anticlinal fold faulted on its northwest side. (See fig. 12.) There was apparently some alteration of the Shady dolomite adjacent to the quartzite which resulted in the formation of massive chert beds by the replacement of the dolomite by silica from circulating waters, for massive chert is not normally present at the base of the Shady. Similar chert beds have been observed at many fault contacts of the dolomite in the Appalachian region.

The manganese deposits occur chiefly in the clay and chert derived from the Shady dolomite close to the quartzite. The ore ranges from nodular psilomelane to manganiferous iron ore, the latter predominating, and although a considerable tonnage can probably be developed, the better-grade manganese ore will constitute only a small part of the whole.

The developments at the time of visit consisted of 12 or more prospecting openings spaced at intervals along the top of the ridge for about 2,000 feet from its northeast end, beyond which chiefly occur iron ores that were formerly mined near the southwest end of the ridge. The openings comprise deep, narrow, well-like pits, trenches, and larger open cuts, some having a depth of 30 feet.

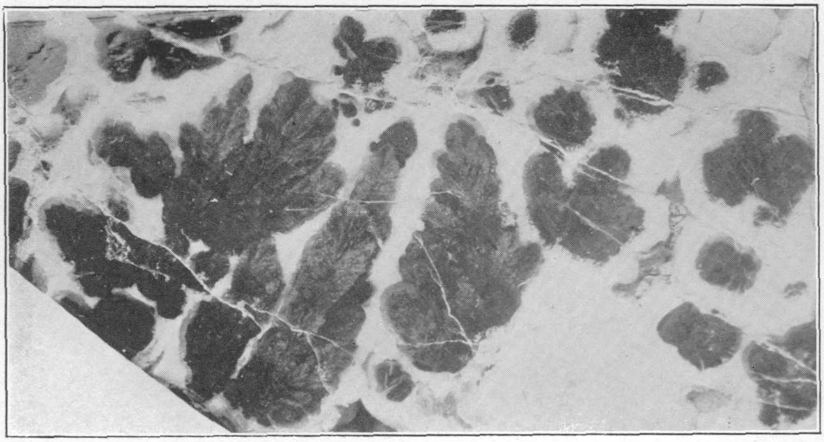
The ore is chiefly dull, somewhat impure, nodular psilomelane, a small part being crystalline manganite, and is inclosed in banded yellowish and dark waddy clay. Some of the waddy clay contains also thin laminae of shiny ore and crystalline nuggets. In the chert ledges adjacent to the quartzite the ore is in a gangue of white crystalline secondary quartz full of drusy cavities. Some of the ore on the southeast slope is brown iron ore containing thin leaves of feathery manganite crytals ranged along fracture planes.

The best showings are at the north end of the hill, in the main opening, which is a trench about 30 feet long, 10 feet wide, and 10 feet deep, with a pit in the bottom about 5 feet deep. (See fig. 12.) Wash ore occurs in bands throughout the clay. The banding of yellow clay and dark manganiferous clay is approximately parallel to the footwall of massive chert, which dips steeply to the southeast and probably represents original bedding. Most of the ore mined before the time of visit came from this pit. About one-fourth of the ore consists of nodular lumps, the largest being about 10 inches in diameter. The other three-fourths is wash dirt, most of which occurs in the yellowish clay. A short distance southwest of this opening about 10 tons of waddy ore and a very little hard ore were obtained from a cross trench 18 feet deep.

Back of these openings, on the northwest crest of the ridge, a shaft was being sunk at the time of visit in a ledge of siliceous rock carrying considerable ore. The rock is largely crystalline quartz inclosing many small, detached, plumose, dendritic manganese oxide nodules (see Pl. XVIII), which vary in size and number and appear to increase in quantity with depth, so that the deposit farther down may prove to be a workable milling ore, as claimed by the owners. At a depth of 12 feet, reached at the time of visit, such ore had not yet been encountered. The nodules are composed of manganite with a core of pyrolusite.

The manganese oxide that formed the plumose nodules appears to have been segregated and to have taken form in the quartz when the silica was in a gelatinous state, for the nodules are unconnected and have parallel orientation, as if they were floated in the quartz. The quartz has since crystallized around them with comb structure facing small interstitial spaces. A similar mode of formation is suggested for a milky-white chalcedony inclosing dark feathery manganese plumes in clear chalcedony from Thompson Hollow, 10 miles southwest of Front Royal, Va., collected in the study of the manganese deposits of Virginia. (See Pl. XIX.) The feathery plumes are similarly oriented and detached and appear to have taken their form when the mineral was free to move and segregate in a liquid or gelatinous substance. Although it may be suggested that the plumose manganite nodules in quartz at Wilson Hill may have been formed by the partial replacement of limestone or chert by manganese oxide and the later replacement by quartz of the rest of the matrix (see Pl. XVIII), seemingly a very unlikely process, this explanation could not apply to the plumose chalcedony from Thompson Hollow, as the feathery phantoms of manganese oxide are so frail that they could not retain their form unless protected by the inclosing transparent silica (Pl. XIX). These two minerals were unquestionably deposited at the same time, the manganese oxide being free to assume its feathery form while floating in unconsolidated silica. A photomicrograph of the plumose manganese in chalcedony shows this even more clearly. (See Pl. XX, *B*.)

The next opening toward the southwest on the crest of the ridge, a 25-foot trench 7 feet wide and 5 feet deep, is said to have yielded 2 tons of nodular lump ore and 10 tons of wash ore. It is excavated in reddish-brown clay in which little ore showed at the time of visit.



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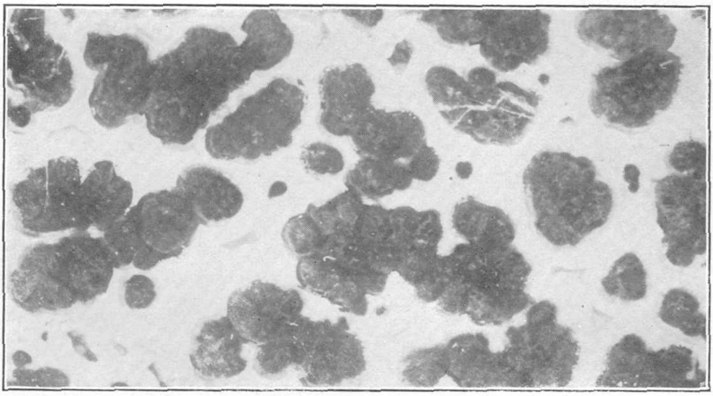
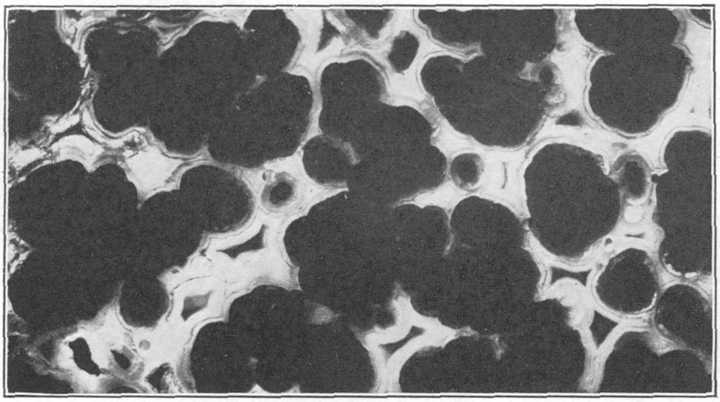


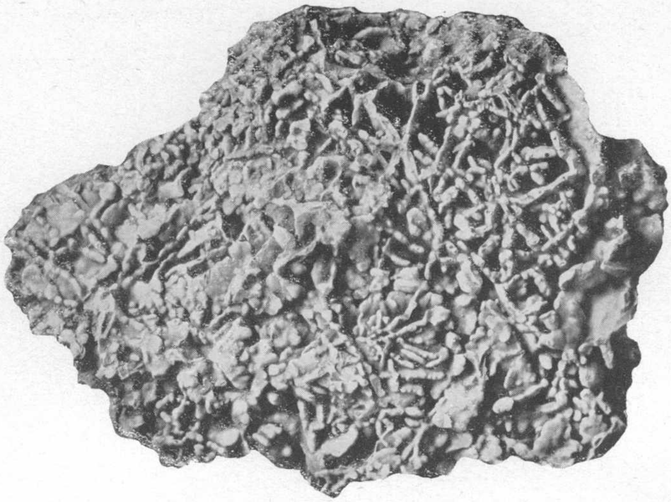
B



C

FEATHERY PHANTOMS OF MANGANESE OXIDE IN CHALCEDONY.

Shown on polished surfaces. From Thompson Hollow, 10 miles southwest of Front Royal, Va. × 3. *A*, Longitudinal sections of phantoms in translucent chalcedony; *B*, cross sections of phantoms shown in *A*; *C*, cross sections of the opaque chalcedony cells that inclose the phantoms shown in *B*. *B* and *C* are photographs of the same part of the specimen, exposed for different lengths of time.

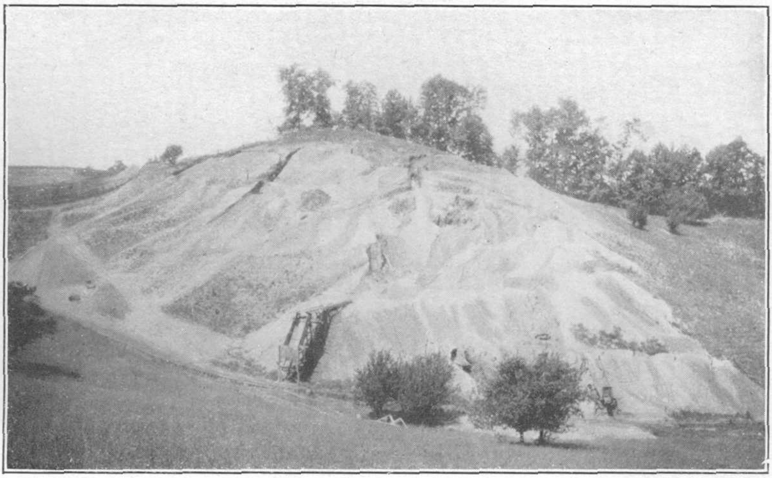


A. CELLULAR PSILOMELANE.

Made up of noded walls that may formerly have been crevice fillings in rock that has since been dissolved. From Elk mine, Tenn. Natural size.

B. PHOTOMICROGRAPH OF A LONGITUDINAL SECTION OF FEATHERY MANGANESE OXIDE PHANTOMS IN TRANSLUCENT CHALCEDONY, SURROUNDED BY OPAQUE BANDED CHALCEDONY.

Similar to phantoms shown in Plate XIX, *A*. From Thompson Hollow, 10 miles southwest of Front Royal, Va. × 10.

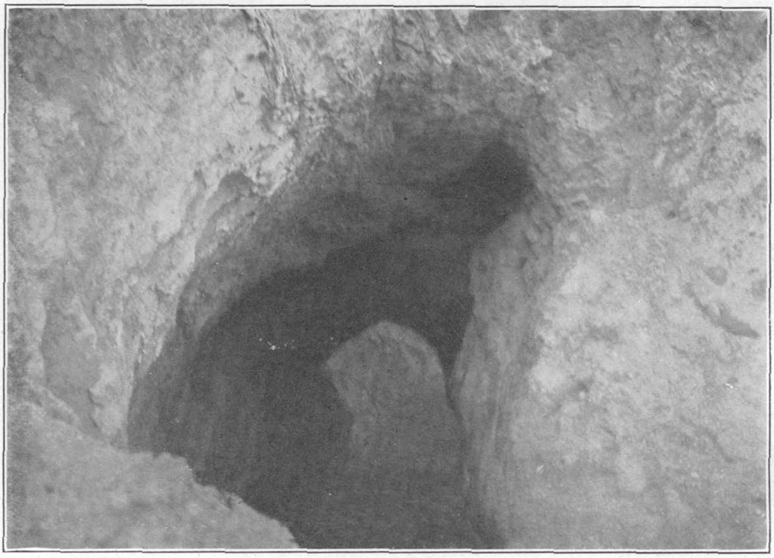


A. OPEN WORKINGS OF DRY RUN MINE, NEAR BUTLER, TENN.

Main pit at time of visit near top of the hill at left; older shallower workings at right; old tunnel at foot of hill, to right of tipple.

B. LARGE LIMESTONE PINNACLES, RESIDUAL FROM SUBSURFACE EROSION, EXPOSED IN DEEP SURFACE WORKINGS OF EMBREE MINE, BUMPASS COVE, TENN.

The ore-bearing clays iu solution depressions have been removed to a depth of 40 or 50 feet.



A. IRREGULAR PIT FOLLOWING MINERALIZED SANDY BEDS IN DECOMPOSED WATAUGA SHALE, ELK MINE, NEAR BUTLER, TENN.

B. ENTRANCE TO PIT SHOWN IN *A*, SHOWING HARD UNWEATHERED FOLDED WATAUGA SHALE IN HANGING WALL.

Several hundred feet beyond this trench along the crest a wide shallow pit exposed massive chert, covered at the surface with thin sheets or shell-like plates of ferruginous manganese ore. When the soil was stripped the deposit appeared at first glance to be of good quality, but the ledges proved to be chert with only a thin coating of ore.

Toward the southwest end of the tract the surface rises more rapidly, and the soil and clay are thicker. Several well-like pits, 5 to 30 feet deep, had been sunk along the crest in yellowish to purple clay containing scattered chert fragments. A little lump and wash ore was generally present, and only in the deepest pit at the southwest end of the belt was any considerable amount of ore seen. The showing of ore in these small pits was not favorable.

On the slope of Wilson Hill, several hundred feet southeast of the crest, four pits closely spaced up and down the slope, about 18 feet deep, expose some manganiferous iron ore with a little psilomelane and thin plates of feathery brilliant pyrolusite on joint planes in massive ledges of liver-colored dense ferruginous chert. The quantity of ore exposed in the faces was small. A few hundred feet eastward, diagonally down the slope from these pits, a shaft 22 feet deep, nearly all its depth in slide material, shows thin layers or sheets of manganiferous iron ore and soft wad dipping southeastward, approximately parallel with the surface. Still farther down the east slope, about 200 feet vertically below the highest pit on the crest of the hill, a cut 9 feet wide and 3 feet deep exposes an ore-bearing layer 8 feet wide, composed largely of massive manganese ore. It passes beneath a covering of 1½ feet of surface soil and yellowish clay and appears to extend into the hillside. A ton of lump manganese ore, 2 tons of wash ore, and a ton of manganiferous iron ore lay on the dump.

Wagner prospect.—The Wagner prospect is on a wash-covered terrace at the head of Little Dry Run, 4½ miles northeast of Butler. It is on the D. A. Wagner property and was prospected under a lease by A. H. and J. L. McQueen, of Butler. A pit 12 feet deep exposes wad and a little hard bluish psilomelane sporadically embedded in the terrace wash and descending into underlying variegated dark and yellow residual clay of the Shady dolomite. The fragments of ore have a rough exterior and are partly stalactitic in structure. Larger lumps of float ore are found on the surface. Although the deposit has not been proved to be workable, its location in the same syncline with the successful Dry Run mine, next to be described, is favorable.

Dry Run mine.—The Dry Run mine is 3 miles northeast of Butler. It was owned and operated by A. H. McQueen, of Butler, who sold it late in 1918. In 1917 nearly 600 tons of ore was shipped, and in 1918 about 1,200 tons. The better grade of ore, comprising the lump and larger wash ore, averaged 44 per cent manganese and 1.65 per cent iron, and most of it ranged from 1 to 10 per cent silica, although some ran up to 14 per cent. The lower-grade ore, comprising the medium-sized and fine wash ore, averaged 37 per cent manganese, 1.75 per cent iron, and 23 per cent silica. The ore is therefore seen to be nearly free from iron but rather high in silica.

The mine is on a low rounded hill at the foot of the northwest slope of Dry Run Mountain, 200 feet above the creek and about 2,350 feet in altitude. (See Pl. XXI.) An 1,800-foot tram descends from the mine to a 22-foot double-log washer on Little Dry Run,

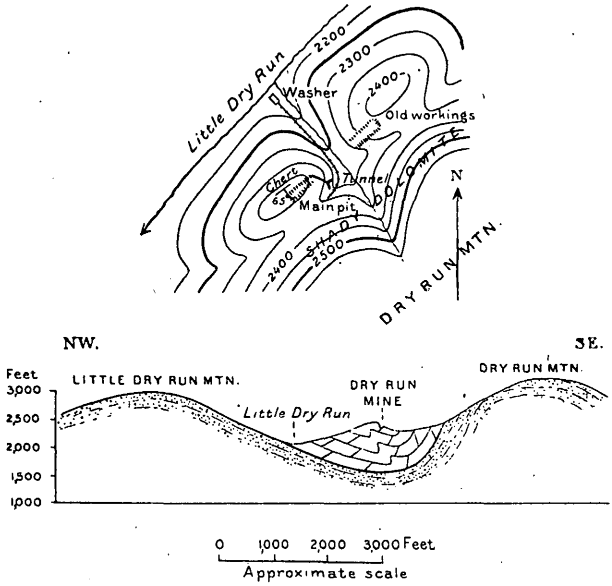


FIGURE 13.—Sketch topographic map of vicinity of Dry Run mine and geologic section through main pit.

where the ore is washed, the water being supplied from the creek by a gravity flume. The inclosing dirt is black but is easily removed, yielding an unusually clean product of washed ore.

The deposit occurs in residual clay of the Shady dolomite, which occupies the synclinal valley between the Dry Run Mountain and Little Dry Run Mountain anticlines. Although there are no rock outcrops near by, a layer of chert in the pit apparently dips southeastward, and the deposit appears to lie on the northwestern limb of the syncline, the chert forming the northwest footwall. The ore zone ranges in width from 2 to 15 feet, and the deposit has been opened for a length of 800 feet.

There are three main openings. (See fig. 13.) The southern opening, which was the site of active mining at the time of visit, is a pit 20 feet deep at the face and about 80 feet long. The ore lies in a bed of dark manganiferous clay, 4 to 6 feet thick, which strikes N. 20° E., dips 65° ESE., and contains psilomelane nodules. It is underlain by dark-drab clay with some wad, which rests on the chert footwall. (See fig. 14.) Overlying it is barren yellow clay, which contains in its upper part streaks or layers of angular purple shale fragments that apparently fill old solution channels in the Shady dolomite, the shale fragments being derived from the overlying purple Watauga shale.

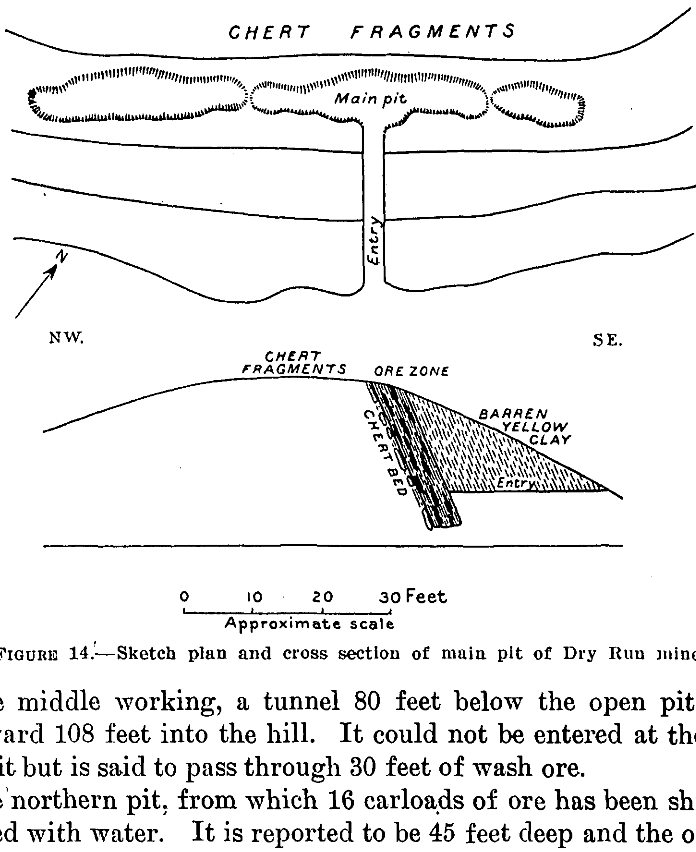


FIGURE 14.—Sketch plan and cross section of main pit of Dry Run mine.

The middle working, a tunnel 80 feet below the open pit, runs westward 108 feet into the hill. It could not be entered at the time of visit but is said to pass through 30 feet of wash ore.

The northern pit, from which 16 carloads of ore has been shipped, is filled with water. It is reported to be 45 feet deep and the ore bed to be 14 feet wide. It was abandoned because of the increase of overburden with depth in following down the dip of the ore bed to the southeast. At the time of visit it was being unwatered, so that work on the deposit could be resumed. Although considerable ore has been mined, there is still apparently a large amount of ore remaining in depth and probably also in both directions along the strike. Thus far prospecting along the strike has not revealed the ore bed, but the area of bench land between the mine and the Wagner prospect on the north merits careful exploration.

Judging from the exposures seen, the statement of the owners that the ore bed runs about 75 per cent ore seems to be correct. The ore bed has been left unmined at several places where the overburden was heavier than elsewhere, but it is apparently of the same high grade as the part already taken out and can be profitably mined by the use of suitable machinery such as a steam shovel or drag-line scraper. The ore is mostly psilomelane but contains also a little pyrolusite and manganite. The washed ore is almost all nodular or botryoidal. An unusual specimen comprising a cluster of radiating rods is illustrated in Plate III (p. 8).

Watauga River mine.—The Watauga River mine is 2 miles southeast of Butler, on the upper northwest slope about 30 feet below the crest of a low ridge, which is the southwestward continuation of Dry Run Mountain. The crest is 400 feet above Watauga River and 2,400 feet in total elevation, standing at about the level of the old valley floor in this region. The mine is operated by J. L. McQueen, of Butler, who installed a double-log washer a few hundred feet below the mine, on the wagon road near the river. The deposit occurs in decomposed Watauga shale, which here dips 35° SE. At the time of visit half a ton of manganiferous iron ore lay at the mouth of the cut.

The developments consist of an open cut about 40 feet wide and an old shaft 30 feet deep, from the bottom of which a 50-foot drift is reported to run southeastward into the ridge. A tunnel was being driven lower on the hillside to open the pit wider and deeper. The cut shows decomposed Watauga shale weathered to yellow sandy clay forming a vertical east wall and black waddy clay containing some nodular ore, apparently filling a pocket 20 feet deep on the west side. The pocket resembles a solution-channel filling. The lower workings, said also to carry ore, were not accessible at the time of visit.

Cable prospect.—The Cable prospect is 2 miles southeast of Butler, on the Cable property, and has been prospected by J. E. Reece, of Butler. It is at an elevation of 2,200 feet, on the lower southeast slope of the same ridge as the Watauga River mine, from which it is about 500 feet distant. The deposit occurs in decomposed Watauga shale conformable with the bedding, which dips 35° SE.

The openings consist of an old tunnel at the foot of the ridge, which is driven across the structure of the shale, and a shaft starting 60 feet higher than the tunnel. Although these old workings were made in quest of iron ore, some manganese ore was also found. The shaft, which is caved, shows an ore-bearing zone of yellow clay about 8 feet wide, containing scattered nodules of psilomelane and wad and overlain by a bed of iron ore. The tunnel is in harder purple sandy shale, in which are interbedded thin layers of residual yellow sandy clay containing scattered nodules of manganese ore. The amount of ore, however, is apparently too small to be mined.

Goss mine.—The Goss mine is 5 miles southeast of Butler and about 2 miles south of Casper. It is at the southwest end of Stone Mountain, about 300 feet above Watauga River, at an altitude of about 2,350 feet. It was operated by the W. C. Goss Manganese Co., of Butler, which by June, 1918, had shipped a carload of ore said to have run 40 per cent in manganese. The deposit occurs in clay and chert residual from the Shady dolomite adjacent to hard purple Watauga shale and in the overlying wash. It is opened by several cuts 20 to 30 feet deep, which cover a vertical range of more than 100 feet.

In the lowest or main opening, which is a narrow cut 30 feet deep at the face, there is a bed of thinly laminated yellow clay which contains sparsely scattered small nodules and irregular small bodies of ore interbedded with chocolate-colored buckfat clays, which strike N. 25° E. and dip 80° SE. The ore is chiefly psilomelane, containing considerable silica in the form of finely crystalline quartz, lining cavities. The ore was cleaned in a double-log washer at the foot of the slope, to which it was carried by a steep covered flume. It was then hauled by wagon to Butler for shipment, a distance of more than 12 miles. The small amount of ore, its high content of silica, and the long haul to the railroad rendered the further working of this property unprofitable.

Moody prospect.—The Moody prospect is 5 miles southeast of Butler, just northeast of the Goss mine, on the north slope of the same ridge. It is on the W. R. Moody property and was opened by C. H. White, of Elizabethton. About 3 tons of ore was mined, washed at the Goss plant, and shipped with the ore from the Goss mine. The mineral zone lies along the foot of the steeper part of the northwest slope of Stone Mountain, on a narrow bench at about 2,500 feet elevation. It is in residual clay of the Shady dolomite, which dips steeply away from the Erwin quartzite of the mountain and seems also to be faulted, for the belt of dolomite is very narrow. It has been prospected at intervals for a distance of one-fourth of a mile northeast of the Goss property.

At the southwest end of the property, adjacent to the Goss mine, the prospect pits attain a depth of 18 feet. They expose yellow soil and clay containing many fragments of chert characteristic of the Shady dolomite, and dolomite outcrops below the northeasternmost pit. Small irregular bodies of wad and scattered nodules of psilomelane occur sparingly in the clay. Although some of these nodules are dense and heavy and contain crystalline manganite, the amount of ore encountered did not warrant mining.

CARTER COUNTY.

Carter County, of which Elizabethton is the county seat, lies southwest of Johnson County and adjacent to the North Carolina State line. It is largely mountainous, only its western part being occupied by valleys. It contains 18 or more manganese mines and prospects, about half of which have been productive. Most of them lie along a narrow belt on the northwest slopes of Gap Creek Mountain and Iron Mountain, which trend northeastward through the center of the county. (See fig. 18.) Some lie on the south and southeast slopes of Holston Mountain, in the northeastern part of the county.

BUTLER DISTRICT.

Elk mine.—The Elk mine is near Lineback, on Elk Creek, 2½ miles south of Butler. It is on the Hately & Lunsford tract and was operated by the McQueen Manganese Co., of Butler. The 60 tons of ore produced contained an average of 38.07 per cent manganese, 38 per cent iron, and 19.27 per cent silica. The last carload shipped is said to have averaged 42.76 per cent manganese.

The mine is on two small hills on opposite sides of a small valley west of Elk Creek, 130 feet above the creek. The log washer, which is beside the creek, is reached by an inclined tram from the mine 1,600 feet long. The deposits occur in decomposed Watauga shale, the general structure of which is monoclinal, the beds striking N. 35° E. and dipping on an average 45° NW., but they are somewhat folded.

The main or older opening is a pit 20 feet wide and 30 feet long, on the northwest side of the valley, from which an irregular incline descends along the ore zone down the bedding to a depth of 40 feet. The shale is largely weathered to soft yellow sandy clay, but some less weathered beds are still purple. (See Pl. XXII.) An overburden of 2 to 8 feet of earthy soil and purple shale fragments covers the residual clay. The ore is mostly psilomelane disseminated in a bed of soft yellow sandy clay, probably a disintegrated calcareous sandstone. This ore-bearing bed is thin, and the ore is not uniformly distributed in it, so that the incline which follows it is intricately ramifying. Most of the ore mined came from a depth of more than 15 feet.

The more recent opening, on the southeast side of the valley, is a cross trench 15 feet deep, from the bottom of which a shaft descends 60 feet, largely in purple shale. A drift at its bottom follows an ore bed in soft yellowish clay. About one-fourth of a ton of coarse cellular lump ore and 20 tons of wash ore lay on the dump, and more than 40 tons had been shipped. The cavities in the lump ore are lined with crystalline manganite, and this ore is said to average more than 40 per cent manganese. The cellular ore is made up of thin, noded platy walls which apparently formed on joint and bedding planes of the original calcareous rock and in part as replacements of that rock, and the unreplaced parts have subsequently been dissolved out. (See Pl. XX, *A*.) The wash ore is mostly of nut to pea size.

At the time of the visit the deposit seemed to be largely worked out, and the mine was reported closed down shortly thereafter, in July, 1918. However, as the ore in the decomposed Watauga shale is so variable in its occurrence, other equally good deposits may yet be discovered in the vicinity.

Dubault prospect.—The Dubault prospect, on the Dubault farm, 2 miles southwest of Butler, was opened by J. E. Reece, of Butler. It is on a low, flat-topped hill, 2,100 feet in altitude, on the north side of a deep narrow valley draining eastward into Elk Creek. The deposit is in a narrow northeast-trending belt of yellow residual clay containing fragments of chert inclosed in the Watauga shale and probably derived from impure dolomite beds in the formation such as are exposed on Elk Creek. It lies between hard purple sandy shale on the west and whitish shale on the east. At the time of visit only one cut 6 feet deep had been dug, exposing chocolate-colored clay which contained a few scattered nodules of psilomelane and wad. A little float is seen, but the indications are not favorable.

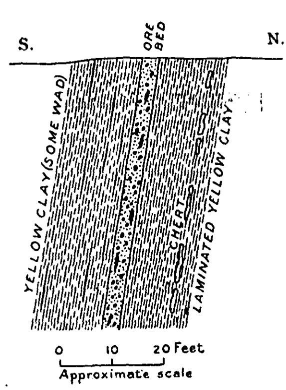


FIGURE 15.—Sketch of face of Younce prospect pit, near Butler, Tenn., showing ore replacing thin sandy bed in Watauga shale.

Younce prospect.—The Younce prospect is 2 miles southwest of Butler and one-fourth of a mile west of the Dubault prospect, on the farm of S. S. Younce. It was originally opened by the McQueen Manganese Co., but in May, 1918, was being developed by J. E. Reece, of Butler. About one-third of a ton of ore was on the dump. The openings are on a flat-topped hill, of 2,180 feet elevation, near the head of the narrow valley passing the Dubault prospect. A narrow irregular pit had been dug which follows down a thin ore-bearing bed of residual sandy clay in the Watauga shale to a depth of 50 feet. The rocks are nearly vertical, dipping 80° S. (See fig. 15.)

The deposit consists of scattered small nodules of psilomelane and thin streaks of wad in a 4-inch bed of yellow sandy clay. The footwall is yellow laminated clay, in which is a thin bed of chert 12 inches below the ore-bearing layer. The hanging wall is banded yellow and drab clay containing a little wad. The ore-bearing bed is so thin that even if it were much richer than it is shown to be in the present pit it could not be profitably mined.

Cobb Creek prospect.[22]—The Cobb Creek prospect is 2½ miles northwest of Butler, on a hill west of Highhealth, on Cobb Creek. It is on the farm of C. S. Morley, of Butler, and was opened by A. H. McQueen, of Butler. The deposit occurs on the top of a flat-topped hill or terrace and lies in disintegrated Watauga shale in the same structural belt with the Doe Valley mine, on the northeast. It is opened by a pit 40 feet wide by 50 feet long and 3 feet deep from which a ton of ore, most of it of high grade, was obtained.

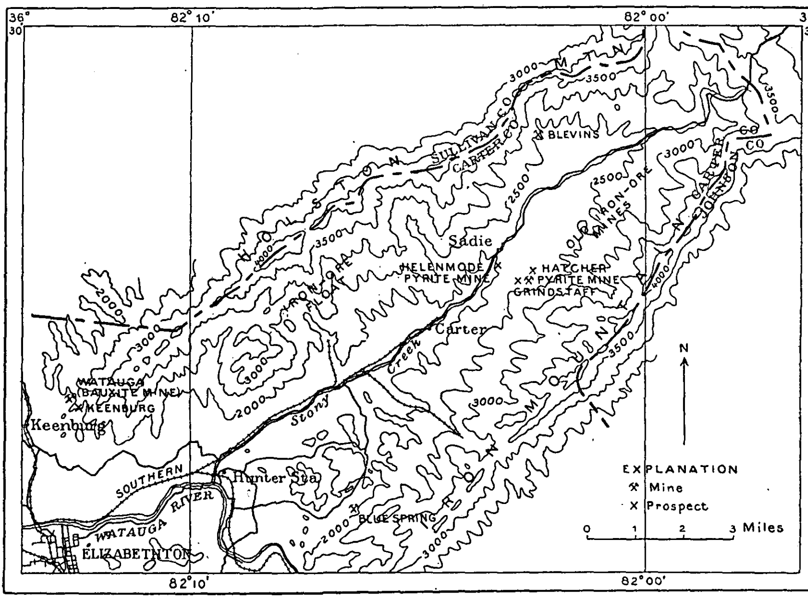


FIGURE 16.—Topographic map of Stony Creek district, showing location of manganese mines and prospects.

It was thought by those who examined the deposit that it would prove workable.

STONY CREEK DISTRICT.

The Stony Creek district is in the northeastern part of Carter County and comprises Stony Creek valley, which is about 5 miles in width, between Holston Mountain on the northwest and Iron Mountain on the southeast, and extends from Elizabethton 16 miles northeastward to the county line. (See fig. 16.)

Blevins mine.—The Blevins mine is in the northeast corner of Carter County, 1½ miles up Blevins Hollow northwest from Colesville, on the Stony Creek branch of the Southern Railway. It is owned by Mrs. Isaac Blevins, who lives on the property. Captain

[22] From notes by A. H. McQueen and Nelson Dale.

Robinson, of Elizabethton, opened the mine several years ago and shipped a carload of ore in 1917. No further work has been done.

The mine is on the top of a small terraced spur of Holston Mountain, part of the old valley floor, at an elevation of approximately 2,500 feet. The deposit occurs in surface wash of light-brown to chocolate-colored clay 8 to 10 feet thick and in underlying yellow residual clay derived from the lower part of the Shady dolomite, for greenish sandy shales of the basal part of the Shady outcrop at the stream below.

As exposed by a dozen or more openings scattered over the upper part of the hill the deposit has a horizontal extent of more than 500 feet. The openings are mainly small pits 8 to 10 feet deep, and a large cut on the north side of the hilltop which extends to a maximum depth of 18 feet. The ore in most of the pits is nodular psilomelane with dull luster, sporadically embedded in the clay and more plentifully at a depth of 8 to 10 feet, near the base of the surface wash. In the large cut there are also two or three layers, each 1 foot thick, of soft black wad and pyrolusite interbedded in the light-yellow to chocolate-colored residual clay which dip gently north. There seems to be considerable ore present, but judging from the earthy appearance of the psilomelane on the dump it will not run over 35 per cent manganese.

Hatcher prospect.—The Hatcher prospect is in the northeastern part of Carter County 1 mile east of Sadie station, on the Stony Creek branch of the Southern Railway. It is on the Hatcher tract and was opened about 1903 by Col. J. N. Adams, of Charleston, Tenn. H. E. Graves, of Bristol, has more recently prospected it.

It is on a terraced spur on the lower northwest slope of Iron Mountain, at an elevation of approximately 2,350 feet. (See fig. 17.) It is about 150 feet above the opening of the neighboring Hatcher sulphur mine, where iron pyrites has been mined in the upper layers of the Erwin quartzite.

The deposit occurs in residual clay of the Shady dolomite just above the Erwin quartzite, which dips 40° NW., away from the mountain. A pit 4 feet deep on the top of the terrace is in dark-reddish mealy soil, containing a few nodules of psilomelane and some iron ore. A few fragments of float ore are also scattered over an acre of the adjacent surface. The amount of ore is apparently very small.

Grindstaff prospect.—The Grindstaff prospect is southwest of and just across the small hollow from the Hatcher prospect, on a similar terraced spur. It is owned by G. L. Grindstaff, by whom it has been prospected by auger borings to a depth of 4 feet. The geologic and surface relations are similar to those at the Hatcher prospect.

Other prospects in Stony Creek valley.—Several old iron mines on the northwest slope of Iron Mountain, all now closed, are still plainly visible from the valley bottom. Some of them are on benches similar to those at the Hatcher and Grindstaff prospects, and the reported occurrence of float manganese ore at such places agrees with the indications. Prospects on the southeast slope of Holston Mountain were also reported. Excellent float iron ore, locally called "cannon" ore because of its denseness, hardness, and heaviness, occurs on this

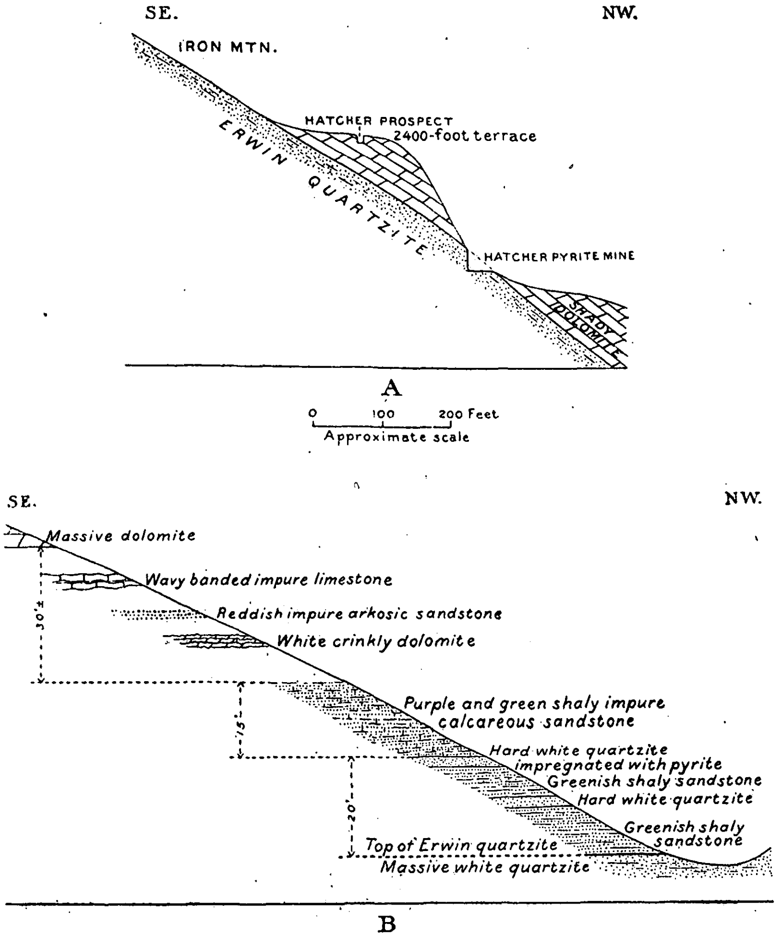


FIGURE 17.—A, Geologic section through Hatcher pyrite mine and manganese prospect; B, Detailed section of base of Shady dolomite near Helenmode pyrite mine and Hatcher manganese prospect. Quartzite beds at the base of the Shady or at the top of the Erwin are pyritized.

mountain slope and is especially plentiful in the Unaka National Forest west of Winner station.

Blue Spring mine.—The Blue Spring mine is in the north-central part of the county half a mile south of Blue Spring and 4 miles east of Hunter station, on the Southern Railway. It is owned by the Carrigan heirs and was operated by Walker & McKenna, of Elizabethton. It is credited with a production of more than 500 tons of manganese ore, of which 11 carloads was shipped many years ago. More recently 75 tons was shipped by Col. J. N. Adams, of Charleston, Tenn., who installed a log washer just below the mine. A carload of ore was mined and shipped in 1917 by H. V. Maxwell for H. E. Graves, of Bristol, and Mr. Maxwell[23] reported that during 1918 two carloads was mined and shipped by W. S. Douglas, who also installed a double-log washer.

The mine is on a terraced spur on the lower northwest slope of Iron Mountain, at an elevation of 2,000 to 2,200 feet, which corresponds with the tops of many neighboring spurs and ridges regarded as remnants of the old valley floor.

The older workings were deep open cuts on the hillside and are largely caved. Their dumps still show a considerable amount of good wash ore, particularly the higher ones, which are on the Virginia Iron, Coal & Coke Co.'s land, now forming part of the national forest. The recent workings comprise several trenches 8 to 10 feet deep and associated short tunnels. Most of them expose dark manganiferous clays at the surface underlain by horizontally banded clays. The ore lies in chocolate-colored sandy surficial clay, which is generally not over 5 feet thick, the underlying yellow clay, apparently residual from the lower beds of the Shady dolomite, being mostly barren.

The ore is chiefly hard psilomelane in nodules ranging up to 8 inches in diameter and in larger irregular masses. There is also present considerable soft black pyrolusite, which must be collected by hand to be saved. The areal extent of the deposit is large, and considerable minable ore is believed to be still in the ground.

Keenburg prospect.—The Keenburg prospect is in the western part of Carter County, 3 miles north of Elizabethton and 1 mile east of Keenburg, on the Southern Railway. It is on the property of the Southern Minerals Corporation, of Boston, Mass., adjacent to that company's bauxite opening. It is on a spur known as Red Bird Hill, at the southwest end of Holston Mountain, on a bench 2,200 to 2,300 feet in altitude, which is a little higher than most of the hilltop remnants of the old valley floor in the vicinity.

The deposit occurs in residual dark-red mealy clay of the basal part of the Shady dolomite and in the adjacent Erwin quartzite. The quartzite outcrops at the top of the spur above the bench, where it strikes N. 30° W. and dips 40° SW. Its brecciated ledge, cemented by manganese ore, has been prospected but is too siliceous to be profitably mined. The deposit on the terrace below the quartzite ledge is opened by shallow pits at several places. Small fragments of manganese ore are found in the upper surficial reddish and pale-

[23] Maxwell, Henry V., Manganese ore of east Tennessee: Eng. and Min. Jour., vol. 107, No. 3, p. 149, Jan. 18, 1919.

lavender clays in the bauxite pits and cuts, and float ore and many chert fragments are scattered over the face of the bench. The ore is chiefly nodular and stalactitic psilomelane, some of which is coated with black shiny ore and contains a little crystalline manganite.

The amount of ore exposed in the openings is too small to be profitably mined but might be saved as a by-product if the bauxite is mined.

HAMPTON DISTRICT.

The district that produces the most manganese in Carter County is the Hampton district, which comprises the region around Hampton, in the central part of the county. It includes not only the valley between the Stone Mountain-Pond Mountain group on the southeast

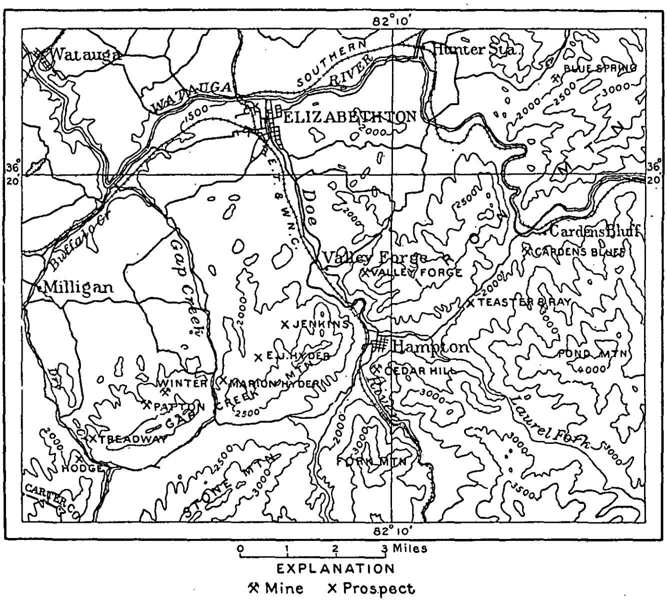


FIGURE 18.—Topographic map of Hampton district, Carter County, showing location of the manganese mines and prospects.

and the Gap Creek Mountain-Iron Mountain group on the northwest, in which Hampton is situated, but also the edge of the Appalachian Valley at the northwest foot of the group last named. (See fig. 18.)

Cardens Bluff mine.—The Cardens Bluff mine is about 4 miles northeast of Hampton and half a mile southwest of Cardens Bluff, the nearest railroad station on the Southern Railway. It is owned and operated by A. D. Reynolds, of Bristol, and L. L. McQueen, of Butler. In 1917 the ore shipped amounted to 182 tons and averaged 36.56 per cent manganese, 9.05 per cent iron, and 22.51 per cent silica. Several carloads was in the bins at the washer at the time of the visit, and 400 tons was reported shipped during the first half of 1918, which had an average analysis of 30 per cent manganese, 10 per cent iron, and 25 per cent silica. Owing presumably to the high silica and low manganese content of the ore, the mine was closed down late in the autumn of 1918.

The mine is on the upper west slope of a prominent terrace at an elevation of 2,200 feet, a remnant of the old valley floor, the northwest foot of Pond Mountain. (See fig. 19.) The deposits occur in yellowish to reddish residual clay and chert fragments of the Shady dolomite, the chert having been partly replaced by ore. The overburden is about 3 feet of soil and clay. Just below the mine unweathered dolomite outcrops dipping 85° NNW.

An open cut about 80 feet across and extending up the hill 200 feet opens the face in three benches, each 6 to 12 feet deep. The ore mined came chiefly from a zone 1 to 6 feet below the surface, which was well exposed in the face of one of the benches for a width of 20 feet. In the deepest part of the working ore-bearing clay continues to the bottom of the cut.

The ore is chiefly wad, psilomelane, and pyrolusite, in part crystalline but much of it soft and sooty. The washed ore looks dirty, resembling earthy chocolate-colored lumps of clay, and analyses show that it contains much insoluble matter, which consists of silica and probably alumina. The ore is conveyed from the mine down a short hand-cable incline to a loading platform and thence by a gravity and horse tram to a log washer on a small creek about one-fourth of a mile west.

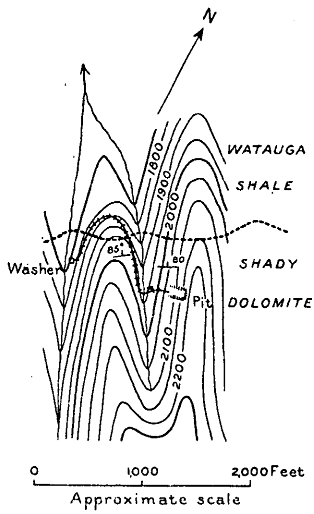


FIGURE 19.—Sketch map of the vicinity of Cardens Bluff mine, showing topographic and geologic relations.

Teaster & Ray prospect.—Two miles southwest of the Cardens Bluff mine prospecting has been done beside the Hampton road by M. G. Teaster and T. J. Ray, of Elk Park, N. C. On a low hill south of the road at the head of the small branch of Doe River a pit 4 feet deep is reported to expose lumps of psilomelane in earthy clay wash containing sandstone fragments. This flat divide on which the deposit lies is probably part of the old valley floor. On the spur of Pond Mountain southeast of the prospect, about 500 feet above the road, manganese is reported to have been found near ledges of Erwin quartzite, and the overlying Shady dolomite is probably the source of the wash deposit.

Cedar Hill mine.—The Cedar Hill mine is 1 mile south of Hampton and one-third of a mile from the East Tennessee & Western North Carolina Railroad. It is owned by the Stiles heirs, of California. It was worked for iron about 1890 and was only recently leased and opened for manganese by the Maxwell Manganese Mining Co., of Elizabethton. At the time of visit (May, 1918) a force of 10 men was at work and a carload of ore had been washed in a 20-foot single-log washer. Later a double-log washer was installed, and by the end of the year 11 cars of ore had been shipped which showed by analysis from 46.51 to 48 per cent manganese, 8 to 8.45 per cent iron, 4.5 to 5.65 per cent silica, and 2.11 to 4.92 per cent alumina.

The mine is on the top of a low terraced spur at the northwest end of White Rocks Mountain, at an elevation of 2,150 feet, or about 350 feet above the adjoining lowland of Doe River where the washer stands. (See fig. 20.) Water is conveyed by flume to the washer from a dam in the river. The ore is carried by a cable incline 1,400 feet long on the slope and a gravity and mule tram 900 feet long on the valley bottom.

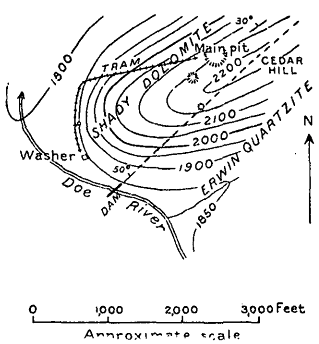


FIGURE 20. — Sketch map of vicinity of Cedar Hill mine, showing topographic and geologic relations.

Small pits have been opened on the top of the terrace adjacent to old iron pits, in one of which a ledge of good brown iron ore is still exposed. The ore zone lies between clay containing yellow chert with drusy cavities, derived from Shady dolomite, exposed on the slope below, and Erwin quartzite, which outcrops on the mountain slope above.

The main opening is a large open cut running southeastward into the north side of the spur, with a face about 30 feet high. A tunnel, badly slumped, runs still farther into the spur. From the side of the large cut runs a newer opening 20 feet wide which has a face 15 feet high, almost all composed of dark manganiferous clay and soil interbedded with yellow clay. Both the yellow and the dark clays carry plentiful nodules of psilomelane, but the dark clay is noted for large pockets of soft ore which is graphitic in character yet nodular in form and has a radiate needle structure. As most of this soft ore crushes to powder on being handled and would be lost in the washer, it is bagged at the pit and shipped unwashed. The nodular psilomelane is mostly small, consisting of nut ore, pea ore, and screenings, and the carload analyses would probably show a much lower content of manganese if the higher-grade soft ore were not saved and mixed with it. A 5-foot horse of barren yellow clay is exposed in the middle of the cut. This appears to be unmoved residual clay of the Shady dolomite, whereas the ore-bearing clay is apparently residual clay that has slumped and settled into solution depressions and pockets in the old land surface or valley floor and has there become impregnated with ore.

The ore reserves appear to have amply justified the enlargement of the plant. A considerable area of prospective ground is untouched on the hilltop. Mr. Maxwell said that float ore has been found all along the foot of the northwest slope of the mountain from the Cedar Hill mine to the Cardens Bluff mine, and as the geologic and surface conditions are favorable for ore accumulation in this belt other good deposits may be expected on benches of the same elevation as these mines.

Valley Forge mine.[24]—The Valley Forge mine, formerly known as the Toncray mine, is in the central part of the county, three-fourths of a mile east of Valley Forge, on the East Tennessee & Western North Carolina Railroad. It is owned and operated by the Valley Forge Mining Co., of Bristol, Va. It is reported to have shipped in 1917 about 800 tons of ore, of which 50 tons averaged 43 per cent manganese, 3 per cent iron, and 6 per cent silica. Average analyses of carload shipments of this ore were later reported to have run 42 to 46 per cent manganese, 4.8 to 8 per cent iron, and 9.2 to 12 per cent silica. It is reported that during the year 1918 5 carloads of ore was shipped to the steel plant at Bethlehem, Pa.[25]

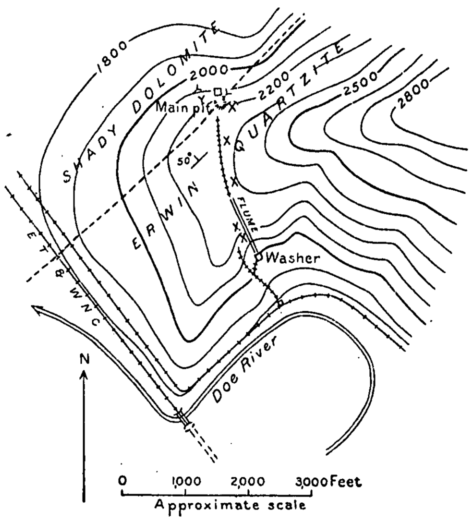


FIGURE 21.—Sketch map of vicinity of Valley Forge mine, showing topographic and geologic relations.

The mine is on the northwest slope of the southwest end of Iron Mountain, at an elevation of about 2,240 feet, and about 500 feet above and three-fourths of a mile north of Doe River. (See fig. 21.) It is on a short terraced spur projecting to the northwest, the surface of which is a remnant of an old valley floor. Similar benches at about the same level on spurs to the northeast have similar geologic and surface relations and are therefore favorable places to prospect. Old caved pits and dumps on immediately adjacent portions of the ridge were opened for iron ore many years ago.

[24] Description by F. C. Schrader.
[25] Maxwell, Henry V., op. cit., p. 149.

The deposit occurs in residual clay of the Shady dolomite near its contact with the underlying Erwin quartzite, which outcrops to the southeast. The structure is monoclinal, the dip of the rocks being about 60° NNW. The clay is mostly dark reddish or chocolate-colored. The ore is sporadically embedded in it in the form of nodules and aggregates.

The deposits are mostly contained in a mineralized zone about 60 feet wide, which trends east-northeast for about 400 feet and seemingly passes through the spur, for they are exposed on both sides. They have a known vertical range of about 160 feet. On the northwest slope of the spur developments begin at an elevation of 2,100 feet in yellow clay, but no ore was found below an elevation of 2,175 feet, from which point the developments extend interruptedly up the 35° slope to where the tram crosses the ridge at 2,280 feet elevation. Surface indications of ore continue up the slope to the top of the spur at 2,340 feet elevation.

Three tunnels on the northwest slope of the spur, not enterable at the time of visit, form a considerable part of the development. The lowest tunnel, 150 feet in length, is driven southwestward in yellow clay and encountered no ore. The intermediate tunnel, 100 feet in length, runs southward and is said to have found a trace of manganese ore in red clay. The upper tunnel, starting near the collar of the shaft and at the lower limit of the main deposit, runs southwestward and is said to be 120 feet long, with ore present throughout its length. The ore is said to be best developed, however, at depths between 10 and 15 feet, and about all the ore thus far mined seems to have come from depths not exceeding 30 feet. The seat of active operations at the time of visit was an open pit on the northwest side of the spur at about 100 feet below the crest, in the vicinity of the upper tunnel and a little higher than the shaft. The ground being worked seems to be a continuation of the upper ore-bearing zone in the shaft, which passes through 5 feet of dark-reddish ore-bearing clay, then 18 feet of barren yellow clay, below which ore is again found.

The ore is mostly hard psilomelane. It occurs in rough nodules and slabs or fragments composed of aggregate botryoidal and mammillary forms. There is present, however, a moderate amount of soft crystalline and sooty pyrolusite and wad. The wad includes dark-brown nodules 2½ inches in diameter, seemingly of good-grade ore.

The equipment consists chiefly of a four-log washer and pump, with about 4,000 feet of pipe line, half a mile of tram, cast-iron flume, gasoline engine, and several buildings. The washer is on the southeast slope of the spur at a point about midway between the mine and the river, whence a gravity tram extends southward to the railroad at the river, where also is placed the pump which raises water to the washer and mine. From the mine the ore is raised 80 feet by a gasoline engine up a short inclined tram to the crest of the ridge, from which point it is flumed to the washer. The mine was expected to produce about 40 tons of ore a day when fully equipped. Exposures on both sides of the ridge appear to indicate that the ore reserves are large.

Jenkins prospect.—The Jenkins prospect is in the southwestern part of the district 2 miles southwest of Valley Forge. It is owned by the Abe Jenkins heirs and was opened by J. N. Koch and associates, of Knoxville, in 1917, when, it is reported, a carload of ore was mined and shipped and the prospect was then abandoned as unprofitable. The ore is said to consist chiefly of nodular psilomelane and to have run 36.20 per cent manganese, 4.78 per cent iron, and 17.71 per cent silica.

The prospect is on a flat-topped spur about 2,200 feet in elevation, on the northwest slope and near the northeast end of Gap Creek Mountain. It is in residual clay of the Shady dolomite. Float ore is reported on adjacent spurs at this general level, and manganese deposits probably extend along the entire northwest slope of the mountain.

Hyder prospects.—The Hyder prospects are 2½ to 3 miles southwest of Valley Forge, 1 to 2 miles beyond the Jenkins prospect. One is on Eliza Jane Hyder's farm and another is farther southwest on Oscar Hyder's farm, both on flat-topped spurs of Gap Creek Mountain about 2,200 feet in elevation. Another prospect still farther southwest, near Gap Creek, is on Marion Hyder's farm, likewise on a bench which is 2,150 feet in elevation. These prospects are all small surface openings in dark manganiferous clay lying on yellow clay residual from Shady dolomite and show some psilomelane ore. They were opened by J. N. Koch and associates, of Knoxville, but not sufficiently to determine their worth.

Winter mine.—The Winter mine, also known as the Taylor mine, is 6 miles southeast of Johnson City and 4 miles south of Watauga Point, on the East Tennessee & Western North Carolina Railroad. The property is owned by the Taylor heirs and was opened by the Maxwell Manganese Mining Co., of Elizabethton, which in 1917 mined and shipped a carload of ore, including some ore from the near-by Patton mine, said to have analyzed 45.9 per cent manganese. In May, 1918, about 40 tons of good-grade wash ore, mostly of nut and pea size, lay on the mine dump, and 20 tons of washed ore was at the washer. Late in 1918 the mine was leased by the Max Mining Co., of Braemar, Tenn., and a double-log washer was at once installed.

The mine is on a bench 2,200 feet in elevation on a low spur on the northwest slope of Gap Creek Mountain. (See fig. 22.) The trough in which the ore was washed is on a small headwater branch of Powder Creek, a short distance below the mine.

The deposit occurs in banded residual clay containing round cherts, derived from lower beds of the Shady dolomite. Two beds of wad and hard ore in dark clay, each 1½ feet thick, alternate with

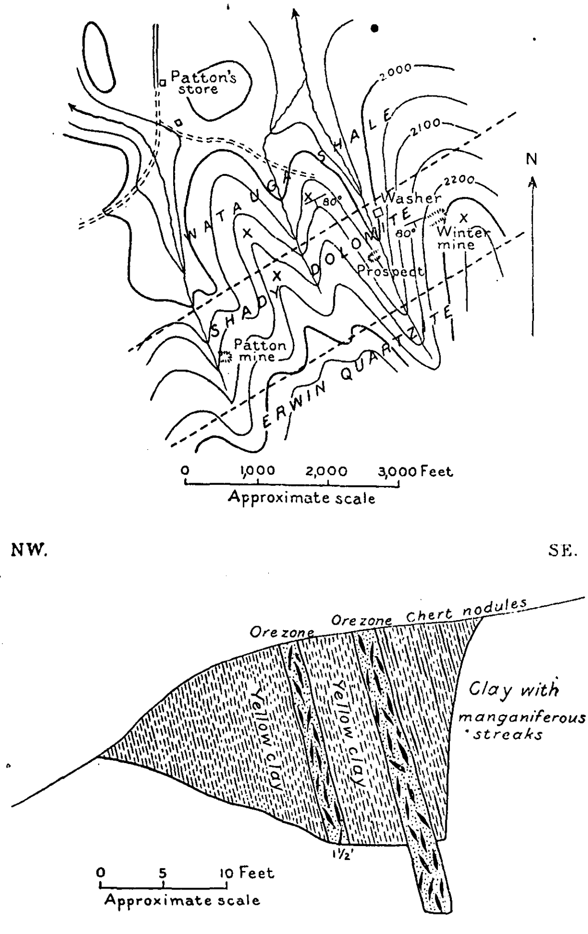


FIGURE 22.—Sketch map of vicinity of Winter and Patton mines, showing topographic and geologic relations, and sketch of the face of Winter mine pit, showing two ore zones in yellow clay.

banded yellow to red clay, somewhat streaked with manganese films and stains along the foliation planes. These beds strike N. 60° E. and dip 80° SE. (See fig. 22.) Purple shale of the Watauga outcrops to the northwest on the lower slope of the spur and has the same dip, indicating a steeply overturned monocline. The Erwin quartzite, fragments of which strew the surface of the steep slope above, outcrops higher on the mountain.

The ore consists of psilomelane and manganite, more than 50 per cent being crystalline manganite in part lining cavities. It occurs in nodules and irregular lumps, some weighing several hundred pounds. Its pitted or cellular character is apparently due to the fact that fragments of rock have been dissolved out of the ore. Some ore still firmly incloses fragments of chert.

The deposits are opened chiefly by a 40-foot cut, 16 feet deep at the face, and by an inclined shaft 20 feet or more in depth. The cut is in clay laminated by dark manganese stain and crossed by a zone 4 feet wide which contains nodules and a narrow band of soft ore. The shaft is 8 feet to the north of the cut and follows the ore zone down the steep dip.

Small pits extend 50 feet or more northeast of the mine toward old workings near the crest of the spur, and deposits are probably distributed over an area of several acres near the mine. Float ore is reported to have been traced northeastward along the slope of the mountain for more than a mile. Southwestward across a small ravine on the steep slope of the interstream bench, some pits reveal good nodular ore in characteristic dark-red soil, indicating that this terrace also contains similar deposits. Another opening on the lower northwestern part of the same spur is in purple Watauga shale and shows only a little manganese ore.

Patton mine.—The Patton mine is 6 miles southeast of Johnson City, half a mile southwest of the Winter mine, on the same mountain slope. The property is owned by the Taylor heirs. The deposit was first opened in a small way in 1908 by S. Joberg, who shipped a little ore. In 1917 it was operated by the Maxwell Manganese Mining Co., of Elizabethton, which produced 30 tons of ore averaging 42.27 per cent manganese, 6.16 per cent iron, and 13.48 per cent silica. Late in 1918 the mine was leased to the Max Mining Co. and was operated in conjunction with the Winter mine.

The mine is opened by a pit at the foot of the steep north bank of a narrow gulch at the head of Powder Branch. (See fig. 22.) The pit extends below the bottom of the gulch and was flooded with water. The 20-foot face of the cut is yellow clay, residual from the Shady dolomite, and streaked with layers of wad and crossed by red-clay seams. The beds dip 55° S., being probably overturned in a steep monocline. The ore-bearing layer of dark waddy clay, which extends nearly to the surface, has a width of about 20 feet and carries masses of good ore.

The ore is nodular psilomelane with considerable crystalline manganite. Several lumps 2 feet in diameter of good ore were noted on the dump. The indications are that the property contains a fair reserve of workable ore.

Treadway prospect.—The Treadway prospect is 6 miles southeast of Johnson City and 1½ miles southwest of the Patton and Winter mines, already described, in the same belt with them, on the lower northwest slope of Gap Creek Mountain. It is in a small ravine on the east side of Dry Creek Gap, at an elevation of about 2,100 feet. The property is owned by George Treadway, of Okolona, and was prospected by W. H. Kemler, of Johnson City.

The deposit is in dark residual clay of the Shady dolomite apparently close to the contact of the Erwin quartzite. The structure is belived to be monoclinal, the Watauga shale on the slope below standing vertical and striking parallel with the mountain. A cut 12 feet deep at the face is driven into the north side of the ravine, exposing dark dry powdery clay and sandy wash containing a few small nodules of hard psilomelane and irregular bodies of wad. Some larger pieces of float ore of good grade occur below the cut, samples of which are reported to have analyzed 40 per cent manganese. The prospect is unpromising.

Hodge prospect.—The Hodge prospect is 6 miles southeast of Johnson City, on the southwest side of Dry Creek Gap, half a mile from the Treadway prospect last described. It is on a low bench on the northeast end of Little Mountain. It is owned by Frances Hodge, of Okolona, and was prospected by W. H. Kemler, of Johnson City.

The deposit is in residual clay of the Shady dolomite and in overlying sandy wash. A small offset of the mountain front at the gap is apparently due to a local syncline in the Shady dolomite and underlying quartzite, and the prospect apparently lies in this syncline. Dolomite outcrops at the creek.

The property has been prospected by several pits about 6 feet deep which show some siliceous manganese ore in reddish clay, but in the fields below large masses of good-grade psilomelane ore were plowed up and are reported to have analyzed 40 per cent manganese. Although the showing in the pits is poor the high-grade float ore on the slope and the apparent synclinal structure are favorable for the occurrence of a deposit of workable size, and further prospecting on the top of the bench above the present pits is recommended.

UNICOI DISTRICT.

Unicoi district is chiefly in Unicoi County and is described on page 81. One of the mines in this district, however, is in Carter County and is described below.

T. J. Brummett mine.—The T. J. Brummett mine is near the southwest county line, 4 miles northeast of Unicoi, on the Carolina, Clinchfield & Ohio Railroad. It is on the farm of T. J. Brummett, of Unicoi, and was operated by the Southern Manganese Corporation, of Birmingham, Ala. Some prospecting, presumably for iron, was done here in early days, but no further work was done until the spring of 1918, when the deposits were opened for manganese by W. H. Kemler, of Johnson City. By the middle of May an open cut 20 feet deep and several smaller pits had been dug and 10 tons of ore had been placed on the dump. The ore was said to run about 52 per cent in manganese. In October, 1918, the company is said to have shipped from this mine and the neighboring Susan Brummett

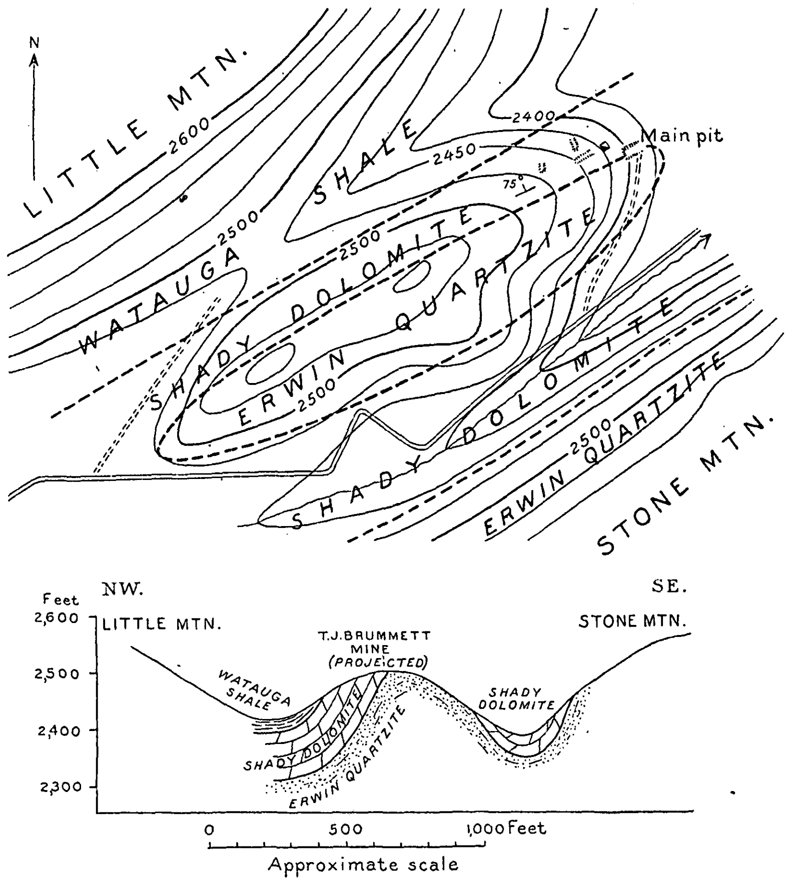


FIGURE 23.—Sketch map of vicinity of T. J. Brummett mine and geologic section through the mine, showing topographic and geologic relations.

and Britt mines 140 tons of manganese ore to the Southern Manganese Corporation, at Anniston, Ala.

The mine is on the north side of a small hill connecting Little Mountain and Stone Mountain at the heads of Scioto and Dry creeks, Little Mountain being the southwestward continuation of Gap Creek Mountain. The mine is on a bench approximately 2,400 feet in elevation, which accords in height with the stream divide and other neighboring valley-floor remnants. The small hill at the divide rises 150 feet above the bench. (See fig. 23.)

The deposit occurs in residual clay of the Shady dolomite at its contact with the Erwin quartzite, the structure being steeply monoclinal. The Scioto-Dry Creek valley is in general a syncline between quartzite mountains, faulted on its northwest side and inclosing Watauga shale in the center. Erwin quartzite is brought up on a local anticline on the small knob above the mine, and the narrow syncline lying southeast of the mine plunges southwestward down Scioto Creek and merges with the larger syncline. The Shady dolomite outcrops on the northwest side of the anticlinal hill adjacent to the quartzite, striking N. 45° E. and dipping 75° NW. The mine is in residual clay derived from this dolomite on the north slope of the hill. Watauga shale outcrops at the west foot of the hill.

The ore is chiefly psilomelane and occurs as nodules, lumps, and irregular bodies embedded in dark-red clay. Some lumps 2½ feet in diameter were seen, but most of the pieces are less than 3 inches across. Some of the ore has a botryoidal and mammillary surface, and much of it is cellular. Some is composed of thin, wavy concentric layers. On the east side of the main cut the ore is sandy and apparently replaces the Erwin quartzite at the contact. At the west side, next to a bed of iron ore, the manganese ore is speckled with small flakes of iridescent hematite. The deposit has been exposed by prospecting for about 500 feet in length and 150 feet in width, but all the material is not minable ore. Its depth has not been determined but probably does not average more than 15 feet.

The main cut is 40 feet long, 15 feet wide, and 15 feet deep at the face. It runs southwesterly into the hillside, apparently along the Erwin-Shady contact. Greenish and red sand on the east side, inclosing white quartzite masses veined with manganese, apparently represent the quartzite ledges on top of the hill. Between this and the dark-red soil of the Shady dolomite is a vertical layer of red hematite and black clay with manganese ore, and another vertical layer of manganese and iron ore occurs on the west side of the pit. The intervening red clay contains good nodular ore throughout and has yielded most of the ore thus far mined. Its lower limit has not yet been reached.

Fifteen feet west of the main cut an old shaft 10 feet deep exposes some good ore beneath an iron capping. Forty feet farther southwest a trench 80 feet long and 15 feet deep in red clay shows considerable manganiferous-iron ore from the surface down and a small amount of manganese ore in the lower part. Forty feet westward a 7-foot pit in red clay shows some ore in its lower part.

About 300 feet southwestward from the main cut and 15 feet higher up the slope a 12-foot cut with a face 5 feet high in dark earthy clay shows good psilomelane, pyrolusite, wad, and manganite from the surface to the bottom and has yielded considerable wash ore.

UNICOI COUNTY.

Unicoi County adjoins Carter County on the southwest. It is narrow and mountainous, its southeast boundary, also the line between Tennessee and North Carolina, following the crest of Iron, Unaka, and Bald mountains and its northwest boundary following the crest of Buffalo and other mountains. The long valley between these two lines of mountain chains is chiefly tributary to Nolichucky River, which crosses the county at its narrowest part, midway of its length. The manganese deposits occur chiefly at two active mines, the Susan Brummett and Britt mines, in the Unicoi district, and a few prospects in the Bumpass Cove district, in the northwestern part of the county.

UNICOI DISTRICT.

The Unicoi district embraces the area around the town of Unicoi, in the northeastern part of Unicoi County, including the valleys of North Indian Creek and its tributaries. Mining is restricted to the valley of Scioto Creek. (See fig. 24.)

Susan Brummett mine.—The Susan Brummett mine is 3 miles northeast of Unicoi, on the Carolina, Clinchfield & Ohio Railroad, on the farm of Susan Brummett, of Unicoi. It was operated by the Southern Manganese Corporation, of Birmingham, Ala., and produced some ore about 1885, and it then lay idle until it was reopened in the spring of 1918 by W. H. Kemler, of Johnson City. Later it was taken over by the Southern Manganese Corporation. The ore produced by this corporation was shipped with that taken from the

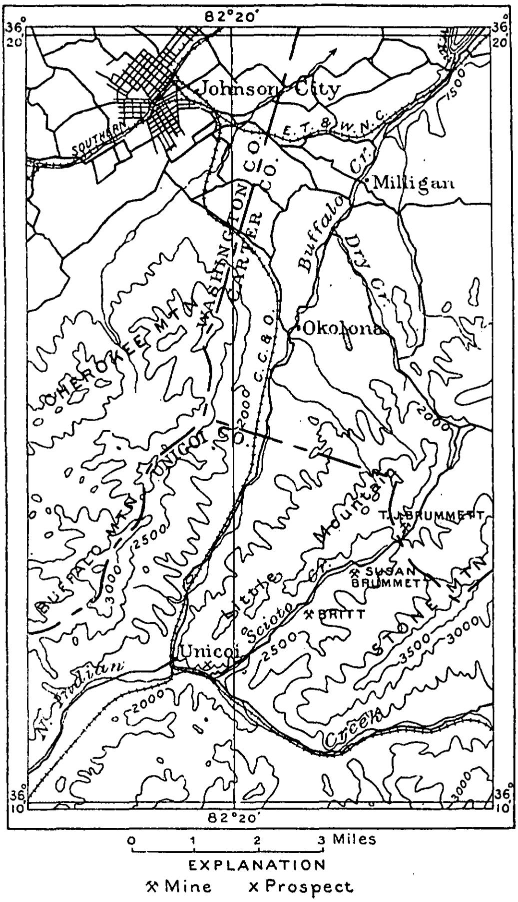


FIGURE 24.—Map of Unicoi district, showing location of manganese mines and prospects.

T. J. Brummett mine. The mine was equipped with a double-log washer and storage tanks, and as the creek utilized for the washing carried but little water it was the company's intention to lay a pipe line from North Indian Creek, near Unicoi, to the mine. According to Maxwell[26] the plant was later equipped with grizzlies, trommels, picking belt, and Harz jigs.

The mine is on the east side of Scioto Creek, at the northwest foot of Stone Mountain, on a terrace about 50 feet above the creek. It is in surface wash and dark-red clay which lies between outcrops of Watauga shale at Scioto Creek and Erwin quartzite on Stone Mountain and is evidently residual from Shady dolomite in a northwestward-dipping monocline. The surface below the mine is strewn with chert from the Shady. Surface indications of ore are reported to have been traced for 5 or 6 miles northeast from Unicoi along the southeast side of Scioto Valley. Part of this land is included in the Unaka National Forest, in which no mining had been done.

The deposit is opened mainly by an open cut running northward 50 feet into the hill from a small ravine. It is 10 to 20 feet wide and 20 feet deep at the face. The ore occurs chiefly at the bottom of the surface wash, but a little is found in the underlying dark-red residual clay. Most of it is psilomelane, and it includes a little manganite and pyrolusite. The ore is of low grade, much of that from the surface wash inclosing sand grains, and it is reported to analyze 38 per cent manganese. The company intended to wash all the dirt handled, as it was said to run one-third ore.

Britt mine.—The Britt mine is in the northeastern part of Unicoi County, 1 mile southwest of the Susan Brummett mine and 2 miles northeast of Unicoi. It is on the farm of J. L. Britt, of Unicoi, and was first opened in 1898 by Colonel Kirk, who shipped a carload of ore. It was reopened early in 1918 by W. H. Kemler, of Johnson City, and later in the year was taken over by the Southern Manganese Corporation. According to Maxwell[27] a double-log washer well equipped with accessories for efficiently treating the ore was installed, and the ore produced was shipped with that from the T. J. Brummett mine.

The mine is on a bench on the east side of Scioto Creek, about 50 feet above the creek, at the northwest base of Stone Mountain. The deposit is in surface wash which overlies brownish variegated clay of the Shady dolomite near its contact with the underlying Erwin quartzite on the southeast, the structure being monoclinal. As no rock outcrops were observed the dip was not definitely determined.

[26] Maxwell, H. V., Manganese ore in east Tennessee: Eng. and Min. Jour., vol. 107, No. 2, p. 149, Jan. 18, 1919.

[27] Op. cit., p. 149.

The deposits are opened by about 10 narrow cuts running northwestward into the hill from a small side ravine and spaced over a distance of 300 feet. Other prospect pits were reported several hundred yards north of the mine but were not visited. The longest cut is 60 feet and the deepest is 22 feet at the face. Little ore was seen in the walls of most of the cuts. The cut closest to the sandstone contact at the southeast, which is also the largest and deepest, shows two layers of dark wad carrying psilomelane interbedded with dark slickensided clay which incloses sandstone fragments and persists to the bottom of the cut.

The ore is of low grade, high in iron and silica, and there is doubt whether it can be profitably worked unless all the dirt handled proves to be wash ore. It is chiefly nodular psilomelane, much of which incloses grains of quartz, and some pieces have a thin coating of red oxide of iron. Small fragments of crystalline manganite and soft black pyrolusite and wad are also present.

About 80 tons of wash dirt, a few tons of coarser red-coated ferruginous manganese ore, and considerable iron ore lay on the dump. and several tons of screenings had been washed in a trough by a strong current of water in a flume.

Unicoi prospects.—Several other prospects or surface showings of ore are reported in the vicinity of Unicoi in the national forest. Old iron pits and discarded machinery were seen on the slopes of the surrounding hills, and manganese indications occur in a road cut at the south end of Little Mountain. Manganese float is reported on the bench 2,100 to 2,200 feet in elevation all along the northwest foot of Little Mountain, and some prospecting had been done by Mr. Blevins, of Unicoi. As the geologic and surface conditions are favorable for the occurrence of manganese ore and as it is in the same ore zone as the Winter and Patton mines, this bench from Unicoi northeast to Dry Creek Gap is a desirable place to search for workable deposits.

BUMPASS COVE DISTRICT.

Bumpass Cove lies southwest of Embreeville, partly in Unicoi County and partly in Washington County. As most of the opened manganese prospects are in Unicoi County, they are all described here under the head of Bumpass Cove district. The cove is almost entirely inclosed by mountains.

Embree prospect.—The Embree prospect is at the northwestern border of the county near the head of Bumpass Cove, 3 miles southwest of Embreeville. It is on the private railroad of the Embree Iron Co., which is an extension of the Embreeville branch of the Southern Railway, running from Johnson City. The deposit extends northeastward across the county line into Washington County.

The property is owned by the Embree Iron Co., of Chicago, Ill. Iron ore was mined here by the company for many years, and more recently zinc and lead have been chiefly mined on the south side of the cove. Manganese has been only recently discovered, and prospecting by the company began in 1918. The manganese deposits are on the northwest side of the cove on a bench about 2,070 feet in elevation, which is a remnant of an old valley floor. (See fig. 25.)

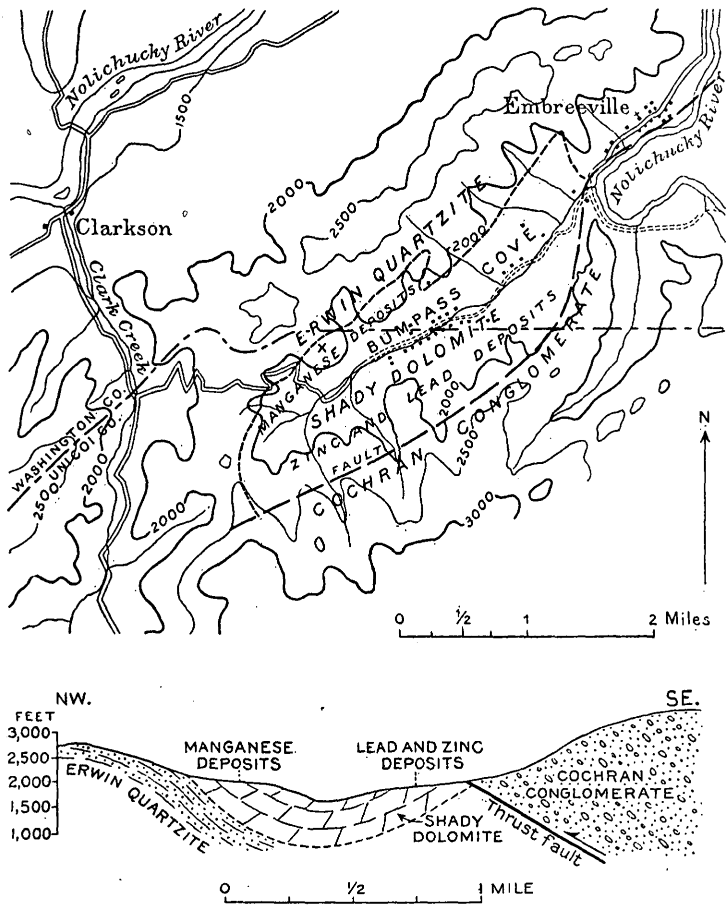


FIGURE 25.—Sketch geologic map of Bumpass Cove, showing location of manganese and other metalliferous deposits, and geologic section across the cove.

The deposit lies chiefly in dark-reddish and yellowish clay residual from the Shady dolomite close to the contact with the underlying Erwin quartzite. The structure is monoclinal, the quartzite dipping 45° SE. Fresh Shady dolomite outcrops almost horizontally near the valley road in the bottom of the Bumpass Cove syncline. (See fig. 25.) The deposit trends northeast, parallel with the strike of the rocks, and is opened interruptedly for a distance of half a mile by pits, shafts, and cuts to depths of about 20 feet. Openings in the thick surface wash on the terrace reveal more iron ore than manganese, but larger amounts of manganese probably occur at greater depth in the underlying residual clay. Solid bedrock has not been struck in the manganese pits on the terrace, but on the south side of the valley great pinnacles of it have been exposed in the deep zinc workings. (See Pl. XXI, *B*, p. 58.)

The ore consists largely of psilomelane in nodules and small lumps of irregular size and form, and a considerable part of it is soft black pulverulent material consisting of pyrolusite and wad, locally called

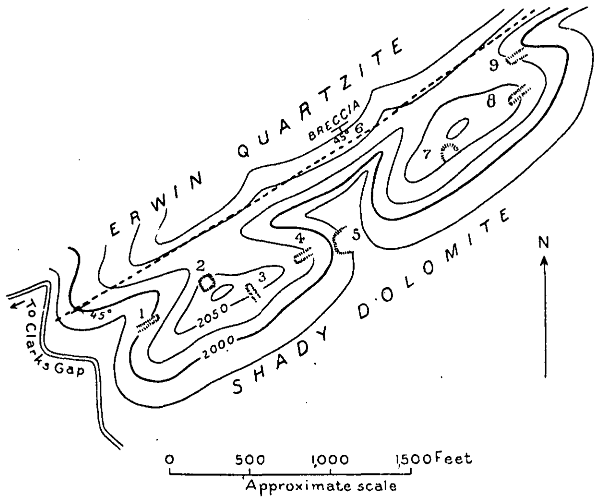


FIGURE 26.—Sketch map of the vicinity of the Embree manganese prospect. 1, Main pit exposing clay containing chiefly nodules of psilomelane and some fragments of chert; 2, shallow pits containing some ore and many fragments of chert: 3, deep trench exposing chiefly iron ore; 4, cut exposing pockets chiefly of high-grade needle ore; 5, old iron-ore pit containing many fragments of chert and, at bottom, some good-grade manganese ore; 6, brecciated quartzite cemented and in part replaced by manganese oxide; 7, shallow pits exposing many fragments of chert; 8, some ore of good grade and many fragments of chert in shallow trench; 9, new deep trench in yellow clay, with needle ore in bands and pockets of black wad.

"plumbago," which it resembles. Crystalline manganite in the form of "needle" ore is also present in considerable amount. Some nodules several inches in diameter are composed of psilomelane and acicular manganite arranged in alternate concentric layers. (See Pl. VII, p. 10.)

The southwesternmost opening, which is just east of the Clarks Gap road, about 50 feet above an outcrop of Erwin quartzite (see fig. 26), is a shallow trench in the surface of the bench that runs northeastward and exposes clay containing chert and sandstone fragments. Psilomelane nodules and soft pyrolusite ore are sparingly present. An old iron-ore pit scars the east slope of this bench, and at its northeast side a deep cut has been recently driven in from a small ravine, in the walls of which considerable good-grade ore shows. Large nodules of needle ore, such as are illustrated in Plate VI, were obtained here. In an old pit in the ravine manganese ore occurs in banded clay containing many cherts and probably residual from the basal part of the Shady dolomite. On the slope northwest of this pit a ledge of brecciated quartzite, which has been cemented and partly replaced by manganese ore, has been opened but is too siliceous to be a workable ore.

On the bench on the northeast, especially at its northeast side, are several openings, two of which are deep cuts exposing considerable ore, some of which is good needle ore. Bands 6 to 8 inches thick of black wad alternating with yellow buckfat dip northwest at a low angle into the bench, suggesting a syncline. A high ledge of brecciated ferruginous quartzite, which lies northeastward across a ravine, is apparently Erwin quartzite on the southeast limb of the syncline.

Farther northeast, in Washington County, the bench on the lower slope of the mountain was being systematically prospected with a Keystone churn drill to a depth of about 200 feet for zinc and lead and incidentally for manganese.

Although no manganese ore has been shipped from the property, so far as known, several tons of high-grade ore had been hauled to the railroad, and enough such ore showed in the walls of the prospect to warrant mining on a small scale. The tops of the terraces, which have a thick cover of wash, have not been tested to sufficient depth to determine the presence of ore in the clay, where the thicker deposits may be expected.

WASHINGTON COUNTY.

Washington County, of which Johnson City is the county seat, lies west of Carter and Unicoi counties and includes a small part of the Appalachian Mountains along its southeast border, in which manganese ores have been reported. Those in Bumpass Cove have already been referred to. A deposit at the head of Dry Creek, between Cherokee and Buffalo mountains, was also reported. According to the geologic map published by the United States Geological Survey,[28] a small area there is underlain by clay residual from the Shady dolomite in a deep syncline faulted on the southeast side and is therefore favorably located for the accumulation of ore deposits.

GREENE COUNTY.

Greene County, of which Greeneville is the county seat, lies west of Washington County. Its southeast boundary, which is also the State boundary, follows the crest of the Bald Mountains. The

[28] Keith, Arthur, U. S. Geol. Survey Geol. Atlas, Roan Mountain folio (No. 151), 1917.

county contains several manganese deposits, all of which occur 10 to 14 miles south of Greeneville, in the intermontane valleys of the Appalachian Mountains. The deposits include the Haysville, Sylvia, Lamb, and Payne prospects, all in the Haysville district.

HAYSVILLE DISTRICT.

The Haysville district includes the area which surrounds the old iron mines and furnace at Haysville and extending thence south to the State line.

Haysville prospect.—Haysville and the old Haysville furnace are 10 miles in direct line or about 14 miles by road south of Greeneville. The deposits are half a mile south of the furnace, at the site of the old Haysville iron mine. The property is owned by the Unaka Development Co., of Greeneville, Tenn., which has recently done some exploratory work on it. In 1917 the Virginia Iron, Coal &

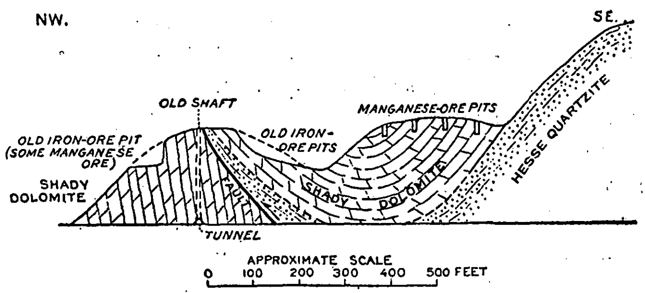


FIGURE 27.—Sketch geologic section through the Haysville prospects.

Coke Co. dug many pits and tunnels, exposing iron ore and some manganese.

The iron and manganese deposits occur on a terraced hill at the northwest foot of a low spur of Bald Mountain. Dolomite is exposed on the lower north slope of the hill, where it dips 80° S., and it occurs on the south side of the hill at the crest and lower down. Quartzite masses at the crest and quartzite in the dump from the shaft suggest that the body of the hill is Hesse quartzite. The structure is complicated but seems to consist of a local sharp anticline of Hesse quartzite, faulted on its northwest side and overthrust upon the Shady dolomite. A shallow syncline of Shady dolomite is inclosed between it and the quartzite monocline of the main mountain. (See fig. 27.) This low hill is covered with old workings for iron, chief of which is a tunnel 750 feet long, running northwest into the hill from a small branch of Back Creek and connecting with a shaft 180 feet deep sunk from the top of the hill. Several large cuts on both the north and south slopes of the hill mark the extent of the old mining industry. The overburden covering the iron-ore ledges and bedrock is 10 to 30 feet of clay and wash, which contain small fragments of iron ore and some manganese ore. Most of the iron ore mined is said to have contained about 5 per cent manganese.

From an old cut 100 feet wide and 80 feet high at the face, a short distance north of and down the slope from the shaft, at an elevation of about 1,650 feet, several tons of pyrolusite ore was recently taken out. The ore is partly of fine-shot type and partly soft and powdery. Some of the ore was bagged and shipped to New York for making paint or stove polish and was reported to have assayed more than 50 per cent manganese with but little iron or silica. It is, however, too impure for chemical ore. Some harder psilomelane and iron balls with soft waddy ore inside are also present. The deposit lies in pockets in residual clay and chert of the Shady dolomite, and the ore was mined from short tunnels and pits near the bottom of the large cut. In one pit a band of soft waddy clay stands vertical, parallel to a 3-inch seam of barren clay, and these layers probably represent the original bedding. A ledge of weathered buff chert, coated and seamed along joint planes with manganese, which is exposed in the upper part of the cut, is also nearly vertical, dipping 80° S., and is probably overturned. A tunnel recently driven southward into the face of the big cut penetrated a considerable amount of soft clayey and ferruginous wad and farther into the hill is reported to have encountered some excellent manganese ore. The ore is not easily accessible because of the depth at which it occurs, and much of it, being soft, is expensive to mine because of the care required in handling it.

In the southerly pit on the saddle connecting the hill with the mountain and close to the Hesse quartzite outcrops a lump of very high grade psilomelane was found at a depth of about 30 feet. It lies in yellow clay derived from the Shady dolomite, and fresh dolomite is encountered in some of the adjacent pits.

Judging from the hundred or more prospect pits that have been sunk the Haysville tract is mainly an iron-ore property, even though much of the iron ore is manganiferous and good manganese ore has been found in several places.

Sylvia prospect.—The Sylvia prospect is 11 miles south-southwest of Greeneville and 4 miles southwest of Haysville furnace. It was operated as an iron mine by the old Haysville Iron Co. prior to 1874 and has recently been opened for manganese by Leroy Park and J. C. Park, of Greeneville, who have acquired the property.

It is on a bench about 2,170 feet in elevation, on the front of a spur at the northeast end of Meadow Creek Mountain, a remnant of an old valley floor. The mine was reached by a good wagon road from Cove Creek, on the east

The deposit occurs in residual clay of the Shady dolomite close to the contact with the underlying Hesse quartzite, which forms the spur just back of the mine. The geology is complicated by faulting. A small knob north of the mine is composed of soft sandstone which stands nearly vertical and probably represents a small anticline of the underlying quartzite, from which the structure at the mine is interpreted to be that of a small local syncline. A shaft and several pits not more than 12 feet deep had been dug in the bottom of the old iron mine, but they had caved in. A little manganese ore disseminated in yellowish-red clay and fragments of buff chert seamed with a white fibrous mineral, wavellite, lay on the dump. The ore is psilomelane of good grade in small nodules and irregular fragments. Samples are said to have analyzed 52 per cent manganese, but the run-of-mine ore will not average so much. Unless further prospecting discloses a better deposit the prospect will not be profitable to work.

Lamb prospect.—The Lamb prospect is near the south corner of the county, about 13 miles south of Greeneville and 2½ miles south of Limestone Springs, and is on the Scott Lamb farm south of the Allen Stand road, in an open field a short distance west of the tenant cabin. It is on the lower northwest slope of the mountains just east of Cove Creek, at about 1,800 feet elevation, in the saddle of a terraced ridge which is a remnant of an old valley floor.

The deposit occurs in red clay residual from the Shady dolomite near the contact with the overlying Watauga shale, the structure being monoclinal. It is opened by a shallow shaft sunk many years ago, apparently for manganese. The shaft is now caved. A specimen of fairly good grade nodular psilomelane was found on the dump. It is reported that a series of old manganese prospects extends eastward from the shaft for half a mile or more, some of which look encouraging.

Payne prospect.—Leroy Park, of Greeneville, has reported that he obtained samples of good-grade ore from property owned by Henry Payne, on the upper south slope of the Meadow Creek Mountains, 9 miles from Del Rio, Tenn., and 9 miles from Hot Springs, N. C., on the Southern Railway. The prospect was not visited by the writers. According to the geologic map published by the United States Geological Survey [29] the surface there is underlain by Shady dolomite resting on Hesse quartzite and Murray slate, which seems to show that the deposit is associated with the Shady dolomite.

COCKE COUNTY.

Cocke County, of which Newport is the county seat, lies southwest of Greene County, adjacent to the North Carolina State line. The

[29] Keith, Arthur, U. S. Geol. Survey Geol. Atlas, Asheville folio (No. 116), 1904.

southeastern part of the county is mountainous, and the manganese deposits occur at the foot of the mountain slopes on or near remnants of the old valley floors of French Broad and Pigeon rivers. They occur in the Del Rio and Newport districts, but mention is made by Harder[30] of manganese ore also near Cosby, west of Denny Mountain.

DEL RIO DISTRICT.

The Del Rio district is in the eastern part of the county, in the heart of the mountains around the town of Del Rio, which is on French Broad River and on the Morristown-Asheville line of the Southern Railway. The more prominent mountains in the district are Meadow Creek, Neddy, and Stone mountains on the northwest and the northeastward continuation of the Great Smoky Mountains on the southeast, the crest of which is followed by the State line.

Wood mine.[31]—The Wood mine is 5 miles northeast of Del Rio, on the south slope of the Meadow Creek Mountains, and is owned by Nick Wood, of Del Rio. It was last worked in 1906 by J. N. Adams and associates, of Charleston, Tenn., and it is reported that some ore was then shipped. It is on the steep south slope of the mountains, at an elevation of 2,170 feet, in brownish to chocolate-colored clay, apparently residual from dolomite, resting on the Hesse quartzite near its contact with the overlying Shady dolomite and seems to be at or near an east-west fault.

The principal opening is a pit 15 feet in diameter and 8 feet deep, which formerly was somewhat deeper. Its approach is a 50-foot cut which runs N. 60° E. into the hill. Ore is shown more or less throughout the walls of the pit and the cut, and about 2 tons of shipping ore and 10 or 12 tons of wash ore lay on the dump. The ore is nearly all of the coarse hard nodular or lump type. It consists almost wholly of massive psilomelane with very little concentric banding or botryoidal and stalactitic forms. Much of the weathered portion is pitted. Pitting is seen also in the croppings at the southwest edge of the pit, where massive coarse ore stands 6 to 8 inches above the surface for a width of 6 feet. The preservation of the croppings seems to be due to the presence of quartz. Wavellite is more or less plentiful throughout the ore as a secondary mineral, forming small irregular stringers and veinlets filling fractures, small lenticular bodies, and beads in cavities. On flat surfaces of the ore it occurs as fan-shaped aggregates of radiate fibrous crystals

[30] Harder, E. C., Manganese deposits of the United States: U. S. Geol. Survey Bull. 427, p. 76, 1910.

[31] Descriptions of the Wood, Adams, Blanchard, and Waddell mines and of the Huff and Lamb prospects, the latter in Greene County, are by F. C. Schrader.

up to half an inch in length. The ore, therefore, contains considerable phosphorus.

The deposit trends a little north of east, parallel with the mountains, and seems to dip to the southeast approximately in accord with the country rock, which is exposed in the valley of Laurel Branch, to the southwest. Shallow prospect pits and trenches dug at intervals for a distance of 400 feet east of the mine show traces of ore similar to that at the mine.

The deposit probably contains considerable manganese ore, but owing to its high content of phosphorus and the distance to the railroad it can not at present be profitably worked.

Adams mine.—The Adams mine is 2 miles northwest of Del Rio, in the steep lower slope of the northeast end of Stone Mountain, at an elevation of 1,600 feet. It is 400 feet above and about one-third of a mile distant from the Southern Railway. It is owned by John N. Adams, of Charleston, Tenn. It was last worked in 1908, when it is reported to have produced eight carloads of ore, amounting to about 300 tons, which is probably an overestimate. The ore was shipped to Johnson City, Tenn., unwashed in bags and is said to have averaged 47 per cent manganese.

The deposit occurs in residual clay of the Shady dolomite near its contact with the underlying Hesse quartzite, which here seems to be also a fault contact. Much of the quartzite is deep yellowish brown from impregnations of limonite. The clay is mostly light brownish but is variegated by large and small chocolate-colored to black masses. It contains fragments of partly decomposed quartzite and chert resembling fault breccia, seemingly derived from the lower part of the Shady dolomite. The deposit dips westward into the mountain and is reported to have a thickness of more than 50 feet, its lower limit not having been reached in a 40-foot shaft sunk from the bottom of a cut 15 feet deep. Croppings and surface débris indicate that the deposit probably extends southwestward up the mountain slope.

The ore consists chiefly of layers or beds of massive, soft sooty wad and pyrolusite with considerable hard nodular manganite and psilomelane. The manganite occurs mainly in radial fibrous acicular crystals in concentric bands alternating with hard blue psilomelane. Only the soft ore was shipped for the manufacture of stove polish, it is said. A ton or two of soft ore and 3 or 4 tons of washed ore lay on the dump.

Blanchard mine.—The Blanchard mine is about 2 miles northwest of Del Rio, half a mile south of the Adams mine and on the same spur of Stone Mountain. It is owned by William Blanchard, of Del Rio. It was worked by the Commercial Mining & Milling Co., of Del Rio, in 1902, when it is said to have shipped about 200 tons of unwashed ore averaging 47 per cent manganese. It was later operated by the Barium Lithopone Co., of Philadelphia. Its development consists of five or more openings in the steep east slope of the mountain at elevations between 1,750 and 1,900 feet.

The openings are mostly in the Hesse quartzite or perhaps in transitional beds at the contact with the Shady dolomite, which seems to be also a fault contact. The ore zone appears to be the southward continuation of the mineral zone at the Adams mine. The ore is principally hard, concretionary, nodular psilomelane but includes also some manganiferous iron ore.

At one of the main openings, on the north side of an eastward-sloping spur at 1,850 feet elevation, the deposit seems to consist of a 6-foot bed of good-grade nodular psilomelane in soft white sandstone which dips 40° SW. The ore adheres to the walls of the sandstone and partly impregnates and replaces it. About 50 tons of the ore shipped in 1902 is reported to have come from this opening. At an opening on the opposite or south slope of the spur, 1,790 feet in elevation, conditions are similar except that the workings are more extensively caved and overgrown with vegetation, and the quartzite includes fine conglomerate with small white quartz pebbles. It is reported that 140 tons of ore from this opening was included in the shipment made in 1902. Approximately 4 tons of ore on the dump was of good-grade concretionary nodular psilomelane containing crystalline manganite with radial and parallel fibrous acicular structure. One lump was 2½ feet in diameter. Some specimens show mutually facing comby structure.

In a tunnel a short distance down the ridge toward the southeast the deposit consists mainly of a 2½-foot tabular body of ore in red clay and sandstone dipping 60° WSW., into the mountain. The walls are chiefly altered liver-colored ferruginous siliceous rock, which the ore deeply penetrates and replaces. The ore is similar to that just described, except that in places it is slightly waddy and siliceous from finely crystalline vitreous quartz lining small irregular cavities. Some of it is stalactitic. Some high-grade ore taken from this opening has been shipped, and several tons of concretionary nodular ore lay on the dump.

Waddell mine.—The Waddell or Pigeon Roost mine is 3 miles west of Del Rio and 1½ miles south of West Myers station, on the Southern Railway. It is owned by John B. Waddell, of Springfield, Mo. It was worked in 1892 by Sugars & Oliver, but so far as learned no ore was shipped. In the early part of 1918 it was again worked by the Southern Manganese Corporation, when 10 tons of manganese ore was taken out, which is said to have exhausted the deposit.

The mine is on the south slope of an eastern ridge of Stone Mountain at an elevation of 1,900 feet, on the west side of a gulch that drains southward into Big Creek. It is on a newly made mountain wagon road from the near-by Dicky kaolin mine to West Myers station.

The deposit occurs in dark-reddish ferruginous quartzite, which seems to be the Nebo quartzite, and in overlying clay, which is probably residual from Hiwassee slate. It is opened by a pit 25 feet in diameter which originally may have been 25 or 30 feet deep but is now caved. The ore bed seems to dip to the northeast and to be 8 or 10 feet thick.

About 20 tons of ore on the dump consists chiefly of hard psilomelane nodules and masses, in which radial and parallel aggregate stalactitic structure is dominant. Some fragments are botryoidal on a small scale. The ore heavily incrusts joint plans and fracture surfaces of the quartzite and commonly penetrates and replaces it to a depth of several inches. At a point several feet northwest of the mine specimens of dark wad in clay were exposed in shallow cuts of the wagon road.

Long Creek prospect.—The Long Creek prospect, on a farm of Aleck Huff, of Del Rio, is on the east side of Long Creek, 3 miles north-northwest of Del Rio and half a mile northeast of the Del Rio-Newport wagon road. It is on the side of a low spur at the southwest end of Meadow Creek Mountain and is in chert and clay residual from the Shady dolomite at its contact with the underlying Hesse quartzite. The beds at the prospect seem to be vertical and faulted. In the creek near the road fresh Shady dolomite dips 45° SW.

The developments are old caved workings. A tunnel which runs north into the hill from a small branch of Long Creek follows a ferruginous chert lode which lies at the fault contact of the quartzite on the east and dolomite clay on the west. Several slumped trenches show only reddish clay, but a little psilomelane is present on the dumps. Lumps of iron ore, whch may be somewhat manganiferous, some as much as 1½ feet in diameter, occur as float.

Huff prospect.—The Huff prospect is 4 miles northwest of Del Rio on the Newport-Del Rio wagon road. It is in the lowland north of Neddy Mountain, on a farm of Aleck Huff, of Del Rio. It was first opened for manganese in 1892 by Mr. Icewall, of Atlanta, Ga., who excavated the large pit just northwest of the barn, but no ore was shipped. The pit is in Watauga shale near its contact with the underlying Shady dolomite. The shale, which outcrops a short distance west of the pit, dips 60° E.

In 1918 John N. Adams, of Charleston, Tenn., is reported to have dug the 50-foot open cut in the barnyard. This cut has a face 8 feet high in red clay, probably derived from the Shady dolomite, containing black or dark-gray angular blocks of the so-called ore, some as much as 2 feet in diameter. The so-called ore, many tons of which has been used in the stone fences on the property, is a fine-grained chert, profusely stained and slightly impregnated with manganese, and is composed of 75 to 80 per cent silica and very little manganese or iron. Some of the material is finely porous with scattered cavities half an inch in diameter, closely resembling slag. Some of the cavities and crevices are thinly coated with crystalline manganite. The deposit is too siliceous to be an ore of manganese and has no commercial value.

NEWPORT DISTRICT.

The Newport district includes the area around the town of Newport, on the Morristown-Asheville line of the Southern Railway, in the western part of the county. The known deposits are on the north end of English Mountain.

Newport mine.—The Newport mine, formerly called the Yellow Springs, Carson Springs, and English Mountain mine, is 4 miles west of Newport. The deposit was discovered on the estate of John Sant in 1883 by George Francis, who is said to have mined and shipped 120 tons of unwashed nodular manganese ore taken from a small pit at the mouth of the present working. For some distance beyond this rich body ore was found only in sporadic small pockets, but the work on these pockets led to the discovery of the deposit recently mined by the Newport Manganese Corporation, of Newport. The ore shipped by this company is said to have run about 37 per cent manganese, 8 per cent iron, and 12 per cent silica, although 120 tons of ore that averaged more than 40 per cent manganese was shipped in 1917.

A carload of high-grade ore shipped in 1918 ran 42.85 per cent manganese, 6.25 per cent iron, and 8 per cent silica, and a carload of poorer ore ran 34.78 per cent manganese, 0.11 per cent iron, and 12.10 per cent silica. Analyses of two of these shipments are reported to be as follows:

Analyses of two carloads of ore from the Newport mine.

	1	2
Moisture	5.77	4.68
Manganese (oxide not reported)	37.57	33.89
Fe (oxide not reported)	7.44	8.63
SiO_2	9.42	13.73
Al_2O_3	6.51	6.55
$CaCO_3$	.37	1.05
$MgCO_3$	.40	2.41
BaO	2.10	2.63
	69.58	73.57

Late in the autumn of 1918 the mine was reported to be producing monthly 50 tons of ore, averaging 30 per cent in manganese, from four tunnels. The face of the lowest tunnel is 55 feet below the surface. The tunnels apparently follow an irregular bed containing masses of high-grade ore, some weighing as much as 300 pounds.

The mine is on the northeast terminal slope of English Mountain, at the point where it descends into the valley of Pigeon River. It is at the edge of a bench that stands at an altitude of 1,680 to 1,750 feet. (See fig. 28.) The floor of the main pit of the mine is at an altitude of 1,680 feet, and several prospect pits, some old and some recent, which stand at about the same elevation, show fair indications of ore that extends interruptedly nearly a quarter of a mile southwest of the mine. Both nodular and stalactitic forms of manganese ore are embedded in the clay and wash of this bench.

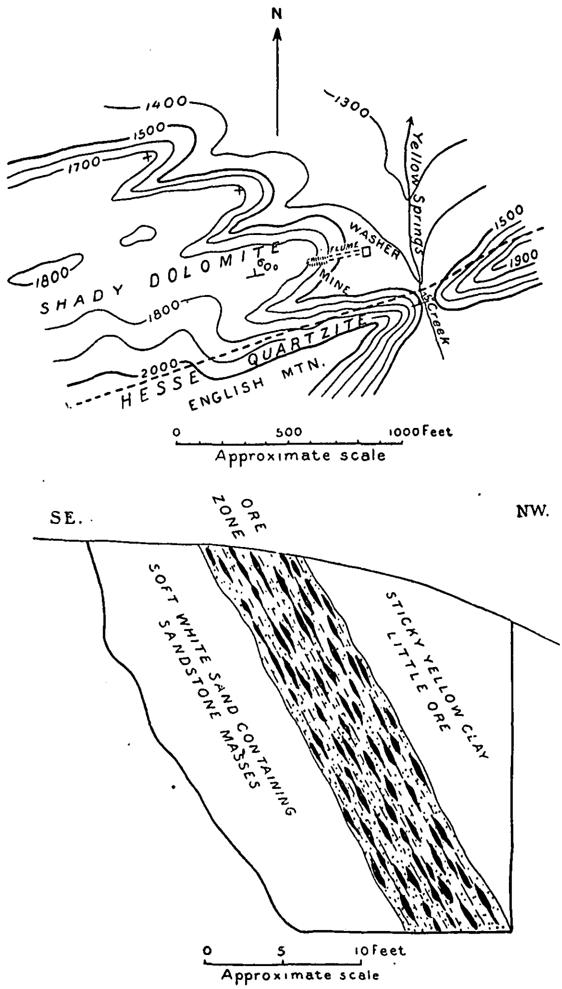


FIGURE 28.—Sketch map of vicinity of Newport mine, showing topographic and geologic relations, and sketch of face of mine pit, showing 6-foot ore zone of banded red and white sand and clay with pockets of ore.

The deposit occurs in residual clay from the basal beds of the Shady dolomite about 100 feet above the Hesse quartzite. The structure at the mine is monoclinal. The quartzite beds of the mountain, only 200 feet away, dip 75° N., toward the valley. The clays in the mine, which show similar bedding, dip 60° in the same direction. The main pit, which trends nearly east and west, is approximately 150 feet long by 50 feet wide and 50 feet deep at the face. It is excavated chiefly in reddish and brownish clay derived from the Shady dolomite and basal transitional beds, although the pit contains also pure-white sand or sandy clay. The clay of the south wall—the footwall—is chiefly white and very siliceous, containing rounded disintegrated fragments of sandstone or quartzite, and was probably derived from a sandstone or sandy limestone. It is firm and compact, so that this wall of the pit stands well. The clay of the north wall—the hanging wall—is sticky and mostly yellow and was derived from limestone or dolomite. The ore is contained in a layer, about 6 feet wide, of banded and partly mixed red, brown, lavender, bluish, and white sandy clay and sticky yellow clay, which evidently represents a brecciated layer at the top of basal sandy beds in the Shady dolomite. (See fig. 28.) The manganese was apparently leached by rising circulating waters from the porous sandy beds below, now left white, and redeposited in the beds next to the impervious clay roof, which was probably brecciated by caving after partial solution. The ore is sporadically embedded in this clay in the form of grains, nodules, and lumps, some as large as 3 feet in diameter. The overburden, which consists chiefly of red clay inclosing quartzite boulders, ranges from 1 to 10 feet in thickness. The ore extends nearly to the surface in the north bank of the pit.

As the ore is mined it is shoveled into the head of a steeply inclined flume 875 feet long, to which water is pumped, and is conveyed to a double-log washer 260 feet below the mine. In its passage down the flume, or launder, much of the ore is washed free of clay, but a considerable percentage of the ore is lost by adhering to barren sticky clay which is not separated in handling but is allowed to go down with the ore and is rolled into balls. On leaving the trommel, after passing through the washer, the ore which does not pass through a one-eighth inch mesh screen is conveyed by carrier belt to the storage bin and on the way is hand-picked by boys and women. About 30 per cent of the washed ore passes through the screen and constitutes the "fines." This part is jigged to further free it from silica.

Jones & McMahon prospect.[32]—The Jones & McMahon prospect is 4 miles southwest of Newport and about half a mile east of the Newport mine. It is on a terrace at the foot of the north end of the east prong of English Mountain, east of Sinking Creek Gap. The property is owned by Jones & McMahon, of Newport. The deposit occurs in wash and possibly extends down into the underlying clay, derived from the Shady dolomite. There are no large

[32] The descriptions of the Jones & McMahon prospect and the Raines mine are taken largely from Harder, E. C., op. cit., p. 76.

openings on the property, but very sandy float ore of irregular and stalactitic form is reported.

Raines mine.—The old Raines mine is 3 miles southwest of Newport and about 1 mile east of the Newport mine, on the George L. Gray farm, which has recently been bought by Barney Hurley, of Newport, who expects to redevelop the mine. It is at the northeast end of English Mountain, on a wash-covered terrace which is underlain by clay residual from the Shady dolomite. It was opened years ago and worked for a short time. The development exposes brown sandstone containing small specks and stringers of manganese minerals which have replaced the sandstone and in places are concentrated enough to be a low-grade siliceous ore. Irregular masses of psilomelane are scattered through the overlying clay.

HAMBLEN COUNTY.

Hamblen County, of which Morristown, near its center, on the Southern Railway, is the county seat, lies northwest of Cocke County and west of Greene County. Manganese ore occurs at several localities in the vicinity of Morristown, chiefly in the Boatman Ridge district, northwest of the city.

BOATMAN RIDGE DISTRICT.[33]

The Boatman Ridge district lies northwest and north of Morristown and includes several parallel northeast-trending chert ridges on which manganese ore has been found.

Lotspeich and Noeton prospects.—On Boatman Ridge, also called River Ridge, 5 miles northwest of Morristown, a prospect has been opened by J. N. Lotspeich, of Morristown. Manganese and manganiferous iron ores have been exposed on the property at a number of places by shallow pits, and it is reported that from one large mass of ore taken out several years ago 2 carloads of manganese ore were shipped. The ore is in residual clay and brecciated chert of the Knox dolomite and is siliceous.

Other prospects are reported on the northeast end of a spur of this ridge, south of Noeton Ferry, near the Tate Springs road, where similar conditions prevail.

Mays and Ivy prospects.—Farther southwest on Boatman Ridge, 6 miles west of Morristown, two prospects have been opened on the adjoining farms of Monroe Mays and G. N. Ivy. The pits are shallow and at the time of visit were slumped, so that little ore was to be seen.

The deposits are in residual chert and clay of the Knox dolomite, close to yellow shales and limestones of the underlying Nolichucky

[33] The descriptions of prospects in this district are taken largely from notes by Arthur C. McFarlan, of the Tennessee Geological Survey.

shale, the rocks dipping 15°–20° SE. The ore is psilomelane in chert, which is brecciated and cemented and partly replaced by the ore. As the ore is not plentiful and contains considerable associated iron and much silica in the form of chert, from which it can not be readily separated, the prospects are not promising.

Curry prospect.—The Curry prospect, 7 miles northeast of Morristown, on the Bright Mills road, is also in the chert hills of the Knox dolomite, at about the same horizon as the prospects on Boatman Ridge. A small amount of psilomelane and iron ore occurs in this pit as a fissure filling and replacement of chert. The deposit apparently is of no commercial value.

Other deposits, according to Penrose,[34] occur southeast of Morristown in red clay, but they were not being worked or prospected and were not visited.

GRAINGER COUNTY.

Grainger County, of which Rutledge, near its center, is the county seat, lies west of Hamblen County, Holston River forming the boundary line. It is mostly valley land, but its northwestern part is crossed by Clinch and Log mountains. Manganese ore occurs at several localities in the valley, three of which are in the Rutledge district and two in the Washburn district.

RUTLEDGE DISTRICT.

The Rutledge district consists of the area around Rutledge, in the center of the county, on the Knoxville-Morristown line of the Southern Railway. The known prospects lie mostly in the hilly Richland Knobs country southeast of the town.

Rutledge mine.—The Rutledge mine is 2 miles southeast of Rutledge, on the farm of J. H. Lowe, of Rutledge, and was operated by J. S. Swann, of Knoxville. No ore had been shipped at the time of visit, May 9, 1918, but about 100 tons was on the dump, 30 tons of which had just been mined. Unwashed ore shipped later in the year was reported from analyses to average 28.86 per cent manganese and 3.57 per cent iron, and on account of the low grade of the ore and its relatively small quantity the mine was closed down.

The mine is on the top of a prominent hill 650 feet above the railroad at Rutledge. The deposit occurs in residual clay and chert of the basal part of the Knox dolomite at or close to its contact with the underlying shale, which is presumably Nolichucky. The shales dip very gently southeastward, into the hill, the structure being apparently monoclinal. However, the presence of pure light-blue fine-grained limestone containing *Girvanella* and other fossils

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[34] Penrose, R. A. F., op. cit., p. 416.

in the midst of the shale on the slope below the mine and dips that indicate a syncline suggest that the Knox may possibly be overthrust on a shale younger than the Nolichucky. Further study of the surrounding region is necessary to determine this point.

The development consists of an open cut along the northwest face of the hill, 150 feet long and 20 feet high, chiefly in yellow and reddish clay residual from the Knox dolomite. (See fig. 29.) In a thin overburden of sandstone and chert wash there is some ore,

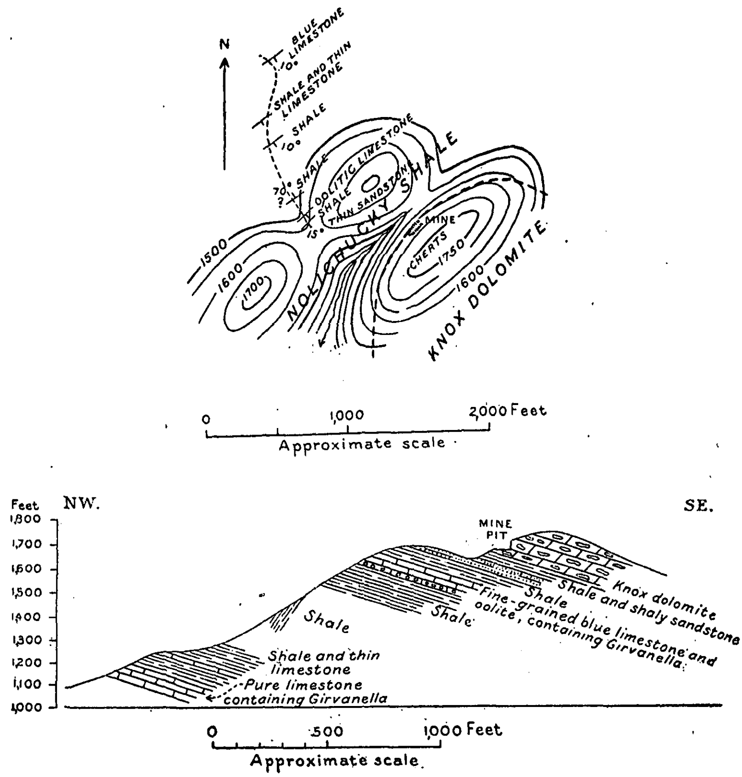

FIGURE 29.—Sketch map of the vicinity of the Rutledge mine, showing topographic and geologic relations, and section of hill on which the mine is located.

which contains scattered sand grains and more iron than there is in the residual clay below, and the top of the hill is covered with chert fragments containing considerable good manganese ore. Several bands of ore are exposed in the face of the cut. The northern band is composed largely of botyroidal masses and nodules of black psilomelane, more or less dulled by impurities and covered with a shell of iron oxide in places half an inch thick, the outer coating being generally a brilliant red oxide. These masses are embedded in sticky yellow clay. (See Pl. IV, *C*, p. 9) A middle band contains a thick body of heavy psilomelane ore inclosed in dense yellow clay. At the south end of the cut yellow clay containing chert partly replaced by manganese is laminated by manganese-stained clay and thin layers of ore which dip 10°–30° NW. and seem to follow the original bedding, as do also the vertical bands of ore. (See fig. 30.) The discordance of this supposed bedding with that of the underlying shale is another indication of faulting.

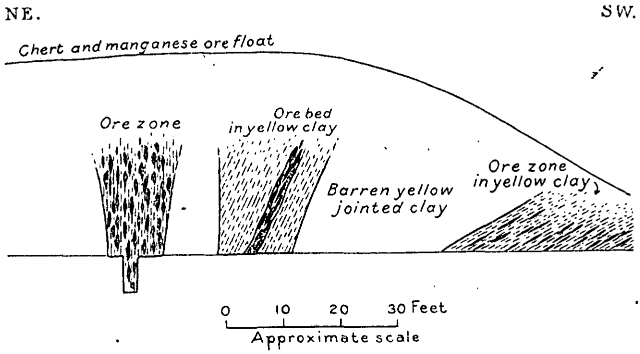

FIGURE 30.—Sketch of face of Rutledge mine pit, showing three ore zones separated by barren laminated and jointed yellow clay.

As most of the ore is embedded in red and yellow sticky clay which fills crevices and indentations in the botryoidal surfaces, it will require thorough washing to prepare it for shipment. As an adequate water supply for this purpose had not been provided, the ore marketed was shipped unwashed and consequently ran low in manganese. The ore in the chert of the overburden and scattered over the surface will require crushing and hand picking to remove much of the silica before it will be suitable to ship.

Harmon prospect.—The Harmon prospect, on the farm of Joe Harmon, of Rutledge, is 2½ miles southeast of Rutledge. It was leased by J. S. Swann, of Knoxville. At the time of visit the deposit was exposed only in the bed and bank of a small branch of Richland Creek. It occurs in yellowish and dark banded clay residual from the Nolichucky shale or the overlying Knox dolomite, the rocks dipping 10° SE. A 3-foot bed of banded clay with dark manganiferous clay containing a little ore crosses the stream bank diagonally, and considerable small psilomelane float lies on the surface. Some of the pebbles in the stream gravels of the valley bottom are cemented with black manganese ore, and the water of the stream blackens pebbles in its bed, showing that the streams carry manganese in solution.

Young and Swann propects.—Manganese float ore is reported on the farm of B. F. Young, of Knoxville, in the Richland Knobs 6 miles south of Rutledge and 2 miles south of Doyal post office. It is in the Knox dolomite and occurs as small fragments mixed with soil and chert. Specimens of manganese float ore have been found on several other farms southwest of the Rutledge mine, one of which, about 6 miles distant and on the top of the high front line of knobs, similar in location to the Rutledge mine, had been slightly prospected and optioned to J. S. Swann and is called the Swann prospect.

WASHBURN DISTRICT.

The Washburn district includes the area around Washburn on the Knoxville-Middlesboro line of the Southern Railway, particularly the valley country northwest of Clinch Mountain. Indications of manganese occur at several localities.

Wallen prospect.—The Wallen prospect is 4 miles northeast of Washburn, on the lower south slope of Copper Ridge, 1½ miles northeast of Puncheon Camp. It is on William Wallen's farm, the mineral rights on which were leased by R. B. Bundren, of Washburn, but no openings had been made. The prospect consists merely of a few large lumps and small fragments of very good grade psilomelane, picked up in the cultivated fields. One lump is said to have weighed 60 pounds. The ore is solid and massive and contains a little manganite and apparently some braunite. Some iron ore is also present in the dark-red clayey soil. The ore occurs on Knox dolomite near its contact with the overlying Chickamauga limestone, which dips about 40° SE. Although the ore is of high grade the quantity is so small that the deposit is not regarded as of commercial value.

Frye prospect.—The Frye prospect is 1½ miles northwest of Washburn and the same distance southeast of Liberty Hill, both on the Knoxville-Middlesboro line of the Southern Railway. It is about 1,400 feet in elevation, on a small spur on the northwest slope of Copper Ridge near Williams Creek. It is owned by Charles Frye, of Washburn, and is undeveloped, consisting merely of nodules and small fragments of manganese ore and waddy clay in the soil of cultivated fields. Similar indications are reported on neighboring farms and on John Dozier's farm, 3 miles to the southwest.

The chert and clay in the soil are derived from basal portions of the Knox dolomite, and the underlying Nolichucky shale outcrops in the run near by. Some of the manganese ore has a fine shotlike structure. Considerable crystalline manganite is present, and the ore is of high grade but apparently too meager for the deposit to be workable.

JEFFERSON COUNTY.

Jefferson County lies south of Grainger and Hamblen counties and like the latter is crossed by many low ridges. Jefferson City, on the Southern Railway, is the county seat.

JEFFERSON CITY DISTRICT.

The Jefferson City district embraces the hills and valley around Jefferson City, in the northern part of the county.

Currens prospect.—Ore is reported on the property of George Currens, of Jefferson City. The exact location was not learned, but the ore is believed to be in the chert of the Knox dolomite, which composes many of the ridges in the neighborhood and may be expected to contain manganese.

SEVIER COUNTY.

Sevier County lies southwest of Cocke County, along the southeast border of the State. Sevierville, near its center, is the county seat. The southern half of the county is mountainous and includes part of the northwest slope of the Great Smoky Mountains, the summit of which is followed by the State and county boundary line. The only manganese deposit known in the county is at the East Fork mine, in the East Fork district.

EAST FORK DISTRICT.

The East Fork district is near the east-central part of the county. It embraces an area of rugged hill country on the north flank of the Great Smoky Mountains along the East Fork of Little Pigeon River, where deposits of manganese have been found.

East Fork mine.[35]—The East Fork mine is on the East Fork of Little Pigeon River near East Fork post office, 10 miles southeast of Sevierville, the terminus of the Knoxville, Sevierville & Eastern Railway. It is on land known as the Widow Owen's property, which is now owned by the Tennessee Manganese Co., of Knoxville, by which the developments were made. At the time of visit its only output was a test carload of ore, which had been shipped by the company.

The mine is on the southeast end of a flat-topped spur of a higher ridge, at an elevation of about 1,200 feet. (See fig. 31.) It is southwest of the river and about 200 feet above it. At the time of visit it was opened on opposite sides of the spur by two cuts and a tunnel. It is reported that a shaft has since been sunk on the south side of the spur. In developing the mine drifts will be run from the shaft northeast into the hill and in the opposite direction below the ravine. Four other small prospect pits are situated on neighboring spurs at intervals along the lode, covering a length of 4,000 feet.

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[35] This mine was examined by Arthur Keith and G. W. Stose in the spring of 1917, and the description here given is from notes made by them.

The deposit lies in a zone of mineralization which has a maximum width of 10 feet and trends S. 40° W., following a vertical contact of slate and dolomite, the slate lying on the southeast and the dolomite on the northwest. The slate is Hiwassee slate, one of the oldest sedimentary rocks in the Appalachian region, and the dolomite is apparently interbedded in the slate. The dolomite is about 60 feet thick and contains some thin-bedded blue limestone.

The deposits occur as nearly vertical beds in the dolomite and slate. The ore is mostly manganese carbonate, which has been altered to oxides near the surface. The ore beds are somewhat lenticular, as is well shown in the main workings, and overlap each other horizontally and probably also vertically. The carbonate ore is apparently a chemical mixture of calcium, magnesium, and manganese carbonates forming a white crystalline mineral which resembles rhodochrosite. The oxidized ore consists chiefly of psilomelane and wad.

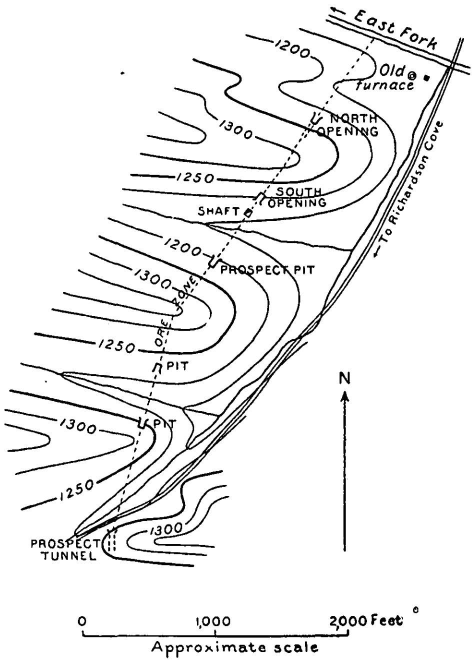


FIGURE 31.—Sketch map of vicinity of East Fork mine, showing mine openings and prospects along outcrop of carbonate ore zone.

The lode and wall rock contain considerable pyrite, much of that in the wall rock consisting of coarse pyritohedrons, whereas minute crystal aggregates are chiefly scattered through the banded ore. Quartz is also common in small stringers, some of which inclose bright anthracitic carbon. A few small calcite veinlets cut the ore.

The northern or main working, an open cut on the north side of the spur, is about 60 feet long, 10 feet wide, and 60 feet deep, with stepped face. A tunnel 100 feet long follows the ore bed in at the bottom of the cut. (See figs. 31 and 32 and Pl. XXIII.) The cut, dug partly before the bedrock or carbonate portion of the lode was discovered to be manganese ore, exposes manganese-bearing clay to a depth of only about 5 feet, where it is succeeded by the unaltered carbonate ore.

The oxide ore occurs in the form of small irregular masses of psilomelane in wad and light manganiferous clay. Much of the clay is the product of weathering of the inclosing manganiferous dolomite. About 6 feet from the portal the tunnel passes into solid carbonate ore. This ore body is lenticular and pinches out at the face of the tunnel, but a bore hole in the southeast wall showed the presence of a body of similar ore in that direction. The open cut also shows the lenticular character of the ore bodies.

The second working, on the south side of the spur, is also an open cut which is 80 feet long, 8 to 10 feet wide, and 40 feet deep, stepped in three benches. The carbonate ore is excellently exposed in the two lower benches, where is shown an ore body having an average width

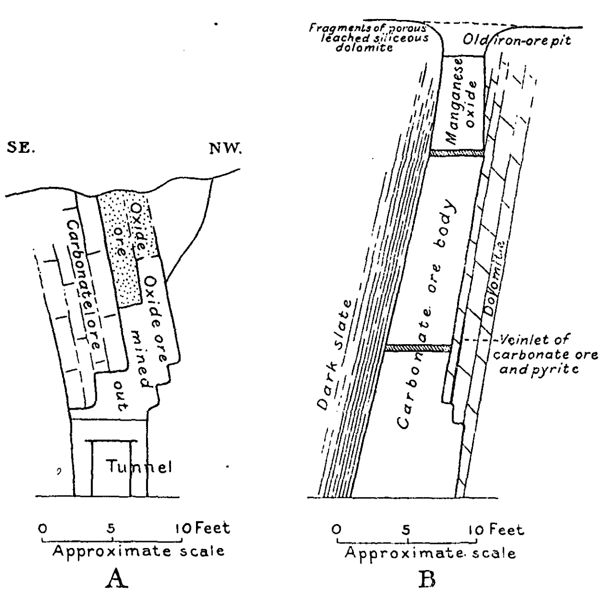


FIGURE 32.—A, Sketch of face of north pit of East Fork mine, showing surface workings of oxide ore and tunnel into carbonate ore; B, Sketch of south pit of East Fork mine, showing upper bench in oxide ore and lower benches in carbonate ore.

of 4 to 5 feet, which contracts and swells and apparently pinches out entirely at the face of the lower bench. The upper bench is in oxide ore, which is chiefly wad but some of it is psilomelane.

Shallow prospect pits along the lode to the southward expose wad and psilomelane mostly in narrow bands; but the northernmost of these openings, across the ravine from the second open cut, exposes a body of solid carbonate ore beneath the oxide. None of the pits, however, are deep enough to determine the size and shape of the carbonate ore body.

The carbonate ore is in part crystalline and in part compact and banded. (See Pl· X, p. 11.) The crystalline ore was evidently deposited first, probably by direct replacement of calcareous rock, either dolomite or calcareous slate. Manganese minerals, which were prob-

A

B

EAST FORK MINE WORKINGS, EAST FORK, TENN.

A, Main open cut on north side of spur, where oxide ore was mined, and entrance to tunnel; *B*, open cut on south side of spur, exposing carbonate ore.

ably originally disseminated in the dolomite or slate, were dissolved by underground circulating waters, and the manganese was redeposited as a crystalline mixture of carbonate of calcium, magnesium, and manganese in the rock adjacent to the solution channels. The ore solutions circulated along joints and fissures at the contact of the dolomite and slate, where there may also have been some faulting. The rhombs of the crystalline mineral show marked zonal structure (see Pl. X), the inner cloudy portion probably carrying most of the manganese. The coarsely crystalline character of this ore indicates that it was deposited some distance beneath the surface, below the zone of oxidation. The dense banded carbonate, in which thin layers of black oxide of manganese are interlaminated, fills spaces between the crystalline masses and is undoubtedly a product of enrichment of the ore at the lower limit of the zone of oxidation. (See Pl. X.)

Athough the analysis of a sample that best represents the crystalline type of mineral shows only 9 per cent of manganese, and the analysis of a selected sample of the banded material shows but 26 per cent, one sample of the banded ore gave 40 per cent (see analyses, p. 15), so it is reasonable to believe that the run-of-mine ore will show a content of manganese between these extremes, possibly more nearly the result obtained by the company from its sample, 37 per cent, which probably included some black oxide ore.

A partial analysis of a sample of carbonate ore made for the company is reported to show that it contained 37.75 per cent of manganese, 7 per cent of silica, 5.26 per cent of calcium, and 2.30 per cent of magnesium.

Should the ore body at the north opening continue to a depth of 50 feet below the tunnel level with an average width of 4 to 5 feet, which it appears to have in the surface exposures, it will be of considerable size and tonnage, but if the high-grade banded ore is due to enrichment near the surface, as above suggested, it may not extend to such a depth, possibly only a few feet below the surface. The shaft and deeper workings now being put down should determine this point.

Because of the carbonate nature of the ore, it is believed by the company's experts that it can advantageously be mixed with oxide ores and save a large amount of limestone flux otherwise needed in the reduction of oxide ore. The company has therefore erected an electric furnace at Cleveland, Tenn., for smelting the ores from the neighboring districts, using electric power from the Tennessee power plant.

BLOUNT COUNTY.

Blount County, of which Maryville is the county seat, lies southwest of Sevier County along the southeast border of the State. The southwestern part of the county is mountainous, and the State and county boundary follow the top of the Great Smoky Mountains, which in places is more than 5,000 feet in altitude. Several deposits of manganese ore are reported in the county, in the Tuckaleeche Cove, Chilhowee Mountain, Greenback, and Louisville districts.

TUCKALEECHE COVE DISTRICT.[36]

Tuckaleeche Cove is a flat-bottomed valley on Little River, in the mountain area southeast of Maryville. It is hemmed in on the southeast by high, steep mountains and on the northwest by ridges through which the river flows in a gorge. Manganese ore is reported at only one place in the cove, at the Townsend prospect.

Townsend prospect.—The Townsend or Webb prospect is in the eastern part of Blount County, half a mile north of Townsend station, on the Little River Railroad. It is on the farm of A. H. Webb, across Little River from the railroad. The river is not here bridged. On the west slope of a hill just south of the farmhouse there is a large amount of float, chiefly in small fragments which are fairly abundant in gullies that trench the surface. The ore is a good grade of psilomelane of high specific gravity. Seams of black manganiferous clay, the largest 4 inches wide, are also exposed in the gullies. The ore seems to follow a small ridge trending northeast. On the adjacent farm of M. A. Webb fragments of psilomelane cementing and replacing chert occur with iron ore, which was once mined. The surface is strewn with well-rounded stream-worn quartzite cobbles, some as much as 6 inches in diameter. The region is underlain by Knox dolomite, and the manganese ore is probably derived from the weathering of cherty dolomite in that formation.

CHILHOWEE MOUNTAIN DISTRICT.[36]

The Chilhowee Mountain district is in the southern part of Blount County and includes the part of Chilhowee Mountain and vicinity near Little Tennessee River.

Sellers prospect.—The Sellers prospect is on the lower southeast slope of Chilhowee Mountain, 1½ miles northwest of Chilhowee station, on the Tennessee & Carolina Southern Railway. It is on the farm of William Sellers, and the mineral rights are owned by J. M. Green and C. A. Benscoater, of Knoxville. On the dump of two old caved openings several small pieces of pyrolusite and manganiferous limonite were found, in one of which manganese minerals occur as cement in a fine quartz conglomerate.

[36] The descriptions of the prospects in the Tuckaleeche Cove, Chilhowee Mountain, and Greenback districts are largely taken from notes by Arthur C. McFarlan, of the Tennessee Geological Survey.

The region is underlain by brownish-gray quartzite and conglomerate, presumably the Hesse quartzite, in which the prospect openings are made. Overlying the quartzite are blue limestone and slate, propably Hiwassee slate, which is older than the quartzite and has been overthrust on it from the southeast.

McMurray and Miller prospects.—A small amount of float manganese ore was reported on the Sam McMurray farm, a mile west of Chilhowee, but no openings were made on the property. Henry E. Colton, of Knoxville, is reported to have had an option on a tract about a mile from the McMurray farm, where high-grade ore had been found some years ago. Ore is also reported 6 miles northeast of Chilhowee, on Rufus Miller's place, southeast of Montvale Springs, on the southeast side of Chilhowee Mountain. The relations at both places are probably the same as at the Sellers prospect.

GREENBACK DISTRICT.[36]

The Greenback district includes the open-valley country in the western part of Blount County, chiefly that which extends for 4 miles northeast of Greenback, on the Louisville & Nashville Railroad.

Williams prospects.—A number of prospects, several of which are here described, occur northeast of Greenback. They are in residual clay and chert of the Knox dolomite at or near its contact with the underlying Nolichucky shale. The structure is monoclinal and overturned, the dolomite dipping 50° SE. The ore is a replacement of chert in the dolomite and occurs largely as nodules and fragments mixed with chert in the residual clay and soil.

The Williams prospects are 3 miles northeast of Greenback. They are on adjoining farms belonging to T. S. and Mrs. A. J. Williams, the mineral rights on which have been leased. Many pieces of good-grade manganese ore float are found in the road and in a number of shallow test pits and trenches on both properties. The ore is psilomelane, small nodules of which lie loose in red residual clay. Some of the nodules are concentrically zoned and have botryoidal surfaces, and some have an outer shell of brown iron ore. Iron ore is more abundant than manganese ore, and the 5 tons of ore on the dump consists chiefly of cherty limonite.

Curtis, Aiken, and associated prospects.—The Curtis prospect is 2½ miles northeast of Greenback, on the farm of T. G. Curtis. A small amount of float manganese ore is scattered over the farm, and it is most plentiful and of highest grade southwest of the Curtis barn. It is a replacement of chert in the Knox dolomite, the replacement in most specimens examined being complete.

The Aiken prospect is on the farm of John R. Aiken, which adjoins the Curtis farm on the southwest, 2¼ miles northeast of Greenback. Float manganese ore is abundant near the crest of the hill just back of the house.

Manganese ore is also reported on the near-by farms of David Crisp, M. A. Willis, James H. Eakers, and J. E. Klepper, the mineral rights of some of which have been leased for development.

LOUISVILLE DISTRICT.

The Louisville district includes the lowland around Louisville, southwest of Knoxville. Manganese ore is reported from several of the low hills with deep-red soil in this region, but only one deposit has been worked or extensively prospected.

Louisville mine.—The Louisville mine is in the northwestern part of the county 4 miles southwest of Louisville and less than a mile by road from the Louisville & Nashville Railroad. It is on the J. B. Cox farm and is leased by the Unaka Minerals Co., of Knoxville. Mining was begun in June, 1918, and in July, at the time of visit, 25 tons of manganese ore had been mined and concentrated in the log washer.

The mine is in open lowland country of the Tennessee Valley, on the gently sloping north side of a low, flat-topped ridge or bench 1,050 to 1,100 feet in elevation. The bench is part of an old valley floor preserved on the tops of the hills in the vicinity. The deposit occurs in residual clay of thin beds of marble in the Chickamauga limestone, probably part of the Holston marble.

The ore-bearing clay is about 10 feet thick and consists of dark chocolate-colored soil and mottled red and yellow clay, which overlies hard, nodular gray limestone or impure marble of the Chickamauga formation. It is overlain by a cover of reddish earthy soil generally a foot thick, which is stripped with plow and scraper before mining. Banding in the ore-bearing clay dips 20° NW., about parallel with the surface slope, and is in part due to creep. Some of the markings are irregular and suggest fragments in a breccia.

The ore is mostly psilomelane and occurs in rough-surfaced lumps, nodules, and grains in dark clay streaks more or less parallel with the inclined structure, the largest lumps being nearly a foot in diameter. Some of the ore is hard and has a botryoidal surface, and some is porous, having cavities lined with soft black sooty pyrolusite. Much of the ore is of the "bird-shot" type, consisting of innumerable small, round shiny black pellets embedded in red clay, which are probably a replacement of pebble structure in the marble. (See Pl. XV, p. 32.) The pellets are somewhat ferruginous and yield a dark-brown powder when crushed. Three-fifths of the ore consists of grains and nodules less than half an inch in diameter, and a jig is needed to save the small particles which pass through a 24-mesh sieve. However, a small washer for screenings, devised by the company as an adjunct to the main washer, is saving most of the fines. Some ore from the slope above the pit is full of sand grains and is so siliceous that it is not saved.

The ground is worked by a hydraulic sluice-flume system comprising five converging ground sluices. (See fig. 33.) As the wash dirt

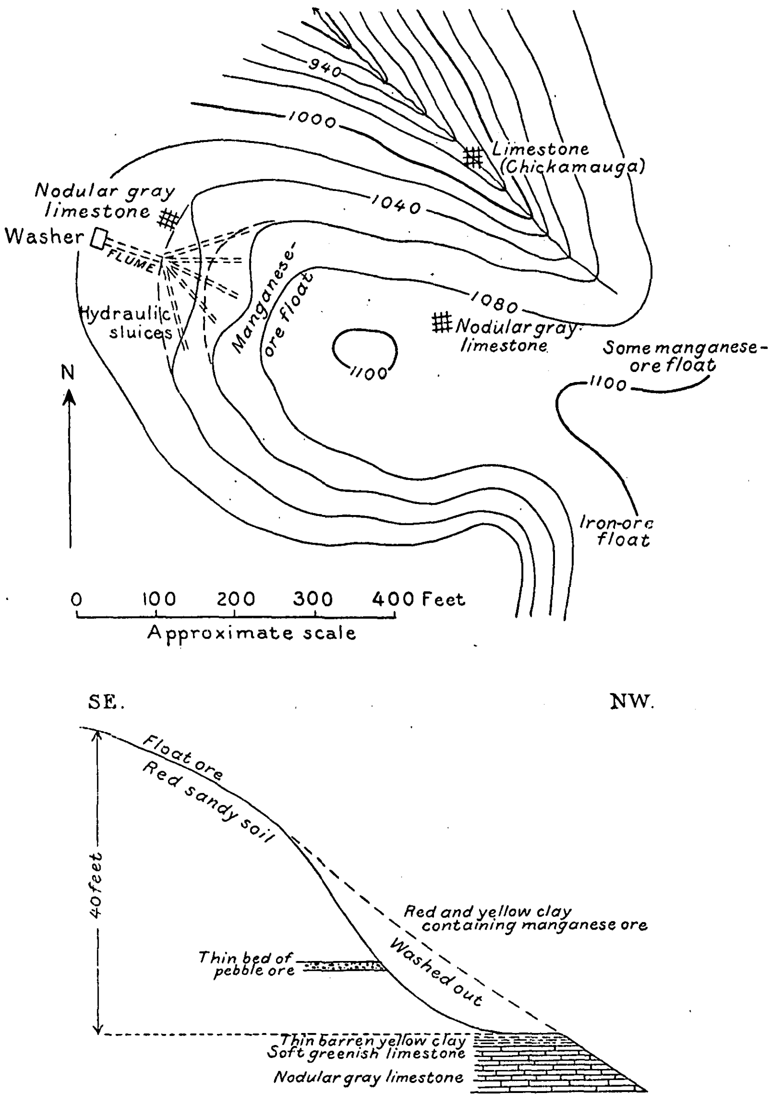


FIGURE 33.—Sketch of topographic map of vicinity of Louisville mine and geologic section through mine pit.

is mined it is shoveled or washed by a strong stream of water from a nozzle into a ground sluice and is flumed down the slope through ground sluices and portable flumes which converge into a large hopper at the head of the washer. For continuous operation this method requires more water than the amount now available—120 gallons a minute. The area stripped and being mined at the time of visit was semicircular with a radius of 70 feet. The deepest part, which was in the middle sluice, was 6 feet deep. All the dirt beneath the overburden, including the yellow clay, is passed through the washer and is reported to concentrate 8 into 1, 8 tons of mine dirt yielding 1 ton of washed ore, which averages more than 40 per cent manganese.

About a quarter of a mile south of the mine, on the same property, the surface of a hill 1,160 feet in altitude is strewn with brown iron float ore of good grade, which is seamed with red, translucent radiate fibrous goethite in layers from paper thickness up to half an inch thick. Some manganese ore occurs with the iron-ore float on the northwest upper slope of this hill. Other hills at this elevation toward the northeast, covered with deep-red soil and having geologic and surface conditions similar to those at the Louisville mine, are apparently just as favorable for the occurrence of manganese ore.

Louisville prospect.—Manganese ore is reported from the Red Hills, southeast of the railroad, 2 miles east of the Louisville mine, but the deposit was not visited. It is probably at the contact of the Holston marble and the overlying Tellico sandstone, the horizon at which high-grade ore is present farther southwest. A manganese prospect has also been reported 2 miles southwest of Louisville.

KNOX COUNTY.

Knox County, of which Knoxville is the county seat, is northwest of Sevier and Blount counties. It is crossed by several low ridges, which trend northeastward, parallel with Tennessee River. There are a few manganese prospects in the Knoxville district near Knoxville and one in the Copper Ridge district, northwest of Knoxville.

KNOXVILLE DISTRICT.

The Knoxville district includes the area around Knoxville within which are the belts of the Red Hills south of the city, two of them extending many miles to the northeast and southwest. It has long been known that these hills contain high-grade hematite and some very pure manganese ore. Although the indications in the district are so far not favorable, further prospecting may well be undertaken in these hills, particularly along the contact of the red Tellico sandstone and the underlying Holston marble, at the horizon at which rich deposits of ore occur farther southwest.

Fitzgerald prospect.[37]—The Fitzgerald prospect is about 6 miles southwest of Knoxville and 3 miles south of Bearden station, on the

[37] The descriptions of the Fitzgerald and Green prospects are largely taken from notes by Arthur C. McFarlan.

Southern Railway. It is on the farm of J. H. Giezentanner and was worked on shares by Paul Fitzgerald. It was opened to the depth of 10 feet, and from the excavation about 15 tons of ore was taken out and put on the dump. The ore occurs in a shaly phase of the Tellico sandstone which dips generally to the southeast but at many places in other directions. It occurs in thin, irregular seams, which follow the bedding planes of the rocks. The ore is of medium grade and contains considerable clay and some brown iron ore. Near the northern boundary of the property considerable sandy float ore occurs, and on the adjoining farms of Mrs. W. C. Badgett and L. F. Currier large amounts of iron ore are reported.

Green and neighboring prospects.[37]—On the farm of J. C. Green, 2 miles southwest of Bearden station, a small amount of manganese ore float occurs scattered over the surface of the Red Hills and a pit 3 feet deep exposes light pyrolusite and wad in small seams in clay. The Tellico sandstone on the hills dips 58° SE.

On the adjoining farm to the south, owned by C. S. Morel, a little psilomelane and sandy iron-ore float occur, and northeast of the Green property a considerable quantity of good-grade hematite occurs on L. D. Tyson's farm, on which have also been found several large pieces of high-grade manganese ore.

COPPER RIDGE DISTRICT.

The Copper Ridge district includes the belt of northeastward-trending chert ridges that lie northwest of Powell. Only one prospect is known in this district.

Haworth prospect.—The Haworth prospect is reported to be 8 miles northwest of Knoxville and 2 miles west of Powell, on the Knoxville, Jellico & Fonde division of the Southern Railway. It is on a farm owned by W. L. Haworth, of Knoxville, on the top of Copper Ridge. The ore consists of psilomelane cementing and partly replacing chert from the Knox dolomite and is found as float in the fields. Although much of the ore collected is of high grade, the quantity is apparently too small to be profitably worked.

ANDERSON COUNTY.

Anderson County lies northwest of Knox County. Clinton, in its eastern part, is the county seat. Its northwestern part is mountainous, being occupied by the Appalachian Plateau, a dissected or eroded table-land composed of Carboniferous coal-bearing rocks. In the southeastern or valley portion of the county a few prospects of manganese ore have been reported, chiefly in the Pine Ridge district north of Clinton.

[37] The descriptions of the Fitzgerald and Green prospects are largely taken from notes by Arthur C. McFarlan.

PINE RIDGE DISTRICT.

The Pine Ridge district lies northwest of Clinton and extends for 3 miles along Pine Ridge, a low ridge trending northeastward along the foot of Walden Ridge, here the front mountain of the Appalachian Plateau. Pine Ridge is composed of shales and sandstones of the Rome formation, which in general dips southeastward and is equivalent, in part at least, to the Watauga shale, which occurs farther northeast in the Great Valley. According to the geologic map [38] published by the United States Geological Survey the formation is faulted along its northwestern side against Chickamauga limestone. The ore apparently is associated with this fault.

Bright & Howell prospect.—The Bright & Howell prospect, owned by D. M. Bright and D. A. Howell, of Knoxville, is reported to be on the northwest side of Pine Ridge, 5 miles north-northwest of Clinton, at Cane Creek gap. A shallow pit is said to expose good manganese ore. The ore is apparently at the fault contact, replacing the Chickamauga limestone.

Manganese ore is also reported to be exposed in the road cut through Pine Ridge, 3 miles northwest of Clinton.

Wallace prospect.—A prospect reported near Coal Creek, on the farm of Hack Wallace, of Clinton, is probably also on Pine Ridge. It was opened in 1914, and a ton of ore reported to contain 48 per cent manganese, 1.60 per cent iron, and 8 per cent silica was shipped. In 1918 it was leased to T. F. Narramore, who is said to have started the development of the prospect.

LOUDON COUNTY.

Loudon County adjoins Blount and Knox counties on the west. The town of Loudon, on Tennessee River near the center of the county, is the county seat. The surface is a broad open valley crossed by low hills which trend northeast. Manganese deposits occur in the Loudon and Fork Creek Knobs districts.

LOUDON DISTRICT.

The Loudon district includes the area around Loudon, particularly the Red Hills area, south of the town. This area is a direct continuation of the ore belt northeast of Sweetwater, where some of the highest-grade ore has been mined.

Cates prospect.—The Cates prospect is 1½ miles south of Loudon. It is on the farm of J. K. Cates, of Loudon, and was leased by the Lafollette Iron Co., of Lafollette, Tenn. It is on the crest of a low spur or bench on the northwest slope of a higher hill which trends

[38] Keith, Arthur, U. S. Geol. Survey Geol. Atlas, Briceville folio No. 33.

northeast. The hill is composed of chert from the Knox dolomite, which is apparently overthrust on the Holston marble. The ore lies on the Holston marble near the fault and may have been deposited by mineral-bearing waters circulating along the fault.

The deposit consists chiefly of brown iron ore too siliceous to be of value. Some of it probably carries a little manganese, but no manganese ore was observed. The siliceous ore covers the surface of the low spur, and about 50 tons of it has been gathered into piles. A trench about 15 feet long and 9 feet deep exposes deep-red sandy clay soil containing similar ore. As the trench does not reach the bottom of the ore-bearing clay, ore richer in manganese may yet be found at greater depth. The deposit lies in red clay derived from the Holston marble but is not overlain by Tellico sandstone at the Cates prospect, as it is in places to the southwest, where it carries high-grade manganese and iron ores.

FORK CREEK KNOBS DISTRICT.

The Fork Creek Knobs district embraces the Fork Creek Knobs and adjacent Bat Creek Knobs, a Red Hills belt that lies chiefly in the northern part of Monroe County but extends across the southeast corner of Loudon County. Manganese and iron ores occur in many places on these hills, as at the Galbraith mine, in Loudon County, and the geologic formations are similar to those in the Sweetwater district, on the west, where other high-grade manganese deposits occur.

Galbraith mine.—The Galbraith or Henley mine is 8 miles southeast of Loudon and about the same distance southeast of Lenoir, both on the Southern Railway. It is 1 mile southeast of Jackson Ferry, on Little Tennessee River, from which point the ore is conveyed by boat downstream to Lenoir. The property is owned by P. C. Henley, of Loudon, and the mineral rights are owned by H. N. Curd, of Lenoir. The deposit was first opened in 1901 and more recently has been leased and operated by Charles Galbraith and Judge Webb, of Knoxville. In the summer of 1918 the mine was leased and operated by the Southern Manganese Corporation, of Birmingham, Ala. In May, 1918, about 100 tons of manganese ore had been mined and washed, one carload of which had been shipped, part of it to New York for chemical uses, and another carload was on the way to the railroad.

The mine is on a small knoll, 920 feet in altitude, on the northwest slope of a prominent ridge that forms the northeast continuation of the Fork Creek Knobs. The deposit occurs in Holston marble that dips 30° SE., into the knoll, which has a synclinal structure (see fig. 34) and was probably formerly capped with

Tellico sandstone. The ore is embedded in red clay that is residual from the Holston marble and that is covered with a few feet of surface wash, which contains rounded river cobbles and pebbles.

The principal opening is a cut in the northwest slope of the knoll 100 feet long by 30 feet wide and 12 feet deep at the face. (See fig. 34.) The ore begins in the wash close to the surface and extends down into the residual clay. The deeper part of the cut has been filled in, but the ore was said to continue to a depth of 30 feet. In test pits dug at the side of the cut some good ore was found, but the pits were not deep enough to determine the lateral extent of the workable deposit. Considerable siliceous iron ore covers the surface north of the mine and was formerly mined for iron.

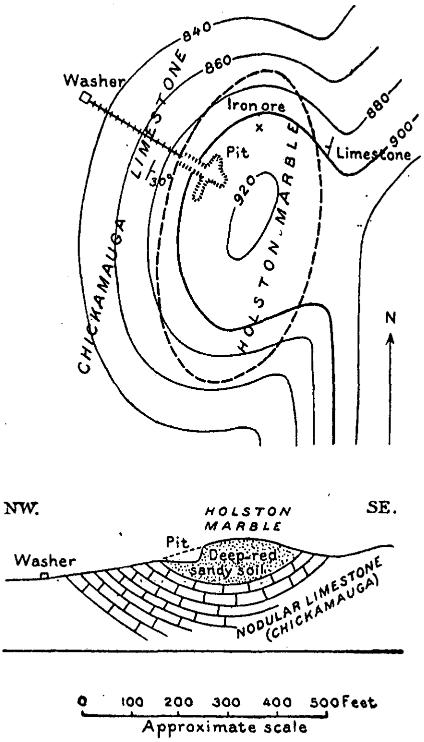


FIGURE 34.—Sketch map of vicinity of Galbraith mine and geologic section through mine pit, showing topographic and geologic relations.

The ore consists chiefly of small lumps of psilomelane and contains a little soft pyrolusite and some manganiferous iron. It is conveyed from the mine to the washer by a cable tram about 200 feet long. A simple jig was formerly used but has been discarded, and the ore is washed in a double-log washer and then screened. A flume and pump were being installed to increase the water supply. The washed ore ranges from fine screenings to lumps 4 inches in diameter, but most of it is less than 2 inches in diameter, and much of it is screenings. It is clean, is of high grade, and is estimated to average 45 per cent manganese. It is shipped in bags and barrels.

MONROE COUNTY.

Monroe County, of which Madisonville is the county seat, is one of the southeastern border counties of the State. It adjoins Blount County on the southwest and Loudon County on the south. The southeastern part is mountainous, being occupied by the foothills of the Unaka Mountains. The northwestern part is valley or lowland crossed by many parallel lines of low hills trending northeastward. Manganese deposits occur at several localities, which are grouped into the Fork Creek Knobs, Sweetwater, Madisonville, and Tellico Plains districts. The Fork Creek Knobs district lies partly in Loudon County.

FORK CREEK KNOBS DISTRICT.

Mills prospect.—The Mills prospect is in the northern part of the county, 8 miles northeast of Sweetwater, on the Southern Railway, and 2 miles south-southwest of Eve Mills. It is on the property of J. C. Mills, of Sweetwater, on the upper northwest slope of a prominent ridge—one of the Fork Creek Knobs. It is at the unconformable contact of the Tellico sandstone on the Holston marble, and the structure is monoclinal, the rocks dipping about 30 SE., into the ridge. The Holston marble on the steep western slope is overlain by red sandstone of the Tellico, and the crest of the ridge is composed of gray sandy marble within the Tellico.

Late in April, 1918, no openings had been made, but on the western slope, just below the base of the Tellico sandstone, there were ample indications of high-grade red hematite iron ore, with which was a little manganese ore float. A lump 1½ feet across of high-grade psilomelane ore was found on the east crest of the ridge associated with the marble interbedded in the sandstone. As the high character of the ore found at the surface and the generally favorable conditions for the accumulation of ore seemed to warrant prospecting, the ground was leased by the Southern Manganese Corporation, of Birmingham, Ala., and was later thoroughly prospected, with the result, however, that only 3 tons of ore, containing 41 per cent of manganese, was taken out during the exploration, whereupon the property was abandoned.

SWEETWATER DISTRICT.

The Sweetwater district is in the northwestern part of Monroe County, and it includes the ore-bearing belt of the Red Hills and the lowland on either side extending from Sweetwater to Philadelphia, east of the Southern Railway. The Red Hills are so named from their covering of deep-red soil. The geology of the Red Hills area is shown on the map, Plate XXIV.

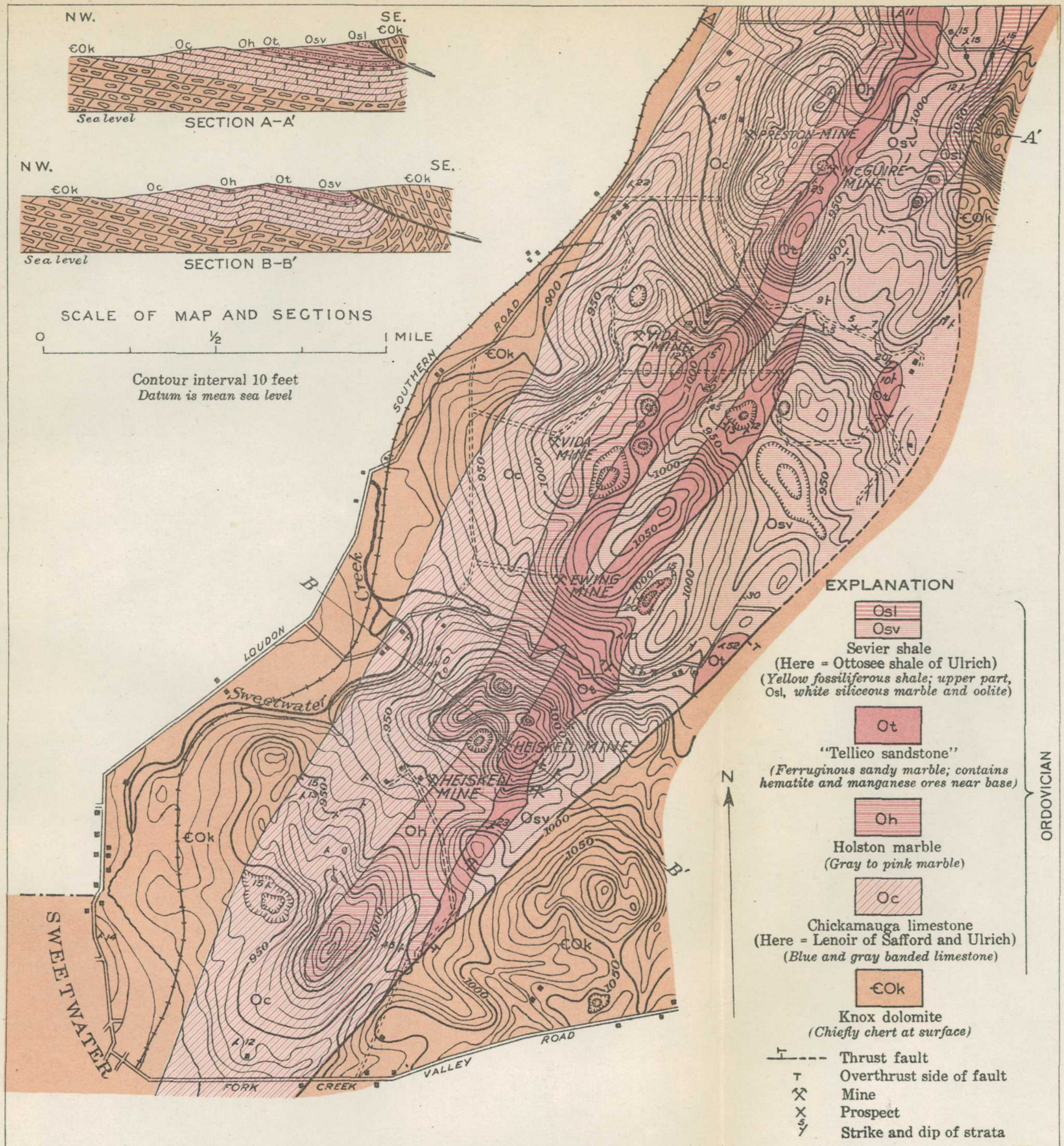
McGuire mine.—The McGuire mine is on J. Frank McGuire's farm, 4 miles northeast of Sweetwater, 3 miles south of Philadelphia, and half a mile from Gilman switch, on the Southern Railway. It is in the same Red Hills belt of mineralization as the Heiskell mine, near Sweetwater, and is similarly situated on the lower northwestern slope of the hills, at the frontal edge of a westward-facing terrace 950 feet in altitude and about 100 feet above the valley bottom. Ore was first mined here in the early nineties. The mine is now being operated by the Southern Manganese Corporation, of Birmingham, Ala.

Late in April, 1918, the main development, which is at the south end of the property, was a 40-foot cut, 20 feet deep at the face. (See Pl. XXV.) It consisted in part of reopened old workings from which considerable ore had been taken. The new workings had yielded at the time of visit 3 tons of high-grade ore, which lay on the dump. A carload of this ore subsequently shipped is reported to have run 41.13 per cent manganese.

On the terrace, about 30 feet east of the face of the cut, a shaft sunk in residual clay was reported to have passed through a 3-foot bed of manganese ore at a depth of 23½ feet and another shaft about 50 feet farther east to have passed through a bed of ore 7 inches thick at a depth of 33 feet. The ore in the shafts was believed to be a continuation of the ore in the cut, which dips southeast, with the bedding, and later development work proved this belief to be correct.

By October, 1918, the mine had been opened by a main inclined tunnel 165 feet long driven southeastward from the face of the cut, with drifts to both sides 60 to 100 feet long, connected by other inclined longitudinal drifts. (See fig. 35.) The workings follow a bed of ore more or less continuous near the bottom of the decomposed ferruginous Tellico sandstone. The mine was reported to be shipping monthly 40 tons of ore averaging 44 per cent manganese.

The deposit is at the unconformable contact of the Tellico sandstone on the underlying Holston marble. In Plates XXV and XXVI the ribbed sandy crystalline limestone (Tellico) is clearly seen filling channels beween reefs of Bryozoa and other organisms in the underlying red marble. The section of the rocks at the mine is given in the table on page 21. The structure of the rock is monoclinal, the dip being approximately 25° SE. The Holston marble is banded, medium to coarse grained, and fossiliferous, containing abundant remains of crinoid stems, Bryozoa, and a few brachiopod shells. In the main workings of the mine the floor, where unweathered, is apparently Holston marble, but the ore bed in places lies within the decomposed sandy rock of the Tellico. However, the larger bodies of ore occur in depressions and solution channels in the upper surface of the marble, which are filled with weathered products of the overlying Tellico formation. For instance, the 40-foot cut and the old tunnel followed an ore zone in sandy clay which filled a depression between rock pinnacles. Its footwall on the northwest side consisted of granular grayish Holston marble capped by pinnacles of sandy banded marble of the Tellico, in which only small lenses of ore occur. On the southeast or hanging-wall side 10 feet of nearly



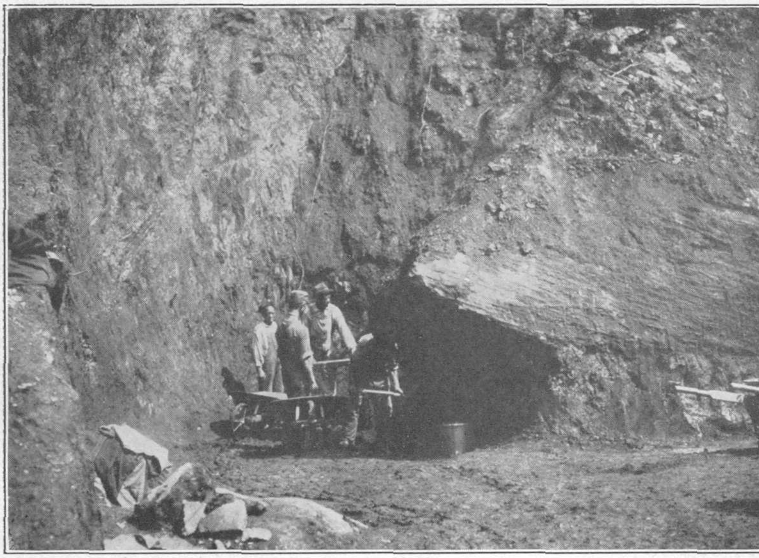
GEOLOGIC MAP AND STRUCTURE SECTIONS OF THE RED HILLS AREA NORTHEAST OF SWEETWATER, MONROE COUNTY, TENN.

Showing the relation of manganese mines and prospects to the geologic formations

By Arthur C. McFarlan

Geology somewhat revised by G. W. Stose

ENGRAVED AND PRINTED BY THE U.S.GEOLOGICAL SURVEY.

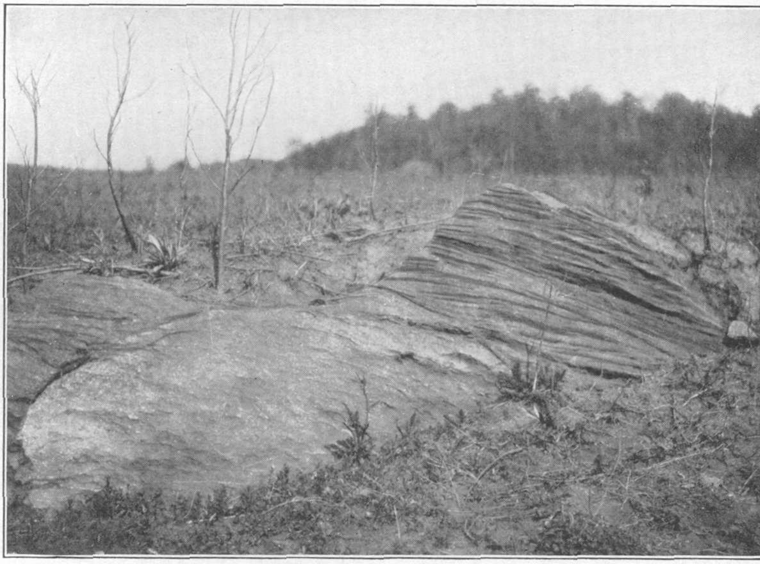


A. PIT OF McGUIRE MINE, NEAR SWEETWATER, TENN.

Preparatory to driving tunnel in deeply disintegrated material to left of rock mass.

B. UNCONFORMITY AT BASE OF TELLICO SANDSTONE NEAR OPENING OF McGUIRE MINE, TENN.

Dark sandy ribbed limestone unconformably overlying lighter-colored reef-bearing red calcareous mud rock at the top of the Holston marble. The sandy beds fill a channel between prominent white reefs of Bryozoa (*r*).



A

B

UNCONFORMITY AT BASE OF TELLICO SANDSTONE NEAR OPENING OF McGUIRE MINE, TENN.

A, General view of ledge, showing cross-bedded sandy-ribbed Tellico sandstone overlapping reef-bearing Holston marble, similar to exposure shown in Plate XXV, *B*; *B*, nearer view of overlapping beds, showing white Bryozoa reef in underlying calcareous mud rock of Holston marble.

barren yellowish-red sandy clay grades downward into 10 feet of reddish-black sandy clay, in which are scattered tabular pieces of ore 6 inches thick and rounded boulder-like masses, some as much

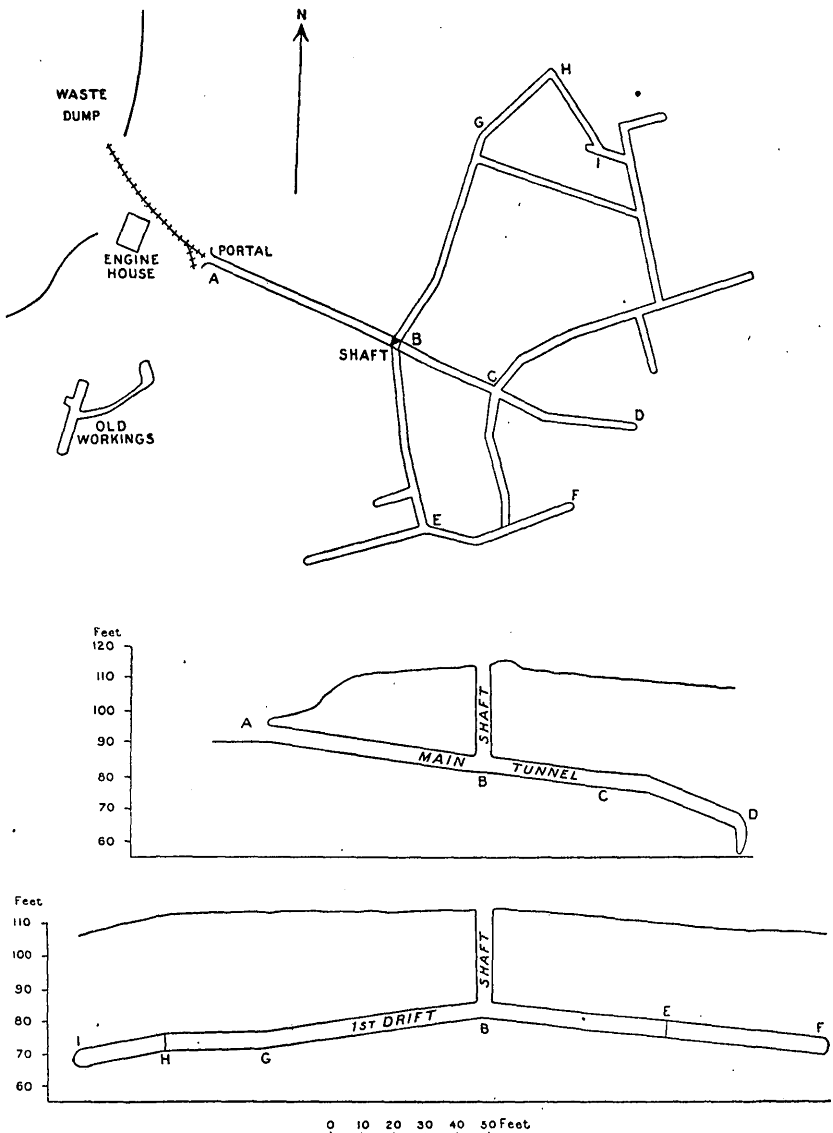


FIGURE 35.—Plan and cross sections of the workings of the McGuire mine. The tunnel and drifts, which follow the ore bed, show gentle dip of ore bed to the southeast. (From plat of mine workings by Southern Manganese Corporation.)

as $2\frac{1}{2}$ feet in diameter. This residual clay lies in the depressions between pinnacles of Holston marble that follow fissures and fractures that have been enlarged into solution channels.

The Tellico sandstone in this part of the terrace is decomposed to a depth of 40 feet, being weathered to a soft dirty-brown sand, in which, however, the original bedding and rock structure are still well preserved. In places where the decomposition and solution have penetrated deeper than elsewhere the bedding of the disintegrated material is much disturbed, and the material is cut by many steep slickensided slip planes, indicating that it has moved and has settled into solution channels in the underlying marble. The manganese mineral, which is believed to have been originally disseminated in the ferruginous Tellico sandstone, was dissolved by the descending percolating waters that decomposed the rock and was concentrated in the lowest porous beds through which the waters could percolate. Wherever a boss or pinnacle of undecomposed rock stood the deposit was thin or absent, and wherever a solution pocket or channel occurred and the overlying decomposed sandy material slumped into it, thicker ore deposits were formed and were practically continuous.

Most of the ore is hard, compact shiny steel-blue psilomelane, but with it is some sooty black pyrolusite and wad. The compact psilomelane contains a cleavable crystalline steel-blue mineral which resembles braunite and is similar to the mineral at the Heiskell mine. Most of the ore occurs in a tabular bed which is nearly continuous and generally ranges from 6 to 18 inches in thickness. It is mined in slabby fragments and masses about 2½ feet in maximum length and 5 or 6 inches in thickness, which are readily separated from the dark dirt and are shipped without washing. Some of the dark dirt from which the ore has been hand picked is said to contain 5 per cent of manganese and 33 per cent of iron, the rest of it being largely quartz.

The north end of the property has been prospected by many deep circular pits or shafts. Most of these are on the flat top of the hill at an altitude of 950 feet and are sunk in soft residual red sandy clay between high sharp pinnacles of marble. The pinnacles were carved by subsurface erosion, and many of their walls are vertical or overhanging. One pit follows down a vertical solution wall for 30 feet. The rocks dip 22° SE. The sandy beds of the Tellico, which disintegrate into the red sandy clay in which the ore occurs, outcrop at the west crest of the hill. Some yellow shale is present in the pits but is believed to have come from the overlying Sevier shale that was let down into solution pockets and not to have been originally interbedded in the marble. The ore is said to lie on the marble below the shale. Although the ore is of fairly high grade, much of it is deeply pitted and breaks into small fragments or crumbles to a soft powder, so that it will be difficult to save in mining. Several tons of such ore was on the dump at the time of visit. Other pits on the western slope of the hill, at 920 feet in altitude, are in similar soil-filled depressions in the marble. and some high-grade ore was taken out, but the quantity is relatively small.

Preston prospect.[39]—The Preston prospect is 3½ miles northeast of Sweetwater, near the Loudon pike. It is on the west slope of a low rounded ridge just west of the McGuire mine, on the farm of J. N. Preston, of Sweetwater, and was prospected under option by Joe Corn. The ridge is composed of Chickamauga limestone which dips 12° SE., the structure being monoclinal. The ore is mostly float, consisting of nodular pieces of psilomelane scattered in considerable quantities along the crest and on the western slope of the ridge for more than half a mile. With the manganese ore is a large quantity of good-grade hematite float. Some ore replacing chert is also found. About 1½ tons of iron and manganese ore was gathered in piles, and several tons of high-grade ore previously gathered had been sold to the Southern Manganese Corporation.

The occurrence of pieces of leached Tellico sandstone in the soil suggests that the ore may have been derived by weathering from the rocks of the ridge on the east, where the McGuire mine is situated, and transported as hillside wash before the small intervening valley was formed.

Vida mine.—The Vida mine is 3 miles northeast of Sweetwater and about half a mile southeast of Gilman siding on the Southern Railway. It is owned by C. D. Smith, of Memphis, Tenn. It was mined for iron ore more than 20 years ago by W. D. Gilman and was prospected for manganese some years later. The iron deposits were described by E. F. Burchard in Bulletin 16 of the Tennessee Geological Survey, on the red iron ores of east Tennessee. The iron ore was taken from two large pits, half a mile apart, some 20 to 30 feet deep, in soft, dry dirty-red sandy clay. Much of the ore was soft, but many fragments of hard ore are still found in the pits. These are mostly blocky to platy fragments of black iron ore, somewhat earthy in texture, and apparently contain considerable manganese. Small lumps of good-grade bright psilomelane, having smooth rounded shiny surfaces, which average 43 to 46 per cent manganese, are also fairly plentiful but apparently are not present in sufficient quantity to be workable for manganese alone. No effort has been made to mine the property for manganese, although several prospecting pits have been recently dug.

The deposit lies in red earthy clay containing glassy sand grains, apparently derived from disintegration of Tellico sandstone. At the bottom of the pit are bedded yellow clays dipping steeply northwest,

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[39] Description chiefly from notes by Arthur C. McFarlan.

apparently representing the caved roof of a solution channel in the underlying Holston marble or Chickamauga (Lenoir) limestone, which outcrops with gentle eastward dips just below. (See fig. 36.)

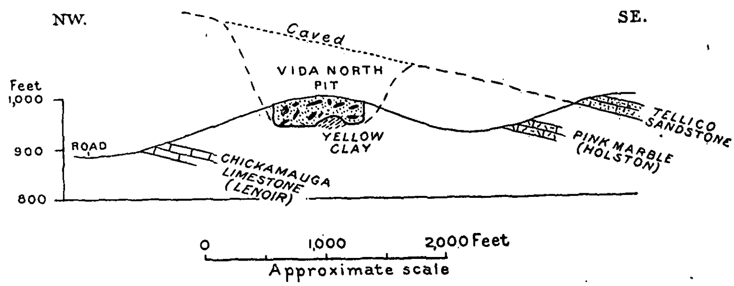

FIGURE 36.—Sketch geologic section through north pit of Vida mine, showing the probable origin of the ore deposit in the filling of a caved-in channel.

The ore deposit is therefore in residual Tellico material let down and preserved in a caved-in channel in the underlying Holston marble. It was derived from rocks similar to the highly ferruginous sandy crystalline limestone exposed on the hill east of the pit, in which thin leaves of bright hematite occur along joints and bedding planes. Much of the surrounding upland appears to be equally favorable for manganese ore, which may be present in sufficient quantity to be worked.

Ewing mine.—The Ewing mine is half a mile south of the Vida mine and about half a mile from Gilman siding, on the Southern Railway. It is owned by Robert Ewing and was worked for soft iron by J. J. Fitzgerald and H. L. Smith, of Sweetwater, up to June, 1918, when it was closed down because of car shortage. It is on Holston marble near its contact with the Tellico sandstone—a similar location to that of the Heiskell mine, just to the south. As considerable manganese ore is present it may be workable for manganese.

Heiskell mine.—The Heiskell mine is 1½ miles northeast of Sweetwater. It is owned by Harry Heiskell, of Sweetwater, and was being operated on option by H. L. Smith, also of Sweetwater. It is credited with a production of more than 100 tons of high-grade manganese ore. At the time of visit (April, 1918) a carload of ore had recently been shipped, and about 40 tons lay on the dump. The deposit has been opened by four pits, covering a length of about 1,000 feet. The mine is on a hillside which slopes gently northwestward to Sweetwater Creek. The hill is about 1,050 feet in altitude and is heavily covered with deep-red residual soil and clay produced by weathering of the rocks when the top of the hill was part of the old valley floor. The mine is at the contact of the Holston marble and the unconformably overlying Tellico sandstone. The rocks dip 22°

SE., and coarse red sandy granular marble beds of the Tellico sandstone cap the Holston marble at the west crest of the hill. (See fig. 37.)

The deposits occur in the residual red sandy soil and clay derived from the Tellico sandstone. The ore is unusually pure, solid, compact psilomelane and occurs chiefly in thick, blocky pieces, some a foot or more across, embedded in the clay. The blocks have irregular or pitted surfaces. The mineral breaks with a conchoidal fracture, and a freshly broken or polished surface presents a mottled effect, due to cleavage faces of included crystals, seemingly of braunite. Associated with the ore in the mine are fragments of high-grade red hematite. The ore is all lump ore and is shipped without washing. It is said to run 58 per cent in manganese. The inclosing clay is

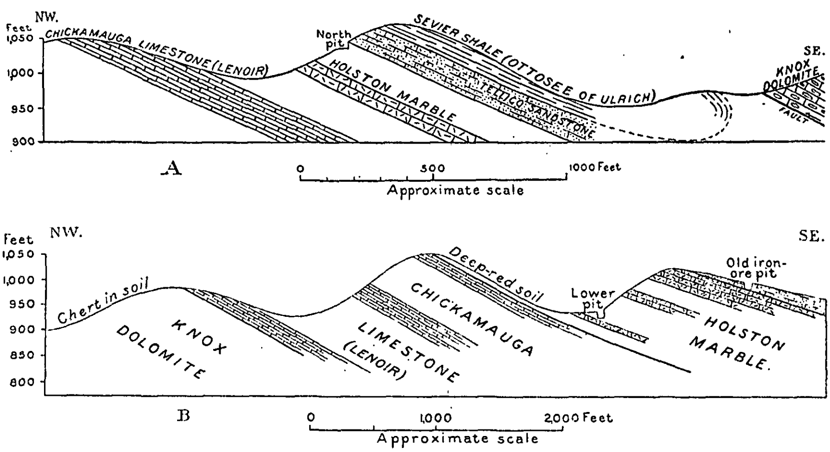

FIGURE 37.—Sketch geologic sections at the Heiskell mine. A, Section through north pit; B, section through south pit.

dry and pulverulent and is easily removed in handling, so that no washing plant is required, and the cost of mining is very low.

Two of the pits are on the hillsides and two in the lowland at the foot of the hill. The northern pit, which is on the upper part of the hillside at the Holston-Tellico contact, shows best the original relation of the ore to the rocks. Here the ore lies in dark-reddish sandy clay, which fills deep solution hollows in the upper surface of the marble. It is apparent that the manganese and iron oxides had been concentrated into beds and lenses of ore in the disintegrated Tellico sandstone by solution and redeposition in the process of weathering and had been broken up and finally left as residual masses in the residual sandy clay. Some of the ore preserves molds and casts of the fossils originally contained in the rock, showing gradual replacement. (See Pl. XIV, p. 31.) From this small pit, no more than 6 feet in depth, 33 tons of hand-picked blocky psilomelane ore, estimated to analyze 58 per cent manganese, had been mined, and from an adjacent pit a carload of similar ore had been mined and shipped.

At the south end of the property, on an adjoining low hill close to the road, iron ore was formerly mined in a pit at the Tellico-Holston contact. The ferruginous pebbly bed just below the deposit is well shown here. (See Pl. XV, *B*, p. 34.) Good hematite and some manganese ore still showed in the pit, but no ore had been recently taken out.

The pit that was being actively worked at the time of visit lies at the south foot of the hill on which the north opening occurs. It was 18 feet deep, in dull dark-reddish sandy clay largely derived from Tellico sandstone, which had moved down the slope by creep and wash and accumulated at its foot. Fragments of porous fossiliferous Tellico sandstone and of associated ore, derived from the outcrops above, were sporadically distributed in the clay, the fragments of ore being much smaller than those in the upper pit and more widely scattered. They extended, however, to the bottom of the pit, which was apparently all in surficial detritus. The methods employed in mining were wasteful, and considerable ore is believed to have been left in the ground.

The northeastern pit is also in the lowland at the foot of the hill. It is 10 feet deep, in sandy red-clay wash from the hillside. The ore is chiefly hematite, but some good-grade manganese ore had been taken out, of which about 8 tons lay on the dump.

Manganese ore is reported to have been found on the Red Hills northeast of the Heiskell mine, and as the land between the Heiskell and McGuire mines is geologically similar to that at the mines and therefore favorable for the occurrence of high-grade manganese and iron ores, it should be thoroughly prospected. These geologic conditions, however, do not continue southwest of the Heiskell mine.

Dickey prospect.—The Dickey prospect is 1½ miles north-northwest of Sweetwater, on the farm of J. A. Dickey. It is on the top of Black Oak Ridge, a chert ridge in the Knox dolomite. About 20 years ago George Loring and James Schell, of Sweetwater, opened the deposit and according to reports shipped 2 carloads of good-grade manganese ore. Since that time the property has been idle. The general run of ore is probably too siliceous to be profitably worked.

McDonald prospect.—The McDonald prospect is 4 miles southeast of Sweetwater and about the same distance from the Southern Railway. It is on the McDonald farm, in the lowland near the head of Fork Creek. It was prospected by the Southern Manganese Corporation, of Birmingham, Ala. It is on the northwest side of a low hill, about 50 feet above Fork Creek, in residual clay and chert of the Knox dolomite.

A pit 10 feet across and 15 feet deep exposes about 5 feet of red surficial clay and chert fragments overlying yellowish residual clay, which contains a little ore, especially at its top, where 1½ feet of darker clay carries ore in blackish blotches, streaks, and disseminations. The ore is psilomelane that has partly replaced chert and that incloses small angular fragments of chert, which give it the appearance of a breccia. On the dump was about 400 pounds of ore, which was said to average 43 per cent manganese, but it was of much higher grade than the run of mine will be. The prospect is not promising.

MADISONVILLE DISTRICT.

The Madisonville district includes the limestone valley around Madisonville, in which the Knox dolomite is ore bearing in places.

Kimbrough prospect.—The Kimbrough prospect is reported to be 4 miles northeast of Madisonville and about 2 miles southeast of Fagan station, on the Louisville & Nashville Railroad. Iron ore was mined here many years ago, and later the ground was prospected for manganese and reported to be worthy of development. More recently the Southern Manganese Corporation leased and opened up the property with the expectation of developing it as an iron mine. It is reported that this company found very little manganese ore, and although the quantity of iron ore was said to be fairly large, the development was stopped and the lease abandoned. The deposit is apparently in chert and clay residual from Knox dolomite close to its contact with the underlying Nolichucky shale.

TELLICO PLAINS DISTRICT.

The Tellico Plains district lies in the southwestern part of Monroe County and embraces the flat valley which extends from Tellico Plains to the Red Knobs on the west and to Starr Mountain on the southwest. The Ervin prospect, just within the Red Knobs area, is here included under this district for convenience in description.

Ervin prospect.—The Ervin prospect is 4½ miles northwest of Tellico Plains and 1½ miles south of Mount Vernon, on the Tellico Plains branch of the Louisville & Nashville Railroad. It is on the farm of Carroll Ervin, of Tellico Plains, and has been prospected by the Southern Manganese Corporation, of Birmingham, Ala.

The deposit is on a low terrace on the northwest slope of a prominent ridge of the Red Knobs, close to Shoal Creek. It occurs in buff to red sandstone which resembles the Tellico, inclosed in a syncline. (See fig. 38.) Thin buff to green shale beneath the sandstone dips 30° SE. on the northwest side of the syncline and 75° NW. on the southeast side. Beneath the shale on the northwest side is fossiliferous blue to gray crystalline limestone, which also dips 30° SE. Although the red sandstone resembles the Tellico it is probably in the lower part of the Sevier formation, for the associated greenish shales and limestones contain fossils that are probably similar to those found in the Ottosee shale of Ulrich.

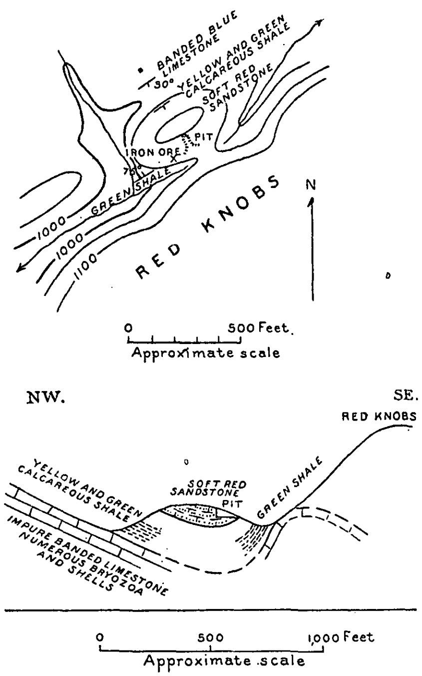

FIGURE 38.—Sketch topographic map of vicinity of Ervin prospect and geologic section through the prospect pit. The red sandstone and the underlying shale and limestone in the section are probably the lower part of the Sevier shale.

The principal opening is a cut running 75 feet northwestward across the rock structure and having a maximum depth of 10 feet. The ore is chiefly thin shells of siliceous iron, only a small amount of psilomelane and manganite being present. The iron is largely in a solid ledge or crust, and the manganese ore is scattered in the underlying clay. The surface of the terrace northeast of the cut is literally covered with siliceous iron-ore crusts.

The iron ore is too siliceous to form a workable deposit, and the amount of manganese ore present is apparently too small to be of commercial value.

Cardin prospect.[40]—A similar deposit occurs on W. J. Cardin's property, a short distance southwest of the Ervin property. It is on a small hill adjacent to the Red Knobs and lies in sandstone and shale overlying marble, probably in the Sevier formation. It is opened by an old cut formerly mined for iron, and the showing of manganese ore is very small.

Groundhog Mountain prospect.—The Groundhog Mountain prospect is 3 miles southwest of Tellico Plains, on Groundhog Mountain. It is on the farm of J. H. Curd, of Tellico Plains, and was opened for manganese several years ago.

Groundhog Mountain, which is a ridge about a mile long, is composed chiefly of scolithus-bearing white quartzite, believed to be Hesse

[40] Description is from notes by A. C. McFarlan.

quartzite, underlain on the northwest side by coarse dark-gray glistening dolomite, probably Shady dolomite, which is brecciated and largely changed to chert. On the lower northwest slope shale, probably Athens shale, dips southeast into the mountain and overlies Chickamauga limestone on the road. (See fig. 39.) The Cambrian quartzite and dolomite are apparently overthrust on the Athens shale from the southeast, and may be a small outlying remnant of the

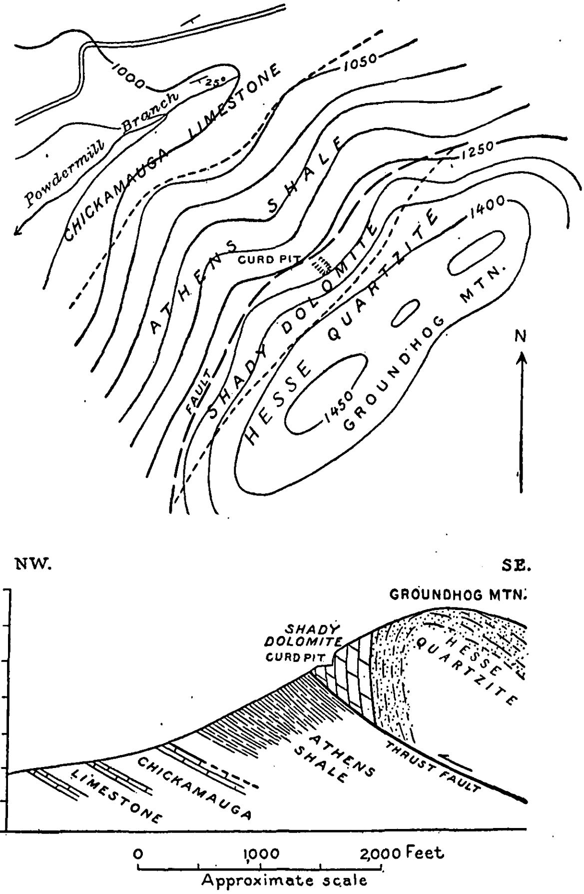

FIGURE 39.—Sketch map of the vicinity of Groundhog Mountain prospect and geologic section through Curd prospect pit.

great overthrust mass that forms Starr Mountain, 5 miles southwest. The dolomite has been silicified and mineralized by solutions that circulated along the fault. The surrounding lowland is strewn with fragments of scolithus-bearing white and red sandstone and pitted drusy chert derived from these rocks. It is reported that during the Civil War iron ore was extensively mined from the quartzites on top of Groundhog Mountain.

The principal opening is an old cut, called the Curd pit, in the middle of the northwest slope. It is 25 feet long and 15 feet deep at the face. The ore in part replaces a dolomite-chert ledge, and some nodular ore is embedded in dull-yellowish clay derived from the disintegrated dolomite. It is mostly psilomelane and contains a little crystalline manganite and soft pyrolusite. Some of it shows concentric layers of hard dull psilomelane and soft pyrolusite. The replacement of the chert follows fracture planes, from which it penetrates into the interior in rounded nodular masses. (See Pl. V, *C*.)

Smaller pits were dug on the slope above and below the main opening. Those below, however, show only a few small pieces of manganese-bearing chert float similar to the ore in the main cut.

The manganese ore is of good grade, but the quantity seems to be small. Further prospecting along the line of outcrop of the mineralized zone is necessary to determine the extent of the deposit.

Beaty and Kilby prospects.[41]—The Beaty prospect is southeast of Jalapa, about 3½ miles southwest of Tellico Plains and just southwest of Groundhog Mountain, on the land of N. H. Beaty. Here on a small knoll underlain by variegated shale, believed to be Watauga shale, manganese ore occurs in considerable quantity as float in the soil. The ore is hard and of high specific gravity and is probably good-grade psilomelane, which is thought to replace the shale. It is said that large pieces of manganese ore were obtained from a pit on the property.

Other manganese and iron ore prospects are reported along the belt of low hills southwest of Groundhog Mountain, at one of which, on the Kilby farm, 4 miles from Groundhog Mountain, the manganese indications are said to be especially favorable.

McMINN COUNTY.

McMinn County, of which Athens, near its center, is the county seat, lies directly west of Monroe County. It is largely lowland or valley, crossed by many low, straight ridges, which trend northeastward. Manganese deposits are reported at four localities—in the Sweetwater, McMinn Ridge, Athens, and Charleston districts. The Sweetwater district lies chiefly in Monroe County and is described under that heading.

SWEETWATER DISTRICT.

Hansard prospect.—The Hansard prospect is near the eastern border of the county, 3 miles west of Sweetwater, and is therefore in the Sweetwater district. It is on the farm of J. B. Hansard, of Sweetwater. The mineral rights were leased by the Southern Manganese Corporation, of Birmingham, Ala., but the deposit was not worked.

The prospect is on the northwest edge of a chert ridge overlooking the valley of Pond Creek near its head. The ore replaces chert

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[41] Description of the Beaty prospect is largely taken from notes by Arthur C. McFarlan.

of the Knox dolomite and is found in scattered pieces on the surface and in the soil. The ore mineral cementing and in part replacing chert is psilomelane of good grade, said to run 51 per cent manganese. A few masses of such ore 1 foot across, containing much chert, were found along the road, and a small quantity of ore embedded in yellow clay was recently dug from a well near the barn. The northwestern slope of the ridge was prospected by several shallow pits, which at the time of visit showed mostly iron ore. It was reported that from these pits and the surrounding fields about 600 pounds of ore averaging 52 per cent manganese had been gathered and shipped. The general run of ore, however, will probably not average more than 40 per cent manganese, on account of its large content of silica, and the deposit therefore has no commercial value.

ATHENS DISTRICT.[42]

The Athens district embraces the part of the Red Hills area around Athens. The hills lie south, southeast, and northeast of the town.

Gilbert prospect.—The Gilbert prospect is a mile southeast of Athens, on the farm of I. W. Gilbert, just south of the Etowah pike. It consists of showings of soft ore in residual yellow clay soil of the Tellico sandstone, which here dips about 30° SE.

A small black streak of soft pyrolusite and wad is exposed in a wagon road on the property, and similar material is seen at several places, at one of which, in a small creek near by, it is continuously exposed for nearly 50 feet and appears to be a seam along the bedding. Some good red hematite occurs on the ridge top.

J. H. Jones prospect.—On the J. H. Jones farm, which adjoins the Gilbert farm on the east, float manganese ore and considerable iron ore occur. The deposit is in shale overlying the Tellico sandstone, mapped as Sevier shale in the Cleveland folio of the Geologic Atlas of the United States Geological Survey. Some of the ore is of good grade and is chiefly pyrolusite. The showing, however, is very poor, and does not seem to warrant further prospecting.

M'MINN RIDGE DISTRICT.

The McMinn Ridge district embraces the chert hills in the west-central border of McMinn County and contains the Pierce, Reed, Webb, and other prospects.

Pierce prospect.—The Pierce prospect is 8 miles west of Riceville, on the Southern Railway, close to the western boundary of the county. It is on the farm of G. I. Pierce, of Riceville, 2 miles from the wagon road leading to Vigor, and had been prospected by W. M. Patton, of Cleveland, who held an option on the mineral rights.

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[42] The descriptions of prospects in the Athens, McMinn Ridge, and Charleston districts in McMinn County are largely from notes by Arthur C. McFarlan.

The deposit is in the Knox dolomite, which is weathered to a very cherty soil. It is opened by a pit 6 feet deep. Considerable ore is present, but more than half of it is brown iron ore. The manganese ore is psilomelane replacing chert and is said to run 52 per cent manganese. Probably a select sample of the pure mineral will run as high as that, but the chert in the ore can not be removed without expensive treatment, and the run-of-mine ore will analyze much lower.

Several new pits sunk along the trend of the ridge north of the old pit are reported to show a better grade of ore and indicate that the ore follows a certain horizon in the rocks, but even so the deposit has no commercial value.

Reed and Webb prospects.—Manganese ore replacing chert in the Knox dolomite is also found on the same chert ridge on the Henry Reed and Webb farms, southwest of the Pierce property. Conditions at these places are probably the same as at the Pierce prospect.

CHARLESTON DISTRICT.

The Charleston district embraces chiefly the area of the Red Hills lying east of Charleston and Calhoun, partly in McMinn County and partly in Bradley County. The hills begin with a small hill at Climer, trend northeastward, and expand to a belt 2½ miles wide, continuing at this width past Athens.

Bishop and associated prospects.—The Bishop prospect is in the southwestern part of McMinn County, near Hiwassee River, on the farm of J. M. Bishop. The deposit is apparently in the Holston marble near the contact of the overlying Tellico sandstone on one of the Red Hills. The rocks dip slightly to the southeast. The Tellico is here a pronounced sandstone and is not as calcareous as it is farther southwest, near Cleveland, where some of the best manganese deposits in this formation occur.

The prospect consists of nodules and fragments of high-grade psilomelane lying loose in red sandy clay exposed in the road. The nodules are small, the largest being 3 inches in diameter. The ore is similar to that being mined in the Cleveland district south of Cleveland, and although the showing is small the immediate vicinity is well worthy of further prospecting.

A small quantity of manganese and larger quantities of iron ore occur on adjoining properties in the Red Hills, particularly on the farms of J. B. Liner, J. M. Lawson, and T. M. McKnight. Sandy iron ore and sandy psilomelane, which occur generally on all the properties, are partial replacements of the Tellico sandstone.

BRADLEY COUNTY.

Bradley County lies southwest of McMinn County, from which it is separated by Hiwassee River. It is the southernmost county of the manganese belt. Cleveland, its county seat, is near its center. The county is crossed from northeast to southwest by many low ridges, which give it a hilly appearance. The western boundary follows White Oak Mountain, a ridge somewhat higher than the others. The county contains a number of successful manganese mines and many prospects, most of which have been opened at the contact of the Holston marble and Tellico sandstone, but two of them are in Fort Payne chert. The Charleston district extends into this county from McMinn County.

CHARLESTON DISTRICT.

Underwood mine.—The Underwood mine is 3½ miles south-southeast of Charleston and 1 mile south of Hiwassee River. It is on the farm of I. M. McAllister, but deposits are prospected also on the adjoining farms of other members of the McAllister family and that of Jack Thompson. The mine was opened by W. B. Underwood and was later operated by W. E. Hamilton & Co., of

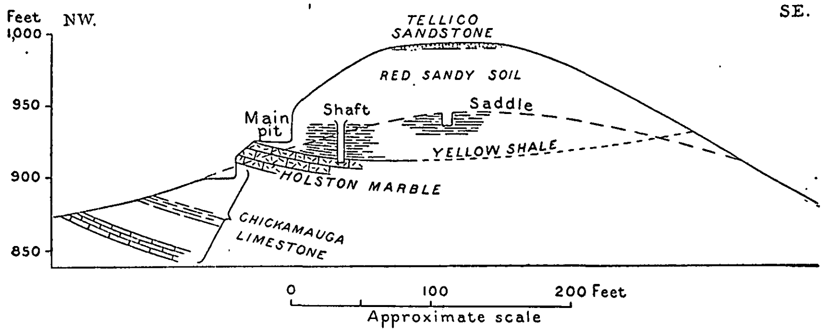


FIGURE 40.—Sketch geologic section through pit of Underwood mine.

Columbus, Ohio, on a royalty basis. At the time of visit, April, 1918, about a ton of rather low-grade manganese ore and several tons of iron ore lay on the dump. Later in the year about 6 tons of psilomelane and iron ore was on the dump.

The prospect is on the slope of a prominent hill of the Red Hills belt, about 1,000 feet in elevation. The principal opening is a 70-foot cut on the northwest face of the hill 80 feet below the top. It runs northward along the hillside and is 12 feet wide and 20 feet deep at the face. There are two other small openings on the northwest slope and a shaft pit near the crest of the hill toward the saddle to the south.

The hill is capped by soft red sandstone of the Tellico, which is underlain by thin yellow shale, probably also part of the Tellico, and this by light-gray marble of the Holston. The beds lie in a minor syncline with gentle dips, so that the yellow clay is exposed not only in the pits on the upper slopes but in the saddle to the south. (See fig. 40.)

The deposit is of the Tellico-Holston type, but in the processes of rock weathering, solution of the underlying limestone, and resulting slide, creep, and slump it has moved somewhat downhill and occurs in a mixture of clay and rock débris resembling old hillside wash, covering the marble.

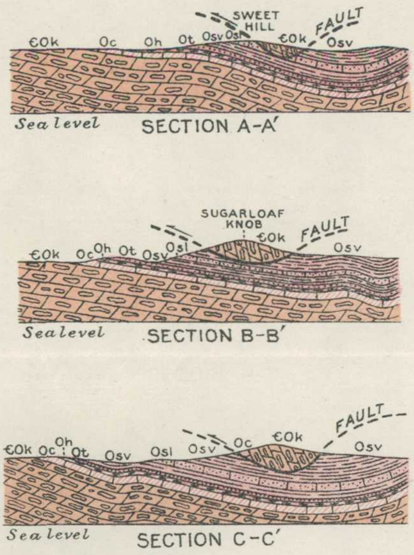
The manganese ore is chiefly psilomelane and wad, inclosed in dark-red clay irregularly streaked with dark waddy sand. The psilomelane occurs as loose fragments and chunks, the largest weighing several hundred pounds. Good-grade hematite and some brown iron ore are also present.

The shaft near the saddle, 20 feet deep, is in nearly barren yellow shale and at the bottom penetrates firm gray marble, which contains a few seams and stringers of ore. The amount of ore yielded by the workings is small compared with the volume of material excavated. However, float ore is reported to occur to the northeast along the crest of the hill, where later prospecting is said to have been more favorable. As the presence of some good-grade ore is established and the rocks at this horizon are known to be generally ore-bearing in this region, a workable deposit may yet be found.

CLEVELAND DISTRICT.

The Cleveland district is in the southwestern part of Bradley County, embracing the vicinity of Cleveland and that part of the Red Hills area which extends thence about 12 miles south to the State boundary. Plate XXVII is a geologic map of the Red Hills mineral belt, in which some of the best deposits of manganese ore in the State have been found. Although the ore-bearing red sandstone of this district is here referred to as "Tellico sandstone," following the usage in the Cleveland folio, it contains fossils of the same age as those in the Ottosee shale of Ulrich and is apparently a thin sandy bed interbedded in the basal part of the Sevier shale.

Hambright mine.—The Hambright mine, the most northern mine of the group in the Cleveland district, is 8 miles south of Cleveland and 2 miles east-northeast of Marble switch, the nearest station on the Southern Railway. It lies in the Red Hills east of the Cleveland-Dalton pike. It is owned by H. F. Hambright, of Cleveland, and is operated by Fitzgerald & Lanskey, of Chicago, who acquired the lease from Ryan & Thomason. In the first half of 1919 the mine shipped 120 tons of unwashed hand-picked ore that averaged more than 50 per cent manganese, and about 50 tons of similar high-grade ore lay on the dump. The ore was shipped to the Tennessee Coal, Iron & Railroad Co., at Birmingham, Ala., and to the Carnegie Steel Co., at Pittsburgh, Pa. Considerable ore has since been mined.



Note.—The fault plane on which the Knox dolomite was overthrust northwestward was originally nearly horizontal but has since been folded, and most of the overthrust mass has been eroded. Only a narrow belt of Knox dolomite has been preserved in a downfold of the fault plane, which forms the line of chert-covered hills from the State line to Sugarloaf Knob and from Sweet Hill to the north limit of the area mapped. Between Sweet Hill and Sugarloaf Knob the overthrust Knox dolomite has been entirely removed except on one chert-covered hill northeast of the marble quarry, where a small remnant still remains

EXPLANATION

ORDOVICIAN

Osv / Osl / Osv — Sevier shale (Equivalent in this area to Ottosee shale of Ulrich) *(Yellow fossiliferous shale; white siliceous marble, oolite, and ferruginous sandy beds, Osl)*

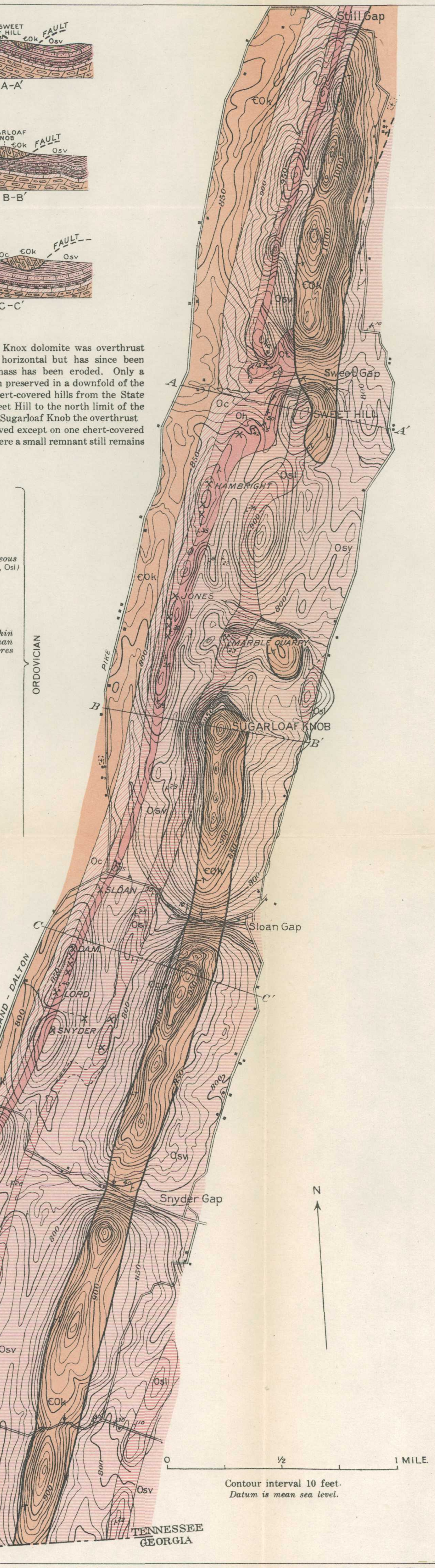
Ot — **"Tellico sandstone"** *(Ferruginous sandy limestone and thin yellow shales, probably younger than Tellico, hematite and manganese ores near base)*

Oh — Holston marble *(Gray to pink marble)*

Oc — Chickamauga limestone (Equivalent in this area to Lenoir of Safford and Ulrich) *(Blue and gray banded limestone)*

€Ok — Knox dolomite *(Chiefly chert at surface)*

Thrust fault
Overthrust side of fault
Mine
Prospect
Strike and dip of strata
Strike of vertical strata



GEOLOGIC MAP AND STRUCTURE SECTIONS OF THE RED HILLS AREA SOUTHEAST OF CLEVELAND, BRADLEY COUNTY, TENN.

Showing the relation of manganese mines and prospects to the geologic formations

By Arthur C. McFarlan

Geology revised and interpreted by G. W. Stose

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

The mine is in an open field, on a gently rolling rounded hilltop that trends northwestward and forms a terrace between the limestone valley and a line of higher hills on the east. (See Pl. XXVIII.) The main opening at the time of visit, in May, 1918, was a pit 500 feet long, which trends N. 30° E. (See fig. 41 and Pl. XXIX.) It was about 200 feet wide in its broadest part, near the north end, and had a maximum depth of 30 feet. The mine was operated by a horse-power bucket hoist and wagons, but later it was equipped with a steel boom and spherical grab scoop and an engine. Several six-wheel scrapers also were added for excavating a new trench which cuts across the hill at the north end of the working. This trench is 60 feet wide, 20 feet deep, and 300 feet long and was intended to aid in developing deeper workings.

The deposit occurs chiefly in the basal part of the so-called "Tellico sandstone" at its unconformable contact with the underlying Holston marble. The structure is monoclinal, the rocks dipping from 25° to 80° SE. (See section, fig. 41.)

The lower beds of the "Tellico sandstone" are reddish sandy limestones, containing grains of glassy quartz which are segregated in thin layers, so that on weathering the rock first changes to a closely banded or ribbed sandy limestone, then to a porous friable red sandstone, and finally to loose red sand or sandy clay. That the sandy limestone is unconformable on the marble is clearly shown in pits of the near-by D. A. M. mine, illustrated in Plate XIII (p. 30). The iron and manganese set free by rock weathering were redeposited in seams or certain porous layers in the underlying rocks but were largely concentrated into a definite bed of ore at the base of the weathered zone near the contact of the marble. The ore bed in part retains the original granular texture of the porous sandstone, and imprints of the fossils contained in the rock are still preserved, especially in the iron ore. (See Pl. XIV, p. 31.) Glassy grains of quartz are still present in beds that are transitional from the sandstone to solid psilomelane. Where the inclosing rock has weathered away pieces of this ore bed became scattered through the slumped residual clay and sand, in which they are now found as loose blocky fragments.

In the upper part of the pit the ore occurred as irregular blocky or slabby masses and fragments several inches thick, embedded in dark-red sandy clay, but in depth the ore took the form of a nearly vertical layer a foot or more thick which roughly follows the contact of the marble and sandstone. (See fig. 41.) This nearly vertical bed of ore was exposed at the bottom of the northeast-trending pit (see Pl. XXIX), where red sandy clay, which represents the disintegrated "Tellico sandstone," forms the southeast or hanging wall and red and yellow blotched clay, which represents the Holston marble, forms the northwest or foot wall. The ore bed apparently flattened out toward the top of the excavation and dipped gently southeast, in conformity with the bedding of the marble in the footwall. Near the north end of the pit the ore bed turns sharply eastward but is repeated just beyond, in the wider part of the pit, by either sharp folding or faulting. In the north wall of this pit the marble dips 25°–30° S., under the ore bed, and in this, the deepest part of the excavation, the largest body of ore was found. Small masses or thin sheets of ore that occur in the clay west of this bed probably represent seams of ore deposited within the marble, some of which are to be seen in the marble of the footwall. Recent movement of the rocks along slickensided nearly vertical joints slightly offset these stringers.

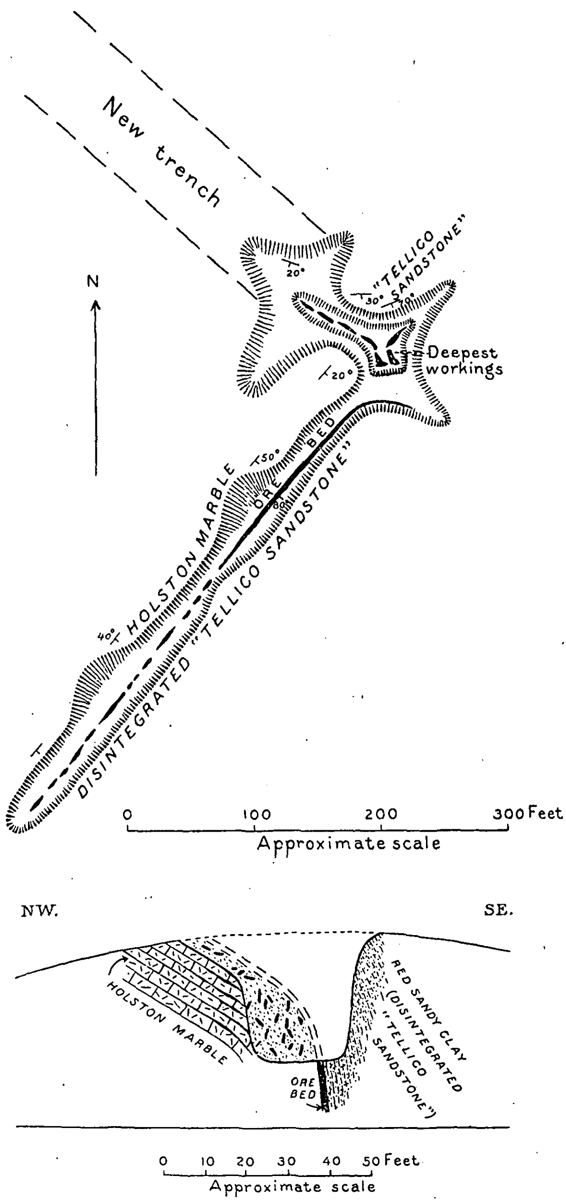
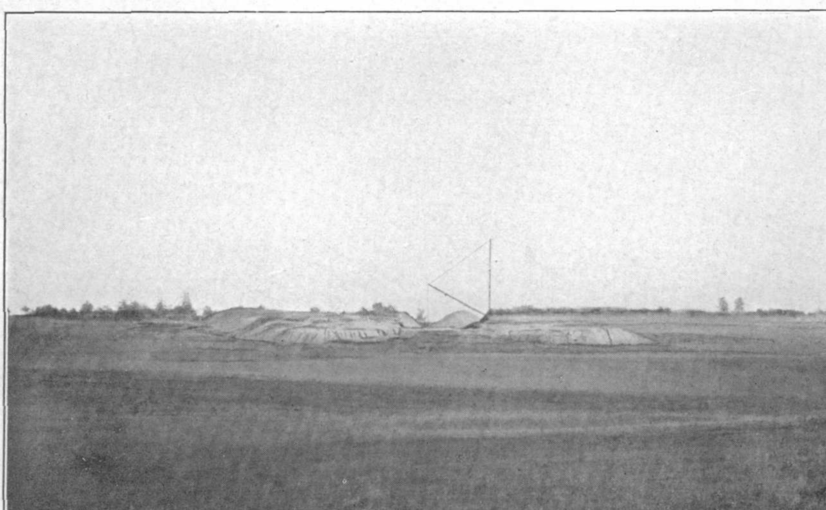


FIGURE 41.—Sketch map of the Hambright mine, showing relation of ore bed to geologic formations, and geologic section across the mine pit, showing the vertical ore bed flattening out with the structure to the west.

The ore consists chiefly of hard psilomelane but includes also manganite, pyrolusite, and wad. The two latter minerals in places completely replace sandstone and constitute a friable mass locally known as "black sand" ore, some of which was mined in the eastern part of the deep workings. Associated with the manganese ore is

A



B

HAMBRIGHT MINE, NEAR CLEVELAND, TENN.

A, View from hill to the east, showing large waste pile from recent excavations; *B*, view from the west, showing wide trench recently excavated through the hill to the deeper workings on the east side. The hills in the valley all have about the same elevation and are parts of the old valley floor.

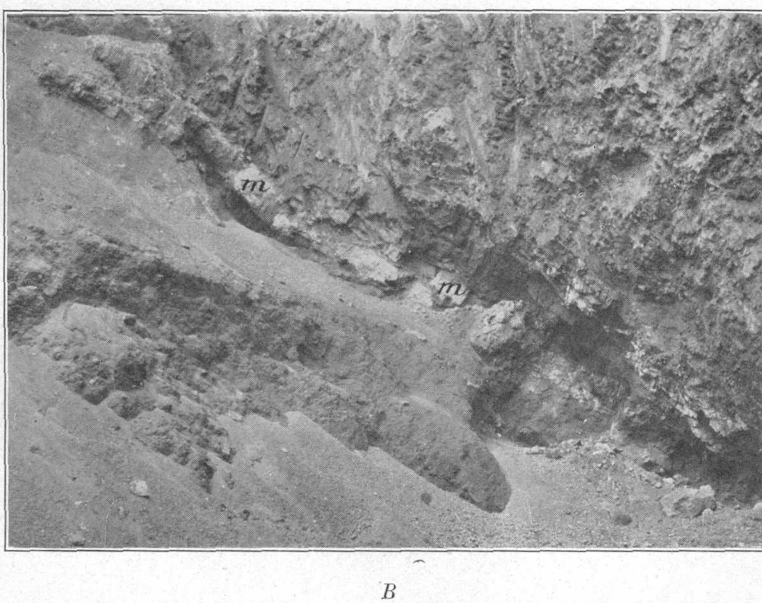
A

B

HAMBRIGHT MINE WORKINGS, NEAR CLEVELAND, TENN.

A, General view of longitudinal trench, looking north, showing piles of mined high-grade lump ore; *B*, north end of trench, where the ore bed curves to the right and the deepest workings are located, showing vertical bed of solid ore (*m*) in bottom of pit.

A



B

NORTH WALL OF MAIN PIT OF LORD MINE, NEAR CLEVELAND, TENN.

A, Upper part of wall, showing sandy-ribbed limestone of Tellico in pinnacle (at left), grading into disintegrated rock composed of red sandy clay, and manganese ore bed (*m*) at bottom of exposure; *B*, lower part of wall, showing 6-inch ore bed (*m*) at base of disintegrated Tellico sandstone.

very pure hematite in slabby blocks, which preserves impressions of fossils and contains round shiny pebbles.

Several hundred feet south of the main opening two cross trenches had been dug in search of the ore zone. They were 8 to 10 feet deep and exposed only dark-red sandy clay with little or no ore. It seems reasonable, however, to expect the ore to continue both northward and southward from the present workings, although it may be offset by faulting or folding.

On the farm of Bird Hambright, just north of the Hambright mine, some good float manganese ore and red hematite have been found at several places on the gentle hill slopes, but small prospect pits have thus far failed to find an ore body. As the ground is somewhat lower than the hilltop at the mine the ore-bearing residual clays may be largely removed by erosion.

M. V. Jones prospect.—The M. V. Jones prospect is about three-fourths of a mile south of the Hambright mine and 2 miles east of Marble switch, on the Southern Railway. It is in open fields on the upper slope of the low red hill east of the Cleveland-Dalton road. It is at the unconformable contact of the "Tellico sandstone" on the Holston marble, the relations being similar to those at the Hambright mine. The section exposed comprises 40 feet of ferruginous banded marble, overlain by 30 feet of soft yellow shale, which is capped by 10 feet of calcareous sandstone. The sandstone is full of Bryozoa similar to those in the Ottosee shale of Ulrich and weathers to red porous sandstone. The structure is locally synclinal, the beds dipping 35° SE. on the western slope and lying horizontal on the top of the hill.

Within an area about 300 feet in diameter on the top and upper western slope of the hill the north end of the property has been prospected by numerous pits and shafts to a maximum depth of 25 feet. Only small quantities of soft manganese ore and pulverulent red iron ore in deep-red clay were found. Near the south end of the property, just north of the Rock Quarry Gap road, in the middle of the west slope of the hill, six or more pits from 10 to 20 feet deep are sunk in red sandy clay lying in solution hollows between steep-walled marble pinnacles. Fragments of high-grade hematite are rather abundant, but no manganese ore other than traces of wad and pyrolusite was found. The marble is banded with thin layers of dark highly ferruginous material and probably contains on the average 5 per cent of iron. A yellow shale, which intervenes between the marble and the red sandstone, is highly fossiliferous, containing chiefly Bryozoa similar to those at Sweetwater.

Similar geologic and surface conditions exist south of the Rock Quarry Gap road on the property of J. H. Jones, where some prospecting has been done, but indications are not favorable for finding a workable deposit of manganese ore.

Sloan prospect.—The Sloan prospect is about 1 mile south of the M. V. Jones prospect, on the same line of the Red Hills, at the northwest base of the low ridge on which the Lord and D. A. M. mines are situated. It is close to Flint Springs, which is 2 miles southeast of Marble switch, on the Southern Railway. It is owned by the Sloan heirs, one of whom, W. B. Sloan, farms the property. The prospect was developed under option by E. C. O'Brien for the Seaboard Steel & Manganese Corporation.

The rocks penetrated consist of Holston marble overlain by calcareous "Tellico sandstone." The structure is monoclinal, the rocks dipping 30° SE., into the hill. The deposit is opened by a cut which runs into the hill 20 feet and is about 25 feet deep at the face. Brown even-grained marble dipping 20° SE. is exposed in the face, at the top of which is soft ferruginous red sandstone of the "Tellico."

The ore is embedded in red sandy clay, which fills large solution pockets in the upper surface of the marble. About 2 tons of high-grade hematite and good-grade manganese ore, most of it in the form of slabs half a foot to 1½ feet across, lay on the dump. This material was probably in part gathered from the adjacent fields, where considerable float ore occurs, for little ore shows in the sides of the pit. The fields on the hill slopes southeast of the pit have been tested only by auger borings and should be thoroughly prospected by pits, for it is believed by the writers that the better ground lies on higher land in that direction.

D. A. M. mine.—The D. A. M. mine is about half a mile south of the Sloan prospect and 2 miles southeast of Marble switch, on the Southern Railway. It is on the same low ridge with the Lord mine, which adjoins it on the south. It is the oldest mine in the district and is reported to have shipped several years ago about 300 tons of 50 per cent manganese ore and more recently 50 tons that averaged 53 per cent manganese. It has been operated by Davis, Artz & McCrossin, of Cleveland, but was idle when visited in May, 1918. It was reported, however, that it had been sold early in 1918, and the resumption of operation was expected.

The workings are extensive and lie in a north-northeast-trending belt 200 feet wide, which has been opened for a length of 500 feet. They are on the upper part of the southeast slope of the ridge and consist mostly of crosscuts at intervals along the contact of the "Tellico sandstone" and the Holston marble. They descend with the dip of the rocks at an angle of about 25° SE. (See fig. 42.) Most of them are shallow, but one reaches a depth of 45 feet.

The deposit occurs at the unconformable contact of the "Tellico sandstone" on the Holston marble. (See Pl. XIII, p. 30.) The

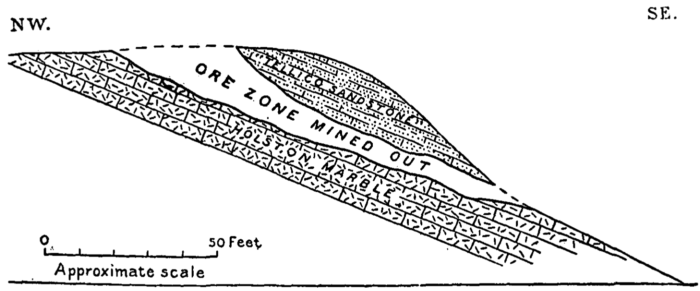


FIGURE 42.—Sketch section through a pit of the D. A. M. mine, which follows down a weathered zone in a channel at the contact of the "Tellico sandstone" and the Holston marble and comes out to daylight below.

structure is monoclinal, the marble dipping 25° ESE. at the north end and 50° ESE. at the south end of the property. Most of the "Tellico sandstone" has weathered to a dark-red residual soil and sandy clay from 2 to 8 feet thick but is deepest in solution pockets and channels in the upper surface of the marble.

The ore occurs chiefly at the bottom of the disintegrated material and is more plentiful in the clay that fills solution channels and pockets. Some is deposited in crevices along the bedding and joints of the wall rock of the channels. (See Pl. XIII.) It comprises both manganese ore and iron ore. The manganese ore is high-grade psilomelane containing more than 50 per cent manganese. The iron ore is pure red hematite and preserves impressions of fossils that were in the marble.

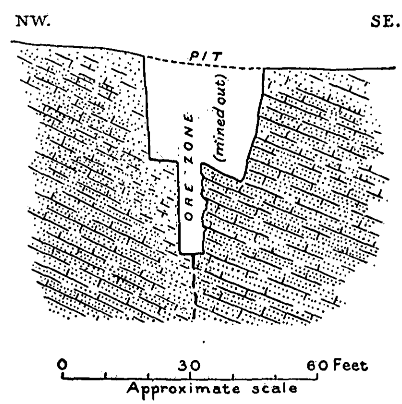


FIGURE 43.—Section of pit and shaft at north end of D. A. M. property, which follow a weathered zone along a vertical crevice in "Tellico sandstone." The southeast wall is unweathered crystalline limestone ribbed with ferruginous sandy bands about 1 inch apart. The pit is in dark manganese-stained sandy clay containing slabs of ore.

At the north end of the property a pit and shaft follow the vertical wall of a weathered zone along a solution crevice to a depth of 45 feet. (See fig. 43.) Thin seams of hematite and a little manganese ore show in the bedding and fracture planes of the bedrock, and ore is said to have occurred throughout the sandy clay that filled the weathered zone. At a depth of 32 feet the shaft is reported to have passed through an 18-inch bed of solid ore, which probably marks the bottom of completely weathered rock.

The ore constituents seem to have been dissolved out of beds in the lower part of the "Tellico sandstone" and concentrated at the bottom of the disintegrated rock, mainly in solution channels, by percolating waters. The lower beds of the "Tellico" seem to be the most easily percolated, and solution channels are therefore most plentiful at the base of these beds. The more accessible pockets of ore probably have been mined out in the present workings, but there is reason to believe that workable pockets of high-grade ore still exist in the unworked ground between the pits and in solution channels along the contact of the "Tellico" and Holston below the present workings.

Lord mine.—The Lord mine is 11 miles south of Cleveland and 1¾ miles east of Weatherly switch, on the Southern Railway. It is on the Boyd farm, which adjoins the D. A. M. mine on the south. The mineral rights are owned by the C. H. Lord Corporation, of Chicago, Ill., and the mine was operated under lease by the Tennessee Manganese Co., of Cleveland, Tenn. It is credited with a production in 1917 of 650 tons and in the first half of 1918 with 1,500 tons of high-grade ore, said to have averaged 58 to 60 per cent manganese.

The mine is on the same low broad-topped red hill on which the D. A. M. mine is situated, one of the similar hills of this vicinity which are remnants of an old valley floor now standing at 950 feet altitude. Cobbles of quartzite scattered over the tops of several of the hills indicate that some large stream once had its channel on this old valley floor. The manganese deposit occurs in the "Tellico sandstone" at its unconformable contact with underlying Holston marble. (See fig. 44.) The structure is monoclinal, the rocks dipping 40° SE. The disintegrated sand and clay which carry the ore fill pockets and solution channels in the upper surface of the marble, some of which follow down the dip of the rocks.

The deposit is opened by an east-west cut 300 feet long by 100 feet wide on the west side of the hill. At its face, in the highest part of the hill reached, the cut is 50 feet deep. (See Pl. XXX.) The eastern or deeper part of the cut is for most of its depth in dark-red sand which is crossed by clay bands dipping 40° SE. These disintegrated rocks preserve all the features of the sandy marble of the "Tellico," including thin yellow calcareous-shale streaks, from which they were derived by decomposition and leaching of the calcareous matter. The unaltered marble which is exposed at the bottom of the cut is ribbed with ferruginous siliceous bands somewhat cross-bedded and lenticular and contains thin lenses and stringers of hematite running along the bedding and joint planes. At the contact of siliceous banded marble and purer marble is a layer of nearly pure manganese ore, 6 inches to 2 feet thick, which had been followed along a solution channel down the dip some distance below the bottom of the cut. It is the main ore body and is the source of much of the loose lump ore scattered in the sandy clay in the western part of the cut. It seems to be continuous across the cut for about 40 feet along the strike.

West of the ore bed the red sandy clay in the pit is banded in various directions, contains masses of yellow clay resembling coarse breccia, and has many slickensided planes coated with bright-red clay.

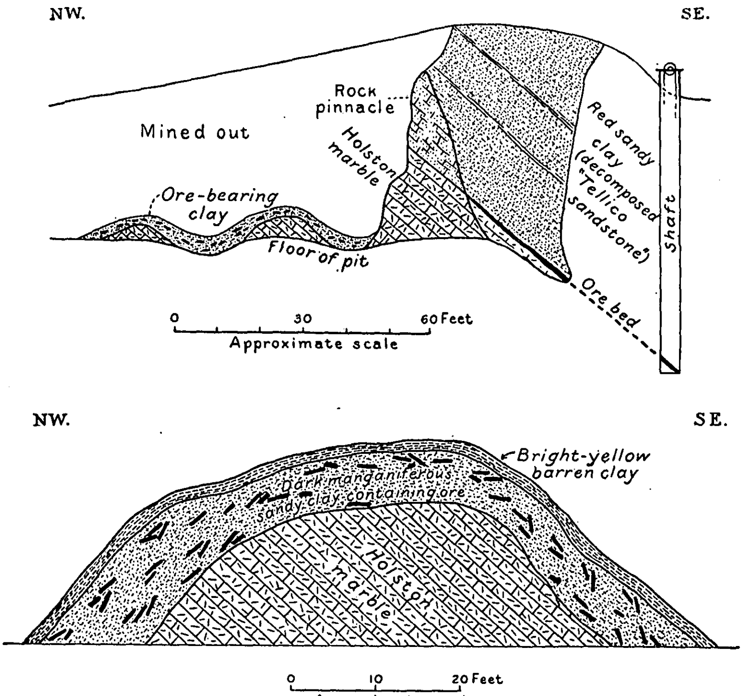


FIGURE 44.—Sketch section of main cut of Lord mine, showing ore bed at contact of "Tellico sandstone" and Holston marble and ore-bearing residual clay resting on the uneven solution surface of the marble, and detailed sketch of one of the pinnacles of Holston marble in floor of cut, showing relation of overlying ore-bearing clay.

These materials were evidently derived by disintegration from the "Tellico sandstone," which formerly covered the marble, and its waste was let down on the irregular surface of the Holston marble pitted and channeled by solution under cover. Bosses of fresh marble 5 feet or more high, exposed in the bottom of the pit, are covered with a layer 6 to 10 inches thick of dark sandy clay, in which most of the loose ore fragments occur, and this is generally covered with a thin layer of bright-yellow barren clay, probably residual from clay beds in the lower part of the "Tellico," which separates it from the overlying soft dark-reddish sandy clay derived from higher beds in the "Tellico sandstone." (See fig. 44.)

About 50 feet east of the main cut, on the east slope 15 feet below the top of the ridge, a vertical double-compartment shaft was started to reach the main ore bed and mine it by drifting. The shaft passed through 10 feet of red clay at the surface, next through 32 feet of yellow clay, and then into soft black waddy, earthy sand. It was later reported to have passed through the ore bed into Holston marble at a depth of 60 feet, and the ore was said to have improved with depth.

The ore is chiefly massive hard psilomelane but includes a little soft pyrolusite and wad. It is nearly all lump ore and is shipped unwashed. A little barite was observed in some ore. In the clay overlying the manganese ore in the western part of the mine there is considerable soft, pulverulent red hematite, greasy to the feel.

The mine was formerly equipped with a heavy derrick-like apparatus about 60 feet long with cable and bucket attachment, but it was found to be too unwieldy for the work. At the time of visit a drag-line scraper was being used, and more recently an automatic loader and dumper type of scraper having a bucket capacity of 1½ cubic yards was said to be in use.

A prospect tunnel was run into the hill from the valley east of the mine some years ago but did not reach the ore. On a small knoll across the valley, about 500 feet east of the mine, two prospect trenches about 6 feet deep that have been dug in red clay show a little wad and hematite but almost no hard manganese ore. These openings are on a marble bed associated with yellow Sevier shale at a higher horizon than the ore bed at the mine.

Snyder prospect.[43]—The Snyder prospect is just south of the Lord mine, on the Snyder farm, 1½ miles from Weatherly switch, on the Southern Railway. It is undeveloped, but a short-time option is held on it by the Tennessee Manganese Co.

Only a small amount of float ore was found on the red hill on which the Lord mine is situated. The best showing of ore is on the east slope of a red hill of "Tellico sandstone" near its contact with Knox dolomite along a thrust fault, on the east side of the property. The Knox dolomite, which is represented by a prominent ridge covered with white cherty soil, is thrust westward against red sandstone of the "Tellico," which dips steeply southeast, apparently on the east limb of an overturned syncline inclosing Sevier shale.

Some good-grade float ore, consisting chiefly of psilomelane similar to that at the Lord mine, occurs at the base of the chert ridge close to the fault. The indications are regarded as favorable for finding a workable ore deposit.

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[43] The descriptions of the Snyder, Gee, Brown, and Wolf prospects are largely from notes by Arthur C. McFarlan.

Hannah prospect.—The Hannah prospect is on Mrs. Hannah's farm, 1¼ miles south of the Lord mine and about 2½ miles by road from Weatherly switch, on the Southern Railway. It has been opened by a trench 10 feet deep by the Tennessee Manganese Co., which has a lease on the mineral rights and took out 8 tons of ore.

The prospect is on the west slope of a red hill south of the one on which is the Lord mine. It is in residual red sandy clay on the "Tellico sandstone" close to the unweathered underlying Holston marble, which forms the floor of the pit. The marble is siliceous and contains yellow shale bands which dip 45° SE. The overburden consists of about 10 feet of the clay. On the slope below the trench coarse crystalline marble is underlain by white and blue limestone of the Chickamauga.

Gee prospect.—The Gee prospect is on the farm of Burley Gee, 10 miles south-southwest of Cleveland, just west of the Cleveland-Dalton pike and about a mile south of McDonald, on the Southern Railway. It is on the crest of a chert ridge in the Knox dolomite and is opened by a small prospect pit.

The ore is psilomelane, which fills fractures and cements and in part replaces fragments of chert. It occurs in considerable amount scattered over the surface and embedded in the residual clay, but sufficient work has not been done to establish the quantity of ore present or its grade. Similar showings are said to occur on the neighboring Davis farm.

WHITE OAK MOUNTAIN DISTRICT.

The White Oak Mountain district lies 8 miles northwest of Cleveland in White Oak Mountain, the crest of which forms the western boundary of the country. Manganese ore is reported from several places in the district.

White Oak Mountain mine.—The White Oak Mountain mine is near the west boundary of the county 8 miles northwest of Cleveland. It is owned and operated by the White Oak Manganese Corporation, of Pittsburgh, Pa. It has produced about 40 tons of manganese ore and about 1,000 tons of manganiferous iron ore, which still lay on the dump at the time of visit. The mine is on the crest and upper east slope of one of the ridges of White Oak Mountain, at elevations ranging from 1,100 feet to 1,300 feet. The property covers 998 acres, and pending the outcome of litigation as to the title to a large part of the land the mine was shut down.

The deposits are distributed in a wide belt stretching 3 miles along the ridge and reaching from its crest to the bench on its eastern slope. (See fig. 45.) They are opened by many cuts, pits, and shafts, some of which reach a depth of 30 feet. Part of the ore occurs in ledges of Fort Payne chert on the crest of the ridge, the structure of which is monoclinal, the rocks dipping 10°–15° SE. Other deposits, on the bench on the east slope, are in cherty soil derived from weathered cherty limestone of the Fort Payne chert. The dip of the beds flattens eastward, and the beds turn up sharply in a syncline, the hard chert and sandstones of the formation making a line of low foothill ridges along the eastern base of the mountain. At the south the syncline is divided by a low anticline. (See fig. 45.)

The section exposed on the property is approximately as follows:

Section at White Oak Mountain mine, 8 miles northwest of Cleveland, Tenn.

	Feet.
Soft greenish to buff clay and white kaolin, containing decomposed crinoidal white to rusty chert	15+
White chert full of crinoid segments	30
Cherty white sandstone, with nodules and geodes. Manganese stains on joints	10±
Sandy shale and thin beds of crinoidal chert	90±
Black shale (Chattanooga); exposed	40

The largest opening is a trench about 80 feet long, 30 feet wide, and 15 feet deep, in the north-central part of the property. It is on a bench on the east slope of the mountain about 100 feet below the top. A tunnel has also been driven into the hill at this place. The cut exposes shaly chert, which dips gently southeast about parallel with the surface. Three layers of the chert are impregnated with ore, the ore-bearing layers being a foot thick in places. Of the 1,000 tons of ore which lay on the dump at the time of visit about 40 tons was good-grade psilomelane, containing about 40 per cent manganese. The rest of the ore was largely good-grade brown iron ore, in part manganiferous. A short distance south of the trench, on the lower slope of the hill, a shaft 75 feet deep penetrated 22 feet into black shale below the ore-bearing chert. At the time of visit a 4-inch diamond-drill hole was being sunk adjacent to the shaft in order to pass through the barren shale to ascertain whether or not ore lay beneath it.

At the south end of the property an opening on the crest of the ridge exposes chert ledges in which manganese ore fills joints and fractures and in part replaces the chert, forming tabular masses several inches in thickness. Similar openings have been made at several places on the crest of the ridge. These unweathered bedrock deposits are probably not of commercial value, owing to the expense of mining and of separating the ore from the chert.

At the north end of the property a trench at the back of a bench on the upper east slope of the ridge exposes weathered thin-bedded chert carrying considerable manganese ore, and a shallow pit on the bench is in loose chert, likewise with manganese ore. Considerable manganese ore was obtained from the pit, but much of it is siliceous from the contained chert.

All the deposits seem to have a common origin. The ore was probably derived from the Fort Payne chert, in which it was concentrated by circulating waters in crevices, along bedding planes, and replacing the chert. These mineralized ledges, which outcrop on the crest of the ridge, are too hard and siliceous to be profitably mined. On benches on the east slope of the ridge at an elevation of

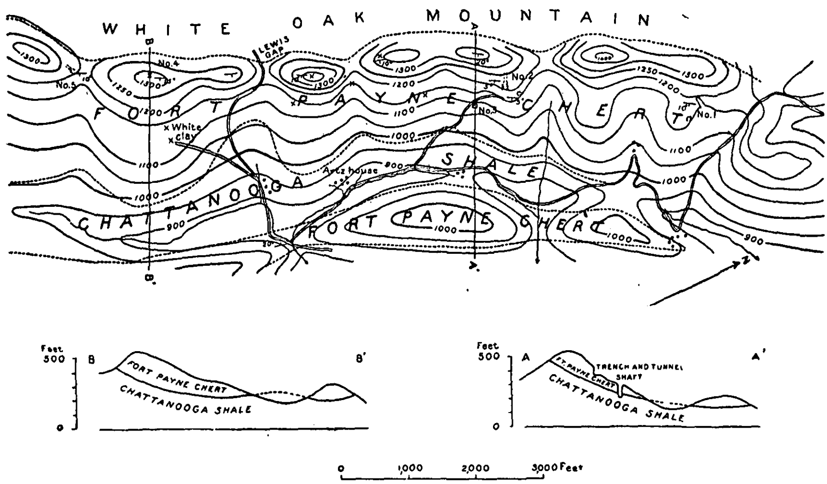

FIGURE 45.—Sketch map and section of the vicinity of White Oak Mountain mine, showing topographic and geologic relations, and outline geologic sections across the ridge. 1, Trench with 15-foot vertical face exposing thin-bedded chert cemented and replaced by manganese ore, and a round test pit, 35 feet deep, in loose chert and soil on terrace; 2, trench and tunnel in shaly chert, partly replaced along three beds and in joints by iron and some manganese ore in thin stringers, and a lower pit exposing cherty sandstone and 6-inch bed of wad in chert; 3, two-compartment shaft 75 feet deep, upper part in chert, lower 22 feet in black shale (Chattanooga); 4, pit and trench, 8 feet deep, in brecciated ledge of massive chert containing small quantity of manganese ore, which partly cements and replaces the chert; 5, short tunnel, in soft white to greenish clay (kaolin) containing some fragments of chert, largely disintegrated. No body of ore was struck in shaft. A 4-inch core drill was being put down at the shaft (3) at time of visit and had gone 15 feet into chert.

1,150 to 1,200 feet, which mark an old erosion surface or peneplain, the rocks are deeply weathered, and the ore has been set free in the residual cherty clay soil but is in part redeposited in the form of lump ore. It is on these benches, therefore, that the better deposits may be expected.

Although the iron and manganese ores in the shaly chert in the largest opening are clean lump ore that can be shipped without washing, the deposits in clay and soil must be thoroughly washed to remove the clay and chert. The bedrock deposit also must be crushed and concentrated by jigs. The ore must then be hauled by wagon or truck 8 miles to the railroad, about half of the distance over rough, hilly roads. Although considerable iron ore and manganiferous ore has been developed on the property, the general low grade of the ore, the high cost of mining and treating it, and the long haul are unfavorable for profitable mining.

Brown and Wolf prospects.—The Brown prospect is on the farm of Jake M. Brown, on White Oak Mountain, 8 miles west of Cleveland and 4 miles northwest of McDonald station, on the Southern Railway. It is on a hill 200 feet above the valley bottom, underlain by Fort Payne chert. The geologic relations are similar to those at the White Oak Mountain mine, 6 miles northeast.

Float ore is locally abundant on the surface and in the soil. The ore consists of psilomelane cementing and partly replacing fragments of chert. At one place a seam of psilomelane not more than 1 inch thick, accompanied on either side by about a foot of soft, decomposed manganiferous and ferruginous rock, was exposed. The ore is too siliceous to be shipped without crushing and removing the chert, and the quantity of ore present is too small to be mined profitably.

Another deposit is exposed in a small pit on the crest of White Oak Mountain on the farm of James Wolf, 2 miles west of McDonald. It is also in the Fort Payne chert. The ore is chiefly manganiferous iron and of too low a grade to be profitably mined.

LIST OF MINES AND PROSPECTS.

Manganese mines and prospects in east Tennessee.

[Arranged geographically by counties, beginning at the northeast corner of the State.]

Mine or prospect.[a]	Location and distance to nearest shipping point.	Owner.	Operator or prospector.	Type of deposit.
JOHNSON COUNTY.				
Shady district:				
Reynolds mine.	3/4 mile northeast of Sutherland; 1/2 mile to siding on Beaverdam R. R.	A. D. Reynolds...	Lehigh Valley Manganese Ore Co.	Shady dolomite.
Neely mine....	1 mile south of Sutherland; 3/4 mile to siding on Beaverdam R. R.	J. A. Neely........	George E. Davis and Laurel Mining Co.	Do.
Sutherland prospect.	1 3/4 miles southwest of Sutherland; 1 mile to siding on Beaverdam R. R.	Wiley and J. F. Sutherland.	Wiley and J. F. Sutherland.	Do.
Hogback mine.	2 1/2 miles south-southwest of Sutherland; 3/4 mile to siding on Beaverdam R. R.	Lehigh Valley Manganese Ore Co.	Lehigh Valley Manganese Ore Co.	Do.
Davis mine....	1/2 mile northwest of Crandull on Beaverdam R.R.	W. J. Parker and E. N. Martin.	Southern Manganese Corp.	Do.
M. E. King prospect.	1 mile northwest of Shady; 1/4 mile to Beaverdam R. R.	M. E. King.......	....	Do.
Maxwell mine.	1/2 mile west of Shady on Beaverdam R. R.	....	Maxwell Manganese Mining Co.	Do.
Wright mine...	3 1/2 miles west of Shady on Beaverdam R. R.	——Wright......	.....do............	Do.
Osborn prospect.	1 mile southwest of Shady on Beaverdam R. R.	Aleck Osborn	Aleck Osborn	Do.
Hopper prospect.	.....do..................	—— Hopper.....	George E. Davis..	Do.
Mountain City district:				
Taylor Valley mine.	Matney; 2 miles to Dollars on Laurel R. R.	I. H. Reece.......	East Tennessee Mining Co.	Fault plane.
Silver Lake mine.	Silver Lake station on Laurel R. R.	Wiley Sutherland.	Silver Lake Mining Co.	Terraced stream gravel.
Wills mine.....	1 mile east of Wills on Laurel R. R.	Oscar Wills.......	Laurel Mining Co..	Shady dolomite.
Silver Lake prospect.	1 mile east of Wills on Laurel R. R.	.....do............	Silver Lake Mining Co.	Do.
Wills prospect.	.....do..................	.....do............	Oscar Wills........	Do.
Newton Cornett prospect.	2 miles east of Wills on Laurel R. R.	Newton Cornett...	Laurel Mining Co.	Do.
Mary Cornett prospect.	2 1/2 miles east of Wills on Laurel R. R.	Mary Cornett.....	.....do...........	Do.
Wright prospect.	3 miles east of Wills on Laurel R. R.	Ward Iron Co.....	W. C. Wright......	Do.
Nelson King prospect.	3 miles northeast of Mountain City on Laurel R. R.	Nelson King......	(Undeveloped)....	Do.
Shouns prospect.	2 1/2 miles south of Mountain City; 1 mile to Shouns on Southern Ry.	Virginia Iron, Coal & Coke Co.	.....do...........	Watauga shale.
Doe Valley mine.	7 miles southwest of Mountain City; 7 miles to Doe on Southern Ry.	E. C. Fritz........	East Tennessee Mining Co.	Do.
Butler district:				
Proffit prospect (reported).	5 miles northeast of Butler; 2 miles to Doe on Southern Ry.	Stacy Proffit......	(Undeveloped)....	Erwin quartzite.
Wilson Hill mine.	1 mile south of Neva on Southern Ry.	Superior Manganese Corp.	Superior Manganese Corp.	Shady dolomite (faulted).

[a] Locations of prospects marked "reported" were obtained by correspondence or through other persons and not by personal visit.

Manganese mines and prospects in east Tennessee—Continued.

Mine or prospect.	Location and distance to nearest shipping point.	Owner.	Operator or prospector.	Type of deposit.
JOHNSON COUNTY—continued.				
Butler dist.—Con.				
Wagner prospect.	4½ miles northeast of Butler on Southern Ry.	D. A. Wagner	A. H. and J. L. McQueen.	Shady dolomite.
Dry Run mine.	3 miles east-northeast of Butler on Southern Ry.		A. H. McQueen	Do.
Watauga River mine.	2 miles southeast of Butler on Southern Ry.		J. L. McQueen	Watauga shale.
Cable prospect.	do	—— Cable	J. E. Reece	Do.
Goss mine	5 miles southeast of Butler on Southern Ry.		W. C. Goss Manganese Co.	Shady dolomite.
Moody prospect	do	W. R. Moody	C. H. White	Do.
CARTER COUNTY.				
Butler district:				
Elk mine	2½ miles south of Butler on Southern Ry.	Hately & Lunsford.	McQueen Manganese Co.	Watauga shale.
Dubault prospect.	2 miles southwest of Butler on Southern Ry.	—— Dubault	J. E. Reece	Do.
Younce prospect.	do	S. S. Younce	do	Do.
Cobb Creek prospect.	2½ miles northwest of Butler on Southern Ry.	C. S. Morley	A. H. McQueen	Do.
Stony Creek district:				
Blevins mine	1½ miles northeast of Colesville on branch of Southern Ry.	Mrs. Isaac Blevins.	Capt. Robinson	Shady dolomite.
Hatcher prospect.	1 mile east of Sadie on branch of Southern Ry.	—— Hatcher	H. E. Graves	Do.
Grindstaff prospect.	do	G. L. Grindstaff	G. L. Grindstaff	Do.
Blue Spring mine.	4 miles east of Hunter on Southern Ry.	Carrigan heirs	Walker & McKenna.	Do.
Keenburg prospect.	1 mile east of Keenburg on Southern Ry.	Southern Minerals Corp.	Southern Minerals Corp.	Shady dolomite and Erwin quartzite.
Hampton district:				
Cardens Bluff mine.	½ mile southwest of Cardens Bluff on Southern Ry.	Reynolds & McQueen.	Reynolds & McQueen.	Shady dolomite.
Teaster & Ray prospect (reported).	1½ miles northeast of Hampton on East Tennessee & Western North Carolina R. R.	M. G. Teaster and T. J. Ray.	M. G. Teaster and T. J. Ray.	Wash from Shady dolomite.
Cedar Hill mine.	1 mile south of Hampton on East Tennessee & Western North Carolina R. R.	Stiles heirs	Maxwell Manganese Mining Co.	Shady dolomite.
Valley Forge mine.	¾ mile southeast of Valley Forge on East Tennessee & Western North Carolina R. R.	Valley Forge Mining Co.	Valley Forge Mining Co.	Do.
Jenkins prospect.	2 miles southwest of Valley Forge on East Tennessee & Western North Carolina R. R.	Abe Jenkins heirs.	J. N. Koch and associates.	Do.
E. J. Hyder prospect.	2½ miles southwest of Valley Forge on East Tennessee & Western North Carolina R. R.	Eliza Jane Hyder	do	Do.
Oscar Hyder prospect.	do	Oscar Hyder	do	Do.
Marion Hyder prospect.	3 miles southwest of Valley Forge on East Tennessee & Western North Carolina R. R.	Marion Hyder	do	Do.
Winter mine	6 miles southeast of Johnson City; 4 miles to Watauga Point on East Tennessee & Western North Carolina R. R.	Taylor heirs	Max Mining Co.	Do.
Patton mine	do	do	do	Do.
Treadway prospect.	6 miles southeast of Johnson City; 3 miles to Carolina, Clinchfield & Ohio R. R.	Geo. Treadway	W. H. Kemler	Do.
Hodge prospect.	do	Frances Hodge	do	Do.

Manganese mines and prospects in east Tennessee—Continued.

Mine or prospect.	Location and distance to nearest shipping point.	Owner.	Operator or prospector.	Type of deposit.
CARTER COUNTY—continued.				
Unicoi district:				
T. J. Brummett mine.	4 miles northeast of Unicoi on Carolina, Clinchfield	T. J. Brummett...	Southern Manganese Corp.	Shady dolomite.
UNICOI COUNTY.				
Unicoi district:				
Susan Brummett mine.	3 miles northeast of Unicoi on Carolina, Clinchfield & Ohio R. R.	Mrs. Susan Brummett.	.....do............	Do.
Britt mine.....	.....do..................	J. L. Britt........	.....do............	Do.
Unicoi prospects.	Near Unicoi on Carolina, Clinchfield & Ohio R. R.	Unaka National Forest.	—— Blevins.....	Do.
Bumpass Cove district:				
Embree prospect.	3 miles southwest of Embreeville on Embreeville branch of Southern Ry.	Embree Iron Co...	Embree Iron Co...	Do.
GREENE COUNTY.				
Haysville district:				
Haysville prospect.	12 miles south of Greeneville on Southern Ry.	Unaka Development Co.	Unaka Development Co.	D
Sylvia prospect.	11 miles south of Greeneville on Southern Ry.	....	Leroy & J. C. Park.	Do.
Lamb prospect.	13 miles south of Greeneville on Southern Ry.	Scott Lamb.......	Leroy Park.......	Do.
Payne prospect (reported).	16 miles southeast of Greeneville; 9 miles to Del Rio on Southern Ry.	Henry Payne.....	.....do............	Do.
COCKE COUNTY.				
Del Rio district:				
Wood mine....	5 miles northeast of Del Rio on Southern Ry.	Nick Wood.......	(Inactive).........	Do.
Adams mine...	2 miles northwest of Del Rio on Southern Ry.	John N. Adams..	.....do............	Do.
Blanchard mine.	2 miles northwest of Del Rio; 1 mile to Southern Ry.	William Blanchard.	Barium Lithopone Co. (inactive).	Do.
Waddell mine..	3 miles west of Del Rio; 1½ miles to West Myers on Southern Ry.	John B. Waddell..	(Inactive).........	Quartzite.
Long Creek prospect.	3 miles northwest of Del Rio on Southern Ry.	Aleck Huff........	.....do............	Shady dolomite.
Huff prospect..	4 miles northwest of Del Rio on Southern Ry.	.....do............	.....do............	Do.
Newport district:				
Newport mine.	4 miles west of Newport on Southern Ry.	Sant estate........	Newport Manganese Corp.	Do.
Jones & McMahon prospect.	4 miles southwest of Newport on Southern Ry.	Jones & McMahon.	(Inactive).........	Do.
Raines mine...	3 miles southwest of Newport on Southern Ry.	Barney Hurley....	.....do............	Do.
HAMBLEN COUNTY.				
Boatman Ridge district:				
Curry prospect.	7 miles northeast of Morristown on Southern Ry.	—— Curry......	(Undeveloped)....	Knox dolomite.
Noeton prospect.	5 miles north-northwest of Morristown on Southern Ry.	....	.....do............	Do.
Lotspeich prospect.	5 miles northwest of Morristown on Southern Ry.	....	J. N. Lotspeich...	Do.
Mays prospect..	6 miles west of Morristown; 3 miles to Asapa on Southern Ry.	Monroe Mays......	(Undeveloped)....	Do.
Ivy prospect...	.....do..................	G. N. Ivy..........	.....do............	Do.

Manganese mines and prospects in east Tennessee—Continued.

Mine or prospect.	Location and distance to nearest shipping point.	Owner.	Operator or prospector.	Type of deposit.
GRAINGER COUNTY.				
Rutledge district:				
Rutledge mine.	2 miles southeast of Rutledge on Southern Ry.	J. H. Lowe	J. S. Swann	Knox dolomite.
Harmon prospect.	2½ miles southeast of Rutledge on Southern Ry.	Joe Harmon	(Undeveloped)	Do.
Young prospect (reported).	6 miles south of Rutledge on Southern Ry.	B. F. Young	do	Do.
Swann prospect (reported).	7 miles southwest of Rutledge on Southern Ry.		J. S. Swann	Do.
Washburn district:				
Wallen prospect	4 miles northeast of Washburn on Southern Ry.	Wm. Wallen	(Undeveloped)	Do.
Frye prospect.	1½ miles northwest of Washburn on Southern Ry.	Chas. Frye	do	Do.
JEFFERSON COUNTY.				
Jefferson City district:				
Currens prospect (reported).	Near Jefferson City, on Southern Ry.	George Currens	do	Do.
SEVIER COUNTY.				
East Fork district:				
East Fork mine	10 miles southeast of Sevierville, on Knoxville, Sevierville & Eastern Ry.	Tennessee Manganese Co.	Tennessee Manganese Co.	Carbonate ore in older dolomite.
BLOUNT COUNTY.				
Tuckaleeche Cove district:				
Townsend prospect.	½ mile north of Townsend on Little River R. R.	A. H. Webb	(Undeveloped)	Knox dolomite.
Chilhowee Mountain district:				
Miller prospect.	6 miles northeast of Chilhowee on Tennessee & Carolina Southern division of Southern Ry.	Rufus Miller	do	Hesse quartzite.
Sellers prospect.	1½ miles northwest of Chilhowee on Tennessee & Carolina Southern division of Southern Ry.	William Sellers	H. E. Colton (deceased).	Do.
McMurray prospect.	1 mile west of Chilhowee on Tennessee & Carolina Southern division of Southern Ry.	Sam McMurray	(Undeveloped)	Do.
Greenback district:				
Aiken prospect.	2½ miles northeast of Greenback on Louisville & Nashville R. R.	John R. Aiken	do	Knox dolomite.
Curtis prospect.	2½ miles northeast of Greenback on Louisville & Nashville R. R.	T. G. Curtis	do	Do.
Crisp prospect.	do	David Crisp	do	Do.
Klepper prospect.	do	J. E. Klepper	do	Do.
A. J. Williams prospect.	3 miles northeast of Greenback on Louisville & Nashville R. R.	Mrs. A. J. Williams	do	Do.
T. S. Williams prospect.	do	T. S. Williams	do	Do.
Louisville district:				
Louisville mine.	4 miles southwest of Louisville; 1 mile to Louisville & Nashville R. R.	J. B. Cox	Unaka Minerals Co.	Holston marble.
Louisville prospect (reported).	2 miles southwest of Louisville; 1 mile to Louisville & Nashville R. R.			Holston-Tellico contact.

Manganese mines and prospects in east Tennessee—Continued.

Mine or prospect.	Location and distance to nearest shipping point.	Owner.	Operator or prospector.	Type of deposit.
KNOX COUNTY.				
Knoxville district:				
Fitzgerald prospect.	3 miles south of Bearden on Southern Ry.	J. H. Giezentanner	Paul Fitzgerald...	Holston-Tellico contact
Green prospect.	2 miles southwest of Bearden station on Southern Ry.	J. C. Green........	J. C. Green........	Do.
Copper Ridge district:				
Haworth prospect (reported).	2 miles west of Powell on Knoxville, Jellico & Fonde division of Southern Ry.	W. L. Haworth...	(Undeveloped)....	Knox dolomite.
ANDERSON COUNTY.				
Pine Ridge district:				
Bright & Howell prospect (reported).	5 miles north of Clinton on Louisville & Nashville R. R.	D. M. Bright and D. A. Howell.	....	Chickamauga limestone (faulted?).
Wallace prospect (reported).	7 miles northwest of Clinton on Louisville & Nashville R. R.	Hack Wallace.....	T. F. Narramore..	Do.
LOUDON COUNTY.				
Loudon district:				
Cates prospect .	1½ miles south of Loudon on Southern Ry.	J. K. Cates........	Lafollette Iron Co.	Holston marble (faulted?).
Fork Creek Knobs district:				
Galbraith mine.	8 miles southeast of Loudon; 12 miles by water to Lenoir on Southern Ry.	Charles Galbraith and Judge Webb.	Southern Manganese Corp.	Holston-Tellico contact.
MONROE COUNTY.				
Fork Creek Knobs district:				
Mills prospect..	8 miles east-northeast of Sweetwater on Southern Ry.	J. C. Mills........	.....do............	Do.
Sweetwater district:				
McGuire mine..	4 miles north-northeast of Sweetwater; ½ mile to Gilman siding on Southern Ry.	J. Frank McGuire.	.....do............	Do.
Preston prospect.	3½ miles northeast of Sweetwater; ½ mile to Gilman siding on Southern Ry.	J. N. Preston.....	Joe Corn..........	Holston-Tellico wash?
Vida mine.....	3 miles north-northeast of Sweetwater; ½ mile to Vida switch on Southern Ry.	C. D. Smith.......	Vida Iron Co.....	Holston-Tellico contact.
Ewing mine....	2½ miles north-northeast of Sweetwater; ½ mile to Gilman siding on Southern Ry.	Robert Ewing....	J. J. Fitzgerald and H. L. Smith.	Do.
Heiskell mine..	1½ miles northeast of Sweetwater on Southern Ry.	Harry Heiskell....	H. L. Smith......	Do.
Dickey prospect (reported).	1½ miles northwest of Sweetwater on Southern Ry.	J. A. Dickey......	(Inactive).........	Knox dolomite.
McDonald prospect.	4 miles southeast of Sweetwater on Southern Ry.	—— McDonald..	Southern Manganese Corp.	Do.
Madisonville district:				
Kimbrough prospect (reported).	4 miles northeast of Madisonville; 2 miles to Louisville & Nashville R. R.	—— Kimbrough	.....do............	Do.

Manganese mines and prospects in east Tennessee—Continued.

Mine or prospect.	Location and distance to nearest shipping point.	Owner.	Operator or prospector.	Type of deposit.
MONROE COUNTY—continued.				
Tellico Plains district:				
Ervin prospect.	1½ miles south of Mt. Vernon on Athens and Tellico Plains division of Louisville & Nashville R. R.	Carroll Ervin......	Southern Manganese Corp.	Sevier shale(?).
Cardin prospect	2 miles southwest of Mount Vernon.	W. J. Cardin......	(Undeveloped)....	Do.
Groundhog Mountain prospect.	3 miles southwest of Tellico Plains on Athens and Tellico Plains division of Louisville & Nashville R. R.	J. H. Curd........	Southern Manganese Corp.	Shady dolomite (faulted)
Beaty prospect.	3½ miles southwest of Tellico Plains on Athens and Tellico Plains division of Louisville & Nashville R. R.	N. H. Beaty......	N. H. Beaty......	Watauga shale(?).
Kilby prospect (reported).	6 (?) miles southwest of Tellico Plains on Athens and Tellico Plains division of Louisville & Nashville R. R.	—— Kilby......	(Undeveloped)....	Unknown.
M'MINN COUNTY.				
Sweetwater district:				
Hansard prospect.	3 miles west of Sweetwater on Southern Ry.	J. B. Hansard.....	(Undeveloped)....	Knox dolomite.
Athens district:				
Gilbert prospect.	1 mile southeast of Athens on Southern Ry.	I. W. Gilbert......	.....do............	Tellico sandstone.
J. H. Jones prospect.	.....do....................	J. H. Jones........	.....do............	Sevier shale.
McMinn Ridge district:				
Pierce prospect.	8 miles west of Riceville on Southern Ry.	G. I. Pierce.......	W. M. Patton.....	Knox dolomite.
Reed prospect..	.....do....................	Henry Reed.......	(Undeveloped)....	Do.
Webb prospect..	.....do....................	—— Webb......	.....do............	Do.
Charleston district:				
Bishop prospect.	3 miles east of Charleston on Southern Ry.	J. M. Bishop......	.....do............	Holston-Tellico contact.
Liner, Lawson, and McKnight prospects.	3 miles (by road 4 miles) east of Southern Ry.	J. B. Liner, J. M. Lawson, and T. M. McKnight.	.....do............	Do.
BRADLEY COUNTY.				
Charleston district:				
Underwood mine.	3½ miles southeast of Charleston on Southern Ry.	I. M. McAllister...	W. E. Hamilton & Co.	Do.
Cleveland district:				
Hambright mine.	8 miles south of Cleveland: 2 miles to Marble switch on Southern Ry.	H. F. Hambright..	Fitzgerald & Lanskey.	Do.
M. V. Jones prospect.	9 miles south of Cleveland; 2 miles to Marble switch on Southern Ry.	M. V. Jones.......	M. V. Jones.......	Do.
Sloan prospect.	10 miles south of Cleveland; 3 miles to Marble switch on Southern Ry.	W. B. Sloan.......	E. C. O'Brien.....	Do.
D. A. M. mine..	10½ miles south of Cleveland; 2 miles to Weatherly switch on Southern Ry.	Davis, Artz & McCrossin.	Davis, Artz & McCrossin.	Do.
Lord mine.....	11 miles south of Cleveland; 1¾ miles to Weatherly switch on Southern Ry.	C. H. Lord Corporation.	Tennessee Manganese Co.	Do.
Snyder prospect.	11 miles south of Cleveland; 1½ miles to Weatherly switch on Southern Ry.	—— Snyder.....	.....do............	Tellico sandstone (faulted).

Manganese mines and prospects in east Tennessee—Continued.

Mine or prospect.	Location and distance to nearest shipping point.	Owner.	Operator or prospector.	Type of deposit.
BRADLEY COUNTY—continued.				
Cleveland dist.—Continued.				
Hannah prospect.	13 miles south of Cleveland; 2¼ miles to Weatherly switch on Southern Ry.	Mrs. Hannah......	Tennessee Manganese Co.	Holston-Tellico contact.
Gee prospect...	10 miles south-southwest of Cleveland; 1 mile to McDonald on Southern Ry.	Burley Gee........	Burley Gee........	Knox dolomite.
White Oak Mountain district:				
White Oak Mountain mine.	8 miles northwest of Cleveland on Southern Ry.	White Oak Manganese Corp.	White Oak Manganese Corp.	Fort Payne chert.
Brown prospect.	8 miles west of Cleveland; 4 miles to McDonald on Southern Ry.	Jake M. Brown....	Jake M. Brown...	Do.
Wolf prospect.	2 miles west of McDonald on Southern Railway.	James Wolf.......	James Wolf.......	Do.

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