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MANGANESE DEPOSITS IN THE NEVADA DISTRICT WHITE PINE COUNTY, NEVADA

BY

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MANGANESE DEPOSITS IN THE NEVADA DISTRICT,
WHITE PINE COUNTY, NEVADA

By Ralph J. Roberts

ABSTRACT

The Nevada district, 10 miles southeast of Ely, Nevada, has been one of the principal producers of manganese ore in the State. Between 1917 and 1938 more than 15,000 tons of ore containing between 26 and 47 percent of manganese was shipped from the district; in addition about 5,000 tons of gold-silver ore has been shipped.

The rocks in the district are interbedded limestones and shales of Mississippian age. For the most part they dip steeply to the southwest, but they are locally folded and have been cut by three sets of faults--thrust faults, tear faults, and normal faults.

The manganese ore bodies are irregular, podlike, or tabular in shape. Most of them extend along normal faults, but others replace limestone adjacent to faults, and one is along a thrust fault. They are almost completely oxidized to a depth of 170 feet. The ore consists predominantly of pyrolusite with some wad and psilomelane. These minerals may have been formed by the oxidation of rhodochrosite and alabandite.

The ore remaining in stopes and found by diamond drilling indicates reserves estimated at 15,000 tons containing 30 percent or more of manganese. An additional 10,000 tons of 30-percent ore may lie in unexplored ground. It is estimated that about 5,000 tons of ore containing between 10 and 30 percent of manganese remains in the stopes, in pits, and on the dumps.

INTRODUCTION

The Nevada district is in east-central Nevada, 10 miles southeast of Ely (fig. 29). It has been one of the principal producers of manganese ore of metallurgical grade in the State. The deposits occur in a belt half a mile long and 1,000 feet wide, in sec. 10, T. 15 N., R. 64 E., on the north side of Steptoe Valley in the western foothills of the Schell Creek Range. U. S. Highway No. 6 passes 3 miles to the west of the district;

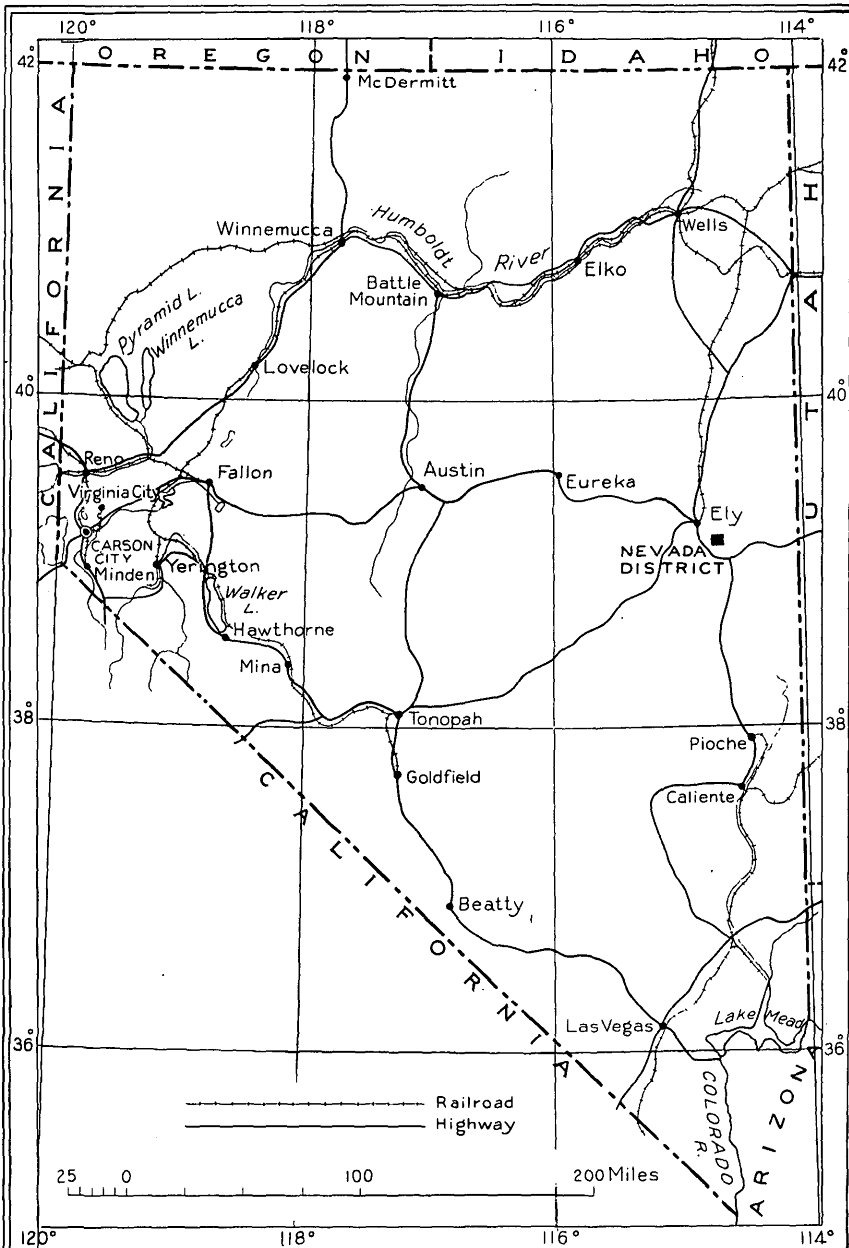

Figure 29.—Index map of Nevada showing location of the Nevada district.

dirt roads which are passable except for short periods in winter and spring, extend to the mines from the highway. Ely is the nearest shipping point.

Although prospectors seeking gold and silver ores had located claims and mined some silver ore in the Nevada district as far back as 1869,[1] they did no extensive development work and the claims lapsed. D. C. McDonald located the property now known as the Steptoe mine in 1910 and is reported to have shipped a carload of ore in that year. There was little further activity in the district until 1917 when rising prices stimulated production of manganese. An adjoining claim, now part of the Manganese mine holdings, was located by Joseph Vietti, and shipments of manganese ore from the two properties were made in 1917 and 1918, and at intervals from 1920 to 1938. Some gold-silver ore was shipped from the Manganese mine between 1936 and 1939. When the district was visited in 1940 only assessment work was being done.

Only two properties in the Nevada district, the Manganese and Steptoe mines, have produced manganese ore. Their total recorded production is 15,814 tons, of which 11,077 tons contained between 35 and 47 percent of manganese. This amounts to more than a third of the ore containing 35 percent or more of manganese produced in Nevada to 1940. The remaining 4,737 tons of ore produced in the district contained between 26 and 35 percent of manganese.

In addition to manganese ore, Mr. Caesar Caviglia reports that about 5,000 tons of gold and silver ore has been mined and shipped from the Vietti workings of the Manganese mine in recent years.

The Manganese mine includes the Vietti, Caesar-John, and adjoining workings on the Manganese claim (pl. 49). The Steptoe

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1/ Lincoln, F. C., Mining districts and mineral resources of Nevada, p. 252, Nevada Newsletter Publishing Co., 1923.

mine includes the McDonald workings, Central pit, Northwest pit, and Southeast pit on the Packard No. 2, Essex, and Essex No. 1 claims.

The only published report on the Nevada district was based on examinations made by Pardee and Jones 2/ in 1918. This report briefly describes the ore deposits as they were in early stages of development.

Recorded production of manganese ore from the Manganese and Steptoe Mines, Nevada district, Nev., 1917-38 1/

Manganese Mine

Year	Gross tons	Composition (percent)					Gross value
		Mn	SiO_2	Fe	P	H_2O	
1917....	100	43.0	5	....	...	....	$2,000
1918....	1,200	44	8	3	...	....	24,000
	580	35	.....	....	...	....	11,600
1920....	656	41.8-47.1	8.0	....	.01	4	9,993
1924....	804	37.0	9	....	...	3.5	9,278
1925....	400	38	9.0	....	.02	4	2,900
1926....	357	33.0	.....	....	...	....	3,280
	1,607	36-37	2/ 15	....	...	....	17,640
1927....	678	36	10	....	.5	4.0	8,250
1929....	90	33.94	.....	....	...	3.67	917
1930....	1,489	41.24	.....	....	...	....	17,617
1938....	43	38.75	.....	....	...	4.47	......
	8,004						107,475

Steptoe Mine

Year	Gross tons	Mn	SiO_2	Fe	P	H_2O	Gross value
1917....	466	43.67	13.14	7.92	...	....	10,620
	316	36.46	20.73	7.92	...	....	1,808
1918....	2,075	35	.....	....	...	....	41,500
1920....	2/ 105	35	.....	....	...	....	2,100
1927....	558	41.27	10	7	...	4.0	7,376
1929....	1,642	32.21	20	....	...	4.36	14,610
1930....	2,648	26.77	20	5	...	....	19,055
	3/ 7,810						97,069

1/ Figures furnished by the Bureau of Mines, U. S. Department of the Interior; published by permission of the owners.
2/ Estimated.
3/ 3,520 tons contained more than 35 percent of manganese.

The Nevada district was mapped by the writer and John M. Nelson in June and July 1940. Valuable information concerning the mines was furnished by Caesar and John Caviglia and Mr. and

2/ Pardee, J. T., and Jones, E. L., Jr., Deposits of manganese ore in Nevada: U. S. Geol. Survey Bull. 710-F, pp. 216-218, 1919.

Mrs. Marcotte. Mr. Charles H. Hyder courteously gave permission to publish diamond-drill data and other information in the files of the American Machine & Metals, Inc. Mr. Glenn C. Reed, who supervised the drilling, also furnished valuable information. The Consolidated Coppermines Corporation kindly permitted the use of maps of the area made by E. N. Pennebaker and J. A. Richards. The writer is indebted to T. B. Nolan, H. G. Ferguson, F. C. Calkins, and S. G. Lasky of the Geological Survey, and Prof. Charles Merriam of Cornell University, for helpful suggestions during field and office work. Charles Milton and W. E. Richmond, of the Geological Survey, aided in identification of the manganese minerals.

GEOLOGY

The rocks exposed within the area mapped (see pl. 49) are all of sedimentary origin with the exception of a sheared rhyolitic intrusive in the Southeast pit. The sedimentary rocks consist of limestones and shales of Mississippian age which crop out in belts trending northwest. They have been tilted to the southwest and are locally folded, and they are cut by faults which have caused some repetition of rock units. These rocks can probably be correlated with Mississippian rocks near Ely,[3] but, because of the complex faulting and uncertainty in correlation of the rocks within the Nevada district, it is more convenient to designate them by such terms as lower limestone and lower shale, and to list them as if they formed a normal stratigraphic sequence.

All three limestone units mapped contain identical fossils of lower Mississippian age, and therefore may be parts of a single unit repeated by faulting. The upper shale, which contains upper Mississippian fossils, is so similar to the middle shale,

3/ Spencer, A. C., The geology and ore deposits of Ely, Nevada: U. S. Geol. Survey Prof. Paper 96, pp. 25-27, 1917.

in which no fossils have been found, as to suggest that the two are also parts of a single unit repeated by faulting. The middle shale conformably overlies the lower limestone, which in turn conformably overlies the unfossiliferous lower shale.

Quaternary pediment gravels and alluvium conceal large areas of bed rock.

Sedimentary rocks

Lower shale.--The oldest unit mapped, the lower shale, crops out only in the northeastern part of the area shown in plate 49. This shale is light red to brown and contains lenticular limy and sandy layers in a few places. It is estimated to be more than 200 feet thick, but since its base was not mapped its true thickness is not known. The lower shale resembles the Pilot shale of the Ely district,[4/] and may be of the same age.

Lower limestone.--The lower shale grades upward into the lower limestone, except where the contact is faulted. This limestone is light to dark gray; it is, for the most part, thin- to medium-bedded, and contains layers of shale and shaly limestone. Chert layers and nodules are locally abundant near the base and top. The unit appears to be over 800 feet thick northeast of the Vietti shaft, but its apparent thickness may be in part the result of faulting. The lower limestone is similar to the Joana limestone near Ely;[5/] both limestones contain fossils of lower Mississippian age.

Middle shale.--The middle shale is thin-bedded, and its colors are light to dark brown, red, or green. It contains sandy layers where exposed in the valley north of the John shaft. This shale overlies the lower limestone conformably in most places, but is everywhere in fault contact with the middle limestone. Its true thickness is therefore not known, but it is

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4/ Spencer, A. C., op. cit., p. 26.
5/ Idem.

probably more than 300 feet. No fossils were collected from the middle shale, but it is similar to the Chainman shale of upper Mississippian age [6] near Ely.

Middle limestone.--The middle limestone contains almost all of the known manganese ore bodies. It is thin- to medium-bedded and contains a few shaly and cherty layers. As it is in fault contact with the underlying and overlying shales where the contact is exposed, its true thickness is not known, but it appears to be at least 400 feet thick near the Caesar and John shafts. This unit is cut by faults of considerable displacement which have separated two blocks of the limestone completely from the central area. The middle limestone contains lower Mississippian fossils that are identical with those collected from the lower limestone, and it is probably also correlative with the Joana limestone near Ely.[7]

Upper shale.--The upper shale resembles the middle shale in appearance and also contains sandy layers, particularly in the upper part. As its contacts are faulted where observed, and as it may be folded, its thickness is not known. Upper Mississippian fossils were collected from the shale, and it is probably correlative with the Chainman shale near Ely [8] and the upper part of the White Pine shale at the type locality near Hamilton, Nev.[9]

Upper limestone.--The upper limestone is more than 500 feet thick. Its upper part is generally massive and locally contains chert nodules and layers. Its lower part is thin- to medium-bedded shaly limestone.

The lower part of the upper limestone is similar in lithology to the middle limestone, and both may be parts of a single unit repeated by faulting. Lower Mississippian fossils were

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6/ Spencer, A. C., op. cit., pp. 26-27.
7/ Idem, pp. 25-26.
8/ Idem, pp. 26-27.
9/ Muller, S. W., personal communication.

collected from the upper limestone in several places, and it is probably correlative with the Joana limestone near Ely.[10/]

Age.--The rocks within the area shown in plate 49 were mapped by Spurr [11/] as Cambrian and Silurian, but fossils collected from all three of the limestone units mapped during this investigation were determined by Mr. J. S. Williams, of the Geological Survey, to be of lower Mississippian age (Madison, with possibly some Brazer affinities).

Fossils collected from the Joana limestone 14 miles northwest of Ely also proved to be of lower Mississippian age.

The fossils collected from the upper shale are assigned by Mr. S. W. Muller, of the Geological Survey, to the upper Mississippian. They are equivalent in age to the upper part of the White Pine shale near Hamilton, and to the Chainman shale near Ely.

Rhyolite

The only igneous rocks exposed in the area are lenses of a faulted rhyolitic intrusive in the Southeast pit. The rhyolite has been greatly altered, but quartz, biotite, and kaolinized feldspar can be recognized in hand specimens. The age of the rhyolite is not definitely known, but it may be correlative with the Pliocene (?) rhyolite near Ely.[12/]

Structure

The limestone and shales crop out in belts trending northwest, parallel to the trend of the Schell Creek Range in this area. The major structure appears to be homoclinal; in general the beds dip steeply southwest, but there are exceptions because of local folds. Complex faulting, by thrust and normal faults,

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10/ Spencer, A. C., op. cit., pp. 25-26.
11/ Spurr, J. E., Descriptive geology of Nevada south of the fortieth parallel and adjacent portions of California: U. S. Geol. Survey Bull. 208, p. 40, pl. 1, 1903.
12/ Spencer, A. C., op. cit., pp. 40-42.

has broken and displaced the beds. Thrust faulting has caused some repetition of units, but because of poor outcrops and because the stratigraphic succession is not definitely known, the details of thrust faulting have not been entirely worked out.

Folds.--With the exception of minor warps, only one fold was mapped. This fold is a small anticline near the south end of section A-A'. There has been considerable drag folding along some of the faults, but these folds do not generally extend far from the faults.

Faults.--The oldest faults are steep thrusts along contacts between shale and limestone; they trend northwest and dip southwest. Three were mapped, but others which are inferred but do not crop out are shown in plate 49, sections A-A' and B-B'. One of the mapped thrusts locally separates the lower limestone and lower shale and has caused the outcrop width of the limestone to vary from 450 to 1,000 feet. Another thrust fault bounds the middle limestone on the northeast; it is exposed in both the Caesar and Vietti shafts, and is the locus of an ore body in the Vietti shaft. The third thrust separates the upper shale and upper limestone, bringing the massive upper part of the limestone in contact with the shale except along the line of section A-A', where the thin-bedded lower part is exposed.

The amount of displacement along the thrust faults is not known, but it may exceed several hundred feet. The relative age of the thrust faults and ore bodies is likewise not definitely known, but since most of the ore bodies are in later, normal fault zones it appears probable that thrust faulting preceded ore deposition.

The thrust faults have themselves been displaced by two systems of transverse faults. One system trends north to northeastward, and the other trends northwestward. Most of these faults appear to be normal faults, but some of them may be tear faults related to the thrusts.

The two faults that parallel the southwest end of the line of section A-A' may be tear faults. The lower part of the upper limestone in that area was apparently cut out by thrusting except in the block along the line of the section. Other tear faults may pass east of the Vietti workings and the Northwest pit, but in both places they are obscured by normal faulting.

The faults that determine the locations of most of the ore bodies of the district appear to be normal faults whose maximum vertical displacement may be more than 400 feet. In places movement along these faults has shattered the limestones for as much as 25 feet on either side. The shattered zones are locally silicified.

Some normal faults, apparently of small displacement, cut the ore bodies; most of these probably preceded oxidation for they are obscured by coatings of iron and manganese oxides that extend along them. There are also postoxidation faults, but none were seen whose displacement exceeded 10 feet.

ORE DEPOSITS

General character and mineralogy

The manganese and gold-silver ore bodies of the Nevada district are for the most part in the middle limestone, though there are showings of manganese oxides in the lower and upper limestones and one small ore body was mined near the top of the upper shale. Except where the fault zone or wall rock is silicified, the ore bodies do not crop out prominently; in places the only surface indication of an underlying ore body is a slight staining by manganese and iron oxides.

Most of the manganese ore bodies are replacement deposits and fissure fillings in fractured zones along faults. Favorable limestone beds adjacent to faults were also replaced by manganese minerals in some places. The manganese ore bodies in fault zones are commonly of irregular shape (see pl. 50, McDonald ore body, and pl. 51), though they may be podlike or tabular. Generally the manganese oxides occupy only a part of the zones and are irregularly distributed laterally and vertically. The oxides occur in pods, masses, and veins in partly replaced limestone and silicified limestone and shale. Ore bodies along bedding planes are lenticular or irregular in shape. The Vietti ore body (see pl. 50), for example, is lenticular, but pinches and swells down dip.

The manganese ore consists of pyrolusite, wad, and psilomelane, listed in order of relative abundance. Pyrolusite generally makes up more than 80 percent of the ore, but wad is locally predominant. Iron oxides are generally present in the ore but are most abundant just outside the borders of the ore bodies. All these minerals are in finely porous to cavernous masses, but in the deeper workings the pore spaces are commonly filled with crystalline calcite. Braunite was reported by J. T. Pardee [13/] from the Central pit shaft, but was not recognized in specimens collected during this investigation. The gangue minerals are calcite, quartz, and locally fluorite; they vary widely in relative abundance from place to place. The quartz is in veinlets in the ore and limestone, and locally it has replaced limestone in and adjacent to the ore bodies.

The gold-silver ore body in the Vietti workings is of irregular shape. It is composed of iron oxides, galena, which is almost completely altered to the carbonate cerrussite and to the phosphate pyromorphite, calcite, quartz, and fluorite. These minerals replace limestone and line cavities in limestone on the hanging wall of the manganese ore body. In the ore that has been shipped, silver has averaged about 4 ounces and gold about 0.2 ounces to the ton.

13/ Pardee, J. T., and Jones, E. L., Jr., op. cit., p. 217.

Origin

The ore bodies were formed by hydrothermal solutions which rose along faults and deposited the ore minerals as fissure fillings and as replacement bodies in fractured wall rock along the fault zones. The ore bodies are now almost completely oxidized so that their original composition must be inferred. The only primary mineral observed was a little galena found in workings close to the Vietti shaft. As analyses of the ore show small amounts of zinc and copper, it is probable that sulfides of these metals were also original constituents of the ore bodies. Iron oxides which are within the manganese ore bodies and around their borders were presumably formed by the oxidation of pyrite or other iron-bearing minerals.

No primary manganese minerals have been recognized in the manganese deposits of the Nevada district or in those near Ely. Rhodochrosite and alabandite (MnS) are found, however, 350 feet below the surface at the Siegel mine in the Schellbourne district about 35 miles north of the Nevada district,[14] and these minerals may have been the sources of the manganese oxides in the Nevada district.

The manganese and iron oxides appear to have migrated downward during oxidation, for they locally line cavities in limestone and replace limestone and shale. Moreover, the croppings of the manganese ore bodies are generally porous and of low grade, and indicate that manganese and other metals have been leached from them. The extent of migration is not known but may have been considerable in some places.

The depth of oxidation is not known; the water table has not been reached in the workings, and the deepest ore found in drilling (170 feet vertically below the surface) is entirely oxidized. The oxidized zone probably extends at least 200 feet

[14] Pardee, J. T., and Jones, E. L., Jr., op. cit., p. 214.

below the surface, and oxidized ore bodies may extend beyond that depth.

Localization, size, and grade of ore bodies

Most of the ore bodies are in fractured zones at their intersections with cross faults and at the intersections of faults with favorable beds. The middle limestone contains most of the ore bodies, possibly because it was more highly fractured than the other limestones and, therefore, more permeable to the mineralizing solutions.

The ore bodies in fault zones (see pls. 50-51 and figs. 30 and 32) range from a few feet to 170 feet in length and from a foot to 40 feet in width, and they extend down dip as much as 70 feet. The irregularly shaped ore bodies adjacent to faults are as much as 40 feet long, 15 feet wide, and 20 feet thick. The Vietti ore body which is along a fault contact between limestone and shale, extends down the dip more than 240 feet. It ranges in thickness from a foot or less to more than 15 feet and is as much as 100 feet long.

Most of the ore mined required sorting before shipping in order to eliminate blocks of unreplaced limestone, silicified limestone, and shale. The grade of this sorted ore has ranged from 26 to 47 percent of manganese. Parts of the ore bodies mined from the Caesar-John and Vietti workings were high enough in grade to be mined and shipped without sorting; they contained on the average about 38 percent of manganese.

In the ore shipped silica has ranged from 5 to nearly 21 percent, and iron has ranged from 2 to 8 percent. Phosphorus has generally been below 0.03 percent, though one analysis showed 0.5 percent. The zinc content of the ore averaged about 0.10 percent, but was as high as 0.7 percent in one analysis. Lead, copper, alumina, and sulphur were low. The analyses in the table on page 298 and in the one below show the general range in composition in percent.

Analyses of diamond-drill cores from the Manganese Mine, Nevada district, Nevada 1/

Drill-core No.	Depth below collar (feet)	Mn	MnO_2	SiO_2	Fe	Pb	Cu	CaO
1	Not known..	36.26	56.49	17.30	2.35	0.224	.....	9.48
2	....do.....	28.71	44.52	45.70	3.10	.098	.....	.76
	2-9	34.66	53.97	34.80	2.10	.196	.....	2.05
	9-14	35.97	56.28	25.60	1.55	.154	.....	4.64
	$15\frac{1}{2}$-17	40.89	63.00	31.00	1.60	.132	.....	.37
3	98-101	32.11	49.98	24.50	1.18	.132	0.005	8.10
	101-108	36.96	57.33	29.95	2.15	.036	.005	2.48
	108-114	36.50	56.91	30.40	1.48	.036	.005	4.86
4	119-126	38.94	60.90	8.96	1.27	.036	.....	6.30
	126-128	26.51	41.58	9.06	1.15	.036	.....	6.80
5	80-85	33.00	51.26	18.87	1.27	.036	.....	7.00
	85-90	25.74	38.27	33.54	1.12	.036	.....	8.80
	90-95	37.29	56.70	22.75	1.92	.096	.....	6.50
	95-100	16.50	29.82	38.27	3.50	.048	.....	7.30
	100-110	28.71	42.63	11.28	2.39	.048	.....	13.00
7	156-165	37.17	58.29	3.30	1.01	.156	.....	12.10

1/ Compiled from figures furnished by C. A. Hyder, Trout Mining Division, American Machine & Metals, Inc.

Reserves

Most of the manganese ore shipped from the Nevada district has been used in the production of manganiferous pig iron by the Columbia Steel Co. Since a relatively low-grade ore can be used for this purpose and a high silica content is permissible, it was not necessary to concentrate the ore. It was found, however, that the zinc content exceeded the maximum allowed by the Columbia Steel Co.,[15/] and consequently no ore has been shipped to this company since 1930.

15/ Mr. C. S. Keighley, general superintendent of the Columbia Steel Co., Ironton, Utah, courteously gave permission to publish the following specifications for the purchase of manganese ores (June 5, 1941):

Mn...... Sufficient to cover all charges for freight, etc., F. O. B. Ironton plant.

S....... 0.008 percent (maximum) for each percent of manganese in the ore.

Zn...... .05 percent (maximum, dry basis) allowed without penalty.
.20 percent (maximum, dry basis) allowed with penalty.

As...... .10 percent (maximum, dry basis) allowed without penalty.
.30 percent (maximum, dry basis) allowed with penalty.

The ore must be free from lead and other nonferrous metals, and must be 4 inches and under in size, with a minimum of fines.

As the crude ore does not meet ferromanganese specifications for manganese and silica content it would have to be concentrated. To lower the silica content sufficiently might prove difficult and costly as the manganese oxides in the ore are intergrown with fine-grained quartz.

According to Mr. C. H. Hyder, of the Trout Mining Division of the American Machine & Metals, Inc., tests on a carload of ore from the Vietti and Caesar-John workings of the Manganese mine in 1938 showed that it can be concentrated to battery grade (70 percent of MnO_2). The lime (CaO) content of the concentrate, however, was too high, and although the lime could be removed by acid leaching, the ore reserves did not appear to warrant the installation of the necessary equipment.

Further milling and metallurgical tests should be made to determine a suitable treatment for the ore.

The probable reserves of the Manganese and Steptoe mines to a depth of 200 feet below the outcrop, as estimated from the results of drilling by the American Machine & Metals, Inc., and the quantity of ore apparent in the stopes amount to about 15,000 tons containing 30 percent or more of manganese. The greater part of this tonnage is in downward and lateral extensions of the Vietti and Caesar-John ore bodies. It is possible that an additional 10,000 tons of 30-percent ore may be found in ore bodies not yet discovered. There is also material containing between 10 and 30 percent of manganese remaining in stopes, pits, and on the dumps. It is estimated that 5,000 tons of this grade may be available, and more may be found in unexplored ground. Ore of this grade would be costly to concentrate.

MINES

Manganese mine

The Manganese mine holdings comprise four claims; the Manganese claim was located in 1917 by Joseph Vietti, and the

Manganese Nos. 2, 3, and 4 claims adjoining the Manganese claim were located in 1927. The property is now owned by Catherine Vietti and John and Caesar Caviglia of Ely, Nev.

The workings, all in the middle limestone, aggregate about 1,500 feet of shafts, drifts, and cross cuts and include one open pit. Most of the development work has been done in two areas explored, respectively, by the Vietti workings and Caesar-John workings.

Vietti workings

The Vietti workings (see pl. 50) include an inclined shaft and drifts at several levels. They explore two ore bodies, a gold-silver ore body on the upper levels, and a manganese ore body on the lower levels. Both are in limestone just above the middle limestone-middle shale contact, which is probably a thrust fault.

Gold-silver ore body.--The gold-silver ore body on the upper levels is in silicified limestone on the hanging wall of the fault. The ore is porous and is stained by iron and manganese oxides; fluorite is locally present in cavities. The gold-silver ore is almost completely oxidized, but small masses of galena encrusted by cerussite and pyromorphite have been found in the stope above the 6,877-foot level. Two stopes have been mined, one north of the Vietti shaft and above the 6,877-foot level, the other south of the shaft above the 6,842-foot level. The localization of the ore appears to have been determined by steep fractures in the hanging-wall limestone. Both stopes extend nearly to the surface, and Caesar Caviglia estimates that they have yielded about 5,000 tons of ore. In the lower part of each stope, gold-silver ore lies just above the manganese ore body.

Manganese ore body.--The manganese ore body replaces limestone just above the shale. The ore body is composed of several lenses (see pl. 50, section A-A') which dip 25°-40° SW. and pitch down the dip. Several postoxidation faults were noted, but none has displaced the ore more than 5 feet.

Above the 6,877-foot level the manganese oxides are sparsely distributed throughout porous silicified limestone. On and below this level most of the ore consists of porous to cavernous pyrolusite, though in places it contains considerable wad and some psilomelane. On the lower levels pore spaces in the oxides are commonly filled in part with calcite. Irregular masses of manganese oxides locally replace the limestone wall rock adjacent to the ore body, and small veins of oxides extend some distance from the ore body. The boundary between limestone and ore is sharp in most places, although iron and manganese oxides generally stain the limestone for several feet beyond the limits of the ore body.

The causes that determined the location of the ore body are not entirely clear. The manganese-bearing solutions may have ascended along the thrust-fault zone and deposited manganese minerals, which were later oxidized, in the fractured hanging-wall limestone. The present ore body, however, may owe part of its manganese content to concentration during oxidation. On the upper levels the manganese ore lies just below the gold-silver ore stope. The porous gold-silver ore contains some manganese oxide, and manganese may have been leached from it, transported downward, and deposited on the shale footwall. The extent of migration is not known, but it may account for a considerable portion of the ore body.

The Vietti ore body has been mined for 160 feet down the dip, and drilling has shown that the ore body continues at least 80 feet further (to an altitude 170 feet lower than the collar of the Vietti shaft). The ore ranges in thickness from less than 1 foot to more than 15 feet; the average thickness of the ore mined was about 5 feet. Caesar Caviglia estimates that this ore body has yielded about 6,000 tons of ore containing between 35 and 40 percent of manganese.

Five drill holes were put down to explore the ore body below the workings. Holes 1 and 2 (see pl. 50, section B-B') were drilled down the dip of the vein from the 6,804-foot level. Hole 1 passed into the hanging wall at 12 feet and hole 2 was abandoned at 17 feet where the ground became difficult to drill.

Holes 3 and 4 were drilled from the 6,874-foot level and hole 5 from the 6,866-foot level in the McDonald workings northeastward to intersect the Vietti ore body. All of them penetrated ore above the shale-limestone contact, as shown in plate 50, sections D-D' and E-E'. Analyses of the cores given in the table on page 298 show that the ore is for the most part high in silica, but the manganese content of most of the samples is comparable to that of ore shipped.

Caesar-John ore body

The workings on the northwest end of the Manganese claim (see pl. 51) explore the Caesar-John and adjacent ore bodies.

The Caesar-John ore body follows a fault zone which strikes eastward and dips steeply south. The fault zone is as much as 50 feet wide, but it does not consist of manganese ore for more than a part of this width; the masses of manganese oxide are irregularly distributed throughout the fault zone, in and adjacent to small fractures. Porous pyrolusite and wad are the most abundant minerals, but psilomelane is present in some places. The cavities in the ore are generally lined by calcite. Two small pods of manganese oxides were stoped above the 6,847-foot level, but because the ore became low grade and siliceous the stopes were not extended to the surface. In the 6,847-foot-level drift the ore body is lenticular and not more than 6 feet wide.

Holes 7 and 8 (see pl. 51, section A-A') were drilled to explore the ore body below the workings. Hole 7 showed 5 feet of ore 60 feet below the 6,847-foot level, but hole 8, in the same plane but at a steeper angle, was entirely in limestone and shale; presumably, then, the ore pinches between the two holes.

The location of the ore body just west of the John shaft (see pl. 51, section B-B') was apparently determined by the intersection of faults parallel to the vein with cross fractures that strike about N. 35° E. A block 30 feet long, 10 feet wide, and as much as 20 feet thick was stoped from this area.

The workings on the 6,893-foot level explore an ore body that extends along the bedding and is apparently controlled by steep N. 15° W. cross fractures. Ore was mined to the surface at one place but most of the manganese oxide masses were small and irregularly distributed through the shattered silicified limestone. The block of ore stoped north of the open pit was 55 feet long, 4 to 20 feet wide, and about 6 feet in average thickness.

Steptoe mine

The Steptoe mine adjoins the Manganese mine workings on the west and southwest. The property includes the Steptoe, Jane, and Storm claims which were staked by D. C. McDonald in 1910. In 1917 the claims were sold to A. B. Bowen and W. S. Holmquist, who mined and shipped manganese ore in 1917 and 1918. Later the claims lapsed and in 1922 they were relocated by McDonald and A. L. Nicholson, who renamed them the Essex, Packard No. 2, and Essex No. 1. From 1927 to 1930 Arnold Millick and Pete Topholm leased the property and shipped ore. The property has been inactive since 1930. It is now owned by Mrs. Ruth Marcotte and Mrs. Muriel Brown of Ely.

The workings, which are chiefly on the Essex and Packard No. 2 claims, consist of three open pits and about 300 feet of underground workings on the McDonald vein.

McDonald ore bodies

The McDonald ore bodies (see pl. 50) are in the middle limestone, just southwest of the Vietti workings. They have yielded over 3,000 tons of ore, 400 tons of which, shipped in 1918, contained about 40 percent of manganese and the rest between 26 and 32 percent. Two ore bodies have been mined; one of them extended along a silicified fault zone trending about N. 40° W., the other replaced limestone along bedding adjacent to the fault zone.

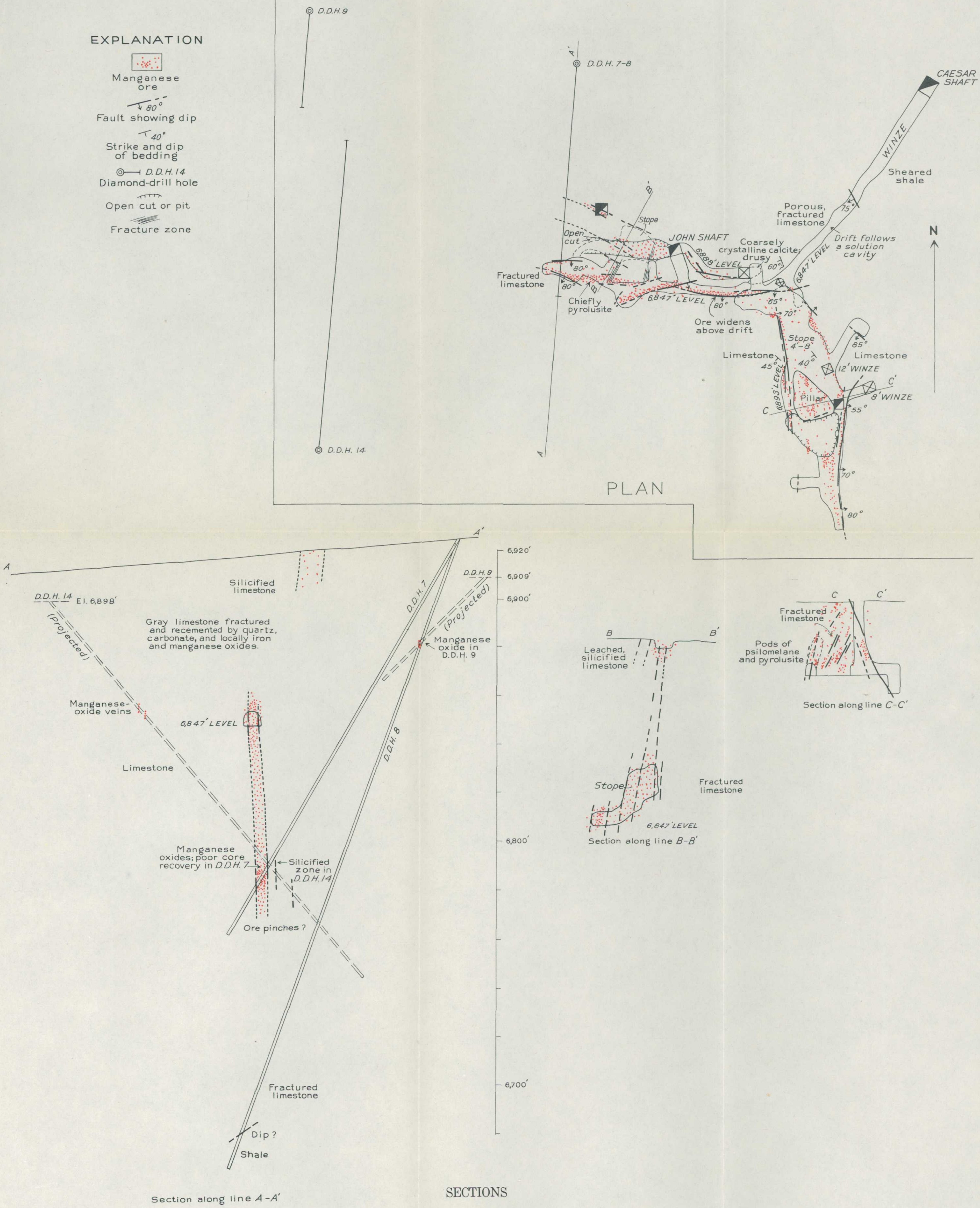
The ore body along the fault zone has been explored for a length of 170 feet and a depth of 70 feet. At the McDonald shaft this ore body was as much as 25 feet wide, but individual pods of ore in the fault zone appear to have been small. On the 6,866-foot level the limestone is cavernous; one cave several feet long has been partly filled with interbanded iron and manganese oxides and calcite.

The ore body formed by replacement of limestone along the bedding (see pl. 50, section C-C') was of good grade adjacent to the fault zone. This ore body was irregular in shape and it was 60 by 20 by 6 feet in maximum dimensions.

Northwest pit

The Northwest pit, on the Essex claim, (see fig. 30) has yielded over 2,000 tons of ore, but judging from the size of the waste dump and material remaining in the pit, the ore was of low grade. The pit is 35 feet deep, 75 feet long, and 40 feet in greatest width.

The ore body is in the middle limestone, which is here in fault contact with the upper shale. The limestone was shattered



GEOLOGIC PLAN AND SECTIONS OF THE CAESAR-JOHN WORKINGS

50 0 100 Feet

along the contact by two sets of faults, one striking about N. 20° W., the other striking north to N. 50° E. The ore body in

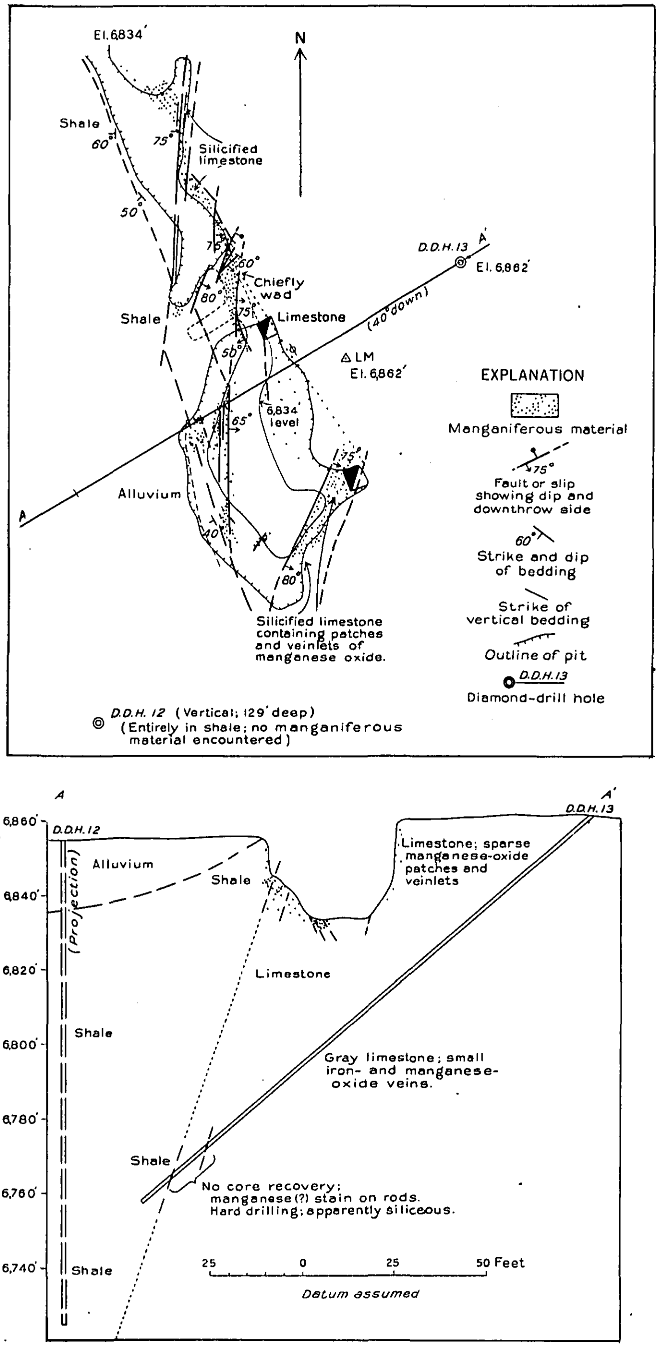


Figure 30.—Geologic map and section of the Northwest pit, Essex claim.

general parallels the N. 20° W. faults, but pods and veins of oxides also extend out along faults of the northeasterly system.

Two diamond-drill holes (see fig. 30, section A-A') were put down to explore the ore body below the workings. Hole 12 is entirely in shale, having been abandoned before reaching the shale-limestone contact. Hole 13 may have cut a manganiferous zone between 138 and 150 feet below the collar, but since no ore was recovered the grade of the material is not known.

Across the valley northwest of the Northwest pit there are showings of manganiferous oxide in shallow pits and shafts. The

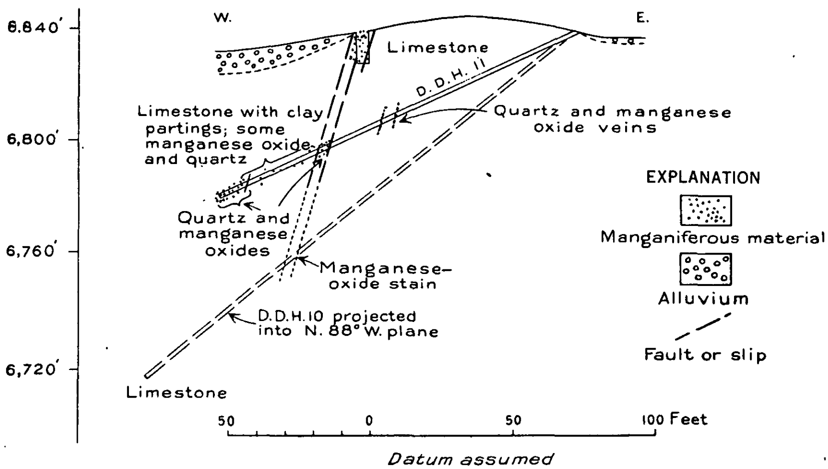


Figure 31.—Section N. 88° W. along diamond-drill holes 10 and 11, Essex claim.

material exposed is of low grade and contains considerable quartz. Two drill holes (see fig. 31) were put down to explore these showings at depth. Neither hole was entirely successful since core recoveries were poor, but there may be some ore west of the 12-foot shaft. The grade of the material is not known.

The shallow workings 175 feet southeast of the Northwest pit show manganese oxides enclosed in brecciated limestone extending along faults that strike N. 15° W. None of the exposed material is of good grade, but further prospecting may be warranted.

Central pit

The Central pit on the Essex claim (see fig. 32) is 80 feet long and up to 40 feet wide, and it ranges in depth from 8 feet at the east to 25 feet at the west end. According to Pardee 16/ the Whim shaft near the west end originally extended to a depth of 70 feet; the ore is said to have pinched at the bottom of the shaft. In all, the Central pit is reported to have yielded about 1,400 tons of manganese ore.

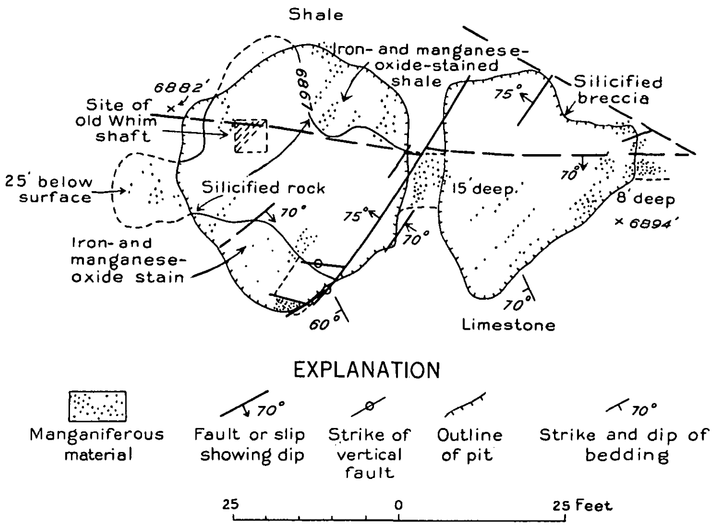


Figure 32.--Geologic map of Central pit, Essex claim.

The ore body extends along a fault contact between limestone and shale; in the main it replaces limestone, but locally it extends out into the shale. Although little ore remains in the pit the ore body apparently had an easterly trend and was nearly vertical. The ore now exposed contains considerable iron oxide. Pardee reported that dense braunite and psilomelane occur at a depth of 60 feet in the shaft.

16/ **Pardee, J. T., op. cit., p. 217.**

Southeast pit

The Southeast pit (see fig. 33) is in silicified upper shale near its fault contact with the upper limestone. The silicified zones were probably formed by alteration of calcareous layers in

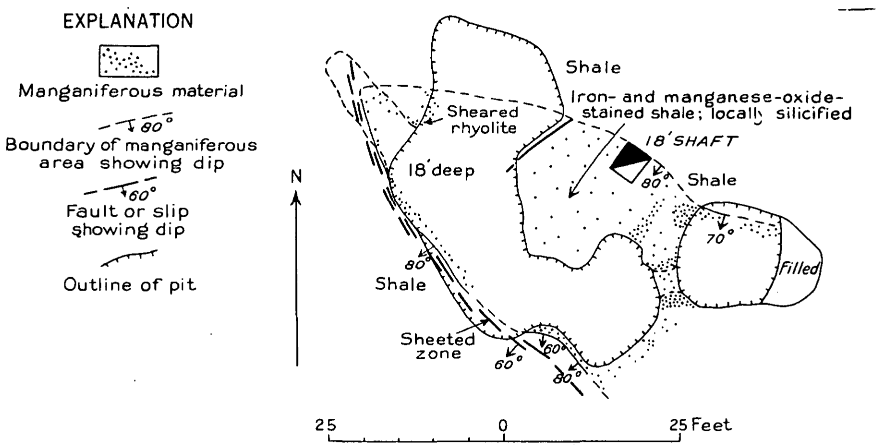


Figure 33.—Geologic map of Southeast pit, Essex No. 1 claim.

the shale. The pit is 18 feet deep, and it is said that little ore was found in it; most of the material now exposed is of low grade.

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