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VIRGINIA CONSERVATION COMMISSION
VIRGINIA GEOLOGICAL SURVEY
ARTHUR BEVAN, *State Geologist*

Bulletin 59

Manganese and Quartzite Deposits in the Lick Mountain District Wythe County, Virginia

By

F. W. STEAD and G. W. STOSE

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1943

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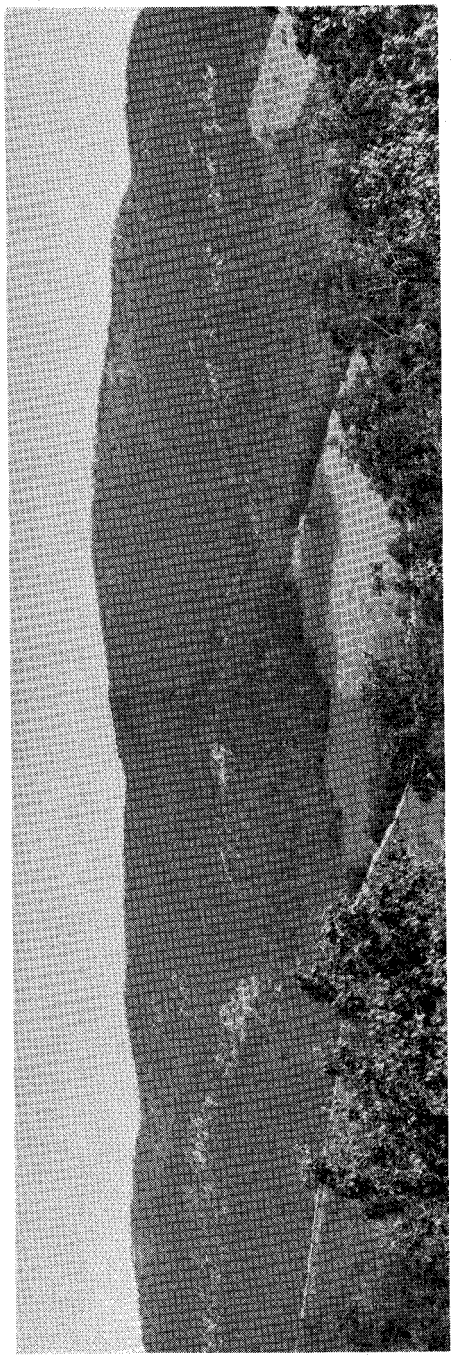
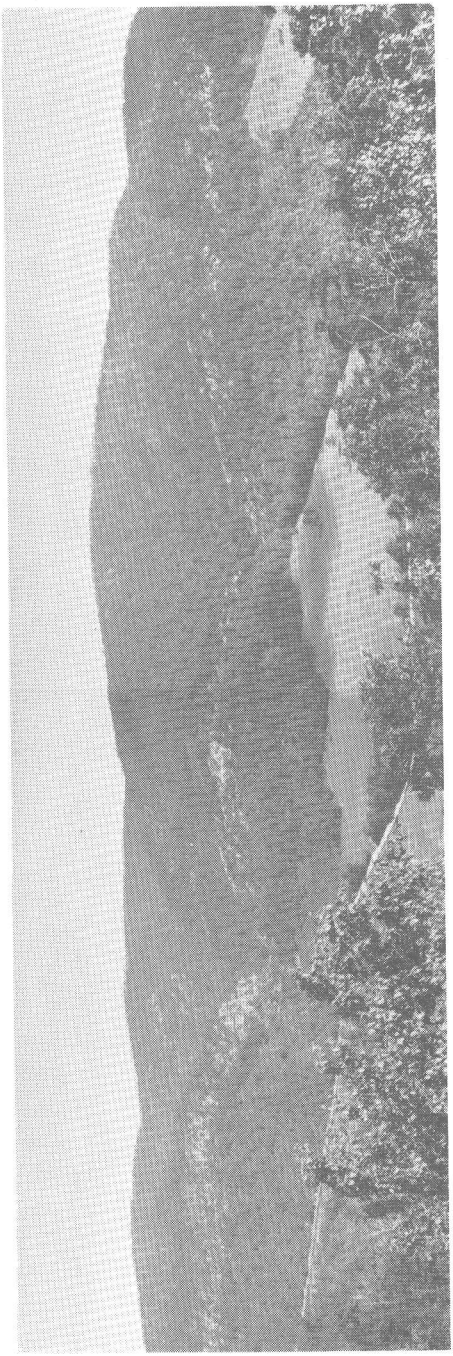


Panoramic view of Lick Mountain, looking north from a hill west of Liberty Church. Erwin quartzite, dipping steeply south, makes the continuous ledges along the south spurs of mountain. Falls Branch gap in these ledges is at the left; another gap is in the ravine to right. Other Erwin quartzite ledges, also dipping south, form the dip slope of the mountain.



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COMMONWEALTH OF VIRGINIA
VIRGINIA GEOLOGICAL SURVEY
UNIVERSITY OF VIRGINIA

CHARLOTTESVILLE, VA., August 2, 1943.

To the Virginia Conservation Commission:

GENTLEMEN:

I have the honor to transmit and to recommend for publication as Bulletin 59 of the Virginia Geological Survey series of reports a manuscript and illustrations of a report on the *Manganese and Quartzite Deposits in the Lick Mountain District, Wythe County, Virginia,* by Mr. F. W. Stead and Mr. G. W. Stose of the Geological Survey of the United States Department of the Interior. The field work and preparation of the report were by the Federal Geological Survey, which has released the report for publication by the State Geological Survey.

In addition to the mining of manganese ore in this district for use in war industries, quartzite of a high degree of purity is being extensively mined for similar use. The description of the geologic relations of the manganese ore and the quartzite should be helpful to present operators and to all others interested in the development of these resources in that part of Wythe County.

The detailed geologic map accompanying the report presents new interpretations of geologic structure and relations, which mark a distinct advance upon previous interpretations of the complex geologic conditions in that part of the State.

Respectfully submitted,

ARTHUR BEVAN,
State Geologist.

Approved for publication:
Virginia Conservation Commission,
Richmond, Virginia, August 2, 1943.
R. A. GILLIAM, *Executive Secretary and Treasurer.*

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MANGANESE AND QUARTZITE DEPOSITS IN THE LICK MOUNTAIN DISTRICT, WYTHE COUNTY, VIRGINIA[1]

By F. W. STEAD AND G. W. STOSE

ABSTRACT

The manganese deposits in the Lick Mountain district, near Wytheville, Wythe County, in southwestern Virginia, are for the most part siliceous and of low grade, but they are of present interest because the ore in them can be used, without previous beneficiation, in the electric furnace for making alloys of silicon and manganese. The ore consists of manganese oxides, chiefly psilomelane, intimately associated with silica. Concentration of this siliceous ore, involving the separation of the manganese from the silica, would be difficult. The district has produced about 600 tons of high-grade ore—300 tons in or about 1900 and 300 tons in 1918—and up to November 1942 about 800 tons of low-grade ore, of which 700 tons contained 12 per cent of manganese and about 100 tons contained 24 per cent of manganese. The probable reserves of ore containing about 12 per cent of manganese are estimated at 9,000 tons; the possible reserves of ore containing about 9 per cent of manganese are estimated at 44,000 tons. The reserves of high-grade ore that could be concentrated efficiently and economically to a product containing 40 per cent or more of manganese are very small.

The manganese deposits occur in the Lower Cambrian Erwin quartzite and in residual material derived from the overlying Lower Cambrian Shady dolomite. The larger deposits lie along brecciated zones in the Erwin quartzite.

The Erwin quartzite is quarried on Lick Mountain for metallurgical use. Reserves of more than 2,000,000 long tons have been blocked out. Deeply weathered Erwin quartzite is used for building sand.

[1]Published with the permission of the Director, Geological Survey, U. S. Department of the Interior.

INTRODUCTION

Despite the fact that they are siliceous and of low grade, the manganese ores of the Lick Mountain district in Virginia are of present interest, for they are being utilized in the electric furnace, without prior beneficiation, to produce alloys of silicon and manganese. Ore used for this purpose has consisted of well-cemented pieces, ranging in diameter from seven-eighths of an inch to 6 inches, composed essentially of silica and manganese oxide and containing only minor quantities of iron oxide, alumina, and phosphorus. Also of present interest are the deposits, in this district, of pure, compact quartzite, which is likewise directly utilized in the electric furnace for making metallic silicon and various alloys of silicon.

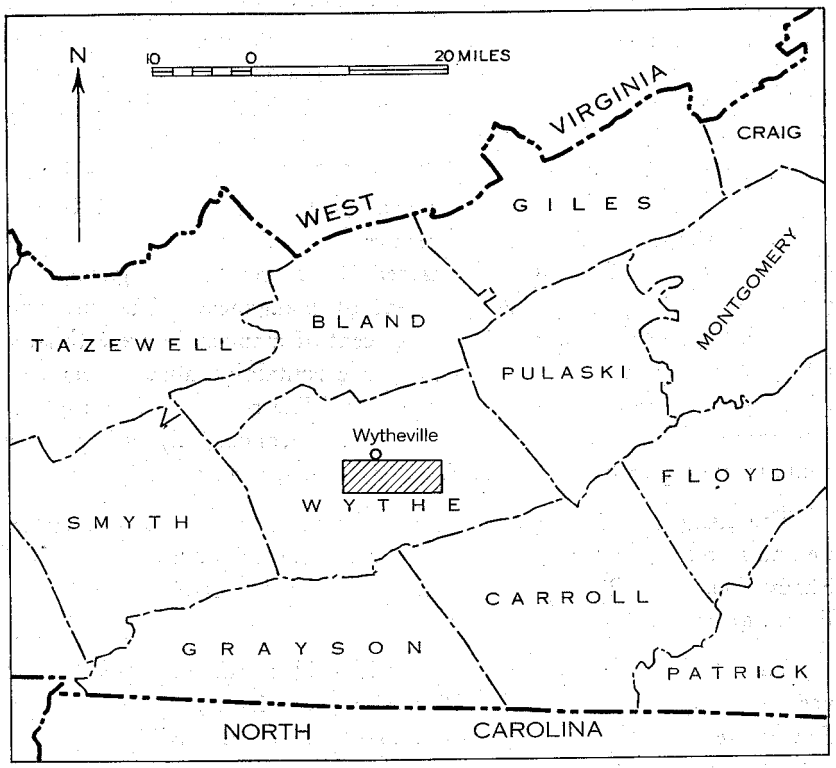

Figure 1.—Index map of southwestern Virginia showing location of Lick Mountain district.

The Lick Mountain district is an east-west belt of high parallel ridges, 14 miles long and 4 to 5 miles wide. It lies in the central part of the Speedwell and adjoining Max Meadows quadrangles, and in the central part of Wythe County in southwestern Virginia (Fig. 1). Numerous secondary roads extend into the district from nearby main highways. Several shipping points on the Norfolk & Western Railway are within 10 miles of the active mines.

Manganese ore was first produced in the district about 1900, when 300 long tons of hand-sorted high-grade ore was shipped from the Big Lick deposit. In 1918, the same deposit yielded another 300 tons of similar ore. Early in 1942 the Sand Mountain Sand Corporation shipped 400 long tons of highly siliceous ore containing 11.86 per cent of manganese from its Manganese Workings No. 1 (Pl. 1). In August 1942, the same company shipped 92 tons of ore containing 24 per cent of manganese from Manganese Workings No. 2, and 41 tons containing 12 per cent of manganese from Manganese Workings No. 3; and up to the middle of October 1942 it had shipped 228 tons of ore containing 12 per cent of manganese from Manganese Workings No. 5.

In 1941 a total of 5,000 tons of metallurgical-grade quartzite was shipped from the Archer quarry (Pl. 1, Quartzite Workings No. 1) on Sand Mountain by John A. Archer.

All the deposits herein described lie within a tract of 14,000 acres, known locally as the "Big Survey," that is controlled by J. C. Shaffer, C. R. Huddle, and J. Wolfington, of Wytheville, Va. The tract is leased to the Sand Mountain Sand Corporation, which is now mining manganese ore and quartzite.

The manganese deposits of the district were described by Stose, Miser, Katz, and Hewett [2] in 1919. The present report, which describes deposits discovered and developed since that time, is based on two months of field work in the late summer and fall of 1942. The work was facilitated by generous cooperation on the part of Charles R. Huddle and Charles R. Huddle, Jr., of the Sand Mountain Sand Corporation. Edward N. Cooper, Jr., kindly supplied maps and information on Manganese Workings No. 1 and Quartzite Workings No. 3. H. D. Miser directed the work, and the writers are indebted to him for much helpful advice.

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[2]Stose, G. W., Miser, H. D., Katz, F. J., and Hewett, D. F., Manganese deposits of the west foot of the Blue Ridge, Virginia; Virginia Geological Survey Bulletin 17, pp. 127-130, 1919.

GEOLOGY

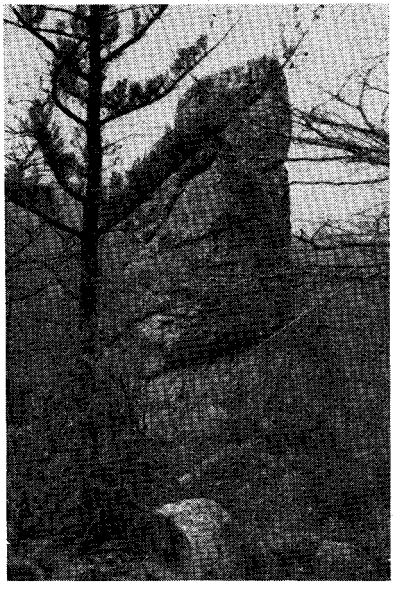
THE ROCKS

The rocks of the Lick Mountain district are Lower Cambrian quartzite, shale, and dolomite, exposed in an anticlinal uplift. The sequence and the general character of these rocks are shown in Table 1, and their distribution is shown on Plate 1.

The lowest formation exposed in the core of the uplift is the Hampton shale. This rock, being softer than the overlying Erwin quartzite. generally forms deep valleys within the mountains, but some of the high ridges of the west-central part of the district consist of Hampton shale from which the protecting quartzite has been removed by erosion. Good exposures of the Hampton shale may be seen on the Wytheville-Ivanhoe road near a point due south of Wytheville and just north of the crest of the ridge.

The Erwin quartzite is the most resistant formation in the area and forms all of the highest peaks and most of the highest ridges. The thick-bedded quartzite near the middle of the formation (Pl. 3B) makes prominent ledges on the crest of the ridges, and the edges of the quartzite beds, which generally dip south, are exposed in north-facing cliffs 100 feet or more in height. Chimney Rock (Pl. 3A) and High Rock are conspicuous features consisting of Erwin quartzite. The formation is well exposed on the Wytheville-Ivanhoe road, south of Wytheville. A complete section of it may be seen just south of the crest of Lick Mountain. The massive ridge-making quartzite, together with the underlying softer quartzites at the base of the formation, has been mapped separately to show the structure.

The Shady dolomite is poorly exposed within the mountains, because it is deeply weathered and largely covered with debris from the adjacent Erwin quartzite. It is mapped in many places where no dolomite is exposed but where red clay soil, iron ore, and ferruginous drusy chert indicate its presence above the quartzite.



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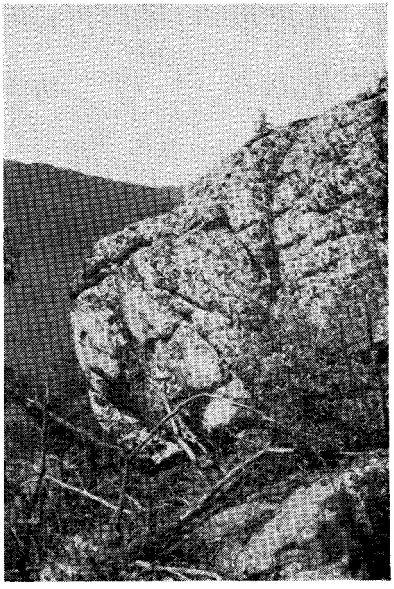

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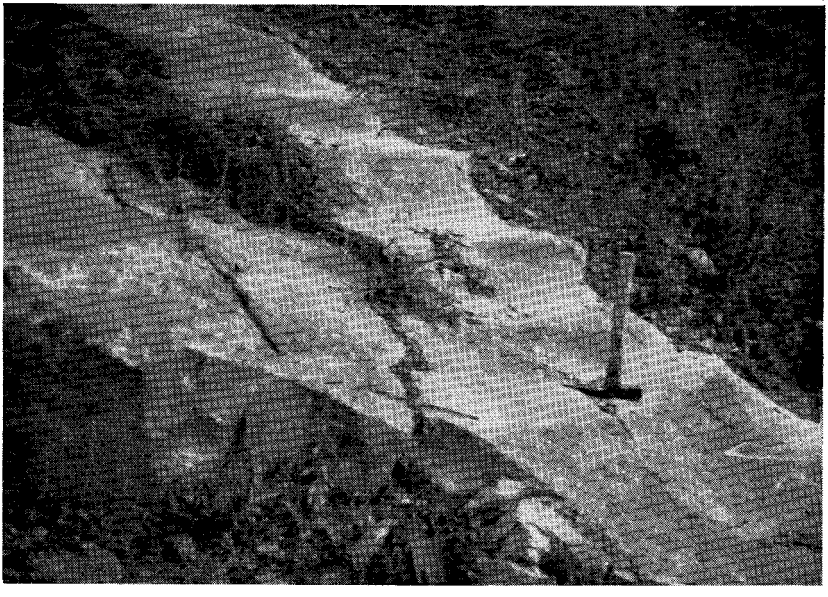
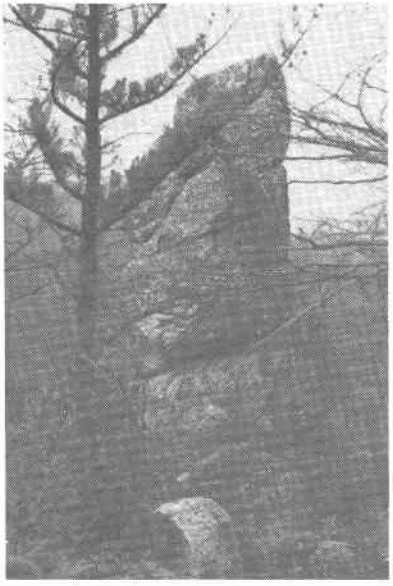


C.

A, Chimney Rock, a north peak of Lick Mountain. B, Massive ledges of Erwin quartzite, dipping south near west end of Sand Mountain, 1½ miles west of High Rock. C, Giant ripples in uppermost Erwin quartzite, half a mile south of Mt. Ephraim Church.



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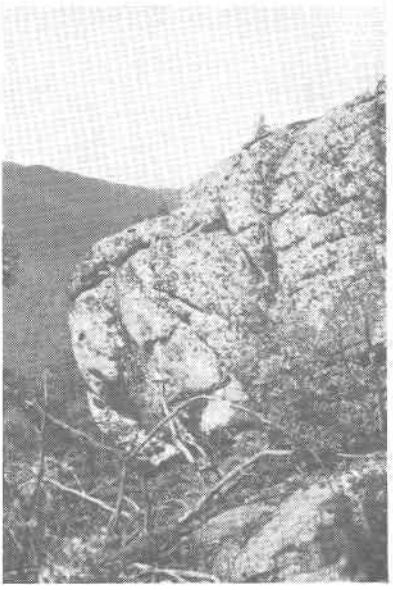

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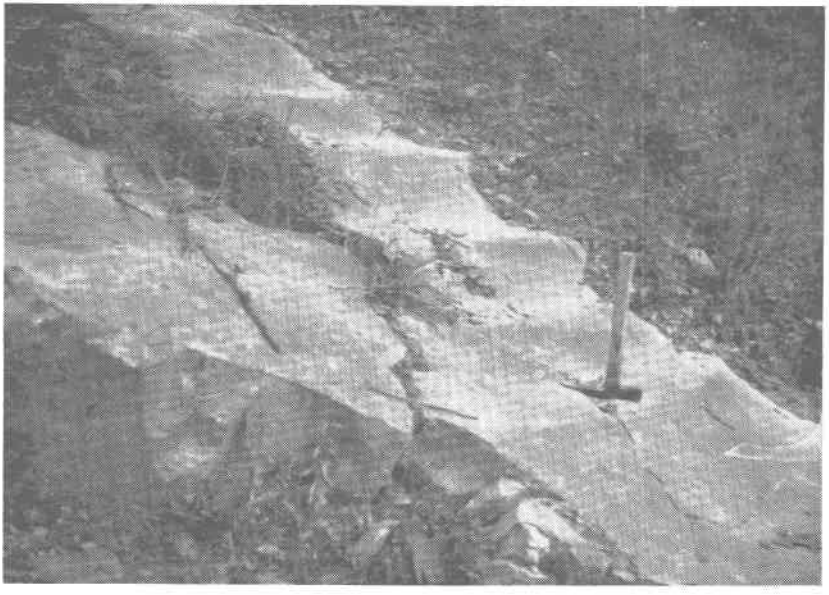

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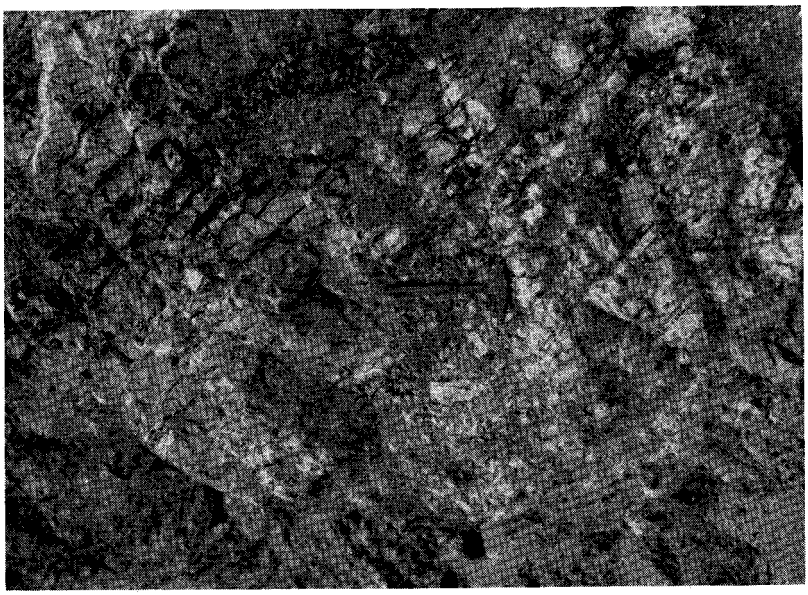
A, Chimney Rock, a north peak of Lick Mountain. B, Massive ledges of Erwin quartzite, dipping south near west end of Sand Mountain, 1½ miles west of High Rock. C, Giant ripples in uppermost Erwin quartzite, half a mile south of Mt. Ephraim Church.



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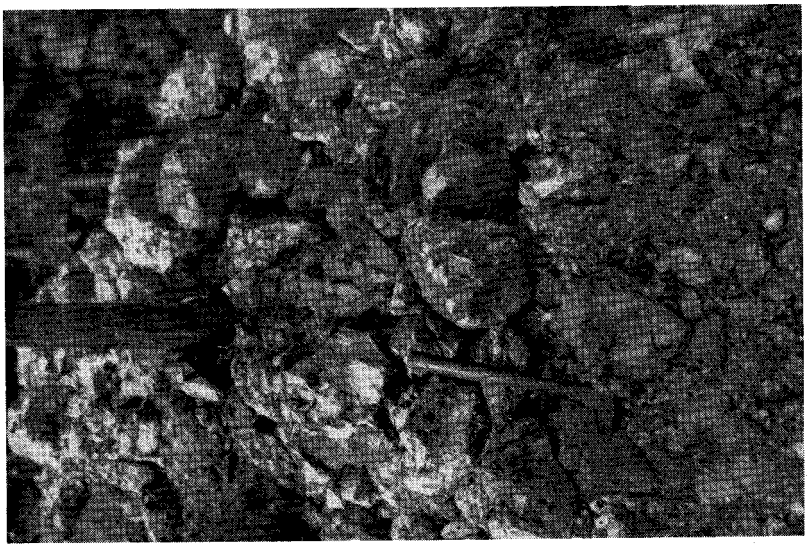
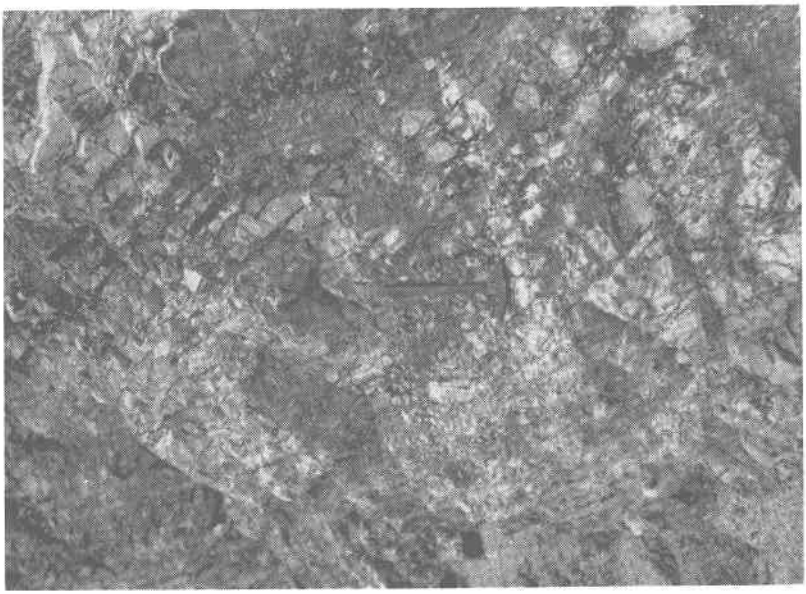


A.

A, Sheared and brecciated Erwin quartzite. B, Siliceous manganese ore in brecciated quartzite.



B.

A.

A. Sheared and brecciated Erwin quartzite. B. Siliceous manganese ore in brecciated quartzite.

TABLE 1.—*Sedimentary rocks in the Lick Mountain district, Wythe County, Virginia*

Age	Formation	Thickness (feet)	Character
Lower Cambrian	Rome formation	1,000 ±	Upper member, red shales and sandstones. Middle member, calcareous shale, blue limestone, siliceous limestone, and massive dolomite. Lower member, red shale and sandstone, some green shale, and some dolomite.
	Shady dolomite	1,000 ±	Upper member (saccharoidal member), massive white to light-gray, coarsely crystalline, very pure dolomite. Lower member, (Patterson member) dark-blue to dark-gray, banded and knotty dolomite, with blebs of white crystalline calcite.
	Erwin quartzite	50-100	Ferruginous, laminated, fossiliferous, coarsely granular to conglomeratic quartzite at top; thin, rusty, micaceous quartzite and shale below.
		350 ±	Ridge-making and cliff-making white, vitreous to granular quartzite, generally *Scolithus* bearing; medial bed, with fewer *Scolithus*, weathers laminated and pitted.
		50 ±	Thin beds of quartzite interbedded with shale; 5-foot conglomerate bed at base.
	Hampton shale	500 + (Base not exposed)	Argillaceous shale, generally light-gray to buff at surface, dark-gray when fresh; weathers to buff and rusty shale fragments. Includes some scattered thin quartzite beds and some arenaceous shales. Considerable iron content in upper portion.

STRUCTURE

The dominant structural feature of this district is a composite anticlinal uplift whose axis trends a little north of east. It consists of several subordinate folds, whose axes pitch eastward and westward, respectively, away from the center of uplift, to die out and disappear under a cover of younger rocks. The axial planes of these folds lean to the north. The folds may be overturned in places along the north front of the uplift.

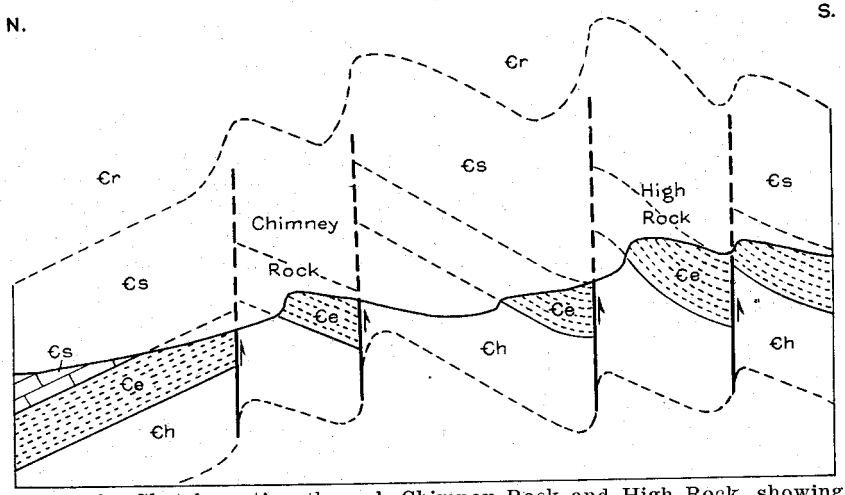


Figure 2.—Sketch section through Chimney Rock and High Rock, showing fault blocks and their interpretation.

East-west faults, with upthrow on the south side, which strike parallel or nearly parallel to the length of the folds, are interpreted as high-angle south-dipping reverse faults. The faults divide the uplift into a number of long, narrow, differentially elevated blocks (Pl. 1). Many of the faults extend along the steeply dipping north limbs of anticlines, so that most of the individual fault blocks have a south-dipping monoclinal structure, as shown in the sections on Pl. 1. The displacement on any individual fault probably does not exceed 1,000 feet. The displacements decrease in general away from the center of the uplift, in conjunction with the decrease in the severity of the folding. The faults resulted from the displacement of the resistant beds of the Erwin quartzite which yielded to compression by fracturing and displacement rather than by tight folding (Fig. 2). The faulting seems to have occurred at the same time that the rocks were folded.

MANGANESE DEPOSITS

The manganese minerals of the district are oxides, chiefly psilomelane, with some wad and pyrolusite. Except in occasional lumps that are especially rich, the manganese oxides are intimately mixed with silica, which is mostly in large fragments of sandstone or in sand grains, but partly in masses formed by silicification of dolomite. This silica can not at present be separated economically by the customary methods of beneficiation. The ore shipped from the present workings has contained from 7 to 25 per cent of manganese, 40 to 75 per cent of silica, and less than 5 per cent of other impurities, including iron, alumina, lime, and phosphorus. Such ore, because it consists essentially of manganese oxides and silica, is locally termed "manzite," a contraction of manganese oxides and quartzite.

The deposits may be grouped into three types, whose form, areal extent, and persistence in depth are related to the local structure of the containing rocks. These types, in order of their importance, are as follows:

The first type of deposit, exposed in Manganese Workings No. 1 and No. 5 and probably in No. 4, occurs along brecciated and crushed zones in the Erwin quartzite. Manganese oxides fill, either partly or completely, the fissures and cracks in the breccia. Where these openings are not completely filled with manganese oxides, the remaining space may later be filled with either clay or halloysite (Fig. 3). The sandstone fragments in the breccia are for the most part unaltered, the contacts between them and the coating of manganese oxide being sharp. Manganese oxide that has replaced the cementing material and individual grains of the sandstone forms a minor portion of the ore. Deposits of this type are localized along the east-west high-grade reverse faults, where the Erwin quartzite has been crushed and brecciated. Where one wall consists of the Hampton shale, the breccia is cemented and replaced by iron oxides rather than manganese oxides.

The second type of deposit, exposed in Manganese Workings Nos. 2 and 3, is localized in the transitional beds between the Erwin quartzite and the Shady dolomite. These beds comprise interbedded argillaceous dolomite, arenaceous dolomite, calcareous and ferruginous sandstone, and quartzite. Their thickness appears to be more than 50 feet. Since Manganese Workings Nos. 2 and 3 are just north of a major east-west fault, the transitional beds have been somewhat crushed and the harder

sandstones brecciated. Manganese oxides fill fissures and cracks in the fractured beds of sandstone and quartzite and partially replace the sandstone fragments. The dolomitic beds also were in part silicified, and later the clay derived from weathering of the dolomitic beds was replaced by manganese oxides without extensive replacement of the silicified part of the beds. The ore thus formed, which represents the larger and higher grade part of the deposit, resembles a fine-grained sandstone partially replaced by manganese oxides.

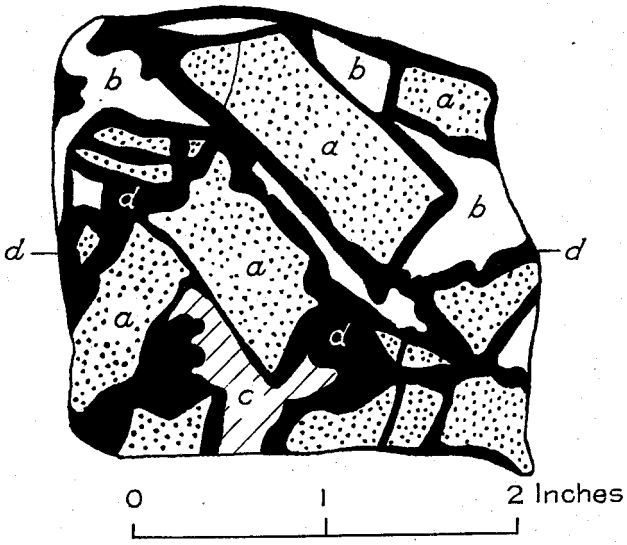
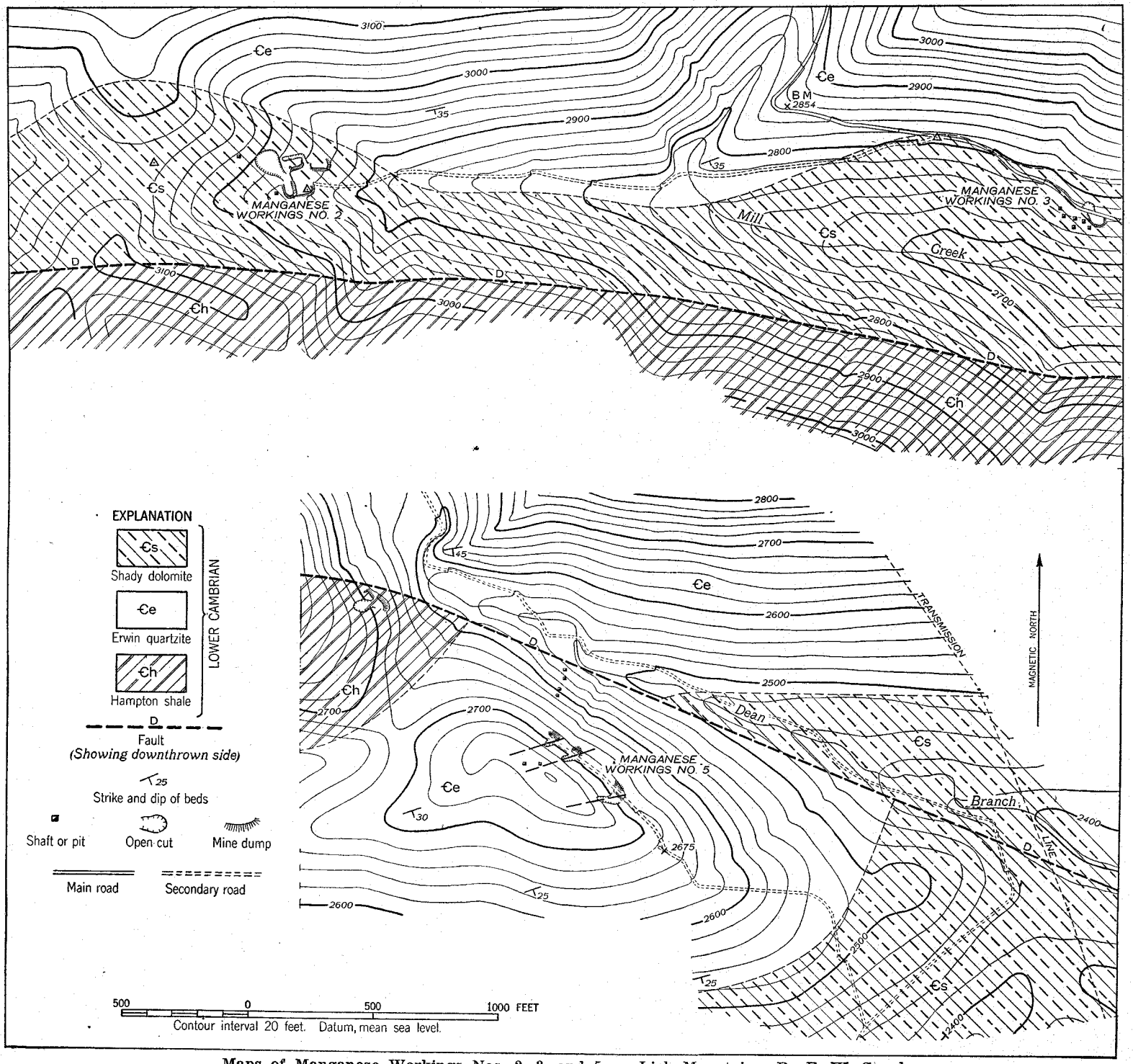


Figure 3—Sketch of brecciated ore from Manganese Workings No. 5. *a*, Sandstone fragments; *b*, halloysite filling cavities; *c*, clay filling cavities; *d*, psilomelane coating sandstone fragments.

The third type of deposit, exposed in Manganese Workings No. 4, in the Erwin quartzite, consists of medium-grained sandstone, the quartz grains of which are firmly cemented with manganese oxides. As the ore is full of grains of quartz sand that are not replaced—though some smaller grains may have been completely replaced—it is believed that the original cementing material was either soluble silica or carbonate and that it was replaced by manganese oxides. Deposits of this type are localized in suitably cemented sandstone on or near ridge crests and on benches high up on the flanks of ridges. The segregation of the manganese in them may have been controlled by former physiographic conditions, rather than by structural conditions. The relation of man-



Maps of Manganese Workings Nos. 2, 3, and 5 on Lick Mountain. By F. W. Stead.

ganese ores to physiographic forms has been discussed in a previous report[3] and will not be further considered here.

From the foregoing brief discussion it can be concluded that future prospecting should be directed to favorable structures and horizons, particularly to the brecciated zones in the Erwin quartzite and to transition beds between the Erwin quartzite and the Shady dolomite. Since the manganese oxides appear to have been deposited from circulating ground waters[4], not all favorable structures and horizons have been mineralized, but only those which had channels that permitted slow circulation and permeation of manganese-bearing solutions.

RESERVES

The manganese reserves of the Lick Mountain district consist of highly siliceous low-grade ore containing from 5 to 25 per cent of manganese. In this ore the silica and the manganese oxides are intimately associated. Such methods of beneficiation as washing, jigging, and floatation are not adaptable economically at present to the production of a high-grade manganese concentrate from this siliceous ore. Siliceous ore is now being utilized directly, however, in the electric furnace when it is in firm, well-cemented pieces from seven-eighths of an inch to 6 inches in diameter and consists essentially of silica and manganese oxides, with only minor quantities of iron, alumina, lime, and phosphorus. As mined at present for this purpose, the siliceous ore contains a considerable amount of barren rock or inferior ore, which is eliminated in part by hand sorting and by selective loading into the mine trucks. Reserves of high-grade ore that could be concentrated efficiently and economically to a product containing 40 per cent or more of manganese are so small as to be negligible.

The estimation of reserves is difficult, for it involves consideration of the above-noted physical property, as well as of chemical composition. Two other factors that have been employed in the estimation of reserves are based on the present mining data; namely, one long ton in place contains 15 cubic feet, and one long ton, as mined, contains 15 to 20 parts of barren rock or inferior ore to one part of siliceous low-grade ore.

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[3]Stose, G. W., and Miser, H. D., Manganese deposits of western Virginia; Virginia Geological Survey Bulletin 23, p. 52, 1922.

[4]Stose, G. W., Miser, H. D., Katz, F. J., and Hewett, D. F., op. cit., pp. 54-56.

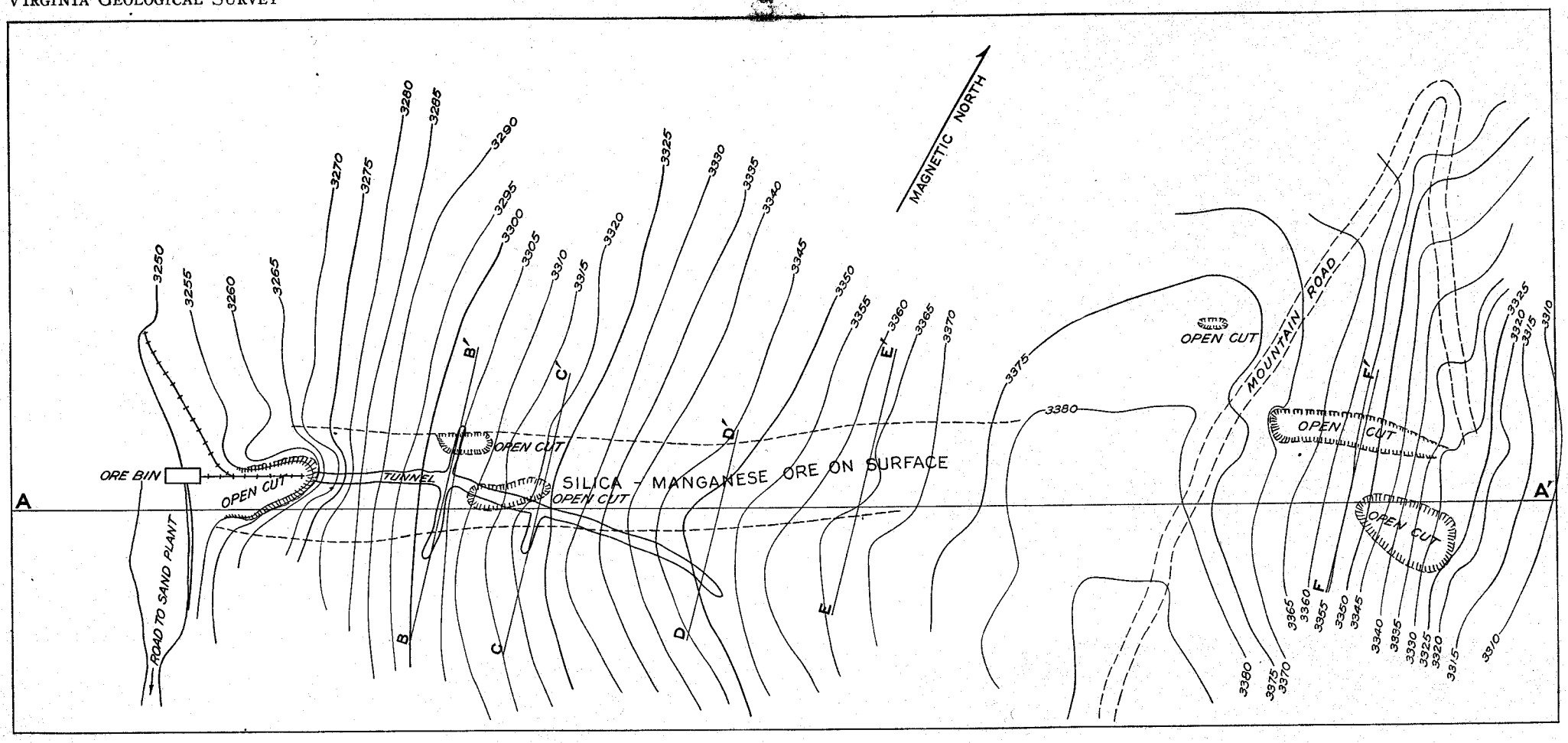
Production has tended to follow up the blocking out of minable ore so closely that the proved or measurable reserves are never large. The reserves of the district are therefore given in terms of probable ore and possible ore. The reserves of probable ore are estimated from the probable size of ore bodies that are in part exposed in tunnels, prospect pits, and open cuts. The reserves of possible ore are estimated from the extent of favorable structural conditions exposed in scattered shallow prospect pits.

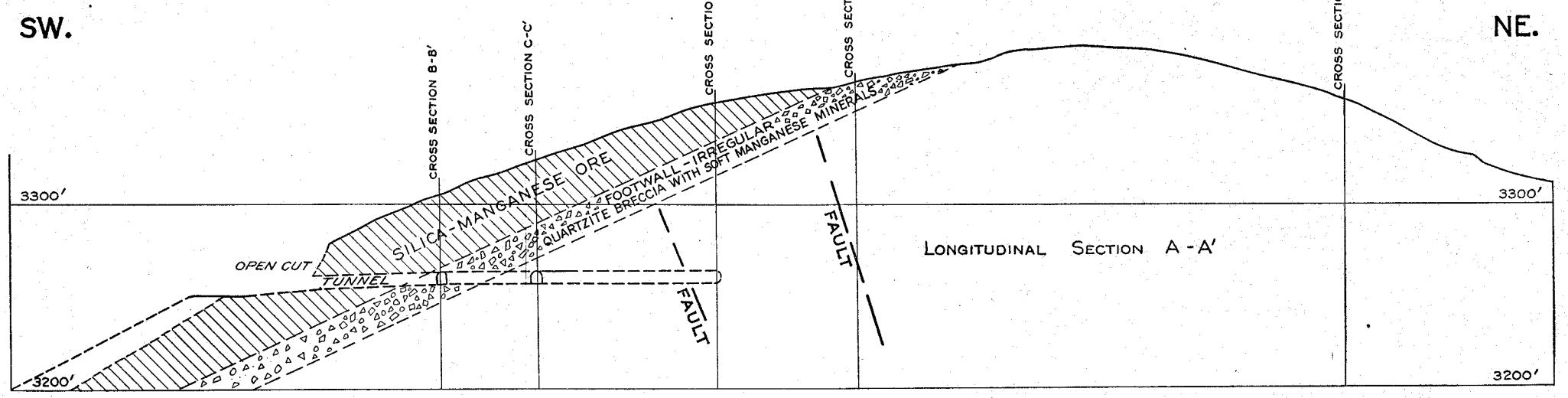
The reserves of the Lick Mountain district are estimated to be about 53,000 long tons of siliceous low-grade ore containing, on the average, 10 per cent of manganese. Of this total, about 9,000 long tons consists of probable ore containing about 12 per cent of manganese, and about 44,000 long tons consists of possible ore containing about 9 per cent of manganese.

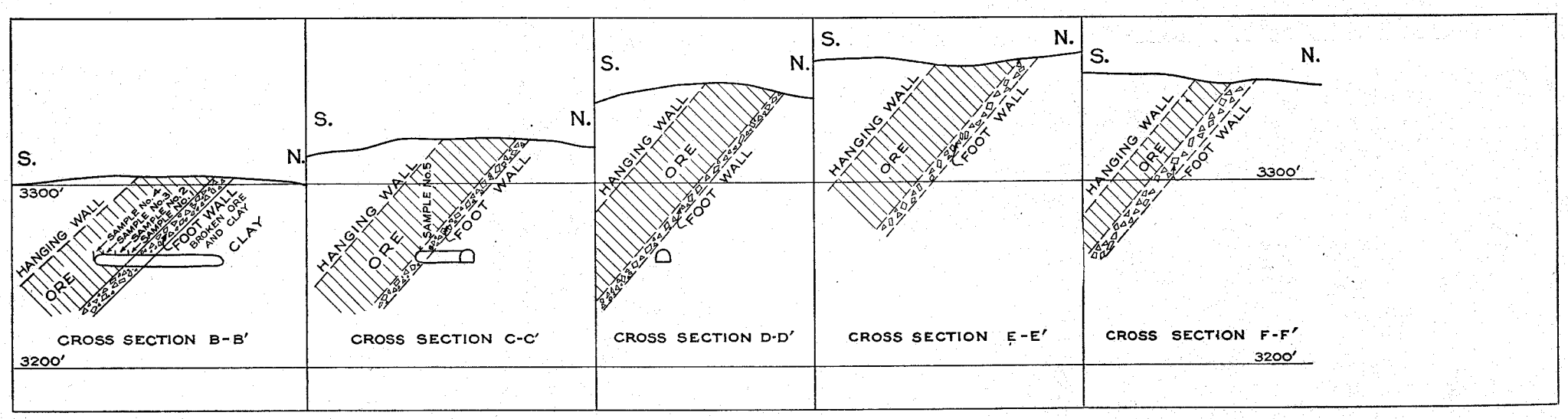
MINES AND PROSPECTS

Manganese Workings No. 1.—The workings are described and numbered in the order used by the Sand Mountain Sand Corporation. Manganese Workings No. 1, also known as the Lots Gap Manzite Prospect, are located 5 miles east-southeast of Wytheville and 1½ miles west of Lots Gap, on a southern spur of Lick Mountain, at an altitude of 3,200 feet. The workings consist of a tunnel 230 feet long together with many shallow pits and cuts. These openings have explored a brecciated zone in the Erwin quartzite for a distance of about 300 feet along the strike. The zone strikes east-west, dips to the south at a high angle, and has a width of at least 50 feet (Pls. 4A, 6, and 7A). The displacement along this zone can not be determined, since both the footwall and the hanging wall are Erwin quartzite.

The ore body consists mostly of psilomelane, but partly of soft earthy manganese oxides which fill fissures and cracks in a crushed and brecciated sandstone in the Erwin quartzite. Extensive replacement of the sandstone fragments in the breccia is not common. The ore body is best described as a sandstone breccia cemented with manganese minerals. The minable ore is very irregular in distribution because of the variable character and thickness of the brecciated zone. The physical properties of the ore are not entirely satisfactory for direct utilization in the electric furnace, which requires firmly cemented pieces from seven-eighths of an inch to 6 inches in diameter, for a considerable







Map and sections of Manganese Workings No. 1 on Lick Mountain. By E. N. Cooper, Jr., February, 1942.

part of the ore consists of friable sandstone fragments, coated with manganese oxides, which might disintegrate to objectionable fines if so used. The ore consists essentially of silica and manganese oxide. Shipments of ore have had an average content of 11.86 per cent of manganese and 74 per cent of silica. Analyses, made by the Sand Mountain Sand Corporation, of samples of ore from lateral drifts from the tunnel (Pl. 6), are as follows:

Analyses of ore from lateral drifts, Manganese Workings No. 1

Sample	Mn	SiO_2	Al_2O_3	Fe	P
1	6.56	86.09	1.05	0.50	0.033
2	5.34				
3	4.89				
4	6.28				
5	10.67	72.99	1.18	0.45	0.079

A total of 433 net tons of low-grade siliceous ore, shipped early in 1942, has been produced from these workings. Analyses of the shipments are given in the table below.

TABLE 2.—*Record of shipments made early in 1942 from Manganese Workings No. 1, Lick Mountain district*

(Data furnished by Sand Mountain Sand Corporation)

Car No.	Weight (pounds)	Mn (per cent)
1	91,180	8.13
2	104,900	7.03
3	97,400	11.10
4	96,940	12.87
5	94,300	11.66
6	92,620	11.07
7	97,420	16.79
8	97,160	16.48
9	95,680	11.64
	432.95 net tons	11.86

Composite analysis of cars Nos. 3, 4, 5, and 6

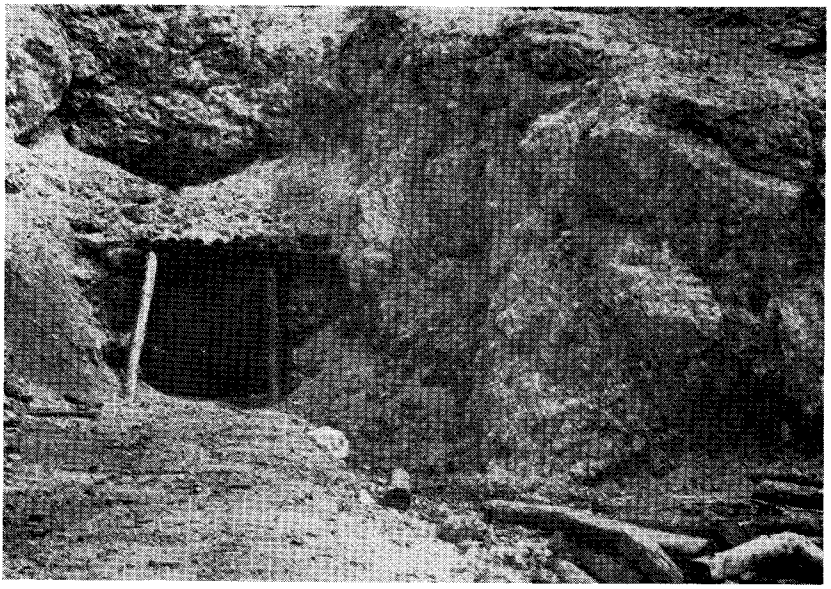
	Per cent
Manganese (Mn)	11.67
Silica (SiO_2)	73.82
Iron oxide (Fe_2O_3)	2.02
Alumina (Al_2O_3)	1.30
Titanium oxide (TiO_2)	.11
Lime and magnesia (CaO + MgO)	.06
Phosphorus (P)	.062

Manganese Workings No. 2.—Manganese Workings No. 2, in what is known as the Big Lick deposit, are 3½ miles south of Wytheville and half a mile west of the Ivanhoe-Wytheville road. They are 200 yards east of the divide between the heads of Venrick Run and the Vaughan Branch of Mill Creek, at an altitude of 3,000 feet. Available records indicate that about 300 tons of hand-picked high-grade ore was shipped about 1905 by Fred Main, and that another 300 tons of hand-picked high-grade ore was shipped in 1918 by J. C. Shaffer. The deposit was visited in October 1917, and was described in a report.[5]

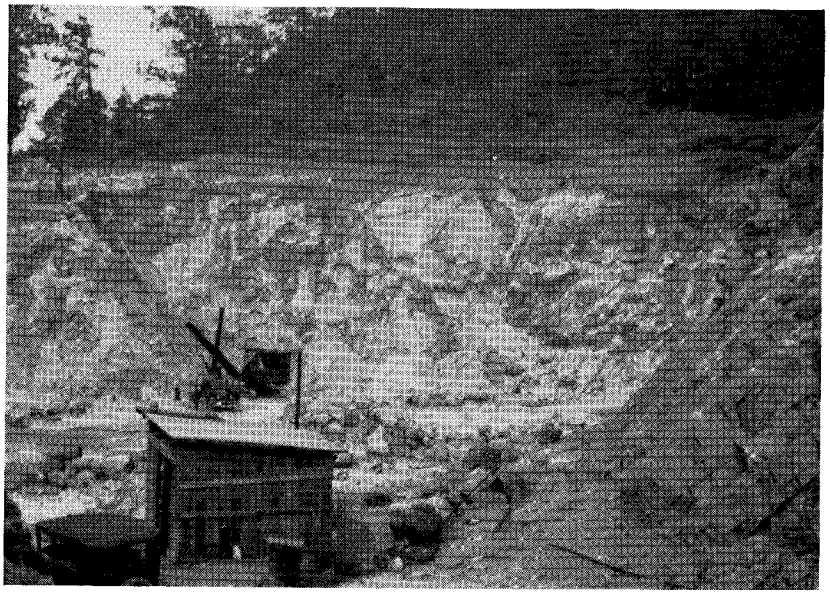
The present workings, not including the previous openings which are completely caved, consist of a large open pit 120 feet long, 90 feet wide, and 25 feet deep at the face (Pl. 5). The pit exposes the transitional beds between the Shady dolomite and the Erwin quartzite, which strike roughly east and dip about 30° S. These beds, which have a thickness of at least 50 feet, comprise interbedded argillaceous dolomite and arenaceous dolomite—largely weathered to clay—sandstone, and quartzite. A major east-west high-angle reverse fault with upthrow on the south, about 300 feet to the south of the workings, has crushed and fractured the transitional beds.

The ore from these workings is of two types. The first and most important type resembles a porous sandstone breccia cemented and partially replaced by manganese oxides. It consists of manganese oxides that have replaced clay resulting from the weathering of the dolomite, in and about fine-grained siliceous masses formed by replacement of dolomite. In places the manganese oxides have partially or completely replaced the siliceous masses, forming large lumps of high-grade ore. The second type of ore at this locality occurs in fractured sandstone

[5]Stose, G. W., Miser, H. D., Katz, F. J., and Hewett, D. F., op. cit., p. 129.

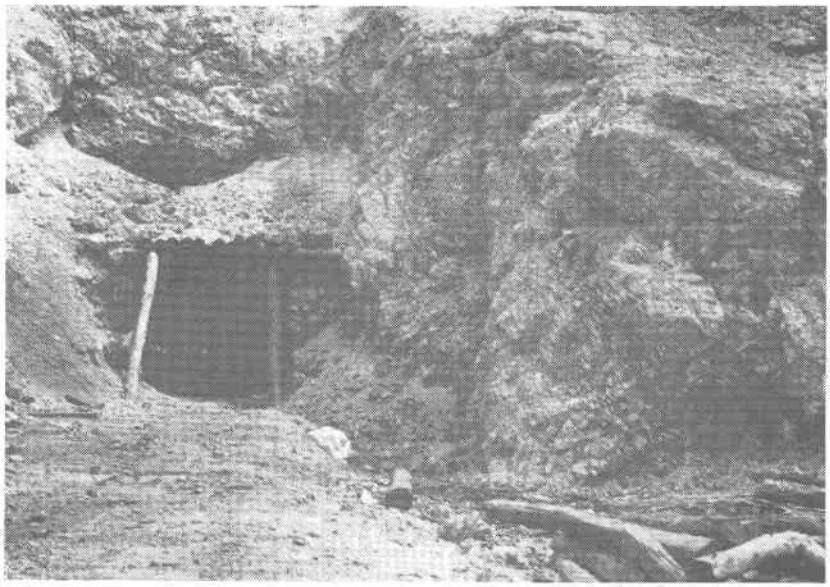


A.

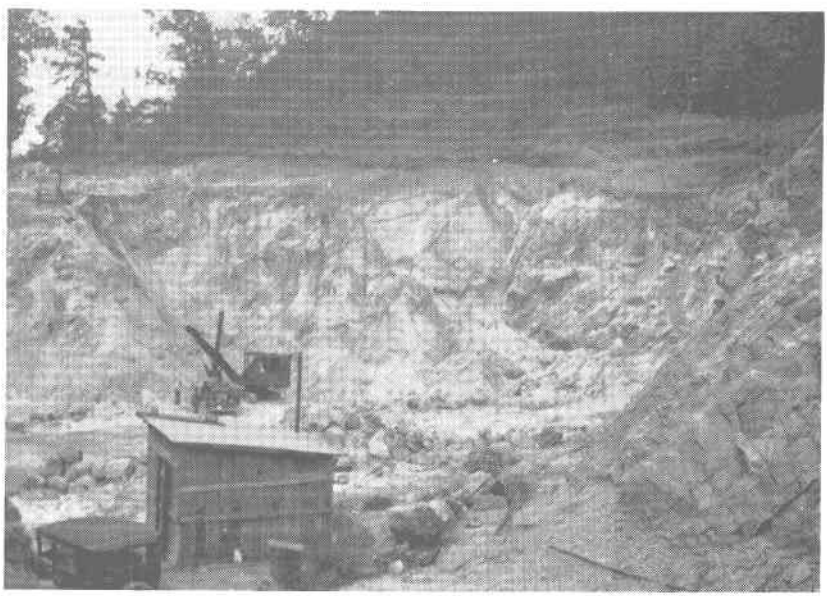


B.

A, Entrance to tunnel in brecciated Erwin quartzite at Manganese Workings No. 1. B, Pit of Sand Mountain Sand Corporation at Lots Gap on Lick Mountain.



A.



B.

A, Entrance to tunnel in brecciated Erwin quartzite at Manganese Workings No. 1. B, Pit of Sand Mountain Sand Corporation at Lots Gap on Lick Mountain.

and quartzite beds, in which the manganese oxides have filled fissures and cracks and have partially replaced both the cementing material and the detrital quartz grains of the sandstone fragments. Excluding occasional high-grade lumps, both types of manganese ore at the locality are highly siliceous and contain from 40 to 70 per cent of silica, with from 10 to 25 per cent of manganese. Analyses also show the presence of much barium, some cobalt, and a little tungsten. As a siliceous ore, this material is physically and chemically satisfactory for direct utilization in the electric furnace, but it may require washing to remove excessive clay.

The ore body, as thus far explored, is tabular in outline and seems to be restricted to the superficial part of the transitional beds between the Shady dolomite and the Erwin quartzite.

A total of 600 tons or more of high-grade ore was produced at least twenty years ago by careful hand-picking of high-grade lumps of ore. A representative shipment of 92 long tons of siliceous ore, made in August 1942, contained 24 per cent of manganese.

Manganese Workings No. 3.—Manganese Workings No. 3 are 4 miles southeast of Wytheville and 1½ miles west of Liberty Church. They are immediately adjacent to the Wytheville-Ivanhoe road, on the north slope of Mill Creek Valley, at an altitude of 2,780 feet. They consist of one open pit 60 feet long, 30 feet wide, and 20 feet deep at the face. (See Pl. 5.)

The pit is 3,200 feet east of Manganese Workings No. 2. It extends along the strike of the contact between the Shady dolomite and the Erwin quartzite and exposes the same transitional beds and the same types of ore as Manganese Workings No. 2. Since these beds and types of ore are fully described above, Workings No. 3 will not be described in detail.

A shipment of 41 long tons of siliceous ore made in August 1942 contained 12 per cent of manganese.

Manganese Workings No. 4.—Manganese Workings No. 4, a prospect rather than a mine, are 4½ miles southeast of Wytheville and three-quarters of a mile due north of Liberty Church. They extend along the crest of the ridge to the north of Mill Creek, at an altitude of 3,200 feet. They consist of at least eight shallow cuts, none of which is more than 4 feet deep. These cuts explore the Erwin quartzite,

which has a south-dipping monoclinal structure, for a length of about 1,000 feet along the strike.

The ore is hard manganese oxide impregnating a medium-grained sandstone, to a depth of at least 4 feet, by replacing the original cementing material and some of the smaller grains of quartz. Manganese oxides are also deposited along joint crevices and fissures. Since the deposit is adjacent to a major east-west fault, it is believed that manganese-cemented quartzite breccia, similar to the ore at Workings No. 5, may underlie the present workings. The ore is highly siliceous and can not be concentrated profitably at present. It is estimated to contain from 10 to 15 per cent of manganese and from 45 to 75 per cent of silica. In physical character and chemical composition, the ore is suitable for use in the electric furnace. No ore has been shipped from these workings.

Manganese Workings No. 5.—Manganese Workings No. 5 are 4½ miles southeast of Wytheville and half a mile west of Glade School. They are on the north slope of the ridge south of Dean Branch, at an altitude of 2,700 feet. The workings consist of a series of open cuts, distributed along the north flank of the ridge for a distance of more than 500 feet, which explore irregular brecciated zones in the Erwin quartzite. These zones trend slightly north of east, along minor branch faults of the major east-west high-angle reverse fault, which lies immediately to the north of the workings (Pl. 5).

The ore body consists of manganese oxides, chiefly psilomelane, filling cracks and fissures in crushed and brecciated Erwin quartzite (Pl. 4B). Where these openings are not completely filled with the manganese oxides, the remaining space may be filled with either clay or halloysite, which contains about 40 per cent of alumina. The minable ore, essentially a sandstone breccia cemented by manganese oxides, is localized in the highly brecciated zones along minor faults between areas of less fractured sandstone. Though highly variable in their thickness and spacing, these brecciated zones are fairly uniform in attitude, tending to stand vertical and to strike N. 70° E. The ore contains from 10 to 15 per cent of manganese and consists of firmly cemented pieces. Analyses of the manganese oxide show considerable cobalt and some barium. The ore is highly siliceous and not readily amenable to concentration, but it may be directly utilized in the electric furnace.

A total of 288 long tons of siliceous ore containing about 12 per cent of manganese had been shipped by the middle of October 1942.

QUARTZITE DEPOSITS

The Erwin quartzite of the Lick Mountain district varies from a quartzose sandstone to a compact quartzite consisting of quartz grains cemented with silica. Compact quartzite, when it meets certain physical and chemical requirements, may be directly utilized in the electric furnace to produce metallic silicon and alloys of silicon. Physically, the quartzite must be sufficiently compact and well cemented so that it may be quarried, broken into fragments from seven-eighths of an inch to 6 inches in diameter, and shipped without disintegrating to an objectionable degree into smaller fragments. Chemically, it must be composed of nearly pure silica.

Analyses of samples of rock from the workings, given in the following table, show that the samples have a sufficiently high degree of purity to be classed as of metallurgical grade.

TABLE 3.—*Analyses of quartzite samples from the Lick Mountain district, Wythe County, Virginia*

	1	2	3	4	5	6	7
SiO_2	99.25	97.63	98.91	98.90	98.70	99.37	99.04
Al_2O_3	0.22	1.25	0.37	0.32	....	....	....
Fe_2O_3	0.22	0.25	0.29	0.29	....	....	....
TiO_2	0.13	0.23	0.12	0.16	....	....	....

1-4. From Quartzite Workings No. 3.
5-7. From Quartzite Workings No. 2.

The reserves of metallurgical-grade quartzite in the district are considerably in excess of any foreseen demand for many years to come. A partial estimate of the reserves already blocked out indicates a minimum of 2,000,000 long tons of quartzite that is compact and sufficiently pure to meet specifications.

The three quartzite operations in the district are as follows:

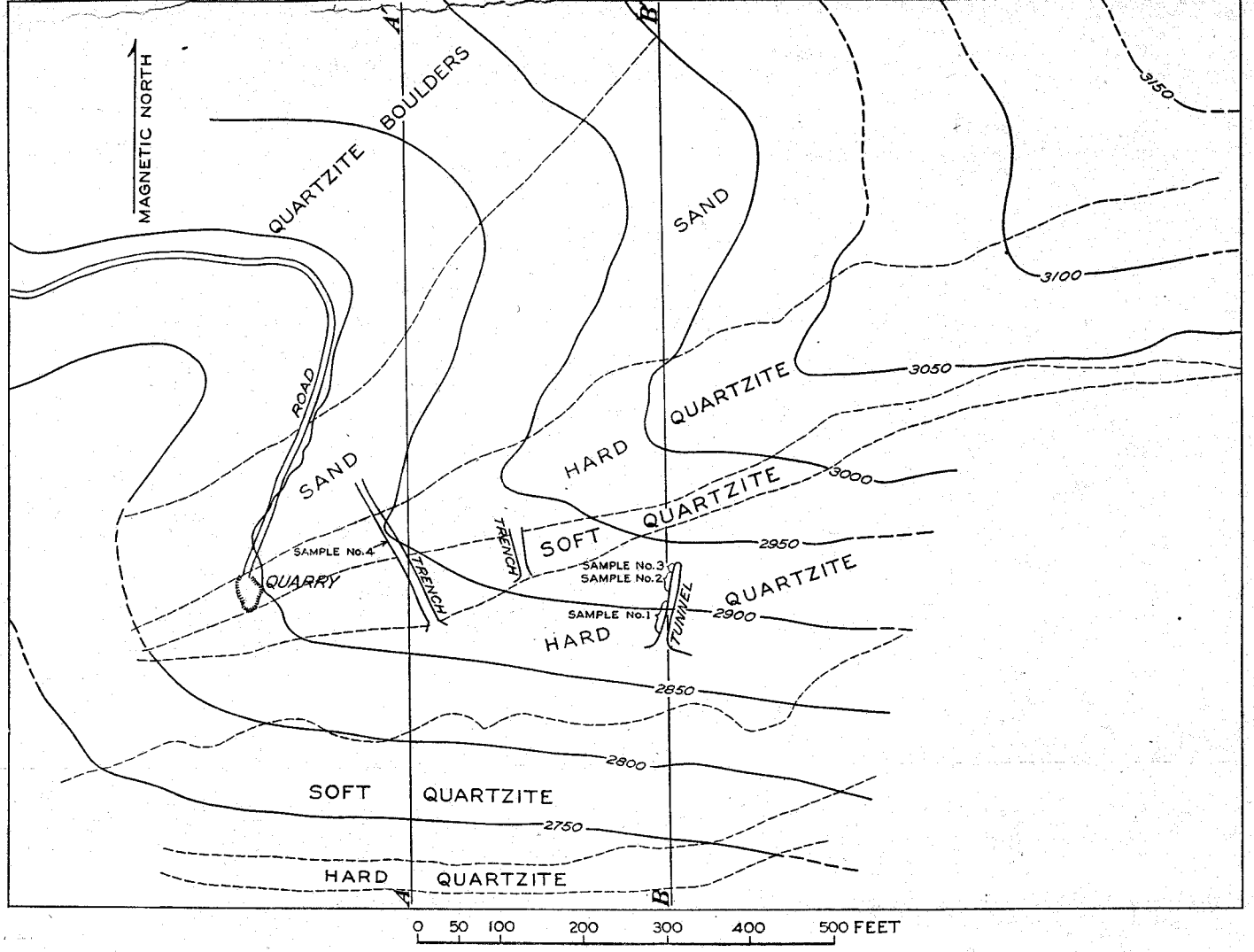
Quartzite Workings No. 1, also known as the Archer quarry, are 2½ miles south of Wytheville and 1 mile southeast of the Sand Hill School. They lie on the south slope of Sand Mountain, at an altitude of 2,650 feet. A large open cut has exposed about 60 feet of compact thick-bedded quartzite, striking N. 70° E. and dipping 35°-40° S. In 1941, about 5,000 long tons of metallurgical-grade quartzite was shipped from

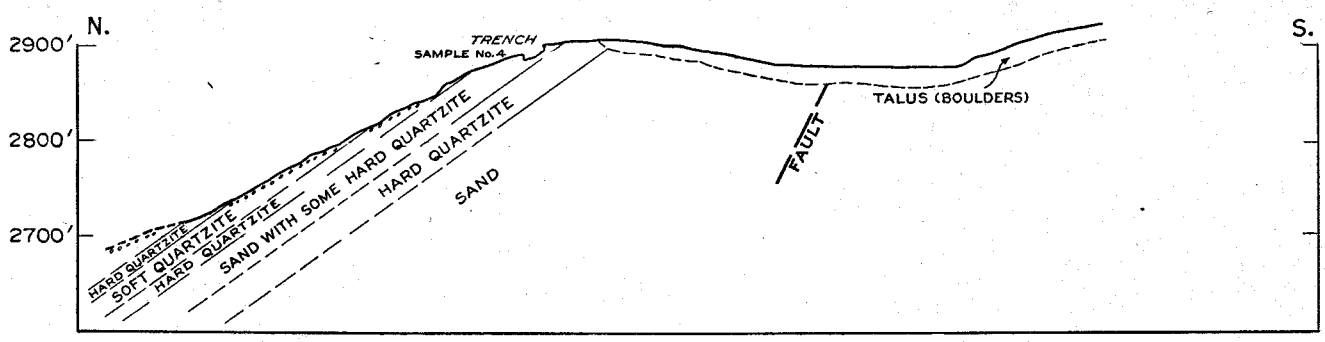
this cut by John A. Archer, who was operating the property under a lease. The shipments averaged 98 per cent silica. The property is not being worked at present.

Quartzite Workings No. 2 are 3 miles south of Wytheville and a quarter of a mile south of Venrick Run. They lie on the northeast spur of Stuart Mountain at an altitude of 2,500 feet. At present, talus boulders of compact quartzite are being mined. The Erwin quartzite crops out above the talus slope in massive, compact beds striking N. 60°-70° E. and dipping steeply southward. The physical character of the quartzite (samples 5-7 in Table 3) is satisfactory for use in the electric furnace, and the rock is more than 98 per cent silica. Production at these workings has just started.

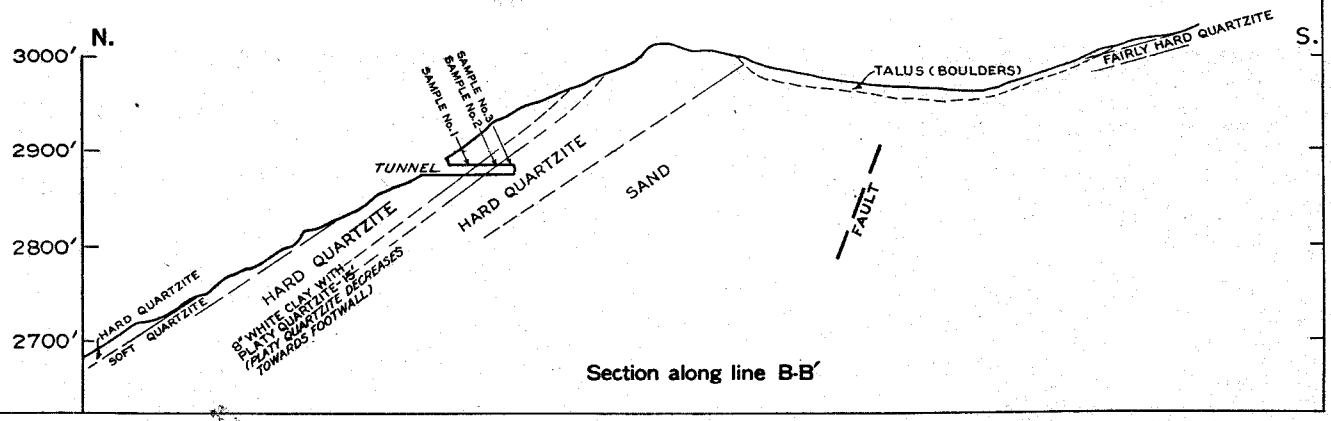
Quartzite Workings No. 3 are 2½ miles south of Wytheville and half a mile east of Quartzite Workings No. 1. They lie at an altitude of 2,850 feet on the south slope of Sand Mountain. A tunnel and two trenches have exposed a layer of compact thick-bedded quartzite about 80 feet thick, striking N. 70° E. and dipping 40° S. (Pl. 8). Analyses (samples 1-4 in Table 3) show that the compact quartzite is more than 98 per cent silica. A considerable and easily accessible tonnage of metallurgical-grade quartzite is proved by these openings, but there has been no production from these workings to date.

Where deeply weathered, the Erwin quartzite disintegrates into sand which has been dug for building sand at many favorable places in the district. The Sand Mountain Sand Corporation has an extensive pit at Lots Gap, at the east end of Lick Mountain (Pl. 7B). The pit, which extends across the strike, is about 500 feet long, 400 feet wide, and 50 feet deep. An aerial tram over a mile long has been constructed from the pit northward to a mill at the foot of the mountain, on U. S. Highway 11. The mill is equipped with screens, bins, and a washing plant. Most of the rock at the sand quarry crumbles readily into sand, and the harder masses are not used.





Section along line A-A′

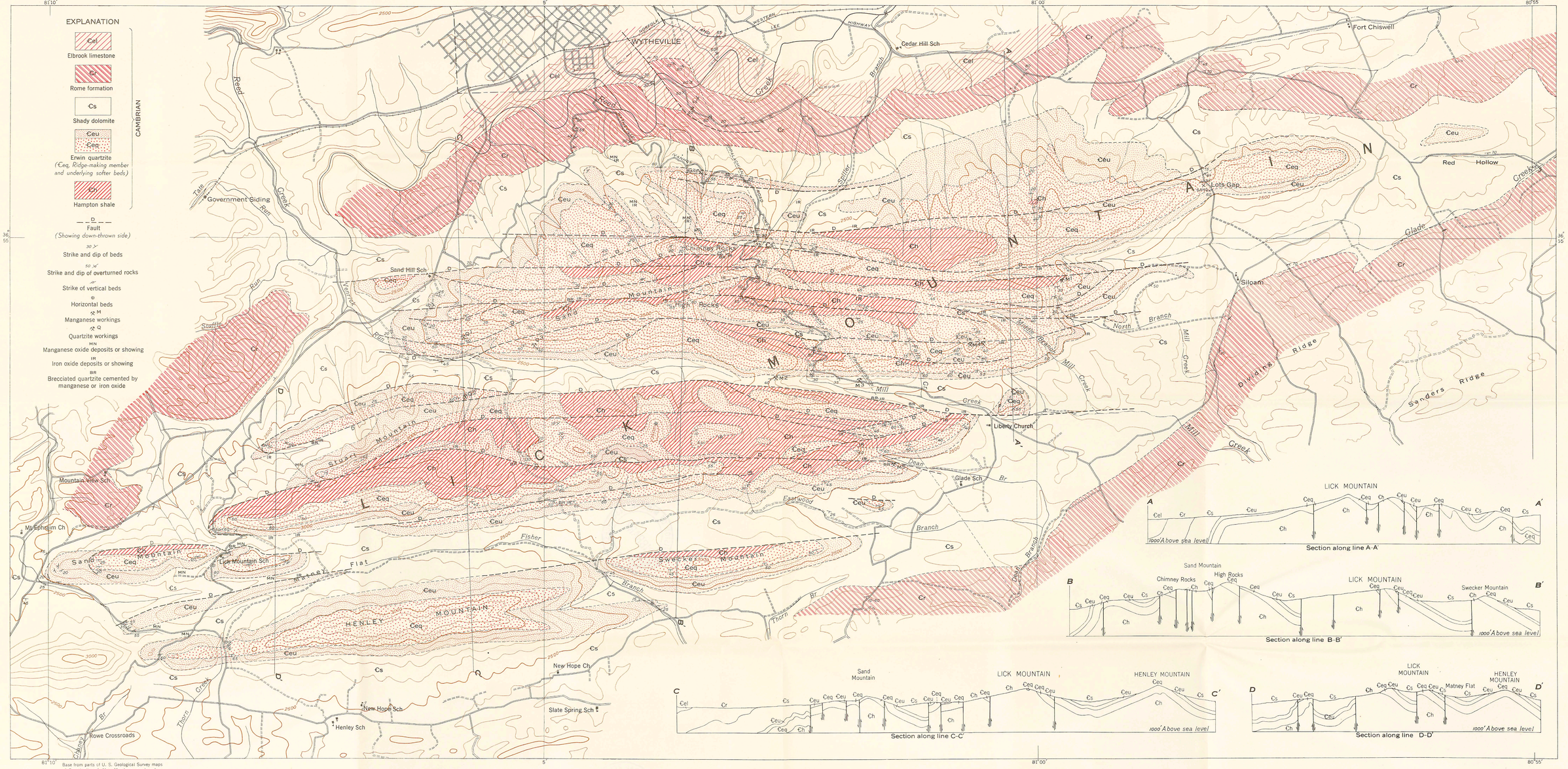


Section along line B-B′

Plan and sections of Quartzite Workings No. 3 at west end of Sand Mountain. By Sand Mountain Sand Company, February, 1942.

IN COOPERATION WITH
U. S. DEPARTMENT OF INTERIOR
GEOLOGICAL SURVEY

VIRGINIA CONSERVATION COMMISSION
GEOLOGICAL SURVEY
ARTHUR BEVAN, STATE GEOLOGIST



Base from parts of U. S. Geological Survey maps of Speedwell and Max Meadows quadrangles.

GEOLOGIC MAP AND STRUCTURE SECTIONS OF LICK MOUNTAIN AREA, WYTHE COUNTY, VIRGINIA

By George W. Stose and Frank W. Stead

Scale 1:31250

1 0 1 2 Miles

5000 0 5000 10000 Feet

Contour interval 100 feet

Datum is mean sea level