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THE THREE KIDS MANGANESE DISTRICT CLARK COUNTY, NEVADA

BY

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(Pages 297–319)

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THE THREE KIDS MANGANESE DISTRICT, CLARK COUNTY, NEVADA

By C. B. Hunt, V. E. McKelvey, and J. H. Wiese

ABSTRACT

The Three Kids manganese district, in Clark County, Nev., has produced between 15,000 and 20,000 tons of ore, which contained between 30 and 40 percent manganese, 1.5 percent iron, and 12 percent silica. It is estimated that the reserves in the district aggregate about 5,500,000 tons of ore averaging about 10 percent manganese. Of this amount about 800,000 tons contains more than 20 percent manganese and 4,700,000 tons contains from 5 to 20 percent manganese.

The manganese ore is a sedimentary deposit and consists of wad interbedded with lake or playa sediments belonging to the Muddy Creek formation of Pliocene (?) age. Where the manganese content is as high as 30 percent, the wad forms thick massive beds separated by thin almost barren partings. Where the content is low, the wad forms very thin lenses or small irregular blebs scattered through sandstone, or a cement for the sand grains. The zone of manganiferous beds ranges from about 10 to 75 feet in aggregate thickness, but at most places the thickness is between 25 and 40 feet.

INTRODUCTION

The Three Kids district is 15 miles southeast of Las Vegas and 8 miles northwest of Boulder City, in Clark County, Nev. (see fig. 31). The principal workings are slightly less than 2,000 feet above sea level at the upper edge of the sloping plain along the northwest foot of the River Mountains.

Good roads connect the district with the nearby towns. About 10 miles southeast of Las Vegas the main paved highway leading to Boulder City is joined by a graded, secondary road that passes a mile north of the principal mines. These roads have no steep grades and would be easy to maintain for trucking. The distance by road from the district to either Las Vegas or Boulder City is about 16 miles, and to the nearest point on Lake Mead, which

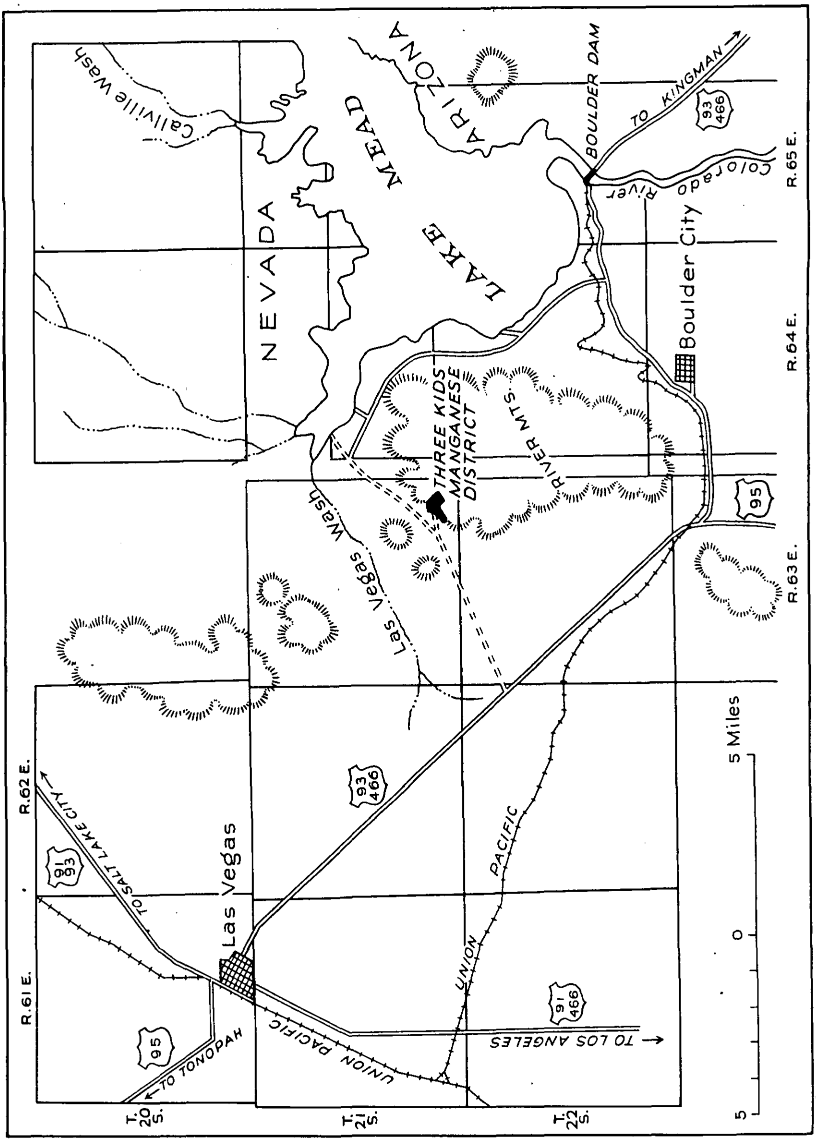

Figure 31.--Map of southern Nevada showing location of the Three Kids manganese district (black).

is about 700 feet lower, it is about 6 miles. A branch line of the Union Pacific Railroad extending from Las Vegas to Boulder City passes about 6 miles southwest of the district.

This report contains the geologic record of a cooperative investigation of the district by the Bureau of Mines and the

Geological Survey, United States Department of the Interior, during the winter of 1940-41. The Survey party studied the geologic features of the district, made a geologic and topographic map on the scale of 100 feet to 1 inch, and made the geologic interpretation of the drill cores recovered by the drilling of the Bureau. The northern part of the district was mapped by V. E. McKelvey and J. H. Wiese, and the remainder, including mine workings, by C. B. Hunt and V. H. Johnson. The Bureau of Mines party carried out a program of exploration by trenching and sinking shafts, by drilling with diamond core drill, and by taking numerous samples of the workings and cores. The Bureau work was directed by C. H. Johnson, and Malcolm Roberts supervised the sampling.

H. G. Ferguson and F. C. Calkins, of the Geological Survey, offered many helpful suggestions and criticisms during the preparation of the report.

Production

According to Jones [1/] the Three Kids deposit was discovered in the fall of 1917, and by the summer of 1918 it had produced about 12,000 tons of ore, which contained approximately 40 percent manganese, 1.5 percent iron, and 12 percent silica. All of this ore was taken from the open pit near the western edge of the Three Kids claim. Several thousand tons in addition was produced in 1919 and 1920, by exhausting the block of ore in this open pit and opening underground workings at the center of the claim.

Only a few hundred tons of ore was produced during the period 1920-40, but the M. A. Hanna Co., which recently took over the Hydro group of claims, and the Western Minerals Exploration

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1/ Jones, E. L., Jr., Deposits of manganese ore in Nevada: U. S. Geol. Survey Bull. 710, p. 222, 1920.

Co., which took over the Three Kids mine and the Annex and Las Vegas groups of claims, have further explored the deposits by diamond drilling.

In the fall of 1940 these owners and the owners of the Lowney claim granted permission to the Bureau of Mines to drill, trench, and sample their properties in order to determine the total quantity of ore.

In April 1941, the Bureau of Mines, under contract with the Western Minerals Exploration Co., stripped the surface cover from part of the old Three Kids mine and removed about 3,650 tons of ore by open-pit methods. This ore was trucked to the Bureau of Mines Electrometallurgical Laboratory at Boulder City for metallurgical tests.

GEOLOGY

The general geology of the district has been described by Hale,[2/] Jones,[3/] and Hewett and Webber.[4/] As pointed out by them, the manganese deposits are in sedimentary rocks, which overlie a thick series of volcanic rocks. Both the sedimentary and volcanic rocks have been tilted and faulted. The sedimentary rocks are part of the Muddy Creek formation,[5/] which is an extensive lake and playa deposit of Pliocene (?) age in southern Nevada and northwestern Arizona. The volcanic rocks are assumed to be part of the middle Tertiary eruptives which are widespread through the southwest. The following section illustrates the sequence and character of the rocks in and near the district.

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

3/ Jones, E. L., Jr., op. cit., pp. 222-232.

4/ Hewett, D. F., and Webber, B. N., Bedded deposits of manganese oxides near Las Vegas, Nev.: Nevada Univ. Bull., vol. 25, No. 6, pp. 5-17, 1931.

5/ Longwell, C. L., Geology of the Muddy Mountains, Nev.: U. S. Geol. Survey Bull. 798, pp. 90-96, 1928.

Sequence and character of rocks on the north side of the River Mountains, including the Three Kids manganese district

	Feet
Pliocene (?) Muddy Creek formation:	
11. Shale, sandy shale, sandstone, gypsum..........	250+
10. Conglomerate; like basal conglomerate (number 5 below) of the formation except for absence of basaltic lava flows and flow breccias. This and overlying unit exposed close to the west and north sides of the Three Kids district, but not present within the district...	75-150
Angular unconformity.	
9. Shale, sandy shale, sandstone; thickness varies on account of the unconformity at top. Maximum thickness..........................	50
8. Conglomerate; like basal conglomerate (number 5 below) of the formation except for absence of basaltic lava flows and flow breccias. Lower 25 feet locally is massive. This and overlying unit exposed east of the Three Kids district, but not present within the district....................................	50-100
Angular unconformity.	
7. Gypsum, red beds; gypsum, red clay, tuff, sandy shale, sandstone; gypsum beds are massive but contain thin contorted interbeds of clay and silt; thickness varies because of the unconformity at the top. Maximum thickness.......	1,000
6. Manganiferous beds; mostly wad at south end of Three Kids graben; elsewhere composed largely of tuffaceous sand containing wad in thin beds and in finely disseminated blebs........	10-75
5. Basal conglomerate; andesitic (?) lava, flow breccia, and interbedded, evenly bedded conglomerate containing pebbles, cobbles, and boulders derived from underlying volcanic rocks; some boulders are a foot in diameter, but pebbles predominate and are mostly less than 2 inches in diameter; boulders generally are isolated in reddish-brown laminated matrix. Thickness varies because of basal overlap......................................	0-500
Angular unconformity.	
Miocene (?) volcanics:	
4. Lava and flow breccias; stony glass, chocolate color; feldspar is uniformly sodic plagioclase; hornblende common. Thickness varies on account of the unconformity at the top....	0-300
3. Felsitic lava; white vitrophyre, contains boulders of frothy pumice and granular light-gray glass; uppermost 50 feet is thin-banded black or dark-gray perlitic glass containing biotite phenocrysts............................	200

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Sequence and character of rocks on the north side of the River Mountains--Continued.

	Feet
Miocene (?) volcanics--Continued.	
2. Felsitic lava or breccia; white vitrophyre containing boulders of dense stony glass; phenocrysts of plagioclase and biotite; weathers tan or yellow..................................	200
1. Latite; reddish brown; plagioclase and biotite phenocrysts; groundmass is dense stony glass containing microlites of plagioclase. Examined only at the hill at the south end of the Lowney claim................................	300+

Miocene (?) volcanic rocks

The age of the pre-Muddy Creek volcanic rocks in the Three Kids district cannot be accurately determined, but they are tentatively assigned to the Miocene because they resemble the other middle Tertiary eruptives in the southwest and are overlain by late Tertiary sedimentary deposits. These rocks were not examined in detail, but their general appearance is indicated in the preceding table. They include latitic lava and flow breccia, almost all porphyritic, with a more or less glassy groundmass.

The River Mountains consist of these volcanic rocks, but only the upper 1,000 feet of the series is exposed in the district. The flows dip outward from the mountains and extend beneath the Muddy Creek formation, which overlaps them with an angular unconformity.

Muddy Creek formation

The Muddy Creek formation is a lake and playa deposit which is probably of Pliocene age. About 1,000 feet of the formation is exposed in the district. The general lithologic character and sequence of the exposed beds are shown in the section on page 301.

The formation was deposited in a basin produced by earlier deformation which controlled the topography of the sides of the basin. The graben in which the Three Kids mine is located (see pl. 45) came into existence before Muddy Creek time and was an elongate topographic depression that connected with the more open part of the basin to the north. The formation evidently was deposited upon a rough surface produced by the erosion of faulted and tilted blocks of the underlying lavas, for it extends unconformably across different members of the lava series, and in places the strata at the base of the formation are cut off by overlap against the old erosion surface.

The Muddy Creek formation can be divided into several members, each having a basal conglomerate overlain by finer-grained beds. The members are separated by angular unconformities. Only one of the members is exposed in the area shown on plate 45.

The conglomerate of the oldest beds of the Muddy Creek formation in the Three Kids district contains boulders of volcanic rocks in a reddish, fine-grained or gritty matrix, which is so abundant in most places that the boulders commonly are isolated or even widely separated. The conglomerate is well bedded, and even thin beds persist for hundreds of feet. Interbedded with the conglomerate are lava flows and layers of breccia, apparently andesitic in composition. These are few and thin in the district, but they are more numerous and thicker to the east.

The conglomerate is absent in the southeastern part of the Three Kids graben, where younger beds rest directly on the volcanic rocks. In the southwestern part of the graben the conglomerate is at least 25 feet thick, and it thickens northward to 125 feet at the drill hole 100 feet north of the northeast corner of the Triangle fraction claim. In the western part of the district the conglomerate is at least 250 feet thick. Numerous exposures of the unconformity at the base of the conglomerate indicate that this variation in thickness is due largely to basal overlap.

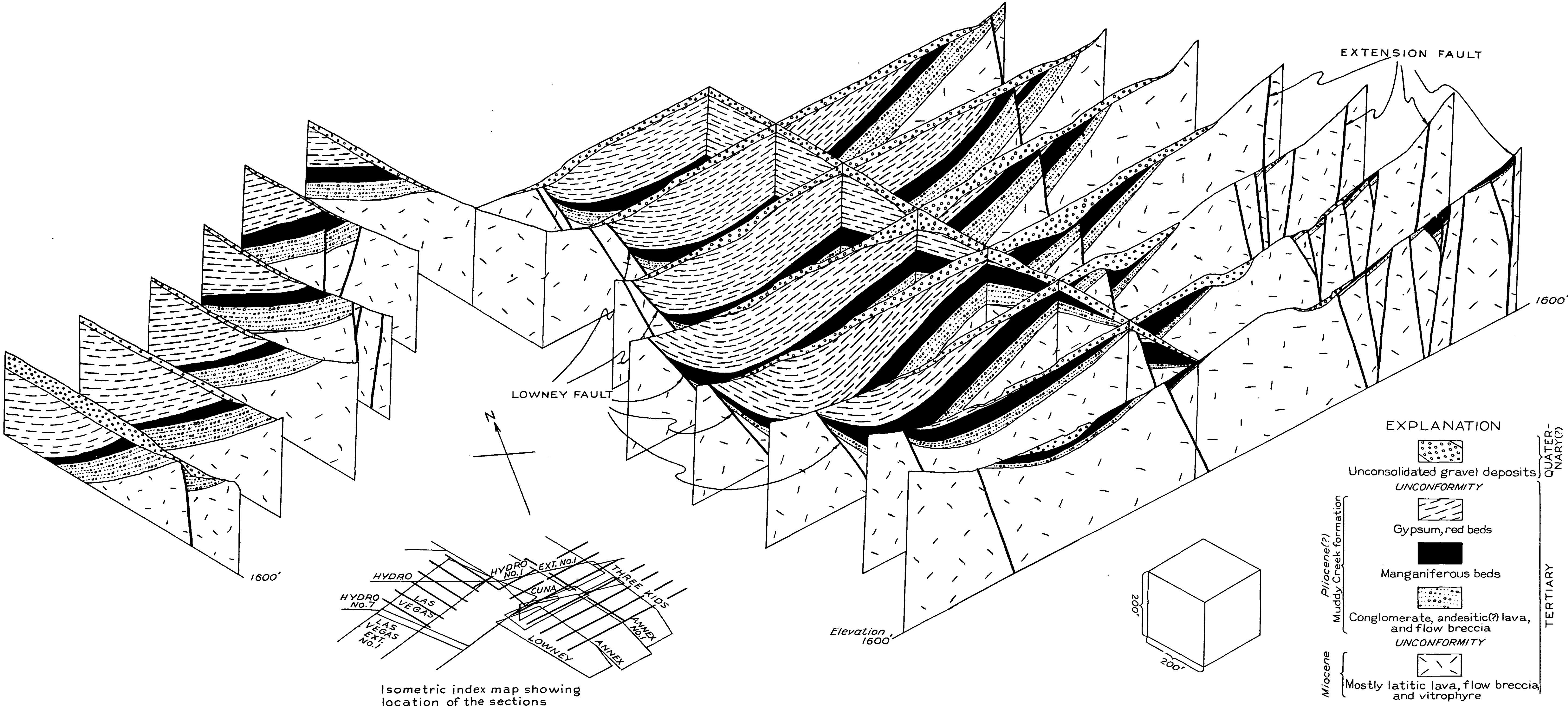
A zone of manganiferous beds as much as 75 feet thick overlies the conglomerate and at places extends beyond the conglomerate onto the volcanic rocks. In the southeastern part of the Three Kids graben, at the site of the Three Kids mine and for a short distance to the west and northwest where the zone of manganiferous material is more than 50 feet thick, it is composed of beds of massive wad with partings of sand or silt. Some of the partings are almost paper-thin minute laminae; a few are as much as a foot thick. Many are contorted like the partings in gypsum beds, as if the wad, like gypsum, had been plastically deformed.

In the small fault blocks east of the mine the manganiferous beds contain a high proportion of sand and clay and are of lower grade than at the mine. Westward also the proportion of sand and clay increases.

Northward in the graben the thickness of the zone of manganiferous beds diminishes and the proportion of sand and clay increases, although at the north end of the district, west of the Lowney fault, drill holes reveal 75 feet of beds containing 15 to 25 percent manganese. In the western part of the district, the manganiferous zone is usually less than 25 feet thick, and the wad here occurs only in thin beds and in irregular blebs, which are scattered through some of the sand layers.

Individual beds of manganese oxide cannot be traced more than a few feet, and yet the strata overlying the conglomerate are manganiferous, seemingly continuously so, for at least 6 miles across the north end of the volcanic hills. The deposits and their origin are described in more detail on pages 306 to 314.

The zone of manganiferous beds is conformably overlain by gypsum and fine-grained clastic rock. The gypsum beds range in thickness from mere laminae to as much as 10 to 15 feet thick. Thin partings of red shale and sandy shale are abundant in the gypsum, and thin partings of gypsum are equally abundant in the



ISOMETRIC DIAGRAM SHOWING THE GENERAL GEOLOGIC STRUCTURE OF THE THREE KIDS DISTRICT

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thicker beds of shale and sand. Where gypsum predominates the bedding is much contorted. Also, there are many beds of gray tuff, a few inches to a few feet thick, composed of delicate shards of glass.

This series of gypsum and red beds attains a maximum thickness of 1,000 feet or more, but locally it is much thinner because these beds were faulted, tilted, and eroded before the deposition of the overlying member of the Muddy Creek formation.

Gravel deposits

Gravel deposited in a recent period of erosion overlies and conceals the Muddy Creek formation in the greater part of the Three Kids graben and in the western part of the district. In some places the gravel is as much as 60 feet thick (see pl. 46).

Structure

The Three Kids manganese district is on the northwestern flank of the uplifted volcanic rocks in the River Mountains. The manganiferous beds, together with the other strata belonging to the Muddy Creek formation, dip in general northwestward from the uplift, but this general structure is obscured by block faulting. Practically all the faults are normal. Most of them trend northward or northwestward, and on most of these the downthrow is to the east.

The general structure of the district is illustrated by the map and block diagram in plate 47. In the eastern part of the district is the Three Kids graben, which has been dropped between the Extension and Lowney faults. The western part of the district comprises a series of small, northwest-dipping fault blocks along the Las Vegas and Las Vegas Extension claims. Almost certainly the structure, as illustrated, is greatly over-simplified, for most of the area is so covered with gravel that the structure between the drill holes is largely a matter of conjecture. For

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example, it seems likely that the Three Kids graben is broken by many small faults like those exposed in the vicinity of the Three Kids mine (fig. 34), but the drill holes are not spaced closely enough to reveal the position or number of small faults.

The faulting and tilting began before the deposition of the Muddy Creek formation and were repeated intermittently after the deposition of the part of the formation that is exposed in the district.

Some details of the structure, as revealed by the mine workings, are described on pages 315 to 319.

MANGANESE DEPOSITS

Character of the ore

Practically all the manganese oxide is porous, brown, earthy wad. Only traces have been found of another oxide, probably manganite, which occurs as small, soft needles having a brown streak. At some places, particularly in the western part of the district, thin beds of wad have been cemented by opal, and these beds usually contain more or less green chloritic material.

Jones [6/] reported that a 1-foot cube of ore weighed 81 pounds when taken from the Three Kids mine and 73 pounds after being exposed to the air for a few months; the wad therefore must have contained at least 10 percent water. The results of a similar test by Malcolm Roberts of the Bureau of Mines are shown graphically in figure 32.

The densities of a few ore specimens, as determined by Jones and by Malcolm Roberts and C. H. Johnson of the Bureau of Mines, range from about 1.2 (26.7 cubic feet per ton) to 2.2 (14.6 cubic feet per ton). [7/] In general, the ore of low density contains 30 to 40 percent of manganese and that of high density contains less than 10 percent manganese.

6/ Jones, E. L., Jr., op. cit., p. 226.
7/ Oral communication.

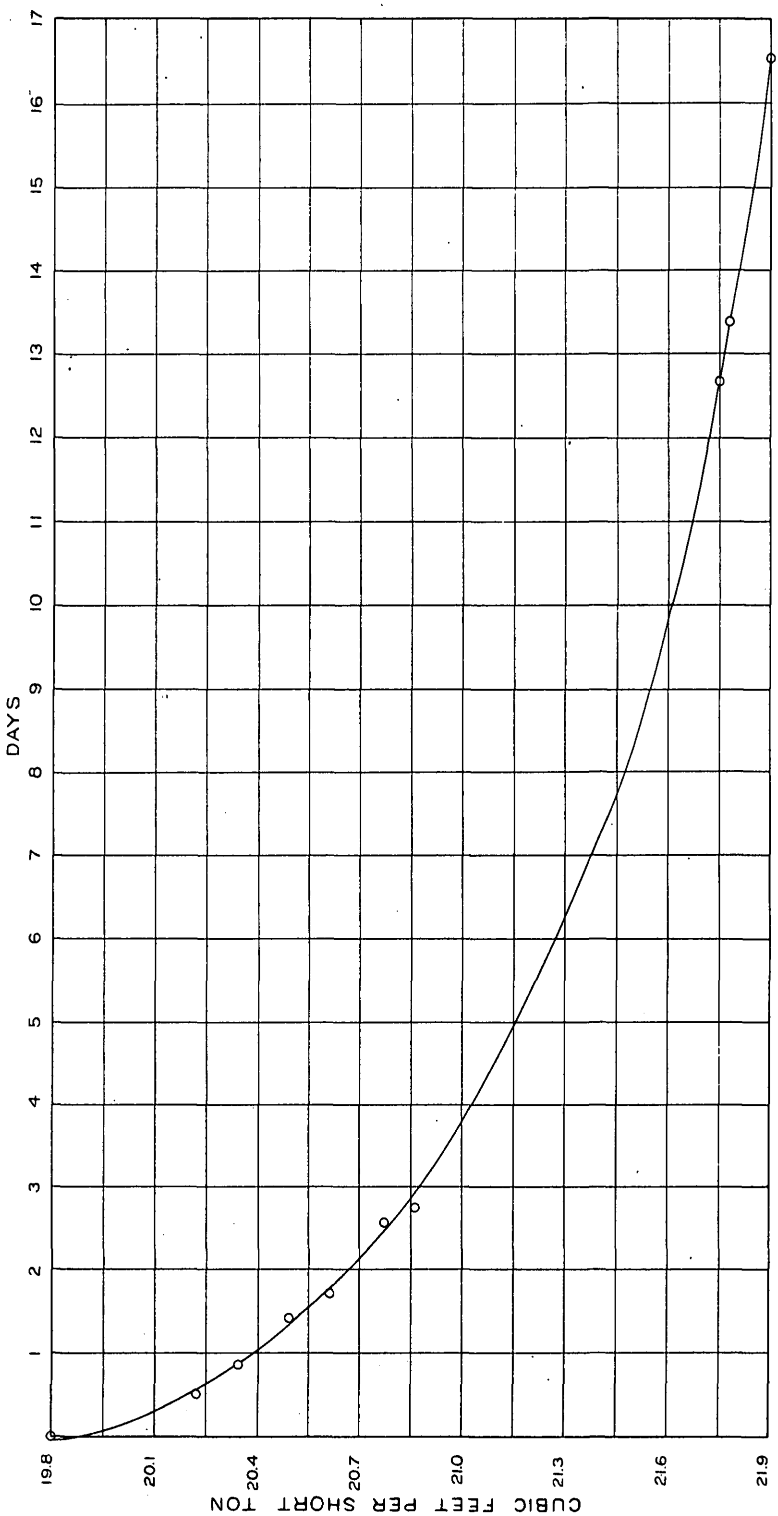

Figure 32.--Graph showing loss in weight, at room temperature, of a block of Three Kids manganese ore (grade about 35 percent Mn) during the first 17 days after it had been mined. Prepared by Malcolm Roberts of the Bureau of Mines.

The only complete analysis of the ore is that given below, quoted from Jones.[8]

Analysis of manganese ore from Three Kids deposit
[Smith, Emery & Co., Los Angeles, Calif., analysts]

MnO_2	56.04	MgO	1.41
MnO	7.08	CuO	.49
Fe_2O_3	1.68	ZnO	None
Al_2O_3	1.85	P_2O_5	.07
SiO_2	13.73	SO_3	.43
PbO	2.07	As_2O_3	.06
BaO	.02	$K_2O + Na_2O$	3.82
CaO	Trace	H_2O by difference	11.25

A large part of the impurities must consist of clay, sand and tuff, the proportions of which vary widely. Hewett and Webber[9] describe the residual material after dissolving the manganese in sulfurous acid as follows:

> The most abundant grains are volcanic glass, plagioclase, quartz, and biotite that largely range from 0.2 to 0.5 millimeter in diameter, but there are also numerous perfect crystals of the zeolite phillipsite and the carbonate of lead, cerussite.

Where the manganese content is high, the wad is massive and forms thick beds separated by thin partings of slightly manganiferous sand. Where the manganese content is low, the wad forms very thin lenses free of sand, cement in the matrix of the sand, or small blebs scattered through sand.

Form of the deposits

The manganiferous zone, as a whole, persists at one stratigraphic position for at least 6 miles, though individual beds within the zone are lenticular. In places, moreover, the manganese oxide may cut slightly across the bedding, or, rarely, a lens of high-grade ore may end abruptly against barren sand.

Manganese oxide also occurs outside of the main ore zone, forming thin lenticular beds in the underlying conglomerate and overlying gypsiferous red beds. Only a few of these lenses are more than 6 inches thick, and none are thick enough to constitute

8/ Jones, E. L., Jr., op. cit., p. 226.
9/ Hewett, D. F., and Webber, B. N., op. cit., p. 14.

ore. A few veins of manganiferous opal cut the volcanic rocks, but only a very few are as much as an inch wide.

Grade and thickness

Figure 33 shows the principal variations in grade of the manganiferous beds. The three places at which the manganese is most concentrated are all on relatively high fault blocks, which had been considerably displaced before the Muddy Creek formation was deposited. In the southeastern part of the Three Kids graben, where the grade of the ore is highest, the zone of manganiferous beds is about 50 feet thick and consists almost wholly of beds of wad separated by thin lenses of sand. At the Three Kids mine the grade as a whole averages somewhat less than 35 percent manganese, although it has been reported that 40-percent ore was shipped from here during 1917-18. The grade diminishes in all directions from the Three Kids mine.

To the east, in the small prospect pits close to the Extension fault, wad occurs in thin beds and as a minor constituent of the cement of sandy beds. The beds of wad average about 20 percent manganese, but the average for the whole zone is much less. To the north, and also to the west, the manganiferous zone maintains its thickness but becomes progressively leaner and more impoverished, although the change in manganese content is less abrupt in these directions than to the east. About 800 feet northwestward from the Three Kids mine, the manganiferous zone averages only 10 to 15 percent manganese and the thickness is slightly more than 50 feet. Where the valley in the graben opens northward and merges with the plain that slopes northward from the mountains, the average manganese content is less than 5 percent.

In most of the western part of the district, the manganese content is about 5 percent and the thickness of the manganiferous zone is only about 25 feet. North of the Las Vegas shaft, however, the manganese content is much higher and the zone is 75 feet or more thick.

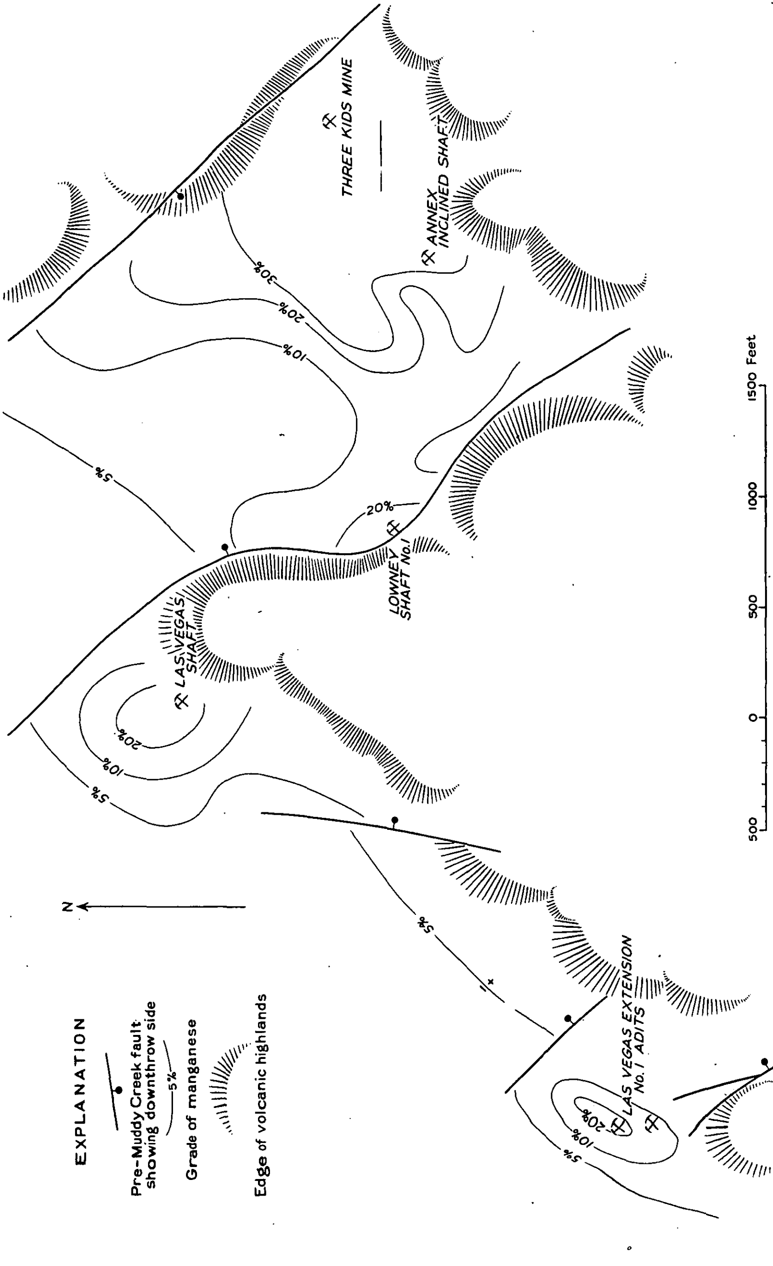

Figure 33.--Map showing the lateral variation of grade of the manganiferous beds in the Three Kids district.

In the southern part of Las Vegas Extension No. 1 the ore is richer than in adjoining areas, although the whole series of beds contains, on the average, only about 10 percent manganese. The percentage is only half as high beyond the fault 200 feet north of the shaft.

Although the grade of the ore varies considerably in the district, the most abrupt change of grade for the series of manganese-bearing beds as a whole is found between two drill holes 50 feet apart in the center of the Three Kids graben. In one of these holes the zone is about 50 feet thick and averages 31.6 percent manganese; at the other the zone is about 58 feet thick and averages only 20.2 percent manganese. More abrupt variations of grade occur along individual beds within the ore zone. In some 5-foot beds, the manganese content decreases a third within a distance of 5 feet.

Variations vertically across the ore zone are very abrupt, as shown by the following logs, chosen as representative of high-grade and low-grade blocks of ore:

Section of high-grade ore

	Thickness (feet)	Manganese (percent)
Gray crumbly sand and silt, impregnated with manganese oxide..................	5	28
Do..............................	5	32
Do..............................	2½	33
Do..............................	4	28
Thin-bedded sand and silt, impregnated with manganese oxide; two partings ½ inch thick are barren...............	5	34
Do..............................	2½	14
Thin-bedded sand and silt impregnated with manganese oxide and separated by thin beds of massive wad.............	5	39
Do., but includes a few 1/32-inch partings of sand................	5	35
Do., with thicker low-grade beds..	5	27
Sand and silt impregnated with manganese oxide............................	5	18
	44	Average 29.5

Section of low-grade ore

	Thickness (feet)	Manganese (percent)
Sandy clay impregnated with manganese oxide..................................	1	19
Fine-grained sand with small blebs of manganese oxide......................	1	19
Do..............................	5	22
Do., except that top 18 inches is gypsiferous silt that contains only traces of manganese.......	5	8
Do.; blebs of manganese oxide widely spaced except in bottom 6 inches......................	3	10
Do.; blebs of manganese oxide widely spaced..................	7	10
Do..............................	11	10
Do..............................	5	13
Do., but contains a ½-inch bed of massive wad....................	5	8
	43	Average 11.4

Origin

Jones 10/ believed that the ore was formed by replacement of the tuffs and sand beds by manganese oxide introduced along the fissures and faults, whereas Hale 11/ and later Hewett and Webber 12/ ascribed a sedimentary origin to the deposits.

Apparently the main reasons for suspecting a genetic relation between the ore bodies and the faults are the abundance of faults exposed in the mine workings and the occurrence of ore along the fault at the north adit on the Las Vegas Extension No. 1 claim. But the detailed geologic mapping of the district, and reconnaissance mapping in the region adjoining the district, show that the manganese oxide does not bear any orderly relation to the faulting. Furthermore, the ore along the fault explored by the north adit on the Las Vegas Extension is not due to replacement along a fissure but is a block of the ore bed

10/ Jones, E. L., Jr., op. cit., p. 225.
11/ Hale, F. A., Jr., op. cit.
12/ Hewett, D. F., and Webber, B. N., op. cit., pp. 15-16.

now bounded on each side by stratigraphically higher beds as a result of reversed movement on the fault (fig. 35, C).

Veins of manganiferous opal, generally associated with earlier chloritic material, occur in the volcanic rocks, and along some of these veins the host rock has been slightly altered by leaching for a width of a quarter of an inch. Crosscutting and bedding veins of similar materials occur, however, in the Muddy Creek formation and in volcanic rocks throughout the southwest. These veins are younger than the manganese beds and probably were formed by relatively recent supergene processes. An adequate source for the silica is at hand in the abundant tuffs of the Muddy Creek formation.

The evidence favoring a sedimentary origin of the manganese has been summarized as follows:[13]

1. In their broader relations, tabular bodies of manganese oxides are found in a persistent zone about 100 feet above the base of a series of volcanic tuffs and gypsum beds.
2. The thin partings of tuffaceous material between the layers of manganese oxide are known to persist at least 100 feet in several places without great change in thickness, even though the surfaces of contact are not precisely sharp and definite. In their larger dimensions the layers of both oxides and partings are lenticular. These features are consistent with the idea that the beds accumulated in intermittent playas under arid conditions.
3. The most abundant oxide of manganese is brown earthy wad. Wad has been noted widely in residual deposits as well as in stratified material of recent origin, but does not seem to be recorded as a product of hypogene replacement.
4. The variations from the hardness and coherence characteristic of the normal earthy oxide seem to depend upon cementation by opal and chalcedony or by neotocite, all probably of recent supergene origin under the arid conditions prevailing in this region.
5. In thin sections of distinctly bedded materials no evidence of replacement of tuffaceous material or silicate minerals by manganese oxides has been noted. In the few places where small masses of wad of irregular shape appear to replace tuffs, it seems more probable that they have been formed recently by water of surface origin.

In general, these conclusions have been sustained by the geologic mapping, and the manganiferous beds are now known to extend, essentially at one stratigraphic horizon, far beyond the limits of the Three Kids district.

13/ Hewett, D. F., and Webber, B. N., op. cit., pp. 15-16.

The manganese may have been supplied by hot springs,[14] but whether the concentration of manganese at the south end of the Three Kids graben and at other places in the district is due to proximity to the source or to environmental factors is uncertain.

Reserves

Apart from rock with less than 5 percent manganese, which probably would not be worth mining, the mapped portion of the Three Kids district contains about 5,500,000 short tons of ore, averaging about 10 percent manganese. Of this amount about 800,000 tons contains more than 20 percent manganese and probably would average only slightly less than 25 percent. The remaining 4,700,000 tons of ore, ranging from 5 to 20 percent manganese, probably would average 7 or 8 percent.

These estimates assume that the weight of 20 cubic feet of ore in place is approximately 1 short ton, as is indicated by the measurements of Roberts, Johnson, and Jones (p. 306). It is assumed, further, that the full thickness of the manganiferous zone would be mined, and that the thickness and grade change at a uniform rate between the places where those factors are known. Selective mining might obtain considerably more ore of commercial grade than is indicated by these estimates, because at some places rich parts of the beds are of minable thickness and at other places lean partings are thick enough to be excluded.

In making estimates of reserves of the different grades of ore, one must consider the fact that the tenor of the beds as a whole is known to change laterally by as much as 3 percent of manganese in 5 feet and that of the individual 5-foot beds by as much as 15 percent of manganese in 5 feet.

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

Application of geology to mining

The Muddy Creek formation is overlain by poorly consolidated gravel deposits, and all mine workings would have to be cribbed carefully. These unconsolidated deposits might also cause trouble at strip mines because they would not stand at the same angle of repose as the underlying, more consolidated beds, which need but little support. Plate 46 shows the extent of the unconsolidated deposits and gives some idea of their thickness.

In at least three ways the structural history (see p. 305) has an important bearing on the distribution of ore and the economic development of the region. In the first place, it is not safe to project faults from older to younger strata, because a fault having considerable displacement in the volcanic series may have been formed before the Muddy Creek rocks were laid down, or may displace the Muddy Creek much less than it displaces the volcanic rocks. Secondly, it is not safe to assume that the ore bed at a given place is not faulted simply because overlying strata are not faulted there. And, thirdly, the intermittent uplift and faulting permitted erosion to bevel the faulted strata so that at some places younger strata extend across the bevelled edges of the ore bed, which may for this reason vary abruptly in thickness. Hence prospecting, especially if extended beyond the borders of the district, must depend on interpretation of structures that are not fully exposed.

Both the geologic map (pl. 45) and the isometric diagram (pl. 47) greatly generalize the structure of the district, although it is unlikely that any large faults have been overlooked. The probability that the ore is broken by numerous faults should be considered in planning mining operations. Most of the known faults are parallel, or nearly so, to the strike of the beds, so that trenches parallel to the faults could be made of nearly uniform depth. Extensive underground development should be preceded by enough exploration to reveal the structure fully.

MINE WORKINGS

The largest workings in the district are on the Three Kids claim. At the underground workings and open pit to the south, the ore zone, at least 50 feet thick, is revealed in a series of three small, westward-dipping fault blocks (fig. 34). Three other fault blocks are exposed in the open pit 200 feet west of the underground workings.

On the Annex and Annex No. 1 claims the main workings consist of a vertical shaft more than 60 feet deep, an inclined shaft 130 feet long, and an inclined shaft 75 feet long on each side of which are two large rooms each about 50 feet long.

The vertical shaft reached ore under the gravel 23½ feet below the surface. The bottom of the shaft is just below the base of the ore zone, the stratigraphic thickness of which is about 32 feet. The beds strike N. 10° E. and dip 30° NW., so that a greater thickness of ore undoubtedly underlies the gravel northwest of the shaft.

The workings of the two inclined shafts are shown on plate 45. The longer shaft roughly follows the bedding of the ore northwestward, and its face must be close to the fault that cuts off the ore by raising the volcanic rocks to the west (pl. 45). The other shaft crosses the bedding southeastward and the rooms are wide drifts along the strike of the beds.

On the Lowney claim, the Lowney shaft No. 2, which was opened by the Bureau of Mines, reveals a stratigraphic thickness of 36 feet of ore striking N. 50° W. and dipping 20°-25° NE. The Lowney No. 1 shaft, about 30 feet deep, connects with a hall that extends about 80 feet to the northwest (see pl. 45). At these workings the ore, 7½ feet thick, dips 40° NE. At the prospect opening 50 feet southeast of the shaft the ore is about 3 feet thick. At these workings the ore probably is thinned by

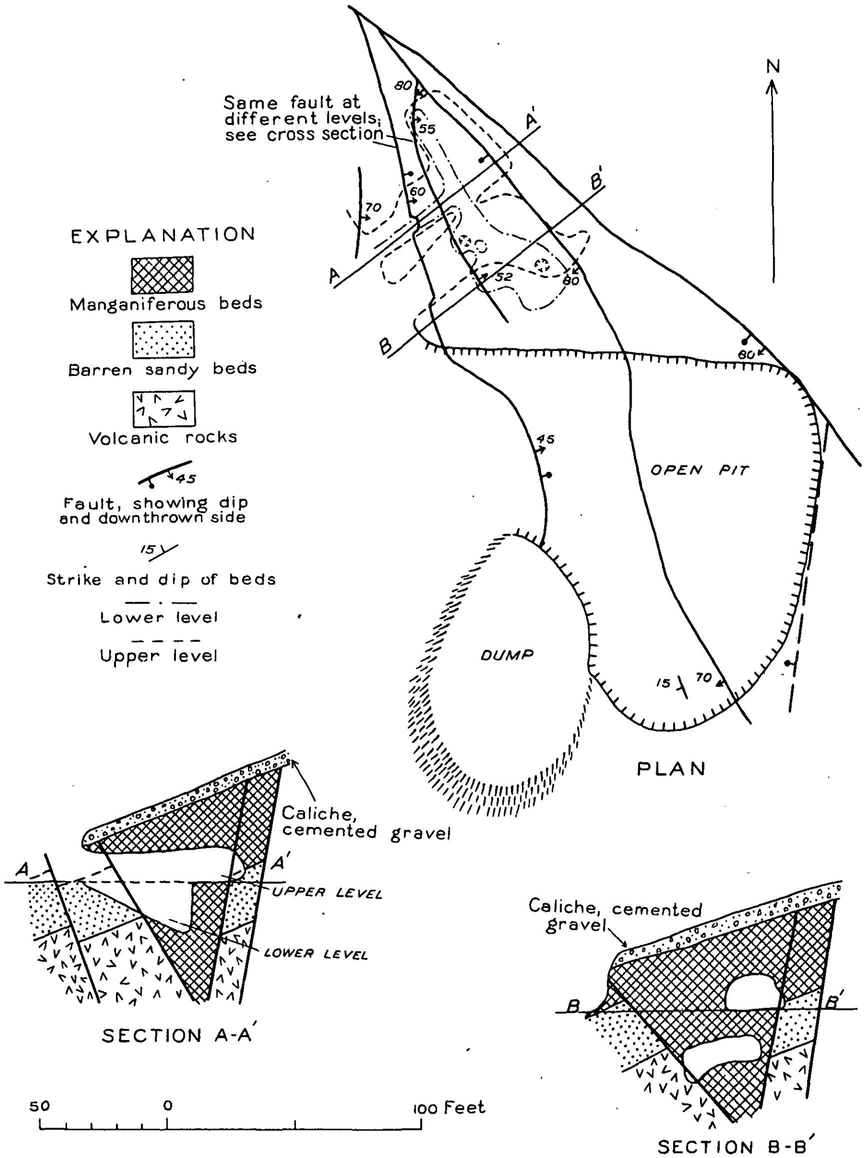

Figure 34.--Map and sections showing the geology and workings at the Three Kids mine.

drag against the Lowney fault, for much greater thicknesses of ore were encountered in the drill holes to the east.

The deepest shafts on the Las Vegas and Las Vegas Extension No. 1 claims are each about 25 feet deep. On the Las Vegas

Extension No. 1, there are two adits 60 and 100 feet long respectively (pl. 45 and fig. 35). The beds dip about 40° NW. and are broken by several faults that trend nearly at right

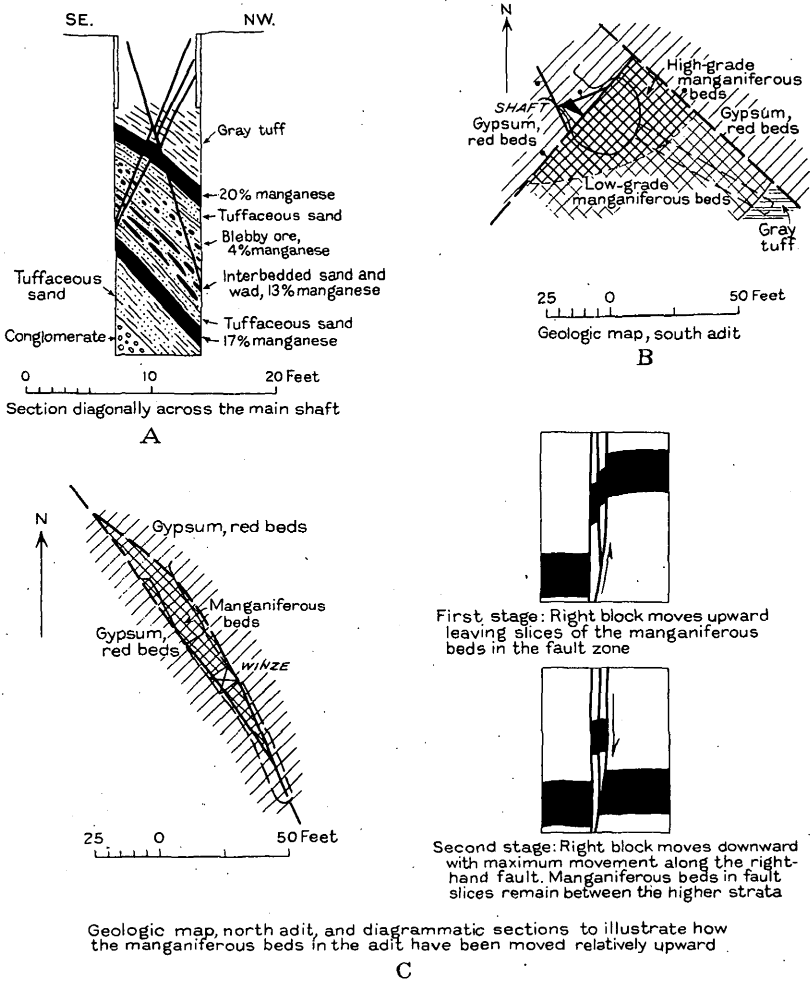

Figure 35.—Sketch maps and sections of the principal workings on Las Vegas Extension No. 1 claim.

angles to the beds. Several faults are exposed at the south adit (fig. 35, B). At the north adit a block of ore occurs in a fault slice between blocks of the gypsum and red beds that are stratigraphically higher than the ore (fig. 35, C).

The structure of the ore zone in the vicinity of the Las Vegas shaft is not fully understood. In general, the zone dips about 25° NW., but it is broken by faults, the pattern of which cannot be fully determined because of the incomplete exposures. The trend of most of the faults seems to diverge about 15° from that of the beds.

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