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PRELIMINARY REPORT ON THE BEDDED MANGANESE OF THE LAKE MEAD REGION NEVADA AND ARIZONA

BY

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By V. E. McKelvey, J. H. Wiese, and V. H. Johnson

ABSTRACT

Bedded deposits of manganese oxide are widely distributed in a basal sedimentary rocks of the Muddy Creek formation, in the Lake Mead region of southern Nevada and northwestern Arizona. The sedimentary rocks are late Tertiary lake or playa deposits, and consist of tuffaceous siltstone and sandstone, conglomerate, and gypsum, with locally intercalated pillow basalt. They lie in several more-or-less connected basins, generally folded and faulted near their margins by recent uplift of the enclosing hills. The manganese oxide, generally wad, is found mostly in the tuffaceous sandstones and siltstones, but in places it occurs in minor amounts in the other sedimentary rocks as well.

The Geological Survey has prepared detailed maps of the deposits; the four most promising deposits—the Three Kids, Fanny Ryan, Boulder City, and Virgin River—have been explored by the Bureau of Mines. Ore reserves in these four deposits are: 2,500,000 tons averaging about 20 percent manganese in the Three Kids deposit; 2,400 tons averaging about 15 percent manganese in the Fannie Ryan deposit; 15,000,000 tons averaging 3 or 4 percent manganese in the Boulder City deposit; and 134,000 tons averaging 13 percent manganese in the Virgin River deposit.

INTRODUCTION 1/

Bedded manganese deposits occur in late Tertiary sedimentary rocks at several places in the southwest—in the Artillery Mountains region, Arizona;2/ in the Lake Havasu basin, Arizona;3/ and in the vicinity of Lake Mead in southern Nevada and northwestern Arizona (fig. 9). These deposits form a group that "convincingly display that the manganese oxides were laid down as a part of the sedimentary rocks that contain them".4/ For the most part the ores are low grade, but because of their wide distribution they form an important part of domestic manganese reserves.

The largest of the Lake Mead deposits—the Three Kids, Fannie Ryan, Boulder City, and Virgin River deposits—have been mapped by the Geological Survey and explored by drilling and trenching by the Bureau of Mines. The Three Kids deposit has been described previously 5/ and will be reviewed only briefly here.

The Lake Mead region is traversed by U. S. Highways 91, 95, 93, and 466, and all of the deposits, except those of the Virgin River district, can be reached by desert roads extending a few miles from one of these highways. The Virgin River district is accessible only by boat. A branch line of the Union Pacific Railroad extends to Boulder City. Boulder Dam provides a local source of power, and although the deposits have no immediate water supplies, all are within 5 miles of Lake Mead.

Most of the deposits were discovered in the fervor of prospecting inspired by World War I and have received little attention since. The only production has come from the Three Kids mine. A total of between 15,000 and 20,000 tons was shipped from 1918 to 1920. In 1941 the Bureau of Mines trucked 4,000 tons to its Boulder City pilot plant for experimental purposes. In 1942 and 1943 the Manganese Ore Co. mined 394,000 tons from an open pit and about 60,000 tons was treated in the sulfur-dioxide leaching plant built at the mine by the Defense Plant Corporation; the remainder was stockpiled.

1/ Since this report was prepared in March 1942, the Manganese Ore Co. has further explored and mined a portion of the Three Kids deposit. It is hoped that the information acquired during the course of their operations will be published later.

2/ Lasky, S. G., and Webber, B. N., Manganese deposits in the Artillery Mountains region, Mohave County, Arizona: U. S. Geol. Survey Bull. 936-r 1942.

3/ Hadley, J. B., Manganese deposits of the Lake Havasu basin, Arizona: U. S. Geol. Survey, unpublished report, 1942.

4/ Hewett, D. F., Sedimentary manganese deposits, in Ore deposits of the Western States (Lindgren volume), pp. 488-489, Am. Inst. Min. Met. Eng., 1933.

5/ Hale, F. A., Manganese deposits of Clark County, Nevada: Eng. and Min. Jour., vol. 105, pp. 775-777, 1918.

Jones, E. L., Jr., Deposits of manganese ore in Nevada: U. S. Geol. Survey Bull. 710, pp. 222-232, 1920.

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Hunt, C. B., McKelvey, V. E., and Wiese, J. H., The Three Kids manganese district, Clark County, Nevada: U. S. Geol. Survey Bull. 936-1, 1942.

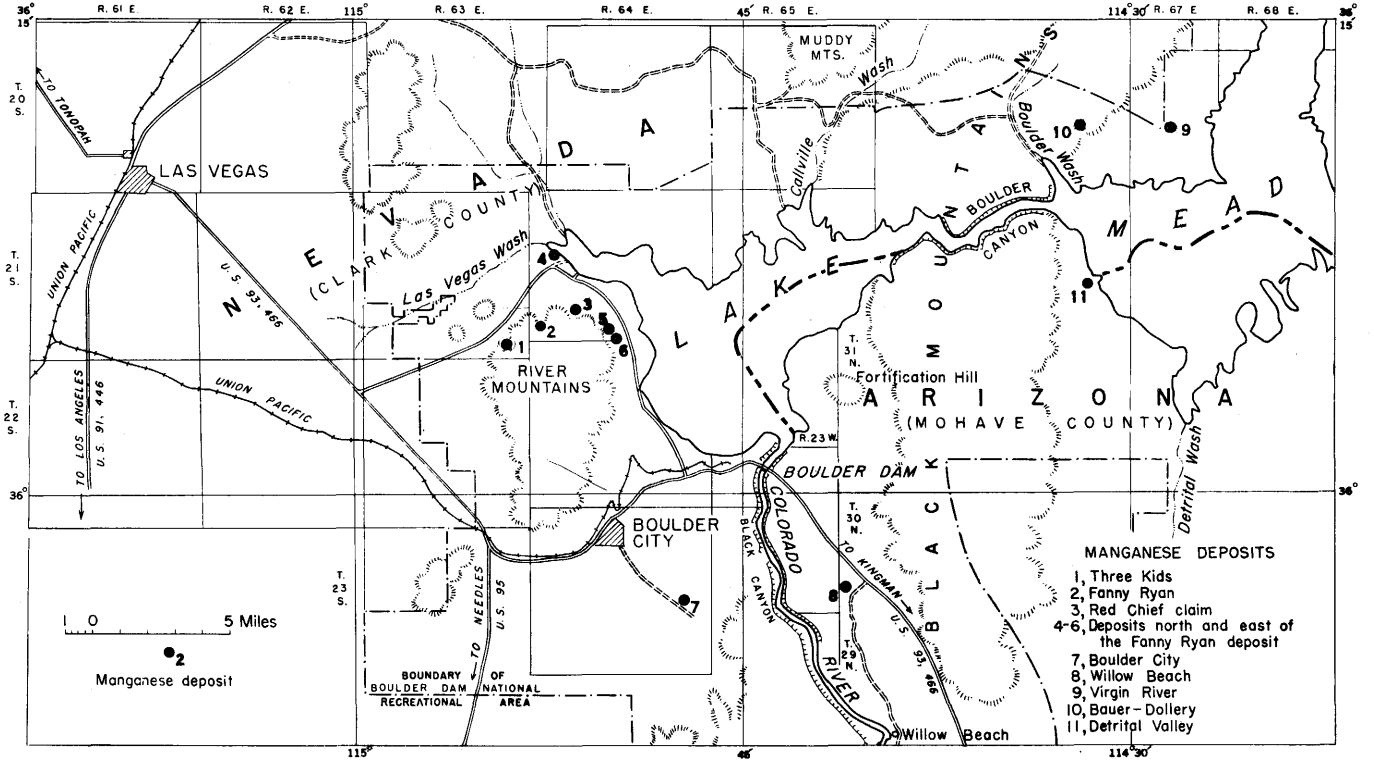

Figure 9. Map of the Lake Mead region, Nevada and Arizona, showing the location of bedded manganese deposits

Field work by the U. S. Geological Survey began in October 1940 and continued intermittently until February 1942. The investigations were under the general supervision of D. F. Hewett, C. B. Hunt, and S. G. Lasky. It is a pleasure to acknowledge the cooperation of C. H. Johnson, W. H. King, and J. H. Soulé of the Bureau of Mines; M. C. Lake and A. A. Peugnet of the Manganese Ore Co.; Carl Lehnert of the National Park Service; and Otto Littler of the Bureau of Reclamation.

GEOLOGY

The Lake Mead region is within the Basin and Range Province. The regional structure is that of isolated mountain uplifts, separated from one another by intermontane basins filled with Tertiary continental deposits: coarse and fine detritus derived from the surrounding mountains, pyroclastics and volcanic flows, and evaporites. These rocks were deposited under both terrestrial and lacustrine conditions during a period of volcanic activity accompanying uplift and deformation of the mountains.

Stratigraphy

The regional lithologic sequence of Miocene (?) sedimentary and volcanic rocks varies greatly in detail, but contains many broad features of similarity. These general features of lithologic similarity, insofar as they may be assumed to represent similar stages in the local history of diastrophism, vulcanism, and sedimentation, make possible regional correlations. The generalized lithologic sequence of the rocks associated with the manganiferous deposits is given on the facing page.

Miocene(?) volcanic rocks

The Miocene(?) volcanic rocks underlying the Muddy Creek formation consist of interbedded latitic breccia, tuff, and flows. They crop out in or near each of the districts studied.

Pliocene(?)

Muddy Creek formation.—The Pliocene(?) rocks of the Lake Mead region have been assigned to the Muddy Creek formation by Longwell;6/ the formation is subdivided here into three units, each separated by an angular unconformity.

Unit no. 1 consists of a succession of interbedded basalt and andesite flows and flow breccia, overlain by conglomerate,

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6/ Longwell, C. R., Geology of the Muddy Mountains, Nevada: Am. Jour. Sci., 5th ser., vol. 1, pp. 39-62, 1921; U. S. Geol. Survey Bull. 798, 1928. Geology of the Boulder Reservoir floor: Geol. Soc. America Bull., vol. 47, pp. 1393-1476, 1936.

Generalized sequence of late Tertiary rocks of the Lake Mead region

Age	Formation and Member	Character	Thickness (feet)
Pliocene(?)	Muddy Creek formation		
	Unit no. 3	Conglomerate and sandstone, grading into siltstone, clay, tuff, limestones and gypsum outward into the basins. Includes basalt flows and breccia in the Virgin River district.	0-1,000
	Angular unconformity		
	Unit no. 2	Conglomerate, sandstone, and shale.	0-300
	Angular unconformity		
		Gypsum (manganiferous in places), limestone, red clay, siltstone, and sandstone.	0-1,500
	Unit no. 1	Tuffaceous sandstone and siltstone, nearly everywhere manganiferous in part, locally extremely so.	0-150
		Well-bedded conglomerate, underlain by basalt and andesite flows and agglomerate; interbedded basalt flows and gypsum in Virgin River district.	0-2,000
	Angular unconformity		
Miocene(?)	Volcanic rocks	Latitic flows, glass, and breccia.	0-1,500
		Interbedded andesite flows on northeast side of River Mountains.	
	Angular unconformity		

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sandstone, manganiferous tuffaceous sandstone and siltstone, clay, tuff, and gypsum, locally manganiferous. Thin beds of limestone are interbedded with the basalt north of the Three Kids deposit. On the west side of the Virgin River deposit, the basal part of unit no. 1 contains much interbedded gypsum, and the beds above the manganese contain interbedded basalt flows and breccia. Limestone overlies the manganiferous beds at the Bauer-Dollery deposit on the west side of the Virgin River district, and at the Willow Beach deposit. Pillow structures in the flows and the presence of evaporite indicate most of these rocks are of subaqueous origin.

Unit no. 2 overlaps the older beds but, because it in turn is overlapped by younger beds, has only a small area of outcrop. The conglomerate and sandstone of this unit are probably of fluviatile origin, and may represent a period when the basins were nearly dry.

Unit no. 3 has the greatest area of exposure of any of the rocks of the Muddy Creek formation. Conglomerate and sandstone beds of this unit grade outward from the hills into fine silt, red clay, and impure gypsum beds. At the Three Kids deposit, unit no. 3 consists of fine clay, tuff, gypsum, and thin limestone beds; at the Virgin River district, it consists of conglomerate underlain by basalt flows and flow breccias. The sedimentary rocks of unit no. 3 are probably of fluviatile and playa origin.

Structure

The rocks of the Muddy Creek formation lie in structural basins adjacent to mountain uplifts. Manganese deposits are known in four such basins: the Callville, Dry Lake, and Black Canyon basins, which contain the deposits of the Las Vegas district, and the Virgin-Detrital basin which contains the Virgin River district. The types of structures characterizing these basins are shown in plates 39-44, and have been discussed by Longwell.7/

The present boundaries of the basins probably correspond closely in most places to those existing at the time of the deposition of the Muddy Creek formation. Near the edges the rocks dip steeply basinward and, because deformation continued during deposition, the older beds dip more steeply than the younger. Thus at or near the edges of the Callville and Virgin-Detrital basins the beds of unit no. 1 dip 20° to 50° away from the mountains, beds of unit no. 2 dip 10° to 20°, and beds of unit no. 3 dip 5° to 10°. In the Callville and Virgin-Detrital basins, faults are most numerous in the older rocks at or near the edge of the basins. The faults are nearly all normal block faults whose displacements range from a few inches to several hundred feet and whose strike generally parallels either the strike or the dip of the rocks. Synclinal folds are prominent on the north side of Lake Mead in the Virgin-Detrital basin (pl. 42) and along the north edge of the River Mountains in the Callville Basin, where they are associated with block faults (pl. 39).

Two or three miles out from the hills the rocks are nearly flat-lying, but a few small domes are found in the Callville and Virgin-Detrital basins.

7/ Longwell, C. R., op. cit., 1936.

BEDDED MANGANESE DEPOSITS

Although manganiferous beds in the Muddy Creek formation are widely distributed and the deposits vary in detail, they have many features in common, and are all probably the result of the same type of mineralization.

Type of ore

The mineralogy of the manganese minerals is not fully known. Most of the manganese is in the form of wad—a soft, dark-brown to black, earthy material that probably consists of a mixture of oxides and is better regarded as a rock than as a distinct mineral species. In places a hard mineral, probably psilomelane, may be found mixed with the wad or as small stringers or veins. Small, needle-like crystals, probably of pyrolusite or manganite, occur but are uncommon. Neotocite has been described from the Three Kids deposit by Hewett.8/

The wad ore is soft but compact and breaks readily into large blocks; it consists of all gradations from massive beds of wad containing no megascopic impurities to fine particles sparsely disseminated in a matrix of tuffaceous silty sandstone. In the most abundant type of ore, wad exists as soft blebs or irregular nodules up to a quarter of an inch in diameter, as irregular and discontinuous laminae, or as fine particles in a matrix of gray to reddish tuffaceous silty sandstone. Most of the blebs and nodules are discordant to the bedding, and nearly all of them are without structure; exceptional blebs however, have a submetallic luster and a concentric structure.

Much of the ore has a matrix of gray or white tuff, volcanic sand, and pink tuffaceous silt. Barren partings are discontinuous and of the same composition as the matrix of the ore.

The conglomerate underlying the ore at the Three Kids and Fannie Ryan deposits contains some manganese, mostly of secondary origin, and fine-grained beds of sandstone within the conglomerate are manganiferous. The conglomerate in unit no. 3 contains secondary manganese oxides at places in the Callville Basin.

In many places in the Lake Mead region, gypsum of unit no. 1 lying above the general ore zone contains some wad in irregular pockets and finely divided particles, as well as large black crystals of manganiferous selenite resembling black calcite.

The wad has been wholly or partly opalized at many localities, forming a hard, vitreous rock which breaks with a conchoidal fracture. At the Three Kids deposit the top 2 or 3 feet of ore, at the outcrop and at the old surface underneath the gravel cover, is partly silicified and impregnated with small amounts of gypsum and calcite. The ore in the Lowney area at the Three Kids deposit has a matrix of coarse pumice or tuff, and much of the ore associated with this tuff is

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8/ Hewett, D. F., and Webber, B. N., op. cit., p. 13.

highly silicified. Lenses of red and green jasper, having the texture of the blebby ore, are associated with some of the ore at the Three Kids, Fannie Ryan, and Virgin River deposits.

In addition to the clastic, tuffaceous, gypsiferous, and siliceous components forming the matrix, other impurities are known in small amounts. The Three Kids ore contains 0.5 to 15 percent of iron, 0.1 to 5 percent of lead, 0.005 to 0.3 percent of copper, 0.1 to 5 percent of barium, and the zeolite phillipsite is reported to be abundant.9/

Red and green aureoles surround the ore at many places in the Lake Mead region. These aureole zones are from a fraction of an inch to 1 or 2 feet in thickness and are in irregular and jagged contact with the manganiferous beds. The color sequence is invariable: black within the ore, then red or brown, then green. The red and green zones have the same texture as the ore.

The density of the ore varies from about 1.2 (26.7 cubic feet per ton) to 2.2 (14.6 cubic feet per ton). As a general rule, the higher the grade, the lower the density. Exceptions to this rule are caused by variations in grain size, mineralogy of the ore, and degree of compaction.

Form and extent

Although the manganese deposits are within sedimentary rocks and have a general tabular form, in detail the ore is lenticular, and the grade and thickness of any particular horizon varies widely over short distances.

Unit no. 1 of the Muddy Creek formation contains at least traces of manganese nearly everywhere it is exposed in the Callville Basin, and although the outcrops are few, they are distributed over a distance of about 10 miles along the strike. In the Virgin River district, manganese in beds of the same general age as those of the Callville Basin is irregularly distributed along a total strike length of about 6 miles, but the individual deposits are small and isolated.

Gypsum beds in the upper part of unit no. 1 contain small amounts of manganese sporadically distributed for a strike distance of about 6 miles in the Callville Basin. A zone containing thin beds of manganiferous gypsum is traceable for about 8 miles in the Virgin River district north of Lake Mead, and a similar zone crops out for a distance of about a mile south of Lake Mead in Detrital Valley.

Size and grade of ore bodies

Few concentrations of manganese are of sufficient thickness and grade to be called ore bodies, even in loose usage of

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9/ Hewett, D. F., and Webber, B. N., op. cit., p. 14.

the term. At the Three Kids deposit three distinct localizations of manganese mineralization were outlined by diamond drilling. The main ore body, broken by faults into five separate blocks, underlies a total area of about 30 acres, averages about 50 feet thick, and contains 18 percent manganese. The Las Vegas ore body underlies an area of about 6 acres, averages about 40 feet thick, and contains 15 percent manganese. The Las Vegas Extension ore body occupies an area of a quarter of an acre, averages about 30 feet thick, and contains 15 percent manganese.

The Fannie Ryan ore body is about 4 feet thick, averages 7 percent manganese, and underlies an area of about 1½ acres.

The Boulder City deposit is from 40 to 65 feet thick, but averages only 2 to 4 percent manganese. Because of its very low grade, it has not been fully explored but is known to underlie at least 70 acres.

Four ore bodies at the Virgin River deposit underlie areas of 6, 2, 1, and one-quarter acres, respectively, and average about 10 feet thick, and 10 percent manganese.

Origin

The wad deposits of the Lake Mead region, and some of those of the Lake Havasu and Artillery Peak regions as well, are believed to be syngenetic sedimentary deposits—that is, deposited at the same time and in the same fashion as the enclosing rocks—because their characteristics are those of ordinary sedimentary deposits.10/ The deposits are finely bedded; the wad occurs in layers which are ostensibly pure, as well as in layers composed predominantly of other materials. The pure and impure layers of wad are intimately interbedded with barren layers of similar texture; in addition, the wad persists at essentially the same stratigraphic position over large areas.

The presence of such elements as lead and copper led Hewett 11/ to suggest hot springs as the local source of the manganese. The close regional association of the ore with pillow basalt flows suggests the additional possibility that the manganese was contained in solutions that accompanied the eruptions or was leached from the subaqueous flows.

The form in which the manganese was held in solution, and the factors that brought about its precipitation and localization are conjectural. The localization of the manganese might have been a function of nearness to its source. The depth of the water and the proximity to the shoreline may have played a part in the localization of the manganese at the time of its deposition, as suggested by (1) the fact that several of the deposits occur on the high side of pre-ore faults; (2) that most of the deposits are found on the edge of structural basins; and (3) that the long axis of most of the ore bodies parallels the edge of the basins. Secondary action may have

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10/ Hewett, D. F., Sedimentary manganese deposits, in Ore deposits of the Western States (Lindgren volume), pp. 488-489, Am. Inst. Min. Met. Eng., 1933; Lasky, S. G., and Webber, B. N., Manganese deposits in the Artillery Mountains region, Mohave County, Arizona: U. S. Geol. Survey, Bull. 936-r, p. 438.

11/ Hewett, D. F., and Webber, B. N., op. cit., p. 16.

brought about at least some of the localization of the manganese in the high-grade deposits, as suggested by the decrease in the grade of the ore down the dip of the beds in the Three Kids, Fannie Ryan, and Virgin River deposits and by the parallelism of the long axis of the ore bodies to the surface.

Reserves

The manganiferous deposits of the Lake Mead region are low grade and cannot be beneficiated by ordinary metallurgical methods. However, a satisfactory concentrate was produced from this ore in a sulfur-dioxide leaching plant built in 1943 by the Defense Plant Corporation adjacent to the Three Kids mine, and the Bureau of Mines has produced metallic manganese by the electrolyte process in its pilot plant at Boulder City. The grade of ore required for a commercial operation based on these or other processes will depend on highly variable economic and technologic factors. Consequently, the reserves of the Three Kids, Fannie Ryan, Boulder City, and Virgin River deposits are stated graphically to show the amount and grade of ore available at various cut-off limits (figs. 10-13).

The ore bodies at the Three Kids deposit have been fully explored and sampled by the Bureau of Mines and the Manganese Ore Co. Measurable reserves include 2,500,000 tons of ore above a 10 percent cut-off, averaging 20 percent manganese. Probably 1 to 2 million tons of these reserves could be mined by open pit methods; the remainder would have to be mined underground.

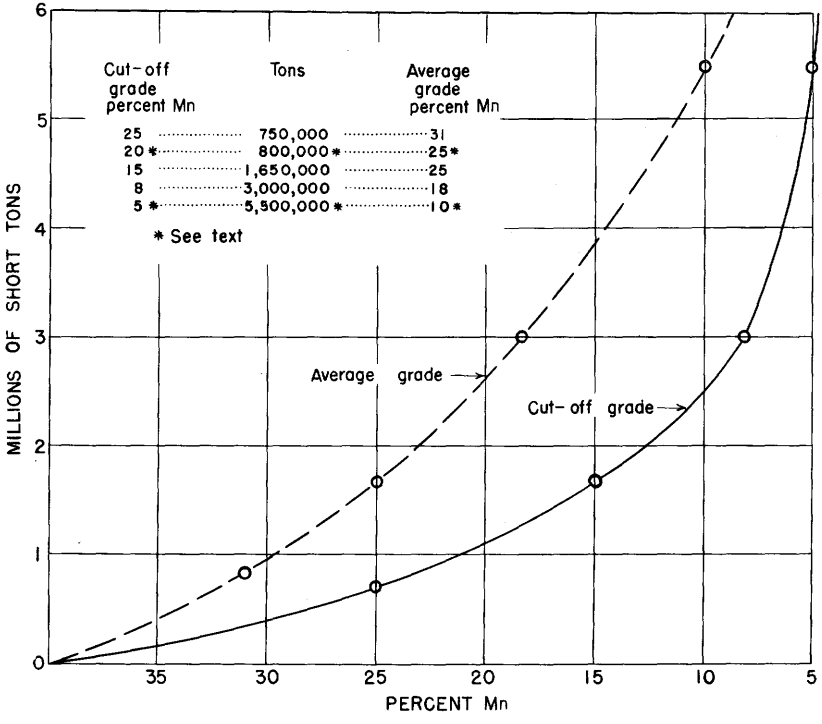
The U. S. Bureau of Mines has outlined the Fannie Ryan ore body by drilling and trenching. The ore could be shipped easily to the Three Kids plant, which is only about a mile away. However, to maintain a 20 percent average, it would not be possible to mine below an 18 percent cut-off and only 400 tons of such ore is available (fig. 11). If ore could be mined to a 10 percent cut-off, about 2,400 tons averaging 14 percent manganese could be mined.

Explorations at the Boulder City deposit indicate 15,000,000 tons of ore above a 1 percent cut-off, averaging about 3 percent manganese; of this tonnage about 1,000,000 tons may be inferred to be above a 5 percent cut-off and to average about 7 percent. Although higher-grade ore exists it is so intimately mixed with lower-grade ore that it could not be mined separately.

Measured ore at the Virgin River deposit includes 134,000 tons above a 10 percent cut-off, averaging 13 percent manganese. The small tonnage and inaccessibility of the deposit will prevent production for some time.

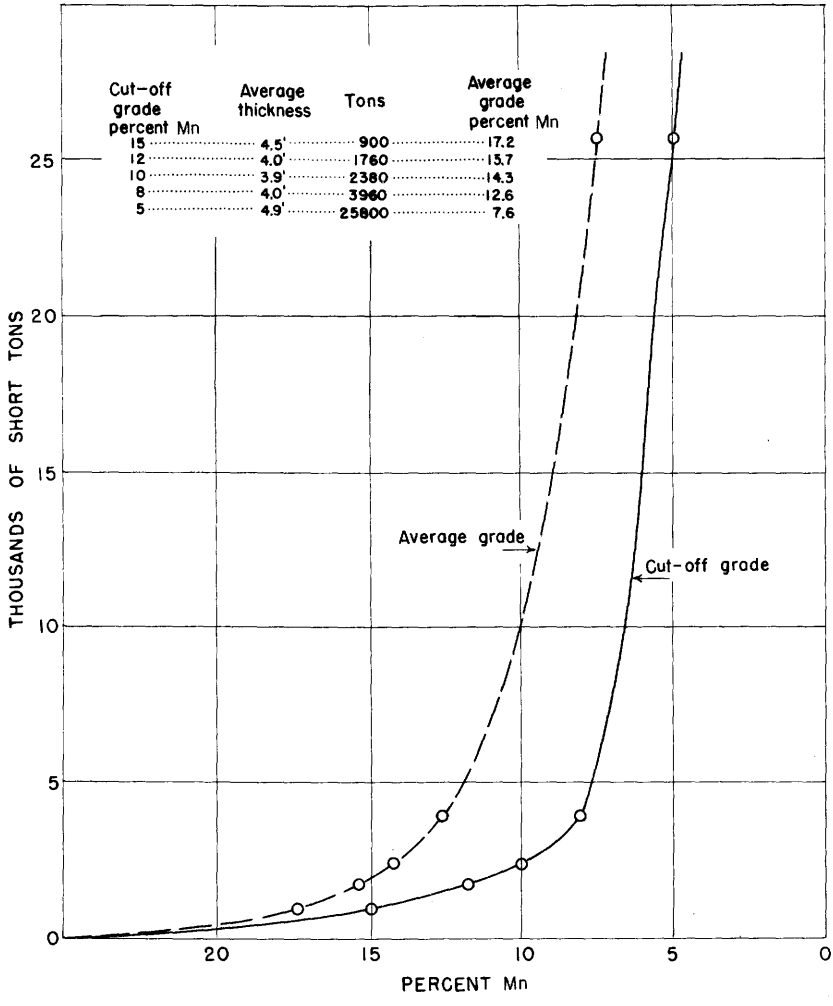
Other deposits in the Lake Mead region are so low grade or small that they have not warranted systematic sampling, and no detailed reserves can be stated for them. The Bauer-Dollery deposit in the Virgin River district contains about 20,000 tons of ore above a 1 percent cut-off, averaging 5 percent manganese.

Ore at the other prospects does not warrant any estimate but does serve to indicate the presence of several millions of tons of plus 1 percent ore in the sedimentary deposits of the Muddy Creek formation, throughout the region.



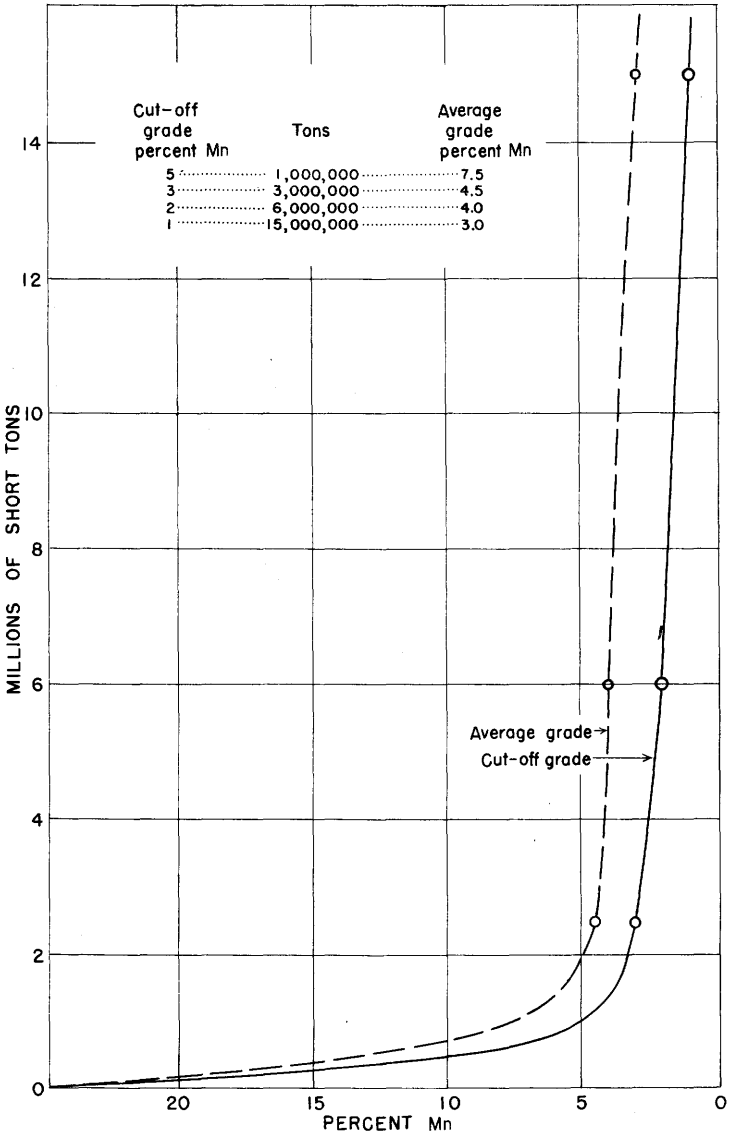
Reserves have been computed on the basis of diamond drilling data supplied by the Bureau of Mines and the Manganese Ore Company; the known ore bodies have been explored and the figures stated constitute measured ore. Tonnages above cut-offs of 5, 8, 15, 20, and 25 percent are shown. The figures for the 8, 15, and 25 percent cut-offs were computed by C. H. Johnson of the Bureau of Mines, and V. E. McKelvey, and assume selective mining of that portion of the bed containing ore above the cut-off; the minimum mining width was taken at 3 feet, but in only one or two instances were there any thicknesses less than 5 feet. The 5- and 20 percent cut-offs were computed by C. B. Hunt and are based on the assumption that no portions within the bed will be selectively mined, and excludes only low-grade material at either the top or the bottom of the bed. Circumstances are such that the two methods, for all practical purposes, agree for the 5-percent cut-off, and this figure is included in the graph; the 20-percent cut-off is included only in the table. The tonnages in both the table and the graph are cumulative.

Figure 10. Reserves at the Three Kids deposit



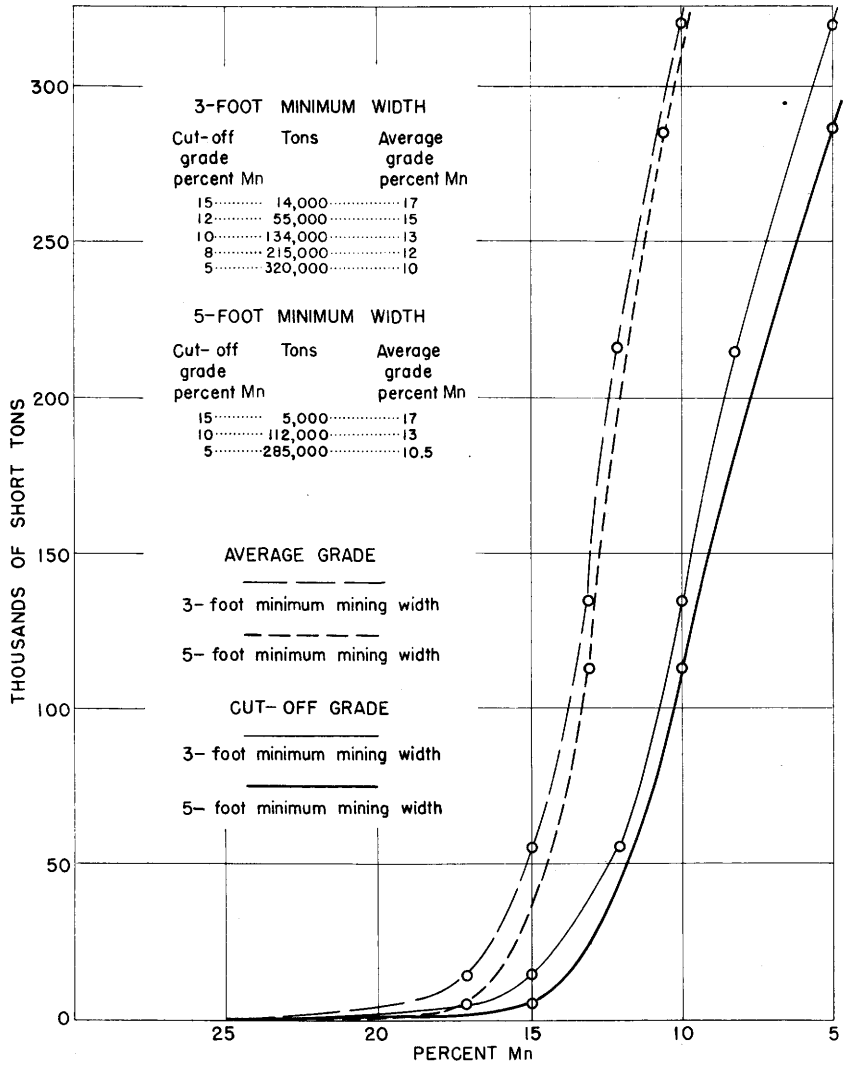
The reserves have been outlined by drilling and trenching by the Bureau of Mines and, as the limits of the ore containing more than 5 percent manganese have been established, the reserves given below constitute measured ore. Cut-offs of 5, 8, 10, 12, and 15 percent manganese were used in calculation, and the grade and thickness were proportioned to these cut-offs from drill holes or trenches containing ore below the cut-off grade. No minimum mining width was taken, but only two thicknesses were less than 3 feet; the average thickness is indicated in the table. The reserves above an 8-percent cut-off include some ore that would have to be mined selectively from either the top or the bottom of the bed, but its thickness is greater than 3 feet. The tonnages are tabulated and expressed graphically, and are cumulative.

Figure 11. Reserves at the Fannie Ryan deposit



The reserves are based on samples obtained by the Bureau of Mines from two drill holes and a vertical shaft, all widely spaced. However, because of the apparent uniformity of the ore, the tonnage stated may be classed as indicated ore (the samples have been taken to indicate the grade of the ore, and the tonnage is based on the assumption that the ore extends for a distance under cover equal to one half the length of the outcrop or 1,500 feet). The proportion of the ore above the various cut-offs was arrived at by applying the proportion of ore above those cut-offs in the drill holes and shaft to the whole deposit. These are probably good for the 1-, 2-, and 3-percent cut-offs, and, as the ore above the 3-percent cut-off is at the top of the bed it could probably be mined separately. Higher-grade ore could not be mined separately, and the curve above the 3-percent cut-off represents the character of the ore rather than the tonnage that could be mined selectively. The tonnages are cumulative and are rounded off to the nearest million.

Figure 12. Reserves at the Boulder City deposit



Reserves at the Virgin River deposit are based on samples taken by the Bureau of Mines from 65 trenches and 18 drill holes. Exploration has defined the limits of ore containing more than 5 percent manganese, and the figures stated constitute measured ore. Cut-offs of 5, 8, 10, 12, and 15 percent were used in the calculation of ore above a minimum mining width of 3 feet; cut-offs of 5, 10, and 15 percent were used in the calculation of ore above a minimum mining width of 5 feet. The grade and thickness were proportioned to the cut-offs from drill holes or trenches containing ore of less than the cut-off grade or minimum mining width. The tonnages are tabulated and expressed graphically, and are cumulative.

Figure 13. Reserves at the Virgin River deposit

DESCRIPTION OF MANGANESE DEPOSITS

Las Vegas district

The Las Vegas district includes: the Three Kids and Fannie Ryan deposits; other small outcrops of manganiferous rocks on the flanks of the River Mountains and at the west end of the Callville Basin; the Boulder City deposit in the Dry Lake basin; and a small deposit at Willow Beach, Ariz., in the Black Canyon basin. All are within the Boulder Dam National Recreational area.

Three Kids deposit

The Three Kids deposit is about 15 miles east of Las Vegas and 8 miles northwest of Boulder City, in Clark County, Nev. (fig. 9) A paved road leads from U. S. Highway 93-466 to the deposit.

The manganese deposits are along the southeast side of an open syncline or trough that strikes northeast, and is cut by the Lowney fault, which trends northwest. The block east of the Lowney fault, which is down-dropped, is a subsidiary asymmetrical syncline whose axis strikes northwest. Most of the ore is along the margins of this syncline; its eastern limb is broken into a number of isolated slices by numerous north-trending faults. The old Annex mine, Three Kids mine, and Three Kids open pit are in such fault slices.

Interbedded manganiferous sandstone and siltstone above the conglomerate of unit no. 1 occupy the subsidiary syncline and extend for about 2 miles along the River Mountains south of the Lowney fault. Three ore bodies 30 feet or more thick contain as much as 40 percent manganese (see p. 91). Detailed stratigraphic studies show that the matrix of the lower part of the ore-bearing formation is gray or white tuff, and the upper part is pink tuffaceous siltstone.

Fannie Ryan deposit

The Fannie Ryan deposit is about a mile east of the Three Kids deposit and is accessible from the Las Vegas Wash highway by two desert roads (pls. 39 and 40). The Bureau of Mines conducted an exploratory program from late October 1941 to early January 1942 during which seven holes were drilled and several trenches dug and sampled.

The geologic section differs little from that at the Three Kids deposit. The conglomerate of unit no. 2 overlaps unit no. 1; in the northern part of the area it in turn is overlapped by unit no. 3.

The structure also is similar to that of the Three Kids deposit and consists of an asymmetrical syncline, bounded by a fault on the west.

Manganese is sporadically distributed in the sandstones within and just above the conglomerate, but only one ore body contains more than 5 percent manganese. This ore body is exposed

for a length of about 400 feet, north of a cross fault in the east side of the syncline. Adjacent to the fault the ore is 7 feet thick and averages 23 percent manganese; at the other end of the outcrop it is 1 or 2 feet thick and contains only traces of manganese. South of the fault, the manganese-bearing beds are thin, low grade, and discontinuous. Down dip the ore body, as tested by five drill holes, is about 3 feet thick and for the most part contains less than 5 percent manganese. Within the conglomerate, from one to three thin maganiferous beds not exposed at the surface were found by drill holes.

On the west side of the basin the manganese-bearing formation was tested by two drill holes; there it is about 10 feet thick and averages less than 5 percent manganese.

The manganiferous sandstones exposed at three places north of the main part of the Fannie Ryan workings are too thin and low grade to merit exploration.

Deposits east of the Fannie Ryan deposit

East of the Fannie Ryan deposit beds of the Muddy Creek formation are step-faulted around the north edge of the River Mountains and outcrops of unit no. 1 are few, due to extensive overlap by the conglomerate of unit no. 3. However, of four exposures of unit no. 1, three contain manganese(pl. 39).

A bed of manganiferous sandstone, 6 feet thick and containing 3 or 4 percent manganese, is exposed for about 100 feet in a wash on the Red Chief claim, about 1 3/4 miles northeast of the Fannie Ryan workings. The ore is underlain by conglomerate and overlain by gypsum; it is cut off by a fault on the south and overlapped on the north by the conglomerate of unit no. 3.

At another outcrop of the same sequence, about 2 miles east of the Fannie Ryan workings, the ore is 2 feet thick and contains about 5 percent manganese. The bed is cut off on the south by a fault, and on the north by conglomerate of unit no. 3.

At the easternmost exposure, about 100 yards west of the highway and about 2½ miles east of the Fannie Ryan workings, the ore is exposed on the north side of a small dome. It is about 5 feet thick, and contains about 5 percent manganese. Thin layers of hard manganese oxides are present at the base of sandy laminae in red clay overlying the ore.

In the creek bank at the mouth of Las Vegas Wash, on the east side of a basalt hill, the manganiferous beds are 8 feet thick, and contain about 5 percent manganese. Overlying the basalt west of the hill is about 5 feet of beds containing traces of manganese.

Boulder City deposit

The Boulder City deposit is about 5 miles southeast of Boulder City, in secs. 23 and 24, T. 23 S., R. 64 E. A good dirt road leads from Boulder City to the deposit. The Bureau of Mines sank a vertical shaft and drilled two holes on the deposit during December 1941, and January 1942.

A flat-lying silty gypsum bed, 60 to 65 feet thick, contains 3 to 5 percent manganese, as oxides in small pockets, in lenses of silt, and dispersed through the matrix. A bed of light-gray tuff, 2 to 5 feet thick, and a 4-inch layer of fibrous gypsum are persistent at the base of the ore; a cream-colored tuff, 5 feet from the top, is likewise persistent. About 50 feet of silty sandstone is exposed underlying the lower tuff. The manganiferous beds are overlain by 10 to 20 feet of sandy siltstone, which becomes conglomeratic to the west, and by 5 to 10 feet of recent gravel.

The beds dip 2° to 4° south. Very likely they are downfaulted against basalt, conglomerate, and latitic volcanics which crop out about half a mile east.

The manganiferous beds crop out over an area of about 40 acres, and drilling proved that they underlie an additional 30 acres of the terrace. The manganese thins out to the east and west. A lens of manganiferous silt 2 feet thick and 100 feet long crops out about half a mile to the north, and before erosion it may have been continuous with the ore at the main outcrop. Very likely the manganese extends an equal distance south of the present outcrop.

Although the manganese content is low, the large tonnage of easily available ore, coupled with its favorable geographic location, stimulated metallurgical research and two processes of extraction were considered by the Bureau of Mines: (1) beneficiating the ore by flotation to make at least a 15 percent concentrate, and then leaching the concentrate at the Three Kids plant (a 10 percent concentrate with 85 percent recovery was made by flotation early in February 1942); (2) leaching the ore in place or heap-leaching. Estimates on the cost of preparing the deposit for leaching the ore in place or for heap-leaching have been made by C. H. Johnson of the Bureau of Mines and these figures (10 cents a ton for leaching in place and 15 cents a ton for heap-leaching) are so low that this method may eventually receive further consideration.

Willow Beach deposit

The Willow Beach deposit is about 13 miles southeast of Boulder City, and 5 miles north of Willow Beach in Mohave County, Ariz.(fig.9). An unimproved dirt road, extending south from U. S. Highway 93-466 to Willow Beach, passes within 200 yards of the deposit.

Three manganiferous limestone beds from 8 inches to 2 feet thick are exposed for a distance of about half a mile around the edges of a wash. The beds are separated by 2 to 10 feet of barren limestone and fine silty sandstone. The ore consists of fine particles of wad in a limestone matrix, and averages 2 to 4 percent manganese.

Virgin River district

The Virgin River district includes the Virgin River and the Bauer-Dollery deposits north of Lake Mead and the Detrital Valley deposit south of Lake Mead. All are within the Boulder Dam National Recreational area.

Virgin River deposit

The Virgin River deposit is about 25 miles northeast of Boulder City, in T. 20 S., R. 67 E., Clark County, Nevada, and is accessible only by boat(pls. 42-44). The manganese deposits were discovered by Daniel Bonelli about 1900, and brief references to the deposit have been made by Birkenbine, Harder, and Longwell.12/ The Bureau of Mines dug and sampled 65 trenches during April and May 1941, and conducted an exploratory drilling program from October 1941 to January 1942.

The Muddy Creek formation at the Virgin River deposit includes beds correlative with all three units of the Muddy Creek formation in the Callville Basin. Unit no. 1 consists of pillow basalt and andesite flows and agglomerate interbedded with gypsum and fine clastics. Thorough intermixture of much of the gypsum and basalt suggests that the gypsum was deposited while the basalt was being extruded on the lake floor. The conglomerate of unit no. 2 unconformably overlies unit no. 1 and is in turn overlain unconformably by a series of massive basalt flows and conglomerates of unit no. 3.

Three discontinuous manganese-bearing beds occur near the base of unit no. 1, and higher in the section a zone of thin manganiferous beds in gypsum is traceable for about 8 miles.

The Virgin River deposit is on the flanks of a southeast-plunging syncline whose south limb dips slightly more steeply (25° to 40°) than the east limb (15° to 35°). The south limb is slightly warped, forming a subsidiary south-plunging syncline and a low elongate dome. A few minor north-south faults occur in the east limb.

Deposits of manganese minerals are localized in four places, two on the east limb and two on the south limb. The east-limb ore bodies are 900 and 2,600 feet in length but diamond drilling shows them to be less than 200 feet in width. Their thickness is from 2 to 29 feet and their manganese content averages about 7 percent.

On the south limb, three manganiferous beds are separated by basalt flows. Only the upper two of these beds contain ore in worthwhile quantities. The upper bed is from 10 to 25 feet thick, and, of an outcrop 1,800 feet long, about 150 feet contains about 7 percent manganese; the rest of the bed averages about 3 percent manganese. The middle bed crops out discontinuously for a distance of more than 3,000 feet; for 900 feet the bed is from 5 to 20 feet thick and averages about 10 percent manganese. The lower bed crops out only for a distance of about 200 feet; it contains less than 5 percent manganese.

As shown by diamond drilling the southern half of the lower ore body extends down dip for about 500 feet. Elsewhere the ore extends less than 200 feet down dip. The lower bed crops out in two places about a mile south of the other ore bodies, is about 5 feet thick,and contains about 5 percent manganese.

12/ Birkenbine, John, Mineral Resources U. S., 1902, p. 141, 1904.
Harder, E. C., Manganese deposits of the United States: U. S. Geol. Survey Bull. 427, p. 158, 1910.
Longwell, C. R., op. cit., p. 1424,1936.

Bauer-Dollery deposit

The Bauer-Dollery deposit is about 2 miles west of the Virgin River deposit and is accessible only by boat(pl. 42).

The stratigraphic section is similar to that at the Virgin River deposit and the rocks are probably of the same general age. Three thin, discontinuous manganiferous sandstone beds are interbedded with basalt flows, lenticular limestone beds, gypsum, and fine clastics. Several basic dikes intrude the bedded rocks. The deposit is on the north side of a broad dome where the beds, which dip 10° to 35°N., are broken by several northwest-trending faults.

The highly lenticular manganese beds consist of sandstone containing wad, psilomelane, pyrolusite, and manganite. Locally the beds containing wad are as much as 6 feet thick, but for the most part are not over 2 feet thick. They probably average less than 5 percent manganese. A few small lenses of psilomelane, about a foot thick, probably average 40 percent manganese. The small tonnage, low average grade, and the inaccessibility of the deposit will prohibit any immediate production.

Detrital Valley deposit

A zone of clayey gypsum containing several lenticular manganiferous beds crops out for about a mile on the west side of Detrital Valley, Ariz., near Lake Mead (fig. 9). The zone, which dips about 15° NE. is about 200 feet thick and is similar in appearance to the manganiferous gypsum beds in unit no. 1 on the north side of Lake Mead in the Virgin River deposit (see p. 100). The manganiferous beds are a few inches to 2 feet thick and are separated by 15 to 20 feet of barren gypsum. Although the zone has not been sampled, the average grade is probably less than 1 percent manganese.

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