DEPOSITS OF MANGANESE ORE IN NEVADA.

By J. T. Pardee and E. L. Jones, Jr.

INTRODUCTION.

Manganese is rather widely distributed in Nevada. In addition to the small amounts that occur in rocks generally it is more or less abundant in many of the metalliferous quartz lodes and in deposits of other types.

Manganiferous silver ore has been produced for many years in Nevada, but manganese ore for use in the manufacture of steel was not mined in this State prior to 1916. Beginning with that year the increased demand for manganese due to the war caused old workings known or supposed to contain manganese ore to be reopened and also led to several new discoveries, of which the Three Kids deposit, near Las Vegas, is a conspicuous example.

The amount of manganese ore mined in Nevada in 1916 was small, but thereafter production increased rapidly, reaching a maximum of about 9,000 tons in the second quarter of 1918. Afterward the production declined, and in December, 1918, it practically ceased. Altogether during the war Nevada, in addition to a large amount of manganiferous material used for flux in lead and copper smelting, contributed about 25,000 tons of manganese ore, or about 2 per cent of the total amount needed by the country.

The deposits mentioned herein were investigated by the Geological Survey in 1917 and 1918 for the purpose of estimating the available ore reserves. In the summer of 1917 the Pioche district was examined by J. B. Umpleby and some of the deposits near Golconda and Sodaville by E. S. Larsen. In June, 1918, E. L. Jones, jr., examined the Las Vegas district. The Siegel and Nevada districts and several of the deposits near Ely and Golconda were examined by J. T. Pardee prior to June 15, 1918. Between that date and September the examinations were continued by J. C. Jones, of the Mackay School of Mines, at Reno, whose work covered the State generally. The results of Umpleby's work have been published elsewhere.[1] The descriptions of the deposits examined by J. C. Jones were compiled from the memoranda he filed with the Survey by E. L. Jones, jr.,

[1] Umpleby, J. B., Manganese fluxing ore at Pioche, Nev.: Eng. and Min. Jour., vol. 104, p. 760, 1917.

and J. T. Pardee. The description of the Las Vegas district was written by E. L. Jones, jr., and the remainder of the report was written by J. T. Pardee.

The approximate location of the deposits described herein is shown on Plate X.

CLASSIFICATION AND GENERAL FEATURES OF THE MANGANESE DEPOSITS.

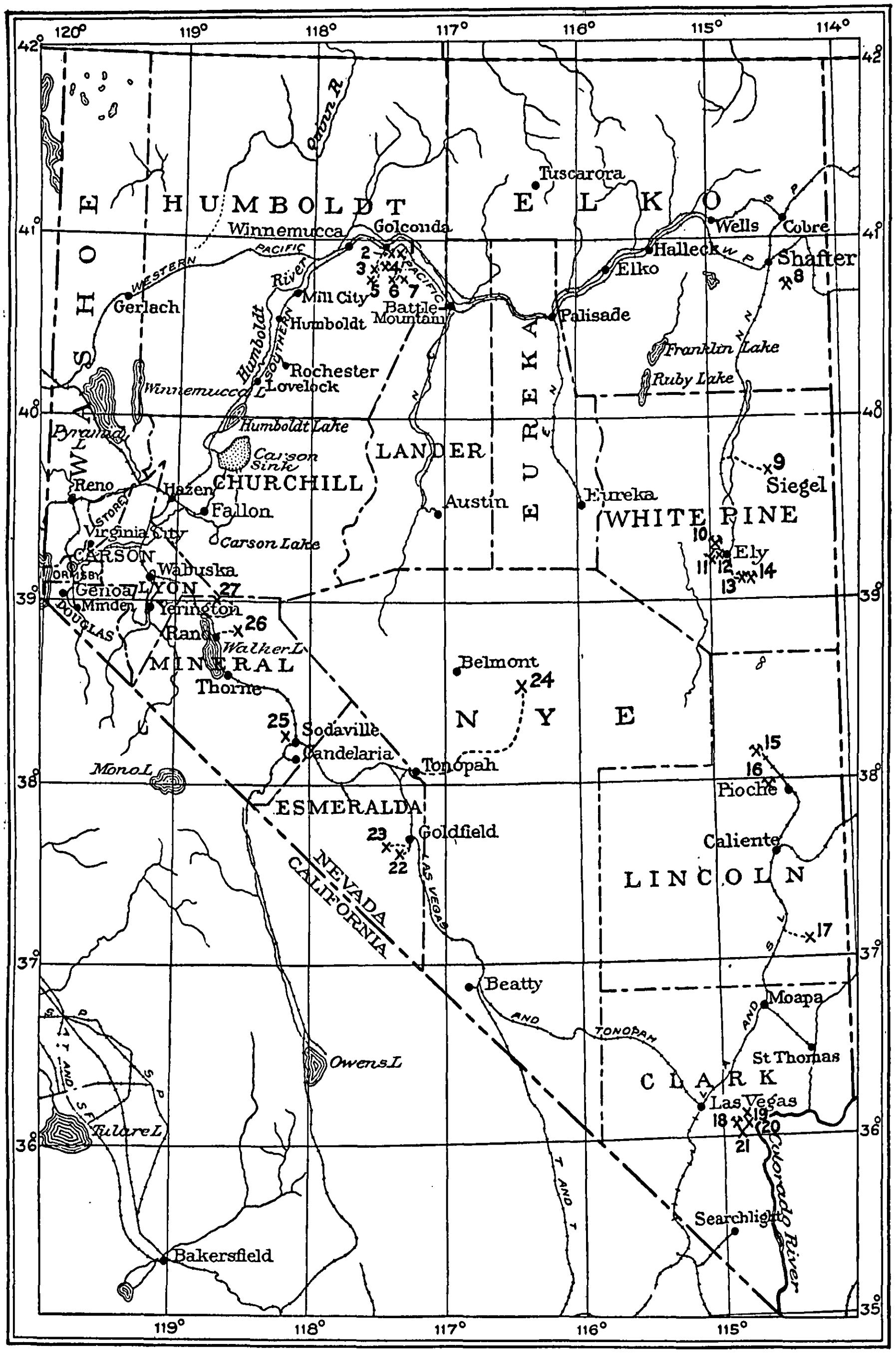
DEPOSITS FORMED BY REPLACEMENT OF COUNTRY ROCK BY CARBONATE OR SILICATE MINERALS THAT HAVE BECOME PARTLY OR COMPLETELY OXIDIZED.

Many of the Nevada deposits may be more or less confidently classified as having been formed by the replacement of country rock by carbonate or siliciate minerals that have become partly or completely oxidized. The deposit at the Siegel mine is clearly of this type, as are also those at the Prince Consolidated Co.'s mines at Pioche, the Keystone and others near Ely, and the Bullshead and O'Neill mines in the Spruce Mountain district. The Darky and Black Metals mines and the deposits in the Nevada district have features characteristic of this group, though complete evidence of their relationship is perhaps wanting.

As a rule these deposits are formed along fractures, and most of them are in limestone. A characteristic feature of the oxidized ore bodies of this group is their cavernous texture, which contrasts strongly with the generally compact texture of the unoxidized manganiferous material in the lower zones. Vein quartz and small amounts of silver, lead, or zinc minerals are generally present throughout. In the unoxidized zone the manganese occurs most commonly in the form of rhodochrosite, the carbonate, and rhodonite, the silicate. In the Siegel mines the rather uncommon mineral—alabandite, a sulphide of manganese—is more or less abundant, and in the Pioche district the manganese occurs as manganiferous siderite, a carbonate of manganese and iron. In the oxidized zone the manganese minerals generally form an indeterminate mixture, though in places individual minerals can be recognized. Of these pyrolusite and manganite appear to be the most abundant, with psilomelane and a very soft, pulverulent material, usually classified as wad, next in order. Braunite appears to be rather common in the deposits of the Nevada district.

Manganese ore from these deposits has been produced from the oxidized zone only. As a rule it is rather siliceous but low in iron and phosphorus.

The ore so far produced by the Siegel mine and the mines of the Prince Consolidated Co., because of its content of silver and other metals and its fluxing properties, has been used in copper and lead



0 50 100 150 MILES

EXPLANATION

⚒ Mine X Prospect ------- Wagon and automobile road

INDEX MAP SHOWING MANGANESE DEPOSITS IN NEVADA.

MINES AND PROSPECTS.

1. Iron Mask.
2. Surprise (Navarine).
3. Major.
4. Hansen & Knudsen.
5. Black Diamond.
6. O'Brien & Tucker.
7. De la Vega.
8. Darky.
9. Siegel.
10. Willoughby.
11. Federal Ely.
12. Keystone.
13. Bowen & Holmquist.
14. Witcher & Vietti.
15. Black Metals.
16. Prince Consolidated.
17. Smith & Dobbins.
18. Las Vegas group.
19. Lowney.
20. Yount.
21. Three Kids.
22. Gaillac.
23. Dunnigan
24. Surprise (Wiswall).
25. Black Jack.
26. Ballbearing.
27. Bullion.

smelting rather than the manufacture of steel. The total production of ore of this kind has been large, the mines of the Prince Consolidated Co. being credited with more than 600,000 tons. In 1917 and 1918 somewhat more than 200,000 tons of manganiferous iron ore used for flux was produced in Nevada, by far the most of which came from the Prince Consolidated Co.'s mines above mentioned.

From other deposits of this group about 4,500 tons of manganese ore for use in making steel was produced in 1917 and the first half of 1918. Most of this ore came from the Nevada district and the Darky mine.

The reserve of manganiferous iron ore in the Pioche district is estimated to be more than 500,000 tons. All other deposits of this group are estimated to contain a total minimum reserve of about 6,000 tons of manganese ore and 15,000 tons of material which contains from 10 to 35 per cent of manganese.

The form and occurrence of these bodies clearly show that they were formed by solutions ascending through fissures or other channels in the rocks, and their similarity to the type of metalliferous lodes generally regarded as emanations from deep-seated intrusive magmas suggests that they have a similar origin.

DEPOSITS FORMED BY REPLACEMENT OF COUNTRY ROCK BY OXIDE MINERALS.

A group that includes the deposit of the Three Kids mine, at Las Vegas, and several comparatively small deposits elsewhere may be classified as replacement deposits formed by oxide minerals.

The deposits occur as irregular veins and in other forms, the Three Kids deposit being a flat-lying lenslike or tabular mass. Most of them occur in lavas and tuffs of probable Tertiary age. The ore is not cavernous, though it may be porous. Soft material, presumably the mineral wad, occurs generally and forms the bulk of the Three Kids deposit. The other more common oxides are generally present in varying amounts. Vein quartz was not observed, but commonly the ore contains a moderate amount of silica, which is apparently derived from incompletely replaced masses of the country rock. Generally some calcite or gypsum and a little iron oxide are present. Iron and phosphorus are low. The Iron Mask and Success claims, east of Golconda, and the Black Jack prospect, near Sodaville, are especially interesting because they contain small amounts of tungsten.

The total production from deposits of this group to June 15, 1918, is more than 12,000 tons of manganese ore, all but a small part of which came from the Las Vegas district.

Approximately a minimum total of 2,000 tons of manganese ore is estimated in reserve in the deposits of this group outside of the Three Kids mine, at which a large amount additional was in reserve in June, 1918. The reserve of material containing less than 35 and more than 5 per cent of manganese is estimated at 50,000 tons, most of which is on the Bullion claim.

The manganese oxides that form the ore bodies of this group were apparently deposited by solutions that followed fractures and seams in the rocks, but the source from which the solutions obtained the manganese is obscure.

SILICATE AND CARBONATE LENSES IN METAMORPHIC ROCKS.

There remain to be considered several deposits near Golconda that are classified as silicate and carbonate lenses in metamorphic rocks. These bodies, most of which are superficially oxidized, have tabular and lenslike forms and occur along bedding planes in Triassic shale and quartzite. The completely oxidized parts consist of rather soft and friable fine-grained material that appears more or less glossy, like coal. Associated with it is much hard, dense, somewhat glossy black material which appears to the unaided eye to be completely oxidized but which the microscope shows to be made up partly of unaltered silicate. Both kinds of material form ore that is fairly rich in manganese, though the harder ore is highly siliceous.

A few carloads of manganese oxide were shipped from the Hansen & Knudsen mine. No production is reported from the other deposits of this group.

The reserves in these deposits are estimated to amount to at least 6,000 tons of moderately siliceous manganese ore. In addition there is a large quantity of highly siliceous material containing less than 35 per cent manganese.

Unoxidized parts of these bodies are dense and hard and composed mainly of rhodonite and quartz. Specimens from the O'Brien & Tucker deposit show a very bright pink color and take a high polish. Material of this kind is at present generally considered worthless as a source of manganese. The amount in reserve is apparently very large.

The origin of these bodies is not clearly shown, but their occurrence as described suggests that they were deposited with the inclosing sedimentary rocks and later altered somewhat by metamorphism.

MINES AND PROSPECTS.

SCHELLBOURNE DISTRICT.

SIEGEL MINE.

The Siegel mine is on the eastern slope of the Schell Creek Range about 5 miles south of the old mining camp of Schellbourne and 40 miles northeast of Ely, Nev., from which it may be reached conveniently by automobile. The nearest station on the Nevada Northern Railroad from which ore is shipped is Cherry Creek, about 20 miles from the mine.

Records for the period 1902–1908 show a production of about 1,200 tons of rich silver ore that averaged 37.4 per cent of manganese. The ore was smelted at Salt Lake City to recover the silver; the manganese, which by reason of its fluxing properties added somewhat to the value of the ore, went into the slag. During the last few years the mine has been closed, but in June, 1918, steps were taken to reopen it for the purpose of producing manganese as well as silver ore. Since then the operator has reported (January, 1919) that no practical method for recovering both metals had been devised up to the time the armistice was signed and the abnormal demand for manganese ceased. The mine is owned by Sam Lazarus, of St. Louis.

The rocks exposed in the vicinity of the Siegel mine are quartzite, shale, and limestone, of which the quartzite is the oldest and the limestone the youngest. The quartzite and the limestone each appear to be several thousand feet in thickness; the shale, which is indurated, schistose, and micaceous, is about 200 feet thick. All appear to be conformable and presumably are of Cambrian age. The limestone occupies the slopes in the vicinity of the mine, and the quartzite and shale those to the east. The general strike is about north and the dip 45° W. Faults are shown here and there in the mine workings and indicated on the surface by sharp jogs in the formation boundaries. Except a few small rather siliceous greenish gray dikes that are probably to be classified as granodiorite porphyry, no igneous rocks were seen near the mine. About a mile to the northeast, however, a large area of lavas begins, and in the Snake and Egan ranges, to the east and west, respectively, granular intrusive rocks occur.

The underground workings, most of which were in good condition in 1918, comprise adit levels, drifts, raises, and stopes that penetrate Siegel Mountain from the northeast and aggregate nearly 7,000 feet in length. The Sommer tunnel and the lower and upper St. Anthony tunnels are crosscuts to the St. Anthony vein at elevations of 7,800, 8,050, and 8,150 feet, respectively. The Allan tunnel, at 8,250 feet, and an adit at 8,350 feet open the Black Eagle deposit, and smaller workings are made on the Black Eagle No. 3 and several other claims.

The principal ore bodies so far discovered are distributed through an irregular northwestward-trending belt somewhat less than a mile in length. The St. Anthony vein, which has yielded four-fifths of the ore produced to date, occurs at the south along a N. 50° W. fracture that dips 60° N. and cuts the limestone. Its general form is tabular; the productive portion, which ranges from 1 to 15 feet in thickness, extends from the surface downward about 400 feet on the dip and shows a maximum width (stope length) of 300 feet at the level of the lower St. Anthony tunnel. It pinches before reaching the Sommer tunnel and ends on the west at a broken zone that marks a northeasterly fault of considerable throw. The Black Eagle deposit is a short distance northwest of the St. Anthony, from which it is separated by the northeasterly fault mentioned. It consists of several irregular pipelike bodies, most of which occur along bedding planes near a fault that strikes N. 45° W. and dips 45° SW. The fault movements, which are indicated by gouge and breccia and horizontal grooves on the walls, took place mainly before the ore was deposited. About 2,000 feet farther northwest a short adit on the Black Eagle No. 3 claim exposes an ore body from 2 to 6 feet thick, and several smaller deposits are exposed by workings elsewhere in the mineralized belt.

As shown by the St. Anthony workings oxidation is practically complete to a depth of 350 feet. Below this level the vein is saturated with water and characterized by rhodochrosite and the rather uncommon mineral alabandite, a sulphide of manganese. This mineral occurs in massive granular aggregates and as intergrowths with rhodochrosite. It is iron-black, gives a dark-green streak, and splits readily on cubical cleavage planes that show a metallic luster somewhat less brilliant than that of galena. Its hardness is 3.5, it is easily scratched with a penknife, and the application of cold dilute hydrochloric acid, without even powdering the mineral, causes rapid effervescence, with the evolution of hydrogen sulphide. When exposed to the weather specimens soon lose their luster and acquire a coating of black manganese oxide. This fact, together with its green streak and the ease with which cold dilute hydrochloric acid attacks it, serve to distinguish alabandite from galena or any other sulphide that may resemble it. Other constituents of the vein are quartz, calcite, pyrite, and galena. Except part of the calcite, which forms secondary veinlets, all the minerals appear to be of the same generation. A banding parallel to the walls is indistinctly shown, and there are fragments of partly replaced limestone in the ore. A sample representative of this part of the vein yielded 18 per cent of manganese, 7.9 per cent of iron, and 37.6 per cent of silica. Two selected samples reported show respectively 3.7 and 54.4 ounces of silver to the ton, 8.2 and 27.5 per cent of manganese, and 7.6 and 1 per cent of lead. Rather curiously the sample low in lead and high in manganese shows the more silver.

In the oxidized zone the vein filling consists chiefly of manganese oxides with more or less quartz and calcite and locally iron oxides and cerusite (lead carbonate). The manganese oxides are mostly soft, fine grained, and intimately mixed with one another. Pyrolusite is probably the most abundant mineral. The body is cavernous throughout, a result of the net loss in volume during oxidation of the parent minerals.

Parts of the body that contain more than the average amount of silver form irregular shoots from which the ore shipments have been made. Car samples representing 1,200 tons, four-fifths of which came from the St. Anthony and the remainder from the Black Eagle, show an average of 37.4 per cent of manganese, the range being from 23.3 to 45.1 per cent. Other constituents range approximately as follows: Iron, 3 to 10 per cent; lead, 0.5 to 4 per cent; zinc, 1 to 2.5 per cent; silver, 70 to 270 ounces to the ton; and gold, a trace to 0.05 ounce to the ton. Silica was not determined, but presumably it was rather high. Except that they may be less rich in silver, the remaining parts of the ore body appear to have about the same composition as those worked out. Several analyses reported of selected samples show from 25 to 55 per cent manganese, from 5 to 7 per cent iron, from 3 to 11 per cent silica, and less than 0.03 per cent phosphorus. One fairly complete analysis is as follows:

Analysis of manganese ore from the Siegel mine.

[Mississippi Iron Co., analyst.]

Manganese (Mn)	37.95
Iron (Fe)	6.96
Silica (SiO_2)	9.70
Alumina (Al_2O_3)	2.50
Lime (CaO)	1.50
Magnesia (MgO)	.40
Sulphur (S)	.187
Phosphorus (P)	.022
Barium (Ba)	None.
Loss on ignition	16.73

The Black Eagle deposit is explored only in the oxidized zone, where it is similar to the St. Anthony in structure and composition. Near the surface it contains a dark-brown manganese oxide that forms soft compact masses made up of concentric layers that show a fibrous or prismatic structure and a greasy luster. Its crystal habit suggests manganite, of which it is probably an alteration product. One sample reported from the Black Eagle No. 3 showed 39.6 per cent of manganese and 9 ounces of silver to the ton; another sample showed 50.54 per cent manganese and 13 per cent of insoluble matter and consisted of a soft pulverulent bluish-black oxide that is somewhat abundant in this deposit.

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In places near the deposits described, especially the Black Eagle and the Black Eagle No. 3, the limestone is stained brown with manganese and iron oxides. A tunnel a short distance north of the Black Eagle No. 3 shows 40 feet of brownish crystalline limestone whose color is due to thin films of iron and manganese oxides in seams. Fresh, nearly white specimens of the rock give distinct reactions for iron and manganese, which are presumably present as carbonates. There is also considerable magnesia. Similar material is exposed by a tunnel on the Black Eagle claim, from which a sample yielded 4.9 per cent of manganese and 1.8 per cent of iron. A mixed carbonate of calcium, manganese, and iron occurs in the St. Anthony vein at the level of the Sommer tunnel.

In the deposits described a moderate amount of richly manganiferous material is available and in prospect, and a larger amount may be expected with further development work. Some of it is apparently of the grade known as dioxide ore, which has a special value, but all the material contains silver, the recovery of which without impairing the value of the manganese oxides is an interesting metallurgic problem.

NEVADA DISTRICT.

BOWEN & HOLMQUIST AND WITCHER & VIETTI MINES.

A moderate amount of ore was produced in 1917 and the first half of 1918 from manganese deposits in the Nevada district, about 10 miles southeast of Ely. In June, 1918, Bowen & Holmquist and Witcher & Vietti were operating the Steptoe group and the Manganese claim, respectively, from which the ore was hauled to the Nevada Northern Railroad at East Ely by autotrucks.

The known deposits are confined to an area at the east edge of Steptoe Valley, half a mile long from north to south and 1,000 feet wide. The local relief is slight, and the general elevation about 7,000 feet. On the east the Schell Creek Mountains rise 2,000 to 3,000 feet above the valley.

The area, which is within a section mapped as Devonian by Spurr,[1] is underlain by rather indistinctly bedded limestone that strikes N. 25° W. and dips steeply eastward and shale that is very poorly exposed. On the west these rocks pass beneath the alluvium of Steptoe Valley.

The manganese deposits are parts of irregular jaspery quartz lodes that replace the limestone along fractures, joints, and bedding planes. They form thick podlike or pipelike masses, of which some are cut by the present surface and some end below it. At the north, on the

[1] 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.

Steptoe claim, a lode of red and yellow jaspery-looking quartz crops out here and there for a distance of 300 feet or more. It strikes N. 25° W., the same as the limestone, stands nearly vertical, and ranges from a few feet to 30 feet in width. Manganese oxides are distributed irregularly through it. At the widest part a large pit known as the glory hole exposes an ore body 12 feet wide and 35 feet long that extends from the surface downward at least 35 feet. About 1,500 feet to the southeast, along a smaller quartz lode, a body exposed by the Jane shaft is about 10 feet thick and 50 feet wide at the 25-foot level. It tapers above and below and extends from a point near the surface 50 or 60 feet downward on a 45° E. slope. At intermediate points at least two other bodies of comparable size to those described have been found. One at the whim shaft on the Steptoe claim is formed along a small discontinuous east-west lode and extends to a depth of 70 feet. The other, at the whim shaft on the Manganese claim, is very irregular in form and strikes nearly due north. From all these bodies small irregular streaks of ore lead off here and there along joints in the limestone. On the Storm claim, southwest of the Jane shaft, red jaspery quartz and manganese oxides crop out over an area 30 feet wide and 70 feet long. As far as it is penetrated by a shaft 35 feet deep this lode is broken and contains but little high-grade ore.

The bodies described are generally loose, friable, and cavernous. The principal constituents are manganese oxides, quartz, and calcite. In places there is considerable fluorite, and small amounts of iron oxides are general. Assays are said to show the presence of about 2 ounces of silver to the ton. Commonly the manganese oxides form a rather indefinite mixture, the bulk of the material being soft and noncrystalline. Part of it resembles wad and part has the properties of pyrolusite. Fine crystals of a hard steel-gray oxide, tentatively determined as braunite, are scattered through the mass, and manganite and psilomelane also occur. In the whim shaft on the Steptoe claim an 8-inch streak of ore so hard and dense as to suggest cast iron occurs at a depth of about 60 feet. It consists of psilomelane in which plumose aggregates of finely crystalline braunite are embedded.

The vein quartz is fine grained but not chalcedonic. Commonly it is brecciated, and the cracks are filled with manganese oxides. Calcite coats the walls of open spaces. In the ore body on the Manganese claim compact fluorite forms branching veinlets, the manganiferous material between them being loose and open.

In the ore so far shipped manganese ranged from 35 to 48 per cent; silica from 4 to 22 per cent; iron from 2 to 8 per cent; and phosphorus from 0.01 to 0.03 per cent. The higher-grade ore represents selected material and the lower-grade ore run of mine.

The structure of the oxidized ore suggests that it was formed by the alteration of some parent mineral in place and practically without any migration of the manganese. The cavernous texture of the ore indicates shrinkage during oxidation. The unoxidized ore was dense, as is shown by the veinlets of fluorite, which must have filled cracks before the mass became oxidized and cavernous. The parent mineral, which was probably rhodochrosite, made room for itself by replacing the limestone. It came in from below after the quartz.

A moderately large tonnage of manganiferous material is in sight, and a larger amount is probably to be discovered by further exploratory work.

ROBINSON (ELY) DISTRICT.

PRODUCTION AND GENERAL FEATURES.

In 1917 and 1918 small amounts of manganese oxide ore were produced here and there in the Robinson district. In June, 1918, Watson & Holmquist were leasing on the Keystone and James Dick and others on the Federal Ely properties. A small deposit near the head of Verzan Canyon had recently been worked, and shipments by James Willoughby and other lessees were reported from the Columbia, Badger, and other claims near Ruth and the Golden Fleece mine, east of Lane. Until the middle of June, 1918, a total production of about 700 tons was reported.

In the Robinson district, the geology of which is described in detail by Spencer,[1] Paleozoic limestones are intruded and strongly metamorphosed along an eastward-trending zone by masses of monzonite porphyry. The great copper deposits are within this zone, and precious-metal lodes, in which most of the manganese deposits occur, are found along its borders. The occurrence of manganese within the metamorphic zone, in the small deposit near the head of Verzan Canyon, is exceptional.

The bodies so far exploited are near the surface. They consist of the softer oxides, mainly pyrolusite and wad, together with more or less quartz, calcite, and a little iron. In the ore shipped manganese ranges from 40 to 45 per cent and silica from 3.5 to 14 per cent. Iron is low and there is commonly a little silver. A few thousand tons of ore was estimated as the amount probably to be expected with further development work.

FEDERAL ELY MINE.

The Federal Ely mine is on a gentle northwest slope about a mile northeast of Copper Flat. The general elevation is about 6,900 feet, and the local relief is slight. At the mine the formation is the

[1] Spencer, A. C., The geology and ore deposits of Ely, Nev.: U. S. Geol. Survey Prof. Paper 96, 1917.

Pennsylvanian Ely limestone. Westward this rock passes beneath the Arcturus limestone, also Pennsylvanian, and a short distance to the south it is traversed by the principal zone of intrusion and metamorphism of the Ely district.

The manganese deposits occur in proximity to a quartz lode whose discontinuous outcrops can be traced 1,000 feet or more in a N. 50° E. direction. The workings consist of several shallow pits on the Selma No. 2 claim, the largest of which covers (June, 1918) about half an acre. The ore forms tabular or flat lenslike bodies from a few inches to 3 feet thick that lie on the gently sloping rock surface beneath the soil. Eastward, however, the ore becomes fragmental and mixed with the soil. On the west it gradually sinks deeper and passes into the limestone on a bedding plane that dips 20° NW.

The ore consists chiefly of the softer manganese oxides, which are intimately mixed together and therefore difficult to determine. Pyrolusite and wad are doubtless the principal minerals. Secondary calcite has filled open spaces in the ore and thus cemented it rather firmly. Jaspery vein quartz is abundant, but it generally forms bodies separate from the manganese. At one place a little galena and cerusite are associated with the manganese.

The ore as selected for shipment carries 40 to 42 per cent of manganese and 4 to 8 per cent of silica. The percentage of iron and other constituents was not reported. Evidently there is considerable lime and locally some iron. Material rejected in sorting the ore for shipment is said to run about 25 per cent of manganese and 6 per cent or more of silica.

There is considerable unexplored ground in which ore like that in the pits may be expected, and although the streaks are mostly too small to be followed profitably under cover, some development work in the expectation of finding larger shoots or chambers in the limestone is warranted.

KEYSTONE MINE.

The Keystone mine comprises workings scattered over 3 or 4 acres southeast of Keystone Hill. Under the head of bed deposits carrying precious metals, Spencer[1] refers to the Keystone as follows:

> On the west side of the upper end of Robinson Canyon, southeast of Keystone Hill, there are mine workings from which oxidized manganiferous silver-lead ores were taken many years ago. The Ely limestone is here made up of massive beds, and the ore bodies occur locally along well-defined partings between these beds.

The ore bodies are of flattened podlike or pipelike forms and are as much as 10 feet thick and from 40 to 100 feet long. Little ore is to be seen in these old workings, but there are several piles of manga-

[1] Spencer, A. C., op. cit., p. 128.

niferous material on the dumps. At the north outcrops of jaspery quartz with manganese oxides are abundantly distributed through an acre or more. These bodies vary in composition from place to place, but portions of them rich enough to be workable form irregular streaks and bunches from a few inches to 3 feet thick.

The ore is chiefly a rather soft, cavernous mixture of manganese oxides, probably pyrolusite for the most part. In places in the old workings there is a compact material determined as wad. Cavities in the ore contain more or less secondary calcite and a little iron oxide. Ore sorted for shipment is reported to contain 40 to 42 per cent of manganese and 12 per cent or less of silica. Assays show the silver content to be as much as 15 ounces to the ton.

DEPOSIT NEAR VERZAN CANYON.

A small shipment of manganese ore was made prior to June, 1918, from a deposit on the slope north of Verzan Canyon, about 2 miles west of Lane. This deposit is in an area of monzonite porphyry near the middle of the principal zone of intrusion and metamorphism of the district. It occupies a small shallow basin at the surface of the porphyry, beneath a few feet of soil and talus. The material composing it, which is classified as wad, is structureless, soft, dark brown, noncrystalline, rather compact and tough, and of low specific gravity. In places around the margins of the deposit there has been some replacement of porphyry by manganese oxides. At the upper end of the deposit a small vein filled with psilomelane and calcite cuts the porphyry. Near by the rock outcrops show a little manganese oxide in seams.

WILLOUGHBY LEASE.

During the first half of 1918 James Willoughby shipped 60 tons of high-grade ore from a claim of the Nevada Consolidated Copper Co., 2 miles southwest of Lane, a station on the Nevada Northern Railroad. The claim covers outcrops of manganese ore at an altitude of 7,050 feet above sea level, or about 500 feet above the railroad.

The country rock is massive, flat-bedded Ely limestone of Pennsylvanian age that has been invaded by dikes and large masses of quartz monzonite and related intrusive rocks.

The manganese ores occur in the oxidized zone of lead-copper veins and form irregular bunches and lenses in the limestone adjacent to the veins. The largest ore body thus far explored is 25 feet long, 2½ feet thick, and 10 feet wide. Several other bodies are almost as large. Ore is mined from shallow open cuts, and the depth to which the oxides extend is not known. The ore is a soft brownish-black material of low specific gravity, composed chiefly of wad with some psilomelane. These oxides have replaced the limestone and to a less extent have filled open spaces. Quartz and opal accompany the manganese minerals.

JACK RABBIT DISTRICT.

BLACK METALS MINE.

The Black Metals mine is in the Jack Rabbit district, 14 miles north of Pioche, and within a quarter of a mile of the narrow-gage railway at the Jack Rabbit mine.

The deposit is formed along a N. 65° E. fault in a massive brown crystalline limestone of Cambrian age. It consists of irregular lens-like bodies, the largest of which is from 15 to 20 feet in diameter and from 10 to 15 feet thick in the middle. The bodies are composed of manganese oxides, chiefly wad, psilomelane, and pyrolusite, with more or less calcite, quartz, and limonite. About half of the material as mined can be sorted to a product running 40 to 50 per cent of manganese and less than 5 per cent of silica. A few hundred tons has been produced, and a smaller amount is in reserve.

SPRUCE MOUNTAIN DISTRICT.

BULLSHEAD MINE.

A deposit containing manganiferous silver ore, the property of the Bullshead Mining Co., is in the Spruce Mountain district, about 16 miles southwest of Jasper siding on the Western Pacific Railroad. The elevation is about 8,000 feet, and the local relief is as much as 6,000 or 7,000 feet. There is a good road with a down grade amounting to about 2,000 feet from the mine to the railroad. The deposit is a vein formed by replacement along a fracture that cuts Carboniferous limestone. Its upper part consists of oxidized material carrying more or less silver and about 20 per cent of manganese. From this material ore containing from 30 to 35 per cent of manganese and about 10 to 15 per cent of silica can be sorted, but it also carries 7 ounces or more of silver to the ton.

The oxidized material extends to an average depth of 40 or 50 feet, forming a tabular body about 18 inches thick. It consists chiefly of pyrolusite, psilomelane, limonite, and quartz. Details concerning the unoxidized part of the vein, including the parent mineral of the manganese oxides, are lacking.

No shipments of manganese or manganiferous ores from this deposit for use in the manufacture of steel are reported. Though a moderate amount of ore suitable for that purpose could be produced, it would doubtless be more profitable to treat all the material as manganiferous silver ore.

O'NEILL MINE.

The mine of R. C. O'Neill, about 16 miles southwest of Jasper siding on the Western Pacific Railroad, yields a manganiferous silver ore similar to that of the Bullshead mine, described above. A few carloads of ore running about 33 per cent of manganese and containing more or less silver could be sorted from the oxidized manganiferous material in reserve.

LAS VEGAS DISTRICT.

LOCATION.

The Las Vegas manganese district embraces a small area in Clark County, Nev., on the south side of Las Vegas Wash, about 16 miles southeast of Las Vegas. The district is also about 8 miles west of a point in the great bend of Colorado River, where it turns and flows south.

HISTORY OF MINING.

The development of manganese deposits in the Las Vegas district was the result of the widespread publicity given during the European war to the necessity for the development of a supply of manganese ore in the United States and the high prices offered for the ores, which made the exploitation of domestic deposits, though remote from the consuming centers, profitable. One of the most valuable deposits of the district is the Three Kids, which was located in the fall of 1917 by Edwards, Marrs & Jefferson, of Las Vegas. An option on this property was obtained by Gillice, Connor & McCoy, who formed the Manganese Association. The company began production from the Three Kids deposit in November, 1917, and by April, 1918, it had shipped 130 carloads of ore. In April the Three Kids mine and the Las Vegas group, which adjoins it, were purchased by Thomas Thorkildsen, of Los Angeles. The name of the original organization was retained. Under the new ownership the rate of production from the Three Kids deposit was greatly increased, but in July, 1918, during intensely hot weather, the output was curtailed because of the scarcity of labor. Adjoining the property of the Manganese Association is a group of claims owned by the Lowney Manganese Association, and about 1 mile east of the Three Kids deposit are other manganese claims. These comprise the principal holdings, but to July 1, 1918, the Three Kids deposit was the only productive source of manganese ore in the district.

ACCESSIBILITY AND TRANSPORTATION COSTS.

The Three Kids deposit is accessible from Las Vegas, on the Los Angeles & Salt Lake Railroad, by a wagon road 16 miles long, which traverses for most of the way the broad valley of Las Vegas Wash. The valley soil is a light-colored silt in which the traffic wears deep ruts and in dry weather grinds to a thick deposit of fine dust. The maintenance and sprinkling of this road involve considerable expense, which is borne by the company. The ore is hauled to Las Vegas by a fleet of motor trucks and a caterpillar tractor, at a cost reported to be $5.25 a long ton. The ore is shipped to furnaces east of Mississippi River and is used in making ferromanganese. Water and supplies are hauled to the mine.

MINING METHODS.

The mining of the Three Kids ore body is simple. An overburden from 2 to 12 feet thick which directly overlies the deposit is broken up and removed by horse-drawn scrapers; the ore is then mined by the open-pit method. The deposit is drilled from the top, and with each round of blasts a great quantity of ore is broken down. The fragments of ore are generally of large size. Large pieces may be handled with little difficulty because of the low specific gravity of the ore, but where necessary the fragments may be reduced by chopping with axes and streaks of sand that adhere to some of the ore may be scraped off.

The ore was hauled out of the pit on an inclined track in cars attached to a cable operated by a gasoline engine and was dumped into ore bins about 150 feet west of the pit. As the ore body was worked out to the east against the slope of the hill it became thinner, and the base of the ore became relatively higher, and at the time of visit a trestle was being built to the working face from which the ore can be trammed directly to the bins without power.

PRODUCTION.

To July 1, 1918, this deposit produced about 12,000 tons of ore that contained approximately 40 per cent of manganese, 1.5 per cent of iron, and 12 per cent of silica. At that time the production was at the rate of 60 tons a day with a force of 47 men. As shown by the shafts and drill cores several thousand tons of ore remained in the deposit.

GEOGRAPHY.

The manganese deposits occur in some low hills that border Colorado River and might be regarded as outliers of the Eldorado Range, south of Las Vegas Wash, or of the Muddy Range, north of Las Vegas Wash. The manganese deposits are in the bottoms of washes, on mesas and hill slopes at elevations of about 2,000 feet above sea level, from a few feet to 500 feet below the summits of the hills. Numerous washes or gulches drain northward to Las Vegas Wash, but near the manganese deposits none of them contain water. Las Vegas Wash carries an underground flow, and there are several wells along its course, which is traversed by the road to Las Vegas. The Three Kids mine lies on the east side of the mouth of an arroyo that enters the alluvial plain sloping to Las Vegas Wash.

The climate is extremely arid, and the average annual rainfall is probably less than 5 inches. There are no trees near the deposits, but a scattering growth of greasewood and several other smaller shrubs is found on the mesa and extends part way up the hill slopes.

GEOLOGY.

Volcanic flows and tuffs compose the hills adjacent to the manganese deposits, and tuffs, sand, clay, gypsum, and gravel beds flank the hills and underlie the mesa or plain extending to Las Vegas Wash. Rhyolite and andesite tuffs and breccias are the most abundant volcanic rocks, and associated with them are a few basaltic flows and dikes. The rhyolites are both light and dark colored. Most of them have a dense glassy groundmass, but some are scoriaceous and flow banded. Biotite is the most conspicuous mineral of the rhyolite, where it forms well-developed crystals in the groundmass. The tuff beds are white, gray, green, and pink, and they vary in texture from fragments an inch or more in diameter to rather fine sand. On the hillside above the Three Kids deposit tuff beds which are exposed by prospect holes are composed of fragments of gray rhyolite and andesite set in a matrix or groundmass of pink calcite which has been partly replaced by manganese oxides. In the open pit of the Three Kids mine a fine-grained pink sand is underlain by a green sand in which there are large fragments of rhyolite. On the Las Vegas group the manganese deposits are contained in pink sands derived from the erosion of volcanic material. North of the Las Vegas group of deposits gypsiferous clays predominate, with some beds of volcanic ash and tuff and beds of pure gypsum as much as 50 feet thick. The sedimentary series strikes N. 30°–45° E. and dips 15°–45° NW. East of the Three Kids group, across a ridge of volcanic rocks, some low hills are composed of pink, gray, and yellow sand and clay beds overlain by bedded and slightly indurated gravel and wash deposits. These beds have a low dip to the northwest.

The volcanic rocks are regarded as being of Tertiary age, and the sedimentary rocks, which were derived largely from their disintegration, are believed to have been deposited in a lake of probable Miocene age.

The sedimentary and igneous rocks have been folded and faulted. The lacustrine deposits show an observed distortion up to 45°, and they have also been cut by small faults and fissures. Extensive faulting is believed to have occurred in the volcanic rocks, but faults are difficult to trace because of the mantle of débris. This faulting is indicated by the tilting, distortion, and irregular distribution of easily recognized beds of white tuff in the darker flows. Small faults and fissures are shown, however, in pits and open cuts in the manganese deposits. They range in strike from northeast to northwest, and some strike nearly north. All have steep dips. In most of these faults the displacement is small. The fault which limits the Three Kids ore body on the west may have a considerable displacement, but no measurement of it could be obtained. The faulting occurred both before and after the deposition of manganese oxides. That faulting occurred before the deposition of the oxides is shown in several places where tuff and clay beds are replaced by manganese oxides adjacent to the fissures, the relations being such that there is little doubt that the manganese solutions were introduced along the fissure and replaced the beds adjacent to it. Faulting that took place after the deposition of the ore is shown in the Three Kids ore body, where the deposit is limited on the west by a well-defined fault and other faults in it displace the ore a few feet. On the hillside above the Three Kids deposit a breccia consisting of angular fragments of ore, andesite, and rhyolite is embedded in a gray calcareous material that is believed to be travertine. This rock weathers irregularly; the calcareous matrix dissolves and the fragments of volcanic rocks and ore stand out as knobs incrusted with a secondary white calcareous substance. The faults that cut clay and sand beds generally contain clay gouge, and the fault planes are slickensided and striated.

ORE DEPOSITS.

The manganese deposits of the Las Vegas district have been formed by the replacement of tuffs and of sand and clay beds derived from the disintegration of volcanic rocks. Most of the deposits are clearly associated with faults or fissures, but a few low-grade deposits in the bedding planes of sand and clay have no apparent connection with faults. The replacement of the sand, clay, and tuff by manganese oxides is extremely diverse. It is most complete in the Three Kids deposit, where a bed of fine-grained sand or clay is largely replaced, though microscopic examination of the ore shows unreplaced grains and a chemical analysis indicates many impurities. In some of the beds of tuff-breccia on the hillside above the Three Kids deposit manganese oxides have partly replaced the pink calcareous matrix, but they have not attacked the fragments of rhyolite. On the Las Vegas group clay and sand beds are replaced by manganese oxides for several feet on each side of fissures that cut them. The ore becomes lower in grade as the distance from the fissure increases.

The Three Kids deposit is the only one of any considerable size thus far discovered in the Las Vegas district. Its size has not been fully determined, but ore has been removed from a fan-shaped body that in its greatest dimensions is about 250 feet long, 200 feet wide, and from 2 to 25 feet thick. Other deposits in the district are of lower grade than the Three Kids, and most of them are in vertical tabular bodies a few feet wide and generally not more than 60 feet long.

The typical ore of the district is a dark-brown fine-grained porous material that is of notably low specific gravity. The ore is rather tough or leathery. It contains 10 per cent or more of water. A block of ore sawed into a 1-foot square from the Three Kids deposit when removed from the deposit weighed 81 pounds but after exposure to the air for a few months weighed 73 pounds. Most of the ore in the Three Kids deposit is homogeneous, but around the borders of the deposit the ore is more or less interlaminated or mixed with sandy layers, and the deposit itself contains streaks of unreplaced sand or clayey material to a maximum thickness of 1 foot. The manganese oxides are chiefly a brownish-black amorphous substance believed to be wad, with here and there streaks and grains of pyrolusite. Psilomelane and other hard manganese oxides were observed only in one deposit of the Las Vegas district.

The following analysis of ore from the Three Kids deposit shows the presence of numerous impurities, many of which are probably in unreplaced material of the sand or tuff bed. Some of the material, however, such as lead and copper oxides, was probably introduced by the solutions that deposited the manganese oxides. Iron oxides form only a small percentage of the ore and can rarely be detected.

Analysis of manganese ore from Three Kids deposit.

[Smith, Emery & Co., Los Angeles, Calif., analysts.]

Manganese dioxide (MnO_2)	56.04
Manganese oxide (MnO)	7.08
Silica (SiO_2)	13.73
Alumina (Al_2O_3)	1.85
Iron oxide (Fe_2O_3)	1.68
Lead oxide (PbO)	2.07
Barium oxide (BaO)	.02
Lime (CaO)	Trace.
Magnesia (MgO)	1.41
Copper oxide (CuO)	.49
Zinc oxide (ZnO)	None.
Phosphoric anhydride (P_2O_5)	.07
Sulphuric anhydride (SO_3)	.43
Arsenic oxide (As_2O_3)	.06
Soda (Na_2O) and potash (K_2O)	3.82
Moisture (combined water and carbon dioxide), by difference	11.25
	100.00
Total manganese (Mn)	40.91
Total available oxygen (O)	10.31

Aside from the impurities in the ore itself, gypsum and calcite occur in veinlets that cut the deposits, and many deposits are directly overlain by an efflorescence of gypsum mixed somewhat with manganese oxides and clay. Gypsum occurs in the Three Kids ore body in numerous seams and veinlets as much as 4 inches thick. The gypsum is in coarsely fibrous crystals deposited at right angles to the walls of the fissures. Gypsum in veins and efflorescences is also abundant on the Lowney Manganese Association claims and on the Las Vegas group.

Calcite is much less abundant than gypsum, but it was noted in small veinlets cutting low-grade manganese deposits above the Three Kids deposit, and fine-grained pink and gray calcite is also a prominent constituent of rhyolite tuff-breccias that have been partly replaced by manganese oxides.

MINES AND PROSPECTS.

THREE KIDS GROUP.

The Three Kids group comprises three claims that lie across an arroyo where it emerges from some low volcanic hills. The only productive deposit thus far developed is on the Three Kids claim,

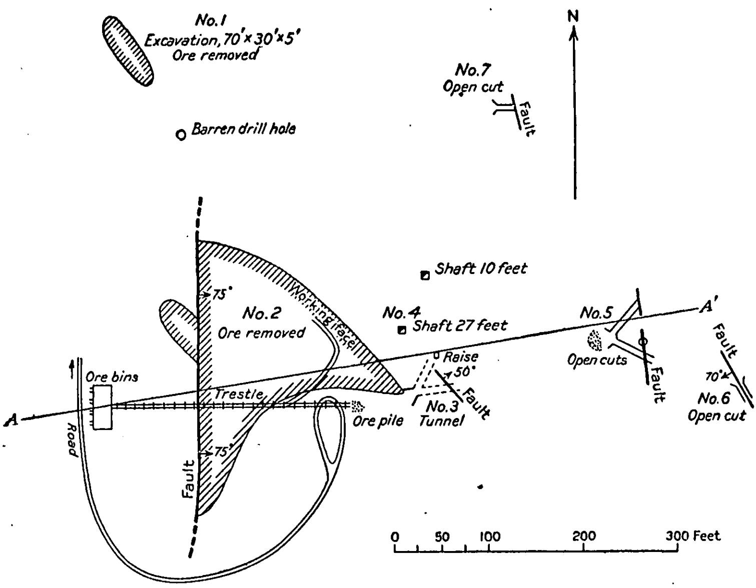

FIGURE 38.—Plan of workings of the Three Kids group, Las Vegas district, Nev.

which lies on the east side of the mouth of the arroyo. The plan of the principal workings on this claim is shown in figure 38, and a cross section of the deposits and associated rocks is shown in figure 39. No. 1 of figure 38 is a pit about 70 feet long, 30 feet wide, and 5 feet deep. Here the ore has been mostly removed from the deposit.

At the borders of the pit some pink sandy material about 3 feet thick is partly replaced by manganese oxides and is overlain by porous gypsum and manganese oxides, and this in turn by several feet of angular débris. Between No. 1 and No. 2 rhyolite crops out. Near the outcrop a diamond-drill hole was sunk for a considerable distance below the alluvium, but it is said that no commercial body of manganese ore was found.

The deposit in which open pit No. 2 has been dug has supplied most of the manganese ore shipped from the district. On July 1, 1918, the excavation made by the removal of ore was roughly fan-shaped, with the handle at the south end. The ore body is limited for the most part on its west side by a well-defined fault that strikes about north and dips 75° E. Along this fault the ore body extends for about 275 feet. On the southeast side the deposit gradually thins

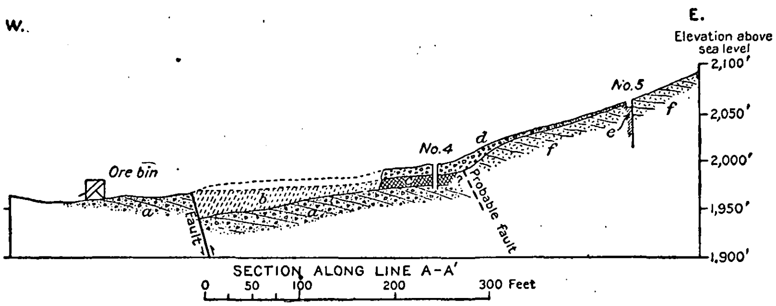

FIGURE 39.—Cross section on the Three Kids group, Las Vegas district, Nev., approximately along line A-A′, figure 38. *a*, Sand and tuff beds; *b*, original position of ore and overburden; *c*, ore; *d*, angular débris; *e*, breccia of volcanic rocks cemented with travertine and partly replaced by manganese oxides; *f*, undifferentiated volcanic rocks.

out, and this part of the pit is marked by an irregular curved line about 300 feet long. The northeast side of the excavation was the working face at the time of the writer's visit, and there a body of ore 12 feet thick was exposed for 60 feet. The greatest thickness of ore in the deposit was near the fault in the western part of the pit, north of its center. Here the ore was in places 25 feet thick, but to the east the deposit became thinner and to the southeast it gradually became too thin and of too low grade to work. The eastern limits of the ore body have not been definitely ascertained, but the writer believes that a fault probably marks the limits of the ore body on the east.

Opening No. 3 is a tunnel at the southeast end of the working face. It consists of two forks, each 40 feet long, making an acute angle with each other. The right-hand fork is apparently driven near the limits of commercial ore, for the manganese oxides are mixed with pink tuff and in places layers of pink tuff 8 inches thick occur in the ore. A fault that strikes N. 45° W. and dips 50° NE. cuts the ore and displaces it downward a few feet on the east or hanging-wall side. In the left-hand fork the ore is 10 feet thick. At the face of the drift a raise to the surface is driven through 11 feet of débris which directly overlies the ore.

Opening No. 4 is a shaft 26 feet deep sunk through 9 feet of débris, disclosing 16 feet of ore. Gypsum veins 4 inches thick occur in the ore. North and east of No. 4 the limits of the ore body are not definitely known. About 75 feet north of No. 4 a shaft 10 feet deep had not penetrated the alluvium. The alluvium and underlying rocks were drilled in several places with a core drill, but data with regard to the location of the holes and thickness of the deposit were not available.

No. 5 consists of two open cuts on the hillside about 80 feet above No. 3. One cut trends S. 70° E. for 50 feet, and the other N. 55° E. for 40 feet. In the southern cut near the face a pink tuff-breccia about 10 feet thick is partly replaced by manganese oxides. The deposit is cut by vertical northward-trending slips or small faults, against some of which replacement by manganese oxides ends abruptly. Seams of gypsum 1 inch thick cut the mineralized tuff, and a mass of porous gypsiferous earth 2 feet thick directly overlies this deposit. The tuff-breccia is composed of angular fragments of rhyolite and andesite of various sizes, cemented together by a pink carbonate, which proved on test to be fine-grained calcite that was probably deposited as travertine. A thin section of the tuff-breccia, examined under the microscope, shows that the matrix is composed mainly of fine-grained calcite, but it incloses small fragments of fresh volcanic material, and even crystals of fresh plagioclase feldspars and flakes of biotite are abundant in it. The calcite of the breccias is first replaced by manganese oxides in filaments and tree-like forms which branch out from cleavage cracks. Very little of the volcanic material is replaced by manganese oxides, and the replacement of calcite is so incomplete that the deposit is without value. The northern open cut is mostly in wash material, but 10 feet back from the face the top of a tuff bed is exposed, which is partly replaced by manganese oxides.

Open cut No. 6 is about 30 feet higher than No. 5. It is driven for 20 feet along a slip or fault, which strikes N. 30° W. and dips 70° SW. A hole 10 feet deep is at the entrance of the cut. On the hanging-wall side of the slip is a breccia 4 feet wide composed of fragments of rhyolite, andesite, and ore in a matrix of gray carbonate. The fragments of ore are fine grained and brownish black. The dominant oxide is wad, and the ore is very similar to that in the main Three Kids deposit. The fragments are both rounded and angular, and they range in size from those smaller than a pinhead to some an inch or more in diameter. The gray carbonate matrix is fine grained, and it cements very firmly the fragments of rhyolite and ore. Under the microscope the matrix is seen to be composed dominantly of fine-grained calcite, but it also contains small fragments of the volcanic rocks and fresh crystals of feldspars and biotite. At the surface, however, where this rock is weathered, the carbonate matrix has been dissolved, leaving projecting knobs of rhyolite and ore fragments coated with a deposit of secondary lime. This occurrence shows clearly that a deposit of ore and tuff was thoroughly shattered by faulting, and the fragments were cemented together by travertine. The deposition of travertine was subsequent to the brecciation of the manganese deposit, whereas in the deposit exposed in No. 5 manganese oxides replaced the travertine matrix of the volcanic breccia.

Open cut No. 7 is on the hillside about 30 feet above the Three Kids ore body. The cut is driven eastward for 20 feet to a northerly fault. Next to the fault is several feet of breccia composed of coarse fragments of rhyolite and fine-grained manganese ore. The breccia is traversed by veinlets of calcite crystals. Some of the tuff fragments are partly altered to epidote. The material is of too low grade to be valuable.

CLAIMS OF LOWNEY MANGANESE ASSOCIATION.

Several claims that make up the Lowney Manganese Association adjoin the Three Kids group on the west and northwest. They were located October 29, 1917. No ore had been shipped from these claims to the time of visit, and the development work on them consisted of a shaft about 50 feet deep, a short tunnel, and several open cuts.

On the Annex claim, which lies on the bench land, two open cuts have been sunk through surface débris and uncovered a deposit of manganese oxides about 18 inches thick that is apparently formed by the replacement of rhyolite or tuff. Gypsum occurs with the ore. The ore is judged to contain about 25 per cent of manganese and is very siliceous. It also contains calcite, for fragments of weathered pieces are coated with a deposit of gray lime carbonate. The manganese oxides are psilomelane and pyrolusite.

On another claim a shaft has been sunk on a vein near the base of the easterly slope of a hill which rises about 300 feet above it. The vein strikes N. 20° W. and dips 50° E. A tunnel 40 feet south of the shaft, 20 feet long, is driven toward the shaft on the vein. The deposit, which is on the hanging wall of the fault, is from 1 to 6 feet wide and replaces reddish clayey material which may be tuff. On the footwall of the deposit near the portal of the tunnel there is a mass of biotite-rhyolite vitrophyre. The length of the ore shoot as disclosed by the development is about 60 feet. The ore is soft brownish-black material of low specific gravity similar to that in the Three Kids, but somewhat lower in grade. Gypsum occurs with the manganese oxides, as small seams in the ore, and as an efflorescence at the surface. About 60 tons of material lay on the dump at the time of visit. The manganese oxides are chiefly wad.

LAS VEGAS GROUP.

The Las Vegas group of seven claims is owned by the Manganese Association. The claims extend westward about a mile from the northern boundaries of the Three Kids and Lowney groups and lie at the base of the northerly slopes of some low hills. From them a gently sloping mesa extends northward to Las Vegas Wash. The claims were located September 22, 1917, by Jefferson, Edwards & Marrs. No ore has been produced from this group. The development work consists of several shallow shafts, tunnels, and open cuts, and a few drill holes. One drill hole is said to be 77 feet deep. The hills at the south side of the manganese claims are composed of rhyolite flows and tuffs. Tuffs, clay, and sand beds with interbedded gypsum underlie the mesa north of these hills.

The manganese deposits were formed by the replacement in varying degrees of clay or tuff beds, and most of them are clearly associated with fault fissures.

Near the site of the manganese camp is working No. 1, which consists of a shaft 25 feet deep, an open cut 25 feet long, 15 feet wide, and 10 feet deep, and a tunnel 25 feet long on a deposit near the intersection of two vertical fissures. One fissure strikes N. 40° W. and the other N. 30° E. The ore replaces pink sandy clay or tuff in varying degrees. In some places the rock is barely stained with the oxides; in others the replacement is fairly complete and the ore approaches the grade of that in the Three Kids deposit.

The tunnel and open cut are driven on the fault that strikes N. 30° E., and the shaft is sunk near them on the intersection of the two fissures. Near the portal of the tunnel the manganese oxides extend about 25 feet east of the fault plane and 10 feet west of it. The material is not of commercial grade, however, because patches of clay and sand are mixed with the manganese oxides, and the separation of ore and impurities is impracticable. The manner in which clay and sand are mixed with the oxides suggests that shearing has taken place since the deposition of the oxides. The manganese oxides extend to the bottom of the shaft, but very little of the material is of commercial grade. Gypsum occurs abundantly in the manganese oxides in seams and as an efflorescence above the deposit. The ore is a soft brownish-black amorphous oxide that is probably wad.

About 400 feet N. 50° E. from working No. 1 is the discovery deposit of the Las Vegas West Extension No. 1 claim. At this point a shallow open cut shows a deposit of manganese oxides about 10 inches thick interbedded in variegated pink, green, and yellow clay and tuff beds. The beds strike N. 30° E. and dip 30° NW. A little black siliceous material, probably a rhyolite segregation containing manganese oxides, occurs on the surface near by. The bedded deposit consists of low-grade, soft manganese oxides.

About 200 feet N. 30° W. from working No. 1 a tunnel 30 feet long with an entrance open cut of 20 feet is driven S. 40° E. along a fissure which is probably the same as that of No. 1. At the portal of the tunnel the pinkish clay and tuff bed is replaced by soft manganese oxides for 10 feet about equidistant on each side of the fissure, but at the face of the tunnel the ore is only 5 feet wide. Wad is the dominant manganese oxide. Veinlets of gypsum are common in the ore, and at the portal of the tunnel above the ore is a mass of porous gypsite. Assays of the ore are said to have shown 32 per cent of manganese, and in appearance the ore is very similar to that in the Three Kids deposit.

The discovery deposit of the Las Vegas claim is at the east end of the Las Vegas group. Three shallow holes within 40 feet of one another sunk into reddish sandy clay and tuff beds show them to be impregnated and partly replaced by manganese oxides, forming a low-grade deposit that contains probably not more than 15 per cent of manganese. The deposit crops out over an area 70 feet long and 30 feet wide. Gypsum is abundant in the deposit.

YOUNT CLAIMS.

A group of claims located by S. E. Yount and associates in December, 1917, lies about a mile east of the Three Kids group. The development work consists of a tunnel 40 feet long and a number of shallow shafts. No ore had been produced to July 1, 1918, and at that time no work was being done on the property.

The claims lie in a gulch draining to Las Vegas Wash at an altitude of 2,000 feet above sea level. Low hills rise about 100 feet above the gulch bottom. The hills are composed of pink, gray, and yellow sand, clay, and tuff, overlain by slightly indurated gravel and wash. The beds strike N. 30° E. and dip 15° NW. The principal deposit occurs apparently in a fault zone that cuts reddish clays. A number of shallow holes have been sunk along this zone for a distance of 150 feet. The ore is a partial replacement of reddish clay by soft manganese oxides, classed as wad. Most of the material exposed by the open cuts is of too low grade to be of value, but at one place there is a body of ore 15 feet long and 4 feet wide that is judged to contain 30 per cent of manganese.

GOLDFIELD DISTRICT.

GAILLAC PROSPECT.

The claim of I. N. Gaillac, 7 miles south of Goldfield, contains an undeveloped manganese deposit that is easily accessible by a good wagon road.

The deposit consists of a fault gouge between limestone and Tertiary rhyolite in which manganese oxides, chiefly psilomelane and pyrolusite, occur as nodules as large as 8 inches in diameter. The largest exposed mass of manganese-bearing material is 40 feet long and 6 feet wide and probably extends to a depth of 20 feet or more. Considerable ore containing 40 per cent of manganese, 5 per cent of iron, and less than 5 per cent of silica could be selected from it.

DUNNIGAN PROSPECT.

The claim of E. O. Dunnigan, 5 miles south of Goldfield, contains a small amount of manganese oxide ore in reserve. No shipments from this claim are reported. The deposit consists of veins in rhyolite that range from an inch to a foot or two in width and extend to a depth of 10 feet or less. The vein minerals are psilomelane, pyrolusite, and quartz.

RAND DISTRICT.

BALLBEARING CLAIM.

The Ballbearing claim of J. Y. Anderson is an undeveloped manganese prospect 8 miles east of Rand. The deposit is made up of lenses and gash veins in rhyolite that contain pyrolusite, psilomelane, quartz, and chalcedony. The largest body is about 15 feet long, 10 feet deep, and 10 feet thick. Other bodies range from the dimensions given to those of a mere seam or veinlet. A small ore pile on the dump of a 20-foot shaft contains approximately 41 per cent of manganese, 8 per cent of iron, and 10 per cent of silica. A good downgrade road extends from the claim to the Southern Pacific Railroad at Rand.

From the material in reserve a few carloads of similar ore could be selected.

HOLY CROSS DISTRICT.

BULLION MINE.

The Bullion group of three claims, owned by R. Z. Hodges, is 12 miles northeast of Schurz, on the Southern Pacific Railroad, from which it can be reached over a good wagon road.

A few tons of manganese ore was shipped in 1918 from shallow surface workings on these claims.

The deposit is 1,000 feet above Walker River at Schurz and 5,100 feet above sea level. The summits of the adjacent mountains rise about 500 feet higher. The region is very arid, the average rainfall being about 5 inches a year.

Stringers and small masses of manganese oxides crop out more or less abundantly for 3,000 feet along the course of a shear zone 50 feet wide that cuts rhyolite and rhyolite tuff of Tertiary age. They consist mainly of psilomelane and pyrolusite that have replaced sheared rhyolite. The greatest depth attained in the workings is 6 feet. The depth to which the oxides extend is not known, but it is probably as much as 25 feet. Although manganese oxides extend along the zone for 3,000 feet, only parts of it may be workable. The largest body of this description, which is 300 feet long and from 5 to 8 feet wide, was estimated to contain 10 per cent of manganese and more than 20 per cent of silica. The associated minerals are quartz and a small quantity of iron oxides, and the zone as a whole was estimated to contain from 50,000 to 100,000 tons of material that will run from 5 to 15 per cent of manganese. The manganiferous material is amenable to concentration, and a high-grade product can be made, but the lack of water precludes treating the material at the deposit by hydraulic gravity processes.

The manganese deposit is associated with manganiferous silver veins, but the parent mineral from which the manganese oxides were derived is not shown.

HOT CREEK DISTRICT.

SURPRISE PROSPECT.

The Surprise claim of T. L. Wiswall and others is about 2 miles north of Tybo and 70 miles northeast of Tonopah, the nearest railway point.

The deposit consists of narrow veins along faults in travertine of Pleistocene or Recent age. The veins are composed of psilomelane and pyrolusite, with more or less calcite, quartz, and limonite. They were formed mainly by an incomplete replacement of the travertine. So far as disclosed by an open pit 5 feet deep the veins are from 1 to 2 feet wide and not very persistent. The material that fills them is estimated to average about 20 per cent of manganese and to be low in silica. Probably 10 per cent of it could be selected to run 40 per cent or more of manganese.

No shipments from this claim are reported.

SODAVILLE DISTRICT.

BLACK JACK PROSPECT.

The Black Jack prospect of C. W. Ward, a small manganese deposit 1 mile southwest of Sodaville, is of special interest because it contains a small amount of tungsten. It was visited in August, 1917, by E. S. Larsen and again in July, 1918, by J. C. Jones. In addition to tungsten the ore is said to assay a small percentage of tin. Samples obtained by Mr. Larsen, however, though giving a strong reaction for tungsten, did not show any tin.

W. S. Palmer[1] reports 2.4 per cent of tungsten in a sample from this deposit that contained in addition 28.25 per cent of manganese, 3.25 per cent of iron, and 4.4 per cent of insoluble residue.

The country rock is quartzite of the Triassic Star Peak formation. In a zone 50 feet wide and 1,000 feet long streaks and veins of manganese oxides and chalcedony replace the quartzite here and there. As shown by a shaft they extend to a depth of at least 20 feet. The largest mineralized mass is a tabular body about 20 feet long and 18 inches thick. It consists of psilomelane, pyrolusite, chalcedony, and gypsum and is estimated to contain from 20 to 25 per cent of manganese and 15 to 40 per cent of silica. Material may be selected in mining to carry 35 to 40 per cent of manganese and 10 to 15 per cent of silica.

No shipments from this prospect are reported.

GOLCONDA REGION.

MAJOR MINE.

A claim owned by Tom Major is situated near the base of the eastern slope of the Sonoma Range, 12 miles south of Golconda, from which it is reached by a good wagon road. It contains a manganese deposit developed by a 40-foot shaft, but no ore had been shipped from it at the time of visit (June 20, 1918). The altitude at the shaft is 5,500 feet, and the maximum local relief is about 2,000 feet. The climate is arid, the average annual rainfall being about 8 inches.

The country rock consists of shale and dolomitic limestone of the Triassic Star Peak formation, which strike N. 55° W. and dip 45° SW. The manganiferous body occupies a circular area 100 feet in diameter between the shale and the limestone. It consists of a mixture of limonite and manganese oxides, chiefly psilomelane and pyrolusite, together with quartz, calcite, and a little galena and rhodonite. The oxides are known to persist to a depth of at least 40 feet. The depth to water level is not known. The deposit is derived from the weathering of manganiferous lead-silver veins in which the parent manganese mineral was probably rhodonite.

IRON MASK GROUP AND ADJOINING CLAIMS.

Some small deposits of manganese oxides about 3 miles east of Golconda that have received more or less notice because of their late geologic age and the fact that they contain tungsten were visited by

[1] Tungsten in manganese ore: Eng. and Min. Jour., vol. 105, p. 780, 1918.

E. S. Larsen in August, 1917, and by J. T. Pardee early in June, 1918. The known deposits are within the Iron Mask group of claims, belonging to the Noble Electric Steel Co.; the Surprise claim, of Louis Navarine; and the claims of Lee Swartz and Sam Casper.

Manganiferous deposits in an area at present covered by the Iron Mask claims were discovered in 1885 and explored a little in the expectation of finding gold or silver. A few years later they were visited by Penrose,[1] who wrote a description including an analysis of the ore that shows among other things the presence of 2.20 per cent of tungsten. Still later they were examined and described by Harder.[2] In 1916 the known area of the deposits was extended southward as the result of a search by J. D. Leonard and others for tungsten and manganese ores. Late in 1917 manganese oxide ore was mined on the Iron Mask claims by the Noble Electric Steel Co., and in the spring of 1918 Louis Navarine made a shipment from the Surprise claim. The total production does not exceed 100 tons. No recovery of tungsten is reported. In July, 1918, the workings were idle.

The area surrounding the deposits is underlain by shale of Triassic age and calcareous tufa deposited by the Quaternary Lake Lahontan. The shale strikes northeastward and is steeply tilted and indurated or rendered somewhat like a hornfels by metamorphism. The tufa extends southward a mile or more from two small knolls mentioned by Harder.[3] It forms a thin, somewhat patchy horizontal sheet that lies on the upturned eroded edges of the shale. As a rule the areal boundaries of the tufa are irregular, but along the west of the knolls a straight line having a direction of N. 25 E. separates tufa for a short distance from shale on the west. As shown by one of the mine workings described on page 237, this line is the trace of a fault that runs parallel to the bedding of the shale and has cut the tufa and downthrown the block on the east.

Most of the known deposits are along a course about three-quarters of a mile in length that coincides with the line mentioned and its southward extension. At the south several small pits expose a thin layer of manganese and iron oxides beneath a few feet of soil and tufa. Northward from these is a pit on the Surprise claim, from which manganese ore was shipped in 1918. Here a layer of ore from 6 to 18 inches thick rests on clay and dips 20° NW., passing beneath the tufa. It is composed chiefly of soft, sooty manganese oxides, with streaks and bunches of iron oxides along the margins. Here and there stringers of the oxides pass upward into the tufa.

[1] Penrose, R. A. F., jr., Manganese, its uses, ores, and deposits: Arkansas Geol. Survey Ann. Rept. for 1890, vol. 1, p. 470, 1893.

[2] Harder, E. C., Manganese deposits of the United States: U. S. Geol. Survey Bull. 427, pp. 153–157, 1910.

[3] Idem, p. 154.

The composition of this body as shown by partial analyses made in the laboratory of the United States Geological Survey is as follows:

Partial analyses of material from the Surprise mine.

[Chase Palmer, analyst.]

Sample G 71, average of 10-inch streak.

Silica (SiO_2)	4.70
Manganese oxide (MnO)	48.96
Oxygen (O)	6.95
Ferric oxide (Fe_2O_3)	12.00
Lime (CaO)	1.99
Baryta (BaO)	4.73
Tungstic oxide (WO_3)	1.54
	80.87
Manganese (Mn)	37.92
Tungsten (W)	1.22

Sample G 72, material showing much iron oxides.

Tungstic oxide (WO_3)	1.90
Tungsten (W)	1.50

The car sample of a 30-ton shipment made in June, 1918, shows 32.5 per cent of manganese, 5.2 per cent of iron, 6.2 per cent of silica, 0.056 per cent of phosphorus, and 1.5 per cent of tungsten.

Northward from the Surprise pit in the order named are a small open cut, a 20-foot shaft, and a large open cut on the Iron Mask claims. In the vicinity of the small open cut the tufa has been removed by erosion and the shale exposed contains a network of quartz veinlets. A vertical northeastward-trending lode 3 feet or more in width is shown by the open cut. It is made up of altered shale in which there are irregular streaks and bunches of manganese and iron oxides and a 6-inch vein of quartz that is brecciated and recemented with manganese oxides. A sample of this vein analyzed in the laboratory of the Geological Survey yielded 0.70 per cent of tungsten trioxide.

The shaft is sunk along a nearly vertical fault plane that strikes N. 25° E. and, for a few feet below the surface, separates shale on the west from tufa on the east. At greater depths both walls are composed of shale and the fault plane appears to coincide with the bedding. A 1-foot vein of manganese and iron oxides that comes up along this fault turns to a horizontal position before reaching the surface and passes eastward into the tufa. The horizontal part of this deposit, which consists largely of iron oxides, is several square rods in extent and ranges from 1 foot to 4 feet in thickness.

The large open cut exposes a flat-lying body of manganese and iron oxides formed along the surface of the shale beneath the tufa.

As exposed the body is at least 150 feet long, 20 feet wide, and 3 feet or more in maximum thickness. It is composed mainly of the softer oxides of manganese, together with some psilomelane. A moderate amount of calcite is intergrown with these minerals. The iron oxides as a rule form separate streaks and patches. Ore shipped by the Noble Electric Steel Co. is said to have contained the characteristic small percentage of tungsten.

The body in general is somewhat cavernous and friable. The shale beneath is quartzose and contains several vertical stringers of manganese that pass into the main ore body.

Specimens from the margin of the deposit show that manganese and iron oxides have replaced the calcium carbonate of the tufa but not the fragments of shale that are commonly embedded in it. The top of the deposit is very irregular because of chambers and chimneys that project into the tufa. Altogether the evidence seems to indicate to the writer that the deposit was formed almost wholly by replacement.

The origin of the deposits is ascribed by Penrose[1] and Harder[2] to hot springs that were contemporaneous with the Quaternary Lake Lahontan. According to these authors the springs supplied manganese in solution to a lagoon temporarily cut off from the lake. From the lagoon the manganese was precipitated, forming a lenticular bed that was covered by tufa during a subsequent stage of high water. The facts set forth are believed to show, however, that the deposit is later than the tufa and was introduced into it through a quartz lode that had been reopened by faulting. The sequence of events was apparently as follows:

A quartz lode formed along a N. 25° E. fracture along a bedding plane in the steeply tilted Triassic shale was exposed by erosion. Subsequently the outcrop of the lode and the adjacent surface of the shale were covered by tufa deposited by Lake Lahontan. Movements between the walls of the fracture brecciated the quartz lode and caused a dislocation of the tufa. Solutions rising through the reopened quartz lode spread out horizontally as soon as the surface between the shale and the tufa was reached and, by replacing the tufa, deposited the flat-lying bodies of manganese and iron oxides.

HANSEN & KNUDSEN CLAIMS.

The Hansen & Knudsen claims, situated in the northern part of the Battle Mountain Range, 11 miles southwest of Iron Point, on the Southern Pacific Railroad, produced a few carloads of manganese ore prior to June 22, 1918.

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[1] Penrose, R. A. F., jr., op. cit., p. 476.
[2] Harder, E. C., op. cit., p. 156.

The deposits lie at an altitude of approximately 5,500 feet above sea level, and the summits of near-by hills are 1,000 feet above them.

The manganiferous outcrops are associated with masses of quartz that stand out from weathered shale and quartzite of the Triassic Star Peak formation. The beds dip at low angles to the southwest. Lenslike bodies that consist of psilomelane and pyrolusite associated with rhodonite and possibly rhodochrosite are as large as 25 feet in greatest diameter and 2 feet thick. Many other lenses of oxidized ore occur which are from 10 to 25 feet in diameter and from 1 to 2 feet thick.

Unoxidized lenses of manganiferous chert in which the manganese occurs as rhodonite form replacement deposits in shale and quartzite. The largest lenses are 50 to 75 feet in diameter and 6 to 10 feet thick.

The deposits are mined from open cuts, and upon being sorted 4 or 5 tons of the material yields 1 ton of ore that contains about 45 per cent of manganese, a little iron, and 10.5 per cent of silica. There is material in sight sufficient to yield a moderate quantity of ore of this grade.

The oxide ore bodies have apparently been derived from the decomposition of rhodonite, which, together with the chert, was deposited as part of the Triassic shale. These deposits appear to be similar in origin to the deposits in the Franciscan formation of California.

BLACK DIAMOND CLAIM.

The Black Diamond claim, owned by the Charleston Hills Mining Co. and Frank O'Leary, is in sec. 2, T. 32 N., R. 39 E., and is accessible from Stonehouse and Golconda by good roads 22 and 28 miles long, respectively. The deposit, which lies at an altitude of 5,000 feet, caps a small hill at the foot of the eastern slope of the Sonoma Range. Hills in the vicinity of the deposit rise about 2,000 feet above it, and the deposit itself is about 500 feet above Humboldt River, the nearest stream. No ore shipments from this claim are reported.

The country rock is quartzite of the Triassic Star Peak formation, which dips 10°–20° W.

In one place material containing manganese oxides covers an area of 400 by 100 feet on the crown of a low hill. The depth of this material is not known, but it may be as much as 20 feet. The material is estimated to contain 30 to 35 per cent of manganese, 2 per cent of iron, 12 to 22 per cent of silica, and 0.05 per cent of phosphorus. By means of careful mining ore can be selected that contains from 45 to 50 per cent of manganese and less than 12 per cent of silica. There are two other deposits of oxidized material nearly as large as the one described but of lower grade. All these deposits consist of psilomelane, manganite, and pyrolusite, associated with quartz, chalcedony, rhodonite, calcite, and limonite.

Other manganiferous deposits consist of quartz-rhodonite veins and stringers from 1 inch to 6 inches wide. These are rather poor in manganese and much too small to be workable, but they are regarded as a possible source of the manganese in the bodies of oxidized material described.

O'BRIEN & TUCKER AND DE LA VEGA CLAIMS.

The O'Brien & Tucker and De la Vega claims are 15 miles south-southeast of Golconda, on the western slope of the Buffalo Range. The nearest railroad shipping point is Stonehouse, 12 miles to the northeast, on the Western Pacific and Southern Pacific railroads. The deposits are developed by shallow pits only, and up to the middle of June, 1918, no ore had been shipped from them. Manganiferous outcrops are distributed through an area a mile wide and about 2 miles long from east to west. The surface is rough, and the altitude ranges from 5,300 feet at the west to 6,500 feet or more at the east. The country rock is shale, which has been strongly indurated by igneous metamorphism.

At the west end of the area, on the Bluebird No. 3 claim, a prominent ledge of silicified shale strikes N. 15° W. Streaks blackened with manganese oxides are distributed alongside this ledge in a zone that is 40 feet wide in one place. As shown by discontinuous outcrops, the manganiferous zone extends at least 1,000 feet southeastward. Pits dug in it at the end of the Bluebird No. 3 claim and on the adjoining Prospector claim show streaks of richly manganiferous material from 4 to 6 feet wide. About half a mile to the east, on the Manganese No. 4 claim, a 5-foot streak of similar material is formed along the parting between beds of shale that strike northwest and dip 65° SW. Several smaller deposits were observed in ground adjoining the claims mentioned, and six or eight others are reported in the eastern part of the area.

The outcrops of the bodies examined consist mainly of a hard, compact manganese oxide ore that appears to be homogeneous but not crystalline. Generally it is characterized by a splintery fracture and a glossy luster somewhat like that of coal. Under the microscope it appears as a fine network of veinlets filled with manganese oxides in a matrix of manganese silicates. Samples of this ore are reported to carry over 40 per cent of manganese. At the depth of a few feet the oxidized material described gives place wholly to the manganese silicate rhodonite. The high polish and bright rose-pink color shown by a specimen that was dressed in the Survey laboratory suggest that this rhodonite is valuable as an ornamental stone. So far as they are explored by the pits the bodies are somewhat broken, but solid fragments as large as 1 foot in diameter may be obtained.

The outcrops contain a few hundred tons of rather siliceous manganese oxide ore, and undoubtedly a large amount of manganese silicate is to be expected below.

UNNAMED DISTRICTS.

DARKY MINE.

The Darky mine, owned by Holmquist & Johnson, is situated in the Toana Range about 8¼ miles east of Decoy, a station on the Nevada Northern Railroad. The claims cover an area approximately 4,500 feet long and 1,800 feet wide. A fairly good road with a down grade all the way leads from the mine to the railroad.

During 1917 and the spring of 1918 considerable high-grade ore was shipped from this deposit. In June, 1918, preparations were being made to resume work under a change of ownership.

The deposit, which crops out at an altitude of 6,000 feet above the sea, is about 300 feet above the valley floor to the west and 1,500 feet below the summits of the adjacent hills.

The country rock is a massive flat-bedded limestone of Carboniferous age which is cut by a fissure that strikes north and dips 75° W. The manganese deposits occur partly in the fissure and partly in the adjacent limestone, which they have replaced. There are several ore shoots, the largest of which is 25 feet long, 8 feet wide, and 60 feet deep. Another one is 20 feet long, 7 feet wide, and 60 feet deep.

The ore bodies consist of psilomelane, pyrolusite, and wad, accompanied by quartz, calcite, and limonite. Ore selected for shipment contains about 45 per cent of manganese and less than 5 per cent of silica.

There is a moderate quantity of ore in reserve.

SMITH & DOBBINS CLAIM.

Claims that contain deposits of manganese oxides and are owned by W. S. Smith and I. T. Dobbins are in the Mormon Range, 24 miles east of Vigo, a station on the Los Angeles & Salt Lake Railroad. The property is developed by a 90-foot shaft, but up to July, 1918, no ore had been shipped from it.

The deposits crop out at an altitude of 3,500 feet above sea level, 300 feet higher than the railroad at Vigo but 2,000 feet or more below the summits of adjacent peaks.

The climate is arid, the average rainfall is about 10 inches, and there are no perennial streams near by.

The deposit is formed on the footwall of a fault that separates limestone from rhyolite tuff. No development work has been done to determine its extent along the strike of the fault, but as shown in the shaft the ore shoot is 2 feet wide and 70 feet deep. The ore consists of wad and pyrolusite, which form nodules of rather low specific gravity in the fault gouge, composed largely of kaolin. The nodules can be selected in mining to form a product that contains from 40 to 44 per cent of manganese and from 15 to 20 per cent of silica. It is believed that a moderate amount of such ore could be won from this deposit and that additional development work might disclose a large quantity.

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