IC bureau of mines information circular 7990

MANGANESE DEPOSITS OF EASTERN ARIZONA

By L. L. Farnham, L. A. Stewart, and C. W. DeLong

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
(1961)

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MANGANESE DEPOSITS OF EASTERN ARIZONA[1/]

by

L. L. Farnham,[2/] L. A. Stewart,[2/] and C. W. DeLong[3/]

INTRODUCTION AND SUMMARY

This paper is one of a series covering mineral resources of the Nation. It describes briefly most of the known manganese deposits of eastern Arizona, which for the purpose of this report includes the counties of Navajo, Apache, Gila, Graham, Greenlee, Pinal, Pima, Santa Cruz, and Cochise. With few exceptions, these descriptions are the result of field examinations by the writers.

Work on this paper was begun in May 1956, and in the following 18 months 151 deposits were examined. The distribution of the deposits by counties is as follows: 1 in Navajo, and 1 in Apache, 37 in Gila, 4 in Graham, 13 in Greenlee, 25 in Pinal, 13 in Pima, 12 in Santa Cruz, and 45 in Cochise.

In surveyed areas the locations of the deposits are described by section, township, and range and in unsurveyed areas, by approximate projections of these subdivisions. The township and range numbers refer to the Gila and Salt River base and meridian.

The history, production, ownership, geologic setting, and mining methods used are discussed for most of the deposits that were visited. Probably, some occurrences have been overlooked, but all of the principal ones have been examined.

Ore dressing studies were made of typical ores from several of the larger districts. The work was performed in the laboratory of the Bureau of Mines Tucson Metallurgy Research Laboratory. The results of these studies are given with the descriptions of the deposits from which the samples were taken.

ACKNOWLEDGMENTS

The writers wish to acknowledge the cooperation and assistance of the owners and operators of the various properties. Special acknowledgments are

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1/ Work on manuscript completed September 1959.
2/ Mining engineer, Bureau of Mines, Tucson, Ariz.
3/ Metallurgist, Bureau of Mines, Tucson, Ariz.

due the Arizona Bureau of Mines and the Federal Geological Survey, whose work has been used freely in the preparation of this paper.

Special acknowledgment also is made to the officials of the Magma Copper Co. for their cooperation during the investigation. The company, some years previously, had mapped the outcrops of the deposits in the northern part of the district. This map was made available to the authors and was a great aid in locating and describing the manganese deposits in the Superior (Pinal County) area.

PHYSICAL FEATURES AND CLIMATE

Arizona is divided into three physiographic regions: The Colorado Plateau region, which covers the northern third of the State; the Mountain region, which is south of the plateau; and the Desert region, which occupies much of the southwestern part of the State. (See fig. 1.) Navajo, Apache, and the northern parts of Graham, Gila, and Greenlee Counties are in the Plateau region. Gila, Cochise, and parts of Graham, Greenlee, and Pinal Counties comprise the Mountain region. The Desert region embraces much of Pima and Pinal and a small part of eastern Santa Cruz County.

The Colorado Plateau region, which covers more than 45,000 square miles of northern Arizona, consists of a broad, rolling surface surmounted by isolated volcanic mountains and cut by numerous canyons. The average altitude exceeds 6,000 feet, and parts of the region contain a heavy growth of yellow pine timber. Annual precipitation[4/] ranges from 9 to 13 inches, and as much as 6 feet of snow falls on places during the winter. The mean maximum temperature at Fort Defiance in northern Apache County is 63.7° F., the mean minimum is 31° F., and the low is -30° F. At Clifton, near the southeast end of the Plateau region, these temperatures are 80.1° F., 53° F., and 13° F., respectively.

The Mountain region occupies a belt 60 to 150 miles wide that separates the Plateau and Desert regions. It is composed of short, parallel ranges surrounded by relatively flat valleys. The annual precipitation ranges from 14 to 19 inches. Except at the higher elevations the snowfall is relatively light. Globe, Gila County, at an altitude of 3,540 feet, has a mean maximum temperature of 77.4° F., a mean minimum of 47.7° F., and a low of 10° F. At Bisbee in southern Cochise County, at an altitude of 5,450 feet, these temperatures are 74°, 48.8°, and 8° F., respectively.

The Desert region is characterized by numerous short ranges rising abruptly from broad desert plains. The mountains generally are low and barren of much vegetation. The climate is hot and dry, the annual precipitation ranging from 7 inches in western Pinal and Pima Counties to nearly 16 inches in Eastern Santa Cruz County. Altitudes in these counties range from 1,400 to 7,700 feet, and summer daytime temperatures at the lower elevations may reach as much as 120° F.

4/ Smith, H. V., The Climate of Arizona: Univ. of Arizona Agri. Exp. Sta., Bull. 197, July 1943, 112 pp.

HISTORY AND PRODUCTION

The presence of manganese in Arizona has been known for many years, but none appears to have been produced until 1915 when manganese ore as such was mined in the Tombstone, Bisbee, and Globe districts. Many years before it had been mined with silver ores in Tombstone and used as a flux in smelters, where it was lost in the furnace slag. Owing to the high prices that prevailed during World War I, considerable hand-sorted ore was shipped from several districts in the State. After World War I, production dropped materially, but it increased again in the late 1920's. In the 10 years following the depression of the 1930's, only 1,682 tons of manganese ore was shipped from the entire State. During World War II, from 1942 through 1945, production increased to more than 24,000 tons. From 1946 to 1952, it amounted to only a few hundred tons annually.

Late in 1951, the General Services Administration (GSA) opened a manganese-purchasing depot at Deming, N. Mex., and early in 1953 began purchasing under a similar program at Wenden, Ariz. Because ore containing 15 percent or more manganese was accepted by these depots, ore production was greatly increased. From 1953 through 1955, the depots received from Arizona 349,521 long tons of ore having a grade of 15 to 35 percent manganese and 17,210 long tons containing over 35 percent.

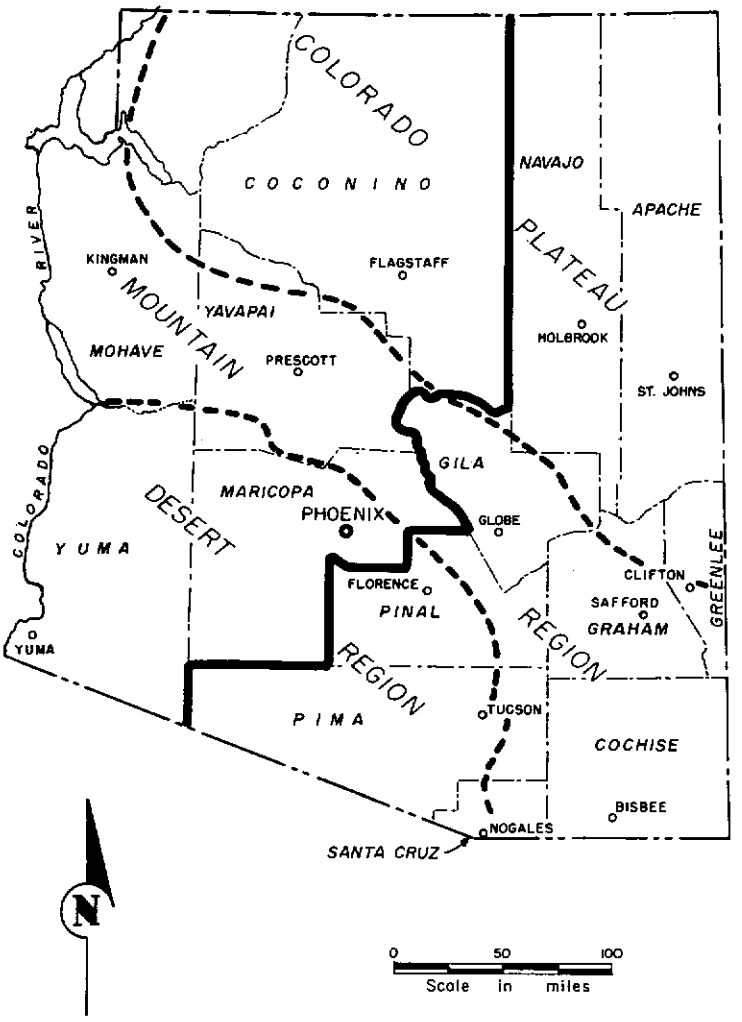

FIGURE 1. - Map of Arizona.

The Wenden depot was closed early in May 1955 after reaching its prescribed quota of 6 million long dry ton units of recoverable manganese. The Deming depot remained open until November 30, 1955, when it reached a similar quota.

As there was no longer a suitable market for ore containing less than 40 percent manganese, many of the smaller mines in the State were closed late in 1955. Custom milling became important after the purchasing depots were closed. The few large companies with concentrating plants continued

to operate their own mines and either bought or custom-milled ore produced by smaller operations.

The entire output of ore and concentrate was shipped under the "carlot" program administered by the GSA. Under this program the minimum acceptable manganese content of the ore or concentrate was 40 percent. In 1956 the production was supplied by 21 operations in 6 counties and in 1957 by 45 operations in 9 counties.

Table 1 gives Arizona manganese production from 1915 through 1957. The data through 1952 were taken from volumes of Mineral Resources of the United States and Minerals Yearbook. The figures for 1953 through November 1955 are from the records of GSA. The tonnages shipped to the Deming and Wenden depots will not be considered production for Minerals Yearbook purposes until shipment is made from the depots in usable form. The 1956-57 production figures are taken from the Minerals Yearbook.

MINERALOGICAL TERMS

The manganese minerals in most of the deposits were classified by visual examination of hand specimens, rather than by X-ray analysis, microscopic examination, or chemical analysis. A few spectrographic and microscopic examinations were made on manganese minerals if they appeared unusual.

The names used for classifying the manganese oxide minerals in the field were as follows: Wad was used as a generic term for soft, colloidal mixtures of hydrous manganese oxides with clay and iron oxides; pyrolusite was identified as material with a high specific gravity, massive appearance, metallic luster, black streak, and the characteristic property of soiling the fingers when rubbed; psilomelane, was the term applied to hard manganese minerals that occurred in massive concretionary or botryoidal forms; and manganite was the name applied to prismatic crystals which filled vugs or formed feltlike masses of small crystals in other manganese minerals.

DESCRIPTION OF DEPOSITS

Apache County

The records of the Deming purchasing depot show that 327 long tons of ore containing 26.5 percent of manganese is credited to Apache County. The source property is stated to be near the State line east of St. Johns but no examination was made.

An examination was made of the only other known deposit, situated in the northeastern part of the county on the Navajo Indian Reservation. (See fig. 2.)

Sonsela Butte Deposit

The Sonsela Butte manganese deposit is in the Navajo Indian Reservation, approximately 24 air miles due north of Forth Defiance and half a mile west of the New Mexico State line. It is on the Chee Dodge ranch in approximate sec.

6, T. 4N., R. 5 W., unsurveyed, as subdivided from the Navajo base line, or sec. 6, T. 31 N., R. 31 E., projected from the Gila and Salt River base line.

TABLE 1. - Arizona manganese production

Year	Long tons			County
	10-35 percent	Over 35 percent	Total	
1915.....	1/1,452	339	1,791	Cochise.
1916.....	1/7,392	3,060	10,452	Do.
1917.....	1/19,053	14,802	33,855	Do.
1918.....	1/6,758	17,612	24,370	Cochise, Maricopa, Pinal, Yuma, and Santa Cruz.
1919.....	1/1,964	529	2,493	(?).
1920.....	1/345	2,402	2,747	(?).
1921.....	0	328	328	(?).
1922.....	0	203	203	(?).
1923.....	0	245	245	(?).
1924.....	0	42	42	(?).
1925.....	0	294	294	(?).
1926.....	46	2,684	2,730	Cochise.
1927.....	179	3,905	4,084	Do.
1928.....	214	3,507	3,721	Cochise, Maricopa, Mohave, and Coconino.
1929.....	45	2,655	2,700	Cochise, Maricopa, and Coconino.
1930.....	48	364	412	Cochise and Mohave.
1931.....	0	40	40	Maricopa.
1932 thru 1939.....	0	0	0	
1940.....	0	311	311	Cochise, Coconino, Mohave, and Yavapai.
1941.....	15	904	919	Gila, Pinal, and Mohave.
1942.....	0	2,630	2,630	Mohave, Coconino, and Gila.
1943.....	7,989	5,160	13,149	Do.
1944.....	285	7,606	7,891	Mohave, Gila, Cochise, Coconino, Pima, Yuma, Yavapai, and Santa Cruz.
1945.....	50	975	1,025	Pima, Coconino, Yavapai, and Mohave.
1946.....	0	0	0	
1947.....	55	118	173	Coconino.
1948.....	0	214	214	Do.
1949.....	0	208	208	Do.
1950.....	0	198	198	Coconino and Gila.
1951.....	200	154	354	Do.
1952.....	0	181	181	(?).
1953 2/...	102,546	1,414	103,960	Virtually all counties.
1954 2/...	137,884	1,817	139,701	Do.
1955 2/ 3/.	106,544	11,276	117,820	Do.
1956.....	0	36,987	36,987	Maricopa, Mohave, Yuma, Yavapai, Pima, and Coconino.
1957.....	0	70,987	70,987	Maricopa, Yuma, Mohave, Gila, Pima, Pinal, Yavapai, Cochise, and Coconino.
Total.	393,064	194,151	587,215	

1/ Used chiefly for smelter flux.
2/ Wenden and Deming stockpiles.
3/ Revised figures, including 1,190 tons on "carlot" program.

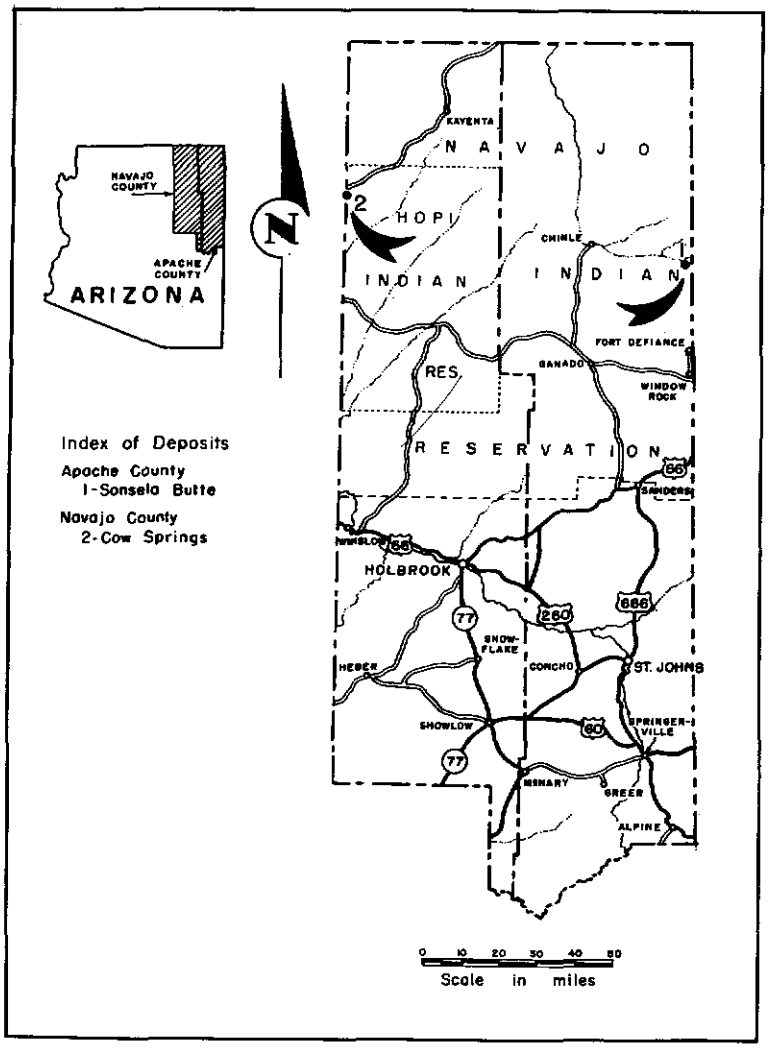

FIGURE 2. - Manganese Deposits, Apache and Navajo Counties, Ariz.

The deposit is accessible from Fort Defiance by traveling 26.3 miles north on the Lukachukai road and northwest on a dim road 1.6 miles to the ranch buildings. The manganese horizon lies along the south and southeast flanks of East Sonsela Butte. The nearest point of the deposit is about 1,000 feet north of the Chee Dodge ranch buildings.

About 1940, American Manganese Mining Corp. sank a few shallow shafts behind the outcrop.5/ In 1954 the University of Arizona, under a mineral-resource survey contract with the reservation, excavated several test pits along the outcrop. There has been no production from the property.

The outcrops of manganese occur in soft, friable, white to buff Chuska sandstone, in bedding about 50 feet above the uppermost orange-red sandstone of the Wingate formation,6/ at an altitude of approximately 7,700 feet.

The manganese mineralization appears to be confined mainly to a relatively thin conglomerate bed and usually presents a miniature, clifflike face on the steep hillside. The outcrop consists of disconnected knobby bunches, botryoidal pods, or irregular lenticular aggregates ranging from 6 to 15 feet in diameter and from 2 to 5 feet in vertical thickness. From these masses, several stemlike extensions may project a few feet downward into the sandstone. These masses of manganese are irregularly spaced along the outcrop. (See fig. 3.) In a good exposure in the small canyon northeast of the ranch buildings, the pods are separated by 10 to 15 feet of barren material; in the next canyon to the west, the average space between pods is twice as great.

5/ East, J. H., Jr., Sonsela Mountain Manganese: An unpublished preliminary Bureau of Mines report, 1941, 8 pp.

6/ Formation names as indicated on Federal Geological Survey open file Preliminary Geologic Map of the Quadrangle Sonsela Butte 4, Ariz.

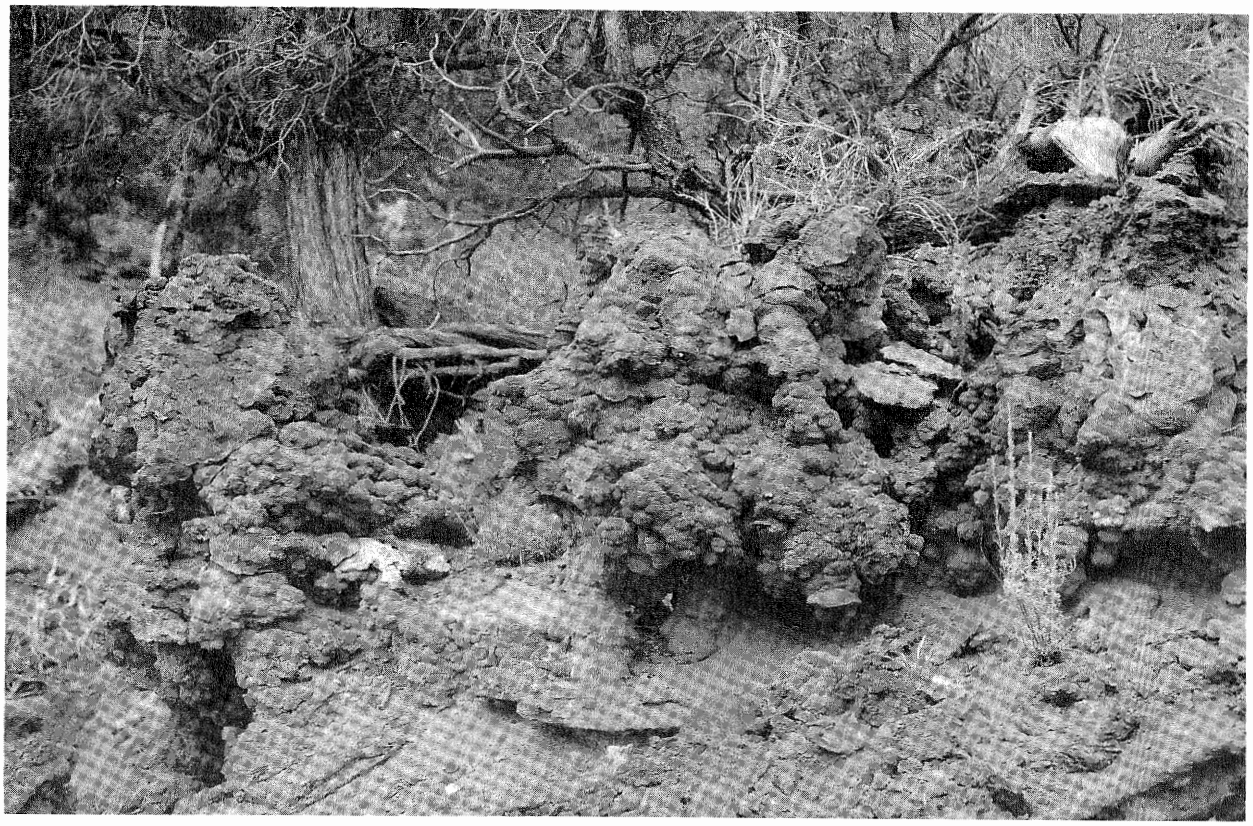

FIGURE 3. - Outcrop of Manganese at Sonsela Butte Deposit.

The length of this outcrop is about 3,000 feet, but the presence of float indicates a much greater length. Dr. E. B. Mayo,7/ who made a detailed investigation of the deposit, states:

> The manganese outcrops were traced for a distance of about 4 miles ***. For most of this distance the manganese is revealed only by float. The bold, black outcrops are relatively far apart.

Elsewhere in the report he states:

> At those places***where the manganese was traced by float, its thickness is unknown. The scarcity or absence of pebble conglomerates in the float, however, suggests that the thicker sections of manganese ore are in channels and form bold outcrops. The thinner conglomerate beds spread out from the deeper channels and may be easily broken up and subsequently covered by slope debris. Gaps in mineralization are, of course, not precluded.

The manganese mineralization is most abundant in the porous conglomerate layer, where the manganese oxides have cemented the gravel and partly replaced

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7/ Mayo, E. B., Haff, J. C., and Krumlauf, H. E., Mineral Resources of the Navajo-Hopi Indian Reservations: Univ. Arizona Press, vol. 1, 1956, p. 41.

the fine sand. As would be expected, the silica content is high--about 53 to 56 percent. Nine samples taken by East[8/] averaged 19.4 percent manganese. The manganese content of samples taken by Krumlauf[9/] ranged from 22 to 26 percent.

Determination of the manganese minerals in a typical specimen of the ore was made by LaMar G. Evans, petrographer, Bureau of Mines, Tucson, Ariz. He states:

> Studies of polished surface show that this sample is a sandstone cemented with pyrolusite and minor amounts of manganite, wad, limonite, and calcite. Spectrographic tests on the manganese minerals gave strong spectral lines for manganese and silicon together with weak lines for barium, iron, calcium, and aluminum.

Navajo County

There are no known productive deposits of manganese in Navajo County. However, the Bureau of Mines 1952 edition of "Materials Survey--Manganese" credits this county with a production of less than 100 tons of plus-35-percent manganese ore during World War II, 1942-45. From the name of the shipper, it appears likely that the ore came from the Heber district, which is in the extreme southeast corner of Coconino County. These deposits have been described in Bureau of Mines Information Circular 7822, "Manganese Deposits of Western Arizona."

Of academic interest only is an occurrence of manganiferous material in sandstone on the Hopi Indian Reservation. (See fig. 2.)

Cow Springs Occurrence

Sedimentary manganese oxides are present in a relatively narrow, discontinuous zone in the sandstone cliffs 4 to 6 miles northeast of the Cow Springs Trading Post. The deposit is in the northwest corner of the Hopi Indian Reservation in approximate T. 35 N., R. 15 E., unsurveyed. The area is at the east border of Coconino County and extends into Navajo County. The line of cliffs forms the northwest end of Black Mesa and is approximately 1-1/2 miles south of the Tuba City-Kayenta road.

The manganese-bearing zone is 200 to 250 feet above the foot of the cliffs at an altitude of approximately 6,300 feet. The loosely consolidated sandstone is cemented with small amounts of wadlike manganese oxides in irregular and discontinuous flat-bedded lenses that lie at several horizons within a zone about 20 feet thick. The lenses range from a few inches to a foot or more in thickness.

8/ Work cited in footnote 5 (p. 6), p. 5.
Note. - P. 5 is the page in the East report cited.
9/ Work cited in footnote 7 (p. 7), p. 45.

This occurrence was noted first by Harshbarger, who stated[10/] that the manganese occurs near the top, flat-bedded unit of the Cow Springs sandstone (Morrison formation), 80 to 100 feet below the unconformable contact with the Dakota sandstone. He also stated that these manganese-bearing beds were traced along the same stratigraphic horizon for more than 5 miles.

Because of their erratic occurrence and low grade (less than 1 percent manganese), the known deposits have no economic value.

Cochise County

Cochise County, which occupies the southeast corner of the State, contains 45 known manganese deposits. The principal ones are in the Bisbee and Tombstone districts. Other small deposits are known in the Courtland-Gleeson district east of Tombstone. Three isolated occurrences are found in widely separated places, one in the Dos Cabezas Mountains in the north-central part of the county, one near its southeastern corner, and one near its southwestern corner (fig. 4).

Manganese-ore production was begun in the county during World War I and has been continued intermittently during short periods of high prices. Estimated production to 1957 has totaled some 49,600 tons of ore and concentrates, which averaged 35 percent or more manganese.

Except for a single lessee operation near Tombstone, no manganese properties in the county were active when visited in September 1957.

Nearly all of the deposits are associated with fracture and fissure zones in Paleozoic limestones.

None of the principal deposits has been fully developed, and their extent (particularly at depth) is not known. In general, the higher grade ores were found close to the surface, and ore containing 35 percent manganese or more undoubtedly has been largely depleted in the present workings. Lower grade ore remains in the bottom of many openings, but it appears unlikely that a substantial tonnage will be found in any one deposit.

Bisbee District

The Bisbee or Warren district is in south-central Cochise County, a few miles north of the Mexican boundary. It covers the southeastern half of the Mule Mountains, a rugged range with altitudes ranging from 5,300 to 7,400 feet. The town of Bisbee, situated near the north-central part of the district, is the county seat. It lies in Mule Pass Gulch along both sides of U.S. Highway 80 and is served by a spur of the Southern Pacific Railway. The towns of Lowell and Warren are a few miles east of Bisbee.

10/ Harshbarger, J. W., Petrology and Stratigraphy of the Upper Jurassic Rocks of Central Navajo Reservation, Ariz.: Univ. Arizona, Ph. D. thesis, 1949, 216 pp.

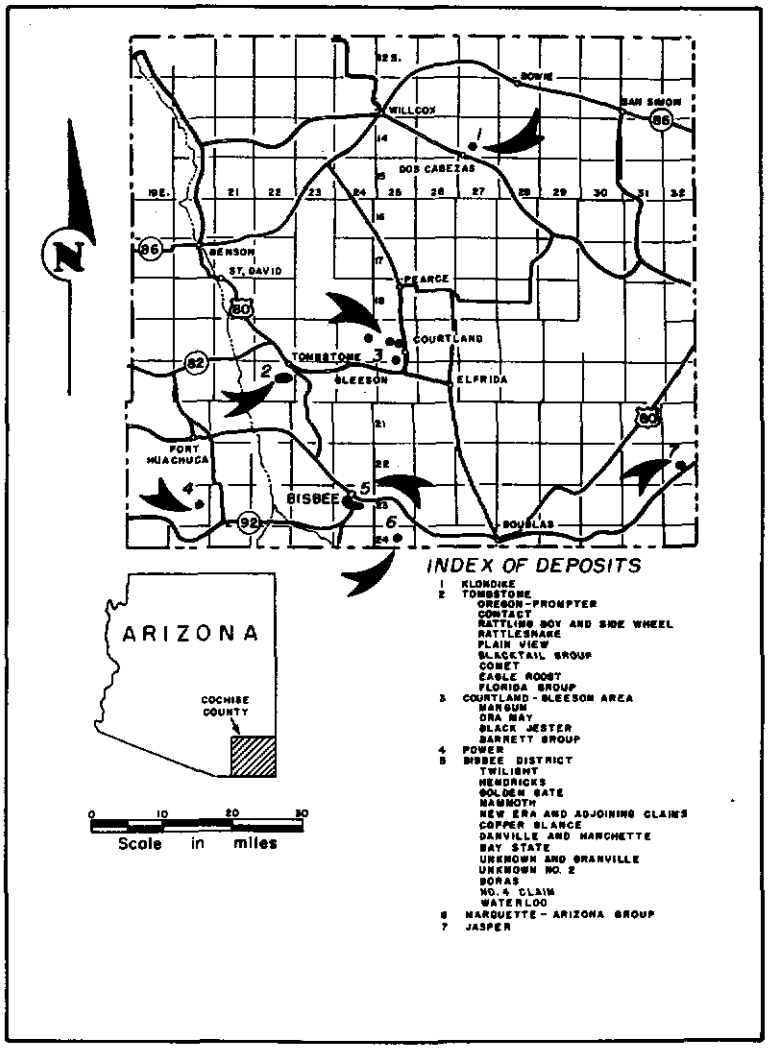

FIGURE 4. - Manganese Deposits, Cochise County, Ariz.

The Bisbee district is one of the oldest and most productive copper districts in the Southwestern United States and at times has been the leading source of manganese in Arizona.

The productive manganese deposits lie mostly within a broad arc extending around the western, southern, and eastern margins of the district. The deposits are 0.5 mile southwest to some 2 air miles south and southeast of Bisbee. (See fig. 5.) Very few deposits are accessible by roads, and most of them can be reached only by trails over which the ore has been carried on pack animals to the nearest roads. With few exceptions all known deposits are on patented claims now owned by Phelps Dodge Corp.

Copper was first produced from the Copper Queen mine in 1884. To June 1958, the total output of the district has exceeded a billion dollars in copper, gold, silver, lead, and zinc.

Manganese ore was first shipped from the Bisbee district in 1916, and production continued until late in 1918 (shortly before the close of World War I). Mining was resumed on the Twilight deposit in 1925 and continued into 1930. The last-known production of manganese ore from the district also came from the Twilight deposit in 1943.

Recorded production from the district has totaled over 35,000 tons of sorted ore containing about 40 percent manganese. Of that amount, 20,891 tons was produced in 1916-18, 13,409 tons in 1925-30, and about 1,100 tons in 1943.

The geology[11 12 13/] of the Bisbee district has been described fully in early reports by the Federal Geological Survey and in later papers by staff

11/ Ransome, F. L., The Geology and Ore Deposits of the Bisbee Quadrangle: Geol. Survey Prof. Paper 21, 1904, 168 pp.

12/ Bonillas, Y. S., Tenney, J. B., and Feuchere, L., Geology of the Warren Mining District: Trans. AIME, vol. 55, 1917, pp. 284-355.

13/ Tenney, J. B., The Bisbee Mining District: Eng. and Min. Jour., vol. 123, 1927, pp. 837-841.

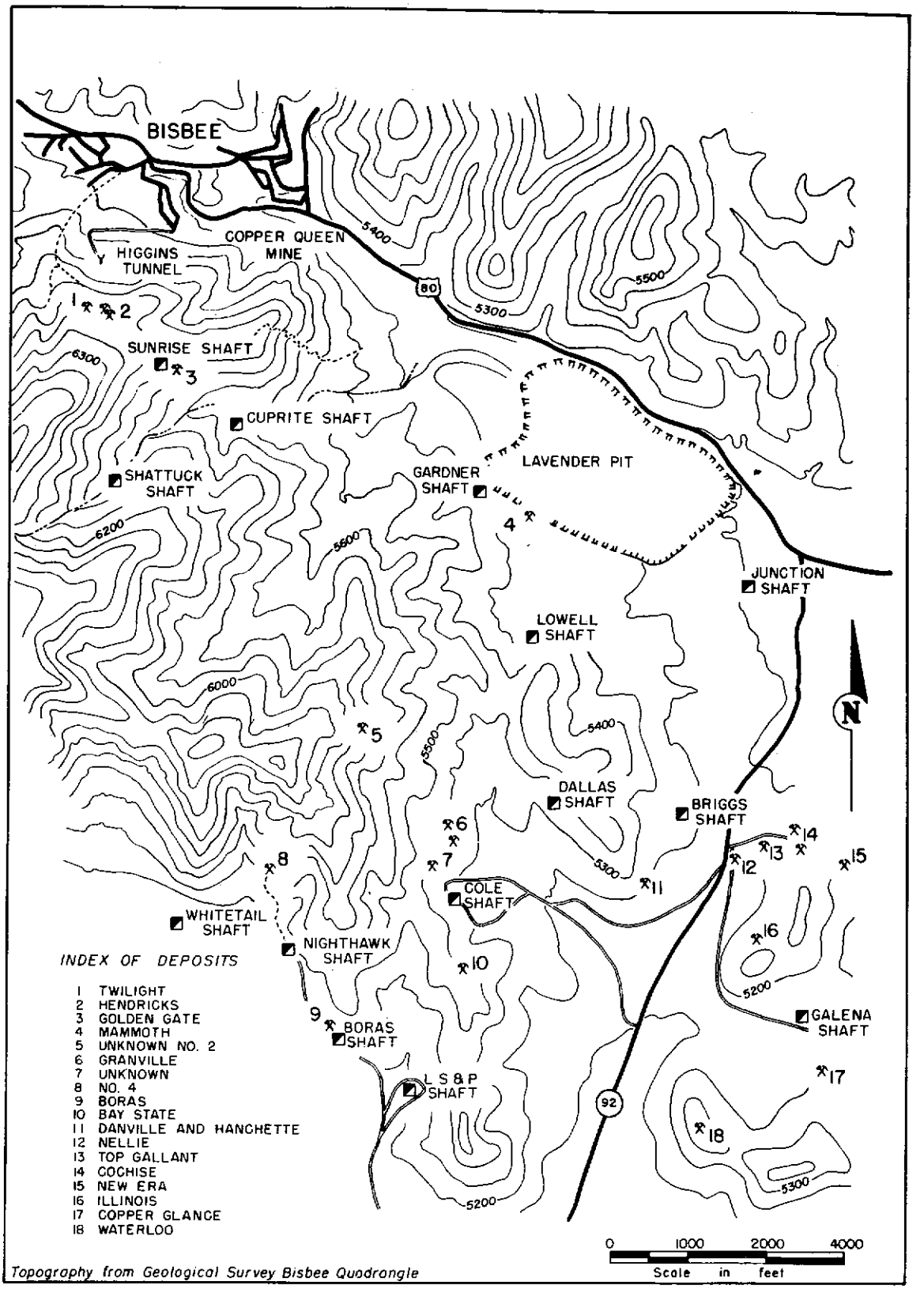

FIGURE 5. - Manganese Deposits, Bisbee District, Cochise County, Ariz.
(Topography From Geological Survey Bisbee Quadrangle.)

geologists of the operating companies. Briefly, the district is characterized by a thick series of Paleozoic beds, chiefly limestones, which have been invaded by a mass of granite porphyry known as the Sacramento Hill stock. The stock, covering an area over a mile square, was intruded into a faulted syncline along the strong, northwesterly trending Dividend fault. The porphyry has been highly altered and consists largely of quartz, sericite, and pyrite. Parts of the mass contain disseminated copper ore enriched by secondary chalcocite.

The higher grade copper deposits lie around the southern side of the stock within a broad arc, where they occur as irregular replacements of favorable horizons in the limestones and along fissures cutting the beds. The principal manganese deposits occupy an outer and upper zone from the one in which the main copper deposits have been found.

Small amounts of manganese mineralization are widespread through much of the district, but only about 20 deposits have been large enough to exploit. Virtually all of these are associated with steeply dipping fissures and fracture zones in the Naco and Escabrosa limestones. Some deposits are veinlike, consisting of a succession of various-size lenticular bunches and strands of ore following the fissures. In other deposits the mineralization spreads from the fissures into the limestone walls, forming irregular replacement masses. Some are a combination of both types.

Among the less common manganese minerals in the district are braunite, hausmannite, hetaerolite, and alabandite. The chief ore minerals are psilomelane and braunite, occurring in a gangue consisting principally of calcite, iron oxides, and quartz with minor amounts of barite. All of the ore contains some copper, the content ranging from 0.25 to more than 2 percent.

The bulk of the ore was mined from opencuts ranging from several feet to about 70 feet in depth. In many deposits the quality of the ore is reported to have changed from high grade to lower grade at depths within 50 feet of the surface. On the other hand, bodies of oxide ore are reported to have been found in the Shattuck mine at a depth of 500 feet and in the Junction mine on the 1,300-foot level.

Regarding the future possibilities for manganese ore in the Bisbee district, J. B. Tenney,14/ former chief geologist of the Copper Queen Branch, Phelps Dodge Corp., made the following comments:

> Manganese mining in the camp during the high war prices, and a little mining since, has been done on the most easily mined and accessible deposits. Practically no attempts have been made to develop them, and little is known definitely of their extent. It has, however, long been realized that manganese deposits of medium grade, and some of high grade, are commonly associated with nearly all the oxidized caps of the larger ore bodies of the camp, usually at a higher horizon,

14/ Wilson, E. D., and Butler, G. M., Manganese Ore Deposits in Arizona: Arizona Bureau of Mines Bull. 127, 1930, p. 46.

than the typical limonite-silica gossans cut by the upper development levels.

With the recent success in the flotation of manganese oxides in laboratory experiments, the lower grade deposits at Bisbee attain greater importance than heretofore. At the Shattuck mine of the Shattuck-Denn Mining Corp., where probably more work has been done than at any other property on levels above the major ore bodies, manganese deposits have been cut at depths up to 500 feet from the surface. It is probable that the unprospected upper zones at nearly all the mines in the district would yield similar deposits.

Ransome,[15/] who investigated the deposits in 1918, had the following to say regarding the manganese ore reserves:

The large number of the deposits in the Bisbee district, their irregular form, the lack of systematic development, and the methods of mining and handling the ore make any reliable estimate of available tonnage utterly impossible. In normal times, it probably will not pay to work deposits of the character here described. Under necessity, however, or with unusually high prices for manganese ore, perhaps 50,000 tons of 40-percent ore would be available. This estimate, which is admittedly rough, is believed to be more nearly a minimum than a maximum. Considerably more material might be obtained by concentration, but it is difficult to see how any profit could be made under ordinary conditions by concentrating the manganese ore.

Since his report was written, about 20,000 tons of ore, containing about 40 percent manganese, has been shipped from the district.

Twilight Claim

The manganese deposit on the Twilight claim has been the largest and most productive in the district. It is situated on a steep hillside about 0.5 mile south-southwest of the Bisbee courthouse at an altitude of some 6,000 feet. Access to the deposit is by a trail that turns off the road to the Higgins tunnel. The portal of the tunnel is nearer the base of the hill, about 1,000 feet directly north of the deposit (fig. 5). The claim is one of an old patented group formerly held by Thomas Higgins and now owned by Phelps Dodge Corp.

The manganese deposit was first worked in World War I, again from 1925 into 1930, and lastly in 1943. Production records for some periods are incomplete, but production through 1943 apparently totaled about 21,000 tons of ore averaging approximately 40 percent manganese. A much larger tonnage of lower grade material was mined, from which the higher grade shipping ore was sorted.

15/ Jones, E. L., Jr., and Ransome, F. L., Deposits of Manganese Ore in Arizona: Geol. Survey Bull. 710; pt. 1, 1920, p. 119.

The manganese ore occurs in irregular replacement masses along a steeply dipping zone of fissures striking eastward and cutting beds of the Escabrosa limestone. The zone is exposed for 1,000 feet or more along its strike and contains several disconnected mineralized areas, some of which crop out on the adjoining Hendricks claim to the east. The largest and most productive ore body along the zone occurs near the eastern end of the Twilight claim. This body is made up of different-size masses of high-grade ore surrounded by lower grade material. It has been exploited in irregular cuts and open stopes that extend continuously along the zone for 200 feet or more. The openings range from 10 to 35 feet or more in width and in places reach a depth of 70 feet below the outcrop. The best ore in the deposit appears to have been localized along steeply dipping fractures trending N. 65° W. and cutting the main fissure zone at an acute angle. The manganese mineralization persists in places to the bottom of the deepest accessible workings.

In earlier reports the chief manganese mineral in the deposit was classified as psilomelane. Later work by Hewett, of the Federal Geological Survey, showed that the dominant mineral was braunite, an oxide of manganese containing about 10 percent silica. Iron oxides and quartz were the principal gangue minerals.

Some of the workings in the now inaccessible Higgins tunnel extended under a part of the deposit to a vertical depth of about 300 feet. Whether an appreciable amount of manganese oxide ore was found at this depth is not known. However, alabandite, the sulfide of manganese, was found on the tunnel level beneath the surface workings. As described by Hewett and Rove,16/ the alabandite and a manganese carbonate mineral replaced parts of several narrow beds of dolomite belonging to the Martin limestone near a fault which separated the beds from similar beds of the Abrigo limestone. The alabandite was present as minute grains disseminated through the carbonate rock. The mineralization was cut in two rather widely separated drifts on the west side of the main tunnel. The occurrences were not explored, and the extent of the alabandite-bearing rock was not disclosed.

Hendricks Claim

The Hendricks is an old patented claim owned by the Phelps Dodge Corp. It adjoins the Twilight claim on the east and is accessible by continuing eastward from the same trail that leads to the Twilight deposit.

The claim was worked on a small scale for manganese during World War I. The production totaled about 350 tons of ore, of which about half contained 40 percent manganese or more and the other half somewhat less than 40 percent.17/ As far as is known, the claim has not been worked since 1918.

The ore was mined from several small openings; some were excavated along the continuation of the Twilight fissure zone, and others were excavated

16/ Hewett, D. F., and Rove, O. N., Occurrence and Relations of Alabandite: Econ. Geol., vol. 25, 1930, p. 41.
17/ Work cited in footnote 15 (p. 13), p. 106.

somewhat farther southeast on a northwesterly trending fracture in the Naco limestone. The higher grade ore occurred in irregular masses that ranged from 2 to 4 feet in width and were as much as a few tens of feet long. In places adjacent to the better ore, lower grade manganese mineralization was exposed for widths of 6 to 10 feet and lengths of several tens of feet.

The manganese minerals comprise the hard oxides, associated with iron oxides and quartz. Some of the ore is reported to have contained small amounts of copper and lead.

Golden Gate Claim

The manganese deposit on the Golden Gate claim of the Phelps Dodge Corp. is about one-fourth mile southeast of the Twilight deposit and a few hundred feet east, down the steep hillside, from the Sunrise shaft. The workings are reached most easily on foot from the Shattuck shaft which is accessible by a road winding up Uncle Sam Gulch. (See fig. 5.)

The only known shipments of manganese ore from the claim were made during World War I. The bulk of the production of 800 to 900 tons was shipped to Bessemer, Ala.

The manganese mineralization, consisting chiefly of the harder oxides, occurs along an irregular fracture zone in limestone. The zone strikes N. 80° W., dips 75° N., and has an exposed length of 300 feet or more. In places on the surface, the manganese minerals occur in narrow stringers and small irregular bunches over widths as much as 25 feet. In the lower grade areas the better ore occurs in rather well defined lenticular strands ranging from 2 to 5 feet in width and from a few to tens of feet in length. The higher grade bodies were mined from shallow opencuts dug at irregular intervals along the outcrop. The largest opencut was about 150 feet long, 3 to 5 feet wide, and 25 feet or more in maximum depth. Near the east end of the cut a shaft, inaccessible at the time of the visit, had been sunk to a depth of perhaps 40 feet.

Two lots of the ore shipped in 1918 contained an average of 38.6 percent manganese, about 5 percent iron, and nearly 2 percent copper.

Mammoth Claim

The Mammoth claim, owned by the Phelps Dodge Corp., lies along the south side of the Lavender pit, a short distance east of the Gardner shaft. Before the Lavender pit was opened, there were two manganese deposits on the claim. During stripping operations for the pit in the early 1950's, the deposits were largely removed or obliterated, and only a small part of one was exposed on the top bench of the pit when the area was visited in October 1957.

The deposits, as developed in 1918, were described by Ransome[18/] as follows:

18/ Work cited in footnote 15 (p. 13), p. 107.

The deposits on the Mammoth claim are on a low spur that extends eastward from the Gardner shaft, just south of Sacramento Hill. They are irregular replacement bodies in fractured Naco limestone close to the contact with the altered porphyry of Sacramento Hill.

Mining has been conducted at two places. At the northwesterly pit about 500 tons of ore had been obtained at the time of the visit, and it was roughly estimated that about as much more was available. From 600 to 700 feet southeast of this pit another pit had been recently opened from which it was expected to obtain at least 1,500 tons of ore. The ore shows no definite walls and does not follow any persistent zone of fissuring.

The ore is psilomelane with nests of barite and small bunches of a green copper-arsenic mineral which is probably the same as that observed in the Twilight ore. Occasionally a little chalcocite is found.

Ransome gave the analyses of four lots of ore shipped from the claim. They contained 38.4 to 43.7 percent manganese, 3.6 to 7.3 percent iron, and 0.5 to 1.11 percent copper.

New Era and Adjoining Claims

Several manganese-bearing fractures crop out on five contiguous claims known as the New Era, Cochise, Top Gallant, Illinois, and Nellie. The group is about 2 miles southeast of Bisbee and lies along the east side of State Highway 92, a short distance south of its junction with U.S. Highway 80 near the east end of the town of Lowell. The deposits are scattered over an area roughly 1,500 feet east-west and as much as 1,000 feet north-south. Some of the fractures are accessible by short side roads branching from an easterly trending dirt road that leaves State Highway 92 about 0.6 mile south of U.S. Highway 80. The easternmost deposit is on the New Era claim about 2,000 feet east of State Highway 92. The claims are part of the property formerly held by the Calumet & Arizone Mining Co. but are now owned by Phelps Dodge Corp.

The larger and higher grade manganese occurrences in the area were exploited in shallow openings during World War I. As far as is known none of the deposits has been worked since that time. The total production is not known but probably amounted to 1,000 tons or more of shipping ore. Ransome mentions that 20 lots of sorted ore from the group contained 40 to 50 percent manganese and 9 to 24 percent combined silica and alumina.

At least 10 separate fissures associated with the ore are found on the claims. The fissures strike northward, are virtually vertical, and cut eastward-dipping beds of the Naco limestone. They range from 50 feet apart in some places to several hundred feet in others. Some fissures contain a succession of irregular masses and lenses of ore for several hundred feet along their strike and others for a few tens of feet only. In places the manganese mineralization replaces limestone beds adjacent to the fissures. Judged by the size of the openings, the better ore bodies ranged from 2 to 6 feet in width and from 20 to 60 feet in length.

The chief manganese minerals are the harder oxides. Small amounts of copper minerals are present in some of the deposits.

Most of the ore was mined in shallow opencuts scattered along the more promising parts of the fissures. The deepest work consisted of two shafts about 25 feet deep. The shafts were inaccessible at the time of the visit, but the ore reportedly was lower in grade at that depth than nearer the surface.

Flotation and sulfur dioxide leaching tests were made on a composite feed that consisted of approximately equal parts of four samples from several mine dumps on the Illinois claim. The composite sample weighed about 400 pounds and represented material rejected during past operations.

The ore in the composite sample was dense and hard. The principal manganese mineral was a zinc-copper-bearing pyrolusite intimately associated with a fine-grained chalcedonic quartz and hematite. Some calcite and limonite also were associated with the siliceous gangue. A partial chemical analysis showed 22.4 percent Mn, 5.6 percent $CaCO_3$, and 0.28 percent Cu. Grinding to minus-200-mesh was indicated for good liberation of the pyrolusite and chalcedonic quartz.

Because of the intimate relation between the manganese and gangue minerals, gravity concentration of the ore was not attempted; however, recovery of metallurgical-grade concentrates by bulk and selective flotation of finely ground charges was investigated thoroughly. Bulk flotation of the manganese from minus-200-mesh wet-ground feeds using oil emulsion collector failed to yield manganese concentrates assaying more than 36 percent Mn owing to excessive contamination of the concentrates by the calcite. In other tests, selective flotation of the calcite with oleic acid, followed by oil emulsion flotation of the manganese minerals, yielded concentrates assaying 42.6 percent Mn with a recovery of 82.3 percent of the manganese. However, the concentrates also assayed 0.49 percent Cu. This copper was in solid solution in the manganese minerals and could not be rejected either by flotation or acid-leaching methods. As the maximum allowable copper in metallurgical-grade manganese is 0.25 percent Cu, flotation did not yield a marketable product.

Dithionate leaching of coarse and fine charges of the ore to extract the manganese in leach solutions that could be processed further to yield a high-grade manganese hydroxide also was investigaged. Only the leaching phase of the process was investigated, because manganese hydroxide precipitates that contain 55 to 60 percent Mn can be recovered readily from the leach liquors once the manganese has been leached from the ore.

Agitation leaching of minus-100-mesh charges of the ore with a 10-percent SO_2-air mixture was not satisfactory because of the slow rate at which the hard, dense ore absorbed the SO_2. Simulated upward percolation leaching of coarse ore with the SO_2-air mixture and alternate downward percolation washing of the solubilized manganese sulfate and dithionate was more successful. Treatment of minus-1/4-inch feed recovered 98 percent of the manganese during a 16-day leach. Consumption of sulfur dioxide was 5 pounds per pound of

manganese recovered, and dithionate formation was 0.6 pound per pound of manganese extracted. A similar test on minus-1/2-inch ore recovered 86 percent of the manganese. Sulfur dioxide consumption and dithionate formation were the same as for the 1/4-inch ore. Dithionate formation was more than enough to compensate losses that would have been incurred in the manganese hydroxide product and in washing the residues if the leach solution had been treated for recovery of the manganese.

Tests on the composite sample demonstrated that treatment of the ore by gravity methods or flotation is impracticable owing to the excessive copper content of the concentrates produced. The ore is amenable to leaching by percolation with sulfur dioxide. However, the sulfur dioxide consumption is high, and it is doubtful if the ore could be treated profitably by this method at the present market value of manganese.

Danville and Hanchette Claims

The manganese deposits on the Danville and Hanchette claims of Phelps Dodge Corp. are about 4,000 feet south of the Lavender pit and 1,000 feet or more south-southwest of the Briggs shaft. (See fig. 5, p. 11.)

The deposits were worked during World War I, and production to March 1918 totaled about 600 tons of sorted ore, most of which was shipped to Bessemer, Ala. The analyses of seven typical shipments, as given by Ransome, showed that the ore contained 46.4 to 47.9 percent manganese, about 3 percent iron, and 0.44 to 2.09 percent copper. Apparently, additional shipments were made between March and October 1918, but their tonnage and grade are not known.

The ore was mined from a number of shallow opencuts and pits excavated along a northward-trending fissure zone in the Naco limestone. The ore bodies ranged from 2 to 8 feet in width and were scattered about 500 feet along the strike of the zone. The larger opencuts ranged from 20 to 60 feet in length and were as much as 10 feet deep.

The chief manganese minerals, as in other deposits in the district, comprise the harder oxides which are accompanied by small amounts of iron oxides and calcite.

Copper Glance Claim

Manganese fissures are found on the Copper Glance claim near the Galena shaft. They are over the ridge south of the New Era claim and may be associated with the same fissure system. The workings are on both sides of the road a short distance southeast of the Galena shaft.

The deposits were worked for manganese during World War I, but the production is not known. Judged by the size of the openings, production probably amounted to a few hundred tons of sorted ore.

The manganese minerals, consisting of the hard oxides and some manganiferous calcite, occur in narrow, elongated lenses and irregular masses along

a fissure zone in the Naco limestone. The zone trends about N. 25° E. and dips steeply northwest. The ore ranges from 1 to 6 feet in width and occurs in disconnected bodies of various lengths for 400 feet or more along the strike of the zone. The largest body had been mined from an opencut about 60 feet long, 3 to 6 feet wide, and 10 feet deep. A small shaft, inaccessible at the time of the visit, had been sunk near the south end of the cut to an estimated depth of 25 feet. About 50 feet south of the shaft another shallow opencut about 25 feet long exposed a lens of ore 1 to 2 feet wide. Farther south along the zone, two more shallow cuts about 75 feet apart showed narrow widths of ore.

Across the Galena shaft dump and north of the largest opencut, several pits and cuts exposed small amounts of ore about 200 feet along the strike of the zone. Apparently, no appreciable amount of ore had been taken from these shallow openings. Undoubtedly, the bulk of the ore output was sorted from material broken in the largest opencut where the deposit was about 6 feet wide.

Bay State Claim

The deposits on the Bay State claim are about 1,000 feet south of the Cole shaft, from which they are accessible only on foot. In World War I, about 800 tons of sorted ore was shipped before March 1918. Ransome reported the earliest shipments contained about 45 percent manganese and 14 to 20 percent silica and alumina, but later shipments were lower grade.

The ore occurs in several disconnected lenticular bodies along three or more steeply dipping fissures in a zone about 100 feet wide. The zone trends northward through beds of the Naco limestone which dip moderately east. The ore bodies range from 2 to 6 feet in width and from 10 to 60 feet in length. They are arranged in an overlapping pattern about 300 feet along the strike of the zone.

The workings consist of seven shallow opencuts and an adit about 60 feet long.

The dominant manganese minerals are the hard oxides, which are accompanied in places by an abundance of iron oxides.

Unknown and Granville Claims

The Unknown and Granville claims are two contiguous fractional claims lying in the south-central part of the district several hundred feet north-northwest of the Cole shaft. Formerly, they were part of the property of Calumet & Arizona Mining Co., but now they are owned by Phelps Dodge Corp.

The manganese occurrences on the claims were worked during World War I, and the reported production totaled 600 to 700 tons of sorted ore assaying 34 to 49 percent manganese and 5 to 20 percent combined silica and alumina.

The deposits are in a zone of nearly vertical, northerly trending fissures cutting eastward-dipping beds of the Naco limestone. The ore occurs

along several parallel fissures in disconnected bodies composed of stringers, veinlets, and irregular bunches of hard manganese oxides scattered several hundred feet along the strike of the zone. The ore bodies range from 1 to 5 feet in width and from short irregular podlike masses to elongated lenses tens of feet in length.

The largest ore bodies were mined from shallow opencuts and pits. The most extensive opening, near the south end of the zone, was an opencut about 110 feet long, 3 to 5 feet wide, and as much as 10 feet deep. Another opencut 60 feet to the north was about 30 feet long and 2 to 4 feet wide. Across the wash, approximately 250 feet farther north, were nine or more shallow opencuts and pits scattered along several fissures occupying an area about 100 feet wide and 300 feet long. Some podlike masses of ore replaced the limestone beds adjacent to the fissures.

Manganiferous calcite, iron oxides, and quartz were the chief gangue minerals.

Unknown No. 2 Claim

The Unknown No. 2 claim of the Phelps Dodge Corp. lies on the steep eastern slope of Escabrosa Ridge 2,000 feet or more north-northwest of the Cole shaft at an altitude of about 5,900 feet, or some 600 feet higher than the deposits on the Granville claim near the base of the ridge. The workings are accessible only by foot trails.

Some manganese ore was mined during World War I, but the amount is not known. It may have been included in the 600 to 700 tons that was reported shipped from the Unknown and Granville claims by Calumet & Arizona Mining Co., which at the time owned the properties.

The manganese mineralization on the Unknown No. 2 claim occurs in disconnected bodies along a well-defined fissure in the Naco limestone. The fissure trends northward, in conformance with the general strike of the limestone, but dips steeply westward, cutting the limestone beds which dip moderately east. Three manganiferous deposits are exposed in shallow openings 350 feet or more along the strike of the fissure. The ore bodies range from 2 to 8 feet in width and from 20 to 150 feet in length.

The workings comprise three opencuts and a short adit. The opencut farthest south is about 150 feet long, 5 to 8 feet wide, and as much as 10 feet deep. Some 60 feet north of the north end of this opening, another opencut as much as 15 feet deep follows the mineralization about 50 feet. From each end of this cut, drifts extend along the fissure for 20 feet south and 16 feet north. From 2 to 4 feet of manganese mineralization is exposed in the faces of the drifts. A third opening, a few tens of feet farther north, consists of an opencut about 20 feet long and 8 feet deep.

The chief manganese minerals are the harder oxides; manganiferous calcite, iron oxides, and quartz also are present.

The ore as a whole was too low grade to constitute shipping ore, and most of the broken material still remains on the dumps of the excavations.

Boras Claim

The Boras claim, owned by Phelps Dodge Corp., is about 2 miles south-southeast of Bisbee, on the southwestern slope of Escabrosa Ridge. The manganese deposits are a few hundred feet north-northeast of the Boras shaft. This shaft is accessible by about a mile of north-northwesterly trending road that branches from State Highway 92 some 2 miles south of its junction with U.S. Highway 80.

Only a limited amount of exploratory work has been done, and as far as is known no manganese ore has been shipped from the claim.

The manganese mineralization, consisting chiefly of the harder oxides, is exposed in places along two or more steeply dipping fissures striking northeast and cutting beds of limestone. The ore occurs in stringers, in narrow veinlets oriented along the fissures, and as irregular bunches replacing the limestone. No ore is exposed for more than a few tens of feet along the strike. The largest deposit is an irregular lenticular body having a maximum width of about 10 feet, from which it tapers to 1 foot or less 20 feet or more along the strike. It has been explored by an opencut and a pit that is approximately 10 feet in diameter and 18 feet deep.

About 75 feet to the east, stringers and veinlets of ore, ranging from a few inches to a foot in width, are exposed for short distances along the outcrop of other northeastward-trending fissures.

No. 4 Claim

The No. 4 claim of Phelps Dodge Corp. is 1.6 miles south of Bisbee and about 0.5 mile north-northwest of the Boras shaft, at an altitude of about 5,700 feet. The deposit is accessible by 0.5 mile of trail that begins at the end of the road near the Nighthawk shaft. (See fig. 5, p. 11.)

The deposit was worked during World War I and to March 1918 had produced about 1,500 tons of ore containing 40 to 48 percent manganese. Apparently, additional shipments were made during the summer and fall of 1918, but no records of the later lots are available.

The ore occurs along an almost vertical fracture and brecciated zone striking N. 25° E. across beds of Escabrosa limestone. The mineralized area ranges from 4 to 15 feet in width and has an exposed length of about 200 feet. In the wider parts of the deposit, irregular prongs of ore extend into the limestone on each side of the zone. These prongs of ore occur sporadically along both the strike and dip of the deposit. Some follow bedding planes, and others cut across the beds.

The ore was mined in an opencut that followed the zone northward into the hillside about 125 feet. The cut ranged from 10 to 20 feet in width and

reached a depth of about 45 feet at the face. Near the face of the cut, an underhand stope extended northward along the zone an additional 50 to 60 feet. This work reached a maximum depth of 20 feet or more below the floor of the opencut, or about 70 feet below the surface.

The chief manganese minerals are the harder oxides. Iron oxides, calcite, and chalcedonic quartz are the principal gangue minerals.

From a few typical analyses given by Ransome, the ore contained 45 to 48.5 percent manganese, 5.8 to 7.0 percent iron, and 0.26 to 0.75 percent copper.

Waterloo Claim

The Waterloo claim of Phelps Dodge Corp. is 2.5 miles southeast of Bisbee and 1,000 feet east of State Highway 92 at a point 1.25 miles south of its junction with U.S. Highway 80. The manganese deposits are on the top and north slope of a rather steep hill and are accessible only on foot.

Manganese ore was mined on the claim during World War I. Production to March 1918, as estimated by Ransome, totaled 1,200 to 1,500 tons of sorted ore containing 34 to 53 percent manganese. Additional shipments may have been made during the summer of 1918, but no records are available as to the tonnage.

The ore occurs in lenses and irregular bodies distributed sporadically along three steeply dipping fissures in the Naco limestone. The fissures strike northward and occupy a zone about 100 feet wide. Ore has been mined from seven or more shallow opencuts that extend some 400 feet along the strike of the zone. The higher grade ore bodies range from 1 to 3 feet in width and from 15 to 70 feet in length.

The deepest working, near the top of the hill, was an open pit 15 to 20 feet in diameter and about 25 feet deep. Two strands of ore about 2 feet wide, with irregular offshoots, were exposed on the sides of this opening. An adit had been driven under the pit from the south slope of the hill.

On the adjoining claim to the southeast, a few narrow manganiferous fissures crop out along the north slope of the ridge. They had been explored in places with a few shallow pits, but apparently the ore proved too narrow to encourage further work.

Marquette-Arizona Group

The Marquette-Arizona group of more than 30 patented claims is at the southeastern corner of the Bisbee district a short distance north of the Mexican border. (See fig. 4.) Manganese ore was found on two claims in NW1/4 sec. 9 and SW1/4 sec. 10, T. 24 S., R. 25 E. The claims may be reached from the town of Warren by traveling south 4 miles to Osborne (Bisbee Junction), then east 7 miles along the Mexican border to a side road branching left near Christianson's Ranch. This side road is followed 1.5 miles north up a broad wash to the southern deposit and about 0.5 mile farther north to the other deposit. The claims are owned by the Shattuck family and Earnest Beyer of Bisbee.

One or two carloads of sorted manganese ore was shipped from the property by lessees in World War I, and reports indicate that a few small truckloads may have been produced in 1954.

The ore, consisting mainly of psilomelane, occurs in stringers, veinlets, and small irregular bunches along fissure zones in the Glance conglomerate. The northern fissure, on which most of the work was done, strikes about N. 25° E. and dips steeply northwest. It is exposed about 250 feet along the strike in several shallow, disconnected opencuts and locally is as much as 8 feet wide. However, the better ore occurs in irregular strands ranging from less than 1 foot to 2.5 feet in width. They usually are localized along the walls of the zone and are accompanied by lower grade material composed of seams and narrow stringers of psilomelane surrounding the larger pebbles and fragments of the conglomerate.

The largest opencut was about 80 feet long, 6 to 8 feet wide, and 4 to 8 feet deep. Judging by the size of the dumps, much of the material broken in the openings along the fissure was rejected as waste.

In the other deposit, 0.5 mile to the southeast, manganese minerals occur along a steeply dipping fissure striking about N. 15° W. It has an exposed length of 80 feet or more, and the mineralized intervals range from 2 to 4 feet in width. A small amount of ore is said to have been sorted from two shallow opencuts about 40 feet apart. One cut is 30 feet long and the other about half that length. In these openings psilomelane occurs in narrow stringers and small irregular bunches similar to those in the northern deposit.

Near both occurrences, minor amounts of manganese ore in the form of seams and small nodules are quite widespread in the conglomerate.

Miscellaneous Occurrences

Small amounts of manganese ore were shipped from the Bisbee district in 1917 and 1918 by Shattuck-Arizona Copper Co. and Houghton Development Co. The ore shipped by the former company was mined partly from shallow surface workings and partly from the 200-foot level of the Shattuck shaft. The surface ore occurred a short distance east of the main shaft along a fissure zone in the Naco limestone. No information was available on the 200-foot-level ore.

About 50 tons of sorted ore, containing 47 percent manganese, was shipped by Houghton Development Co. from a deposit on the south slope of Gold Hill about 5 miles southeast of Bisbee. The ore occurred in small irregular bodies associated with a northwestward-striking fissure in the Naco limestone.

A deposit of oxide ore at an unusual depth was described by Ransome,[19] who visited it in 1918, as follows:

19/ Jones, E. L., Jr., and Ransome, F. L., Deposits of Manganese Ore in Arizona: Geol. Survey Bull. 710, pt. 1, 1920, p. 113.

The exceptional body of manganese ore in the Junction mine of the Calumet and Arizona Mining Co. was found on the 1,300-foot level, about 800 feet northwest of the Briggs shaft, in the Martin limestone, along a north-south fissure. It appeared to be from 12 to 15 feet thick and at least 40 feet long from north to south and to extend for 75 or 100 feet above the level. Not enough work had been done at that time, however, to determine the size and shape of the deposit, and no shipments had been made. East of the manganese the limestone contains considerable disseminated pyrite, sphalerite, and galena.

The ore is chiefly psilomelane but is more cavernous or spongy than most of the surface ores. Sixteen partial analyses, made in the laboratory of the Calumet and Arizona Mining Co., show from 35 to 53 percent manganese and from 6 to 34 percent silica. The average of these determinations is 49.8 percent manganese and 6.2 percent silica.

Some years later, a body of alabandite (manganese sulfide) was found on the 1,900-foot level of the Junction mine in mining lead-zinc ores. It was not fully explored, and its size is not known.

Tombstone District

The Tombstone district is in the southwestern part of Cochise County near Tombstone. Paved U.S. Highway 80 passes through the town which also is the terminus of a spur line of the Southern Pacific Railroad. The district covers a group of relatively low scattered hills and ridges known as the Tombstone Hills. Altitudes range from 4,500 feet at Tombstone to 5,300 feet at the summits of the higher hills.

Rich silver ore was discovered in the area in 1877, and during the next decade Tombstone was the best-known mining camp in the Southwest. In 1881 Tombstone, with a population of about 4,000, was the largest town in Arizona. The district continued to be highly productive until 1886 when many of the larger mines were closed because of the great influx of underground water encountered at depths of 500 feet or more. In 1902, after several of the older companies had been consolidated, a concerted effort was made to lower the water and work the deposits at greater depth. During the next few years the district was quite active, and the 1,000-foot level was reached in the new Pump shaft. However, the cost of pumping proved so great that the work was discontinued in 1911. The lower levels were allowed to fill with water and remain so filled to this day.

In 1914, the Phelps Dodge Corp. acquired many of the properties in the district and, operating for several years under the name of Bunker Hill Mines Co., produced a large tonnage of smelting ore and concentrates. During this period the first manganese ore was shipped. In 1918 the company closed its mill and turned the mines over to lessees.

Tombstone Development Co. acquired most of the mining property in the district in 1933 and operated several mines until 1937. Subsequent operations have been intermittent. Both United States Smelting, Refining & Mining Co.

and Newmont Exploration, Ltd., have at different times done considerable exploratory work on claims leased from Tombstone Development Co.

The total recorded production[20] of the district from 1879 through 1936 was valued at $37,103,008. Silver comprised about 81 percent of the total, gold about 14 percent, and lead, copper, zinc, and manganese the remainder. Since 1936, small-scale operations by lessees have yielded a small production.

The first straight manganese ore was produced during World War I. Production (1915-18) as given by Ransome,[21] totaled 7,354 long tons containing 35 percent or more manganese and 5,581 long tons containing less than 35 percent. Most of the output was produced by Bunker Hill Mines Co. from the Oregon-Prompter mine. Interest in manganese was revived during World War II, and 2 carloads of high-grade ore was reportedly shipped from the Oregon claim.

The next known production of manganese was made in 1953 and 1954, when 452 long tons of crude ore averaging 22.8 percent manganese and 206 long tons of concentrates containing 34.8 percent manganese were produced in the district. The crude ore came from the Prompter mine. The concentrates were recovered in a small, heavy-media plant erected near Tombstone by Arizona Materials & Service Co. The ore yielding the concentrates came largely from the dumps of several scattered deposits on which the company held leases.

When the district was visited early in August 1957, lessees were operating the Oregon-Prompter mine. From February to August 1957 the estimated production had totaled 19 carloads, or 900 tons or more of sorted ore averaging about 24 percent manganese. The ore was consigned to the Mohave Mining & Milling Co., Wickenburg, Ariz. for concentration.

Manganese mineralization is widespread throughout the district and has occurred in various amounts with most of the oxidized silver-lead ores. However, only a very few deposits have produced ore chiefly valuable for its manganese content. These deposits are along the southern margin of the district bordering the richer silver mines (fig. 6).

By far the most productive manganese deposit has been the Oregon-Prompter. Other deposits, which contain appreciable manganese but have been worked principally for their silver content, are the Lucky Cuss, Rattlesnake, Comet, and Contact. Small quantities of manganese concentrates have been recovered from dumps.

The manganese ore occurs in lenticular bunches and pipelike replacement masses along steeply dipping fractures and fault zones, mainly in the Naco limestone. Most of the ore bodies are extremely irregular, ranging from 1 to

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20/ Butler, B. S., Wilson, E. D., and Rasor, C. A., Geology and Ore Deposits of the Tombstone District, Ariz.: Arizona Bureau of Mines Bull. 143, 1938, p. 50.

21/ Work cited in footnote 19 (p. 23), p. 116.

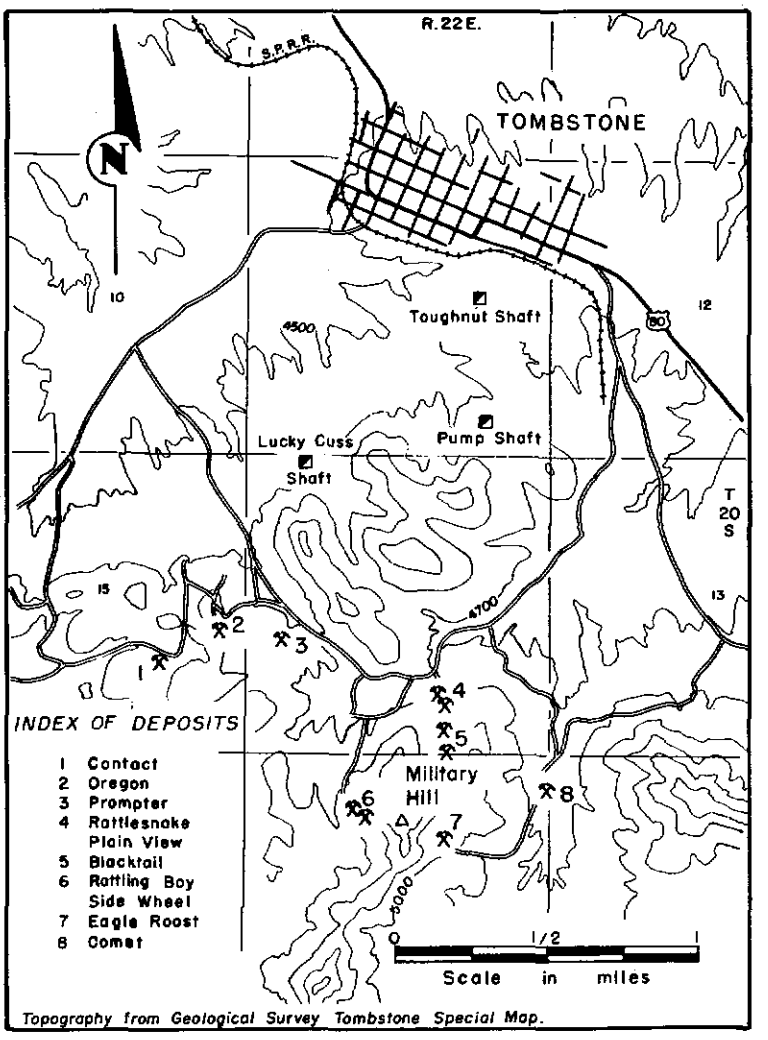

FIGURE 6. - Manganese Deposits Near Tombstone, Cochise County, Ariz. *(Topography From Geological Survey Tombstone Special Map.)*

20 feet in width and from a few feet to 150 feet in length. A few are veinlike, such as the Comet where low-grade manganiferous silver ore has persisted almost continuously along the strike for nearly 1,400 feet.

The chief manganese minerals are pyrolusite, wad, and psilomelane. Small amounts of the rarer zinc-bearing manganese minerals are present in some of the ore. Alabandite, the sulfide of manganese, has been found in deeper parts of the Lucky Cuss mine.

In 1941 an exploration project[22/] was undertaken in the district by the Federal Bureau of Mines to search for strategic minerals. The work comprised mapping and sampling the accessible workings of several of the more promising manganese occurrences and underground diamond drilling from the 100- and 300-foot levels in the Oregon mine. After the project was completed, Needham and Storms reached the following conclusion:

> Results of the work indicated that no great tonnage could be expected from any individual mine or deposit; rather, that the occurrence was spotty, and the tonnage was small and scattered throughout the district. Several hundred tons could be expected to be found here, probably a few thousand in one place, a few hundred in another place, and so on. It is difficult to actually block out tonnage. In all probability the best method would be to mine out a lens or chimney upon discovery to actually ascertain the tonnage contained in it. Being principally silver-bearing, the principal ore shoots were completely mined out years ago. As the manganese occurred with the

22/ Needham, A. B., and Storms, W. R., Investigation of Tombstone District Manganese Deposits: Bureau of Mines Rept. of Investigations 5188, 1956, p. 34.

silver most of it was mined out also, leaving only small spots of low-grade ore here and there.

Exploitation of this ore appeared to depend upon the development of a low-cost milling method that would yield a marketable manganese product and recover a high percentage of the silver. Consequently, in 1944 the Bureau of Mines took large bulk samples from selected silver-bearing manganese deposits in Arizona, among which were six deposits in the Tombstone area.23/

The ore was tested on a semi-pilot-plant scale to recover manganese by the dithionate process of sulfur dioxide leaching, followed by cyanidation or flotation of the residue to recover the silver. Tests on the Tombstone ore indicated that 90 percent or more of the manganese could be recovered readily as a ferrograde product and 80 to 90 percent of the silver could be recovered by flotation or cyanidation.

Oregon-Prompter

The Oregon-Prompter mine is about 2 miles by road south-southwest of Tombstone. The Oregon shaft is in NE1/4SE1/4 sec. 15, and the Prompter shaft is about 1,100 feet farther east in NW1/4SW1/4 sec. 14, T. 20 S., R. 22 E. Both can be reached by traveling about 1 mile along the dirt road that branches left from the Charleston Road 1 mile southwest of Tombstone. (See fig. 6.)

The mine workings cover parts of two adjoining patented claims known as the Oregon and the Prompter. These claims are among the oldest in the district; they were located in the late 1870's and have been held and operated by at least three different owners. They are now part of the large holdings of Tombstone Development Co.

Mining manganiferous silver ore was begun in 1881 at the Oregon-Prompter mine, but it was not until 1915 that any interest was shown in producing manganese. From 1915 through 1918, production from the district totaled 12,935 tons of manganese ore and concentrates. Although small amounts of manganese ore were produced from neighboring mines, it appears that by far the bulk of this production came from the Oregon mine.

Ransome24/ visited the district in 1918 and described the operations at the Oregon mine as follows:

> At the time of the visit, early in March 1918, the Oregon mine was yielding about 2,000 tons of ore a month. It had been in operation about 2 years and had produced about 50,000 tons in all. The material from the higher grade bodies is sorted, and the hard lumps of comparatively pure psilomelane are shipped for the manufacture of ferro-manganese. The residue from this sorting and the material

23/ Romslo, T. M., and Ravitz, S. F., Arizona Manganese-Silver Ores: Bureau of Mines Rept. of Investigations 4097, 1947, 13 pp.

24/ Work cited in footnote 19 (p. 23), p. 115.

from the lower grade bodies is run over grizzlies, and the oversized lumps are again sorted. The rejected material from this sorting with the fines is sent through the concentrating mill near Tombstone. Here the material is concentrated about 8 to 1. The higher grade concentrates, running from 70 to 85 percent of MnO_2, are shipped as "chemical manganese" of which 3 grades are made. The lower-grade concentrates, generally running from 40 to 43 percent manganese, are shipped as furnace ore to steel works in Pennsylvania. The tailings and slimes are partly dried and are shipped to Douglas, Ariz., where they are used for their silver content and fluxing value. Only such ore is mined as will give tailings that are sufficiently argentiferous to pay for shipment. In other words, the manganese ores of the Oregon mine could not be profitably exploited or even mined without loss if they were not argentiferous. In 1917 these ores contained, on an average, 7.78 ounces of silver a ton.

No more manganese was produced until World War II, when 2 carloads of high-grade sorted ore was shipped from the outcrop of a deposit near the Oregon shaft.

The next known production of manganese ore was made in 1953 or 1954, when the Tombstone Development Co. shipped 452 long tons of ore from the property. This ore, averaging 22.8 percent manganese, was shipped to the Government purchasing depot in Deming, N. Mex.

Manganese mining was resumed again on the property in February 1957 by Odell Still and associates under a lease from Tombstone Development Co. When the area was visited early in August 1957, Still said that 19 carloads, or 900 tons or more of sorted ore, had been produced up to that time. The ore, containing approximately 24 percent manganese, was shipped to the plant of Mohave Mining & Milling Co. near Wickenburg, Ariz., where it was concentrated to a marketable product. Five men were employed at the mine when it was visited in August 1957. The ore was being mined in open stopes above the 150-foot level in the Prompter shaft in a hitherto undeveloped area beyond the west face of the old level.

The ore bodies on the property occur in many places along a major east-west fault zone and its branching fissures. The main zone, known as the Prompter fault, dips steeply to the south and extends through most of the southern part of the district. The ore in the Prompter workings occurs along the main fault, whereas that in the Oregon workings occurs largely along a footwall branch known as the Oregon slip. Twelve or more separate ore bodies have been found and mined along the strike of the fault system over a distance of nearly 1,800 feet. (See fig. 7.) Many appear to have been localized where northeast-striking fissures intersect favorable beds or structures in the Naco limestone. This rock occupies the north or footwall side of the fault system. Most of the ore bodies are irregular pipelike masses ranging from a few feet to 25 feet in the horizontal cross section. Others are veinlike or tabular bodies ranging from a few feet to 10 feet in width and from a few feet to 150 feet in strike length. Both types range from less than 100 to several hundred

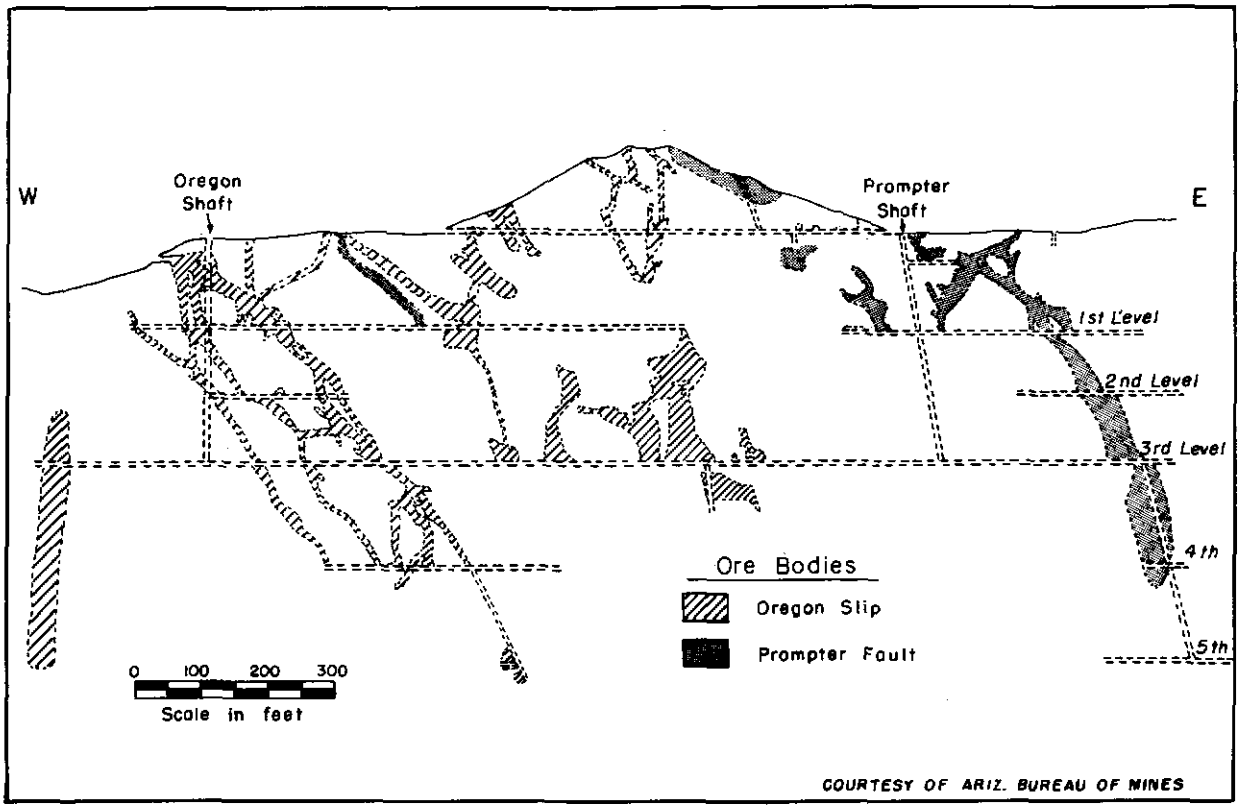

FIGURE 7. - Longitudinal Section Through Oregon and Prompter Mines, Looking North. *(Courtesy of Arizona Bureau of Mines.)*

feet in vertical extent. One ore body has persisted more or less continuously from the surface to water level, a distance of 800 feet or more as measured along its eastward plunge. No distinction can be made between the manganese ore bodies and those mined chiefly for silver, as all contained various amounts of both metals.

The principal workings on the property consist of two shafts, five levels, and a near-surface tunnel driven through the hill separating the two shafts (fig. 7). The Oregon shaft is vertical and the Prompter, which is about 1,100 feet to the east, is inclined at an angle of 70°. Both bottom at the third level, where they are connected. Below this level the mine has been developed and worked from winzes extending to water level. The lowest level is about 800 feet vertically below the highest point on the outcrop. Only the upper tunnel and part of the first level in the Prompter shaft were accessible when the property was visited. Figure 7, showing the distribution of the ore bodies and mine workings in longitudinal section, was obtained through the courtesy of the Arizona Bureau of Mines.

Contact

The Contact deposit is about 1,200 feet west-southwest of the Oregon shaft on the patented Contact claim owned by Tombstone Development Co. The past production has been limited to a little manganese-bearing silver ore, and

there has been no attempt in many years to work the deposit. The underground workings were sampled in 1941 by the Federal Bureau of Mines in connection with its investigation of the manganese resources of the district.

The manganese-silver ore occurs in small bodies along a vein in the Naco limestone occupying the footwall of the Prompter fault. In this area, granodiorite forms the south or hanging-wall side of the fault. The vein strikes eastward and dips steeply to the south in general conformity to the fault.

The deposit was explored by a 250-foot inclined shaft and three levels. The two upper levels are short, but the bottom or 240-foot level follows the vein for several hundred feet, both east and west of the shaft. A few short raises were driven above the two lower levels, and a small irregular stope (about 60 feet high) is near the west end of the bottom level.

A summary of the results of sampling by the Bureau of Mines[25/] states:

> Visual examination of the first level revealed no vein to sample. Systematic sampling of drift bottoms and backs at regular intervals on the second and third levels indicated that on the west side between the second and first levels 37 inches of ore occurred, averaging 10.6 percent manganese. Between the third and second levels on the same side the ore averaged 13.1 percent, and below the 300 it averaged 14.3 percent. On the east side between the second and first levels the remaining ore averaged only 4.1 percent manganese. Between the third and second levels and below the third level it averaged 8.8 percent. Weighted averages for all the ore sampled in the mine indicated a grade of 10 percent manganese. Since very little stoping was done in the mine, it was assumed that silver values during the actual mining operations were not enough to justify such mining. The grade, as indicated in 1941, especially with such a narrow vein (2 feet), did not justify reconditioning the mine for stoping.

Rattling Boy and Side Wheel

The Rattling Boy and Side Wheel are two adjoining patented claims owned by John F. Ross, of Tombstone, Ariz. They lie on the western slope of Military Hill in NW1/4 sec. 23, T. 20 S., R. 22 E. and are accessible over about 3 miles of dirt road trending southerly from the east outskirts of Tombstone. (See fig. 6, p. 26.)

The claims were located and worked to some extent for silver in the early days of the district. The first manganese ore on record was produced in 1955 by Arizona Materials & Service Co., which held a lease on the property at that time. The production, amounting to 66.8 long tons of concentrates averaging 40.3 percent manganese, was shipped to the Government purchasing depot in Deming, N. Mex. The ore from which the concentrates were recovered came from an opencut on the Rattling Boy and from old dumps on the Side Wheel claim.

25/ Work cited in footnote 22 (p. 26), p. 22.

The ore was concentrated in the lessee's heavy-media plant near Tombstone. There are no records of the tonnage or grade of the crude ore removed from the property.

Manganese minerals on the Rattling Boy claim occur in short irregular podlike bunches along the limbs of a minor fold or roll in the Escabrosa limestone. The fold trends northward, and its east and west limbs dip 25° and 30°, respectively. The occurrence has been explored underground at a depth of about 30 feet by short drifts extended from a long crosscut adit driven many years ago in a search for silver ore. In the drift on the west limb of the fold, which is about 150 feet east of the portal of the adit, mineralization extended over a length of 60 feet or more. The ore along the drift occurs in disconnected lenses ranging from a few inches to 3 feet in width and from a few feet to 10 feet in length. The east limb of the fold contains some manganese minerals but has not been explored on the adit level.

The bulk of the output of manganese ore in 1955 was mined from surface workings above the adit. Extensive stripping had been done in this area in an apparent attempt to mine the deposit from an open pit. At the time the claim was visited in August 1957, the bottom of the opening was covered with debris washed in by recent rains, and only one small spot manganese mineralization was exposed.

On the Side Wheel claim, which adjoins the Rattling Boy on the east, five separate manganiferous occurrences are exposed along the steep hillside in an area about 350 feet square. They are associated with steeply dipping fractures striking north-northeast and cutting eastward-dipping beds of the Escabrosa limestone.

The deposits range from irregular pipelike masses, 6 to 8 feet in diameter, to narrow, elongated lenses at intervals along the more persistent fractures. In some places the mineralization spreads for short distances into the beds adjacent to the fractures. The principal deposits on the claim appear to be of this nature. Apparently considerable manganiferous silver ore has been produced from inclined shaft workings that follow the general dip of the limestone beds where they are intersected by a steeply dipping, northeasterly trending fracture. These workings are old and inaccessible, but from surface observations the deposit has been mined in open stopes extending at least 60 feet in depth and 100 feet or more along the strike of the fracture. The stopes near the surface range from 2 to 6 feet in width.

Most of the other manganiferous occurrences on the claim have been explored by shallow opencuts and pits.

Rattlesnake

The Rattlesnake deposit is on a patented claim of the same name and is part of the large group owned by Tombstone Development Co. It is 2 miles directly south of the town of Tombstone and about 0.6 mile east-southeast of the Prompter shaft. The area is reached most readily by following about 2

miles of dirt road that branches right from U.S. Highway 80 near the eastern outskirts of Tombstone. (See fig. 6, p. 26.)

The deposit was discovered and worked for silver in the early 1880's; however, it yielded only a relatively small amount of manganiferous silver ore. So far as is known no straight manganese ore has ever been shipped. When the area was visited in August 1957, the deposit had been idle for many years and the underground work was inaccessible.

The manganese minerals occur in places along a southern branch of the Prompter fault system. This branch, known as the Rattlesnake fault, strikes about N. 80° E., dips almost vertically, and cuts the Escabrosa limestone near the deposit. On the surface manganese minerals are exposed in scattered spots for about 300 feet along the strike of the fault zone. The strongest mineralization ranges from 2 to 5 feet in width and appears to be localized in short, disconnected bodies.

The principal workings consist of a few hundred feet of drifting from the bottom of a 120-foot shaft and two small stopes extending outward for short distances from the ends of the shaft. The accessible parts of these workings were sampled in 1941 by the Federal Bureau of Mines. Ten samples were cut--six in the stopes and four along the back of the east drift within a distance of 200 feet. The sampling showed the ore was very erratic; individual samples contained 1.5 to 26.2 percent manganese and 1.9 to 17.8 ounces of silver per ton over an average width of about 4 feet. The best ore, averaging about 19 percent manganese, was found in the stopes above the bottom of the shaft. The samples taken in the drift contained 1.5 to 16.5 percent manganese and averaged 7.2 percent. The silver content also was erratic, ranging from 1.9 to 17.8 ounces per ton and averaging about 7 ounces per ton.

Plain View

The Plain View deposits are on a fractional unpatented claim adjoining the south side of the Rattlesnake claim. The principal workings are accessible by way of a short side road that continues southward from the Rattlesnake shaft.

The claim was located originally in the 1880's as a silver prospect and since that time has been held by several individuals. In 1950, it was relocated and called the Plain View by the present owner, Joe M. Escapule, of Tombstone, Ariz.

During the early days in the district a small amount of manganiferous silver ore is said to have been mined from the claim. The first manganese was produced in 1954 in the form of concentrates by Arizona Materials & Service Co., which held a lease on the property. The concentrates, amounting to 41.9 long tons containing 26 percent manganese, were recovered from several hundred tons of low-grade ore remaining on dumps of the old excavations. The ore was concentrated in a semiportable heavy-media separation plant erected near the east end of Tombstone. When the area was visited in July 1957 the plant had been dismantled and removed from the district.

The manganese ore occurs along two separate fissures in the Escabrosa limestone. One fissure strikes N. 45° E., and the other strikes almost due north. Both are virtually vertical in dip and may be subordinate fractures branching from the Rattlesnake fault. On the outcrop of the northeasterly trending fissure, manganese oxides are exposed in six separate shallow cuts and pits that were excavated at intervals for 400 feet along the strike. The openings were 20 to 60 feet apart and as much as 20 feet long. They were sampled by the Federal Bureau of Mines in 1941, and six samples taken over widths ranging from 0.5 to 7.5 feet contained 4.2 to 32.9 percent manganese. The weighted average of the samples was 10.2 percent manganese over an average width of 3.2 feet. The silver content also was spotty, ranging from a fraction of an ounce to 12.8 ounces per ton and averaging less than 5 ounces in the six samples.

The other north-striking fissure crops out along the bottom of a wash about 100 feet southwest of the lower end of the workings. Manganese ore is exposed in places about 250 feet along the strike of this fissure. The occurrences range from veinlets less than 1 foot wide to an irregular body, roughly lenticular in plan, ranging from 2 to 7 feet in width and having an exposed length of some 60 feet. The fissure was explored by a vertical shaft about 60 feet deep and two shallow pits near the shaft. About 125 feet farther south, manganese ore is exposed along the fissure in a shallow opencut 12 feet long. In that area the ore occurs in an elongated lens ranging from 8 inches to 1.5 feet in width.

In 1941, the principal exposures along the surface of the fissure were sampled by the Federal Bureau of Mines. Five samples, taken over widths ranging from 8 inches to 3.5 feet, contained 9.8 to 22.8 percent manganese and 1.7 to 10.8 ounces silver per ton. The best ore was found around the collar of the 60-foot shaft. Most of the concentrates produced from the property were recovered from the dump of this shaft.

Blacktail Group

Claims known in 1941 as the Blacktail adjoin the Plain View fraction on the south and lie along the north slope of Military Hill in SW1/4 sec. 14, T. 20 S., R. 22 E. They are not on the records of the County Recorder, and the owner is not known.

Considerable exploratory work has been done in the past, and some manganiferous silver may have been produced. However, there are no records indicating that any straight manganese ore ever was shipped from the property.

The manganese minerals occur in a series of narrow disconnected lenticular bodies along a fissure zone in the Escabrosa limestone. The fissure strikes north, dips nearly vertically, and can be traced for 1,800 feet or more up the north slope of Military Hill into the adjoining Eagle Roost claim which lies on the southeastern flank of the hill. The Blacktail zone appears to be part of the same system of northward-trending fractures that traverse the Plain View claim.

The old workings on the claims are scattered about 1,000 feet along the outcrop of the fissure. They consist of two inaccessible shafts, five shallow opencuts, and an adit about 100 feet long. The deepest shaft is estimated to be approximately 80 feet deep; it is vertical and is close to the north end of any evident mineralization. The other shaft is about 150 feet to the south. It is inclined steeply to the east and probably is about 50 feet deep. The opencuts and the adit were dug at irregular intervals along the outcrop south of the inclined shaft.

The accessible parts of most of the openings were sampled in 1941 by the Federal Bureau of Mines. Thirty-eight samples, taken over an average width of about 2 feet, had an average manganese content of 12.6 percent. The samples were taken over widths ranging from a few inches to 5 feet; they contained 4 to 20 percent manganese and from less than 1 ounce to 11 ounces silver per ton.

Comet

The Comet deposit is on a patented claim known as the Big Comet. It is situated near the east side of the district in NE1/4 sec. 23, T. 20 S., R. 22 E. and can be reached from the eastern end of Tombstone by traveling 1.6 miles south-southwest on a dirt road, then 0.7 mile southeast on a left-hand branch to the Comet shaft. (See fig. 6, p. 26.)

The deposit was worked quite extensively for silver in the early 1900's by Tombstone Consolidated Mines Co. The ore was reported to be relatively low in silver but commanded a premium as a smelter flux, largely because of its manganese content. The few smelter settlement sheets that were available showed that the ore contained 7 to 14 ounces of silver per ton and 8 to 20 percent manganese. None of the manganese was recovered as it passed into the smelter slag. So far as is known, no straight manganese ore has been produced from the deposit. The claim, together with many others in the district, was acquired in 1933 by Tombstone Development Co., the present owner.

The mine has been idle for 40 years or more, and the underground workings were inaccessible when the area was visited in August 1957. The following description of the deposit has been abstracted from previously published reports.

The ore occurs in a well-defined vein along the footwall of a broad porphyry dike intruding the Naco limestone. Both the dike and the vein strike northward and dip steeply to the west, cutting the limestone beds which dip about 25° to the east. The vein ranges from 1 to 10 feet in width, averaging about 2 feet. As shown on an old map, the ore has been stoped almost continuously for nearly 1,400 feet along the 200-foot level and for 800 feet or more on two other levels.

The mine was developed by a vertical shaft 400 feet deep and by four levels extending along the vein for almost equal distances north and south of the shaft. The bottom level, although called the 300-foot level, was actually 400 feet below the collar of the shaft. The ore was mined from cut-and-fill

stopes which extended to various heights between the levels. In some places the stopes were connected to the next level; however, in most places they did not reach the level above, and large pillars of unmined ore were left in the mine.

In 1941, the accessible parts of the mine workings were sampled by the Federal Bureau of Mines in conjunction with its exploration project in the district. As the area north of the shaft was largely caved, the work was confined to the south side and consisted of channel sampling the backs of stopes and the floors of drifts in areas containing appreciable amounts of unmined ore. After completing the work and taking 121 samples, the investigators reached the following conclusions.[26/]

> Results of samples taken indicated that the amount of ore left between the surface and the 100-foot level averaged 12.2 percent manganese. It averaged 10.3 percent between the 100- and 200-foot levels and 10.0 percent between the 200- and 300-foot levels.
>
> Samples taken at regular intervals on the floor of Comet 300-foot level (or bottom level) averaged only 7.7 percent manganese, and samples taken from stoping operations below the 300-foot level averaged only 7.6 percent, with widths of only about 2 feet. Weighted averages for the south side, exclusive of that on the 300-foot level and below, averaged only 10.7 percent manganese.

For more details on the sampling and the silver content of the samples, the reader is referred to the publication cited in footnote 26.

In 1955, Newmont Exploration, Ltd., explored the deposit at greater depth by an inclined diamond-drill hole said to be about 1,100 feet long. The results were not available.

Eagle Roost

The Eagle Roost is a single unpatented claim situated near the southeastern base of Military Hill in NE1/4 sec. 23, T. 20 S., R. 22 E. It is accessible from the Comet mine by about 0.7 mile of rough truck trail. (See fig. 6, p. 26.)

The claim has been held for many years by the present owner, Joe M. Escapule, of Tombstone, Ariz. A small amount of manganese-bearing silver ore has been produced in the past, but so far as is known no manganese ore ever was shipped from the property.

The manganese-silver mineralization occurs in irregular bunches and lenses along the southern extension of the fissure zone that crosses the Blacktail claim. On the Eagle Roost claim the main fissure dips steeply to

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26/ Needham, A. B., and Storms, W. R., Investigation of Tombstone District Manganese Deposits: Bureau of Mines Rept. of Investigations 5188, 1956, p. 22.

the west, cutting the eastward dipping beds of the Escabrosa limestone. The ore occurs along the fissure in a succession of pods ranging from a few inches to 3 feet in width, which are separated by narrow mineralized stringers or barren vein matter.

When the property was visited in August 1957 the principal workings consisted of an adit which followed the main fissure northward into the hillside for 200 feet or more. A small amount of ore had been stoped from the ends of a 25-foot winze sunk about 60 feet north of the portal of the adit.

Two samples were taken in the north end of the adit. One from the face assayed 16 percent manganese across a width of 1.5 feet; the other, taken about 20 feet south of the face, contained 31 percent manganese over a width of 2.5 feet. The respective silver assays were 1.7 and 4.2 ounces per ton.

Florida Group

The Florida group, comprising seven unpatented claims, is 6.5 road miles southwest of Tombstone near the center of sec. 32, T. 20 S., R. 22 E. The claims are accessible over 1 mile of dirt road that branches eastward from the Charleston Road about 5.5 miles southwest of Tombstone.

Manganese occurs in the group as an isolated deposit in the relatively flat alluvium-covered valley lands between the San Pedro River and the Tombstone Hills. A piece of manganese float found by A. B. Rodriguez in 1941 led to discovery of the deposit.

The claims are owned by A. B. Rodriguez and W. C. Mason, of Tombstone, Ariz. In 1954, the claims were leased to Arizona Materials & Service Co., which did much bulldozer stripping along the deposit and mined some ore from a shallow opencut. The ore was concentrated in the company's mill near Tombstone. No records are available on the tonnage mined or the amount and grade of concentrates produced. The concentrates were mixed with those from other properties and shipped to the Government purchasing depot in Deming, N. Mex.

The manganese ore occurs along a steeply dipping eastward-trending fissure in Paleozoic limestones. Seams, veinlets, and small irregular masses of soft manganese oxides crop out in places along about 200 feet of the fissure. The larger masses of ore range from 1 to 3 feet in width, are as much as 10 feet long, and are enclosed by lower grade material composed of seams and stringers of manganese minerals. In spots, this lower grade material attains widths of 6 feet or more.

The workings consisted of an opencut about 100 feet long, 6 feet wide, and as much as 6 feet deep. A small vertical shaft about 30 feet deep had been sunk on the fissure near the east end of its outcrop.

Miscellaneous Occurrences

In addition to the deposits previously described, several other manganiferous occurrences in the Tombstone district were sampled in 1941 by the

Bureau of Mines. The deposits were scattered throughout much of the district, and a summary of the sampling results is quoted as follows:27/

Randolph Louis. Inaccessible; dump samples averaged 12.9 percent manganese.

Rocky Bar. Inaccessible; dump samples averaged 6.8 percent manganese.

Sunset. Test-pit collar averaged 35.9 percent manganese; test-pit bottom averaged only 0.8 percent. Appears to be a pocket that was mined out.

Escondido. Surface dump samples averaged 15.3 percent manganese.

East Side fissure. Vein is spotty. On the 500-foot level, vein is 39 inches wide; it was sampled for a length of 60 feet and averaged 15.6 percent manganese. On the 300-foot level the vein was 37 inches wide, was sampled for 60 feet, and averaged 17.4 percent manganese.

Courtland-Gleeson District

The Courtland-Gleeson district, also known as the Turquoise district, is in south-central Cochise County, about 12 miles by graded dirt road east of Tombstone. (See fig. 4, p. 10.) The settlements of Courtland and Gleeson are about 4 miles apart and lie along the foothills at the southeastern end of the Dragoon Mountains.

Since ore was discovered in the district in the late 1870's, significant amounts of copper, gold, silver, and lead have been produced. Although manganese minerals are generally present in many copper-lead deposits in the area, only four small occurrences are known in which the manganese content has been high enough to encourage exploration. Only one of these has yielded manganese ore.

The chief manganese minerals are pyrolusite, wad, and psilomelane; they occur along fracture zones in Carboniferous limestone.

No work was in progress on any of the manganese deposits when the area was visited in August 1957.

Mangum Claims

Claims held by D. C. Mangum in the early 1940's are about 2 miles by road northwest of Courtland in NW1/4 sec. 17, T. 19 S., R. 25 E. They are accessible by a side road, 0.6 mile long, that branches left or westward from the Pearce Road about 1.5 miles north of Courtland.

27/ Needham, A. B., and Storms, W. R., Investigation of Tombstone District Manganese Deposits: Bureau of Mines Rept. of Investigations 5188, 1956, p. 30.

The claims have not been worked for many years. No location notices were found, and the present owner is not known. During World War II, reports show that 2 carloads of hand-sorted ore, containing about 35 percent manganese, was shipped from the claims by D. C. Mangum.

Manganese oxides in seams, irregular bunches, and isolated nodules are exposed along numerous fractures occupying an area of shattered limestone roughly 300 feet long and as much as 150 feet wide. Most of the mineralized fractures strike northward, and their dip ranges from nearly vertical to 30° W. Short, irregular masses of manganese oxides, several feet wide, replace the limestone in spots where fractures are closely spaced. Isolated nodules of the harder manganese minerals, ranging from the size of a pea to that of a baseball, are widely scattered within the otherwise barren limestone that separates the mineralized fractures. In the largest occurrence, from which much of the ore was mined, the mineralization attains a width of 12 feet in places and has an exposed length of about 30 feet.

The workings consist of several shallow opencuts.

Ora May

The Ora May is a single unpatented claim about 3 miles by road north-northeast of Gleeson, in the north-central part of sec. 33, T. 19 S., R. 25 E. It is accessible by a side road 0.2 mile long that branches left or westward from the Gleeson-Courtland Road about 2.8 miles from Gleeson.

The claim is owned by John R. Cowen, of Gleeson, who located it in 1952. A few tons of manganese ore have been mined, but none has been shipped.

The manganese minerals occur in small irregular bodies along several fractures cutting beds of gray limestone. The fractures strike northward and dip steeply eastward. Four rather widely separated mineralized ore bodies are exposed in an area roughly 250 feet square. The larger ore bodies range from 2 to 4 feet in width and from a few feet to 30 feet in length. They have been explored by scattered opencuts and pits as much as 8 feet deep. The chief manganese minerals are wad and pyrolusite occurring in a gangue of iron oxides and calcite.

Black Jester

The Black Jester group of several unpatented claims is in NW1/4 sec. 16, T. 19 S., R. 25 E. The manganese deposits lie near the base of a hill about 1 mile north of Courtland and a few hundred feet west of the Pearce Road.

When the area was visited in August 1957, location notices were found showing the claims had been located in November 1956 by Harry S. Ruppelius and Louis B. Ellsworth, Jr., of Phoenix, Ariz.

So far as is known, no manganese ore had been shipped from the property.

In the principal deposit, manganese oxides occur as small irregular masses replacing limestone along a northerly trending fracture zone. The mineralization is exposed for 60 feet or more along the strike and ranges from 4 to 12 feet in width. The wider areas contain overlapping lenses of mineralization from 1 to 3 feet wide and up to 6 feet long.

The workings consist of a few shallow opencuts scattered along the outcrop.

Barrett Group

The Barrett group, comprising 20 or more old patented claims, lies largely in the northern half of sec. 13, T. 19 S., R. 24 E., along the southeastern flank of the Dragoon Mountains. The area may be reached by traveling 1.7 miles north from Courtland on the Pearce Road, then left or westward on a side road through the Busenbark Ranch 3.3 miles to a dim road branching left. This road is followed 0.9 mile south, where it terminated in a canyon near the ruins of the old Barrett Camp.

The property was worked in the early days. Some copper was produced in a small smelter, parts of which still remain a short distance north of the former campsite. Evidently, manganiferous material found on some of the claims was mined and used as a smelter flux, but there are no records indicating that any manganese ore was ever shipped.

In 1952 most of the claims were puchased for delinquent taxes by the present owner, C. W. Busenbark, who resides on a ranch about 2 miles northwest of Courtland.

Manganese minerals crop out in two areas, one about 1,500 feet north and the other about 1,500 feet northeast of the former campsite. The northeast croppings are east of the road, well up a steep hillside and accessible only by foot. There, soft manganese oxides occur in irregular bunches and lenses along a fracture, cutting beds of massive gray limestone. The fracture strikes eastward, dips about 70° N., and is exposed for about 75 feet. In one place the manganese ore spreads into the limestone walls for several feet on both sides of the fracture. The manganese minerals, accompanied by iron oxide, are most abundant along the hanging wall of the fracture where they form lenses and irregular bunches ranging from 1 to 6 feet in width. The workings consist of an opencut that extends downward into the east end of a 50-foot adit which reaches a maximum depth of 25 feet. A few small piles of fairly high grade sorted ore remain on the dump of the adit. This deposit may have been the source of some of the manganese-bearing material that was used as a flux in the smelter.

The other principal manganiferous occurrence lies on the opposite side of the canyon about 1,000 feet west of the adit. In this locality several adits and opencuts expose scattered irregular bodies of manganese ore in an area about 200 feet long and as much as 50 feet wide. The mineralization is associated with several northward-striking fractures, some cutting the limestone at high angles and others following moderately dipping bedding planes. Copper

carbonate minerals are abundant in places and occupy the same fracture system as the manganese. Wad and pyrolusite are the chief manganese minerals. They occur in seams, elongated lenses, and sporadic irregular masses. Some of the largest masses are as much as 10 feet in their greatest dimension. Iron oxides are abundant in most exposures, and the bulk of the material has a lower manganese content than that in the dposit on the east side of the canyon.

Jasper or Lucky Strike

The Jasper, formerly known as the Lucky Strike, is an unpatented claim situated in the Guadalupe Mountains near the southeast corner of Cochise County. It lies in sec. 27, T. 22 S., R. 32 E. and may be reached from Douglas, Ariz., by traveling 36 miles east-northeast on the Geronimo Trail. At that point the deposit lies about 150 yards west of the road.

During the early 1940's the claim was known as the Lucky Strike and was held by Ben Taylor and C. R. Johnson, of Douglas, Ariz. It was abandoned some time later and relocated in 1951 as the Jasper by the present owner, Gus Lankson, also of Douglas. Several tons of manganese ore were mined by Lankson but were not marketed.

The deposit comprises numerous interlacing seams, stringers, and small irregular bunches of manganese oxides occurring in an eastward-trending shear zone in volcanic rocks. The zone contains sporadic spots of mineralization for approximately 250 feet along the strike and across widths ranging from several feet to as much as 30 feet. The seams and stringers range from a fraction of an inch to 2 inches in width. In a few places where the seams and stringers are numerous and closely spaced they coalesce, forming occasional irregular bunches of ore up to several inches in diameter. In the zone as a whole, the mineralized fractures are widely separated by barren country rock.

The ore minerals are essentially pyrolusite and psilomelane.

When the claim was visited in August 1957, the principal working consisted of a small vertical shaft about 15 feet deep. Several tons of ore sorted from the material broken in this shaft was estimated to contain 10 to 15 percent manganese.

Power Claim

The Power is an isolated manganese deposit situated near the southwestern corner of Cochise County on the east slope of the Huachuca Mountains near their southern end. The property, consisting of a single unpatented claim, lies far up on the northwest side of Miller Canyon in SW1/4 sec. 23, T. 23 S., R. 20 E. at an altitude of about 6,700 feet. It can be reached from the town of Hereford by traveling west about 9 miles to Nicksville on State Highway 92, then south about 1 mile to the Miller Canyon Road which branches westward. This road is followed up the canyon to the Broken Arrow Lodge, then 3 miles to the foot of a steep winding burro trail, about 0.75 mile long, that leads to the deposit. The trail starts from the north side of the road a few

hundred feet up the canyon from a dwelling on the south side of the road. The workings are about 700 feet higher than the bottom of the canyon.

Little is known of the early history of the deposit. It was worked many years ago for silver, and several carloads of manganiferous silver ore were said to have been produced. The claim was relocated in 1951 by Nick Gregovich and is now held by Ruth Diack, of Hereford, Ariz.

The manganese ore occurs in disconnected, irregular bodies along a fracture zone in Paleozoic limestone. The zone trends northwest, dips steeply northeast, and is mineralized in places for a few hundred feet along its strike. The principal manganese occurrences are exposed near the northwestern end of the outcrop of the zone. In this area the mineralization occurs in an irregular pipelike body flanked by a series of lenses that follow the hanging wall of the zone. The pipelike mass is 12 to 15 feet in diameter, with prongs of ore extending outward short distances into the enclosing limestone. The mineralized lenses, ranging from 1 to 5 feet in width, are exposed in places about 150 feet along the strike.

The pipelike body, which evidently yielded the bulk of the manganiferous silver ore, had been exploited in a roughly circular open pit about 20 feet in diameter and some 20 feet deep. At the northeast side of this opening an adit followed the hanging-wall mineralization northwest about 60 feet.

The other principal workings comprise two adits driven at successively lower elevations down the hillside from the open pit. The uppermost adit is 250 to 300 feet long and apparently extends beneath the surface workings for an estimated 50 to 60 feet. Several narrow lenses of manganese mineralization were found in the adit, but none was of a size comparable with those near the surface. The exposed manganese minerals consisted largely of soft amorphous wad containing considerably less manganese than the pyrolusite ore near the surface.

The lower adit is about 150 feet long. Some small manganiferous lenses were exposed, but no bodies of minable width were revealed.

A grab sample was taken from a pile of some 40 tons of ore that had been hand-sorted from material broken in the open pit. The sample assayed 31 percent manganese and 13.6 ounces of silver per ton.

Klondike Group

The Klondike group of unpatented gold claims contains an isolated manganiferous deposit on the southern flank of the Dos Cabezas Mountains in north-central Cochise County. The deposit is about 3 miles northeast of the village of Dos Cabezas in ~~SW~~SE 1/4 sec. 22, T. 14 S., R. 27 E. It may be reached from Dos Cabezas by traveling east on State Highway 186 for 0.6 mile to a branch on the left. This branch is followed 3.3 miles northeastward up the main Bean Canyon Road to a dwelling where the road ends. From this point a dim foot trail, about 0.7 mile long, winds along the southwest side of the canyon and terminates at the portal of an adit a short distance above the bottom of the

canyon. The outcrop of the deposit is about 100 yards up the steep hillside north of the portal at an altitude of about 6,500 feet.

Before 1941 the claim was held for many years by T. P. Bean, of Dos Cabezas. At present the property is owned by Robert Hyde, of Willcox, Ariz. Except for annual assessment work, the claim has not been worked since about 1939, and no manganese ore has been produced.

Soft manganese oxides, consisting chiefly of wad and pyrolusite, are exposed at intervals about 200 feet along an eastward-trending fault or fracture zone in limestone. The zone dips 45° to 50° N. and appears to conform to the dip of the limestone bedding. The largest deposit, near the east end of the outcrop, is an irregular replacement ore body as much as 10 feet wide. On the surface it tapers rapidly and disappears within about 20 feet. Mineralization appears to have been localized where one or more cross fractures intersect the hanging wall of the main zone. A small, partly filled incline follows the wider part of the deposit downdip for some 10 feet. The adit at the foot of the hill was begun to explore this deposit at greater depth, but the work was stopped before that objective was attained.

About 175 feet to the west, manganese minerals are exposed in two shallow trenches. In this area the manganese minerals occur as narrow stringers rather widely distributed across 8 to 10 feet of sheared limestone. Between the east and west workings, only occasional small spots of mineralization are exposed on the surface.

The manganese minerals are accompanied in places by an abundance of iron oxides.

A sample taken from the largest ore body contained 18.8 percent manganese and 10.2 percent iron.

Gila County

Most of the known manganese deposits of Gila County are found in the Globe Hills within 5 miles north of the town of Globe. (See figs. 8 and 9.) A few deposits occur farther north along the Salt River and to the northwest on the western flank of the Sierra Ancha north of Roosevelt Lake. One isolated deposit containing minor amounts of manganese was found in the northwestern part of the county about 10 miles south of the town of Payson (fig. 8).

Manganiferous silver-copper ores have been mined from parts of the county since the early 1880's. The production of high-grade manganese ore began during World War I. Production records for this period are incomplete, but estimates indicate that about 1,600 long tons of ore containing 17 to 35 percent manganese was shipped between 1916 and 1918. Nearly all of this ore was mined from a single deposit in the Globe Hills, held at that time by Globe Commercial Copper Co. Production of manganese ore was resumed during World War II; at that time the estimated production totaled 8,700 long tons or more of ore containing 27 to 45 percent manganese. Excepting about 300 tons, the entire output was mined from the Globe area and shipped to the Metals Reserve

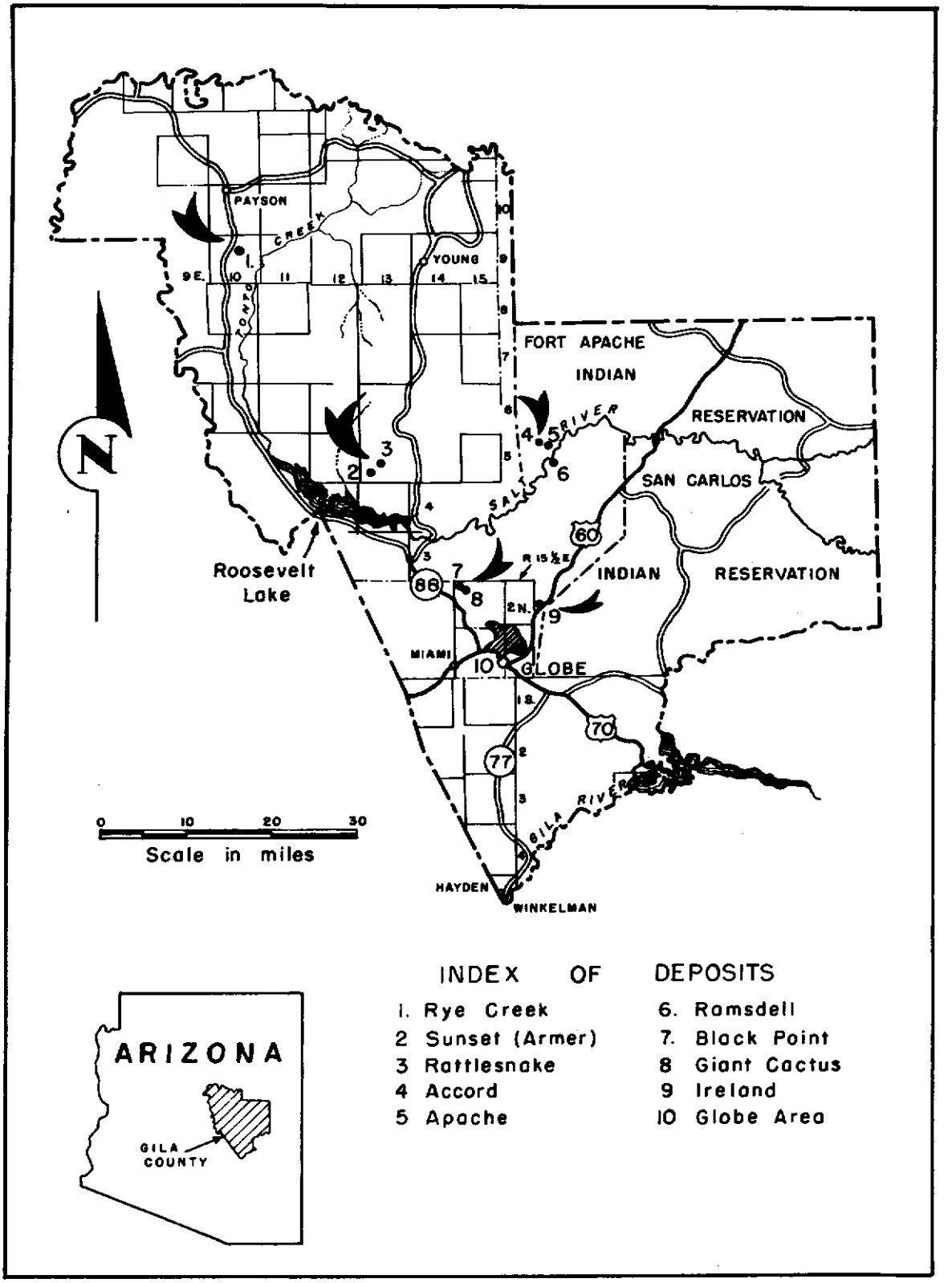

FIGURE 8. - Manganese Deposits, Gila County, Ariz.

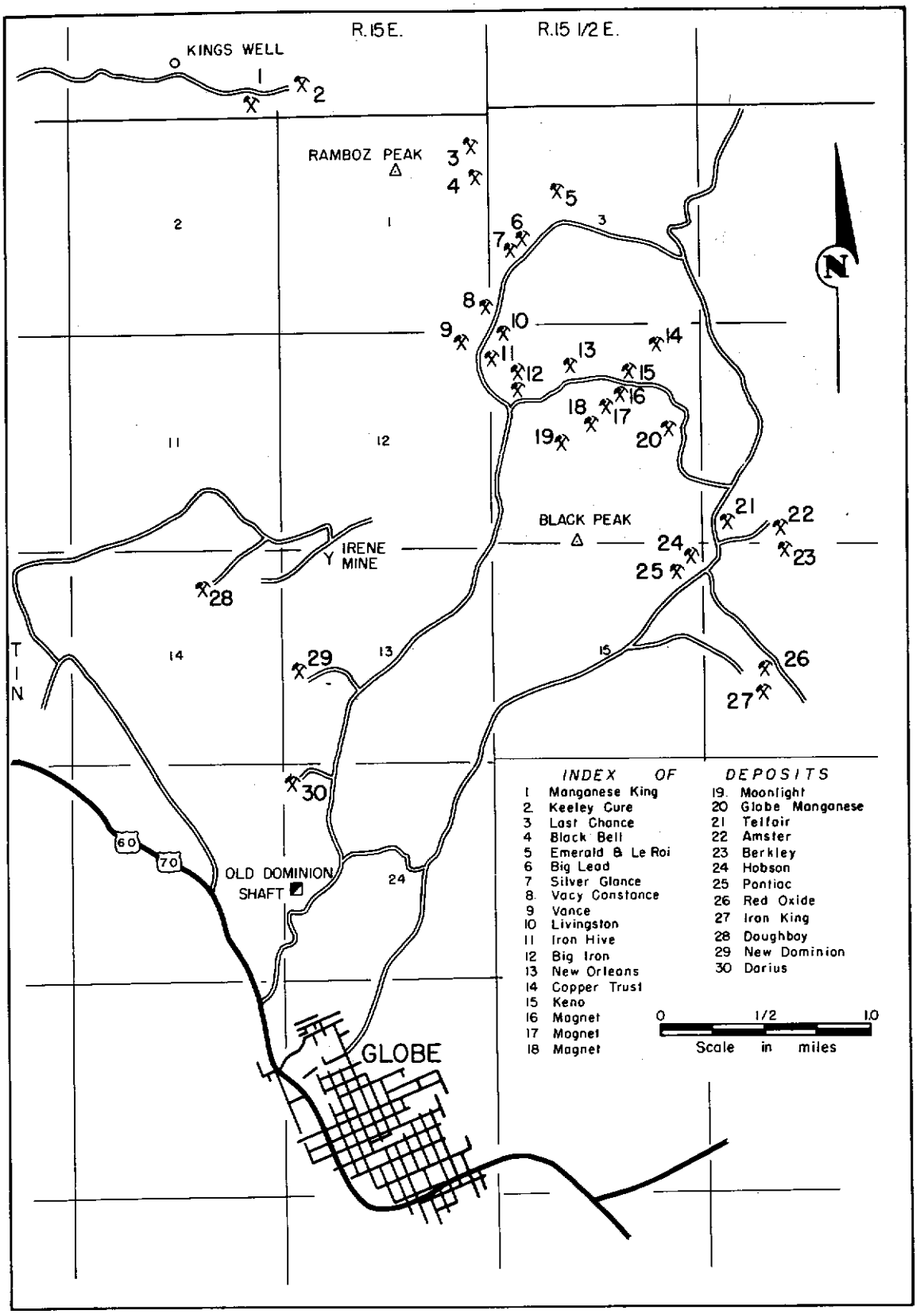

FIGURE 9. - Manganese Deposits Near Globe, Ariz.

Company stockpiles in Deming, N. Mex., and Phoenix, Ariz. The next productive period began in 1952 after the Government reopened the purchasing depot in Deming, N. Mex. From 1952 to November 30, 1955, a total of 14,912 long tons of ore and 115 long tons of concentrates was shipped from the county to the Deming depot. The ore averaged 25.2 percent manganese and the concentrates 38.1 percent. In addition, about 1,487 long tons of concentrates, containing 40 percent or more manganese, was produced from the Apache deposit and shipped under the Government "carlot" program. An unknown amount of these concentrates was produced during the first 3 months of 1956.

Thus, production from the county from 1916 through the early part of 1956 has totaled about 25,212 long tons of ore and 1,602 long tons of manganese concentrates. Of this output, the Globe area yielded nearly all of the ore and about 63 tons of the concentrates.

After the Deming purchasing depot reached its prescribed quota and closed on November 30, 1955, all manganese-mining activity in the county was stopped except at the Apache mine where operations continued until about March 1956.

Late in 1956, production of manganese ore was resumed at the property of Globe Manganese. When the area was visited in May 1957, the operators estimated that about 1,340 tons of ore, averaging 20 to 30 percent, had been produced between December 1956 and April 1957. The ore was shipped to Mohave Mining & Milling Co. near Wickenburg, Ariz., where it was concentrated to a product containing 40 percent or more manganese.

The manganese deposits in the county occur in igneous and sedimentary rocks that range in geologic age from Precambrian to Quaternary. The principal sedimentary host rocks are Paleozoic limestones, Precambrian quartzites, and consolidated beds of gravel that enclose the Apache deposit. The igneous host rocks include diabase, quartz diorite, and granite.

The deposits occur in fault fissures and fracture zones of various attitudes and as irregular bodies replacing favorable beds of sedimentary rocks where these beds lie adjacent to fracture zones. Many deposits in the Globe Hills area are found in a complex pattern of innumerable fault fissures that either traverse large masses of intrusive diabase or occupy the contact zone between the sedimentary rocks and the diabase. Most of the fissures and fracture zones in the area contain more or less manganese minerals, but the productive deposits are localized along the zones in bodies of various size, grade, and shape.

The manganese minerals consist principally of the soft oxides in gangues of unmineralized wall rock, iron oxides, quartz, and calcite. Many of the deposits contain various amounts of lead, zinc, and copper minerals. Silver occurs in appreciable amounts in some ores in the Globe area. Rhodochrosite (manganese carbonate) is present on the dump from an old 200-foot prospect shaft on the Big Iron claim. This mineral is considered to be primary and probably is the source of some of the manganese oxides found on and near the surface. Manganiferous calcite is abundant in several deposits and doubtless is also the source of the richer oxides found in the upper parts of many of the deposits.

In Gila County the greatest known depth attained in any of the deposits worked exclusively for manganese has been about 200 feet. Exploratory drilling has been done to greater depths on several properties, but the results of the drilling are not available. In one deposit opened to a depth of 150 feet, the grade of the ore found at that depth compared favorably with that found near the surface. In other deposits the better ore has been found to grade into poorly mineralized material at depths ranging from 20 to 100 feet below the surface.

Much of the ore containing 20 percent or more manganese has been mined from the developed deposits. Further exploration probably would disclose additional amounts of such ore. However, the bulk of the potential reserves consists of material containing 5 to 15 percent manganese. The inferred tonnage of material of this class, found scattered over the county as a whole, is probably a few hundred thousand.

Ore-dressing tests, made at different times by the Federal Bureau of Mines, have shown that some of the ores are amenable to concentration by ordinary gravity and flotation methods, whereas other ore did not respond well to conventional methods.

Among 30 or more operators in Gila County who shipped manganese ore to the Deming depot from 1952 through 1955, some confusion existed as to the names given to the claims or the deposits from which the ore was produced. In several instances two or more operators shipped ore from the same deposit and each gave it a different name. In 1952 some prospectors in the Globe area located claims on patented ground. This was largely because claim-corner monuments, set decades ago, had been obliterated. Therefore, there may be errors in the location and production of some properties given in the following descriptions. A few deposits credited with a small production could not be found, but so far as is known all major occurrences were visited.

Globe Area

Doughboy

The Doughboy group of nine patented claims covers parts of secs. 11 and 14, T. 1 N., R. 15 E. The principal manganese deposit of the group, known as the New Doughboy, is about 5 miles by road north-northwest of Globe in NW1/4 NE1/4 sec. 14, T. 1 N., R. 15 E. It may be reached from the Globe post office by traveling north on U.S. Highway 60-70 for 1.3 miles to a side road branching right, following this road northward along Pinal Creek about 2 miles to a right-hand fork crossing the railroad, proceeding eastward on this fork up Irene Gulch 1.5 miles to a short access road branching right, and following this branch road southwest 0.4 mile to the New Doughboy shaft. (See fig. 9, p. 44.)

The Doughboy group and the adjoining Comstock group were held for many years by the Tony Trojanovich family, of Globe. Considerable manganiferous lead-zinc ore was mined from the Irene vein which crosses the Comstock group. The first manganese-ore production on record was during World War II, when the

New Doughboy deposit was mined by American Manganese Co. From 1942 through 1944, the company shipped 48 carloads of ore, amounting to approximately 2,200 tons, to the Metals Reserve Company stockpile in Deming, N. Mex. The ore reportedly contained 27 to 41 percent manganese and as much as 2.5 percent zinc. The next attempt to operate the property was made by Comstock Extension Mining Co. in 1949 and 1950. So far as is known, no manganese was shipped at that time because no market could be found for the ore owing to its high zinc content. In 1952 the property was acquired by Globe-Miami Copper-Zinc Corp. During the following 2 years, 1,369 long tons of ore, containing 30.1 percent manganese, was shipped to the Government purchasing depot in Deming. During this period, lessees shipped an additional 58 long tons containing 34 percent manganese.

The total production from the deposit has been about 3,600 long tons of ore probably averaging about 30 percent manganese.

The property was idle when the area was visited in April 1957, but it was reported that operations were to be resumed in the near future by Jolyn Associates under a lease-option agreement with Globe-Miami Copper-Zinc Corp.

The deposit is an irregular body in a faulted block of the Martin limestone. The ore body, as exposed in the near-surface workings, is about 90 feet long and ranges from 6 to 15 feet in width. It strikes about N. 75° E. and dips 50° to 60° S. in apparent conformity with the limestone bedding. The footwall of the deposit is marked by a well-defined fracture, which merges along its strike to the west into a transverse fault zone that evidently limits or forms the western end of the ore body. In this area the ore trends southerly, more or less parallel to the transverse fault (fig. 10). Most of the hanging wall of the deposit is irregular, but in places the ore is bounded by well-defined shears. At the east end of the outcrop the ore splits into two or more strands which taper out along the strike. The higher grade ore in the deposit occurs in strands of different size and irregular masses surrounded by unmineralized limestone and low-grade manganese-bearing rock.

The ore minerals are pyrolusite, wad, and psilomelane. Limonite, quartz, calcite, and jasper are the chief gangue minerals. Some of the ore has contained as much as 4 percent zinc.

The deposit has been exploited through underground workings, most of which were inaccessible at the time of the visit; consequently, the following description is based upon former reports made by personnel of the Bureau of Mines and the Federal Geological Survey.

The early work consisted of an opencut leading to an adit which followed the ore body westward along its strike into the hillside (fig. 10). The ore was mined above the adit in an open stope that extended upward in places for 20 feet to the gravel overburden which covered most of the outcrop west of the portal of the adit. Later, the ore was stoped from inclined-winze workings that extended about 75 feet below the adit. Some years later, a 200-foot vertical shaft was sunk 50 feet or more southwest of the adit portal. Lateral

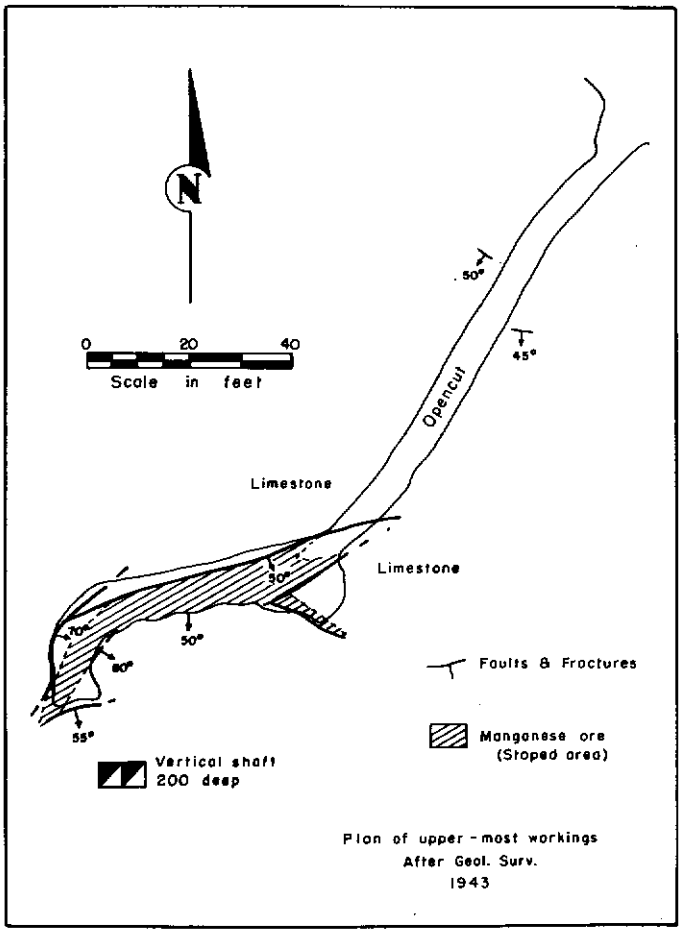

FIGURE 10. - Plan of Uppermost Workings, New Doughboy Deposit. *(After Geological Survey, 1943.)*

work from the shaft connected with the 75-foot level, and ore was found on the 200 level of the shaft. During the next period of activity (1953-54), work consisted largely of selectively mining the ore remaining above the bottom level. In some places square sets were used in the stopes to support the ground.

Most of the ore on the 200 level was said to have contained less manganese and more iron than ore found in the upper parts of the deposit.

Darius

The Darius deposit is on a patented claim of the same name in NW1/4 sec. 24, T. 1 N., R. 15 E., about 2.5 miles north of the Globe post office and some 3,000 feet north of the Old Dominion shaft. It can be reached over a quarter of a mile of access road that branches left from the Big Johnnie Gulch Road about 1.4 miles north of its intersection with U.S. Highway 60-70. The Big Johnnie Gulch Road intersects the highway near the north end of Globe, 0.8 mile northwest of the post office. (See fig. 9, p. 44.)

The claim is one of a large patented group formerly the property of Old Dominion Copper Co. and now owned by Miami Copper Co. Like many other claims in the area the Darius was explored in the early days for copper-silver ore. The first manganese ore, as such, is said to have been shipped during World War II to the Metals Reserve Company stockpile in either Phoenix, Ariz., or Deming, N. Mex. The amount and grade of these first shipments are not known. In 1953, F. A. Sitton, of Phoenix, Ariz., obtained a lease on the claim from Miami Copper Co. and in 1953-54 shipped 2,131 long tons of ore, averaging 20.7 percent manganese, to the Government purchasing depot in Deming. Additional shipments were made but were rejected because their copper content exceeded 0.25 percent, the maximum allowable under the depot specifications. All operations were stopped in 1954, and the mine was idle when visited in February 1957.

The manganese ore occurred in a broad fracture zone along the west side of a tilted block of the Escabrosa limestone. The zone strikes about N. 40° E. and dips from steeply northwestward to vertical, cutting the moderately dipping limestone beds. Dacite flows cover the western and southern sides of the limestone, and diabase occupies much of the surface to the northeast. The manganese minerals are exposed in places for 600 feet or more along the trend of the zone and across widths as much as 100 feet. Within this area the higher grade ore occurs in disconnected, irregular masses localized in the more intensely fractured or shattered parts of the zone. These higher grade masses range from a few feet to 20 feet in width and are as much as 90 feet long. Usually, they are surrounded by lower grade material composed of manganiferous stringers and small sporadic bunches separated by various-size masses of barren limestone. In some places the manganese mineralization follows favorable beds of the moderately dipping limestone adjacent to the steeper fractures.

The chief manganese minerals are wad and pyrolusite. The gangue is composed of silicified limestone, iron oxides, jasper, opal, and some calcite. Small amounts of copper oxide minerals are present in some exposures.

The ore had been mined from opencuts in four of the larger and most promising areas within the mineralized zone. The productive workings near the southwest end of the zone consisted of an inclined opencut, approximately 80 feet long, 12 feet wide, and 10 feet deep at its face. About 50 feet southwest of the opencut the alluvium overburden had been stripped for approximately 300 feet farther to the southwest along the projected trend of the zone. Although some small scattered spots of manganese mineralization were present, no appreciable amount of ore was exposed in the stripped area.

Approximately 40 feet northeast of the northern end of the opencut, ore had been mined in a second opencut about 90 feet long, 8 to 14 feet wide, and as much as 12 feet deep. Both this cut and the one to the southwest were alined close to the northwestern side of the manganiferous zone. Stripping to the southeast exposed low-grade manganese minerals for an additional 80 feet, giving the entire zone a width of about 100 feet in that place.

Some 70 feet east of the second opencut and near the center of the zone was a third opencut about 60 feet long and as much as 15 feet wide and 20 feet deep. The ore broken in the opening had been hoisted on an inclined track extending from the northern side of the cut.

The principal workings farthest to the northeast were about 75 feet from the third cut. They consisted of an opencut 25 feet long and a 20-foot drift extending out of its northern end. In this area the mineralized part of the zone was exposed for about 60 feet along the strike over a width of 10 feet or more. Surrounding overburden concealed any further extention the manganiferous zone may have in this area.

Two old inaccessible shafts of unknown depths had been sunk on an iron- and copper-stained quartzose vein that crops out on the northwest side of the manganese zone. Evidently this work had been done decades earlier in a search

for silver-copper ore. Down the hillside, to the north, an adit had been driven to connect with the older workings. The adit was caved in places and inaccessible at the time the property was visited.

Batch-scale, sink-and-float, flotation and sulfur dioxide leaching tests were made on a composite sample of broken ore from three large cuts on the Darius claim. The sample weighed about 350 pounds and assayed 19 percent Mn, 38 percent $CaCO_3$, 0.98 percent Pb, 1.70 percent Zn, and 0.07 percent Cu. The ore comprised an intergrowth of calcite, wad, quartz, and pyrolusite with small quantities of hematite, gypsum, limonite, and clay. The manganese minerals ranged in size from 35 mesh to about 7 microns. Grinding the ore to pass a 200-mesh sieve was indicated for good liberation of the pyrolusite from the calcite and quartz. Even finer grinding was required to free the more intimately associated wad and calcite.

Sink-and-float concentration of the ore failed to yield a metallurgical-grade manganese product. The ore was crushed to minus-5/8-inch and screened on a 10-mesh sieve for the tests. Separation of the minus-5/8-inch, plus-10-mesh fraction in a heavy medium of 2.94 specific gravity yielded a sink product assaying 30.3 percent Mn and containing 42.4 percent of the total manganese. The float product assayed 7.6 percent Mn and contained 17.6 percent of the total manganese. The remaining 40 percent of the total manganese was in the minus-10-mesh fraction. Sink-and-float concentration of minus-1/4-inch feed gave about the same grade of product. Although sink and float might be used for "scalping" the Darius ore, the procedure is not attractive because of the low manganese recovery.

Both bulk and selective flotation of the ore were investigated to recover a metallurgical-grade manganese concentrate. Bulk flotation of minus-200-mesh wet-ground feeds using oil emulsion was unsuccessful because of excessive dilution of the manganese concentrates by the calcite. Flotation of manganese by the oil-emulsion method is described in detail in recent publications by Rosenbaum and others.[28 29/] Selective flotation of the calcite with oleic acid, followed by oil-emulsion flotation of the manganese, gave better results than bulk flotation. In a typical test a concentrate was recovered that assayed 42.0 percent Mn, 1.2 percent $CaCO_3$, 6.3 percent SiO_2, 0.45 percent Al_2O_3, 6.8 percent Fe, 2.19 percent Pb, 2.95 percent Zn, and 0.16 percent Cu. The manganese recovery was 82.4 percent. Except for the lead and zinc the concentrate met metallurgical-grade specifications. Subsequent fuming tests on nodules prepared from the concentrate with 10 percent of coke reduced the lead and zinc content of the product to less than 1 percent. Thus, the concentrate after fuming assayed 53.1 percent Mn, 8.3 percent SiO_2, 1.0 percent Al_2O_3, 8.68 percent Fe, 0.24 percent Pb, 0.17 percent Zn, and 0.24 percent Cu.

28/ Rosembaum, J. B., and Schack, C. H., Recent Improvements in Flotation of Oxide Manganese Ores: Mines Mag., Colorado, March 1953, vol. 42, No. 3, pp. 67-70.

29/ Rosenbaum, J. B., Schack, C. H., Lang, R. S., and Clemmer, J. B., Pilot Plant Flotation of Manganese Ore From the Maggie Canyon Deposit, Artillery Mountains Region, Mohave County, Ariz.: Bureau of Mines Rept. of Investigations 5330, 1957, 45 pp.

Dithionate leaching of coarse and fine charges of the ore also was investigated to extract the manganese in leach solutions that could be processed further to yield high-grade manganese hydroxide products. The dithionate leach process and the method for recovering the manganese as manganese hydroxide from the leach solutions have been described in several publications.30 31 32 33/ Only the leaching phase of the dithionate process was investigated on the sample, as manganese hydroxide precipitates that assay 55 to 60 percent Mn can be recovered readily from the leach liquors once the manganese has been leached from the ore. Agitation leaching of minus-100-mesh charges of the ore with a 10-percent SO_2-air mixture resulted in an excellent extraction of the manganese. A 2-hour agitation leach extracted 97 percent of the manganese with a sulfur dioxide consumption of 3.2 pounds per pound of manganese extracted. Dithionate formation was 1.9 pounds per pound of manganese dissolved, or more than enough to compensate dithionate losses that would be incurred in the manganese hydroxide product and in washing the leach residues if the leach solutions were treated to recover the manganese.

Bench-scale percolation-leaching tests with sulfur dioxide also were made on minus-1/4-inch and minus-1/2-inch charges of the ore. Briefly, the procedure embraces alternate upward passage of a SO_2-air mixture through the moist agglomerated ore charges to solubilize the manganese and downward percolation with water to extract the soluble manganese. Treatment of the minus-1/4-inch feed for 10 days recovered 80.7 percent of the manganese with a sulfur dioxide consumption of 5.2 pounds per pound of manganese extracted. Leaching the 1/2-inch ore for the same length of time recovered 74 percent of the manganese; the sulfur dioxide consumption was 5.9 pounds per pound of manganese recovered. Apparently, the high lime content of the ore retarded dissolution of the manganese and caused the high consumption of sulfur dioxide. Dithionate formation in leaching the 1/4- and 1/2-inch feeds was exceptionally high--1.8 pounds per pound of manganese extracted.

The Darius ore can be treated either by flotation and nodulizing or by sulfur dioxide leaching methods to recover a metallurgical-grade manganese product. Because the cost is lower and the procedure less involved, treatment by flotation is more attractive.

30/ Ravitz, S. F., Wyman, W. F., Back, A. E., and Tame, K. E., Dithionate Process for Recovery of Manganese From Low-Grade Ores: AIME Tech. Pub. 2064, Metals Technol., September 1946, 10 pp.

31/ Ravitz, S. F., Back, A. E., Tame, K. E., Wyman, W. F., and Dewey, J. L., Semipilot Plant Tests on Treatment of Manganese-Silver Ores by the Dithionate Process: Bureau of Mines Tech. Paper 723, 1949, 45 pp.

32/ Bender, F. N., and Rampacek, Carl, Percolation Leaching of Manganese Ores With Sulfur Dioxide: Bureau of Mines Rept. of Investigations 5323, 1957, 20 pp.

33/ Rampacek, Carl, Fuller, H. C., and Clemmer, J. B., Operation of a Dithionate-Process Pilot Plant for Leaching Manganese Ore From Maggie Canyon Deposit, Artillery Mountains Region, Mohave County, Ariz.: Bureau of Mines Rept. of Investigations 5508, 1959, 54 pp.

New Dominion

The New Dominion, or Stallo, deposit is about 2 miles north of Globe in NW1/4SW1/4 sec. 13, T. 1 N., R. 15 E. It can be reached by 0.5 mile of access road that branches left from the Big Johnnie Gulch Road about 2 miles north of U.S. Highway 60-70. (See fig. 9, p. 44.)

The manganese deposit is on the Stallo and Moody claim, which is one of a large group of old patented claims formerly held by New Dominion Copper Co. The property is presently owned by C. W. Via, of Santa Fe, N. Mex.

Although manganiferous silver ore was mined from parts of the claim much earlier, the first recorded output of manganese ore was in 1953. During 1953-54 a total of 1,947 long tons of ore, averaging 25.8 percent manganese, was shipped to the Government purchasing depot in Deming, N. Mex. Approximately 1,352 tons was produced by C. W. Via and the balance by a lessee, F. A. Sitton.

The manganese minerals occur in veinlets and irregular replacement bodies along a fracture zone cutting flatly dipping beds of the Martin limestone. The zone strikes about N. 80° E. and dips steeply to the north. It has an exposed strike length of some 300 feet and is more or less mineralized across widths as much as 50 feet. The higher grade ore appears to have been localized largely along the footwall of the zone, where it was mined in open stopes as much as 20 feet wide. Lower grade material, grading outward into the hanging wall, is composed of stringers and veinlets of manganese oxide separated by different widths of barren limestone.

The chief ore minerals are wad, pyrolusite, and some psilomelane. The gangue is composed largely of silicified limestone, calcite, and quartz.

At the time the deposit was visited in February 1957, the workings consisted of an inclined shaft about 80 feet deep, a level 30 feet below the surface, and a 50-foot drift extending westward from the bottom of the shaft. The upper or 30-foot level comprised 34 feet of drifting west of the shaft and 50 feet or more of crosscutting to the southwest from near the face of the drift. Some stoping had been done in places above the back of the drift, but no minable ore was found in the crosscut. The work on the 30-foot level east of the shaft consisted of about 40 feet of drifting, which opened into two parallel overlapping stopes separated by a vertical pillar 6 to 8 feet thick. The larger stope was over 100 feet long and ranged from 6 to 20 feet in width, whereas the smaller one was about 45 feet long and up to 12 feet wide. Both stopes were as much as 20 feet high, and each stope contained a short inclined raise extending from the back to the surface. The bottom of the stopes were 10 to 12 feet below the floor of the drift.

No ore was exposed in the shaft below the 30-foot level, and none was found in the westerly trending drift at the bottom of the shaft.

The mine was idle when visited in February 1957. All equipment had been removed except a small, timber headframe over the shaft.

Big Iron

The Big Iron group comprises five contiguous patented claims in NW1/4 sec. 10, T. 1 N., R. 15-1/2 E. and extending southwest into the east-central part of sec. 12, T. 1 N., R. 15 E. Manganese ore has been shipped from two of the claims, namely the Big Iron Nos. 1 and 2. The former claim is sometimes called the Big Dyke. The deposits are about 3.7 miles by road north-northeast of Globe. They can be reached by way of the Big Johnnie Gulch Road, which branches northeast from U.S. Highway 60-70 near the northwestern city limits of Globe, a short distance southwest of the Old Dominion shaft. (See fig. 9, p. 44.)

At one time the claims were part of a larger group held by the old Moline Arizona Mining Co. Years later they were acquired by F. A. Bennett, who sold them in 1953 to the present owner, F. A. Sitton of Phoenix, Ariz. During the next 2 years, lessees produced 73 long tons of sorted ore, averaging 22.3 percent manganese, from the Big Iron No. 1 (Big Dyke) and 48.2 tons, containing 29.2 percent manganese, from the Big Iron No. 2 claim. The entire output, shipped to the Government purchasing depot in Deming, N. Mex., constitutes the first recorded shipment of manganese ore made from the property.

The manganese minerals on both claims occur along fracture zones in diabase. The zones are several hundred feet apart and strike in different directions. The zone on the No. 1 claim strikes north and dips steeply to the west, whereas the zone on No. 2 claim strikes about N. 60° E. and dips 75° NW. Both zones can be traced on the surface for approximately 500 feet and are manganiferous for widths as much as 25 feet. However, the better ore of minable width is found in strands and irregular bunches ranging from 2 to 5 feet in width. Most of the manganese minerals occur in widely spaced, narrow seams separated by altered diabase.

Wad and pyrolusite with some psilomelane are the chief manganese minerals. Quartz and calcite are the principal gangue minerals.

The ore produced from the Big Iron No. 1 claim was mined from a series of shallow opencuts, 4 to 5 feet wide, that were spaced at intervals along the outcrop for about 300 feet.

The work on the No. 2 claim, situated farther up the hillside and about 500 feet north of the cuts, comprised an inclined shaft, a few shallow opencuts near the shaft, and some exploratory bulldozer stripping along the outcrop of the zone. The 48 tons produced from this deposit came largely from a strand of ore as much as 3 feet wide upon which the shaft was sunk.

No work was in progress when the property was visited in March 1957.

Iron Hive

The Iron Hive group consists of two contiguous patented claims in NE1/4 sec. 12, T. 1 N., R. 15 E. They are adjacent to the Big Iron group on the northwest and are readily accessible from Globe by way of the Big Johnnie

Gulch Road, which crosses the claims about 4 miles north of its intersection with U.S. Highway 60-70. (See fig. 9, p.44.)

In the 1920's the claims were part of a large group held by Moline Arizona Mining Co. A decade or so later they were purchased by F. A. Bennett, who in 1953 sold them to the present owner, F. A. Sitton, of Phoenix, Ariz. In 1954, about 402 long tons of ore was shipped from the claims by Sitton to the Government purchasing depot in Deming, N. Mex. The ore averaged 22.7 percent manganese and, so far as is known, was the first manganese ore produced from the claims.

The manganiferous ore is associated with steeply dipping fissure zones striking northward in diabase. Ore was mined on both claims from several areas along two roughly parallel zones a few hundred feet apart. The eastern zone crops out in places along the bottom of the upper end of Big Johnnie Gulch where it trends diagonally across the northeastern half of the Iron Hive No. 2 claim and continues northward for 3,000 feet or more through the adjoining Vacy Constance claim and other properties farther northeast. The other zone is exposed along the west side of the gulch and persists northward from the center of the west claim for about 1,600 feet, where it appears to merge with the eastern zone. Both zones are more or less manganiferous along the surface for most of their exposed lengths and, in places, for widths as much as 50 feet. The manganese minerals occur in seams, veinlets, and various-size sporadic bunches impregnating the sheared diabase. The larger veinlets and bunches range from 1 to 6 feet in width and are separated by barren or lower grade material containing widely separated mineralized seams.

The ore was mined from several scattered opencuts and shallow adit workings. The work on the southern end of the east zone consisted of an opencut about 100 feet long, 8 to 10 feet wide, and 8 feet deep. The mineralized zone exposed in the bottom of the cut was 8 to 10 feet wide and comprised numerous parallel stringers and occasional lenses of manganese and iron oxides. In places the lenses were 2 feet wide and as much as 10 feet in length.

Approximately 350 feet north of the cut, manganese minerals were exposed in a roughly circular area about 50 feet in diameter. Surrounding overburden obscured any further extension of the ore body along the strike. In that area the manganese minerals were deposited in a network of seams, stringers, and irregular masses of different size. Some masses were several feet in their greatest dimensions. The work consisted of an opencut, an old inaccessible shaft, and some exploratory drill holes. The opencut was about 10 feet deep and extended across the south side of the mineralized area. The shaft, near the center of the outcrop, was estimated to be about 50 feet deep. Evidently it had been sunk many years ago, probably to search for silver ore. In 1956, when the property was under option to D. N. Spencer, of Spokane, Wash., the deposit was explored at greater depth by three or more rotary-drill holes about 4 inches in diameter. The results of the drilling were not available.

Ore had been mined on the west zone from three or more opencuts and some inaccessible adit workings, all several hundred feet north of the other deposit. In this area the manganese minerals were exposed in places for

about 250 feet along the strike and for widths as much as 30 feet. The better ore had been selectively mined from higher grade bands and lenticular bunches ranging from 4 to 6 feet in width. They appeared to be largely localized along the west side of the zone.

Wad and pyrolusite with some psilomelane were the chief manganese minerals. The gangue consisted of an abundance of iron oxide with some quartz and calcite.

No work was in progress when the property was visited in January 1957.

Vacy Constance

The Vacy Constance, also known as the Extension, is a single patented claim adjoining the Iron Hive group in NE1/4 sec. 12, T. 1 N., R. 15 E., and SW1/4SW1/4 sec. 3, T. 1 N., R. 15-1/2 E. It is about 4.5 miles north of Globe by way of the Big Johnnie Gulch Road. (See fig. 9, p. 44.)

During the 1920's, the claim was part of the property of the old Moline Arizona Mining Co. Since that time it has been owned by different individuals, including F. A. Bennett, John Corn, T. J. Long, and Louis Winn. At present it is owned by Jolyn Associates, of Wickenburg, Ariz. Although the claim was prospected much earlier for silver, the first manganese ore was produced in 1953. During 1953 and the following 2 years, 547 long tons of sorted ore, averaging about 21 percent manganese, was shipped, mostly by lessees, to the Government purchasing depot in Deming, N. Mex. The shippers included Richard Cocreham, J. W. Thomas, Al Stovall, T. J. Long, T. A. Long, and Frank Witty. Although some of the shipments were credited to the Extension claims, available information indicates that all 547 tons came from the Vacy Constance claim. Operations were terminated in 1955, and no further work had been attempted up to the time the claim was visited in January 1957.

The manganese minerals occur along the same general zone of fissuring that yielded the ore on the Iron Hive group to the southwest. The zone cuts diabase, dips vertically, and follows a general course of N. 20° E. It appears to traverse the full length of the claim and to continue northeast for some 1,500 feet into the Silver Glance and Big Lead claims.

The ore produced from the Vacy Constance claim was mined from the zone in two separate areas--one near the southwest end of the claim at the north end of Big Johnnie Gulch and the other about 900 feet farther north on the opposite slope of a low divide. In both areas, manganese oxide minerals were present in the zone as seams, veinlets, and irregular lenticular masses separated by various thicknesses of altered diabase.

The mineralized area near the southwestern end of the claim had been exploited about 200 feet along the strike by shallow opencut workings. In places the zone was manganiferous over widths of 30 feet. The ore recovered from the area had been selectively mined from the larger and richer deposits, which appeared to have been localized along the west side of the zone in a more intensely sheared area several feet in width. The main work consisted of

an opencut about 150 feet long and as much as 12 feet deep. This opening apparently followed the higher grade part of the zone.

The mineralized area about 900 feet to the northeast was exposed by a shallow opencut and some bulldozer stripping for approximately 100 feet along the strike. In places the zone was more or less manganiferous across widths of 50 feet. The manganese minerals occurred in a network of seams and narrow stringers with small irregular bunches of ore scattered erratically throughout the shattered diabase.

In both areas the chief manganese minerals were pyrolusite and wad with small amounts of psilomelane. Iron oxides, intimately associated with the manganese minerals, were abundant in places. Quartz and calcite constituted the other principal gangue minerals.

Livingston Group

The Livingston group consists of two unpatented claims adjoining the northeast end of the Big Iron group in the northwest corner of sec. 10, T. 1 N., R. 15-1/2 E., some 4 miles by road north of Globe. The claims lie along the top and sides of a prominent ridge occupying the eastern side of the upper end of Big Johnnie Gulch. They are accessible over 0.5 mile of a northerly trending switchback road that leaves the Big Johnnie Gulch Road about 3.7 miles north of U.S. Highway 60-70. (See fig. 9, p. 44.)

The claims were held in 1953 and 1954 by F. A. Sitton, of Phoenix, Ariz. When the area was visited in January 1957, the claims had been relocated in May 1956 by D. N. Spencer, of Spokane, Wash. In 1953 and 1954, the claims were worked by several different lessees; 159.3 long tons of sorted ore, averaging about 25 percent manganese, had been shipped to the Government purchasing depot in Deming, N. Mex. So far as is known, the manganese ore was the first shipped from the claims.

The manganese mineralization occurs in places along two fracture zones cutting diabase. The zones strike N. 50° to 60° E. and dip steeply northwest. The zone to the south has been exposed by bulldozer stripping about 250 feet along its strike; the other zone, some 300 feet to the north, has an exposed strike length of about 50 feet. Both zones range from 2 to 5 feet in width and contain stringers and irregular lenticular bunches of manganese oxides distributed sporadically in the sheared diabase.

The ore had been mined from several shallow opencuts scattered along the wider and better mineralized parts of the fracture zones. An appreciable amount of the shipped ore was said to have occurred as float that had been liberated by weathering.

All equipment had been removed, and the property was idle when visited in January 1957.

Vance

The Vance is an unpatented lode claim lying west of the Iron Hive group in the northeast corner of sec. 12, T. 1 N., R. 15 E. (See fig. 9, p. 44.) It can be reached over 1/4 mile of access road that branches west from the Big Johnnie Gulch Road about 4 miles north of Globe.

Originally the claim was one of the old abandoned Hornsilver group. It was relocated in 1955 by Louis Winn, of Globe, who shipped 58.6 long tons of sorted ore from the claim to the Government purchasing depot in Deming, N. Mex. The shipment contained 23.8 percent manganese.

The ore occurs along a northeasterly trending fissure in diabase. The fissure is exposed about 100 feet along the strike, ranges from 2 to 6 feet in width, and dips steeply to the northwest. The ore was mined in an opencut about 80 feet long that reached a maximum depth of 10 feet. The manganese minerals, consisting chiefly of the softer oxides, occurred in elongated lenses and parallel veinlets separated by altered diabase. The larger lenses reached widths of 3 feet and lengths of 10 feet or more before tapering out along the strike. According to Louis Winn, the best ore was found on and near the surface and the fissure diminished in size and grade at greater depths.

The claim was idle when visited in January 1957.

Silver Glance

The Silver Glance claim, once known as the Dynamite, is 1 of 8 unpatented claims often called the Ramboz group. This claim contains the principal manganese deposit and adjoins the patented Vacy Constance claim on the northeast. It lies in NW1/4SW1/4 sec. 3, T. 1 N., R. 15-1/2 E. and is accessible from Globe over a westerly trending graded road about 1 mile long that branches left from the Copper Hill Road about 5 miles north-northeast of the intersection of Yuma Street and U.S. Highway 60-70 in Globe. (See fig. 9, p. 44.)

The claims originally were located as silver prospects in the early days of the district. Subsequently, they were acquired and held for many years by the late Inez Thomas of Globe. At present the group is owned by the Inez Thomas Estate, of which Margarite Webb, of Globe, and Charles R. Thomas, of Bisbee, Ariz. are the trustees.

The first manganese ore was produced during World War II by lessees W. T. Scholl and L. V. Racine. Records of the Metals Reserve Company show that 441.8 tons of ore, containing 25.6 percent manganese, had been shipped to May 1944. The next known production was made in 1953 and 1954 by lessee John Duber of Globe, Ariz., when 1,204 long tons of ore, averaging 24.1 percent manganese, was shipped to the Government purchasing depot in Deming, N. Mex. When the property was visited in February 1957, all equipment had been removed and no work was in progress.

The deposit is along the same fissure zone as the Vacy Constance and Iron Hive claims to the southwest. The zone lies in diabase, strikes about N. 25°

E., and dips vertically. It can be traced rather continuously for the entire length of the claim and for several hundred feet farther northeast into the adjoining Big Lead claim. The zone is more or less manganiferous in most of the exposures. In some places the manganese minerals occur in widely spaced seams and narrow stringers, forming low-grade areas tens of feet in width. In other places these seams and stringers are more numerous and closely spaced, forming bands and lenses of ore ranging from 1 foot to several feet in width.

Most of the production from the claim was mined from a lens of ore lying along the western side of the zone. This ore body was approximately 180 feet in length and ranged from 1 to 6 feet in width. It was exploited from shaft workings to a depth of some 60 feet. The underground work was inaccessible when the claim was visited, but it is reported that rhodochrosite was encountered in the shaft at a depth of 55 feet. A sample of the unoxidized part of the vein, 2.5 feet wide, assayed 11.5 percent manganese.

The ore was mined in open stopes, which in many places extended to and along the surface for more than 100 feet north of the shaft and about 50 feet to the south. The other work consisted of a few shallow opencuts scattered along the outcrop of the zone. Some of these openings may have yielded 1 or more carloads of ore.

The manganese minerals comprised essentially pyrolusite and wad with some psilomelane. The gangue was composed of iron oxides, quartz, and calcite.

Bracco Group

The Bracco group of 17 unpatented claims lies largely in the central part of sec. 3, T. 1 N., R. 15-1/2 E. Some manganese ore has been produced from four of the claims that occupy the western side of the group. These claims are accessible from a road about 1 mile long that branches westward from the Copper Hill road about 5 miles north-northeast of Globe, Ariz.

Several of the claims were located in 1907 as silver prospects and have been held ever since by members of the Bracco family. The group is now owned by John A. Bracco, of Globe, Ariz. The first manganese ore is said to have been shipped from the property in 1917 and consisted of 1 carload of hand-sorted ore which is reported to have contained about 40 percent manganese. The next known production was in 1953 and 1954 when lessees shipped 153 long tons of sorted ore to the Government purchasing depot in Deming, N. Mex. This ore ranged from 20.5 to 29.2 percent manganese and was mined from the four claims called the Big Lead, LeRoi, Emerald, and Garnet. Other small shipments were made from the claims but were rejected by the purchasing depot because the ore was not amenable to concentration by flotation. Most of the difficulty was caused by the intimate intergrowth of iron oxide with the manganese minerals, which prevented recovery of a manganese concentrate high enough in grade to meet the specifications prescribed by the purchasing depot. All work was stopped in 1954, and the property was idle when the area was visited in January 1957.

The manganese minerals on the Big Lead claim occur along the northeastern extension of the same fissure zone that traverses the Silver Glance and other claims to the southwest. The zone on the Big Lead cuts diabase, is virtually vertical in dip, and strikes about N. 30° E. From the southwest end of the claim the fissure can be followed northward along the surface for about 400 feet where it passes under detrital overburden. Although the fissure contains some manganese over widths as much as 25 feet, the best ore was found along part of the west side of the zone in lenticular bands ranging from 2 to 6 feet in width. One carload of 48.3 long tons, containing 29.2 percent manganese, was marketed from these higher grade bands.

The main workings, near the southwest end of the claim, consisted of an opencut about 200 feet long, 6 to 8 feet wide, and as much as 18 feet deep. Besides the shipments to the Deming depot, additional ore had been sorted from the material broken in the cut. This ore, aggregating some 60 tons, had been placed in piles near the north end of the opening.

Approximately 800 feet northeast of the opencut, another manganiferous zone crops out in places for some 700 feet along the strike. Part of the outcrop lies on what is said to be the Emerald claim and part on the adjoining LeRoi claim. In this area the fissure zone strikes N. 50° to 55° E. and dips from steeply northwestward to vertically. The manganese minerals occur along the zone in seams, in widely separated veinlets, and as small irregular bunches separated by various widths of the enclosing diabase. In places these mineralized areas are exposed across widths of 30 feet or more. The ore produced from the two claims was selectively mined and sorted from shallow opencut workings scattered along the outcrop and situated in areas containing the larger bunches of manganese minerals.

A total of 35.8 long tons of ore, averaging 22.1 percent manganese, was marketed from the Emerald claim and 48.5 long tons, containing 24.2 percent, from the LeRoi claim.

The manganese mineralization on what was said to be the Garnet claim took place along a steeply dipping fracture zone in diabase, which is several hundred feet southeast of the Emerald and LeRoi workings. In that area the fracture was exposed along its northeastward strike for some 60 feet. The better mineralized part of the zone ranged from 3 to 6 feet in width. About 20.5 long tons of ore, averaging 27.3 percent manganese, had been hand sorted from the lower grade material broken in a few shallow pits and opencuts.

The manganese minerals in all of the deposits comprise chiefly wad, pyrolusite, and small amounts of psilomelane. Iron oxides, quartz, and calcite constitute the principal gangue minerals.

Moonlight and Mineral Farm Group

The Moonlight and Mineral Farm group consists of 10 contiguous patented claims situated in SW1/4 sec. 10, T. 1 N., R. 15-1/2 E. and extending southwestward into SE1/4 sec. 12 and the NE1/4 sec. 13, T. 1 N., R. 15 E. (See fig. 9, p. 44.) The Big Johnnie Gulch Road crosses the Mineral Farm No. 2

claim in the south-central part of the property 4.8 miles north of Globe. The Moonlight claim at the northeast end of the group is reached over a 1-mile-long access road that branches westward from the Copper Hill Road about 4 miles north of Globe.

The claims, formerly a part of the property of the old Moline Arizona Mining Co., are now owned by John R. Bacon of Dallas, Tex. Other claims, known as the Mineral Farm Nos. 4 and 5, adjoin the Bacon group on the northwest. However, these claims, which were once a part of the old original group, are now owned by F. A. Sitton, of Phoenix, Ariz.

The only known manganese ore produced from the Bacon property was mined from a deposit on the Moonlight claim. This output consisted of 62 long tons of sorted ore, averaging 25.2 percent manganese, which was shipped in 1953 to the Government purchasing depot in Deming, N. Mex.

The manganese mineralization on the Moonlight claim occurred along a fracture zone striking N. 80° E. and dipping about 60° N. In places the zone follows the contact between quartzite and diabase, and in other places it lies entirely in the diabase. The zone is manganiferous on the surface in disconnected areas for 500 feet or more along the strike and ranges from 4 to 10 feet in width.

Ore was mined from the zone in two opencuts about 75 feet apart. The east cut exposed the mineralized zone for approximately 40 feet along the strike and to a maximum depth of about 10 feet. In this opening the best ore occurred in a strand 3 to 4 feet wide that occupied the hanging wall of the zone adjacent to the quartzite. Lower grade material, composed of narrow, parallel stringers of manganese oxide, extended outward from this better ore for 6 feet or more into the sheared diabase footwall.

A similar vein was exposed in the smaller opencut to the west, where both walls of the zone were diabase.

The manganese minerals consist of wad and pyrolusite occurring in a gangue composed largely of iron oxides, quartz, and calcite.

About 1,000 feet west-southwest of the Moonlight workings, four or more manganiferous veins crop out on the Mineral Farm Nos. 1 and 2 claims in an area approximately 800 feet north-south and 1,000 feet east-west. The veins are 100 to 200 feet apart and range in strike from eastward to northeastward. They appear to dip steeply northward and range from 2 to 10 feet in width; some can be traced several hundred feet along the strike. The manganese along many of the outcrops is largely confined to stain, but in places (especially along the narrower fractures) small lenses of wad and pyrolusite are exposed.

The workings consist of a few shallow pits and scattered opencuts. So far as is known, no manganese has been produced from this area.

Conditions are much the same on the adjoining Mineral Farm claims Nos. 4 and 5, owned by F. A. Sitton. They also contain a rather complex pattern of

veins containing small amounts of manganese minerals. The records in the Deming purchasing depot show that 26 long tons of sorted ore, containing 21.8 percent manganese, was shipped by Sitton from the No. 4 claim. This ore was mined from a shallow opencut about 40 feet long.

No work was in progress when the property was visited in January 1957.

New Orleans

The New Orleans claim is one of the large group of old patented claims held for many years by the late F. A. Bennett and presently owned by F. A. Sitton, of Phoenix, Ariz. The property is about 4 miles by road north of Globe in NE1/4NW1/4 sec. 10. T. 1 N., R. 15-1/2 E. and adjoins the northeast end of the Mineral Farm No. 1 claim. (See fig. 9, p. 44.) The eastern branch of the Big Johnnie Gulch crosses the north part of the New Orleans claim.

The first manganese ore was produced from the claim in 1953 by Thomas C. Vetter, who shipped 223 long tons of sorted ore, averaging 19.7 percent manganese, to the Government purchasing depot in Deming, N. Mex.

The productive deposit occurs along a fault zone at the contact between diabase and quartzite. The zone strikes N. 65° E. and dips about 60° NW. It can be traced for several hundred feet along the strike and in places contains stringers and sporadic bunches of manganese oxides across widths as much as 10 feet. The ore was mined in an opencut that is about 50 feet long, 8 to 10 feet wide, and as much as 6 feet deep. The higher grade ore was localized along the footwall next to the quartzite in short irregular strands ranging from 1 to 3 feet in width. Parallel and interlacing seams and stringers of manganese mineral separated by altered diabase occupied the footwall. Some manganese was present in the quartzite, but the bulk of the mineralization appeared to be in the diabase.

The ore minerals were wad, pyrolusite, and some psilomelane accompanied by iron oxides and calcite.

Other exploratory openings, consisting largely of bulldozer trenching and stripping, were present in several scattered areas on the claim. Although some manganese minerals were exposed in places by this work, it did not appear that an appreciable amount of ore had been mined from the openings.

No work was in progress when the property was visited in April 1957.

Globe Manganese

The property of Globe Manganese, once known as the American group, consists of seven contiguous patented claims situated about 5 miles north of Globe in the east-central part of sec. 10, T. 1 N., R. 15-1/2 E. (See fig. 9, p. 44.) The group can be reached by 0.7 mile of access road that branches left from the Copper Hill Road about 4.3 miles north of the Globe post office.

The claims, known as the Claud, Fierro, Manganese, Spec, Pick, Una, and Dick, were once the property of Globe Commercial Copper Co., which is said to have produced some silver ore in the late 1880's. No attention was paid to the manganese deposits until World War I. In 1916 and 1917,34/ lessees are reported to have shipped about 1,500 tons of manganese ore to eastern smelters. The ore contained 16.7 to 35.5 percent manganese and 8.8 to 11.3 percent iron. Manganese mining was resumed during World War II, when the property was held by T. J. Long and Al Stovall. From July 1942 to April 1943, records indicate that approximately 1,150 long tons of ore, averaging about 34 percent manganese, was shipped to the Metals Reserve Company stockpiles in Deming, N. Mex., and Phoenix, Ariz. Additional ore is said to have been produced after April 1943, but no records are available of these shipments.

Subsequently, the property was acquired by the present owner, T. W. Kimble, of Silver City, N. Mex. In 1943 Ralph Henderson, of Miami, Ariz., obtained a lease and option on the property and in the next 2 years shipped 1,381 long tons of ore, averaging 30.1 percent manganese, to the Government purchasing depot in Deming, N. Mex. During the same period, T. W. Kimble shipped 58.7 long tons containing 33.8 percent manganese to the Deming depot. The mine was closed late in 1955 and remained idle until late in 1956, when Henderson assigned his lease and option to Jolyn Associates, of Wickenburg, Ariz.

Operations were resumed in December 1956. When the property was visited in February 1957, six men were employed under the supervision of Ralph Henderson and about 15 tons of ore was being mined daily. Much of the ore as mined was passed over a 1/2-inch vibrating screen. The undersize, amounting to about two-thirds of the total material handled, was said to average 20 to 30 percent manganese. The screen undersize was shipped to the plant of Mohave Mining & Milling Co. near Wickenburg, Ariz., where it was upgraded by flotation and sintering to a product acceptable under the Government "carlot" program. According to Charles H. Jonas, manager of Jolyn Associates, about 1,342 tons of this screened ore had been shipped between December 1956 and April 1957. Thus, the total known production from the property to April 1957 was 5,431 tons containing nearly 30 percent manganese.

The ore occurs in disconnected lenticular ore shoots along two sinuous fault fissures that crop out along the contact between diabase and Precambrian quartzite. The fissures diverge and are 25 to 150 feet apart. Both trend east to northeast and dip 65° to 80° N. They can be traced more or less continuously on the surface for some 700 feet. The outcrop of the south fissure has a quartzite foot wall and a diabase hanging wall. That condition persists in the main inclined shaft to a depth of about 65 feet, below which both walls of the fissure are diabase. Along the outcrop of the north fissure, quartzite occupies the hanging wall and diabase the foot wall.

34/ Jones, E. L., Jr., and Ransome, F. L., Deposits of Manganese Ore in Arizona: Geol. Survey Bull. 710, pt. 1, 1920, p. 167.

Virtually the entire output of ore was mined from the central part of the south fissure, where it was exploited in places for some 400 feet along its strike and to a maximum depth of about 100 feet. The ore shoots were of various sizes, ranging from 20 to more than 100 feet in strike length and from 1 to 8 feet in width. The higher grade ore, probably 1.5 to 2 feet wide, is said to have been more abundant in the upper 75 feet of the workings where quartzite formed the foot wall of the fissure.

The ore minerals are the softer oxides, wad, and pyrolusite. Iron oxides, with some calcite, and quartz are the dominant gangue minerals.

The workings comprise four inclined shafts and a few opencuts along the south fissure and four shallow openings scattered along the outcrop of the north fissure (fig. 11).

The main working shaft, situated near the west end of the exploited area, was 162 feet deep. Its upper 70 feet was inclined about 70°. Below that depth it flattened to about 60°. At the time the property was visited the lower 60 feet of the shaft was inaccessible. Although some manganese was present in this deeper work, the ore bodies were said to be small, erratic, and lower in grade than those in the upper workings. Two drifts, known as the 75 and 100 levels, extended east and west from the main shaft. The 75 level

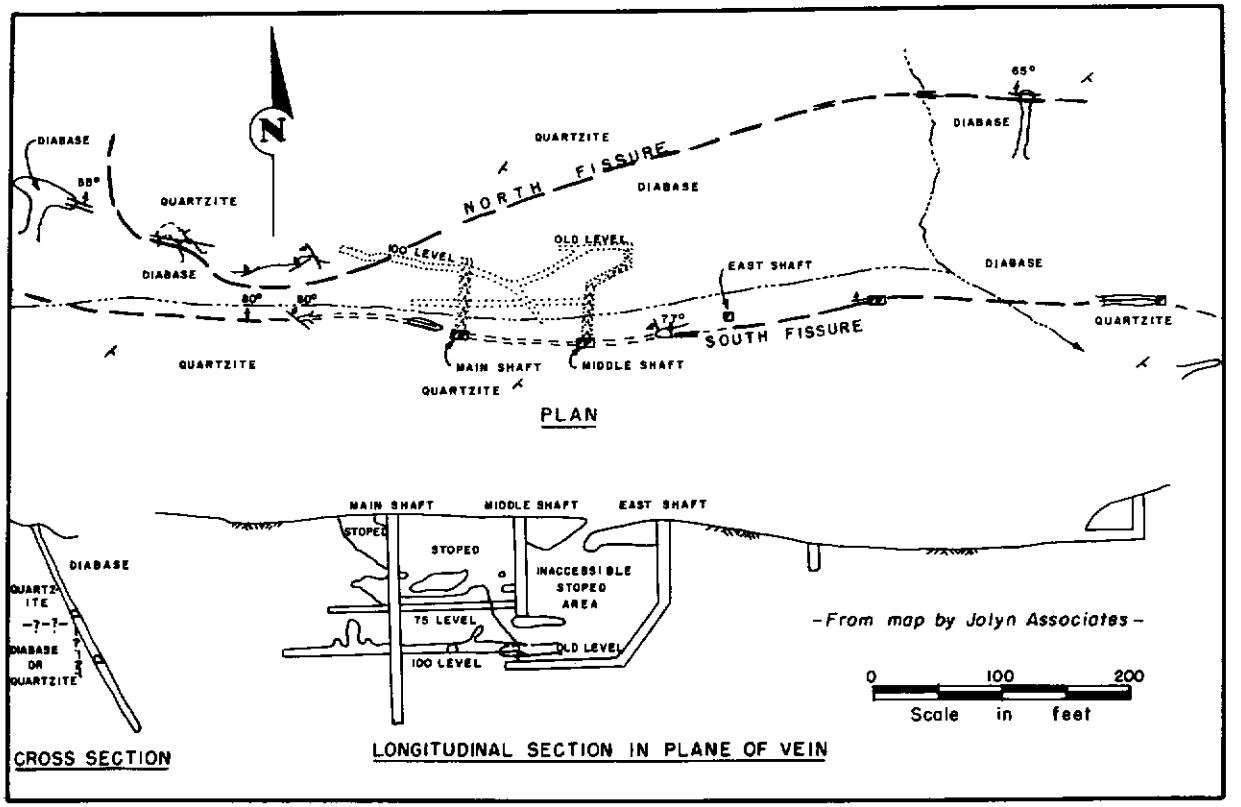

FIGURE 11. - Globe Manganese Mine, Gila County, Ariz.
(From Map by Jolyn Associates.)

had been driven westward about 50 feet and eastward 98 feet, where it connected with an old inaccessible shaft said to be 116 feet deep. The ore above the 75 level and between the two shafts had been mined in open stopes extending in places to the surface. About 110 feet east of the last-mentioned, or middle, shaft is another shaft, reportedly sunk during World War II to a depth of some 100 feet but now inaccessible. The area between the middle and east shaft was inaccessible but doubtless contained many stopes, one of which had broken through to the surface.

The 100 level from the main shaft extended westward 95 feet and eastward about 105 feet, where it broke into an old, partly caved drift driven from the middle shaft. A little stoping had been done above the back of the 100 level west of the main shaft, and a single small stope extended a short distance above the east drift. The operators were planning to do more exploration to the west on the ore showing in the old level driven from the middle shaft.

The carload of ore shipped to the Deming depot by T. W. Kimble was mined from shallow adit workings on the south fissure 500 feet or more east of the main shaft.

A small amount of sorted ore may have been produced from some of the shallow openings along the outcrop of the north fissure. However, the manganese minerals exposed along this fissure occurred largely as narrow stringers and small podlike bunches.

Magnet

The Magnet claim is one of the old patented group formerly owned by Superior & Globe Mining Co. It is situated near the center of sec. 10, T. 1 N., R. 15-1/2 E. and is accessible from Globe either by way of the Copper Hill Road or the road in Big Johnnie Gulch. By the former route, the workings are reached from an access road 0.6 mile long that branches west-northwest from the Copper Hill Road 4.5 miles north of the intersection of Yuma Street with U.S. Highway 60-70 in Globe. (See fig. 9, p. 44.)

The claim was located first in the 1880's and prospected for silver-copper ore. The first manganese ore was produced in World War I under a lease from Superior & Globe Mining Co. Incomplete records indicate that about 100 tons of ore containing 25 percent manganese was shipped at that time. Some years later the property was acquired by F. A. Bennett. In World War II the production of manganese ore was resumed. During that period about 780 tons containing 27 percent manganese is said to have been shipped to the Metals Reserve Company stockpiles, either in Phoenix, Ariz., or Deming, N. Mex. In 1953 the property was purchased by the present owner, F. A. Sitton, of Phoenix, Ariz. The following 2 years 2,427 long tons of ore, averaging about 26 percent manganese, was shipped from the claim to the Government purchasing depot in Deming, N. Mex. Over 2,200 tons of that ore was shipped by lessee Louis Winn of Globe, and the balance was shipped by F. A. Sitton. In 1956, D. N. Spencer, of Spokane, Wash., obtained an option on the property and explored the Magnet and other veins in the area by rotary-drill holes. The results of this work were not available. The property was idle when the district was visited in January 1957.

Manganese minerals occur in a series of lenticular bodies along a vein in a long, persistent fault fissure. The fissure, although rather sinuous along the strike, averages about N. 45° E. and ranges in dip from 40° to 65° NW. In places along the surface, the vein lies entirely in diabase; in other places, it follows the contact between the diabase and tilted blocks of quartzite belonging to the Precambrian Apache group. The fissure is traceable throughout the length of the claim, for 2,000 feet or more to the southwest, and for several hundred feet to the northeast into the adjoining claims.

Production from the Magnet claim came largely from four or more ore shoots at irregular intervals some 1,200 feet along the outcrop. They were separated by stretches of barren or lower grade material ranging from less than 100 to 400 feet in length. Generally, the productive bodies appeared to be lenticular, ranging from 3 to 12 feet in width and from 60 to more than 200 feet in length. In some places ore had been mined to an inclined depth of approximately 100 feet, whereas in other places the ore was said to have become too lean to work profitably within a few tens of feet below the surface. Although the shattered quartzite adjacent to the walls of the vein was mineralized to some extent, the bulk of the ore was in the altered diabase.

The manganese minerals are the soft oxides, comprising chiefly wad and pyrolusite with some psilomelane. The gangue is composed of altered diabase, iron oxides, calcite, and quartz.

When the claim was visited, the principal workings consisted of opencuts dug along the outcrop almost the entire length of the claim and four shafts. The largest and most productive ore body was near the northeastern end of the claim, where the work comprised an opencut and a vertical shaft said to be more than 100 feet deep. The opencut was about 200 feet long, ranged from 6 to 15 feet in width, and was as much as 15 feet deep. Reports indicated that the best ore found in the cut was 2 to 12 feet wide, the wider part apparently being localized at the intersection of a spur vein and the main fracture. Old reports also indicate that, in World War II, ore was mined from this part of the vein in shaft workings that extended 30 feet or more below the bottom of the opencut. This old work had been obliterated by the more recent operations. The 100-foot vertical shaft was sunk in 1956 in the hanging wall of the vein a few tens of feet west of the center of the opencut, and a 50-foot crosscut was driven westward from near the bottom of the shaft. Ore was said to have been found in the upper part of the shaft, but none was found in the crosscut.

Beginning about 250 feet southwest of the vertical shaft, the vein had been explored for some 150 feet along the strike by several shallow opencuts and two old inclined shafts. When the property was visited, the underground workings were inaccessible and their extent was unknown. One shaft appeared to be about 35 feet deep. The mineralized zone in this area ranged from 4 to 7 feet in width, and the higher grade ore occurred in strands 0.5 to 2 feet wide.

Approximately 350 feet farther southwest, ore had been mined from the vein in an opencut about 150 feet long that reached a maximum depth of 20 feet. In that area the ground was mineralized in places for a width as much

as 12 feet, the ore minerals occurring in stringers, veinlets, and irregular masses separated by altered diabase. Some of the larger mineralized masses were 6 feet wide and were said to have persisted along the strike and dip for as much as 20 feet. An appreciable amount of the ore shipped in 1954 was sorted from the material broken in the opencut.

Near the southern end of the claim and approximately 150 feet southwest of the last mentioned opencut, the vein had been explored by a 100-foot inclined shaft and about 150 feet of drifting. From the bottom of the shaft, drifts followed the vein for 85 feet southwest and 65 feet northeast. A raise had been driven on the vein for some 20 feet above the northeast drift, but no stoping had been attempted. The mineralized zone, exposed by this work, ranged from 3 to 7 feet in width and appeared to contain more iron oxide minerals than was evident in other parts of the vein to the northeast.

Another manganiferous ore body was exposed on the Magnet claim about 250 feet northwest of the southern inclined shaft. The ore in this exposure occurred in narrow seams, veinlets, and small irregular bunches in a northeasterly trending fracture zone along the diorite-quartzite contact. The zone in places was 10 feet wide and had been explored by bulldozer stripping about 50 feet along the strike.

Keno

The Keno is a fractional patented claim adjoining the northeast end of the Magnet claim in NE1/4 sec. 10, T. 1 N., R. 15-1/2 E. (See fig. 9, p. 44.) It is accessible over 0.7 mile of road that branches west-northwest from the Copper Hill Road 4.5 miles north of Globe.

Formerly, the claim was part of the group held by the old Superior & Globe Mining Co. and purchased for delinquent taxes by F. A. Bennett. At present the property is owned by F. A. Sitton, of Phoenix, Ariz.

A small amount of ore may have been mined from the claim during World War II, but the first recorded shipments of manganese ore were made in 1953 and 1954 to the Government purchasing depot in Deming, N. Mex. The shipments totaled 591 long tons of sorted ore averaging about 20 percent manganese.

When visited in January 1957, the property was idle and the equipment had been removed.

The deposits occur along the northeast continuation of the same general zone of fissures that contains the ore bodies on the Magnet claim. On the Keno claim, ore has been mined from two diverging fissures in diabase. The most productive fissure is at the south end of the claim; it strikes N. 35° E. and dips about 45° NW. The other, some 500 feet farther northeast, strikes N. 65° E. and dips about 55° NW.

The ore shipped to the Deming depot from the southwestern fissure was selectively mined from several podlike masses of manganese oxide which

occurred about 100 feet along the fissure. The ore bodies ranged from 3 to 6 feet in width and from a few feet to 20 feet in length. The workings in this area consisted of an adit and an inclined shaft. The adit followed the fissure into the hillside about 80 feet, where the mineralization terminated against a transverse fracture. A 25-foot raise extended to the surface from the middle of the adit. The inclined shaft, a few tens of feet southwest of the portal of the adit, followed the fissure down dip. Open stopes from the shaft workings had broken through to the adit level in several places. The shaft and the stopes below the adit were caved, so their extent could not be determined. It was reported that some of this underground work extended 40 feet below the adit.

The fissure near the northeast corner of the claim was in an area of talus and was poorly exposed. The ore had been mined from a steeply inclined shaft that was inaccessible when the property was visited. It was estimated to be about 30 feet deep. Near the collar of the shaft, the manganese deposit ranged from 3 to 6 feet in width and was exposed in places about 40 feet along the strike.

The chief manganese minerals in the deposits are wad and pyrolusite occurring in a gangue of iron oxides, calcite, and quartz.

Copper Trust

The Copper Trust claim is a member of a large group of patented claims formerly owned by the old Superior & Globe Mining Co. The manganese deposit on the group is in NE1/4NE1/4 sec. 10, T. 1 N., R. 15-1/2 E. (See fig. 9, p. 44.) It can be reached over 0.5 mile of access road that branches westward from the Copper Hill Road about 5 miles north of the Globe post office.

The group was located in the 1880's and subsequently acquired and explored for copper by Superior & Globe Mining Co. The principal work at the time consisted of sinking a 900-foot shaft near the south-central part of the property. The venture proved unsuccessful and eventually the entire group was sold by the State for delinquent taxes to F. A. Bennett, of Globe, Ariz. In 1953 the group was purchased from Bennett by the present owner, F. A. Sitton, of Phoenix, Ariz.

The first manganese-ore production of record, from the subject claim, was shipped by lessees in 1954 to the Government purchasing depot in Deming, N. Mex. The shipment consisted of 38.8 long tons of sorted ore averaging 22.2 percent manganese. The ore was not amenable to concentration by flotation, and the shipper was notified that no further shipments to the depot would be accepted; therefore, the work was terminated.

The manganese minerals occur in a fracture zone cutting diabase. The zone trends N. 60° E., dips steeply northwest, and has an exposed length of about 100 feet. It contains veinlets and various-size manganiferous masses over widths as much as 50 feet. The larger mineralized areas, separated by altered diabase, range from less than 1 to 3 feet in width and in some places persist along the strike for 15 feet.

The manganese minerals consist largely of wad and pyrolusite. Much of the ore is highly siliceous and in places contains an abundance of iron oxide intimately associated with the manganese minerals.

The ore shipped to the Deming depot was sorted from the material broken in an opencut about 30 feet long, 8 feet wide, and 8 feet deep. Some exploratory stripping of the talus overburden had been done southwest of the opencut.

The property was idle when visited in January 1957.

Black Bell

The Black Bell group of two unpatented claims is in NE1/4NE1/4 sec. 1, T. 1 N., R. 15 E., 0.5 mile east of Ramboz Peak. (See fig. 9, p. 44.) The property is accessible over 0.7 mile of steep truck trail that branches to the right from the Copper Hill Road about 6 miles north of the intersection of Yuma Street and U.S. Highway 60-70 in Globe.

The claims were located in 1954 by the present owner, Mrs. John Duber, of Globe, Ariz. During the year, 92 long tons of sorted ore, averaging 24 percent manganese, was shipped from the property to the Government purchasing depot in Deming, N. Mex.

The deposit occurs along a fracture zone in diabase. The zone strikes N. 40° E. and dips steeply northwest. The manganese deposit ranges from 2 to 4 feet in width and is exposed in places for about 250 feet along the strike. Soft manganese oxide minerals, comprising chiefly pyrolusite and wad, occur in stringers and narrow elongated lenses in disconnected areas along the outcrop. Jasperoid quartz and iron oxides are the principal gangue minerals.

The ore was mined from three shallow opencuts, ranging from 10 to 30 feet in length and spaced at irregular intervals along the strike of the fracture.

No work was in progress when the claims were visited in March 1957.

Last Chance

The Last Chance group, formerly known as the Lillian, is some 7 miles by road north of the town of Globe in the northeast corner of sec. 1, T. 1 N., R. 15 E. (See fig. 9, p. 44.) The property can be reached by a mile of truck trail that branches right from the Copper Hill Road about 6 miles north of the Globe post office. The ground is said to have been located first as a silver prospect as early as 1875. Since then it has been abandoned and relocated several times. In 1942, the claims were held by Charles Campbell, of Miami, Ariz. Some time later they were allowed to lapse. In 1954 the ground was relocated by the present owner, Charles C. Henderson, of Globe, Ariz. In 1955, 36.3 long tons of sorted ore, containing 30.4 percent manganese, was shipped by Henderson to the Government purchasing depot in Deming, N. Mex.

The manganese minerals occur in places along a vein in diabase. The vein strikes N. 70° E. and dips about 50° NW. It ranges from 8 to 15 feet in width,

but most of the manganese ore was confined to a zone 1 to 3 feet wide that follows the hanging-wall side of the vein. The manganese minerals, consisting essentially of pyrolusite with some psilomelane, occur in small irregular pods distributed erratically along both the strike and dip of the zone. The better mineralized part of the vein has an exposed length of 80 feet or more.

The deposit was explored by an adit about 50 feet long that followed the hanging-wall zone and reached a maximum depth of 25 feet below the surface. From the face of the adit a short crosscut had been driven southeastward to the footwall. In places a few small stopes extended short distances above the back of the adit. There was evidence that ore had been mined in places below the floor of the adit and later the openings had been backfilled. Additional work consisted of a few shallow cuts along the surface southwest of the portal of the adit.

In 1943, before any ore had been mined, two samples about 10 feet apart were cut across the back of the adit. The samples, representing widths of 2 and 2.5 feet, averaged about 25 percent manganese, a trace of gold, and 0.5 ounce of silver per ton.

The property was idle when the area was visited in January 1957.

Pontiac

The manganese deposit on the Pontiac claim is about 4 miles by road northeast of Globe in NE1/4NE1/4 sec. 15, T. 1 N., R. 15-1/2 E. (See fig. 9, p. 44.) It is readily accessible by a short side road that branches left from the Copper Hill Road 3.8 miles northeast of the junction of U.S. Highway 60-70 and Yuma Street in Globe.

The Pontiac claim is a member of a large group of patented claims presently owned by Miami Copper Co. Formerly, the group was the property of the extinct Arizona Commercial Mining Co. The first and only manganese ore produced from the claim was shipped in 1955 by Miami Copper Co. to the Government purchasing depot in Deming, N. Mex. The shipment consisted of 40 long tons of sorted ore averaging 29.6 percent manganese. The property was inactive when the district was visited in February 1957.

Manganese oxides occur on the claim near the northeastern end of a long persistent fault fissure known as the North Vein. As mapped by the Federal Geological Survey,35/ this fissure is nearly 1 mile long. In the past it has produced notable quantities of copper-silver ore from claims farther southwest. On the Pontiac claim the zone strikes N. 65° E. and dips very steeply to the northwest. It occupies the contact between Mescal limestone to the north and diabase to the south. As exposed in this area, the more highly mineralized parts of the outcrop contain seams, veinlets, and irregular disconnected masses of manganese minerals for 350 feet along the strike and over widths as much as 50 feet. Some of the ore occurs in the limestone and some in the

35/ Peterson, Nels P., Geologic Map of Globe Quadrangle: Geol. Survey, 1954.

adjoining sheared diabase. The larger manganiferous masses range from 1 to 4 feet in width and from a few feet to 15 feet in length.

The chief manganese minerals are wad, pyrolusite, and psilomelane. An abundance of iron oxides, with some calcite and quartz, are the principal gangue minerals.

The more promising outcrops along the zone had been explored by shallow scattered opencuts and some bulldozer stripping when the property was visited. The largest opencut, roughly circular in outline, was about 15 feet in diameter and as much as 8 feet deep.

Hobson

The manganese deposit on the Hobson claim is in the northeast corner of sec. 15, T. 1 N., R. 15-1/2 E. (See fig. 9, p. 44.) It is accessible over a few hundred feet of truck trail that branches north from the Copper Hill Road about 4 miles northeast of the Globe post office.

The claim is one of a large patented group formerly held by the old Superior & Boston Mining Co. At present the group is owned by Mrs. E. A. Borge, of Phoenix, Ariz.

So far as is known, no manganese ore was produced from the Hobson claim before 1954, when lessees shipped approximately 47 long tons of sorted ore averaging 25.3 percent manganese to the Government purchasing depot in Deming, N. Mex. No work was in progress when the property was visited in February 1957.

The manganese minerals occur along the northeast continuation of the same fault zone that contains the manganese deposit on the adjoining Pontiac claim to the southwest. The zone strikes N. 55° E. and dips from vertical to very steeply northwest. Diabase lies along the southern side of the fault and the Mescal limestone on the opposite side. The zone contains interlacing seams, veinlets, and sporadic masses of manganese oxides for 250 feet along the strike and over widths ranging from 20 to 50 feet. Along the outcrop farther southwest, the manganese mineralization grades into a predominance of specular hematite. To the northeast the zone ends abruptly against a steeply dipping transverse fault.

The manganese minerals, comprising chiefly pyrolusite and wad, occur in both limestone and diabase. The larger mineralized areas are very irregular, ranging from 1 to 5 feet in width and from a few feet to several tens of feet in length.

The ore was mined in different parts of the zone from the larger mineralized masses. The work consisted of several shallow opencuts and an inclined adit, all of which were in the area immediately southwest of the transverse fault. The inclined adit, driven along the southern side of the zone, was approximately 40 feet long and 6 to 8 feet wide and reached a maximum depth of 20 feet or more. From its face a raise extended to the surface. At the

top of the raise a shallow opencut extended along the strike of the zone about 15 feet. On the opposite side of the zone, some 20 feet north of the adit, an opencut 6 to 8 feet deep and about 4 feet wide followed the zone for approximately 20 feet. Some exploratory stripping had been done farther southwest, but little if any ore was exposed.

Iron King and Red Oxide Claims

The Iron King and Red Oxide are two adjoining patented claims about 4.5 miles by road northeast of Globe in the southcentral part of sec. 14, T. 1 N., R. 15-1/2 E. (See fig. 9, p. 44.) They can be reached over approximately 1 mile of access road that branches right from the Copper Hill Road 3.5 miles northeast of the Globe post office. The greater part of the access road follows the old railroad grade that once extended into the now abandoned camp of Copper Hill.

The claims, now owned by Mrs. E. A. Borge, of Phoenix, Ariz., are part of a group of 51 patented claims formerly owned by the old Superior & Boston Copper Co. This company was active in the early 1900's and produced a substantial amount of copper ore from different claims of the group before terminating operations in 1930. In 1936, the property was purchased for delinquent taxes by the late E. A. Borge.

The first recorded manganese-ore production from the Iron King claim was mined during World War II by lessees Al Stovall and T. J. Long. According to Stovall, about 4,000 long tons of ore, containing 32 to 38 percent manganese, was shipped at that time to the Metals Reserve Company stockpiles in Phoenix, Ariz., and Deming, N. Mex. After the war ended the property remained idle until 1951. In the next 3 years, it was operated for short periods by lessees F. A. Sitton and Falcon Mining Co., who shipped a total of 84 long tons, averaging 24.4 percent manganese, to the Government purchasing depot in Deming, N. Mex. Other shipments were made but were rejected as the ore was not amenable to concentration under the specifications prescribed by the depot.

The only recorded production from the adjoining Red Oxide claim was made in 1954 by lessees Guzman and Schwartz, who shipped 45.9 long tons of ore, averaging 28.0 percent manganese, to the Deming depot. Both claims were idle when the area was visited in February 1957.

The manganese deposits on the Iron King claim occur along a fracture zone occupying a fault contact between diabase and beds of the Mescal limestone. The zone strikes about N. 80° E. and dips from vertical to 75° N., cutting the limestone beds which dip about 20° S. Diabase lies along the footwall or south side of the zone, and limestone forms the hanging wall. Manganese oxides are exposed along the strike of the zone for more than 800 feet and in places extend over widths as much as 30 feet. The higher grade ore appears to be localized along the strike in several disconnected shoots ranging from 30 to 150 feet in length and from 3 to 8 feet in width. Surrounding these enriched parts are lower grade ores in more or less abundance. The manganese minerals occur as stringers, veinlets, and small irregular bunches occupying minor fractures in both the diabase and limestone adjacent to the contact.

The chief manganese minerals are wad, pyrolusite, and some psilomelane. Limonite, quartz, and calcite are the principal gangue minerals. Small quantities of copper, lead, and zinc are present in the deposit. Some samples of the ore have assayed more than 1 percent zinc, 0.10 percent lead, and 0.02 percent copper.

When visited, the Iron King workings consisted of three shafts and a few shallow opencuts. The main shaft, near the west end of the zone, was a vertical 1-1/2-compartment opening about 120 feet deep. Virtually all of the former production from the deposit was mined in open stopes adjacent to this shaft. The ore shoot ranged from 80 to 100 feet in length and from 3 to 8 feet in width. Except for a few pillars the ore was mined continuously from the surface to a depth of 150 feet, or some 30 feet below the bottom of the shaft. At this depth the lowest stope was about 30 feet long, but the limits of ore along the strike did not appear to have been reached. A few samples, taken from near the bottom of the lowest stope, had a manganese content comparable with that found in the upper parts of the ore body.

Approximately 140 feet east of the main shaft an inclined shaft had been sunk in the mineralized zone to an estimated depth of 60 feet. It was partly caved and inaccessible when visited.

Some 400 feet farther east was a third prospect shaft about 20 feet deep. A grab sample of the material broken in that shaft contained 10.5 percent manganese.

The manganese deposits on the neighboring Red Oxide claim occur in a fracture zone cutting the Mescal limestone. This zone, about 700 feet north of the Iron King deposit, strikes N. 45° E. and dips steeply northwest. It can be traced from the road on the old railroad grade about 600 feet to the southwest, where it passes under the large dump of the old Gardner shaft which was sunk in the early days in a search for copper. The manganese occurrences are scattered within the zone, which in places is mineralized over widths of 50 feet. The manganese minerals, consisting of the softer oxides, occur in seams, veinlets, and as irregular podlike masses replacing the limestone. The larger deposits range from 1 to 3 feet in width and from 10 to 30 feet in length. They are separated by widely spaced seams and stringers filled with the manganese minerals.

The carload of ore shipped to the Deming depot was sorted from the material broken in several shallow opencuts. A grab sample of unsorted material, broken in a small cut at the northeast end of the outcrop, contained 10.6 percent manganese.

Flotation and sulfur dioxide leaching tests were made on two samples of ore from the Iron King deposit and one sample from the dump of an opencut at the Red Oxide deposit. Each sample weighed about 100 pounds. The Iron King ores were from the west- and east-shaft dumps. A partial chemical analysis of the samples follows:

Sample	Assay, percent				
	Mn	$CaCO_3$	Pb	Zn	Cu
Iron King, west-shaft dump.....	22.7	13.6	0.43	1.35	0.04
Iron King, east-shaft dump.....	10.5	12.6	.32	.7	.04
Red Oxide dump.....	10.6	38.5	.23	.2	.03

The Iron King, west-shaft sample was a relatively soft, brownish ore with considerable earthy slime associated with hard fragments of manganese-bearing gangue. The principal manganese mineral was zinc-bearing pyrolusite mixed with smaller quantities of wad in a fine-grained gangue of quartz, limonite, iron-stained dolomite, calcite, and minor amounts of sericite, chlorite, and specularite.

The Iron King, east-shaft sample was a compact brownish product containing a small quantity of slime. A compact variety of zinc and lead-bearing pyrolusite was the chief manganese mineral. This pyrolusite was disseminated uniformly throughout the gangue material.

The Red Oxide ore was harder than the Iron King samples and comprised a fine-grained intergrowth of quartz, feldspar, and calcite containing veinlets of zinc- and lead-bearing pyrolusite, wad, and limonite.

As the manganese minerals in the Iron King and Red Oxide ores were finely disseminated, no attempt was made to concentrate the manganese by gravity methods, and efforts were directed toward treating the ores by flotation and sulfur dioxide leaching.

Bulk and selective flotation of the pyrolusite and wad was investigated. Bulk flotation of the manganese and calcite with oil-emulsion collector from minus-100- and minus-200-mesh charges of the three samples failed to yield acceptable manganese concentrates because the froths were diluted with the calcite and silicate gangue. Selective flotation of the calcite from the samples, followed by oil-emulsion flotation of the manganese, also gave manganese concentrates containing less than 40 percent Mn. For example, in tests on the Iron King west- and east-shaft dump samples, the manganese flotation concentrates assayed 36.8 and 27.9 percent Mn, respectively. The manganese recovery from each sample was about 81 percent. Treatment of the Red Oxide dump material yielded a concentrate assaying 32.6 percent Mn with a manganese recovery of 65 percent. The concentrate grade in the tests on the Iron King ores was vitiated by the silica gangue. The low manganese content of the Red Oxide concentrate is attributed to calcite, silicates, and hematite which were not retarded in the manganese flotation step.

Manganese extractions were good from the three samples by agitation or percolation leaching of fine or coarse ore charges with sulfur dioxide. Agitation leaching of minus-100-mesh charges of the three ores with a 10-percent sulfur dioxide-air mixture in pulps containing 17 and 30 percent solids gave excellent manganese extractions in short reaction periods. In tests on the Iron King, west- and east-shaft ores, 98 and 96 percent of the manganese, respectively, were recovered in 2 hours. The sulfur dioxide consumed in

treating the two ores was 2.4 and 3.1 pounds per pound of manganese dissolved. The manganese recovery from the Red Oxide sample was 95 percent, and the required sulfur dioxide was 3.6 pounds per pound of manganese dissolved. Dithionate formation from all of the ores was more than 1 pound per pound of manganese extracted. This quantity was more than adequate to compensate losses that would be incurred in the manganese hydroxide product and in the leach residue if the leach solutions were treated to recover the manganese.

Batch sulfur dioxide percolation leach tests were made on minus-1/4-inch and minus-1/2-inch charges of the ores. The procedure comprised alternate upward passage of sulfur dioxide through the moistened ore and downward percolation washing with water to extract the solubilized manganese. Manganese recoveries of 80 percent were obtained in a 3.5-day leach on minus-1/4-inch charges of the west- and east-shaft Iron King samples. Treatment of the minus-1/4-inch Red Oxide sample for 4.5 days gave a 75-percent recovery of the manganese. Sulfur dioxide consumption in leaching the three samples was 3.0, 3.8, and 4.2 pounds per pound of manganese extracted, respectively. Percolation leaching of the minus-1/2-inch ore feeds resulted in lower manganese recoveries. Only 62 and 68 percent of the manganese was recovered in 3.5-day leaches on the Iron King west- and east-shaft dump samples, respectively. A 3-day leach of the Red Oxide ore sample recovered 60 percent of the manganese. A longer leach probably would have improved manganese recoveries from the three samples. Dithionate formation from the samples, either by agitation or percolation leaching, exceeded 1 pound per pound of manganese extracted.

The batch laboratory tests demonstrated that the Iron King and Red Oxide ores were not amenable to concentration by conventional flotation methods, as the manganese concentrates recovered did not meet metallurgical-grade specifications for manganese. The three ores responded readily to agitation leaching with sulfur dioxide. Manganese recoveries were excellent, and sulfur dioxide consumption was nominal. Percolation leaching of coarse feeds with sulfur dioxide also gave satisfactory manganese extractions, but the sulfur dioxide consumption was higher than with agitation leaching. At present, the only feasible method of treating the Iron King and Red Oxide ores is by leaching.

Telfair

The Telfair claim is one of the large group of patented claims formerly held by the old Superior & Boston Mining Co. and now owned by Mrs. E. A. Borge, of Phoenix, Ariz. It is in SW1/4SW1/4 sec. 11, T. 1 N., R. 15-1/2 E. and is crossed by the Copper Hill Road some 4 miles north of the Globe post office. (See fig. 9, p. 44.)

In the early 1900's, a deep shaft was sunk near the northeastern end of the claim in a search for copper ore. Apparently, however, no manganese ore was produced until about 1954, when lessees shipped 44.8 long tons of sorted ore, averaging 22.3 percent manganese, to the Government purchasing depot in Deming, N. Mex.

The ore was produced from several shallow opencuts scattered along part of a fault fissure striking N. 40° E. and dipping 50° to 70° NW. The fissure

is traceable for several hundred feet along the strike and ranges from 2 to 6 feet in width. Its outcrop to the southwest lies wholly in diabase and its northeasterly part cuts through a sizable block of Mescal limestone dipping moderately southeast. Although the fissure is manganiferous along its outcrop in the diabase, the better ore appears to occur along the limestone-diabase contact. The manganese minerals comprising chiefly wad and pysolusite, are present in seams, veinlets, and small irregular bunches scattered along the fissure.

In addition to the opencuts from which the manganese ore was mined, some recent work had been completed near the southwestern end of the fissure a few hundred feet west of the Copper Hill Road. The work consisted of an inclined shaft estimated to be about 80 feet deep. Although the dump was manganiferous, apparently no appreciable amount of manganese ore had been produced from this part of the fissure. It was said that work had been done in prospecting for silver, which often accompanied manganese minerals in the area. The opencuts, which yielded the manganese ore shipped to Deming, were a few hundred feet northeast of the new shaft.

All equipment had been removed, and the property was idle when visited in January 1957.

Amster

The Amster claim, owned by Mrs. E. A. Borge, is in SE1/4SW1/4 sec. 11, T. 1 N., R. 15-1/2 E. (See fig. 9, p. 44.) It can be reached by an access road 0.5 mile long that branches eastward from the Copper Hill Road about 4.3 miles northeast of the Globe post office. The claim is patented and formerly was a part of the large group owned by the old Superior & Boston Mining Co.

The first manganese ore shipped from the claim was mined by lessees in 1954. At that time, 107 long tons of sorted ore, averaging 23.8 percent manganese, was shipped to the Government purchasing depot in Deming, N. Mex. The claim was idle when the area was visited in February 1957.

The manganese minerals occur along a fracture zone cutting beds of the Mescal limestone. The fracture strikes N. 60° W. and dips about 80° NE., whereas the limestone beds trend eastward and dip moderately southeast. The better mineralized part of the fracture ranges from 4 to 6 feet in width and is exposed on the surface for some 300 feet along the strike. To the southeast, the zone is traceable for an additional 200 feet by occasional small disconnected outcrops. Overburden conceals any extent of the deposit to the northwest beyond the present workings.

The manganese minerals, comprising chiefly pyrolusite and wad, are present in seams, veinlets, and small irregular bunches surrounded by unreplaced limestone. Iron oxides, quartz, and calcite are the principal gangue minerals.

The main workings are near the northwestern end of the outcrop and consist essentially of an opencut about 90 feet long, 4 to 6 feet wide, and as

much as 20 feet deep. The ore that was shipped to the Deming purchasing depot was handsorted from the material broken in this opening.

Another manganiferous occurrence, probably on the adjoining Morlay claim, crops out about 700 feet northeast of the Amster opencut. In this deposit, manganese and iron oxides are present in a fracture occupying the contact between diabase and limestone. The fracture strikes N. 50° E. and dips steeply northwest. It has an exposed length of about 100 feet and the more highly mineralized parts are 1 to 4 feet wide. In 1954, lessees explored the deposit, but evidently produced little, if any, ore. The work consisted mainly of a vertical shaft about 35 feet deep. At that depth the ore contained an abundance of iron oxide, and the work was discontinued.

Berkley

The Berkley claim adjoins the Amster on the south and is one of the old patented Superior & Boston group now owned by Mrs. E. A. Borge, of Phoenix, Ariz. Part of the claim lies in SE1/4SW1/4 sec. 11 and part in NW1/4NE1/4 sec. 14, T. 1 N., R. 15-1/2 E. (See fig. 9, p. 44.) The deposit can be reached from the access road that leads to the Amster claim. At the opencut on this claim, the road turns southward for about 0.5 mile, where it ends at the Berkley workings.

Although the deposit was prospected much earlier for silver, the first manganese ore was shipped in 1954 by lessees to the Government purchasing depot in Deming, N. Mex. The production totaled 87 long tons of sorted ore averaging 25.1 percent manganese. Operations were stopped late in 1954, and no further work had been attempted to the time when the mine was visited in February 1957.

The deposit is of the bedding replacement type with manganese and iron oxides replacing a cherty bed in the Mescal limestone. The mineralized part of the bed ranges from 4 to 6 feet in thickness, strikes eastward, and dips 25° to 30° S. It crops out along the southern side of a narrow wash, where it is exposed for 150 feet along the strike. Ore was deposited along the outcrop in elongated podlike bodies separated by intervals of sparsely mineralized or barren limestone. The longest body extends eastward from the western end of the outcrop for 75 feet, where a relatively barren interval some 50 feet long separates it from another mineralized pod that persists eastward about 25 feet. To the east the bedrock is covered with overburden.

Pyrolusite and wad are the dominant manganese minerals. Iron oxide, quartz, and calcite are the principal gangue minerals.

The workings comprised a 15-foot adit at the western end of the deposit and three short opencuts to the east. The maximum depth reached in any of the openings was about 12 feet.

Keeley Cure

The Keeley Cure group of 10 contiguous unpatented claims covers the southwestern part of approximate sec. 36, T. 2 N., R. 15 E., unsurveyed, and

extends into NE1/4 sec. 1, T. 1 N., R. 15 E. (See fig. 9, p. 44.) The principal manganese deposit on the property is near the northern end of the group about 10 miles by road north of the Globe post office. It can be reached from the post office by following U.S. Highway 60-70 west 3.4 miles to State Route 88 (Apache Trail), then proceeding north on this route 2.4 miles to a dirt road branching right, eastward on the branch 0.6 mile to a road fork, and north on the left fork across the railroad at Radium Siding for 1.5 miles where the road turns eastward and is followed about 2 miles to the deposit. The last 1.5 miles of the road is a mere truck trail containing many sharp curves and steep grades.

The claims were located in 1905 for silver and have been held ever since by members of the T. J. Watts family, of Globe, Ariz.

Some manganese-bearing silver ore is said to have been produced from time to time. However, the first manganese ore, as such, was mined in 1954 from one of the claims by lessee Otto Malone, of Globe. At that time, 81.3 long tons of sorted ore averaging 26.4 percent manganese was shipped to the Government purchasing depot in Deming, N. Mex. From 1954 until the claims were visited in March 1957, only the annual assessment work had been done on the property.

The claims are traversed by several manganiferous fault fissures cutting diabase and tilted blocks of the Apache group quartzites. The most noteworthy of the known manganese fissures on the property occurs in a fault zone striking N. 30° E. and dipping about 70° SE. It lies in diabase throughout its traceable length of several hundred feet. Where exposed in a small explored area, the zone contains manganese minerals for widths of 25 feet or more. The manganese minerals are present in the zone in the form of seams, stringers, and lenticular masses separated by various widths of soft, altered diabase.

The largest exposed ore body occupied the footwall of the zone and consisted of a lenticular strand of ore about 80 feet long. It attained a maximum width of 3.5 feet and tapered to a foot or less at each end. This strand, probably constituting the major source of the ore produced, had been mined upward to the surface in an open stope extending above an adit level. The adit was 75 feet long and extended as much as 20 feet below the surface. Several feet east of the portal of the adit, the hanging-wall part of the zone had been explored by a small opencut and old, caved adit workings of unknown extent. Probably this adit had been driven years ago in a search for silver ore.

The chief manganese minerals are pyrolusite and psilomelane in a gangue of altered diabase, iron oxides, and quartz.

Manganese King

The Manganese King is a single, unpatented lode claim in the southeastern corner of approximate sec. 35, T. 2 N., R. 15 E., unsurveyed, and about 0.5 mile west of the previously described Keeley Cure deposit. (See fig. 9, p. 44.) The prospect openings on the claim lie along the hillside immediately south of the access road leading to the Keeley Cure workings.

The claim is an old silver one dating back to the early days of the district. Since then it has been abandoned and relocated several times. In October 1956, it was relocated as the Manganese King by Dave Lewis, of Globe, Ariz. Although a little manganiferous silver ore may have been produced, there are no records indicating that manganese ore has ever been shipped from the property.

The manganese is deposited in parts of a fault zone in diabase. The zone strikes northeast and dips from vertical to steeply southeast. It is manganiferous in places along the outcrop for several hundred feet and for widths up to 30 feet. The higher grade manganese minerals are in two separate irregular masses ranging from 2 to 5 feet in width and from a few feet to tens of feet in length. The rest of the zone is composed largely of widely separated seams of manganese minerals and much manganese stain.

The workings comprise an old vertical shaft about 20 feet deep and a few shallow opencuts scattered along the outcrop.

The softer oxides, such as wad and pyrolusite, are the dominant manganese minerals.

Ireland

The Ireland property consists of two unpatented claims in approximate sec. 19, T. 2 N., R. 16 E., unsurveyed, some 12 miles by road northeast of Globe near Apache Pass. (See fig. 8, p. 43.) The workings on the property can be reached by 0.6 mile of steep access road that branches left from U.S. Highway 60 about 10.5 miles north of its junction with U.S. Highway 70 east of Globe.

The claims are held by Charles Ireland, of Globe, Ariz. A small but unknown quantity of manganese ore is said to have been produced in World War II. In 1954, while under lease to J. W. Thomas, of Miami, Ariz., 139.4 long tons of ore averaging 24 percent manganese was shipped to the Government purchasing depot in Deming, N. Mex.

The manganese deposit occurs in a steeply dipping dike of altered diabase which has invaded moderately dipping beds of quartzite. The dike strikes N. 55° E., ranges from 3 to 6 feet in width, and is mineralized in places on the surface for 150 feet or more along its strike.

The manganese minerals, consisting chiefly of psilomelane and pyrolusite, occur in seams, narrow stringers, and small irregular bunches distributed sporadically in the diabase. The quartzite walls adjacent to the dike are only weakly mineralized.

The bulk of the ore produced from the deposit was mined near the northeast end of the outcrop in an open stope about 80 feet long, 4 to 6 feet wide, and as much as 15 feet deep. It appeared that the bottom of the stope was once the floor of an adit and that the ore had been stoped upward to the surface from the back of the adit. A few old caved opencuts extended southwest

along the outcrop about 75 feet beyond the face of the stope. Some manganiferous float was present in the surface soil for an additional 100 feet or more to the southwest. In this area the diabase was not evident, but small amounts of manganese minerals in the form of thin seams and stain were present in the quartzite.

When the area was visited in March 1957, all equipment has been removed and the property was idle.

Another manganese occurrence of unknown name and ownership is situated about 0.5 mile S. 23° W. from the Ireland workings. It lies along the eastern side of Cammerman Wash and is accessible by way of a 0.5-mile dirt road that branches left from U.S. Highway 60 about 9 miles north of its junction with U.S. Highway 70.

The deposit occurs in diabase along a shear zone trending N. 70° E. and dipping steeply north. The manganese ores are exposed in the bottom of a bulldozer cut for 200 feet or more along the strike and over widths as much as 12 feet. The manganese minerals, consisting essentially of the softer oxides, occur in strands and irregular bunches ranging from 1 to 4 feet in width and from a few feet to 20 feet in length. These larger occurrences are surrounded by lower grade material containing seams and narrow stringers of manganese oxides oriented in various directions along the minor fractures in the shattered diabase. Limonite is the chief gangue mineral.

No work was in progress in March 1957, and no location notices were found although the workings appeared to be recent. Persons living in the vicinity did not know who owned the property nor who had done the exploratory work.

Black Point

The Black Point deposit, also known as the Malone White, is some 14 miles by road northwest of Globe in SE1/4SE1/4, sec. 6, T. 2 N., R. 15 E. (See fig. 8, p. 43.) The property consists of two unpatented claims and can be reached over a dirt road that branches east from State Route 88 (Apache Trail) 11.5 miles northwest of the Globe post office. After Pinal Creek is crossed this dirt road is followed north 2 miles, thence east on a right-hand fork 0.8 mile to the deposit.

The claims originally were located in World War I, and reports indicate that a little manganese ore was produced at that time. In 1952 and 1953, the property was worked by Copper Hill Mining Co. under a lease from the present owners, Otto Malone and associates, of Globe, Ariz. In 1952, this company shipped 102 tons of ore, containing 16.1 percent manganese, to a custom mill in Deming, N. Mex. operated by the U.S. Manganese Corp. In 1954 about 91 long tons of 25-percent ore was shipped to the Government purchasing depot in Deming, N. Mex. In 1955, John Duber obtained a lease on the deposit and shipped 31.5 tons of ore averaging 28 percent manganese to the Deming depot. No work was in progress when the property was visited in February 1957.

The manganese deposit occurs in a steeply dipping shear and brecciated zone cutting coarse-grained granitic rocks. The zone strikes N. 20° E. across a southwesterly trending ridge and has an exposed length of 350 feet. The best ore occupies the northern half of the outcrop, where it ranges from 4 to 8 feet in width. The ore shipped was either handsorted or screened from the material broken in an opencut 120 feet long, 5 to 7 feet wide, and as much as 30 feet deep. In the deeper parts of the cut the ore is said to have become much lower in grade than that found nearer the surface. In places a network of narrow stringers and seams of manganese minerals extends outward from the sides of the cut for several feet into the sheared wall rocks. Some ore is exposed along narrow fractures that crop out about 30 feet east of the opencut. The fractures are parallel to the main zone and are exposed in places along the strike for 200 feet or more.

The chief ore minerals are pyrolusite and psilomelane occurring in a gangue composed largely of brecciated fragments of granite and manganiferous calcite.

Giant Cactus

The Giant Cactus deposit is 12.5 miles by road northwest of Globe in NE1/4 sec. 8, T. 2 N., R. 15 E. and about 0.8 mile southeast of the Black Point manganese deposit. (See fig. 8, p. 43.) The property is accessible from a dirt road that branches to the right from State Route 88 and 9 miles northwest of Globe. This graded dirt road is followed north along the east side of Pinto Creek 2.4 miles, thence east on a right-hand fork 0.7 mile. At this point a dim access road branching left is followed north 0.4 mile to the deposit.

The property, comprising two unpatented claims, is said to have been located originally during World War II. Since then the claims have been abandoned and relocated several times by different parties. Notices found on the property indicated that the claims were located in 1954 by Thomas M. Farris. Somewhat later they were acquired by the present owners, William Packard and associates, of Miami, Ariz. During the summer of 1955, the property was leased to Jack Long and T. A. Long, of Globe, who shipped 48.5 long tons of concentrates to the Government purchasing depot in Deming, N. Mex. The concentrates, containing 26.2 percent manganese, were recovered from 185 tons of ore treated in a small jig plant owned by Hagen Construction Co. and situated on the outskirts of Globe.

The deposit occurs in a brecciated zone cutting metamorphosed limestone. The zone strikes northwest and dips about 60° SW. in apparent conformity to the bedding of the limestone. The mineralized part of the zone is as much as 40 feet wide and has an exposed length of about 100 feet. Altered igneous rocks crop out along the southeastern end of the deposit. Near its northwestern limits the ore splits into narrow strands that soon lose their identity.

The manganese minerals occur in seams, veinlets, and small irregular bunches surrounding brecciated fragments and masses of barren silicified

limestone. Some larger bunches and veinlets of ore attain widths of 10 inches and may persist several feet along both the strike and dip.

The principal workings consist of an opencut approximately 50 feet long, 18 feet wide, and as much as 12 feet deep.

The chief manganese minerals are psilomelane and pyrolusite. The gangue minerals comprise calcite, iron oxides, and quartz.

The property was idle when the area was visited in February 1957.

Apache

The Apache deposit is 52 road miles north-northeast of Globe, in approximate sec. 10, T. 5 N., R. 16 E., unsurveyed. (See fig. 8, p. 43.) It lies near the southwest corner of the Fort Apache Indian Reservation about 2 miles north of Salt River. The area may be reached from Globe by traveling west on U.S. Highway 60-70 4 miles to State Route 88 (Apache Trail), then north on this route 15.2 miles to a road fork. The right fork, leading to the village of Young, is followed north 7 miles to a graded dirt road branching right, known as the Cherry Creek Road. This is followed east 15 miles to a faint road that branches right some 2 miles northeast of the Cherry Creek ford. This branch continues east some 10 miles to the deposits. The mine workings are at an altitude of 3,500 feet and lie along the sides of a southerly draining wash approximately a quarter of a mile east of a prominent flat-topped mesa known as Medicine Butte.

The first attempt to work the deposits was made late in 1939 by L. A. Kuehne and G. L. Noel, who obtained a lease on 120 acres from the Fort Apache Indian Reservation. Operations were continued intermittently for the next 3 years by Kuehne and other lessees, including A. L. Lampton and Hollis Gray. The records at the Whiteriver Indian Agency show that 302 long tons of sorted ore containing 45.3 to 48.7 percent manganese was shipped during the period by the various lessees to Colorado Fuel & Iron Co., Pueblo, Colo. All operations stopped in 1943, and the property remained idle until 1955.

In January 1955, a new lease was acquired from the Fort Apache Indian Reservation by G. L. Noel, who a few months later assigned it to Al Stovall, of Phoenix, Ariz. Stovall began operations soon thereafter and built a gravity concentrating plant near the north bank of the Salt River about 2 miles south of the deposits. The plant, after treating 10,000 to 12,000 tons of ore, was dismantled and moved from the area in the spring of 1956. According to the records of the Whiteriver Indian Agency, Stovall's production totaled about 1,540 long tons of concentrates. The first 3 carloads of concentrates were shipped late in 1955 to the Government purchasing depot in Deming, N. Mex. Upon analysis, the lots were found to contain more than 0.25 percent copper and hence failed to meet the purchasing depot specifications. As no further shipments could be accepted by the depot, the concentrates produced thereafter were shipped to the State of Arkansas, where they were blended with copper-free manganese ore or concentrates. In this way the copper content was reduced enough to meet marketing specifications. Blending was said to have

entailed such an added expense that the operation of the property was terminated sooner than it otherwise would have been.

The first few lots of Apache concentrates shipped to the Deming depot contained 47 to 50 percent manganese. The grade of the shipments to Arkansas was not available.

Al Stovall relinquished his lease and removed all equipment early in 1956. The property was idle when visited in March 1957.

The manganese deposits occur in fracture zones in partly consolidated beds of gravel resembling the Gila conglomerate. The gravels cover many square miles near the southwest corner of the Fort Apache Indian Reservation. They are composed of various-size fragments of many types of rocks with a large proportion of round pebbles and boulders of quartz. In places the beds are known to be at least several hundred feet thick, and in other places they have been eroded completely. Near the manganese deposits the gravels range from a few feet to at least 100 feet in thickness and, judged from a few bedrock exposures, appear to rest upon an uneven erosional surface of igneous rocks similar in appearance to the diabase farther east in Salt River Canyon.

The principal manganese exposures on the property lie in four zones along a northerly trending belt some 2,000 feet long. Intervening areas are largely covered with alluvium and detritus. This covering obscures the correlation of the different exposures and conceals any further extent they may have. The deposits occur in steeply dipping fracture zones that range in strike from northwest to northeast. The zones differ in width, the manganese oxide minerals occurring in narrow veins, interlacing seams, and small nodular masses distributed erratically in the sheared and shattered gravel beds.

Psilomelane and minor amounts of the softer oxides are the chief manganese minerals. The gangue is composed largely of quartz, unreplaced pebbles, and fragments of gravel.

In the exploited deposit near the southern end of the property, the mineralized zone was about 25 feet wide and was exposed in an opencut about 60 feet along its southeastward strike. The face of the cut was approximately 12 feet high and contained three enriched veins ranging from 1 to 2 feet in width. These higher grade veins extended from the surface to the bottom of the opening and were separated by lower grade material composed of a network of narrow seams, stringers, and small bunches of manganese minerals. Near its face, the opencut had broken into some old adit workings driven on one of the higher grade veins, which probably was the source of some of the ore produced in 1941. Overburden surrounded the opencut and concealed the further extent of the deposit along the strike.

A few hundred feet farther south, stripping had exposed scattered spots of manganese minerals in an irregular area about 150 feet long and 50 feet wide. The exploratory work had not been completed, and the extent of the deposition in this area was not evident when the property was visited.

Approximately 250 feet north of the first-described zone, the largest and most productive of the deposits was exposed in opencut workings about 300 feet along its northerly trend. In this area the deposit appeared to be as much as 60 feet wide near the south end of the cut and not more than 20 feet wide at the north end. This zone contained veinlike strands and irregular masses of higher grade ore, surrounded by interlacing seams and stringers of psilomelane filling the minor fractures in the shattered gravels. The opencut workings reached a maximum depth of some 25 feet. Old reports indicate that some ore was mined in 1941 from this zone in deeper adit workings underlying parts of the present opencut.

About 150 feet north of the opencut, a 30-foot adit had been driven along a well-mineralized vertical fracture striking N. 25° E. and ranging from 1 to 2 feet in width. Here also the gravel adjacent to the higher grade fracture was impregnated with seams and stringers of manganese minerals. The full width of this lower grade material was not exposed. A few scattered shallow opencuts and pits had explored the zone for some 200 feet along its strike to the northeast.

The northernmost deposit is about 1,000 feet north of the largest opencut. In this area the manganese minerals occurred along a vertical fracture zone striking N. 65° E. It ranged from 10 to 25 feet in width and was exposed in an opencut about 100 feet along the strike. To the northeast, beyond the face of the cut, the deposit was covered with 15 to 20 feet of detritus. Some of this covering had been stripped, exposing the top of the deposit for an additional 60 feet. Some stripping also had been done along the trend of the zone southwest of the cut, but no appreciable amount of ore was exposed by the work. The ore minerals in this deposit, as in the others, occurred in enriched strands and irregular bunches separated by a network of seams and stringers of psilomelane surrounding the pebbles and other constituents of the gravel.

Large grab samples were taken from piles of broken ore remaining in the three principal opencuts. The sample from the south opening contained 9.0 percent manganese, that from the largest opencut assayed 8.5 percent, and the sample from the northernmost deposit contained 8.4 percent manganese.

Bench-scale physical beneficiation and sulfur dioxide leaching tests were made on a composite of four grab samples of broken ore from the three major opencuts on the property. The composite sample weighed about 400 pounds and contained 8.4 percent Mn, 3.6 percent $CaCO_3$, and 0.19 percent Cu. Visual and microscopic examination identified the ore as a coarse-grained sandstone cemented with psilomelane and small quantities of pyrolusite and wad. Spectrographic analysis showed the presence of a trace of cobalt and some copper which was inherent in the manganese minerals. Although high-grade psilomelane as coarse as 1/2-inch was found in the ore, grinding to minus-100-mesh was required for complete liberation of the psilomelane from the quartz.

Physical beneficiation of the sample by sink and float and by flotation was investigated. The ore was crushed to minus-5/8-inch and screened on a 10-mesh sieve for the sink-float tests. Separation of the minus-5/8-inch, plus-10-mesh fraction at 2.94 specific gravity yielded a sink product assaying 38.2

percent Mn and 0.6 percent Cu and recovered 69.6 percent of manganese. Sink-and-float separation of minus-1/4-inch feed did not give a better grade of product.

Selective flotation of the manganese with oil-emulsion collector, from minus-100-mesh charges of the ore, produced concentrates approaching metallurgical grade specifications as to manganese but containing excessive copper. In a typical test the calcite first was rejected using oleic acid as the collector. The manganese then was recovered from the calcite rougher tailing by means of an oil-emulsion collector. The flotation concentrate assayed 39.4 percent Mn and 0.7 percent Cu and yielded a manganese recovery of 73.1 percent. A selective flotation test was made on the sink concentrate from the sink-float test on the minus-5/8-inch, plus-10-mesh fraction of the ore. Bulk flotation of the concentrate, after grinding to pass 100-mesh, yielded a froth that assayed 45.8 percent Mn and 0.8 percent Cu. Although the manganese recovery from this product was 98 percent, the overall manganese recovery by sink and float and by flotation was 68 percent. Leaching the concentrate for extended periods with sulfuric acid failed to reduce the copper content. As the copper is in solid solution in the manganese minerals, the ore cannot be beneficiated by physical methods to recover products meeting metallurgical grade specifications.

Representative samples of the ore were treated by agitation leaching of finely ground charges and by percolation leaching of coarse charges using sulfur dioxide. The agitation leach was made on pulps of minus-100-mesh ore. A gas comprising 10 percent SO_2 in air was fed to the pulp, which contained 32 percent solids, at the highest feed rate commensurate with utilization. The ore leached rapidly and completely. About 97 percent of the manganese was recovered in a 2-hour leach with a sulfur dioxide consumption of 2.2 pounds per pound of manganese dissolved. Dithionate formation in the test was 0.7 pound per pound of manganese extracted, which was more than ample for successful recovery of the manganese from the pregnant solutions by precipitation with hydrated lime as practiced in the dithionate process.

As copper in dithionate leach solutions can be rejected before precipitation and recovery of the manganese hydroxide, the Apache sample can be leached successfully to recover a metallurgical grade product. Leaching the ore appears to be the only practical method of treatment at present.

Accord

The Accord claims are on the Fort Apache Indian Reservation in approximate sec. 9, T. 5 N., R. 16 E., unsurveyed, and 1.3 miles west of the previously described Apache deposit. (See fig. 8, p. 43.) The claims can be reached by 2 miles of poor truck trail that branches north from the access road to the Apache mine 6.8 miles east of Cherry Creek.

Little is known of the history of the property. In 1940 and 1941, it was held by L. A. Kuehne under a lease from the Indian agency. There are no records of manganese ore shipments, and the property was idle when visited in April 1957. Apparently, no work had been done for several years.

Manganese minerals occur along two northerly trending veins about 300 feet apart. In places the veins are enclosed in gravel or conglomerate beds similar to those found on the Apache claims, and in other places they cut intrusive volcanic rocks. The better mineralized parts of the veins range from 1 to 2.5 feet in width and dip steeply westward. The east vein can be traced about 400 feet along the surface by infrequent outcrops, and the west vein is exposed some 70 feet along the strike.

The chief manganese minerals are psilomelane and wad, which occur as veinlets and small lenses in a gangue of black and white calcite.

The workings comprised three adits along the east vein and a 15-foot shaft and two shallow opencuts on the west vein. One adit followed the vein about 50 feet, and the two farther north were caved and inaccessible.

Ramsdell

The Ramsdell group, also called Gleeson Flat, consists of seven unpatented claims about 38 road miles north of the town of Globe in the southeastern part of unsurveyed T. 5 N., R. 16 E. (See fig. 8, p. 43.) The deposit is about 1/4 mile south of Salt River and some 2 miles south-southeast of the Apache manganese deposits on the opposite side of the river. The property is reached by traveling 20 miles northeast from the Globe post office on U.S. Highway 60 to Seven Mile Wash, thence north 11.6 miles on a graded dirt road to a road fork. The right-hand for is followed 2.3 miles to a dim access road that branches left about half a mile south of John Peer's ranch buildings at the base of Haystack Butte. The access road is followed northwestward 3.8 miles to the workings. The deposit lies on the north slope of a ridge at an altitude of about 3,100 feet.

The claims were located early in World War II by the present owner, F. T. Ramsdell, of Globe, Ariz. Lessees operated the property for a short time in 1942 and reportedly shipped about 17 tons of handsorted ore to the Metals Reserve Company stockpile in Phoenix, Ariz. In 1951, the claims were leased to P. D. Parker, who did additional exploration work but so far as is known shipped no ore. In 1954, a lease was acquired by George B. Wright and associates, of Globe, Ariz. During that year and the early part of 1955, the lessees shipped 67.9 long tons of sorted ore averaging 28.3 percent manganese to the Government purchasing depot in Deming, N. Mex. All equipment had been removed and the property was idle when visited in February 1957.

The manganese ore occurs in stringers and small lenticular pods along a fissure cutting a massive coarse-grained quartz diorite. The fissure strikes north and dips about 80° E. It was exposed for approximately 250 feet along the strike and ranged from 2 to 10 feet in width. The overburden had been stripped along the projected trend of the fissure for several hundred feet farther south, but only a few narrow and widely spaced manganiferous seams were exposed by this work.

In the exploited parts of the deposit, the manganese minerals occurred in fairly high grade lenses and irregular podlike masses surrounded by a

network of manganiferous seams and veinlets filling the minor fracture of the enclosing diorite. Although virtually exhausted when the workings were visited, the largest lenses of ore were said to have ranged from 6 to 18 inches in width and from a few feet to as much as 10 feet in length.

The principal manganese minerals were psilomelane and pyrolusite occurring in a quartzose gangue.

The workings consisted essentially of three adits driven into the hillside at successively lower elevations. The northmost and lowest adit followed the fissure some 200 feet. It extended under the next or intermediate adit and was approximately 30 feet below it. Only a little minable ore was found in the lower adit. This ore was mined near the face in a stope about 6 feet long that extended a few feet above the back of the drift. The intermediate adit, whose portal was about 100 feet south of the portal of the lowest adit, followed the fissure for 125 feet. Ore had been mined from this part of the fissure in a few small open stopes, one of which had been carried upward 12 feet to the surface.

The upper workings, some 40 feet south of the portal of the intermediate level, comprised a 50-foot opencut and a 30-foot adit extending southward from its face. In places along the opencut the manganese minerals occurred in widely separated stringers and seams that constituted a low-grade zone as much as 10 feet wide. Farther south the zone narrowed and soon lost its identity in the stripped area a short distance beyond the upper adit.

Sunset

The Sunset group, also known as the Armer property, consists of four unpatented claims about 39 miles northwest of Globe and 6 miles north of Roosevelt Lake in NE1/4 sec. 29, T. 5 N., R. 13 E. (See fig. 8, p. 43.) The property can be reached from Globe by traveling west about 3 miles on U.S. Highway 60-70 to the Apache Trail, thence north about 15 miles to a right-hand fork leading to the village of Young, and continuing north on the Young road 13 miles to a left-hand branch on the north side of Roosevelt Lake that leads to Tonto Basin. This branch is followed west 4.5 miles to a right-hand side road which is followed north 3.3 miles to the Armer Ranch headquarters. The deposit is near the top of the ridge about a quarter of a mile southeast of the ranch buildings.

The claims have been held for many years by B. G. Armer, of Globe, Ariz. During World War II, lessees reportedly produced several tens of tons of manganese concentrates in a small gravity concentrating plant erected near the deposit. Subsequently, the plant was removed, and the property remained dormant until 1953. During 1953 and 1954, operations by two groups of lessees resulted in a total production of 103.5 long tons of sorted ore averaging 25.2 percent manganese. The ore was shipped to the Government purchasing depot in Deming, N. Mex. The property was idle when the area was visited in April 1957.

The manganese minerals occur in shattered Precambrian quartzite along a shear zone striking N. 70° W. and dipping about 65° NE. The quartzite beds

trend westward and dip about 25° S. Seams, veinlets, and various-sized irregular masses of hard manganese oxides are exposed in places along the strike of the zone for 500 feet or more and over widths ranging from several feet to as much as 60 feet. To the southeast the outcrop of the zone is covered with soil that contains an abundance of manganese float over a broad area several hundred feet long. The float consists of hard psilomelane ranging from tiny particles to nodules an inch or more in diameter. At the northeast end of the outcrop the ore appears to split into narrow seams and veinlets that lose their identity among large blocks of manganese-stained quartzite. Some pyrolusite and wad accompany the psilomelane. Silica and iron oxides are the dominant gangue minerals.

The ore was mined from shaft workings and a few shallow opencuts scattered along the outcrop in the areas of the larger deposits. Apparently, the bulk of the output came from an open stope adjacent to an inaccessible inclined shaft estimated to be 30 to 40 feet deep. The stope, extending from the surface to the bottom of the shaft, was about 65 feet long and ranged from 2 to 4 feet in width. At each end of the stope near the surface the higher grade ore ranged from 6 to 12 inches in width. An unknown amount of drifting had been done northwest from the bottom of the stope. Additional exploratory work consisted of some bulldozer trenching along the outcrop northwest of the shaft.

A grab sample, taken from a pile of several tons of rejected material from which the better ore evidently had been sorted, contained 9.5 percent manganese and 3.0 percent iron. It appeared that this material had been mined from the shaft workings.

Rattlesnake Claims

The Rattlesnake or Wonder group of four unpatented claims is about 42 road miles northwest of Globe and 2 miles northeast of the previously described Sunset or Armer deposit. The group lies in sec. 15, T. 5 N., R. 13 E. (fig. 8, p. 43.) and can be reached by some 3 miles of access road that branches right from the Armer Ranch Road 0.7 mile north of its junction with the Tonto Basin Road.

Little is known about the early history of the claims. Reports indicate that they may have been located first during World War II and subsequently abandoned. In 1951, they were held by J. C. Rapier and associates, of Globe, who leased them to Charles O. Reidhead. Some exploratory work and road building were completed by Louis Winn in 1954. When the property was visited in April 1957, location notices showed the claims had been relocated as the Wonder group in November 1956 by Mel Coeur, of Denver, Colo. Although a few tons of sorted ore had been mined and still remained on the property, there were no records of shipments.

Manganese minerals occur on the claims along narrow, widely separated fractures in an extensive zone of sheared and brecciated Precambrian quartzite. The zone trends northwesterly, ranges from 50 to more than 250 feet in width, and is about 3,000 feet long. Most of the outcrop is coated with a thin film

of black manganese stain, giving it a deceptive appearance of a large body of manganese ore. In scattered parts of this brecciated mass, high-grade manganese oxides occur along fractures ranging from mere seams to stringers a few inches in width. The individual mineralized fractures rarely persist for more than a few feet along their strikes and are separated by various widths of barren quartzite. In the single explored area on the claims, the mineralized seams and stringers are only a few inches apart and occupy an intensely sheared area about 4 feet wide. In other exposed areas the mineralized fractures may be separated by one to tens of feet of virtually barren quartzite.

When the claims were visited in April 1957 the exploratory work consisted of an inaccessible vertical shaft about 40 feet deep. This shaft had been sunk on the most promising mineralized exposure. It was said that about 5 tons of ore had been hand sorted from the material broken in the shaft.

Psilomelane and pyrolusite are the chief manganese minerals. The gangue consists of brecciated fragments of quartzite and minor amounts of iron oxide.

Rye Creek

The Rye Creek claims, held in 1943 by the late W. J. Trahey, are in the northwestern part of Gila County some 9 miles south of Payson in sec. 17, T. 9 N., R. 10 E. (See fig. 8, p. 43.) They can be reached from Payson by traveling south on the main highway 7 miles to a faint side road that branches left about 0.75 mile north of the Rye Creek store. This branch is followed 2 miles northward up Sycamore Wash to the deposit.

The claims were located in 1943 by W. J. Trahey and evidently were abandoned a few years later after his death. The present owner is not known.

Small quantities of manganese minerals were found in the area along numerous widely separated seams and narrow fractures filled with crystalline calcite. The fractures traverse semiconsolidated gravels and angular detrital material occupying the steep-sided bluffs along the sides of Sycamore Wash. The fractures dip steeply, some to the northwest and others to the northeast. In general, they strike N. 15° E., almost at right angles to the trend of the wash, and range in width from a fraction of an inch to several inches, swelling in places to form short podlike bunches as much as 1.5 feet wide. Some wider and more persistent veinlets are exposed for 100 feet or more along the strike. They occur in widely separated areas in a belt extending along the wash for several hundred feet. In this belt the individual veinlets are at least several feet apart and in places are separated by several tens of feet of the enclosing detrital material. In addition to the white crystalline calcite, some veinlets contain manganiferous calcite and occasional small bunches of pyrolusite.

No ore had been produced from the claims when they were visited, and none of the exposed occurrences were of minable width or grade.

Graham County

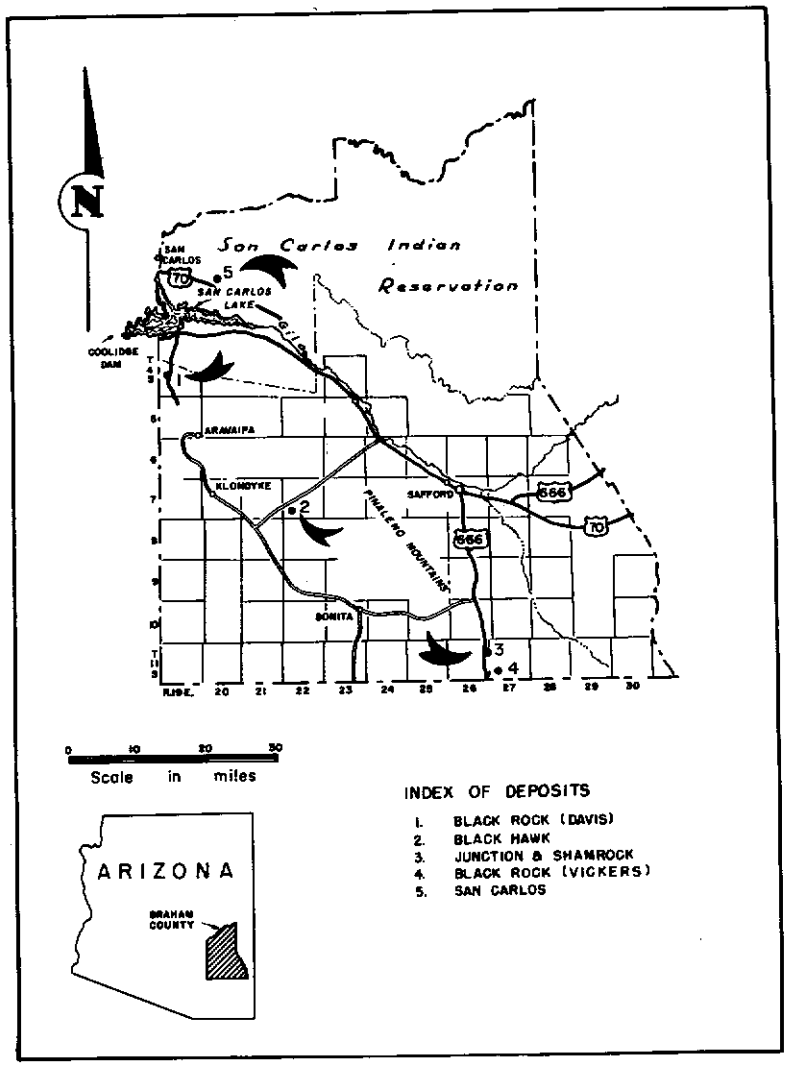

FIGURE 12. - Manganese Deposits, Graham County, Ariz.

To 1957, only five manganiferous deposits had been found in Graham County. They are in widely separated areas in the western and south-central parts of the county (fig. 12).

The first manganese claims were located in World War I, and a small amount of hand-sorted ore (probably less than 100 tons) was shipped at that time. No further interest in manganese was shown until 1953, after the opening of the Government manganese-purchasing depot in Deming, N. Mex. From 1953 through 1955, the total ore production of the county, which came entirely from the Black Hawk deposit, was 16.5 long tons of sorted ore and 220.5 long tons of jig concentrates. The sorted ore contained 47.4 percent manganese and the concentrates averaged 43.7 percent.

The deposits occur in both igneous and sedimentary rocks. Of the two deposits in the northwestern part of the county, one was formed by replacing gently dipping beds of Paleozoic limestone and the other was deposited in Tertiary volcanic rocks. The three deposits to the southeast occur along steeply dipping zones of fracturing or brecciation in Precambrian granitic rocks.

The chief ore minerals are psilomelane and pyrolusite. The gangue is composed largely of white calcite, black manganiferous calcite, and quartz. Manganiferous siderite appeared to be abundant in the limestone-replacement deposit southeast of Coolidge Dam.

A description of the individual deposits in the county follows.

Black Rock (Davis)

The Black Rock group of six unpatented claims is some 13 road miles southeast of Coolidge Dam in sec. 18, T. 4 S., R. 19 E. and about 2 miles south of the southern boundary of the San Carlos Indian Reservation (fig. 12). The claims can be reached by traveling 6.8 miles east from Coolidge Dam toward U.S. Highway 70 to a dirt road branching southward, marked Hawk Canyon, and proceeding south on this road, keeping right at all road forks, 6.3 miles. From there the workings are visible along the limestone bluffs 300 feet or more west of the road.

The claims were located in 1939 by the present owner, L. K. Davis, of Coolidge Dam, Ariz. Other than bulk samples taken for metallurgical testing, no ore has been shipped from the property. It was idle when the area was visited early in October 1956.

Iron and manganese oxides occur on the claims in irregular replacement-type bodies in beds of Paleozoic limestone which strike about N. 10° W. and dip 20° to 25° W. The deposit ranges from 4 to 8 feet in thickness and is exposed in places for approximately 250 feet along the strike. The north end of the outcrop has been explored about 60 feet along the strike with an opencut. In many places the cut is not deep enough to expose the full thickness of the deposit. A short distance south of the opencut a shaft, inclined at 20°, follows the mineralized bed down dip for more than 140 feet. In this opening the deposit ranges from 4 to 6 feet in thickness and persists down the incline for at least 130 feet, below which the shaft is partly filled and inaccessible. The top of the deposit is marked by a well-defined bedding plane, whereas the bottom is undulating. This undulation accounts for the variation in the thickness of the ore bed. In places the mineralized bed contains sizable masses of unreplaced limestone and low-grade, coarsely crystalline calcite.

South of the incline, the mineralized bed is exposed more or less continuously along the strike for about 150 feet. The last exposure is marked by a shallow opencut.

Manganiferous float continues about 150 feet north of the northernmost opencut. Some stripping has been done in this area without apparent success.

In 1941, a composite sample, aggregating about 2 tons, was taken from the deposit for metallurgical testing by an engineer of the Federal Bureau of Mines. The sample, containing 9.2 percent manganese, 22.3 percent iron, and 18 percent calcium oxide, was treated by table concentration, flotation, and magnetic separation in the Salt Lake City laboratories of the Bureau of Mines.[36/] The results of this work showed that the manganese and iron oxides

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36/ Potter, G. M., Ipsen, A. O., and Wells, R. R., Concentration of Manganese Ores From Gila, Greenlee, and Graham Counties, Ariz.: Bureau of Mines Rept. of Investigations 3842, 1946, 12 pp.

were so intimately interlocked that the manganese minerals could not be liberated even by very fine grinding. However, most of the calcite in the ore was rejected by flotation. The resulting enriched iron-manganese product assayed, when sintered, 17.4 percent manganese, 39.5 percent iron, and 7.9 percent silica plus alumina. It was concluded that this product might be of value as a spiegeleisen ore.

According to the owner, L. K. Davis, several samples taken in the inclined shaft contained 12 to 16 percent manganese and about 34 percent iron.

Black Hawk Group

The Black Hawk group of five unpatented claims is about 36 road miles west of Safford, Ariz., in sec. 30, T. 7 S., R. 22 E. (fig. 12). The group lies in the low, rolling foothills bordering the northwest flank of the Pinaleno (Graham) Mountains.

The property can be reached from Safford by traveling 14.3 miles northwest on U.S. Highway 70 to the Aravaipa Road, then west-southwest on this graded road 17.7 miles to a left-hand branch marked Cedar Camp, and then south on this branch (keeping to the left at all road forks) 4 miles to the workings.

The claims were located first in 1951 by J. G. East, of Pima, Ariz. The following year they were leased to Rodham and Rutledge and later to Saber Mining Co. The claims are presently owned by W. M. Carter and associates, of Pima, Ariz. In 1952 Rodham and Rutledge built a sizable jig plant for treating the Black Hawk ore on U.S. Highway 70 near its junction with the Aravaipa road. The plant operated intermittently until the middle of 1955. When the area was visited in September 1956, the plant was largely dismantled, all mining equipment had been removed, and the property was idle.

The entire production from the claims was shipped to the Government purchasing depot in Deming, N. Mex., and totaled 16.5 long tons of hand-sorted ore and 220.5 long tons of jig concentrates. The sorted ore, containing 47.4 percent manganese, was mined by J. G. East. The concentrates, averaging about 43 percent manganese, were shipped by Rodham and Rutledge and Saber Mining Co.

Manganese minerals occur on the property in narrow veins and along a broad fracture zone cutting Precambrian granitic rocks. The veins are largely filled with quartz, seldom exceed a foot in width, and occasionally contain small sporadic bunches of manganese oxide. Little, if any, ore had been recovered from these occurrences. Virtually all ore produced from the property has been mined from a nearly vertical shear or fault zone that strikes N. 70° E. The zone is exposed in places for a few hundred feet along the strike and locally was mineralized over widths as much as 60 feet. The best ore is found in an irregular band several feet in width that lies adjacent to a well-defined striated slip which forms the southern wall of the zone. The rest of the fractured zone contains numerous, but widely spaced, irregular stringers and occasional small bunches of manganese minerals oriented in many directions.

The workings, situated near the southwest end of the zone, consisted of an open pit about 100 feet long, 60 feet wide, and as much as 60 feet deep. The westerly end of the pit sloped downward at an angle of about 45°, whereas the other three sides of the opening were nearly vertical. The broken ore was hoisted from the bottom of the pit on an inclined track laid on the slope at the west end of the excavation.

The manganese minerals comprise hard psilomelane and a little pyrolusite. The more abundant gangue minerals are quartz and calcite.

Junction and Shamrock Claims

These claims are adjoining and are situated on State land in sec. 13, T. 11 S., R. 26 E., 28 miles by road south of Safford, Ariz. (See fig. 12, p. 89.) The claims are about 1 mile east of U.S. Highway 666 in the gently rolling desert area bordering the west side of the San Simon Valley. They can be reached from Safford by traveling south on U.S. Highway 666 for 26 miles to a dirt road branching left. This branch is followed eastward 0.3 mile to the old county road, then left or northward on the county road several hundred feet to an easterly trending right-hand branch, which passes through the Junction claims and terminates at the workings on the Shamrock claim.

The Junction group, comprising three contiguous claims, was located in 1953 by George and John Taylor, of Safford, Ariz. The single Shamrock claim was located in 1951 by John Pospohola and associates, of Safford, Ariz. A location notice was found showing the claim was relocated as the Graham in 1954 by Boone Wangtetal. At present the ground is held by John Pospohola under a mineral lease from the State of Arizona.

So far as is known, no ore has been shipped from either property. Both were idle when the district was visited early in October 1956.

Manganese minerals, consisting largely of psilomelane, occur in the area as thin seams and veinlets along fractures and joints in Precambrian granitic rocks. The mineralized fractures trend northwestward and range in dip from steeply southwest to vertical. Small fragments of hard psilomelane float are widespread over several areas on the claims. Three or more such areas on the Junction group had been explored by shallow bulldozer stripping. In places this work exposed thin, widely separated seams and films of manganese minerals along joints and narrow fractures in the underlying granite. Some of these sparsely mineralized areas were as much as 30 feet wide and several tens of feet in exposed length. Other than stripping, no exploration had been attempted on the Junction claims.

On the Shamrock claim, which adjoins the northeast side of the Junction group, two mineralized fracture zones had been explored by shafts and opencuts. The better mineralized part of the west fracture averaged about 2 feet in width and was exposed for 30 feet or more along the strike. It had been explored by a 20-foot vertical shaft.

The mineral deposit in the other fracture zone, about 150 feet to the northeast, ranged from 6 to 10 feet in width and had a traceable length of some 70 feet before becoming obscured by overburden. This occurrence was explored by an opencut about 50 feet long and as much as 10 feet deep. The manganese minerals in the opening occurred in a network of seams and stringers, which in places where abundant, occasionally coalesced to form small irregular bunches of ore. A vertical shaft (inaccessible when visited) about 30 feet deep had been sunk in the hanging wall of the mineralized zone immediately west of the opencut. Approximately 50 feet northwest of this work, a 15-foot shaft had been sunk on an aplitic dike showing little if any manganese.

Farther northeast and across Sycamore Wash, pits and opencuts exposed narrow fractures that showed some manganese stain and oxidized copper minerals.

Black Rock (Vickers)

The Black Rock group, formerly known as the Vickers property, consists of two unpatented claims on State land in sec. 30, T. 11 S., R. 27 E., about 30 road miles south of Safford, Ariz. (See fig. 12, p. 89.) The group lies in a relatively flat desert area bordering the west side of San Simon Valley and a few miles southeast of the lower foothills flanking the southeastern end of the Pinaleno (Graham) Mountains. The property is reached from Safford by following U.S. Highway 666 south about 26 miles to a dirt road branching left. This branch is followed east 2.5 miles to a right-hand fork which ends on the property.

The claims in the area were located first in World War I, and a small amount of sorted ore is said to have been shipped at that time. In 1938, the group was relocated and held several years by E. F. Vickers, of Douglas, Ariz. When the area was visited in September 1956, notices indicated that the claims were located in 1952 as the Black Rock group by E. Sanchez and associates, of Safford, Ariz. The property was idle, and so far as is known no ore has been shipped during the past decade.

The manganese minerals occur along zones of shearing and brecciation in Precambrian granitic rocks. Two occurrences are exposed on the claims. The northern and principal zone, lying at the base of a dark-colored hill, strikes N. 20° W. and dips about 75° E.; the other zone, some 1,000 feet to the south, strikes N. 50° W. and dips very steeply southwest. The mineralized zone to the south, as exposed in a shallow pit, is as much as 2 feet wide and is exposed along the strike for a few tens of feet before it is obscured by overburden.

The manganese deposit in the north zone ranges from 2 to 8 feet in width and is exposed in places along the strike for approximately 300 feet. In this distance, three disconnected lenticular ore shoots were explored by three shafts. The deepest shaft, inaccessible when visited, was estimated to be 40 to 50 feet deep; the others to the north were 12 and 8 feet deep.

In 1940 an engineer of the Federal Bureau of Mines cut a sample across a width of 5 feet near the bottom of the deeper shaft. This sample contained 15.4 percent manganese.

The chief manganese minerals consist of psilomelane and pyrolusite, which occur as narrow, parallel stringers and in a network of seams surrounding the brecciated fragments of the country rock. Calcite and iron oxides are the principal gangue minerals.

San Carlos Indian Reservation

Manganese has been found on the San Carlos Indian Reservation near the northwestern corner of the county. Two deposits are known in an area 9 miles or more east-southeast of San Carlos, Ariz., in approximate secs. 32 and 33, T. 1 S., R. 20 E., unsurveyed. (See fig. 12, p. 89.) The eastern deposit lies in Salt Creek and the other along one of its tributary washes about 1 mile to the west. The latter is accessible by 2.6 miles of truck trail that branches northward from U.S. Highway 70 about 8.7 miles east of its junction with State Highway 170 to San Carlos. The other deposit is reached by 3.7 miles of truck trail that branches northward from U.S. Highway 70 about 9.3 miles east of the junction of State Highway 170.

Although probably known earlier, the deposits were not explored until about 1956, when a prospecting permit was issued by the tribal council of the reservation to Sever Mining Co., Safford, Ariz. After completing some exploratory work, this company found that the ore contained too much copper to be marketable, and the permit was allowed to lapse. In May 1958, a permit to prospect the deposits was obtained by J. L. Neal, Charles Robert Neal, and Charles Ross Neal, of Globe, Ariz. When the area was visited late in May 1958, a trial shipment of some 20 tons of hand-sorted and cobbed ore had been mined from the west deposit and work was under way to make a similar shipment from the east deposit. It was planned to ship this ore to the Mohave Mining & Milling Co., Wickenburg, Ariz., for upgrading and blending with copper-free manganese ore or concentrates so that the resulting product could be marketed under the Government "carlot" program. Manganese ore or concentrate containing more than 0.25 percent copper is not acceptable under the program.

The manganese minerals in both localities occur in seams, stringers, and small irregular bunches distributed sporadically along fracture and brecciated zones in volcanic rocks.

The ore minerals are chiefly psilomelane, pyrolusite, and wad. Calcite and iron oxide are the principal gangue minerals. The larger mineralized bunches, seldom exceeding 1 foot in greatest dimension, are composed largely of small nodules and stringers of ore mixed with calcite and brecciated fragments of the wall rocks.

Samples assaying 30 percent or more manganese, taken from the deposits, have contained 0.3 to 0.5 percent copper.

The manganese minerals in the eastern deposit, situated along the east side of Salt Creek, occupy a well-defined fracture zone striking northward and dipping about 65° E. The mineralized part of the outcrop is from a few feet to 12 feet wide and is exposed in places for some 300 feet along its strike. Fragments of manganese-bearing float are found for several hundred feet north of the present exposures.

The work consisted of a few opencuts excavated at irregular intervals along 300 feet of the outcrop. Two cuts had been driven into the hillside across the zone, exposing it to a maximum depth of 15 feet below the outcrop. In both of these deeper openings the better ore appeared to give place to much leaner material 10 to 12 feet below the surface.

When the property was visited, four Indian men and two Indian women were employed. The men were mining the ore in places along the outcrop, and the women were sorting and cobbing the material for the trial shipment.

In the western deposit manganese minerals are present in widely scattered stringers and small, irregular, podlike bunches distributed sporadically over an area some 600 feet north-south and 150 feet or more east-west. The ore minerals, accompanied by much calcite, occur along minor northward-trending fractures cutting a vesicular andesite flow. The individual fractures, as much as several inches in width, seldom persist more than a few feet along the strike. Some irregular podlike masses of minerals associated with the fractures are said to have yielded as much as 100 pounds of ore.

The workings comprised a dozen or more widely scattered shallow pits and cuts situated on the larger and more promising outcrops. The trial shipment of ore had been mined from these various openings.

Greenlee County

The known deposits of manganese in Greenlee County lie in its central part, where with few exceptions they are found in the foothill regions bordering the valleys of the Gila River and its tributary streams and washes (fig. 13). Of the 13 known occurrences, 10 have produced some ore.

The first manganese-mining activity in the county began in World War I and ended in 1918. Interest was somewhat revived in 1942 during World War II, when a small amount of ore was shipped. Mining was not resumed until 1952 after the establishment of the Government manganese-purchasing depot in Deming, N. Mex.

The total production in the county from 1917 through 1955 has been about 700 long tons of ore, whose manganese content ranged from 19 to 43 percent, and 1,690 long tons of jig concentrates containing more than 40 percent manganese.

The deposits occur in sedimentary and igneous rocks, which range in geologic age from Precambrian to Quaternary. The deposits in the northernmost part of the county are in Paleozoic limestones. Some farther south, near Morenci and Clifton, are in diorite and Precambrian granite. One is in fractures cutting beds of the Gila conglomerate. The deposits in the south-central part of the county are along zones of fracturing and brecciation in volcanic rocks of Tertiary age.

A description of the individual deposits in the county follows.

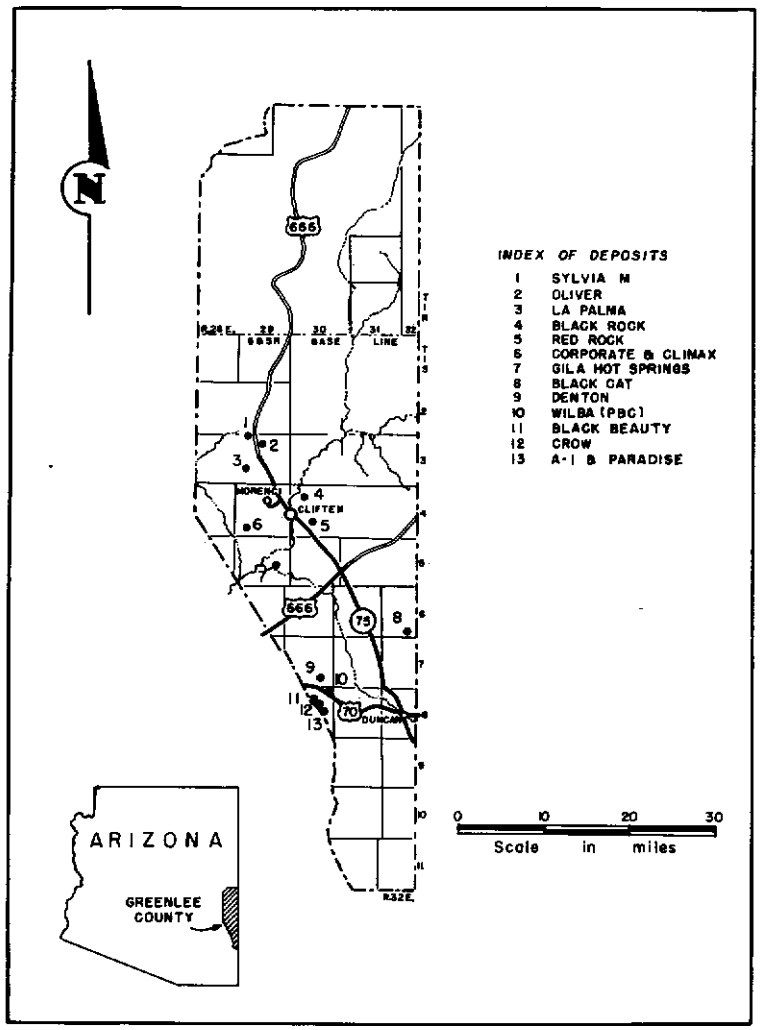

FIGURE 13. - Manganese Deposits, Greenlee County, Ariz.

Oliver Claims

The Oliver group of two unpatented lode claims in in SW1/4 sec. 4, T. 3 S., R. 29 E., some 16 miles by road northwest of Clifton, Ariz. (See fig. 13.) The property can be reached from Clifton by traveling north on U.S. Highway 666 for 14.3 miles to the Granville Recreation Area, northeast on a right-hand branch 1.9 miles to the deposit. Altitudes in the area range from 7,000 to 7,500 feet.

The claims were located in 1955 by the present owner, Ben Billingsley, of Duncan, Ariz. In that year about 160 long tons of sorted ore averaging 18.9 percent manganese was shipped to the Government purchasing depot in Deming, N. Mex. Approximately 155 tons of the ore was produced by Chas. H. Jonas, lessee, and the balance by Ben Billingsley and Roy Wilson. The property was idle when visited in August 1956.

Manganese oxide minerals occur on the claims in a steeply dipping fault or fracture zone cutting beds of gray limestone of Carboniferous age. The zone strikes N. 40° to 50° E. and appears to dip steeply northwest. The limestone beds trend about N. 30° E. and dip 20° NW. They occupy the eastern end of a comparatively narrow belt of Carboniferous rocks that extends westward for several miles. The belt is virtually surrounded by flows of later volcanic rocks. The fracture zone ranges from a few feet to 25 feet in width and is traceable along the strike for 700 feet or more. The manganese minerals within the zone occur in erratically distributed lenses and irregular masses. The best ore was found in the northeastern half of the deposit where the mineralized areas ranged from 2 to 6 feet in width and from a few feet to tens of feet in length.

The deposit had been explored by a short, shallow adit at the northern end of the outcrop and by bulldozer stripping and trenching that extended almost continuously for some 700 feet to the southwest. Some work reached a depth of about 15 feet below the surface.

The manganese minerals consisted of pyrolusite and psilomelane. The gangue was composed of unreplaced limestone, black and white calcite, and a pinkish chert.

Sylvia M Claims

The Sylvia M group of six unpatented claims is in NW1/4 sec. 5, T. 3 S., R. 29 E., about 16 miles by way of U.S. Highway 666 northwest of Clifton, Ariz. The highway crosses the deposit near mileage marker 180, which is 1.5 miles north of Cherry Lodge in the Granville Recreation Area.

The claims were located in 1953 by N. T. Jackson and Marcos Mareno, of Morenci, Ariz. Later that year they were leased to G. S. Buttorff. So far as is known, no ore has been shipped from the property. It was inactive when the area was visited in August 1956.

Manganese minerals occur on the property in a steeply dipping fracture zone cutting gently dipping beds of partly marbleized limestone. The limestone is part of the same belt of Carboniferous rocks found to the southeast on the Oliver claims. The fracture zone strikes N. 55° to 60° E. and is exposed along the east side of a highway cut. In that area, widely spaced stringers and irregular bunches of manganese oxides are exposed for a width of 40 feet or more. Soil covers much of the surrounding area, so the full extent of the deposit is not evident. Manganiferous float is present in places along the strike of the zone for some 70 feet east of the highway and for a somewhat shorter distance to the west. The mineralized stringers range from a fraction of an inch to several inches in width and extend more than a few feet along the strike. The larger manganiferous bunches attain widths of several feet and, in one exposure, are more than 10 feet long.

The exploratory work consisted of a few shallow opencuts. The largest was about 30 feet east of the highway and was a pitlike opening 10 feet deep, 8 feet wide, and 12 feet long.

The chief manganese minerals were pyrolusite and wad occurring in a gangue composed largely of quartz and calcite.

La Palma Group

This group comprises three unpatented claims named La Palma, Venus, and San Francisco. They are about 9 miles northwest of Clifton, Ariz., in approximate secs. 19 and 20, T. 3 S., R. 29 E., unsurveyed. The area is reached over about 3 miles of a steep west-northwesterly trending foot trail that leaves U.S. Highway 666 near the mouth of Cuprite Canyon, about 10 miles north of Clifton.

The group is presently held by Juan Varela and Eugenio C. Rivas of Clifton. Claims were located in the area on lead deposits before 1905. According to Juan Varela the claims were acquired in 1920 by his father, who at that time mined a carload of oxidized lead ore from a shallow shaft on the

San Francisco claim. The ore was transported from the mine to the road on pack animals.

No manganese ore has been shipped from the property.

The deposits are in isolated, rugged terrain along the crest and flanks of a southerly trending ridge at an altitude of 6,500 to 6,700 feet. The manganese minerals, consisting largely of psilomelane, occur in irregular bodies that have replaced beds of Paleozoic limestone. In general, the deposits are conformable to the bedding of the limestone, which strikes N. 40° E. and dips about 20° NW. Four separate occurrences have been found on the Venus claim in an area several hundred feet in diameter. The largest and best exposed one is on the crest of the ridge, where it is explored by an opencut about 50 feet long, 10 feet in average width, and a maximum of 10 feet deep. The mineralized bed in the cut is exposed for about 60 feet along the strike and ranges from 3 to 8 feet in thickness. A short distance west of the opencut the ore-bearing bed has been eroded and the ore is bared about 30 feet along the dip. Along the strike to the east the deposit pinches out. A grab sample taken from a pile of broken ore in the opencut contained 27.4 percent manganese.

In another shallow opencut, 600 feet or more to the northeast and in a lower stratigraphic horizon a manganese deposit about 10 feet long occurs in a cherty limestone bed 1 foot thick.

Other unexplored manganiferous deposits crop out on the dip in areas northwest and southeast of the first-described opencut. Although the occurrences cover a considerable surface area they do not appear to have appreciable thickness.

Gila Hot Springs Claims

The Gila Hot Springs group, formerly known as the Hult Pyrolusite property, comprises four unpatented claims situated about 10 miles by road southwest of Clifton in sec. 26, T. 5 S., R. 29 E. (See fig. 13, p. 96.) The south end of the group is a few hundred feet north of the Gila River and about 1 mile east of Gillard Hot Springs. The property may be reached from Clifton by traveling south on State Highway 75 to a graded dirt road branching right (the old Safford Road), which is followed southwest 2.2 miles to a fork. The right-hand fork toward Gillard Hot Springs is then followed about 4 miles. At that point the principal workings on the property are visible about 1,000 feet south of the road. Access roads cross the group, but they were badly washed in places and impassable when the area was visited early in September 1956.

The claims were located first in 1938 by W. A. Hult, of Morenci. Some exploration work was completed during the next few years, but eventually the claims were abandoned. In 1954 they were relocated by the present owners, H. J. Peters and associates, of Morenci, Ariz. In 1955 a few tons of hand-sorted ore, said to have contained about 40 percent manganese, was produced by lessees. This ore was mixed with ore from other properties in the county and shipped to the Government purchasing depot in Deming, N. Mex.

The manganese ore occurs in lenses and short irregular pods along narrow fractures in Gila conglomerate. Several such fractures were found in the area. They strike a few degrees west of north and cut the gently dipping beds of conglomerate at high angles. The two most extensive deposits on the claims are about 2,000 feet apart. In the northernmost fracture, situated near the telephone line, the mineralized area ranges from a few inches to 2 feet in width and can be traced about 150 feet along the strike. The widest part of the deposit had been explored with a shallow opencut about 30 feet long and an adit driven some 25 feet vertically below the cut. The adit was partly filled and largely inaccessible but appeared to be at least 30 feet long. It was driven southward along the fracture, evidently to reach the wider part of the mineralized lens underlying the opencut.

The other principal deposit to the south was a few hundred feet north of the river. It was exposed in a shallow opencut for about 30 feet along the strike and had a maximum width of 3 feet. Overburden obscured any further extent that the deposit may have had along the strike.

The manganese minerals, consisting mostly of wad and pyrolusite, occur sporadically along the fractures in parallel stringers and podlike masses. The gangue is composed of an abundance of black and white calcite and some barite.

No work was in progress when the claims were visited.

Denton Claims

The Denton property, formerly known as the Thurston and Hardy, comprises six unpatented claims lying mainly in secs. 34 and 35, T. 7 S., R. 30 E., 12.5 road miles northwest of Duncan, Ariz. (See fig. 13, p. 96.) The claims are a few miles north of Ash Peak in the rolling hills bordering the valley of the Gila River. They are accessible by 1.5 miles of dirt road that branches right or northward from U.S. Highway 70 about 11 miles northwest of Duncan.

Claims covering the property were located in World War I by R. V. Thurston and Joseph Hardy. It is reported[37/] that about 1,000 tons of jig concentrates, containing more than 40 percent manganese, was produced during that period. After World War I the claims were allowed to lapse, and they were relocated in World War II by Mitchell Sanders. In the summer of 1942, a carload of ore of unknown grade is said to have been shipped from the property to the Metals Reserve stockpile in Deming, N. Mex. Operations were stopped soon thereafter, and the claims remained idle until late in 1951 when they were acquired by the present owners, Raymond and G. T. Godfrey and associates, of Safford, Ariz. Early in 1952, the owners, doing business as Ace Building & Roofing Supplies, built a small jig plant on the property and commenced producing concentrates. The following year, the company sank a 60-foot inclined shaft and completed about 60 feet of crosscutting in one of the deposits. The

37/ Jones, E. L., Jr., and Ransome, F. L., Deposits of Manganese Ore in Arizona: Geol. Survey Bull. 710, pt. I, 1920, pp. 130-132.

work proved disappointing, as it indicated that the better ore found on the surface did not continue to an appreciable depth. After this work was terminated late in 1954, Ash Peak Mining Co. obtained an option and erected a 1,000-ton heavy-media separation plant on the property to treat the ore occurring on and near the surface that could be mined cheaply by open-pit methods. This company continued operations until late in 1955. When the area was visited in August 1956, all equipment had been removed and the property was idle.

Production in 1952-55 totaled 677 long tons of concentrates averaging 39.3 percent manganese. All concentrates were trucked to the Government purchasing depot in Deming, N. Mex.; about 60 percent was shipped in the name of Grant Godfrey or Ace Building & Roofing Supplies, and the balance was credited to Ash Peak Mining Co.

The principal deposits on the property occur along two roughly parallel zones of shearing cutting a vesicular basalt. The zones are about 1,200 feet apart and range in strike from N. 55° W. to N. 80° W. The north zone dips steeply south, whereas the zone to the southwest dips about 70° N. The manganese minerals are scattered within the fracture zones, where they occur as thin seams, veinlets up to 1 inch thick, and (occasionally) short lenses as much as 2 feet wide. The intervening rock is relatively soft and highly altered basalt of different thicknesses.

In the northern deposit, which was explored to a depth of 60 feet, the mineralized zone was about 300 feet long and 20 to 60 feet wide. When the property was visited, the more highly mineralized parts of the zone had been mined continuously along the strike in an irregular opencut about 250 feet long and up to 20 feet wide. The opencut was 10 feet deep at its western end and as much as 35 feet deep at its eastern end. The opencut was about the last work done, and all former workings (including the 60-foot inclined shaft) were obliterated.

The south fracture zone is 4 to 12 feet wide and in places contains manganese minerals for more than 2,000 feet along the strike. All ore produced before 1952 was mined from this zone. The old workings were opened in 1917-18 and are now inaccessible; they have been described[38/] as comprising two shafts 30 to 84 feet deep, as well as drifts and opencuts that explored the east end of the zone and proved it to be ore bearing for 200 feet. In that area the zone was 10 feet wide, and the ore was found in discontinuous or lenslike veinlets as much as 2 feet wide. At the west end of the zone, the work consisted of a shaft 60 feet deep and opencuts and drifts aggregating 200 feet. There, the best ore was said to be in a fairly distinct vein about 14 inches wide.

Since 1953, some ore has been mined in opencuts from both ends of the south zone. The largest cut, at the western end of the zone, was about 400 feet long, 12 feet wide, and as much as 10 feet deep. The other cut, some 300 feet farther southeast, was about 200 feet long, 8 to 10 feet wide, and as much as 8 feet deep.

38/ Work cited in footnote 37, p. 131.

Several hundred feet southwest of the western end of the south zone, an area covered by considerable manganiferous float was trenched. Apparently, no ore had been mined from that area.

The chief manganese mineral on the property is hard psilomelane which is readily separated from the soft enclosing gangue. Manganiferous calcite is abundant in places, especially at depth where the better ore gives place to this lower grade mineral.

Black Rock Group (Black Magic)

The Black Rock group, comprising four contiguous, unpatented claims, lies mainly in NE1/4 sec. 19, T. 4 S., R. 30 E. (See fig. 13, p. 96.) It is accessible from the business district of Clifton by way of a 2.2-mile road, of which the last half a mile is in the stream bed of Limestone Gulch due north of Clifton. The claims were located early in 1951 by the present owners, Matt and Ed Danenhauer and E. W. Foote, who, under the name of Danenhauer Business Service, trucked to the Deming purchasing depot 29 long tons of ore averaging 31.4 percent manganese. Under a lease agreement, G. S. Buttorff shipped 170 long tons of 37-percent manganese ore from the claims.

The manganese minerals occur in a relatively thick bed of chert within the Longfellow limestone. The upper contact of the chert and limestone is very irregular, and most exposures are on the hillside 20 to 40 feet above the bed of the gulch.

About one-third mile up Limestone Gulch from its junction with the San Francisco River, manganese-bearing chert is exposed at the mouth of a small southward-trending canyon. On the west bank of this tributary wash, a bench 50 feet long by 10 feet high had been cut in the chert bed, and on the opposite side a pit and cut had been excavated in the erratically mineralized chert bed which is nearly 50 feet thick at this place. Danenhauer states that in 1952, under a lease agreement, U.S. Manganese Corp. produced about 400 tons of mine-run ore, which later was concentrated by jigging, from these outcrops.

The next exposure is 0.1 mile farther up the main gulch where the mineralized chert bed is exposed about 150 feet along the north bank in a cut 50 feet wide by 40 feet high. In the bank, a shallow shaft connects with the tops of drifts, but floods have filled the workings with debris. Several cuts have been excavated in the best mineralized areas east of the shaft. It is reported that 40 to 50 tons of sorted ore was produced from these areas.

About 500 feet farther upstream the chert bed crops out on the south side of the gulch, where 10 to 12 tons of sorted ore was produced from four shallow cuts. One is in limestone that was replaced by low-grade manganese ore.

On the north side of the gulch in a bend a few hundred feet farther upstream, a cut 40 feet long by 15 feet wide was excavated along a vertical contact between chert and limestone. The major mineralization was in the chert, but there was some replacement of the limestone wall. A slusher hoist and scraper were used for loading into trucks, and it is reported that 120 tons of ore was produced from this cut.

About 200 feet to the east and on the same side of the gulch, a cut 15 feet long by 6 feet wide was made in a 10-foot band of mineralized chert dipping steeply to the south. Fifteen feet below the cut, at stream level, a northerly bearing 40-foot adit cuts across the chert band, which at this level was only slightly mineralized. Two shafts, 20 and 35 feet deep, were sunk in the bank nearby but were inaccessible when the property was visited in July 1956.

In all the mentioned exposures, the mineralization of the chert bed was erratic and proportional to the intensity of fracturing. Where the fracturing was moderate the manganese minerals were deposited in the fractures and replaced part of the walls, whereas in brecciated areas the manganese minerals replaced the crushed chert particles and formed high-grade pockets. Pyrolusite is the predominating mineral, associated with considerable soft, wad-type manganese. Only small amounts of psilomelane were observed. Except for the two places mentioned, no manganese was found in the limestone.

When visited in July 1956, the property was idle and all equipment had been removed.

Red Rock Claims

The Red Rock group of three contiguous unpatented claims is in W1/2 sec. 32, T. 4 S., R. 30 E. It is accessible from the south end of Clifton by taking the old Duncan Road eastward up Ward Canyon 1.2 miles from its junction with U.S. Highway 666. The outcrop is visible in the cliffs on the north side of Ward Canyon.

The claims were located in 1953 by the present owners, Matt and Ed Danenhauer and E. W. Foote, of Clifton. No ore has been produced from the property; only assessment work has been performed.

Manganese minerals occur in granite along a fault zone, the end of which is exposed in the cliff along Ward Canyon, and along the west side of an unnamed south-trending tributary canyon. The zone strikes N. 50° to 60° E. and dips 60° SE. It is as much as 20 feet wide and is composed of a series of more or less parallel fractures, crosscutting seams, and brecciated areas.

Pyrolusite and some psilomelane, associated with the usual soft wad-type oxides, are present in the seams and fracture planes. Generally they are thin, but pods and irregular concentrations occur at fracture intersections. Local enrichments are found in brecciated areas.

Cursory examination of about 200 feet of the south end of the deposit suggests that concentration by jigging or sink-float methods might produce an appreciable tonnage of marketable manganese. The owner stated that similar deposition occurred along the fault for 1,000 feet or more to the northeast.

Corporate Group and Climax Claim

These two properties are discussed as a unit because they are on the same vein. The Corporate group consists of five contiguous claims, and the side line of the single Climax claim abuts the east endlines of the two easternmost Corporate claims.

The Corporate group was located in 1932 by members of the Hernandez family and now is in possession of Diego Hernandez. The Climax claim was located about 1951 by Victoriano Dominguez and Diego Hernandez.

The claims are situated in SW1/4 sec. 29, T. 4 S., R. 29 E. (See fig. 13, p. 96), and are accessible from Morenci by traveling west on the Eagle Creek road 2.3 miles, then south on a dirt road for 1/2 mile.

A prominent vertical quartz vein, 8 to 10 feet wide, crops out on the south slope of a ridge. It strikes N. 30° E. and can be traced at least 1,000 feet. Manganese minerals are present throughout the vein for 400 to 500 feet along the surface; beyond, in either direction, the quartz is relatively barren. The rock on each side of the vein is diorite.

On the west side line of the Climax claim a 20-foot cut in the vein, 8 feet wide, exposes a 15-foot face. Victoriano Dominguez and Domingo Espinoza produced and sent to the Deming purchasing depot 39 long tons of sorted ore averaging 22.6 percent manganese.

From a shaftlike pit, 80 feet to the southwest on the Corporate No. 3 claim, Diego Hernandez produced 66 long tons of similar-grade ore, which likewise was trucked to Deming. This pit was 20 feet long, 8 feet wide, and 15 feet deep.

The Corporate claims were located for gold, and the many old cuts are unrelated to manganese production. However, one 70-foot adit, approximately 100 feet southwest of the last-mentioned pit, is interesting because it cut the quartz vein and explored it for a length of 40 feet. The scant manganese deposition was confined to irregular vertical bands within the vein material.

The principal manganese mineral of the deposit is pyrolusite, associated with soft wad-like oxides. The gangue material is mainly quartz with smaller amounts of secondary calcite.

The properties were idle when visited in July 1956.

Black Cat

The Black Cat group, comprising two contiguous unpatented claims, is in sec. 33, T. 6 S., R. 32 E., some 18 miles by road north of Duncan, Ariz. (See fig. 13, p. 96.) The claims are less than 2 miles west of the Arizona-New Mexico border. They can be reached from Duncan by traveling north on State Highway 75 for 10 miles to a dirt road branching right, then eastward on this branch 4.4 miles to a left fork which ends on the property.

The claims were located in 1952 by the present owners, L. A. Billingsley and Lewis Dean, of Duncan, Ariz. In 1953-55, about 77 long tons of sorted ore averaging 43.2 percent manganese was shipped by the owners to the Government purchasing depot in Deming, N. Mex.

The ore occurs in lenses along two narrow parallel veins in volcanic rocks. The veins are roughly 800 feet apart, strike northward, and dip steeply to the east. The ore lenses range from a few inches to 2.5 feet in width and from a few feet to several tens of feet in length. They are separated along both the strike and dip by barren intervals or by stringers of ore too narrow to mine.

The west vein, which has produced most of the ore, was mined more or less continuously 150 feet along the strike and to a maximum depth of approximately 50 feet. The ore on and near the surface was mined in opencuts and that at greater depth was mined in open stopes from a 50-foot inclined shaft. The shaft was inaccessible when the property was visited.

A little ore was produced in the east vein from a 30-foot shaft and a short drift. The manganese mineral consisted of hard, massive psilomelane in a gangue composed chiefly of calcite, fluorite, and a small amount of quartz.

The equipment had been removed and the property was idle when the area was visited in August 1956.

Wilba Claims

The Wilba group, also known as the PBC, comprises two unpatented claims situated about 9 miles by road northwest of Duncan, Ariz., in sec. 12, T. 8 S., R. 30 E. The deposit lies near the top of a low ridge about 2 miles directly east of the summit of Ash Peak. It is accessible from U.S. Highway 70 by half a mile of dirt road that branches eastward 8.5 miles northwest of Duncan.

The first claims in the area are said to have been located in the 1890's as silver-gold prospects. Some shallow exploration was done at that time, but eventually the area was abandoned. In 1953 two claims were located as the Black King group by L. A. Billingsley and Louis Dean, of Duncan, Ariz. Somewhat later these claims were relocated by A. H. Bassett and associates, of Santa Rita, N. Mex., and called the Wilba or PBC group. In 1954, a shaft was sunk on the deposit, and 5.5 long tons of hand-sorted ore containing 19.3 percent manganese was shipped by Bassett to the Government purchasing depot in Deming, N. Mex. When the area was visited early in October 1956, all equipment had been removed and the property was idle.

The manganese minerals, comprising chiefly manganiferous calcite, occur in places along a prominent quartz-filled fracture zone traversing volcanic rocks. The zone is traceable by frequent outcrops for more than 2,000 feet along the strike. It ranges from 10 to 30 feet in width, strikes eastward, and dips almost vertically. Near its eastern end the zone contains disconnected lenses and irregular strands of manganese ore in places for about 300

feet along the strike. The deposits are a few inches to several feet wide. The largest exposure consists of a podlike body, which has a maximum width on the surface of about 8 feet and a length of some 20 feet before thinning to 1 foot wide or less at each end. Most of the exploration on the claims was done on this exposure. The work consisted of an untimbered vertical shaft, inaccessible when visited but estimated to be about 30 feet deep. The ore shipped to the Deming depot evidently was hand sorted from the broken material that came from the shaft.

The ore consists almost entirely of manganiferous calcite with occasional seams and small bunches of psilomelane and pyrolusite.

Crow Claims

The Crow group of four contiguous unpatented claims is in sec. 14, T. 8 S., R. 30 E., 11.5 miles by road west of Duncan, Ariz. (See fig. 13, p. 96.) The group is close to the western boundary of Greenlee County and less than 1 mile southeast of the summit of Ash Peak, a prominent landmark. The claims can be reached from Duncan by traveling north on U.S. Highway 70 for 7 miles, thence westward on a graded dirt road 2.7 miles to a road fork. The right-hand fork is followed north 1.5 miles to the claims.

The claims were located in 1951 by the present owners, C. M. Magill and associates, of Duncan, Ariz. In 1954-55, about 70 long tons of sorted ore and 5.5 long tons of jig concentrates were shipped from the property to the Government purchasing depot in Deming, N. Mex. About 63 tons of the ore, averaging 22.4 percent manganese, was produced by the owners; the balance, containing 26.3 percent manganese, was shipped by John T. Morris, lessee. The concentrates, containing 39.6 percent manganese, were recovered from 35 tons of ore concentrated in Ben Billingsley's jig plant, situated in New Mexico about 20 miles east of Duncan.

The manganese deposits occur in two fractures cutting a fine-grained volcanic rock. The northernmost fracture ranges from 2 to 3 feet in width and has a traceable length of 300 feet or more. It strikes almost due north and dips steeply to the west. The other fracture, which is about 1,000 feet to the south, is up to 3 feet wide, strikes N. 50° W., and dips 60° NE. It has an exposed length of some 50 feet. The ore occurs along the fractures in lenticular bodies composed of a network of narrow seams and small irregular bunches of manganese oxides deposited around fragments of the country rock.

The ore was mined in shallow opencuts. The work on the north vein, from which most of the ore was produced, comprised three opencuts spaced at irregular intervals for 250 feet along the outcrop. The openings ranged from 30 to 60 feet in length and 2 to 4 feet in width. They reached a maximum depth of about 10 feet. The shipped ore was handsorted from the material broken in the cuts. The ore produced from the south deposit was sorted from the material broken in an opencut about 40 feet long, 2 to 3 feet wide, and 12 feet deep.

Hard psilomelane is the dominant ore mineral. The gangue consists chiefly of unmineralized fragments of volcanic rock and calcite.

The property was inactive when visited in August 1956.

Black Beauty

The Black Beauty group of two unpatented claims is in sec. 11, T. 8 S., R. 30 E., 12 road miles west of Duncan. (See fig. 13, p. 96.) The deposit lies near the top of a rather steep-sided ridge about half a mile north of the northern workings on the previously described Crow claims and an equal distance southeast of Ash Peak. The workings are accessible by a truck trail that continues northward from the northern deposit on the Crow property.

The claims were located late in 1952 by the present owners, John Pospohola and A. A. Dankworth, of Safford, Ariz. In 1954 the property was operated by Six Plus Mining Co., of Safford, and 32 long tons of sorted ore, averaging 21.2 percent manganese, was shipped to the Government purchasing depot in Deming, N. Mex.

The deposit occurs in a vertical, northerly trending fracture zone cutting volcanic rocks. The more highly mineralized part of the fracture ranges from 1 to 3 feet in width and is exposed about 80 feet along the strike.

The manganese minerals, consisting essentially of hard psilomelane, occur in parallel seams and veinlets in a gangue composed of brecciated fragments of the wall rock, calcite, and quartz.

The produced ore was sorted from the material broken in an opencut 75 feet long, 3 to 5 feet wide, and in places as much as 12 feet deep.

A-1 Claims

The A-1 group comprises two unpatented claims 11 road miles west of Duncan in secs. 23 and 24, T. 8 S., R. 30 E., and about 1 mile southeast of the previously described Crow group. (See fig. 13, p. 96.) The claims can be reached from Duncan by traveling northward on U.S. Highway 70 about 7 miles to a graded dirt road branching left and proceeding westward on this branch 2.7 miles, thence northward on a right-hand fork 1 mile to another right-hand branch which ends on the property.

The claims were located in December 1952 by John Pospohola and A. A. Dankworth, of Duncan, Ariz. In 1954, the property was leased by Chris G. Muller, who shipped 6.4 long tons of jig concentrates containing 41 percent manganese to the Government purchasing depot in Deming, N. Mex. The property was idle when visited in August 1956.

The manganese minerals occur in volcanic rocks along a fracture zone striking northwest and dipping steeply southwest. The better mineralized part of the zone ranges from 6 to 8 feet wide and is traceable for about 50 feet along the strike. Other small and disconnected spots of low-grade ore are present in places on the surface for 200 feet or more to the northwest along the projected trend of the fracturing. The manganese minerals occur in narrow interlacing seams and small irregular bunches surrounding unmineralized fragments of the wall rocks.

The zone had been explored by bulldozer stripping and a small shaft about 12 feet deep. The shaft was sunk in the most promising part of the outcrop and evidently was the source of the concentrates shipped to the Deming depot.

The ore minerals consist of psilomelane and pyrolusite. Wall-rock inclusions and calcite are the chief gangue constituents.

Paradise and SPW Claims

These two unpatented claims adjoin the southern and western sides of the A-1 group. They were located in 1952 by John Pospohola and associates, of Safford, Ariz. Very little exploration has been done, and no ore has been produced from either claim.

Like other deposits in the vicinity, the manganese minerals occur along steep northerly trending zones of shearing and brecciation in volcanic rocks. The principal exposure is found on the SPW claim about 2,000 feet southwest of the A-1 workings. In that area, manganese oxides, consisting largely of psilomelane, occur in a network of seams and narrow stringers in a fracture zone as much as 40 feet wide. Bulldozer stripping exposes the mineralized rock in places for about 100 feet along the strike. The stringers of ore, ranging up to 1 inch in thickness, are closely spaced in some parts of the zone and in other parts are separated by several feet of barren country rock.

Pima County

The principal manganese deposits in Pima County are in the north-central part on the east side of the Cimarron Mountains, which also are known as the Sheridan Hills. This area is known locally as the Drew Springs district, and most of the manganese produced in the county was mined from four deposits in that district. The deposits are accessible over 6.5 miles of graded dirt road that branches west from the Casa Grande-Covered Wells road, 36.5 miles south of Casa Grande or 21 miles north of Covered Wells. Casa Grande is a station on the Southern Pacific Railway and is on State Highway 84. Covered Wells, or Quijotoa, is an Indian village on the Tucson-Ajo road (State Highway 86), 22 miles northwest of Sells, the Papago Indian Reservation Headquarters.

A small production is recorded from several other deposits in various parts of the county, and there are numerous other manganese deposits from which no production is recorded. Figure 14 shows the locations of the various deposits.

Manganese mining activity in the county has been intermittent and was confined largely to the World War periods and the early 1950's. The estimated production to 1956 totaled about 9,500 tons of ore and concentrates containing 35 percent or more manganese. The greatest period of activity followed the opening of the Government purchasing depots in Deming, N. Mex., and Wenden, Ariz.

More than 92 percent of the production was mined in the Drew Springs area from replacement deposits in limestone.

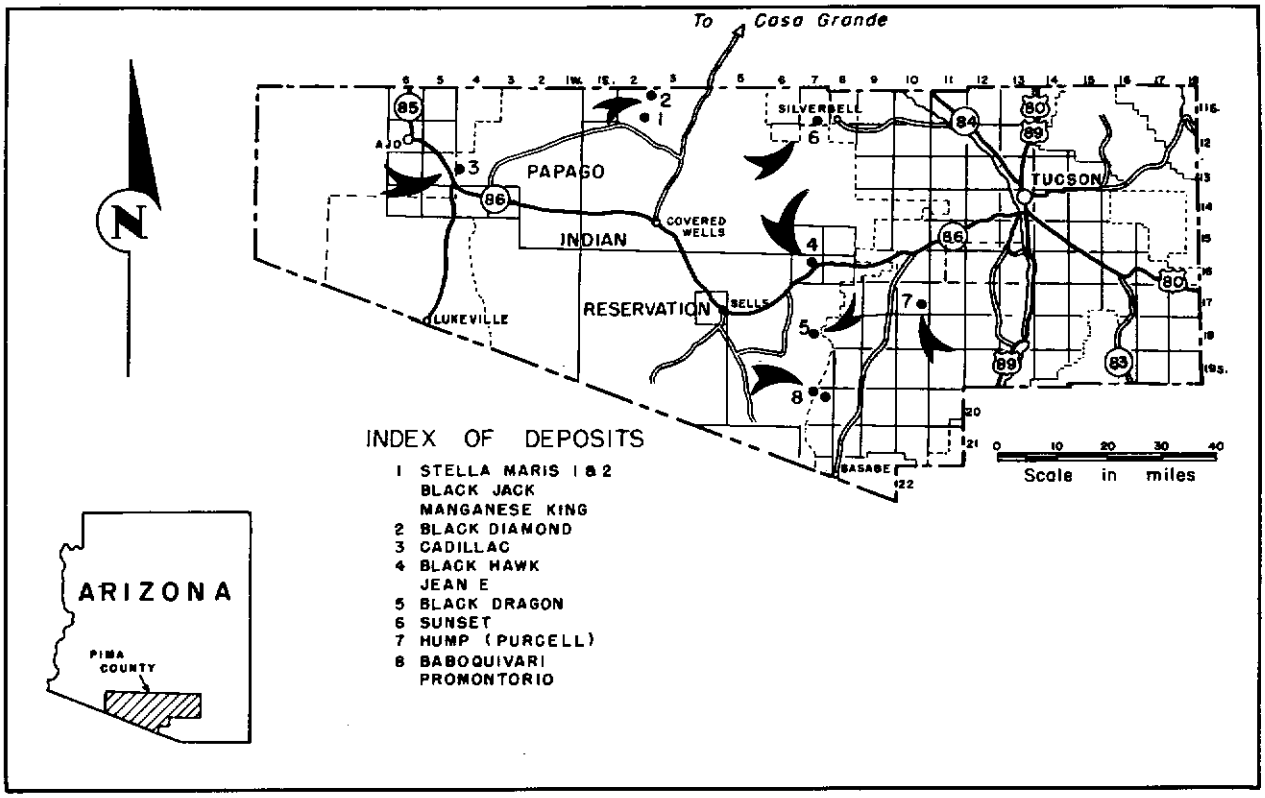

FIGURE 14. - Manganese Deposits, Pima County, Ariz.

Drew Springs Area

The Drew Springs area lies in a small valley on the eastern foothills of the Cimarron Mountains in approximate NE1/4 sec. 35 and NW1/4 sec. 36, T. 11 S., R. 2 E., unsurveyed, of the Papago Indian Reservation. The numerous manganese deposits, occurring within an area approximately 2,000 feet long by 1,000 feet wide, are shown in figure 15 and are keyed by letters to descriptions in the text.

Drew Wash roughly conforms to an east-west axis of folding in sedimentary formations; on the north side, limestone strata dip 30° to 45° N., and on the south side interbedded limestone and quartzite dip about 50° S.

The ownership of mining claims in this area is very confused, as some claims were located, abandoned, and relocated many times from about 1916 into the 1950's. The claims generally were referred to as the Manganese King.

It is reported that 90 tons of sorted ore was shipped from the Drew Wash area in World War I. Elmer and A. L. Lambert reportedly shipped several carloads of ore to steel mills at Birmingham, Ala., from 1939 through 1941. Struckmeyer, Young, Price, and Dorsey later located six claims. Under a lease agreement, R. H. Van Marel and Joe Thurman produced about 900 tons of ore from these claims in 1943-46. The ore was shipped to the Metals Reserve Company stockpile at Phoenix, Ariz. No production was made from 1946 until after the

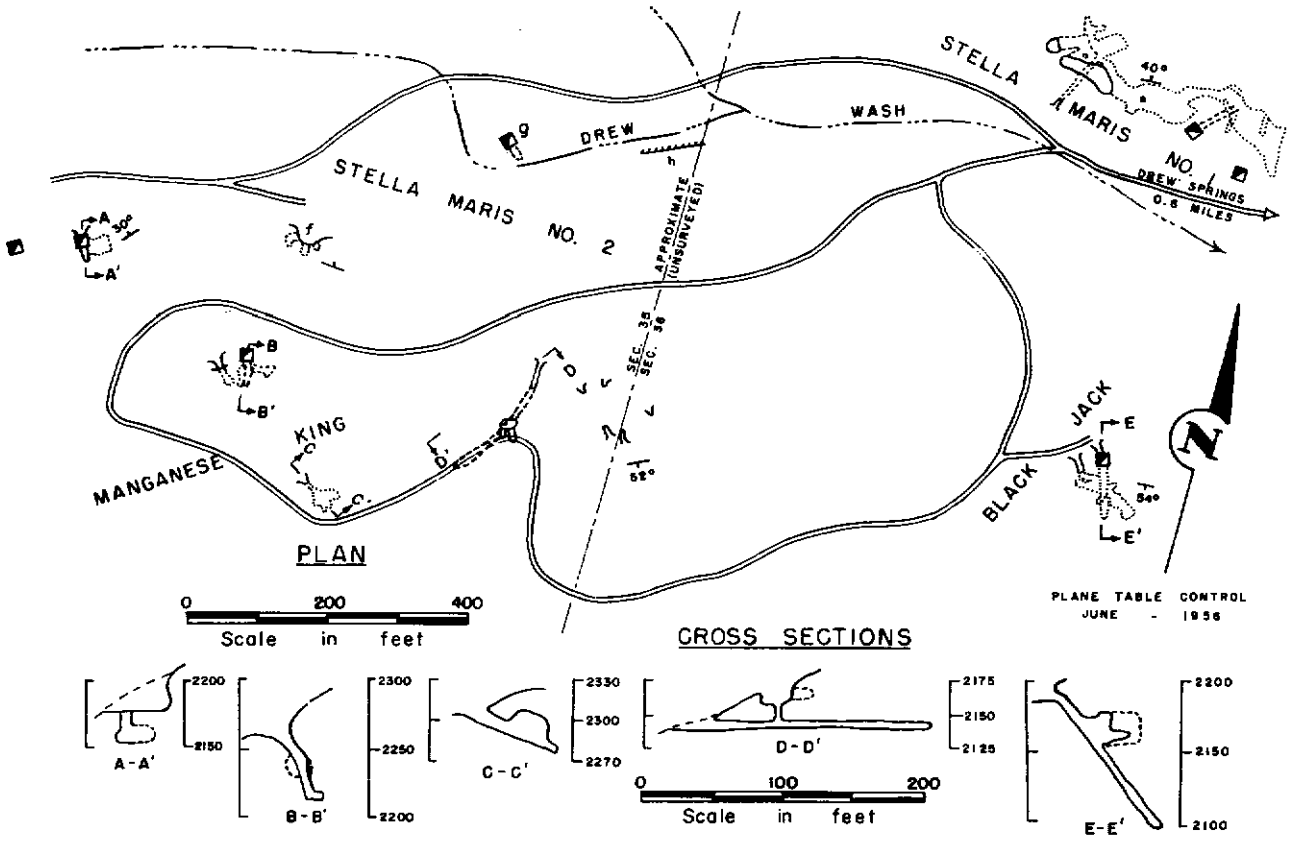

FIGURE 15. - Plan and Cross Sections, Drew Springs Area, Pima County, Ariz.

Government stockpile program was initiated at Deming, N. Mex., and later at Wenden, Ariz., in the early 1950's. At that time a number of relocations were filed.

The 900 tons was credited largely to the Manganese King claims, but probably much of it came from the large surface stope on the claim now known as the Stella Maris No. 1.

As no one was available to show the writer the boundary between the Stella Maris No. 2 and the Manganese King claims, the ownership of a few of the workings may be reported erroneously.

Stella Maris No. 1

The Stella Maris No. 1 claim, in approximate NW1/4 sec. 36, T. 11 S., R. 2 E., unsurveyed (figs. 14 and 15), was located by the present owners, Donald De Silva and L. M. Allinio, of Phoenix, in November 1953. Shortly thereafter, the Black Widow claim was located over part of the deposit by Marcel Van Den Hoeck, of Tucson, but court action in January 1956 awarded the claim to De Silva and Allinio.

A big surface stope, which now is largely backfilled, is known to have been worked as early as 1939. Incomplete records indicate that more than

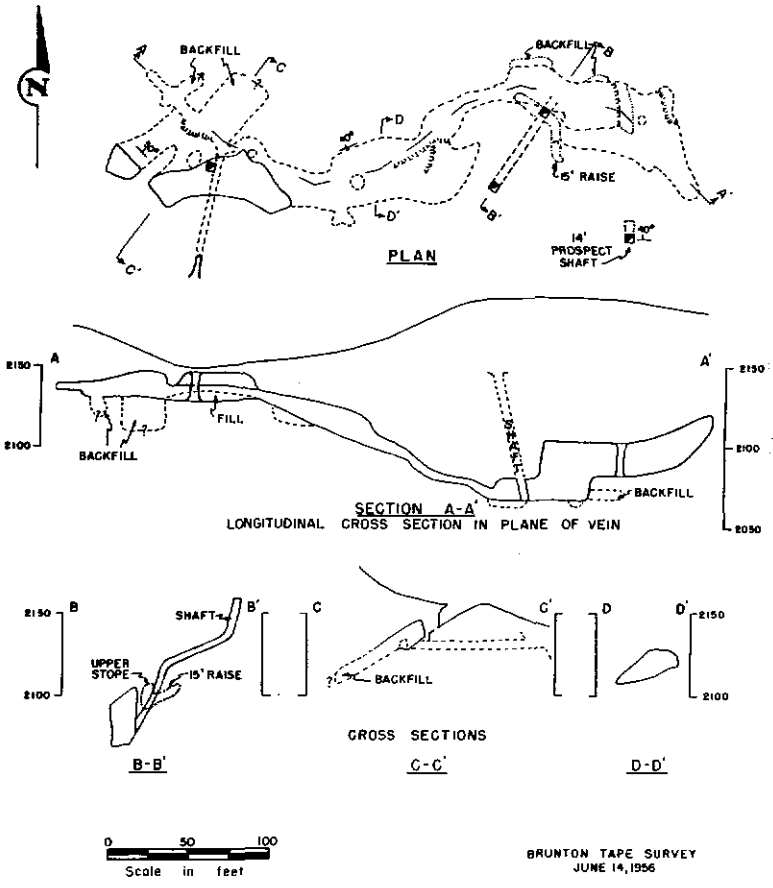

FIGURE 16. - Plan and Sections, Stella Maris No. 1 Mine, Pima County, Ariz.
(Brunton Tape Survey, June 14, 1956.)

1,000 tons of ore containing 35 to 44 percent manganese was produced from the stope through 1946.

The late Al Garen, of Casa Grande made a working agreement early in 1954 with Van Den Hoeck and trucked 25 to 30 tons of manganese to the Wenden purchasing depot before he discovered that De Silva and Allinio were the real owners of the claim. He leased the claim from De Silva and Allinio in March 1954 and thereafter shipped more than 900 long tons of 30- to 40-percent manganese ore to the Wenden purchasing depot. This ore came from an extension of the ore body that had been mined intermittently from 1939 to 1946. Garen, and later his heirs, sank a shaft on the Stella Maris claim early in 1955 and shipped over 3,000 long tons of mine-run ore averaging 47.6 percent manganese to the Deming purchasing depot. From December through March 1956, about 19 carloads of 48-percent manganese ore was shipped under the Government "carlot" program.

The workings of the Stella Maris No. 1 are on the north side of Drew Wash at an altitude of 2,150 feet (figs. 15 and 16). The deposit is a replacement in limestone that has been folded and warped, and its course along both strike and dip is sinuous. The surface stope is in more or less marbleized beds approximately 40 feet stratigraphically above a rhyolite porphyry intrusion that is exposed in the bank of the wash below the workings. The deposit is localized along a bedding-plane fault and often extends into tension fractures in the walls. Post-ore faulting is evident. Near the surface, the predominant ore mineral is psilomelane associated with a little wad. With depth, the ore grades into pyrolusite and minor amounts of manganite.

The west end of the deposit was worked intermittently for about 15 years. It was mined down dip 75 feet or more from surface openings 120 feet long. From the open stope, a 140-foot incline was driven eastward along the strike, from which underground stopes were worked up dip. The thickness of the

deposit in this section ranges from 6 to 12 feet. Production from the incline was suspended because of the increase in iron content.

In February 1955 Al Garen started a shaft on the vein 180 feet east of the open work, reportedly following a 4-inch stringer that increased rapidly in width down the dip. A body of massive ore was mined first from the 100-foot and later from the 125-foot level as one large stope. To provide an escapeway and improve ventilation, he connected the north end of the mine to the old inclined workings.

When the mine was examined in June 1956, the stope was about 140 feet long, 20 to 40 feet wide, and 40 feet high. Except for a 4- to 6-foot band of unreplaced limestone across the vein, the ore was massive pyrolusite associated only with small stringers of crystallized calcite. The ore was broken, hoisted, and shipped without sorting.

The hard, coherent ore gradually changed to friable, granular material in the east end of the mine, and sintering became necessary to make a salable product. The ore was sintered at the plant of Mohave Mining & Milling Co. near Wickenburg.

Through May 1956, the stope produced 5,300 long tons averaging 48 percent manganese.

Approximately 90 feet southeast of the main shaft on the same vein a 14-foot prospect shaft has exposed 4 feet of fair ore consisting of hard manganese oxides cut by numerous calcite stringers.

Stella Maris No. 2

The Stella Maris No. 2 claim, immediately southwest of the No. 1 claim was located early in 1954 by Donald De Silva and M. Allinio. Production records indicate that the owners trucked 417 long tons of sorted ore averaging 26.7 percent manganese to the Wenden purchasing depot. Later, Leon A. Powell, under a lease agreement, sent 122 long tons averaging 28.2 percent manganese to the Deming depot.

The principal working on the south side of and 50 feet above Drew Wash consists of an opening 50 feet wide and extending 20 feet into the hillside (fig. 15, f). From the face of this cut, work was done in three wide underground chambers 10 to 15 feet deep. Manganese minerals are present in limestone that overlies a quartzite member. The contact, exposed in the central opening, strikes east and dips 45° N. The manganese ore, comprising a mixture of hard and soft oxides in irregular bands and concentrations, extends 10 feet or more into the limestone. Some of the softer material contains considerable hematite. The gangue consists of calcite and unreplaced limestone.

On the north bank of the wash, near the location monument, a 15-foot inclined shaft prospected massive, low-grade ore (fig. 15, g). Apparently, work was suspended because of the high iron content. On the south side of Drew Wash about 200 feet east of the shaft, a quartzite bed forms low cliffs

for a length of 100 feet (fig. 15, h). Several shallow cuts have been driven to prospect this bed. Numerous closely spaced veinlets of hard oxides criss-cross the shattered matrix; the intervening areas of quartzite are manganese stained.

All equipment had been removed and the property was idle when visited in June 1956.

Manganese King

The Manganese King group of unpatented claims lies along the ridge on the south side of Drew Wash (fig. 15). The group is owned by Struckmeyer, Young, Price, and Dorsey. In 1955 Manganese King Mining Co. shipped 583 long tons of sorted ore averaging 29.6 percent manganese to the Deming purchasing depot. The production probably came from several of the workings described in this report.

The westernmost productive working consists of a southeasterly bearing 45-foot opencut, which intersects a manganese-bearing stratum of limestone that dips approximately 30° NW., and a 16-foot shaft sunk in the floor of the cut (fig. 15, A).

From the bottom of the shaft, a 20- by 30-foot stope, 6 to 10 feet high, was driven eastward into the mineralized limestone, which is partly replaced with bands and segregations of psilomelane and soft earthy oxides. Parts of the deposit contain considerable hematite. An 18-foot exploratory shaft, 90 feet west of these workings, is in barren limestone except for a slight mineral showing near the surface.

Approximately 300 feet to the southeast at an altitude of 2,260 feet, a 54-foot inclined shaft was sunk in mineralized limestone (fig. 15, B). On the 30-foot level for a distance of 25 feet from the shaft, the limestone is shattered by a series of northwest-trending fractures that dip steeply northeast. This area is erratically, but heavily, mineralized with psilomelane and the softer manganese oxides associated with considerable iron oxide. It was mined to a height of about 15 feet.

A 30-foot drift was driven S. 85° E. from this room, exposing decreasing quantities of manganese minerals. Near the face, occasional lenses of hard manganese, 4 to 6 inches thick, occur along a fault that strikes N. 40° E. and dips 35° NW. Another drift, inclined downward, was driven S. 5° W. for 20 feet, passing through a narrow interbedded member of fine-grained quartzite which strikes northwest and dips steeply southwest. Strength of the mineral deposition decreases downward in the shaft, and a 10-foot drift in the bottom is virtually barren.

Forty feet southwest of the shaft and in the same mineralized zone, a 25-foot adit was driven southeasterly from a 25-foot opencut. This work was in low-grade material consisting of psilomelane, wad, hematite, calcite, and unreplaced rock fragments.

About 200 feet southeast of the shaft and 50 feet higher on the hillside, a downward inclined drift opens into a wide room, 25 feet long and 20 feet high, from which three stub drifts have been driven (fig. 15, C). The workings are in intensely fractured and shattered interbedded limestone and quartzite. Erratic deposition, ranging from narrow-fracture filling to partly replaced zones several feet wide, comprises a mixture of hard and soft manganese oxides intimately associated with iron oxide. The wall rock also is impregnated with hematite. During mining, the broken ore was removed with a slusher hoist and scraper.

A 160-foot drift, bearing S. 20° W. (fig. 15, D), was driven into a thrust-fault zone in which interbedded limestone and quartzite were greatly contorted. The adit was barren of manganese except near the portal where there were narrow stringers and near a raise where small disconnected pods of hard manganese were observed. The raise, about 50 feet inside the adit, connected with a small surface cut some 30 feet above the adit. The cut was 10 by 12 feet in cross section and 8 feet deep. From the cut, two southerly bearing 20-foot adits were driven on a curving, low-angle, thrust-fault contact between limestone and quartzite. An irregular band on the contact as much as 18 inches thick and an intermittent band 3 to 5 feet lower contained small high-grade pods of psilomelane within low-grade soft oxides.

Along the crest of the ridge southeast of the adit, five small opencuts and an area of bulldozer stripping has exposed poor to fair manganese deposition. Limestone and quartzite are interbedded in this area, the formations striking N. 62° E. and dipping S. 52° E.

When the claims were visited in June 1956, all Manganese King workings were idle and all equipment had been removed.

Black Jack

The Black Jack unpatented claim is on the south side of Drew Wash, in approximate sec. 36, T. 11 S., R. 2 E., unsurveyed, just south of the Stella Maris No. 1 claim. (See figs. 14 and 15, pp. 108 and 109.)

The owner of this claim is unknown. Two letters of inquiry, addressed to names on separate location notices, were unanswered.

The Black Jack mine is credited with production of 35-percent manganese ore, shipped as follows: 720 long tons to Wenden by three operators and 520 long tons to the Deming purchasing depot by two operators.

The Black Jack deposit occurs along an east-striking bedding-plane fault; the foot and hanging walls are quartzite and limestone, respectively. The shaft, reported to be 115 feet deep, was sunk on the contact at an inclination of 54° on a bearing of S. 17° E. (fig. 15, E). A drift driven 25 feet westward along the contact from the 20-foot level of the shaft connects with an opencut to the surface. The shaft is sealed on the 42-foot level where a station 15 feet high has been excavated.

A 45-foot drift up to 25 feet wide and 15 feet high runs southeast with the bedding, dipping 35° SW near the end. A high drift runs 35 feet westward along the contact; a 20-foot drift, inclined upward, explores the contact eastward; and 15-foot drift extends southward.

Manganese minerals occur in the limestone adjacent to the fault and extend into fractures in the limestone. They consist of psilomelane and wad-type oxides surrounding unreplaced fragments of limestone. Local areas contain considerable iron oxide. The mineral deposition was continuous in the 45-foot drift but near the end was confined to beds 4 to 6 feet thick. The strength of mineralization decreased to pods and stringers in the south and west drifts.

The shaft and any workings below the 42-foot level were inaccessible when the mine was visited in June 1956. All equipment had been removed, and the property was idle.

Black Diamond Group

The Black Diamond group, comprising four contiguous, unpatented claims, is on the northeast side of the Cimarron Mountains 1.5 miles south of the Pinal County line. It is in the Papago Indian Reservation at an altitude of 2,100 feet in approximate sec. 7, T. 11 S., R. 3 E., and sec. 12, T. 11 S., R. 2 E., unsurveyed. (See fig. 14, p. 108.) The claims were located in mid-1955 by the present owners, Charles A. and Charles E. Pettijohn and Phillip R. Kennedy.

The property is accessible by a fair 7.6-mile dirt road that branches northwest from the Stella Maris access road 1.7 miles from the Casa Grande-Covered Wells road.

Late in 1955, the owners produced 38 long tons of sorted ore containing about 16 percent manganese. This ore was trucked to the Deming purchasing depot.

The principal work was done along a fault zone in quartz diorite, cropping out on a northwest-trending ridge. From the end of a 20-foot opencut, a 70-foot adit inclined at 15° was driven S. 15° E. in the fault breccia immediately west of the footwall. The back of the adit averaged 10 feet above the floor, except for a small stope that was 20 feet high.

The footwall of the fault, where exposed in the workings, strikes S. 40° E. and dips 65° SW. The breccia of the fault zone near the footwall is mineralized mainly with soft manganese oxides associated with small segregations of psilomelane. Psilomelane also occurs as narrow rims around the breccia fragments. Considerable calcite in stringers and blebs is present in the ore.

The ore was removed from the incline by a slusher hoist and scraper, then hand sorted on the dump.

A second deposit, approximately 300 feet N. 60° W. from the incline, was opened by a 17-foot shaft, where a 4-foot-wide manganese-bearing vein followed an east-west fault contact dipping 60° S. The foot-wall side of the fault is highly altered diorite, and the hanging-wall rock is andesite porphyry containing considerable secondary quartz.

The manganese minerals of the vein consist principally of the hard oxides as partial replacements around the breccia fragments and in thin veinlets along fracture planes. A continuation of the vein is visible where it crosses a wash about 50 feet to the east.

All equipment had been removed and the property was idle when examined in May 1956.

Jean E

The Jean E group, comprising five unpatented claims, is in the east-central part of the Papago Indian Reservation, 2.5 miles northwest of the little Indian hamlet of Pan Tak. The property is in SW1/4 sec. 13, T. 16 S., R. 7 E. at an altitude of approximately 3,150 feet. (See fig. 14, p. 100.) The claims are accessible from paved State Highway 86 by a 1/2-mile road that branches northwest 17.5 miles west of Robles Junction or 39.6 miles west of its junction with U.S. Highway 89 near Tucson.

An area containing manganese originally was located as the Black Bear Nos. 1 and 2 claims by A. M. Herreras in 1938. In April 1941, a small trenching project was conducted by the Federal Bureau of Mines on one of the claims. E. J. Freilinger later obtained the claims, worked on the manganese outcrops, sank a vertical 80-foot shaft on a copper-zinc outcrop 1,500 feet or more to the north, and subsequently relinquished the claims. This and the adjacent area were covered by the five Jean E claims located by Drake Mining Co. late in 1954. The company mined about 100 tons of ore that was concentrated in a small jig plant at Tucson. The resultant 17.5 long tons of concentrate, averaging 43.5 percent manganese, was trucked to the Deming purchasing depot.

A fracture zone 300 to 400 feet wide crosses the south end of the hill in rhyolite porphyry, trends N. 50° to 60° W., and dips steeply northeast. Numerous fractures within this zone contain relatively narrow, discontinuous, high-grade veinlets of hard manganese oxides with occasional replacements of softer wad manganese in shattered areas between the fractures. A 4- to 5-foot zone of this type was prospected with an opencut 60 feet long and 10 feet deep. A shaft at the northwest end of the cut was sunk to a depth of 40 feet. At the surface, the ground across the entire width of the shaft was well mineralized, but the intensity of ore deposition decreased downward. At the bottom, the best showing was confined to a high-grade 4- to 6-inch stringer. An old 46-foot shaft at the southeast end of the cut was inaccessible.

The largest working on the property is an opencut 110 feet long, 15 to 30 feet wide, and a maximum of 15 feet deep. The cut followed a vertical fault striking N. 80° E. A 4-foot band of manganiferous material is exposed in the face against the south wall of the fault. Probably, sizable pods of manganese

ore were mined from the intersections of this fault with the northwest-trending fissures. The face of this cut is about 75 feet northwest of the shaft. The broken ore was loaded into trucks with a front-end loader.

About a dozen other pits and cuts, some as much as 25 feet deep, have prospected areas of the best mineral deposition for 300 feet to the north and northwest. The ore is reported to have a low-iron content.

A welded pipe headframe is still in place. A hoist powered by an automobile engine is mounted on the chassis. The property was idle when visited in June 1956 but was still owned by Larry Drake.

Black Hawk

The Black Hawk group, comprising three unpatented claims, lies in SE1/4 sec. 14, T. 16 S., R. 7 E., of the Papago Indian Reservation. (See fig. 14, p. 108.) It is about 2,000 feet west of the Jean E property and can be reached by a continuation of the same access road.

Four claims, covering a mineralized area on the south half of a low rounded hill, originally were located in 1940 by Geo. M. Evans and associates. They were known as the Black Eagle Nos. 1 and 2 and Blue Devil Nos. 1 and 2. In 1954, three claims, the Black Hawk Nos. 1, 2, and 3, covering approximately the same area, were relocated by Edward Brady, Martin Wear, and Luis Carasco, the present owners.

Working under lease agreement, Drake Mining Co. produced 46 long tons of sorted ore averaging 20 percent manganese, which was trucked to the Deming purchasing depot early in 1955.

Crossing the south end of a small rhyolite hill are two fracture zones 300 feet apart, trending N. 50° to 60° W. The fractures are roughly parallel and closely spaced; most are vertical, but some have a northeast dip. Both deposits contain discontinuous, narrow stringers of hard manganese oxides in most of the fracture planes, which show gradual replacement outward from the fracture walls and incomplete replacement of softer wad manganese in shattered areas between the fractures. Some fractures are conspicuous at the surface, as they are heavily coated with shiny desert varnish.

The mineralized area of the north deposit is about 450 feet long and 300 feet wide; the ore to the south, lower on the hillside, is much less extensive. At least 15 cuts and pits have been excavated at places showing the most intensive deposition. A few pits were 10 to 18 feet deep; the widest mineralized zone observed was about 20 inches.

Any extension of either zone to the east is covered by alluvium of the adjacent wash. Because of the similarity of the minerals and the trend of the fractures, it is likely that the Black Hawk and Jean E are on the same fracture zone.

All equipment had been removed and the property was idle when visited in May 1956.

Black Dragon Deposit

The Black Dragon group, consisting of three fractional and six full unpatented contiguous claims, is situated on the Papago Indian Reservation in approximate secs. 15 and 22, T. 18 S., R. 7 E., unsurveyed. (See fig. 14, p. 108.) The claims are accessible from Sells as follows: Go south from Sells 8.5 miles to Topawa (San Solano Mission), then east on a graded dirt road 13 miles to Allison Camp, and then northeast 3.7 miles to the workings at the end of the access road. They also can be reached by turning southeast from a junction 6 miles east of Sells on the Ajo-Tucson highway, traveling about 6 miles to the old Foothills truck trail, then going south about 11 miles on that road to the Allison camp. The property is on the west slope of the Baboquivari Mountains at an altitude of approximately 4,000 feet.

The claims originally were located by Wm. H. Coplen, of Sells in November 1952 and later were purchased by W. S. Talcott, who amended the locations in May 1954.

Production records indicate that Coplen trucked 122 long tons of sorted ore averaging 28.6 percent manganese to the Wenden purchasing depot. Black Dragon Mining Co. (Tucson) shipped 43 long tons of sorted ore averaging 24.7 percent manganese, and Arizona Materials & Service Co. (Bisbee) produced 19 tons of concentrate assaying 36.0 percent manganese. The last two shipments were made to the Deming purchasing depot.

A fracture zone about 300 feet wide strikes north-south along the east side of a low range of hills. Discontinuous manganese minerals are present in some of the fractures for nearly 2,000 feet. Several pits and a 30-foot open-cut have prospected the deposit across the end of a ridge at the north end of the zone, where soft oxides of manganese occur as coatings and narrow fracture fillings in the sheared and fractured rhyolite.

Approximately 600 feet southward across a wash, an opencut 120 feet long, 10 feet wide, and as much as 20 feet deep followed fractures that were more intensely mineralized. Hard and soft wad-type oxides with small amounts of pyrolusite have partly replaced much of the rhyolite within the cut. The zone was drilled and blasted for an additional 100 feet to the south but was not mined. Numerous other mineralized fractures can be traced along the surface by their capping of desert varnish. All equipment had been removed and the property was idle when visited in May 1956.

A small manganese concentrating mill had been erected about half a mile west of the Allison camp. The ore was dumped from trucks on an 8-inch grizzly, slusher-scraped to the plant, crushed in two stages, screened, and concentrated by desliming in spiral classifiers. The mill was idle when visited.

Cadillac

The Cadillac group of five unpatented claims is in approximate sec. 18, T. 13 S., R. 4 W., unsurveyed, in the foothills of the Pozo Redondo Mountains on the west side of the Papago Indian Reservation. (See fig. 14, p. 108.) The claims were located in mid-1953 by the present owners, Alton C. Netherlin, Phil Childs, and Wm. Hibberd, all of Ajo, Ariz. They are approximately 11 miles in an air line southeast of Ajo and are accessible by turning east from the Sells road 9.2 miles from the square at Ajo. This road continues easterly 1.5 miles to a gate in the reservation fence. The major workings of the Cadillac group are about 2 road miles northeast of the gate.

Ore trucked to the Wenden purchasing depot from this deposit totaled 119 long tons averaging 12.3 percent manganese.

The major workings are at the east side of sec. 18 on a fault zone between fine-grained basalt on the west and vesicular basalt on the east. Where exposed in the workings, the contact strikes N. 15° W. and dips 60° E. The principal work consists of an opencut 8 to 10 feet deep and about 30 feet long. Shallow and irregularly spaced bulldozer trenches across the mineralized zone have partly explored about 200 feet of the strike length.

Manganese minerals are present in a breccia zone several feet wide against the vesicular basalt. Psilomelane has replaced much of the cementing material of the breccia zone and appears as rims around unreplaced basalt fragments. West of the breccia zone the sheared and shattered basalt contains manganese oxides in thin fracture fillings and small nodules in decreasing amounts for approximately 25 feet.

A. C. Netherlin and associates produced about 50 long tons of 20-percent manganese ore which was trucked to Wenden. This ore was sorted from material blasted from the opencut in the breccia zone.

Later, a lessee bulldozed much of the overburden from an area about 125 by 200 feet, trenched across the mineralized zone in several places, and widened the opencut. A front-end loader was used to load the better appearing material into trucks for haulage to Wenden. As the manganese content of approximately 70 tons of this material was less than 15 percent, the operation was terminated.

A minor outcrop of manganese has been prospected near the access road about half a mile northeast of the reservation gate. Manganese occurs in a northerly trending shear zone in andesite porphyry and is exposed in two small pits and a shallow bulldozer stripping about 100 feet long. Psilomelane and pyrolusite appear in thin bands along fracture planes, in scattered small disseminations, and as incomplete replacement of the groundmass of the porphyry in a zone about 20 feet wide. No production was made from this area.

The property was idle when visited in May 1956.

Sunset

The Sunset group of three contiguous unpatented claims is situated in sec. 34, T. 11 S., R. 7 E., about 6 miles west of the El Tiro pit of American Smelting & Refining Co. (See fig. 14, p. 108.) The property is accessible from the town of Silver Bell by 3.4 miles of county road and 7.6 miles of desert truck trail. The claims were located late in 1954 by David C. Hartley, the present owner.

In 1955, Hartley produced 66 long tons of sorted ore averaging 28 percent manganese. This ore was trucked to the Deming purchasing depot.

The mine is in the foothills northeast of Greene Valley at an altitude of approximately 2,050 feet. In this vicinity the limestone strata, interbedded with quartzite, have a general northwesterly strike, dipping 60° SW. A relatively narrow vertical fault zone, trending N. 40° E., cuts the limestone bedding. Within the fault zone is an andesite porphyry dike 5 to 10 feet wide. A band of fine-grained epidotized quartzite, 1 to 2 feet wide against the porphyry, forms the north side of the fault.

A replacement deposit of good manganese ore occurred in the limestone bedding on the northwest side of the fault. At the surface it was 6 to 12 feet wide for 30 feet, terminated against the fault, and decreased in width downward. An exploratory adit driven into the hill 25 feet below the outcrop intersected the vein and followed it northwest for 40 feet. This adit and two raises into the opencut on the outcrop facilitated mining the lower part of the ore lens. On the adit level a chimney of ore about 7 feet across lay against the fault, but elsewhere along the strike the ore body had narrowed to 2 feet or less. A 16-foot winze, which was sunk in the adit floor, showed decreasing mineralization.

The principal manganese mineral was psilomelane with minor amounts of the softer oxides, particularly in the lower part of the deposit. A narrow band of manganiferous material followed the north side of the fault. A small amount of manganese, associated with copper oxide staining, was observed in limestone bedding at the top of the saddle about 100 feet to the northwest.

The property was idle when examined in June 1956.

Hump or Purcell Claims

The Hump group, formerly known as the Purcell property, consists of 22 contiguous unpatented claims situated in the foothills on the western slope of the Sierrita Mountains in the west-central part of sec. 26, T. 17 S., R. 10 E. (See fig. 14, p. 108.) The group is about 36 road miles southwest of Tucson and can be reached from the intersection of Mission Road and Ajo Way in Tucson by traveling 20 miles west on State Highway 86 to Robles Junction, then south on State Highway 286 (Sasabe Road) for 8 miles to a dirt road branching left. This branch is followed eastward 8 miles to the claims. The claims, lying at an altitude of 3,800 to 4,000 feet, surround an old silver-prospect shaft

known as the Aguinaldo. The shaft is reportedly about 250 feet deep and is 0.75 mile east of two old adobe buildings known as Lincoln camp. The buildings are said to have been a station on an old stage road from Mexico.

The claims were located for silver-lead early in the history of the district. From 1920 to 1940 they were owned by S. W. and E. M. Purcell, of Tucson. In 1942 they were operated for a short time by Stephen Riess. The present owners, George B. Breidler and his mother, relocated the group in 1946.

Small amounts of silver-lead ore have been produced, but there are no records indicating that manganese ore has ever been shipped from the claims.

The manganese minerals occur as irregular replacement bodies and veins in metamorphosed limestone along or near its contact with granitic rocks. The deposits are found in two tilted blocks of limestone separated by an irregular mass of granitic rock several hundred feet wide. The mineral occurrences strike northward and dip 45° to 80° E. in evident conformity with the limestone. The manganese minerals in the western block of limestone are exposed in several disconnected areas along the contact for 700 feet or more. Three of the largest occurrences are irregular podlike masses ranging from 2 to 15 feet in width and from 10 to 50 feet in length. They are separated by 100 to 400 feet of either barren or sparsely mineralized limestone. In places for several tens of feet west of the granite contact, the limestone contains short, widely spaced veinlets of manganese minerals ranging from thin seams to bands 1 foot or more in width.

The principal manganese deposits in the eastern limestone block are about 800 feet farther north along the east slope of a prominent ridge. In this area the minerals occur in a series of disconnected lenses that are exposed in places for some 500 feet along another limestone-granite contact. The lenses range from 2 to 8 feet in width and from a few feet to 80 feet in length. Other small sporadic occurrences are present in limestone some distance from the granite contact.

The manganese minerals are the soft oxides, consisting chiefly of wad, and pyrolusite. The gangue is composed of iron oxides, silicified limestone, and some calcite.

The workings on the manganiferous exposures in the two areas were limited to shallow prospect openings driven years ago in search of silver ore which is associated with some of the manganese minerals. The work along the west contact consisted of several widely scattered opencuts and two short adits extending from the face of the two larger opencuts.

On the east contact, the most extensive work was an opencut about 60 feet long, 4 to 8 feet wide, and as much as 30 feet deep. Some high-grade manganiferous silver ore had been mined from this opening. Other small opencuts and shallow pits were scattered along the outcrops both north and south of this larger excavation.

Samples taken from some of the larger deposits averaged about 10 percent manganese and 10 percent iron. Selected samples of the highest grade ore that could be sorted from the lower grade material contained 19 to 29 percent manganese and 16 to 21 percent iron.

When the property was visited in May 1957 some silver-lead ore was being mined by George Breidler from claims north of the manganese exposures.

Big Dike

An extensive zone of dark silicified schist, known as the Big Dike, crops out about three-quarters of a mile northeast of the Hump group in SE1/4 sec. 23, T. 17 S., R. 10 E., on the Apex and Ajax claims. The outcrop of the zone is covered with a thin black coating of manganese oxides, giving it the appearance of a huge deposit of manganese. Where examined in several places, the manganese was confined to a paper-thin film covering the weathered outcrop. Some prospect openings, including a 100-foot inclined shaft, were situated on a copper-bearing vein a short distance west of the southern end of the Big Dike, but no workings were found on the manganese-stained outcrop.

Baboquivari

The Baboquivari deposit is in the south-central part of Pima County, some 60 miles by road southwest of Tucson in NW1/4 sec. 11, T. 20 S., R. 7 E., and 4.5 air miles directly south of Baboquivari Peak at an altitude of 4,500 feet. (See fig. 14, p. 108.) The area can be reached from Tucson by traveling westward on State Highway 86 (Ajo Road) 20 miles or more to Robles Junction, then southward on State Highway 286 (Sasabe Road) 30.5 miles to a side road branching right. This side road, marked Santa Margarita North Scales, is followed westward 6 miles to a faint truck trail that branches left just before reaching a fence with a wooden gate. This truck trail is then followed south-southwest 3 miles to the eastern end of the property.

Claims covering the deposit were located originally during World War I, and 1 or 2 carloads of hand-sorted manganese ore is reported to have been shipped at that time. Somewhat later, the property was abandoned and remained so until 1940, when four claims known as the Black Diamond group were relocated in the area by George M. Evans, L. P. Jenkins, and G. S. McCafferty, of Tucson. When the property was visited in May 1957, location notices were found showing that at least parts of the group had been relocated in 1955 as the Red and Black Chief claims by Forest G. Miller and Manuel L. Obregon, whose addresses are unknown.

In April 1941, much of the outcrop of the main Baboquivari deposit was trenched and sampled by the Federal Bureau of Mines. Four trenches, ranging from 35 to 245 feet in length, were excavated across the general trend of the deposit in an area extending roughly 160 feet east-west and as much as 245 feet north-south. A total of 52 samples, cut continuously along the bottom of the trenches, averaged 2.9 percent manganese. Ore-dressing tests made in 1942 on material of this grade in the laboratory of the Bureau of Mines showed a very poor recovery of manganese by tabling and flotation methods. At the

same time, tests made on a higher grade selected sample of the Baboquivari ore, containing about 25 percent manganese, showed a recovery of 81 percent of the manganese in a product assaying 55 percent manganese and 3.6 percent iron. To achieve these results a combination of methods was used, including concentration by tabling and flotation followed by the magnetic separation to remove most of the iron.

In 1953, private parties further explored the deposit by diamond drilling, but the results of this work were not available. When the deposit was visited, the collars of five drill holes were found on the surface in various places within the area sampled by the Bureau of Mines.

The only reported production from the deposit was that made during World War I.

The property was idle in May 1957, and no further attempt to explore the deposit had been made since diamond drilling was completed.

Manganese minerals occur along narrow fractures in a broad zone of shattered and brecciated andesite. The zone trends westward and appears to dip steeply northward. On the surface it contains various-size sporadic areas of manganese deposition for 1,500 feet or more along its strike. The largest area is near the eastern end of the zone and is the one that has been explored. Most of the manganese in this part of the zone is exposed irregularly for approximately 400 feet in strike length and 300 feet in width. It comprises seams and veinlets of manganese oxides separated by masses and fragments of barren country rock of different size. The mineralized fractures range from a fraction of an inch to 1 foot or more in width. The wider veinlets usually trend east-west and are rarely more than a few tens of feet in length. Some dip northward and others appear more or less vertical. Surrounding these are a myriad of thin interlacing seams and stringers of manganese oxides which occupy the minor fractures between the fragments of the shattered andesite. In some places the manganese minerals are disseminated in small blebs throughout the rock.

The chief ore minerals are pyrolusite and psilomelane. Some rhodonite was detected in the ore on which the metallurgical tests were made. Iron oxide is the principal gangue mineral and in some places is as abundant as the manganese oxide.

In addition to the sample trenches, the workings comprise 12 or more shallow opencuts and pits and an old 25-foot shaft from which the ore is said to have been shipped in 1917. The pits and opencuts are scattered throughout the mineralized area; the shaft is near the west end of the area. An open stope about 20 feet long extends to the surface from a drift at the bottom of the shaft.

Promontorio-Black Eagle Claims

The Promontorio-Black Eagle claims are in sec. 3, T. 20 S., R. 7 E., 1.5 miles in an air line northwest of the previously described Baboquivari deposit.

(See fig. 14, p. 108.) Access to the claims is by 1.5 miles of steep foot trail that trends southwest from Weaver Canyon at the west end of the North Scales Road of the Santa Margarita Ranch. It is about 7 miles to the end of this road from its junction with State Highway 286 (Sasabe Road).

In 1941, three contiguous claims, known as the Promontorio and the Black Eagle Nos. 1 and 2, were located by Frank Cota and associates, of Tucson, Ariz. The present owners, if any, are unknown. No ore has been shipped, and the property was idle in May 1957.

The manganese minerals, like those of the Baboquivari deposit, occur in a network of seams and widely spaced narrow stringers in a broad zone of fractured and brecciated andesite. The zone trends west-northwest and appears to dip from steeply northward to vertical. It is manganiferous in places over widths of 300 feet or more. Its dark-stained outcrop is exposed for more than 2,000 feet along the strike. Most of the deposition is confined to a paper-thin coating of manganese oxide on the surface and to seams filling the minute interlacing fractures and joints of the shattered host rock. Some areas along the zone contain widely spaced veinlets of manganese oxide minerals. These veinlets attain widths of several inches but are seldom traceable for more than a few feet in length.

The workings were limited to a few scattered opencuts and assessment-work pits.

Pinal County

The principal manganese deposits of Pinal County are found largely in the eastern and southwestern parts of the county (fig. 17). Most of the 25 known deposits are along the eastern side of the county and are accessible from Superior and Mammoth. The deposits in the southwestern area occur in the foothills of the Silver Reef and Sawtooth Mountains south of Casa Grande. One isolated occurrence has been found near the center of the county southeast of Florence (fig. 17).

The first ore chiefly valuable for its manganese content was shipped late in World War I. Production was resumed during World War II and again in 1953 following the establishment of the Government purchasing depots in Deming, N. Mex., and Wenden, Ariz. Shipments to these depots continued until late in 1955 when the Deming depot closed after reaching its prescribed quota. No manganese properties in the county were active in 1956.

The estimated production from Pinal County to December 31, 1955, has totaled 34,650 long tons of ore, averaging about 28 percent manganese, and 10,157 long tons of concentrates containing 28.8 percent manganese. Of this total, 29,025 long tons of ore, averaging 27.6 percent manganese, and all of the concentrates were shipped in 1953-55 to the Government purchasing depots.

During World War II, about 4,775 long tons, having a manganese content approximately 30 percent, was shipped largely to the stockpiles of the Metals Reserve Company in Phoenix, Ariz., and Deming, N. Mex. Estimates indicate

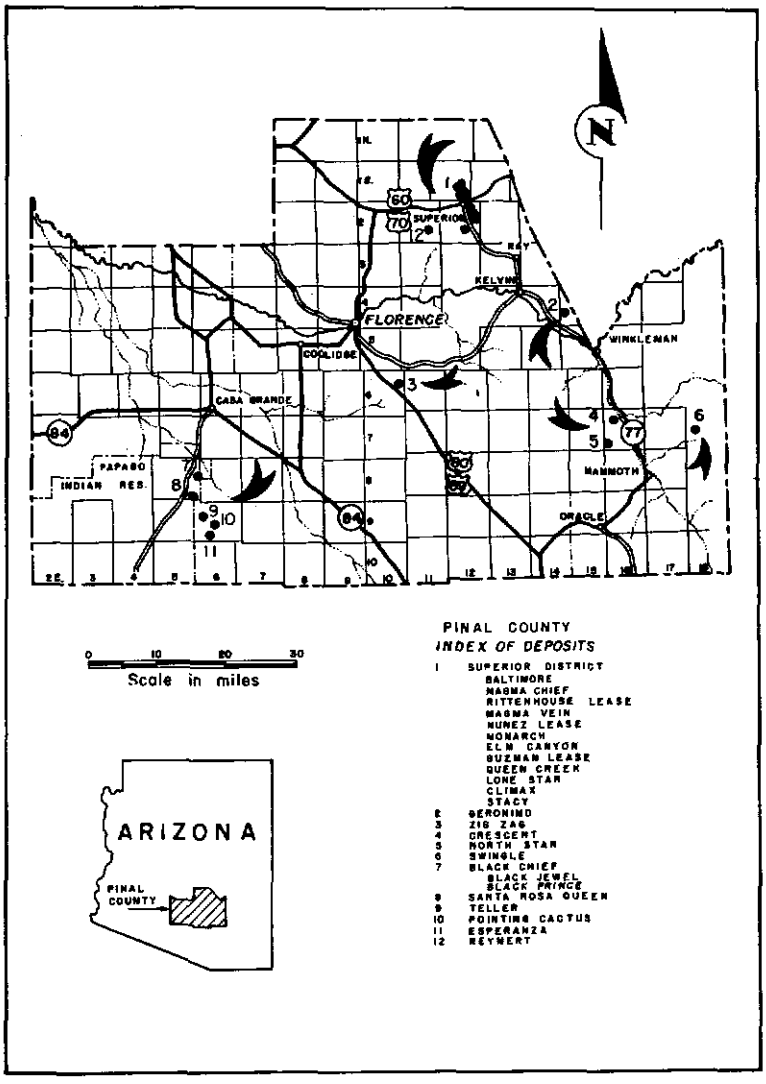

FIGURE 17. - Manganese Deposits, Pinal County, Ariz.

that in World War I about 850 tons of 40- to 44-percent ore was produced. More than 86 percent of the ore and all of the concentrates were produced from the deposits near Superior, Ariz.

The manganese deposits in the county occur in both sedimentary and igneous rocks ranging in geologic age from Precambrian to Tertiary. The principal sedimentary host rocks in the Superior area are of Paleozoic age, consisting of the Escabrosa, Naco, and Martin limestones. The Crescent deposit in Putnam Wash occurs in the Precambrian Mescal limestone. A few small deposits are found in consolidated gravel or conglomerate beds, probably of Pliocene age. The igneous host rocks consist essentially of granite and basaltic lavas. The latter are the principal hosts in the southwestern part of the county.

The manganese deposits occur in steeply dipping veins and fracture zones and as irregular bodies replacing moderately dipping limestone beds. Some deposits are a combination of both types, with part following the fractures and part replacing certain favorable beds adjacent to the veins or fracture zones.

Usually the ore minerals are a mixture of two or more common oxides, such as pyrolusite, wad, and psilomelane. Small amounts of rhodochrosite and braunite have been found in some of the deposits. Black manganiferous calcite, generally containing less than 1 percent manganese, is abundant in certain of the deposits. This mineral, through weathering agencies, is considered to be the source of some of the higher grade oxide minerals. The common gangue constituents of the ore are unmineralized wall rock, calcite, iron oxides, and quartz. Many of the deposits contain lead, zinc, and copper minerals. Silver is found in several deposits in the Superior area, where manganiferous veins and replacement bodies have been mined for that metal.

The depths to which the better ore extends vary greatly in the different deposits. In some deposits the ore grades into much leaner material a few tens of feet below the surface. In others, there has been no marked difference in the grade of ore at depths of several hundred feet. In the Magma mine at Superior, high-grade manganese oxide minerals have been noted in places along the vein as much as 1,900 feet below the surface.

The potential reserve of low-grade ore in the county is large. No specific estimates are possible owing to lack of exploration and development and the inaccessibility of most of the existing underground workings. However, judging from available information it seems safe to infer a total reserve of several hundred thousand tons, probably containing 10 to 20 percent manganese. Much of this tonnage is in the deposits along the eastern and northeastern parts of the county.

The Bureau of Mines at different times has made ore-dressing tests on samples of the ore from several of the larger deposits. This work has indicated that the ore from some deposits is quite amenable to ordinary methods of gravity concentration or flotation. With ore from other deposits these conventional methods either failed to show a satisfactory recovery of the manganese or did not yield a marketable concentrate.

Superior Area

The geology and the copper-gold-silver deposits of the Superior mining area are described in Arizona Bureau of Mines Bulletin 151, published in October 1943. The field work for the bulletin was completed before much manganese ore had been produced from the district; consequently, only the productive deposits of copper-gold-silver ore were described in the publication.

The manganese deposits near Superior are found in a northerly trending belt of Devonian and Carboniferous limestone on the western slopes of a rugged mountainous area lying between the Pinal Mountains to the east and the Superstition Range to the north-northwest. The limestones crop out in a comparatively narrow belt extending about 2 air miles north and 3 air miles south of Superior. (See fig. 18.)

Twelve deposits containing considerable manganese and innumerable small scattered occurrences containing a little manganese are found along this belt. Nine of the main deposits are associated with a series of eastward-trending, steeply dipping fault and fracture zones cutting the limestone bedding. The other deposits are replacement bodies more or less conformable to the attitude of the beds and localized along bedding-plane fractures. The outcrops of the deposits are exposed through a vertical range of 1,200 feet.

Baltimore Claim

The Baltimore claim is one of a large group of unpatented claims held for many years by Kimball Pomeroy and associates. During World War I, it was a part of the property held by Magma Chief Copper Co. In 1949, part of the original group, including the Baltimore, was acquired by Magma Extension

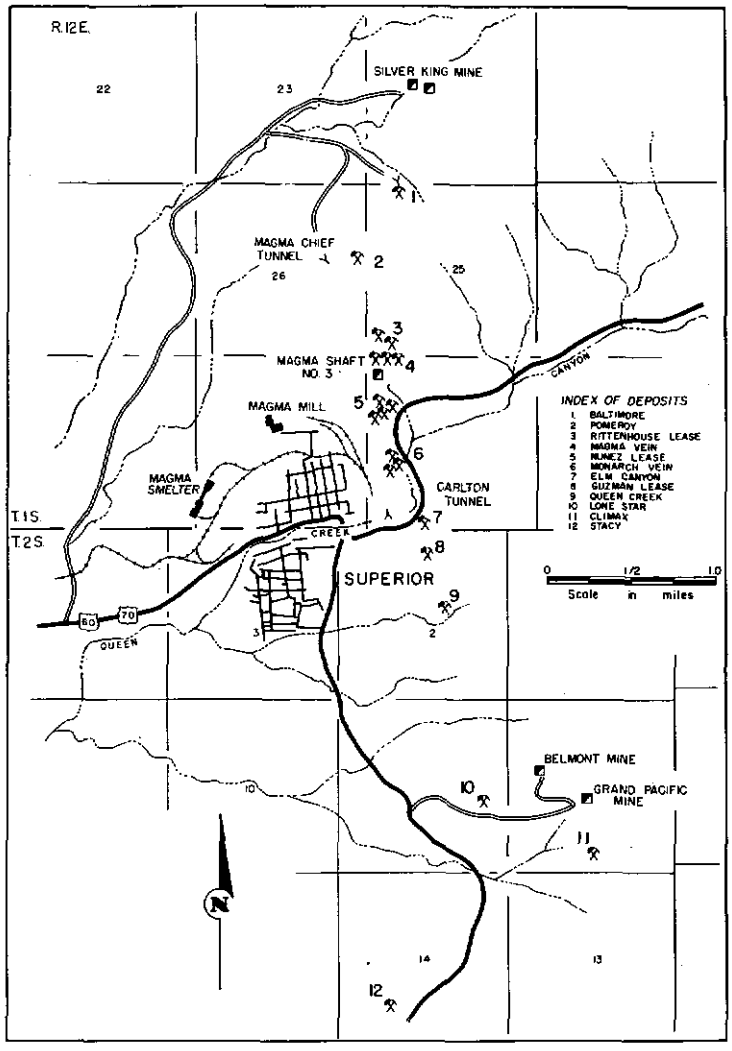

FIGURE 18. - Manganese Deposits Near Superior, Ariz.

Mining & Smelting Co. from the estate of Kimball Pomeroy. At present, the claim is part of a group held by Magma King Manganese Mining Co., of which Ralph J. Pomeroy, of Chandler, Ariz., is president.

The claim is 6 miles by road north of Superior in SW1/4 sec. 24, T. 1 S., R. 12 E., about three-fourths mile south-southwest of the old Silver King mine (fig. 18). The deposit crops out on the north slope of a steep hillside about 4,000 feet above sea level. It can be reached from Superior by traveling west on U.S. Highway 60-70 for 1.6 miles to a dirt road branching right, then 0.3 mile to a right fork. This fork, known as the Silver King Road, is followed 3 miles to a right-hand branch, which continues eastward about 1 mile to the portal of the adit. The outcrop of the deposit is about 400 feet by trail southeast of the adit.

The occurrence was prospected for silver as early as 1880, following the discovery of rich silver ore in the Silver King mine. In 1918, when the property was visited by Jones,[39] the workings consisted of a 35-foot inclined shaft and an adit 175 feet below the outcrop, which was being driven to intersect the deposit. Since 1918, further work has been performed and a small amount of manganiferous silver ore is said to have been shipped in the late 1930's to Magma Copper Co. smelter in Superior. No manganese ore, as such, has been produced. The property was idle when the district was visited in October 1956.

The manganese deposit on the claim occurs as an irregular body along a bedding-plane fracture in the Escabrosa limestone. The deposit strikes N. 70° E. and dips about 45° SW. in apparent conformity with the attitude of the enclosing limestone. The outcrop is fairly well exposed for 90 feet or more along the strike and ranges in width from a few feet near the east end to as

39/ Jones, E. L., Jr., and Ransome, F. L., Deposits of Manganese Ore in Arizona: Geol. Survey Bull. 710; pt. I, 1920, p. 162.

much as 14 feet in the western exposures. Talus overburden covering the hillside obscures any further extent of the deposit along the strike.

The manganese minerals comprise chiefly wad and pyrolusite, accompanied by an abundance of iron oxide, some calcite, and jasper. In the wider parts of the deposit, the better ore occurs in irregular bands ranging from 1 to 6 feet in width, which usually are separated by masses of unreplaced or sparsely mineralized limestone.

The outcrop of the deposit was explored along the strike by a 40-foot inclined shaft, an opencut, and two short shallow adits. From the face of one of the adits, a winze, estimated to be about 50 feet deep, was sunk in the hanging-wall part of the deposit. Both the shaft and winze were without ladders and were inaccessible when the property was visited. Two grab samples, taken from piles of ore removed from the shaft and adits, contained 18.9 percent manganese with 13.8 percent iron and 16.5 percent manganese with 13.5 percent iron, respectively. About 0.3 ounce of silver per ton was found in one of these samples.

Near the base of the hill, some 350 feet north of the outcrop and 175 to 200 feet lower, an adit has been driven to intersect the downward extension of the deposit. The adit extends about 475 feet southward across the beds toward the outcrop. At that point a drift follows the limestone beds along a N. 50° E. course for 110 feet. Near the end of the drift in a short semicrosscut, irregular lenticular bunches of manganiferous material are exposed along a fracture ranging from a few inches to 2 feet in width. In contrast to the surface deposit this mineralized fracture strikes N. 15° to 20° E. and dips about 30° NW. across the bedding of the limestone. Considerable diamond-drill core scattered along the drift indicated that several holes were drilled to the southeast in further search of ore. The results of the drilling are not known.

Magma Chief Deposit

The Magma Chief deposit is near the northern end of the manganiferous belt, 1.6 miles north of Superior in the east-central part of sec. 26, T. 1 S., R. 12 E. (See fig. 18, p. 126.) It is on the patented Picket Post claim which is one of a large group formerly held by Kimball Pomeroy and later by the Magma Chief Copper Co. Presently it is owned by Magma Copper Co. of Superior, Ariz.

The deposit can be reached from Superior by traveling west on U.S. Highway 60-70 for 1.6 miles to a right-hand branch, then 0.3 mile to a right-hand fork known as the Silver King Road. This road is followed north 3 miles, then east on a right-hand branch 0.5 mile to a southerly trending fork leading to the old Magma Chief tunnel. The deposit crops out on the hillside about 1,500 feet east of the portal of the old tunnel, from which it is accessible by 0.5 mile of steep trail.

Although the occurrence doubtless was discovered and explored for silver several decades earlier, the first recorded production was made by lessees in

1939-40. At that time several hundred tons of manganese-bearing silver ore was shipped to the Magma Copper Co. smelter in Superior. Incomplete records indicate that the shipments contained about 19 percent manganese, 7 percent iron, and 15 ounces of silver per ton. So far as is known no manganese ore has been produced from the deposit. All equipment had been removed and the property was idle when the district was visited in November 1956.

The deposit is a typical bedding replacement following a member of the Escabrosa limestone. It strikes N. 10° W. and dips northeast at angles ranging from 20° near the surface to some 30° in the deeper workings. The mineralized outcrop, ranging from a few feet to as much as 12 feet in thickness, can be traced almost continuously along the strike about 600 feet. Its continuation to the northwest is obscured by overburden. At the southeast end of the outcrop, the deposit splits into two strands which gradually taper out along the strike. The thicker parts of the deposit have a banded structure composed of alternate strands of ore, ranging from a few inches to several feet in thickness, and different thicknesses of barren limestone or siliceous low-grade material.

The chief manganese minerals are pyrolusite and wad. The gangue consists essentially of siliceous limestone, iron oxides, calcite, and quartz. Some samples from the deposit contained as much as 5 percent zinc and more than 2 percent lead. Microscopic examination indicated that the high zinc content was due largely to the presence of willemite, a zinc silicate. The lead-bearing mineral was not identified.

The workings, spaced at irregular intervals along the outcrop, consist of two inclined shafts and four shallow opencuts. The northernmost shaft, near the north end of the outcrop, follows the deposit down dip some 200 feet. Several irregular stopes extend outward from the south side of the shaft as much as 30 feet. These stopes are 5 to 8 feet high and are normal to the dip. Although the ore swells and pinches, it is fairly continuous down dip to the deepest accessible workings, which when visited were about 180 feet below the surface.

Approximately 120 feet southeast of these workings, another inclined shaft follows the lower or footwall part of the deposit to a depth of about 50 feet. In this area the manganese-bearing bed ranges from 6 to 9 feet in thickness. Farther southeast, four shallow opencuts, excavated along the outcrop at intervals of 60 to 150 feet, expose the mineralized bed over widths ranging from 8 to 12 feet.

A few samples, taken in the 200-foot shaft workings at different times by engineers of the Federal Bureau of Mines, averaged about 22 percent manganese and 14 ounces of silver per ton over widths of 5 feet. These results compare closely with the grade of the ore shipped from this northern section of the deposit. Five samples, taken from the other excavations along the outcrop to the southeast, averaged about 14 percent manganese and only 1.3 ounces of silver per ton over widths from 4 to 12 feet. Apparently, the higher grade silver ore is confined largely to the northern end of the deposit, which doubtless is why the most extensive work was done in that area.

In 1943 ore-dressing tests were made in the Salt Lake City laboratories of the Federal Bureau of Mines on a sample of the Magma Chief ore assaying 21 percent manganese, 15 percent iron, and 4.6 percent zinc. It was concluded that the best results were obtained by combined jigging and tabling procedures. About 63 percent of the manganese was recovered in a concentrate which, after sintering, assayed 39.3 percent manganese.

In 1946 another sample of the Magma Chief ore was submitted to the Bureau of Mines to determine whether the ore was amenable to treatment by the dithionate process. This process involves the use of sulfur dioxide gas to extract the manganese, then, cyanidation of the leached residue recovers the silver or gold. The sample contained 15.3 percent manganese, 4.6 percent iron, 5.35 percent zinc, 2.2 percent lead, 23 ounces of silver per ton, and a trace of gold. Although only a few small-scale tests were made, the results indicated that the ore was amenable to treatment by the dithionate process, showing an extraction of 95.1 percent of the manganese and 95.3 percent of the silver. Although the cyanide consumption was very high, it was thought that it could be reduced substantially by further experimentation.

Rittenhouse Lease

The Rittenhouse lease, covering a manganiferous deposit on part of the property of Magma Copper Co., is in SW1/4SW1/4 sec. 25, T. 1 S., R. 12 E. about 1 mile north-northeast of Superior, Ariz. The lease derived its name from William Rittenhouse, who in 1941 and 1942 mined silver ore from the deposit under a lease from Magma Copper Co. The workings are on the patented Silver Tip claim and are accessible by a short, winding dirt road that branches north from U.S. Highway 60-70 about 1.8 miles east of the Superior Post Office.

Although the deposit has been operated intermittently for many years as a silver mine, the first manganese ore, as such was produced in 1955. At that time, lessees shipped about 2 carloads of sorted ore, containing 20 to 25 percent manganese, to the Government purchasing depot in Deming, N. Mex. For the 30 years before 1955, production from the deposit is estimated to have totaled 3,670 tons of manganese-bearing silver ore, all of which was treated in the Magma copper smelter. The manganese in the ore passed into the slag and was not recovered. No work was in progress when the deposit was visited in November 1956.

The manganese-silver ore occurs along a nearly vertical vein in massive gray beds of the Escabrosa limestone. The vein strikes N. 65° to 75° W., cutting across the limestone which trends about N. 10° W., and dips 30° E. The vein crops out on both sides of a comparatively narrow steep-walled gulch draining southward into Queen Creek. On the east slope of the gulch, the vein has been mined upward to the surface in open stopes that extend almost continuously 300 feet along the strike. (See fig. 19.) In places the workings reach depths of 80 feet or more below the surface. The stopes range from 2.5 to 10 feet in width, indicating an average vein width of 4 to 5 feet. Virtually all workings are inaccessible.

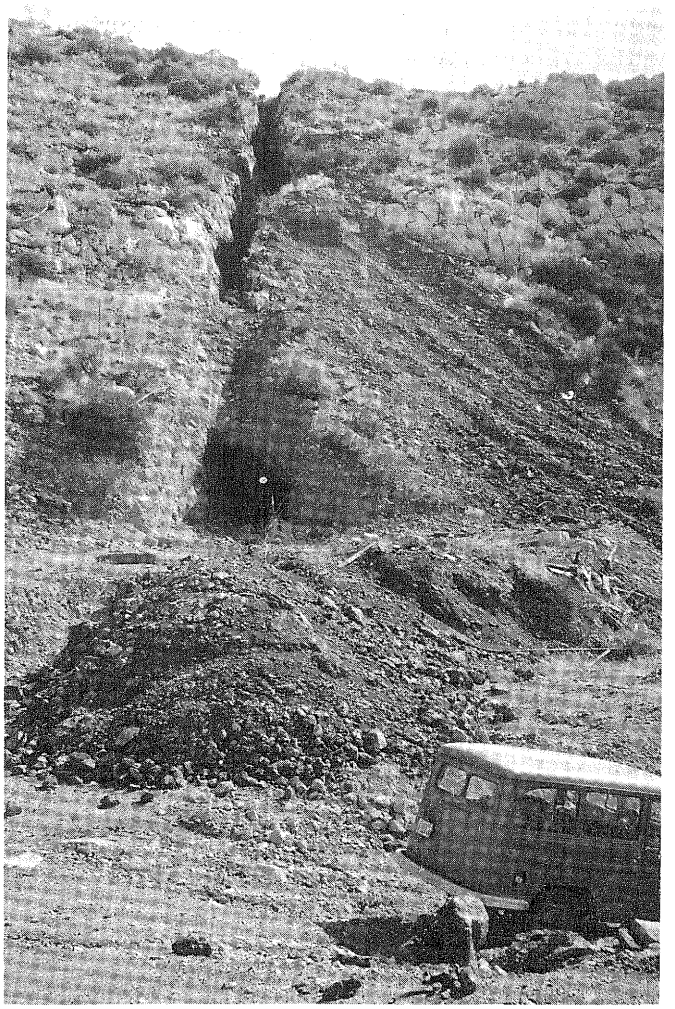

FIGURE 19. - Open Stopes, Rittenhouse Lease.

On the opposite side of the gulch, the vein crops out more or less continuously for some 400 feet westward up the steep hillside. This part of the vein has been explored by a short adit and several opencuts spaced at irregular intervals along the outcrop. Near its western end, the vein is only a few hundred feet north of the glory hole where waste is mined for stope fill in the Magma mine.

Pyrolusite, wad, and hard psilomelane are the chief manganese minerals. The gangue consists principally of calcite, iron oxide, and quartz. Wulfenite, a lead molybdate mineral, is present in places.

Two samples of the vein were taken in 1942 by the Federal Bureau of Mines. One sample, representing 2 feet of ore near the portal of the adit on the east side of the gulch, contained 27.1 percent manganese, 4.3 percent iron, 31.6 percent insoluble, and 7.7 ounces of silver per ton. The other sample, taken across a width of 6 feet near the portal of the adit on the west side of the gulch, assayed 23.8 percent manganese, 2.6 percent iron, 28.4 percent insoluble, and 10.85 ounces of silver per ton.

A manganese-bearing vein, similar in character but less extensive than the one worked by Rittenhouse, crops out in the gulch about 400 feet farther north. This occurrence is exposed for approximately 200 feet on the strike where its better mineralized sections range from 2 to 3 feet in width. In 1943 a small amount of ore containing about 25 percent manganese and 13 to 15 ounces of silver is said to have been mined and shipped from a short, shallow adit that follows the vein westward into the hillside.

Magma Vein

The Magma vein, which yields the bulk of the copper produced by Magma Copper Co., contains appreciable quantities of manganese in many places, especially along the eastern outcrop where it is exposed along the northern part of NW1/4 sec. 36, T. 1 S., R. 12 E. This area is 2 miles or more by road

northeast of the Superior Post Office and about 0.5 mile north of the Queen Creek bridge on U.S. Highway 60-70. (See fig. 18, p. 126.)

Some of the first claims, covering what is now known as the Magma vein, were located in 1875-76. The mine at that time was called the Silver Queen. Little is known of the production before 1910 when the property was acquired by the present owner, Magma Copper Co. Since that time the mine has been a constant and notable producer of copper associated with zinc, silver, and gold. Although small amounts of manganese ore reportedly were mined during World Wars I and II, the only known production of manganese ore from the Magma vein was shipped by lessees in 1955. This ore, totaling 300 to 400 tons and averaging about 26 percent manganese, was mined from opencuts near the eastern end of the outcrop and shipped to the Government purchasing depot in Deming, N. Mex. No manganese ore was being mined when the property was visited in November 1956.

The Magma vein occupies a steeply dipping, easterly trending fault zone cutting sedimentary and igneous rocks ranging in age from Precambrian to late Cretaceous. The zone can be traced on the surface for more than 3,000 feet, being limited on the west by a transverse fault and on the east by younger overlying lava flows. In some of the underground levels below the lava, the vein has been followed for 9,000 feet or more and for widths ranging from a few feet to more than 50 feet. The vein has been developed to a depth of about 4,800 feet below the surface, or some 1,200 feet below sea level. The copper minerals occur in distinct ore shoots replacing the crushed wall rock within the fault zones. Quite recently, sizable bodies of copper ore have been developed in a new section of the mine where the ore occurs as replacement deposits along limestone beds. When the mine was visited the daily production was about 1,500 tons of ore averaging 5.5 percent copper, 2 to 3 ounces of silver per ton, and 0.02 to 0.03 ounce of gold per ton.

The manganese minerals associated with the Magma fault occur in veins and as various-size irregular masses distributed erratically along parts of the zone. On the surface, the minerals are exposed sporadically for more than 1,200 feet along the general east-west trend of the fracturing. Some deposits are in the main fault and its branches and others along adjacent parallel fractures. Similar deposits of manganese oxide have been found underground in and near the vein in parts of the East 1,600- and 1,900-foot levels of the mine. Small amounts of rhodochrosite (manganese carbonate) are found in the deeper parts of the mine below the zone of oxidation.

The largest and most numerous surface deposits crop out a short distance northeast of the Magma No. 3 shaft, where the fault zone cuts across moderately dipping beds of the Escabrosa and Naco limestones. This region contains 10 or more separate manganiferous outcrops in an area roughly 900 feet in strike length and up to 250 feet in width. Some deposits follow steeply dipping fractures striking east-west; others are irregular masses following favorable horizons in the limestone beds. In this area the limestones strike N. 10° W. and dip 20° to 30° E.

The largest manganiferous deposit is near the east end of the vein outcrop and occupies the northern side of the zone. It has an exposed length of some 300 feet. Although it is manganiferous in places over widths of several tens of feet, the higher grade section ranges from 6 to 8 feet in width. For the most part it follows rather well defined fractures striking N. 80° W. and dipping about 75° N. The manganese ore shipped in 1955 came from a 200-foot opencut driven along this part of the deposit. Some ore extends outward from both sides of the opencut. That to the southwest appears as an irregular body replacing a limestone bed. It is not well exposed, and its thickness and lateral extent are not plain. Along the strike the deposit extends westward from the opencut about 100 feet to the edge of a southerly trending wash.

About 150 feet farther west on the opposite side of the wash, manganiferous deposits reappear along the projected trend of the north side of the zone. These deposits can be followed by frequent outcrops for 450 feet up the hillside to the top of the ridge lying northeast of the Superior townsite. The more prominent outcrops range from 50 to 130 feet in length and from 2 to 8 feet in width. Some contain shallow exploratory openings, but so far as is known no manganese ore has been produced from this part of the zone. Copper carbonate minerals are present in some of these deposits.

The southern boundary of the manganiferous area is marked by three separate outcrops exposed for 800 feet or more. They are alined in a general east-west direction and are 200 to 250 feet south of the deposits along the north side of the zone. A few small scattered deposits crop out in the intervening area. In the easternmost deposit along the south side of the area, manganese minerals occur in a steeply dipping fracture having an exposed length of 150 feet and ranging from 2 to 8 feet in width. Some manganese-bearing silver ore has been mined from this deposit from old open stopes which extend to the surface from an adit level. The maximum depth of these stopes is some 20 feet. Approximately 200 feet to the west, an irregular outcrop is exposed 120 feet along the strike and in places is as much as 20 feet wide. About 100 feet farther west near the summit of the ridge, the outcrop of the third deposit extends approximately 200 feet along the strike and ranges in width from 4 to 15 feet. In some wider parts of the last two deposits, the manganese appears to have spread laterally into limestone beds adjacent to the east-west fractures.

The chief manganese minerals are wad and pyrolusite, with minor amounts of psilomelane. Quartz, calcite, and silicified limestone are the principal gangue constituents.

Nunez Lease

The Nunez lease covers a group of manganese deposits on the property of Magma Copper Co. The deposits are 1,000 to 1,500 feet south of the Magma vein zone and lie in the western part of SW1/4NW1/4 sec. 36, T. 1 S., R. 12 E., about 1,000 feet north-northwest of the Queen Creek bridge on U.S. Highway 60-70.

The first manganese ore produced from this area was mined in 1954 after Edward Nunez, of Superior, Ariz., obtained a lease on the property from Magma Copper Co. Operations were continued under the name of Nukal Mining Co. until late in 1955, shortly before the closing of the Government purchasing depot in Deming, N. Mex. During this period, 6,486 long tons of ore was produced that averaged 24.5 percent manganese. Some 3,000 tons was shipped to the Government purchasing depot in Wenden, Ariz., and the balance to the Deming (N. Mex.) depot. All equipment had been removed and the property was idle when visited in November 1956.

The ore output came from four deposits in an area extending about 900 feet east-west and as much as 500 feet north-south. The area is on the steep eastern slope of the ridge lying east-northeast of Superior. All of the manganese deposits appear to be related to steeply dipping fracture zones cutting beds of the Escabrosa limestone. The fractures range in strike from N. 70° E. to N. 70° W. and in dip from vertical to 75° N. The limestone beds in the area trend about N. 5° W. and dip 25° E.

The largest manganiferous deposit in the area crops out near the base of the ridge within 100 feet of the right-of-way of U.S. Highway 60-70. In this deposit manganese is exposed on the surface over an irregular area some 400 feet in strike length and as much as 60 feet in width. The long dimension of the outcrop trends about N. 70° E. Some ore has been selectively mined from the higher grade parts of the outcrop. The principal workings consist of a 20-foot adit and two opencuts, the larger of which is about 50 feet long, 8 to 12 feet wide, and 18 feet at the face.

The second deposit crops out farther up the slope about 300 feet to the southwest. The outcrop of this deposit is lenticular and has an exposed length of about 250 feet. It strikes N. 70° W. and reaches a maximum width of some 50 feet, from which it tapers to a narrow fracture at each end. Much of the 1954-55 production was mined from the wider part of this deposit in an opencut about 80 feet long, 40 feet wide, and 30 feet deep at the face.

Approximately 300 feet west of this opencut the third productive deposit crops out and can be traced westward about 250 feet to the top of the ridge. The ore follows a vertical fracture striking N. 80° E. In a small area on the summit of the ridge the minerals spread out into the limestone beds adjacent to the fracture and form a semicircular mineralized area 20 feet or more in diameter. Excepting this local area, the ore along the fracture ranges from 3 to 6 feet in width. The workings consist of a shallow opencut and some underground drifting extending outward from the bottom of a vertical shaft estimated to be about 30 feet deep. The shaft is in the wide mineralized spot near the top of the ridge. All underground work was inaccessible when the property was visited.

The fourth productive deposit lies about 500 feet north of this shaft and near the south side of Magma Copper Co. limestone pit. In this deposit the manganese minerals occur along a near-vertical fracture zone striking N. 65° to 70° W. The zone is exposed for 150 feet or more along the strike and ranges from 8 to 10 feet in width. Ore has been mined near the eastern end

of the zone in an opencut about 100 feet long, 8 to 10 feet wide, and as much as 30 feet deep. Manganiferous calcite is abundant in parts of the deposit.

Wad and pyrolusite are the principal manganese minerals in the four deposits. Unreplaced limestone, quartz, and calcite are the chief gangue constituents.

Monarch Vein

The Monarch vein, named from the claim on which it occurs, is in Queen Creek Canyon about 3,000 feet south of the Magma vein. The deposit is on ground owned by Magma Copper Co. and lies in NW1/4SW1/4 sec. 36, T. 1 S., R. 12 E. It is about 1 mile by road northeast of the Superior Post Office by way of the old roadbed of U.S. Highway 60-70. The vein crops out on the west side of the old road. The portal of one of the main adits is only a short distance east across Queen Creek.

The Monarch claim was one of a large group owned in the early 1900's by Lake Superior & Arizona Copper Co. In 1920, all property held by this company was purchased by Magma Copper Co.

This deposit has been Pinal County's leading source of manganese ore. It was operated intermittently by lessees during both World Wars and again in 1954-55. Estimated production from 1918, when the first ore was shipped, to the end of 1955 has been 22,600 long tons of ore averaging 30 percent manganese and 10,157 long tons of heavy-media concentrates containing 28.6 percent manganese. Of this total, it is estimated that about 120 long tons of 40- to 44-percent ore was produced during World War I. In 1943-44, 4,330 long tons, averaging 30.7 percent manganese, was shipped to the Metals Reserve Company's stockpiles in Phoenix, Ariz., and Deming, N. Mex. During the next period of activity (1954-55) Al Stovall, of Phoenix, produced 18,150 long tons of ore averaging 29.9 percent manganese and 10,157 long tons of concentrates averaging 28.8 percent manganese. Some 10,000 tons of the ore produced by Stovall was shipped to the Government purchasing depot in Wenden, Ariz., and the rest of the ore and all concentrates were shipped to the Government purchasing depot in Deming, N. Mex. Estimates indicate that the concentrates were recovered from treating about 16,000 tons of crude ore in a semiportable, heavy-media plant erected by Stovall on the outskirts of Superior. The plant was dismantled and the equipment removed from the mine soon after the Deming depot was closed late in 1955. No work was in progress when the deposit was visited in November 1956, and most of the underground workings were inaccessible .

The ore in the Monarch vein occurs along a fault zone striking N. 80° to 85° E. and dipping 60° to 65° S. It cuts limestone beds trending N. 10° W. and dipping 15° to 25° E. The vein crops out on both sides of Queen Creek, which in this area flows southward.

The outcrop on the east side of the creek can be followed up the steep hillside about 300 feet to the new highway near the south end of the Queen Creek bridge. The manganese deposit pinches and swells along the outcrop and ranges in width from a few feet to as much as 20 feet. From the highway

eastward the outcrop is obscure. An opencut about 400 feet east of the highway exposes 2 to 4 feet of manganese ore along one wall of a fracture zone striking N. 80° E. This may be the eastward extension of the Monarch vein. Some exploratory stripping has been done in the area between the highway and the opencut, but little if any ore is evident in the stripped areas.

This eastern part of the vein has been developed and exploited from adit and shaft workings situated at the base of the hillside a short distance above the bottom of Queen Creek. All workings were inaccessible when the property was visited. As described in old reports and by officials of Magma Copper Co., the adit follows the vein eastward into the hillside about 300 feet where it reaches a maximum depth of 90 feet or more below the surface. The ore bodies above the adit level were mined in open stopes of various size and height. Below the adit level the ore was mined for an unknown length along the vein from winzes and an 80-foot shaft near the portal of the adit. Water was encountered in the lower part of the shaft. It was said that the deeper ore contained considerably more zinc than that in the upper levels.

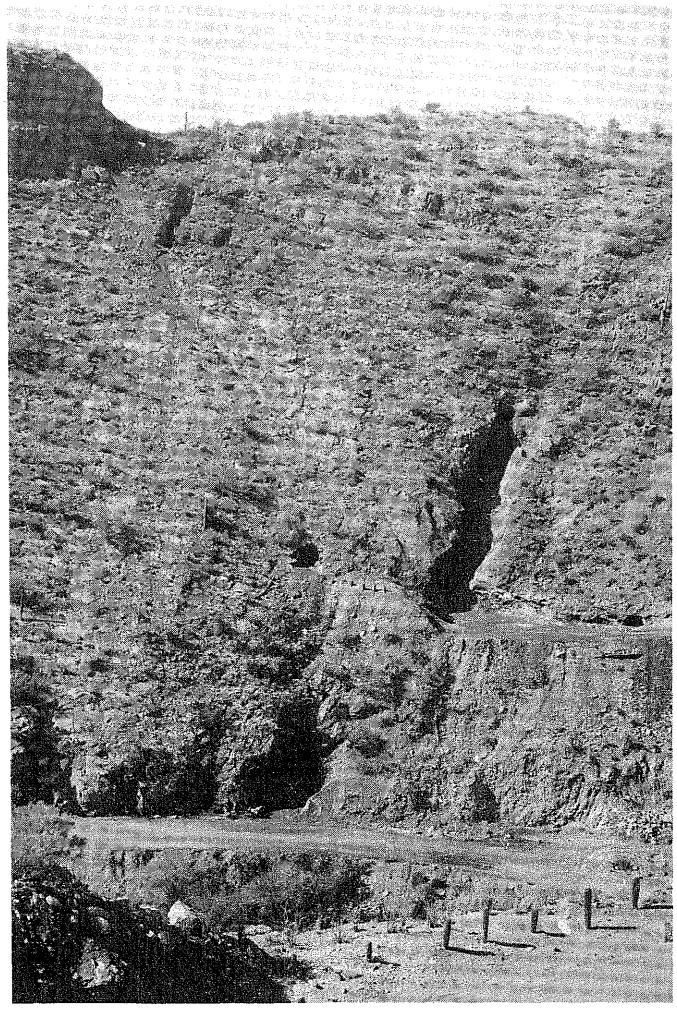

FIGURE 20. - Faulted Segments of Monarch Vein.

On the west side of Queen Creek, the vein crops out beside the old highway and continues westward up the slope of the ridge about 300 feet where it terminates against a northerly trending fault dipping 65° W. (fig. 20). The fault offsets the vein about 200 feet to the south. West of the fault the offset part of the vein continues westward along its normal strike about 80 feet, where it also ends abruptly against a second fault similar in attitude to the first. The second fault displaces the vein about 100 feet south of the first offset segment; therefore, the total horizontal displacement of the vein, caused by both faults, is 300 feet. West of the last fault the vein continues uninterruptedly along its normal strike to the top of the ridge and down the other slope for several hundred feet.

The workings on the west side of the creek comprise several opencuts and considerable underground work. At the base of the ridge immediately west of the old highway, a short adit and opencut expose the vein for a few tens of feet along

the strike. In this area veinlets and irregular bunches of manganese oxides are present in a zone that in places is as much as 30 feet wide. Little, if any, ore appears to have been mined from this part of the outcrop.

From a point about 100 feet west of the old highway, an open stope extends westward along the vein about 200 feet, ending against the first fault. The upper part of the ore in this opening appears to have been mined in an opencut 6 to 10 feet wide and as much as 30 feet deep. The ore underlying the opencut was stoped upward from shaft workings said to be some 60 feet deeper than the floor of the cut. The shaft and these lower workings were inaccessible when the property was visited. In places below the original floor of the opencut, the manganese minerals apparently had spread out laterally 20 feet or more into some limestone beds lying along the hanging wall of the vein.

The work on the offset segment of the vein, lying to the south between the two faults, consisted of an opencut about 80 feet long, 8 feet wide, and 25 feet deep at its west end.

On the southern offset of the vein where it crosses the summit of the ridge, the ore was mined upward from an adit to the surface in an open stope about 150 feet long, 6 to 8 feet wide, and over 50 feet deep. This part of the vein was encountered at greater depth in the Carlton tunnel, about 1,450 feet north of its portal in Queen Creek. The tunnel was driven in the early 1900's in search of copper-gold ore when the property was held by the Lake Superior & Arizona Copper Co. The segment of the Monarch vein where it was intersected on the Carlton tunnel level is about 300 feet vertically below its outcrop on the summit of the ridge. In 1954-55, manganese ore was mined from the vein in an open stope extending 50 to 60 feet above the tunnel level and from winze workings 25 feet or more below the floor of the tunnel. The stope above the level was about 100 feet in strike length and ranged from 4 to 8 feet in width. The work below the floor of the tunnel was inaccessible, and its extent was unknown. The ore produced by this work was said to have had a manganese content similar to that found in the upper part of the vein.

The chief manganese minerals are wad and pyrolusite, which occur in a gangue of siliceous limestone, quartz, and calcite. Small amounts of galena and wulfenite are present in part of the vein. Some of the ore contains appreciable quantities of silver.

Elm Canyon

The Elm Canyon deposit is about 1,500 feet south of the Monarch vein on the Excelsior claim of Magma Copper Co. It lies in SE1/4SW1/4 sec. 36, T. 1 S., R. 12 E., and crops out along the south side of U.S. Highway 60-70 about 0.9 mile east of the Superior Post Office. (See figs. 17 and 18, pp. 124 and 126.)

In 1954, lessees shipped about 1 carload of ore from the deposit to the Wenden purchasing depot. The ore, said to contain 20 to 30 percent manganese, was sorted from material broken in a short adit just below the highway on the east side of Elm Canyon.

The deposit is associated with a steeply dipping fault zone cutting beds of the Escabrosa limestone. The fault zone strikes eastward; the limestone trends N. 20° W. and dips about 40° E. The manganese minerals are exposed on the surface in an irregular area extending about 200 feet east-west along the strike of the fault zone. These minerals are exposed for greater distances north-south, where they have spread out laterally into the adjacent beds. In this area the manganese minerals, consisting largely of wad and pyrolusite, occur in various-size bunches, irregular masses, and veinlets separated by barren or poorly mineralized limestone. The larger and better mineralized masses are veinlike and follow the trend of the major shears within the zone. Along the east end of the deposit the manganese minerals leave the steeply dipping fractures and follow a limestone bed underlying a purplish shale member of the upper Escabrosa formation. The mineralized part of the bed, as much as several feet thick, extends outward from the fault zone for some 200 feet north and for a similar distance south to the edge of Elm Canyon wash. Farther south across the wash, small sporadic outcrops of iron-manganese minerals are exposed along the bed and up the steep hillside for 500 feet or more. At that point the deposit widens appreciably near a small transverse fault. Some ore was mined from the bed in this area in 1955 by lessees Guzman and Schwartz.

In addition to the 25-foot adit, the workings on the Elm Canyon deposit consist of a few shallow pits and opencuts. No work was in progress when the property was visited in December 1956.

Guzman Lease

The deposit, worked by Guzman and Schwartz under a lease from Magma Copper Co., is on the Red Cloud patented claim in the north-central part of sec. 2, T. 2 S., R. 12 E. about 1 mile east of Superior, Ariz. (See figs. 17 and 18, pp. 124 and 126.) It lies near the top of the ridge west of Elm Canyon and may be reached by a steep truck trail that branches southward from U.S. Highway 60-70 about 0.8 mile east of the Superior Post Office.

During 1954, Guzman and Schwartz shipped 271 long tons of sorted ore, averaging 17.8 percent manganese, from the deposit to the Government purchasing depot in Deming, N. Mex. The lease was abandoned late in 1954, and no work was in progress when the district was visited in December 1956.

The deposit from which the ore was mined replaces a limestone bed occupying the upper part of the Escabrosa formation. The mineralized member, lying directly beneath a stratum of purple shale, strikes N. 10° E. and dips 40° E. It can be traced more or less continuously several hundred feet southwest across the Red Cloud claim and north some 800 feet, where it forms a part of the Elm Canyon deposit. Along most of its outcrop in this area, the bed is marked by iron-manganese stain with sporadic deposits containing appreciable amounts of manganese oxide minerals. In the largest deposit, worked by Guzman and Schwartz, a fault zone crosses the bed at almost a right angle. Near the fault the manganese deposit is about 15 feet thick. No great distance beyond the fault the thickness decreases to 6 feet or less. The principal workings are near the fault and consist of an opencut and some shallow underground

work. The opencut is about 100 feet long and 8 to 15 feet wide, and it reaches a maximum depth of 12 feet. In the southern end of the opencut, an inclined shaft about 30 feet deep has been sunk on a strand of the best ore which ranges from 4 to 6 feet in thickness. The strand lies along the top of the bed immediately below the purple-shale stratum. Some lateral work has been done from the bottom of the shaft, but its extent is unknown as the shaft was inaccessible when the property was visited.

Approximately 200 feet north of the shaft, a manganese deposit about 6 feet thick is exposed in a shallow pit. About 80 feet farther north the favorable bed has been explored, probably for silver, by old inclined workings some 30 feet deep. In this area the bed dips 20° and contains an abundance of iron oxides with relatively little manganese.

The bed continues south several hundred feet beyond the transverse fault, but the manganese deposition is thin and sporadic.

Queen Creek

Manganese occurs in several places on the property of Queen Creek Copper Co., which holds 40 claims or more about one-half mile southeast of Superior. The claims, some of which are patented, cover parts of NE1/4 and NW1/4 sec. 2, T. 2 S., R. 12 E. (See figs. 17 and 18, pp. 124 and 126.) The manganese deposits in the northeast quarter are in Cross Canyon and are accessible by 1 mile of fair dirt road that branches east from State Highway 177 about 0.8 mile south of the Superior Post Office. The other mineralized areas are about one-half mile northwest of the terminus of the Cross Canyon road. They lie along the top of a prominent westerly trending ridge and can be reached only by a winding foot trail.

Queen Creek Copper Co. was organized and began prospecting the claims for gold-silver-copper ore in 1916. Operations were continued by the company until 1920. Since 1920, part of the property has been operated intermittently by lessees. Production is reported to have totaled several thousand tons of gold-silver-copper ore. Much of the ore was manganiferous, but so far as is known no appreciable amount of manganese ore, as such, has been shipped from the property.

The manganese minerals, exposed in the northwest quarter of sec. 2, occur largely along two fault zones cutting across beds of Escabrosa limestone. The fault zones are about 300 feet apart and both strike east-west and dip steeply south. The limestone beds trend about N. 30° W. and dip 30° to 35° E.

The northern fault with its subsidiary fractures forms a zone as much as 100 feet wide in which various-size bodies of manganese-iron minerals are exposed some 400 feet along the strike. The mineral bodies, surrounded by limestone, range from narrow veins to irregular masses 100 feet long and up to 20 feet wide. In some larger occurrences the deposition appears to have spread into beds adjacent to the east-west fractures.

The south zone is mineralized in places about 350 feet along the strike and as much as 20 feet in width. Although not well exposed, the mineralized zone appears to reach maximum width near the east end of the outcrop, then gradually narrows westward until it tapers out entirely. Both zones have been explored by scattered adits and shallow opencuts.

The manganese minerals occurring in Cross Canyon are associated with fracture zones cutting diagonally across beds of the Escabrosa limestone. The zones are exposed on both sides of the canyon. The one on the northwest side strikes N. 65° W., dips 45° SW., and has an exposed length of about 300 feet. The mineralized part varies greatly in width, ranging from some 30 feet near the bottom of the canyon to 3 to 4 feet farther northwest. Manganiferous silver ore has been mined in the past from part of this zone in workings consisting of two adits and a series of opencuts extending about 250 feet along the outcrop. The openings range from 4 to 6 feet in width and some attain a depth of 18 feet. In 1954, lessees explored the wider part of the zone in search of marketable manganese ore. Considerable manganiferous material was broken in an opencut near the bottom of the hill, but so far as is known no manganese ore was shipped. The broken material in the cut consisted largely of manganiferous calcite.

Approximately 650 feet east of the opencut, another manganiferous zone has been explored, probably for metals other than manganese, through an old inaccessible inclined shaft said to be about 175 feet deep. This zone, lying near the bottom of a wash, is largely obscured by detritus. It has an exposed length of 30 feet or more, strikes S. 50° E., and dips about 55° SW. The manganiferous part of the zone is about 6 feet wide near the shaft.

Some 300 feet northwest of the shaft, a manganiferous deposit crops out in an irregular zone about 150 feet along the strike. It ranges in width from a few feet to 8 feet, trends N. 60° W., and dips steeply northeast. The only work consists of an old opencut and a shallow pit.

The chief manganese minerals on the property are wad, pyrolusite, and small amounts of psilomelane. The gangue comprises siliceous limestone, iron oxides, calcite, and quartz. The property was idle when the area was visited in January 1957.

Lone Star

This manganiferous deposit is on the Lone Star claim, one of a large group owned by Belmont Copper Mining Co. It is about 2.5 miles by road southeast of Superior in NE1/4SE1/4 sec. 11, T. 2 S., R. 12 E. (See figs. 17 and 18, pp. 124 and 126.) It is accessible from the Belmont mine road, which branches eastward from State Highway 177 about 2 miles south of the Superior Post Office. Other occurrences on claims to the northeast are accessible from the same road.

Mining operations have been conducted intermittently on the Belmont property since the late 1890's, when silver-gold ore was mined from several near-surface deposits. Later, the deeper complex ores, containing copper, lead,

and zinc and some precious metals, were produced from extensive underground workings extending from the 1,600-foot Belmont shaft. Although much of this ore was more or less manganiferous, no records indicate that any ore chiefly valuable for its manganese content ever was shipped from the property.

The manganese deposit on the Lone Star claim is along a bed in the Martin limestone, striking N. 60° W. and dipping 25° NE. The bed is exposed for 200 feet or more along the strike and ranges from 2 to 4 feet in thickness. To the northwest the minerals gradually fade out along the outcrop. Overburden obscures the further extent of the deposit to the southeast.

The bed has been explored by an old inclined shaft following the deposit down dip about 100 feet. A short adit and a few shallow pits comprise the rest of the work.

Approximately 1,500 feet to the northeast, another deposit was found in the Belmont tunnel. The deposit was inaccessible when visited but was described by Jones[40/] in 1920 as follows:

> The ore body, which was encountered about 800 feet from the portal of the tunnel, occurs in limestone just above the contact with the underlying quartzite near a prominent fault that strikes N. 70° W. and dips steeply southwest. The ore body had been explored for 100 feet on the dip of the bed and 15 feet on its strike and is from 1 to 3 feet thick. It consists of manganese and iron oxides and variable amounts of cerussite, wulfenite, and vanadinite crystals***. The upper and larger part of the deposit consists of an intergrowth of psilomelane, manganite, and perhaps some braunite, with minor amounts of iron oxides and crystals of wulfenite and cerussite in cavities in the ore. Some of the manganite is in bundles of fine fiber that somewhat resemble asbestos in texture. A partial assay of selected manganese ore by The Colorado Fuel & Iron Co. is said to have yielded 34 percent of manganese, but the ore is said to be objectionable because of its lead content.
>
> About a quarter of a mile east of the main tunnel***an old tunnel was driven on a vertical fissure that strikes N. 20° W. and cuts massive limestone. Some copper ore was stoped from the vein, but the workings are now caved, and the size and nature of the deposit could not be determined from an examination of the surface. In addition to some copper-stained rock the dump contains 10 tons of manganese-bearing material. Specimens consist dominantly of a massive aggregate of coarse, platy black crystals with a little psilomelane and minute seams of manganite which cut the other oxides. The platy crystals are hard and give a dark-brown streak.*** The mineral is probably braunite.

No mining was in progress on the property when the area was visited in January 1957.

40/ Jones, E. L., Jr., and Ransome, F. L., Deposits of Manganese Ore in Arizona: Geol. Survey Bull. 710, pt. I, pp. 164-165.

Climax

The Climax deposit is on a group of six unpatented claims along the south fork of Pacific Canyon, 3.5 miles by road southeast of Superior, Ariz. The group lies in the south-central part of sec. 12, T. 2 S., R. 12 E. and is accessible by a fair dirt road that branches eastward from State Highway 177 about 2.8 miles south of the Superior Post Office. (See figs. 17 and 18, pp. 124 and 126.)

The claims, now known as the Pacific group, were once part of the property held by the old Grand Pacific Mining Co. In 1951 they were relocated by the present owner, Frederick S. Smith, of Superior, Ariz. The first manganese from the claims was mined in 1954 by lessees Guzman and Schwartz, who shipped 220 long tons of sorted ore averaging 25.6 percent manganese. In 1955, about 47 long tons of similar-grade ore was mined by lessee Juan Ortega. All the ore was shipped to the Government purchasing depot in Deming, N. Mex. The property was idle when the district was visited in November 1956.

The deposit is in the Martin limestone along a fault zone immediately above the Troy quartzite. The zone strikes about N. 50° E. and dips 70° SW. Most of the manganese occurs as a lenticular body about 100 feet long and up to 12 feet wide. The deposit has been mined in an opencut 80 feet long and from now-inaccessible underground workings below the cut that reach a maximum depth of 30 to 40 feet below the surface. Beyond the southwest end of the opencut the ore appears to terminate against a transverse fault. Much iron oxide with some copper minerals are present in this part of the deposit. Beyond the northeast end of the workings the zone contains widely spaced stringers and small erratic bunches of manganese minerals for 150 feet or more along the outcrop. In the wider, exploited section of the deposit the manganese minerals occur largely as irregular masses several feet in their greatest dimension, separated by various-size bunches of barren limestone.

The chief manganese minerals are wad, pyrolusite, and psilomelane. The gangue consists of limestone, manganiferous calcite, and iron oxides.

Stacy Claims

The Stacy claims comprise four unpatented claims at the southern end of the Superior manganiferous area in SE1/4SW1/4 sec. 14, T. 2 S., R. 12 E. (See figs. 17 and 18, pp. 124 and 126.) The property can be reached from Superior by traveling south on State Highway 177 for 3.6 miles, then right on a dirt road a few hundred feet to a road fork. The left-hand fork is followed south-southwest about 0.5 mile to the middle of the property.

The claims were explored for copper-silver ore in the early 1900's, when they were held by Magmatic Copper Co. During World War II, the group was acquired by G. W. Stacy and William Stacy. At present the claims are owned by William Stacy and A. A. Goodspor, of Superior, Ariz. In 1954, lessees explored some of the manganiferous outcrops on the claims, but as far as is known no manganese ore was ever shipped from the property. The claims were idle and the underground work was inaccessible when the area was visited in November 1956.

The manganese minerals occur along fracture zones and as bedded deposits in limestone. Two steeply dipping fracture zones crop out on the property. They are about 500 feet apart. Both strike north, cutting the limestone beds which dip 30° to 35° E. In part of the area separating the mineralized zones, the limestone is covered with dacite, a younger volcanic rock, identical to that forming the cliffs of Apache Leap.

The east zone is manganiferous in places on the surface for about 800 feet along the strike and attains widths of 100 feet. The west zone can be followed by sporadic outcrops for some 300 feet on the strike and in some places is 30 feet wide. The manganese minerals, accompanied by much iron oxide, occur in the zones as interlacing seams, veinlets, and disconnected irregular masses separated by barren or iron-stained limestone. Some larger mineralized masses are several feet wide and reach lengths of a few tens of feet. In places the minerals follow bedding planes in the limestone adjacent to the steeply dipping fractures.

About midway between the two mineralized zones, a vertical shaft was sunk by Magmatic Copper Co. to a depth of about 120 feet. At the same time, two shallower shafts and an adit were completed in different parts of the property. All of this old underground work is now caved. The following description is taken from earlier reports by engineers of the Federal Bureau of Mines, who examined the deeper workings in 1942 when they were still accessible.

The main shaft was started in the dacite flow but soon passed into the underlying limestone. Manganese minerals were found at a depth of 85 feet and persisted in the shaft to a depth of 107 feet. About 97 feet below the surface, two drifts, each about 15 feet long, were driven from each end of the shaft. When the property was visited in 1942, the faces of both drifts were still in well-mineralized material. A sample cut from the back to the floor on both walls of the southwest drift contained 15.4 percent manganese, 31.0 percent iron, and 0.25 ounce of silver per ton. A grab sample of the manganiferous material on the shaft dump assayed 15.8 percent manganese and 33 percent iron. This mineralized body does not show on the surface, and it correlation with the other mineralized zones is not evident. Jones,41/ in his description of the occurrence, states that the body found in the shaft appears to dip 40° W.

Several samples taken from different places on the outcrops of larger exposures contained 13 to 15.5 percent manganese and 25 to 30 percent iron.

Recent exploration consisted of some bulldozer stripping, trenching, and opencutting along the more promising outcrops. Considerable material was broken, presumably in an effort to find ore of marketable grade.

The chief manganese minerals are wad and pyrolusite. Limonite, specular hematite, manganiferous siderite, and calcite occur with the ore minerals.

41/ Work cited in footnote 40 (p. 140), p. 163.

Reymert Mine

The Reymert mine, a former producer of manganese-bearing silver ore, is 8.5 miles by road southwest of Superior, Ariz. The property comprises a group of 18 mining claims covering parts of secs. 15, 22, 23, 26, and 27, T. 2 S., R. 11 E. (See fig. 17, p. 124.) The area may be reached from Superior by traveling west 5.2 miles on U.S. Highway 60-70, then 0.4 mile south on a dirt road to the old highway. This road is followed 0.4 mile west to a left-hand branch which terminates on the property.

Some of the claims were located in 1885 by John Reymert. Production of silver ore commenced soon thereafter and was continued intermittently by several companies and lessees until about 1950. Reymert Extension Silver Mines, Inc., of Superior, Ariz., is the present owner of the claims. Production from the property to the end of 1950 is said to have totaled about 175,000 tons of ore averaging 15.5 ounces of silver per ton and a little manganese. Nearly all the ore was shipped to the copper smelters in Superior and Miami, Ariz., and payments were made only on the silver content. No manganese ore as such has been produced. The average amount of manganese in the shipped ore is not known. Available shipment records, covering nearly 10,000 tons, show an average manganese content of 2.5 percent. A 15-ton sample of the ore, collected in 1944 by the Federal Bureau of Mines for metallurgical testing,42/ contained 4.75 percent manganese and 16.4 ounces of silver per ton. Other samples, taken from different parts of the mine by various examiners, have shown a manganese content ranging from 1.1 to 3.6 percent.

The deposit occurs in a fissure zone cutting Precambrian Pinal schist. The zone ranges from 20 to 100 feet in width. Its manganese-stained outcrop can be readily traced for more than 6,000 feet along the strike. It trends northerly and dips from vertical to 75° E. Part of the zone has been developed extensively from two shafts with several thousand feet of lateral workings. The shafts are about 2,000 feet apart, and both are approximately 400 feet deep. The shipped ore was selectively mined from comparatively narrow elongated oreshoots localized largely along the walls of the zone. The oreshoots ranged from 3 to 15 feet in width and from a few tens of feet to several hundred feet in length. The material separating the oreshoots consists of barren or lower grade vein matter.

In 1945, G. M. Colvocoresses, in a report to Reymert Mining Co., estimated the reserves remaining in the mine above the 200-foot level to be 300,000 to 500,000 tons containing 8 to 10 ounces of silver per ton and about 3.5 percent manganese.

The principal minerals in the deposit are barite, quartz, limonite, manganiferous calcite, and wad. Small quantities of pyrolusite are present in places along the outcrop.

42/ Romslo, T. M., and Ravitz, S. F., Arizona Manganese-Silver Ores: Bureau of Mines Rept. of Investigation 4097, 1947, 13 pp.

In 1945 the 15-ton Reymert sample was tested in the Salt Lake City laboratory of the Federal Bureau of Mines. The dithionate process was used, in which the manganese was extracted with sulfur dioxide gas and the resulting leached residue was treated by cyanidation or flotation to recover the silver. The results of this work showed that the manganese could be recovered readily, but recovery of silver was poor by either cyanidation or flotation.

Crescent Deposit

This deposit has been known in the past by several names. In 1917 it was called the Tarr and Harper mine; during World War II, the Orsen Branch property; and at other times, the San Pedro or Putnam Wash deposit. It is on State land in the center of sec. 8, T. 7 S., R. 16 E., about 12 miles by road northwest of the town of Mammoth, Ariz. (See fig. 17, p. 124.) The property can be reached from Mammoth by traveling north 10.4 miles on State Highway 77, then left on a dirt road which crosses the San Pedro River. This road is followed 0.6 mile to a left-hand fork, which crosses the railroad and enters the sandy bed of Putnam Wash. The wash is followed west about 0.5 mile to the property. The main deposits lie in the hills bordering the north side of the wash at an altitude of 2,400 feet above sea level.

The first five claims were located in 1916 by Tarr and Harper. The deposit was worked in 1917 by Arizona Rare Metals Co., which produced 407 tons of sorted ore containing about 40 percent manganese.43/ In 1918, R. D. Harper resumed operations and shipped five carloads of ore early in the year. After the end of World War I, the claims were allowed to lapse and were relocated in 1936 by Orsen Branch and R. B. Giffen.

In 1943 the property was leased to Jamison and Ward, and a small amount of ore is said to have been shipped to the Kaiser steel mill at Fontana, Calif. In 1953 the claims were acquired under a mineral lease from the State of Arizona by Grant Godfrey and associates, of Safford, Ariz. During 1953-54, 2,825 long tons of ore, averaging 19.8 percent manganese, was shipped from the deposit to the Government purchasing depot in Deming, N. Mex. Additional shipments, amounting to several hundred tons, were made to the depot, but no payment was made because the ore was below the minimum acceptable grade of 15 percent manganese. Of the 1953-54 production, about 2,740 tons was shipped in the name of Grant Godfrey, one of the coowners of the State lease, and the balance was shipped by M. N. West, a sublessee. The property was idle when the district was visited in October 1956.

The property lies in an area of complexly faulted and tilted blocks of the Apache sedimentary rocks which border the northeast margin of the relatively small low-lying Black Hills. The more important manganese deposits on the property are along fracture zones in the Mescal limestone and the adjacent quartzites. A few small deposits have been found along narrow fractures in the fanglomerates which overlie the older sedimentary rocks. Most of the mineralized fracture zones follow the bedding planes in the older rocks, which

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43/ Work cited in footnote 40 (p. 140), p. 170.

strike N. 20° W. to N. 45° W. and dip 25° to 45° NE. The principal deposits on the claims crop out along the sides of two northwesterly trending gulches which drain southeasterly into Putnam Wash. The gulches are 500 to 600 feet apart and separated by a steep-sided ridge rising some 80 feet above their channels.

The entire output of ore has been mined from the deposit which crops out in the gulch to the east. In this area the mineralized zone ranges from 4 to 20 feet in thickness and is traceable for more than 600 feet along the strike. Here the manganese minerals occur in the limestone above a well-defined bedding-plane fracture striking northwest and dipping about 45° NE. This fracture marks the contact between the limestone and an underlying diabase sill. In places the sill has an exposed thickness of as much as 60 feet and is traceable about 500 feet along the bottom of the gulch to the northwest and about 1,000 feet or more to the southeast on the opposite side of Putnam wash. The top, or hanging wall of the sill, as exposed along the east side of the gulch, appears to conform to the strike and dip of the overlying ore zone. On the opposite side of the gulch, the western margin of the intrusive diabase terminates against a northwesterly trending strike fault dipping 35° to 40° SW. The up-dip extension of the ore zone, largely eroded in the channel of the gulch, reappears immediately west of the strike fault and is exposed along the dip for several tens of feet before passing under the overburden covering the steep hillside along the west side of the gulch. In this area the deposit dips about 25° NE., and near its southeast end attains a thickness of 20 feet. It pinches and swells along the strike and in places is only 4 feet thick. A steeply dipping fault striking N. 65° W. appears to limit the extension of this deposit to the southeast.

Over the ridge to the west, manganese minerals occur in an irregular zone of fracturing and brecciation which crops out along the east side of the neighboring gulch. The zone strikes northwest, ranges from a few feet to as much as 20 feet in width, and is exposed more or less continuously about 500 feet along the strike. The exploratory work, limited to one or two small prospect pits, is insufficient to indicate accurately the direction or angle of dip. In places the minerals appear to replace limestone beds dipping moderately to the northeast, suggesting that the deposit may be related to the one in the east gulch. In other places along the outcrop, especially near the southeast end, the manganese minerals occur in steeply dipping fractures apparently cutting beds of quartzite. Although part of this zone is well mineralized, it lacks the higher grade lenses of ore that were found in the deposit to the east.

The ore minerals in the deposits consist of psilomelane, pyrolusite, and manganite, which occur in irregular lenticular masses, veinlets, and interlacing seams surrounding fragments of the unreplaced wall rocks. The chief gangue minerals are iron oxides, quartz, and calcite.

The workings, largely confined to the deposit along the east side of the easternmost gulch, consist of three adits, a 50-foot inclined shaft, and a vertical shaft said to be 80 feet deep. Both shafts and much of the other underground work were inaccessible when visited. The higher grade sections

of the zone have been mined upward from the underground openings to the surface in irregular open stopes, ranging from 3 to 6 feet wide. The stopes, separated by pillars of various lengths, extend about 450 feet along the length of the outcrop.

A substantial amount of the ore produced in 1953-54 was mined from an opencut at the southeast end of the deposit along the west side of the gulch, some 80 feet west of the underground work and about 50 feet higher. The cut was about 45 feet wide and extended approximately 65 feet along the strike of the deposit. Irregular bunches of manganese oxides, intermixed with iron oxides, were exposed in the face of the cut over widths as much as 20 feet. A large grab sample, taken from some of the material broken in the opening, contained 11.3 percent manganese.

Bench-scale physical beneficiation and hydrometallurgical tests were made on a 300-pound grab sample of ore from the southeast end of the Crescent deposit to determine the best procedure for concentrating the manganese into a metallurgical-grade product. A partial chemical analysis of the sample gave 11.5 percent Mn, 4.9 percent Fe, 1.7 percent $CaCO_3$, 0.01 percent Pb, 0.02 percent Zn, and 0.05 percent Cu. Microscopic examination of a representative fraction of the ore revealed that it was a fine-grained sandstone containing psilomelane, limonite, hematite, calcite, and manganite. The association of psilomelane with opaline silica of the sandstone was extremely intimate, and grinding to about 325-mesh was indicated for good liberation of the manganese and gangue minerals.

Several methods of concentrating the ore were investigated. These were sink-and-float concentration, tabling, flotation, and sulfur dioxide leaching of coarse and fine feeds by percolation and agitation.

Before sink-float concentration, the ore was crushed to minus-3/4-inch and screened on a 10-mesh sieve. The plus-10-mesh fraction then was separated at a specific gravity of 2.94. Some concentration of the manganese was obtained, but recovery of a metallurgical-grade concentrate proved impracticable. The sink product assayed 26.3 percent Mn, and the recovery of manganese was only 47 percent.

Representative samples of the ore were crushed to minus-10- and minus-20-mesh for wet tabling. These charges were deslimed in a cone classifier at 20 microns before tabling the sands. A table concentrate, assaying 24.7 percent Mn and accounting for a manganese recovery of 37.6 percent was obtained from the minus-10-mesh feed. Tests on the minus-20-mesh feed gave substantially the same results.

Grinding the ore to pass 325-mesh was required for good liberation of the manganese minerals from the gangue. Oil-emulsion flotation of the manganese from minus-325-mesh charges of the ore failed to yield a high-grade manganese concentrate owing to iron-stained quartz and hematite gangue that persisted in floating. The highest grade concentrates assayed only 35 percent Mn. Efforts to retard the activated quartz and hematite by using conventional gangue depressants in either alkaline or acid pulps were unsuccessful. Better

results were obtained by flotation of a composite product comprising the table concentrate, table middling, and minus-20-micron slime obtained in the tabling test of the 10-mesh feed. Flotation of this product, which assayed 20.5 percent Mn and accounted for 74.8 percent of the manganese in the ore, yielded a metallurgical-grade concentrate assaying 40.0 percent Mn, 11.3 percent SiO_2, 1.1 percent Al_2O_3, 5.7 percent Fe, and 0.10 percent Cu. The lead and zinc content of the concentrate also met specifications for ferrograde manganese. The manganese recovery from the product was 70 percent. However, on the basis of the original ore only 52.4 percent of the manganese was recovered.

A 2-hour, batch, sulfur dioxide, agitation leaching test was made on a pulp of the minus-100-mesh ore. A 10-percent SO_2-air mixture was fed to the leach cell at the highest feed rate commensurate with utilization. The agitation procedure extracted 99 percent of the manganese with a sulfur dioxide consumption of 2.4 pounds per pound of manganese extracted. Dithionate formation was 0.9 pound per pound of manganese dissolved, which was more than enough to compensate losses that would be incurred in the manganese hydroxide product and in washing the leach residues if recovery of the manganese from the leach solution had been attempted.

Bench-scale percolation leaching tests with sulfur dioxide also were made on minus-1/4-inch and 1/2-inch charges of the ore. Briefly described, the procedure embraced alternate upward passage of a SO_2-air mixture through the moist agglomerated ore charges to solubilize the manganese and downward percolation with water to extract the soluble manganese. Treatment of the minus-1/4-inch feed for 3 days recovered 90.6 percent of the manganese with a sulfur dioxide consumption of 3.1 pounds per pound of manganese extracted. Leaching the minus-1/2-inch ore for the same length of time recovered 81.8 percent of the manganese; sulfur dioxide consumption was about the same as that for the 1.4-inch feed. Dithionate formation in the two tests was about 1 pound per pound of manganese dissolved.

Amenability tests on the Crescent ore have demonstrated that leaching with sulfur dioxide will yield good manganese extractions. Concentration of the ore by gravity methods alone is impracticable because of the intimate interlocking of the manganese and gangue. Gravity concentration complemented by flotation, on the other hand, gives a manganese concentrate meeting metallurgical-grade specifications, but manganese recovery is low.

Swingle Claims

The Swingle or Black Reef property consists of two unpatented claims on the western flank of the Galiuro Range at the base of Table Mountain in sec. 20, T. 7 S., R. 18 E. (See fig. 17, p. 124.) The claims are about 13 miles by road northeast of Mammoth, Ariz., and may be reached from the town by traveling north 2.4 miles on State Highway 77, thence right on a dirt road 1 mile to a left-hand branch. This branch is followed northeast 7.6 miles to the upper Miller Ranch. From there the deposit is 3 miles to the northeast and is reached by a winding "jeep" trail with steep grades and sandy washes. The altitude of the property is about 4,500 feet.

The claims, called the Prosperity and Black Monster, were located in 1932 by the present owner, George Swingle, of Winkelman, Ariz. During World War II, the property was leased to Leo Farrington and T. R. Addington, who called it the Black Reef. According to George Swingle, about 100 tons of the ore was shipped at that time as a fertilizer and soil builder.

In 1941, a 2-ton sample of the ore was collected by the Federal Bureau of Mines for metallurgical testing. From the results of the ore-dressing tests made upon this sample in the Bureau's Salt Lake City laboratory, it was concluded, that no appreciable liberation of the iron oxides could be made in feasible grinding ranges because of the complex association of the manganese and iron oxides. Therefore, no marketable manganese products were obtained by tabling, manganese flotation, or magnetic separation. However, the untreated ore, which contained 19.9 percent manganese and 35.8 percent iron, was exceptionally low in objectionable impurities and might be marketed directly as spiegeleisen ore.

The minerals occur in fractures traversing beds of limestone and quartzite of Precambrian age. These rocks form the lower part of the steep escarpment bordering the western side of Table Mountain. Precambrian schists are exposed a few hundred feet south of the deposit. The area occupied by the manganiferous deposits contains several faults. These faults have tilted the beds and so obscured the relationship of the mineralized outcrops that it is not clear whether they are offset segments of a single deposit or represent two or more separate ones. The largest deposit appears to be a vein following a fault fracture striking N. 45° to 50° E. and dipping 60° to 70° SE., which crosses the bedding of the enclosing rocks in some places and follows the beds in other places. At the southwest end, the mineralized part of the vein is 10 to 15 feet wide for approximately 60 feet along the strike. Beyond that, the outcrop narrows to 6 or 8 feet and pinches out rather abruptly to the northeast about 150 feet from the southwest end.

The deposit has been explored at the southwest end along the strike by an opencut about 30 feet long and 10 to 15 feet wide. From the northeast end of the cut, a drift follows the vein for 30 feet, reaching a depth of some 20 feet below the outcrop. Near the center of the drift, a short crosscut extends into the hanging wall. Both the face of the drift and the sides of the crosscut are well mineralized. A shallow winze has been sunk in the floor of the opencut. An old vertical shaft said to be 60 feet deep is situated east of these workings on the hanging-wall side of the vein some 30 feet from the outcrop. Manganiferous material on the shaft dump indicates that the shaft, or workings from it, may have intersected the down-dip extension of the deposit. The winze was filled within a few feet of the floor of the cut, and the shaft was inaccessible when the property was visited.

Approximately 75 feet to the west, near the top of the hill, several manganiferous occurrences are exposed some 200 feet along the strike. In this area the manganese and iron oxides are present in disconnected irregular masses in a zone ranging from 6 to 8 feet in thickness. The zone conforms to the bedding of the limestone, which strikes northeast and dips 20° to 30° SE. at nearly the same angle as the slope of the hillside. This dip is in

contrast to the much steeper dip apparent in the previously described occurrence. In the western area, the exposed masses of ore range from 1 to 3 feet in thickness and are distributed erratically in the soft altered limestone comprising the zone. The workings consist of scattered opencuts and two short adits. Much of the adit work is caved and inaccessible.

The ore is composed essentially of hematite intimately interlocked with pyrolusite and minor amounts of psilomelane. The gangue consists of small amounts of quartz and calcite.

Three samples taken at wide intervals along the outcrop of the principal deposit, across an average vein width of 10 feet, contained 18.5 percent manganese, 38.2 percent iron, 4.2 percent insoluble, and 0.05 percent phosphorus.

North Star Group

The North Star group, also known as the Bear-Buzan property, is about 13.5 miles by road northwest of Mammoth, Ariz., in sec. 30, T. 7 S., R. 16 E. (See fig. 17, p. 124.) The property can be reached from Mammoth by traveling 2.4 miles north on State Highway 77, then left or west on a dirt road following the west side of the San Pedro River 6.5 miles to Capgage Wash, then up this sandy wash, keeping to the right at all road forks, 4.7 miles.

The claims were first located in 1918 by J. W. Norton and were known as the Mogul group.[44/] No ore was shipped at the time, and eventually the claims were allowed to lapse. In 1940 they were relocated by W. D. Beard and Austin Buzan. Some years later amended locations were filed by the present owner, Austin Buzan, of Mammoth, Ariz. The claims were recorded at that time as the Red Bear Nos. 1 to 5.

In 1941 the more favorable appearing outcrops were trenched and sampled by the Federal Bureau of Mines to determine the probable extent and grade of the deposits and obtain large bulk samples for metallurgical testing. Two classes of ore were taken for the metallurgical work, namely, lower grade material thought to represent mine-run ore and higher grade material hand-sorted from the narrower and enriched sections of the deposits. The low-grade ore contained 8.4 percent manganese, and the high-grade ore assayed 32.4 percent manganese. Concentration tests on these samples by tabling in the laboratory of the Bureau of Mines at Salt Lake City, Utah, showed manganese recoveries of 52 and 80 percent on the low- and high-grade ores, respectively. After sintering, the resulting table concentrates assay about 48 percent manganese.

The small samples of ore taken in the trenches for assaying had a weighted average of 20.4 percent manganese. The ore body from which these samples were taken was 150 feet long and averaged 2.5 feet wide.

In 1953 the property was leased to Crystal Dark Mining & Milling Co., which shipped 58.7 long tons of sorted ore averaging about 21 percent

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44/ Wilson, E. D., and Butler, G. M., Manganese Deposits in Arizona: Arizona Bureau of Mines Bull. 127, p. 86.

manganese to the Government purchasing depot in Deming, N. Mex. The following year, C. T. Collopy leased the claims and shipped about 25 long tons of sorted ore containing 25.7 percent manganese to the Deming depot. The property was idle when the area was visited in October 1956.

The manganese minerals on the claims are in sheared granitic rocks along a zone striking north-northwest and dipping 50° to 60° SW. The zone is exposed in places for 1,200 feet or more along the strike and in some areas contains mineralized rock over widths ranging from 10 to more than 100 feet. Most of the ore minerals in the zone occur in a series of veins and fractures of different size filled with calcite. The mineralized fractures are roughly parallel and conform to the strike and dip of the zone. Near its southernmost exposure, the zone contains 12 or more of these manganiferous fractures across a width of 110 feet. The fractures range from a few inches to 2 feet in width and are separated by 3 to 10 feet of unmineralized granite. Some of the wider veinlike fractures persist 100 feet or more along the strike. This part of the zone has been exposed by stripping about 200 feet along the strike. Immediately south of the stripped area, the projected extension of the zone is covered with alluvium.

Approximately 300 feet to the northwest another mineralized area is exposed in places about 350 feet along the strike. In parts of this area the zone is as much as 20 feet wide and contains several overlapping mineralized fractures ranging from 1 to 3 feet in width, separated by either granite or sparsely mineralized black calcite. This part of the zone has been explored by trenching and a few shallow opencuts.

About 150 feet northwest of this work, the zone appears to narrow, the better deposition being confined to a single fracture about 2 feet wide which is exposed in places approximately 100 feet along the strike. This fracture is the northernmost exposure, and any further extent of the zone to the northwest is obscured by overburden. The workings on this part of the zone comprise a shallow opencut about 100 feet long, a 30-foot adit, and an inclined shaft reaching a depth of some 30 feet. The minerals in the lower part of the shaft consist of manganiferous calcite with occasional stringers and small bunches of manganese oxides.

The chief ore minerals are psilomelane and pyrolusite, which occur as seams, veinlets, and small podlike masses distributed erratically along the fractures. The gangue is composed mainly of coarsely crystalline black and white calcite.

Zig Zag Group

The Zig Zag group of five unpatented claims, formerly known as the Chamberlain and later the Hess property, is 12 miles by road southeast of Florence, Ariz., in sec. 12, T. 6 S., R. 10 E. (See fig. 17, p. 124.) The claims are accessible by 2.5 miles of dirt road that branches eastward from U.S. Highway 80-89 about 9.8 miles south of Florence. The deposits lie on the west slope of a small isolated hill rising about 100 feet above the surrounding desert plain.

The claims, originally called the Manganese Queen and Manganese King, were located in World War I and operated in 1917 by a Mr. Chamberlain. Production totaled 74 tons of sorted ore averaging about 40 percent manganese. During World War II, the property was acquired by H. Weir Hess and operated by Sierra Metals Co., of Pittsburgh, Pa. Unauthenticated reports indicate that 400 tons or more of ore of unknown grade was shipped at that time to the stockpile of the Metals Reserve Company in Phoenix, Ariz. Subsequently, the claims were abandoned, then relocated as the Zig Zag group in 1952 by the present owners, R. J. Edwards and Alex Garcia, of Coolidge, Ariz. In 1953 the property was operated a short time by lessees, and a small amount of ore was shipped to the Government purchasing depot in Deming, N. Mex. The copper content of the ore slightly exceeded the acceptable specifications, so no further shipments were made.

The property was idle when the area was visited in October 1956.

Manganese oxides occur on the claims in high-grade streaks and veinlets along three parallel veins in coarse-grained granitic rocks. The veins dip steeply to the southwest, strike N. 10° to 25° W., and are 70 to 100 feet apart. Two are traceable about 600 feet along the strike before they pass under the detritus that surrounds both ends of the hill. The third, or east, vein can be traced by infrequent exposures about 350 feet along the strike. The better ore in the veins occurs in irregular elongated lenses ranging from 50 to 150 feet in length and from a few inches to 3 feet in width. Where the granite is shattered, a network of thin seams of manganese minerals may extend outward for several tens of feet beyond the walls of the veins.

The workings consist of three shafts, several opencuts, and three short adits. The shafts were inaccessible when the property was visited, and the bottoms of the opencuts were covered with broken material sloughed from their sides.

On the west vein the work consists of a trenchlike opencut, which starts near the north end of the outcrop and extends southeast along the vein nearly 200 feet. The opencut ranges from 3 to 4 feet in width and from 4 to 8 feet in depth. About 150 feet to the southeast another opencut follows the vein for 80 feet or more and reaches a maximum depth of 18 feet. A 12-foot drift extends north from the end of this cut. In the face of the drift the vein is about 3 feet wide and contains interlacing stringers of manganese oxide surrounding brecciated fragments of granite. A short distance southeast of this work, the vein has been mined to a depth of some 20 feet in an opening 3 to 4 feet wide and 50 feet long. A few tens of feet farther southeast, near the south end of the outcrop, a small shaft follows the vein downward 20 feet or more. In the shaft the ore veinlets range from 1 to 6 inches in width and are scattered through a zone several feet wide.

Approximately 70 feet east of the central workings on the west vein, the middle vein of the series crops out. It has been explored by a shallow opencut 150 feet long and an inaccessible shaft estimated to be about 100 feet deep. At the north end of the shaft the ore ranges from 3 to 12 inches in width. To the northwest the vein has been exposed several hundred feet by four shallow opencuts ranging from 30 to 80 feet in length.

The third vein, about 100 feet east of the middle vein, has been explored near the south end of its outcrop by an opencut approximately 100 feet long, 3 to 4 feet wide, and as much as 20 feet deep. From the face of the cut a drift follows the vein about 15 feet northwest. The higher grade ore, exposed in the face of the cut and along the drift, ranges from 2 to 6 inches in width.

Hard psilomelane, the dominant ore mineral, occurs in a gangue of manganiferous calcite and quartz.

Geronimo Group

Seven unpatented claims, known in 1942 as the Geronimo group are situated in secs. 18 and 19, T. 4 S., R. 15 E., some 15 miles by road and trail northwest of Winkelman, Ariz. (See fig. 17, p. 124.) The claims lie along the eastern base of the Dripping Springs Mountains, very close to the east-central boundary of Pinal County. The property may be reached by traveling 11 miles northwest from Winkelman on Alternate State Highway 77, then eastward 3.2 miles on a poor dirt road. From this point the deposits are about 1 mile due east and are accessible only on foot.

During World War II, the claims were held by Mrs. Kate Turner, of Winkelman, Ariz. When the area was visited in October 1956, Mrs. Turner could not be found, the present ownership of the claims could not be determined and the property was idle. As far as is known no manganese ore has been produced.

In 1942, the Federal Bureau of Mines collected a 2-ton sample of the ore from the more promising outcrops on the claims. This material was shipped to the Bureau's Salt Lake City laboratory, where ore-dressing tests were made to determine its amenability to concentration. The sample, containing 30.2 percent manganese, was found to be amenable to concentration by combined jigging and tabling; 81.6 percent of the manganese was recovered in a concentrate which, after sintering, assayed 48.9 percent manganese.

The deposits occur along zones of fracturing and brecciation cutting beds of the Gila conglomerate. Four parallel zones 50 to 200 feet apart crop out on the claims along the sides and top of a broad northerly trending ridge. The zones strike about N. 20° W. and dip steeply southeast to vertical. Although some fractures are traceable for well over 1,000 feet along the strike, the manganese ore of minable width and grade is found in widely separated lenses having exposed lengths of not more than a few tens of feet and widths up to about 4 feet. In some places the manganese oxides occur in fairly coarse aggregates and in other places as mere seams cementing the brecciated fragments of the conglomerate.

The exploratory openings are limited to a few widely scattered discovery pits and shallow opencuts. In the bottom of some deeper openings the mineralization appears to consist largely of manganiferous calcite.

The ore minerals consist chiefly of psilomelane and pyrolusite. The gangue is composed of calcite, quartz, and unmineralized wall rock.

In 1942, R. D. Beard, of Winkelman, held four claims adjoining the Geronimo group. The manganese mineralization on the Beard claims is similar to that on the Geronimo group.

Esperanza Claim

The Esperanza is a single unpatented claim on the west slope of the Sawtooth Mountains some 23 road miles south of Casa Grande in sec. 28, T. 9 S., R. 6 E. (See fig. 17, p. 124.) The property can be reached by traveling south from Casa Grande on the Covered Wells road 10 miles to a left-hand branch, south on this branch about 4 miles to a road fork, and south-southeast on the left fork 9 miles to the deposit.

The claim was located in 1954 by the present owner, Fred Andrade, of Casa Grande, Ariz. During that year, approximately 10 long tons of sorted ore containing about 34 percent manganese was shipped to the Government purchasing depot in Wenden, Ariz. The copper content of this ore exceeded 0.25 percent, the maximum allowable under the Government specifications, so the shipper was notified that no further shipments would be accepted by the depot. In 1956 a truckload of ore was mined from the deposit and sold to a private ore buyer in Casa Grande.

The ore occurs in lenses along a fracture cutting volcanic rocks. The fracture strikes N. 20° W., dips very steeply to the southwest, and is exposed about 300 feet along the strike. The ore lenses along the fracture range from several inches to 2.5 feet in width and from several feet to 60 feet in length. The more promising part of the outcrop has been explored along the strike by an opencut approximately 150 feet long and ranging from 3 to 9 feet in depth.

The chief ore minerals are psilomelane and pyrolusite. The gangue is composed largely of brecciated fragments of the wall rocks and black and white calcite.

Santa Rosa Queen

The Santa Rosa Queen group of two unpatented claims is situated on the Papago Indian Reservation in the west-central part of sec. 36, T. 8 S., R. 5 E., about 15 miles by road south of Casa Grande. (See fig. 17, p. 124.) The claims lie on a relatively flat desert valley bordering the southeastern side of the Silver Reef Mountains. They can be reached from Casa Grande by traveling south 10 miles on the Covered Wells road to a left-hand branch. This branch is followed south through White Horse Pass and the Indian hamlet of Shopishk about 4 miles to a right-hand fork, then southwest on this fork 0.5 mile to a right-hand branch which terminates on the property.

The claims were located in June 1955 by M. A. Armenta, A. Bussari, and Fred Andrade, of Casa Grande. No ore has been shipped. The work consists essentially of a discovery pit and a few scattered small opencuts.

The manganese minerals on the property occur in places along a narrow vein cutting a volcanic breccia. The vein strikes N. 25° E. and dips about

60° SW. The mineralized zone ranges from 1 to 2.5 feet in width and can be traced along the strike some 50 feet. The manganese minerals, comprising chiefly psilomelane and pyrolusite, occur in interlacing seams, parallel veinlets, and small irregular bunches accompanied by an abundance of black and white calcite.

The principal work consists of an inclined pit about 12 feet long, 3 to 4 feet wide, and 10 feet deep.

No work was in progress when the claims were visited in October 1956.

Black Chief

The Black Chief, a single unpatented claim, is on the Papago Indian Reservation some 11 miles south of Casa Grande in the central part of sec. 13, T. 8 S., R. 5 E. (See fig. 17, p. 124.) This section, like others bordering the east side of the township, extends east-west about 2 miles. The deposit is a short distance east of the highway near the base of the steep cliffs bordering the west side of the northernmost detached hill of the Silver Reef Mountains. The area is accessible by half a mile of road that branches eastward from the Covered Wells road about 11 miles south of Casa Grande.

The claim was located early in 1954 by Fred Andrade and Donald De Silva, of Casa Grande, Ariz. As far as is known, production from the property has totaled about 6 tons of sorted ore averaging about 27 percent manganese. This ore was shipped by the owners in 1954 to the Government purchasing depot in Wenden, Ariz. A short time later, lessees further explored the deposit with a few shallow cuts and considerable bulldozer stripping.

The manganese minerals are present in a broad, steeply dipping zone of shearing in Precambrian granitic rocks. The zone trends S. 80° E. and is exposed along the strike about 250 feet. In places the zone is mineralized over widths of 50 feet. Most of the zone comprises widely spaced seams and small irregular bunches of manganiferous calcite, psilomelane, and pyrolusite. The higher grade ore occurs along the central part of the zone in a veinlike band 4 to 6 feet wide, which is exposed in places about 60 feet along the strike. The band has been explored by several opencuts, some of which are 8 feet deep. Evidently, the bulk of the ore produced was sorted from the material broken in these openings. The overlying soil and detritus has been stripped from parts of the zone surrounding the opencuts.

The property was idle when the area was visited in October 1956.

Teller (Santa Rosa) Claim

This claim, first known as the Teller and later relocated as the Santa Rosa, is in the central part of sec. 17, T. 9 S., R. 6 E., about 18 miles south of Casa Grande. (See fig. 17, p. 124.) The claim lies in a relatively flat desert area on the northwestern flank of the Sawtooth Mountains at an altitude of 1,650 feet.

The property can be reached from the railroad depot in Casa Grande by traveling south on the Covered Wells road 10 miles to a left-hand branch, thence 1 mile on the branch to a road fork, and proceeding on the left fork 5.5 miles to a right-hand branch, then 1.5 miles southwest on this branch to the deposit.

The claim was located first in 1953 by Fred Andrade and associates. In 1954 about 45 long tons of hand-sorted ore containing 30 to 39 percent manganese was shipped by lessees to the Government purchasing depot in Wenden, Ariz. In 1956, the claim was relocated as the Santa Rosa and is now held by Fred Andrade, of Casa Grande, Ariz.

The manganese occurs along a vein in fine-grained volcanic rocks. The mineralized part of the vein ranges from 1 to 3 feet in width, strikes N. 25° E., and dips steeply southeast. It is exposed about 150 feet along the strike. At its southwest end, the vein splits into a series of narrow stringers which soon lose their identity. Any further extent of the vein along the strike to the northeast is concealed by detritus.

The ore occurs along the vein in lenticular masses which have been mined to a maximum depth of 10 feet in a continuous opencut approximately 130 feet long.

The chief manganese mineral, hard psilomelane, occurs in stringers and small pods in a gangue composed largely of dark calcite.

No work was in progress when the property was visited in October 1956.

Pointing Cactus Group

The Pointing Cactus group, comprising five adjoining unpatented claims, is situated in secs. 21 and 22, T. 9 S., R. 6 E., in the Sawtooth Mountains. (See fig. 17, p. 124.) The property is accessible by a 9-mile road that branches south from the Casa Grande-Covered Wells road about 10 miles south of Casa Grande. The last 3 miles of the road is a primitive truck trail.

The claims were located by Isaac H. Nichols and G. E. Grier, the present owners, in 1953. In this area, a widespread series of northeasterly trending fractures, containing manganese minerals, cut rhyolitic rocks. Occasional fractures are wide enough to be minable.

On claim 1 in the northeast quarter of sec. 21 an opencut exposed several fractures along a mineralized fault striking N. 40° E., and dipping 65° NW. On this fault a 30-foot shaft was sunk, opening a well-mineralized lens 2 to 6 feet wide, from which Dr. Kenneth Dale, of Phoenix, under a lease agreement, shipped 53 long tons of 19.2-percent manganese to the Deming purchasing depot. The minerals consisted mainly of psilomelane in veinlets, pods, and replacements surrounding breccia fragments. This zone was prospected for 200 feet to the northeast, but no other minable lens was found.

A few hundred feet east of the previously described workings on No. 6 claim, an outcropping vein of manganese 4 to 6 inches wide was explored by a cut. At a depth of about 6 feet the vein increased in width to 2 feet and contained heavy granular psilomelane. Work on this lens was suspended when an assay indicated that the ore contained more than the allowable maximum of copper. A grab sample, taken in May 1956, assayed 42.2 percent manganese and 1.75 percent copper.

On No. 2 claim, southeast of No. 1 workings, Nichols mined and shipped to Deming 5.8 tons of 30.7-percent manganese from a cut 15 feet long by 4 feet wide by 6 feet deep. Because the ore contained more than the allowable maximum of copper, no further work was done on the deposit. The deposit was hard massive psilomelane in a vertical fracture striking N. 20° E.

An opencut on a mineralized fracture on No. 5 claim yielded 12 tons of 23-percent manganese, which was shipped to the Wenden purchasing depot. The cut, on a vein striking N. 30° E. and dipping 85° SE., was 20 feet long, 14 feet deep, and a maximum of 6 feet wide. The minerals consisted of hard manganese oxides, intermixed with unreplaced fragments of rhyolite and veinlets of calcite.

The property was idle when visited in May 1956.

Black Jewel

The Black Jewel claim is situated in SE1/4 sec. 13, T. 8 S., R. 5 E., of the Papago Indian Reservation. (See fig. 17, p. 124.) This section is 2 miles long, east to west, as are the other three sections in this tier to the south. The claim is reached by traveling southwest from Casa Grande on the Covered Wells road 10 miles, then south on a dirt road 1.8 miles. The mine is on the south side of and near the base of the northernmost detached hill of the Silver Reef Mountains at an altitude of about 1,550 feet. It is 0.5 mile northwest of the little Indian hamlet of Shopishk.

The claim was located early in 1955 by Leonard J. Hamelitz, Bethel I. Richardson, and Ernest Wilkinson, all of Casa Grande. Later in the year, it was purchased by Donald De Silva and L. M. Allinio, of Phoenix.

One-hundred long tons of sorted ore averaging 29 percent manganese was shipped to the Deming purchasing depot by Harry A. Thurston, of Casa Grande, and C. R. Breedon, of Phoenix. All equipment, except the headframe, had been removed and the property was idle when visited in May 1956.

The manganese minerals occur in a fracture zone striking N. 25° E. in coarse-grained granite. A 55-foot inclined shaft, sunk on the footwall, has an average dip of 55° NW. Ten feet above the bottom of the shaft, a drift follows the vein 20 feet to the northeast and 10 feet to the southwest. The drift was mainly confined to a width of 6 feet against the hanging wall and extended upward 15 feet. A 6- to 12-inch band against the hanging wall contains considerable hematite. The footwall side of the vein contains about 4 feet of calcite and breccia that is mineralized to a smaller extent. Shallow

opencuts have exposed the zone for 10 feet on each side of the shaft. The zone decreases rapidly in width up the hill to the northeast and is covered by alluvium to the southwest.

The predominant manganese mineral is psilomelane, which occurs in fracture planes, as pods, and in irregular segregations. The gangue material is manganiferous calcite and unreplaced breccia fragments.

Black Prince No. 1

The Black Prince No. 1 claim is in SE1/4 sec. 13, T. 8 S., R. 5 E., of the Papago Indian Reservation. (See fig. 17, p. 124.) It is immediately southwest of the Black Jewel, and the workings are at an altitude of approximately 1,525 feet. The claim was located early in 1954, and the location was amended in 1955 by Donald De Silva and L. M. Allinio, both of Phoenix, Ariz.

Two hundred and thirty-six long tons of sorted ore, containing 21 to 31 percent manganese, was shipped to the Wenden purchasing depot by De Silva and Allinio. In the fall of 1954, under lease from De Silva and Allinio, C. R. Breedon, of Phoenix, shipped approximately 11 long tons to the Wenden depot. In the spring of 1955, also under lease agreement to the owners, Alton R. Powell, of Phoenix, shipped 1 truckload to Wenden before the depot closed.

The manganese minerals occur in a fracture zone striking N. 20° E. and dipping 82° NW. in coarse-grained granite.

The work was confined to an opencut 35 feet long, 10 feet wide, and a maximum of 25 feet deep. Hard manganese oxides occur along fracture planes, as pods, and as irregular disseminations. Unreplaced fragments of wall rock and calcite were the chief gangue constituents.

The fissure zone can be traced up the hillside for 100 feet or more and was opened by another cut 75 feet northeast of the principal workings, where the zone is about 9 feet wide and is mineralized weakly for only 3-1/2 feet on the hanging-wall side. Any extension of the zone to the southwest is covered by alluvium.

The mine was idle when visited in May 1956, and all equipment has been removed.

Santa Cruz County

The two principal manganese deposits of Santa Cruz County are 10 to 15 miles south of the town of Patagonia near the village of Harshaw. A few other deposits have been found in widely separated areas in the southern half of the county (fig. 21).

The deposits near Harshaw lie along the eastern side of the Patagonia Mountains at altitudes ranging from 5,100 to 5,600 feet. They are grouped in two areas about 2 miles apart and are accessible from the Patagonia-Washington Camp dirt road which branches from U.S. Highway 82 at Patagonia (fig. 22).

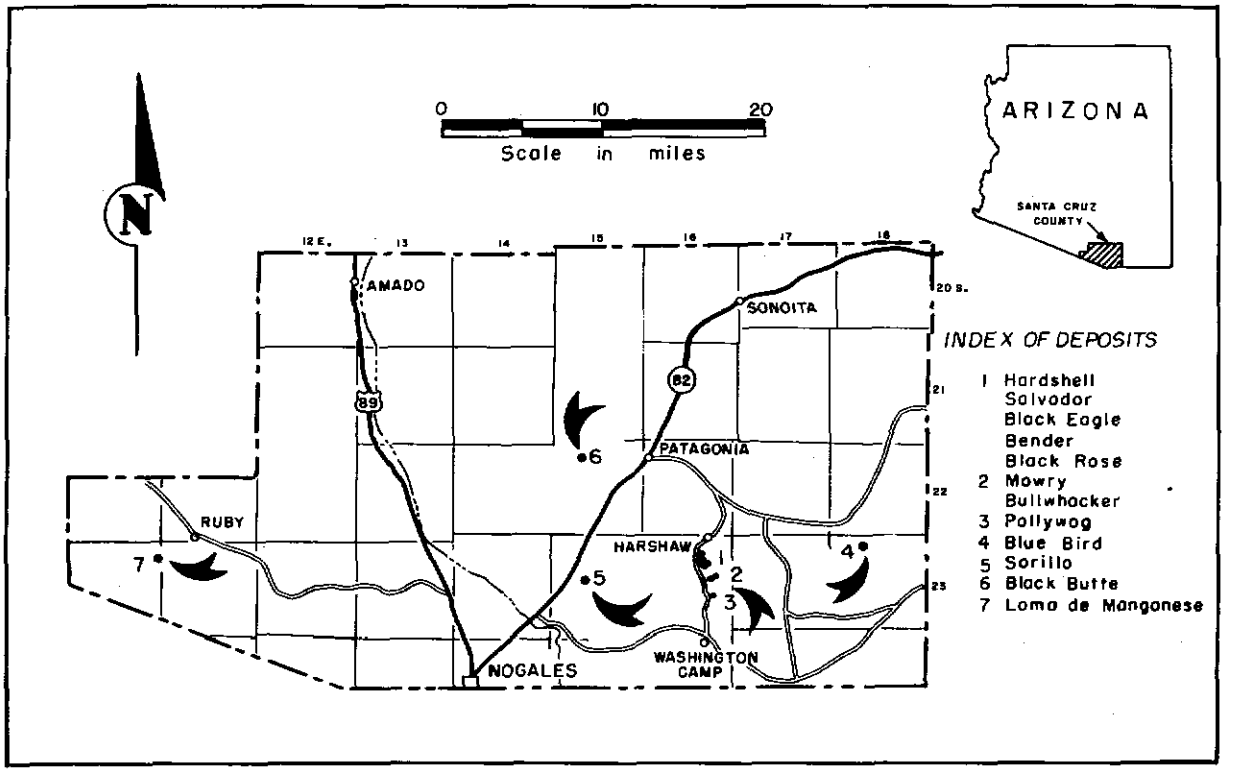

FIGURE 21. - Manganese Deposits, Santa Cruz County, Ariz.

The Fairbanks spur of the Southern Pacific Railroad terminates at Patagonia, which is the nearest rail shipping point for the area.

Some manganese deposits in the county were located and explored or worked for lead-silver ores as early as the 1850's. Since the 1850's many thousands of tons of such ore, containing some manganese, has been produced. However, there was no incentive to mine straight manganese ore until World War I when, according to the meager records available, 1,500 tons or more of ore and concentrates averaging about 40 percent manganese was produced. Most of this production came from the Hardshell and Mowry mines. Manganese mining was resumed in World War II, and 700 to 800 tons of ore containing about 30 percent manganese was shipped to the Metals Reserve Company's stockpile in Deming, N. Mex. The ore came largely from the Mowry and Bullwhacker deposits. The next period of manganese production began in 1952 and continued through most of 1955. During those years, 11,065 long tons of ore averaging 22.8 percent manganese was shipped to the Government purchasing depot in Deming, N. Mex. The bulk of this ore was mined from the Mowry and Bender properties.

All manganese mining in the county was stopped late in 1955 after the Deming purchasing depot closed. None of the properties were active when they were visited in July 1957.

The productive deposits near Harshaw and Mowry occur as irregular bodies along zones of fracturing in Paleozoic limestones. Much of the ore is localized on or near contacts with intrusive granitic and rhyolitic rocks. The other outlying and scattered deposits in the county are found mainly along narrow fractures in volcanic rocks.

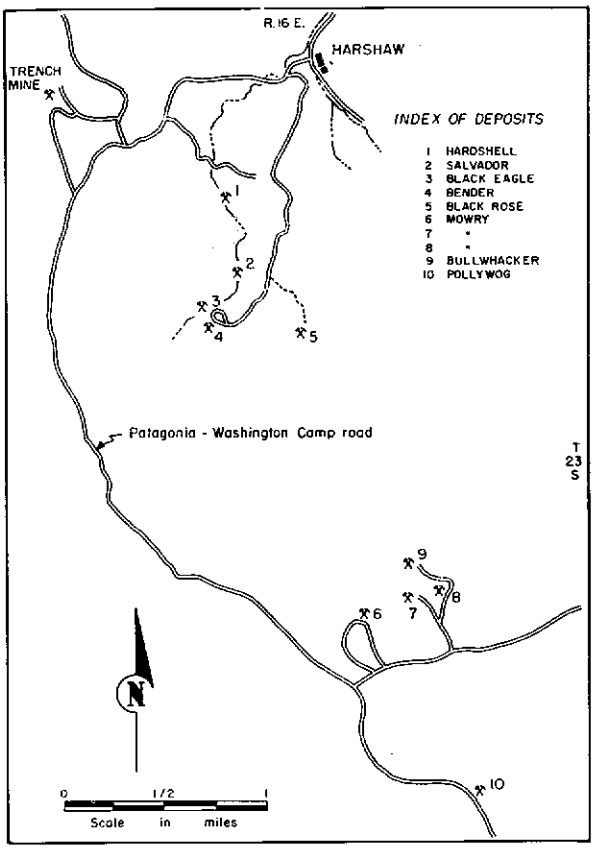

FIGURE 22. - Manganese Deposits Near Harshaw, Santa Cruz County, Ariz.

The chief ore minerals in the larger deposits are the softer oxides, wad and pyrolusite, which usually occur in a siliceous gangue. Various amounts of lead and silver are present in much of the manganese ore. Some alabandite (manganese sulfide) and rhodochrosite (manganese carbonate) have been found as gangue minerals in the deeper lead-silver-zinc ores of the neighboring Trench mine.

The depth to which the manganese ore extends varies greatly in the different deposits. Manganese oxides are reported to be present on the bottom or 500-foot level of the old Mowry lead-silver workings and on the deepest levels of the Hardshell and Bender deposits which are about 250 feet vertically below the outcrop. In some deposits in the area, the ore grades into poorly mineralized material at depths of less than 100 feet.

In the developed sections of the deposits, most ore of minable width, containing 20 percent or more manganese, is exhausted. Doubtless, further exploratory work would disclose additional high-grade ore, but any substantial tonnage would consist principally of low-grade material requiring beneficiation. Inferred reserves remaining in the county are estimated to be about 75,000 tons containing 10 to 20 percent manganese. The bulk of this potential tonnage is in the larger, undeveloped deposits in the two areas south of Harshaw.

Mowry

The Mowry property, an old well-known silver-lead producer, consists of a group of 21 contiguous patented claims lying largely in the south half of approximate sec. 15, T. 23 S., R. 16 E., unsurveyed (figs. 21 and 22). The deposits are accessible from a short side road that branches left from the Washington Camp road about 14 miles south of Patagonia. The claims cover an area of low, gently sloping hills at altitudes ranging from 5,300 to 5,600 feet.

The silver-lead deposits on the property were worked in the early 1850's by Mexicans. The claims were purchased in 1859 and operated for several years thereafter by Lt. Sylvester Mowry, U.S. Army. Production in this period is

said to have amounted to $1,500,000[45/] in lead-silver ore and bullion. During the Civil War the mine was seized by the U.S. Government on the charge that it was supplying lead to the Confederate Army for ammunition. Afterward, the property was worked intermittently by various operators for short periods in the 1870's, 1880's and early 1900's. The estimated production from those operations totaled about $150,000 in lead and silver. In 1936, the property was purchased by the present owner, Karl Peterson, of Nogales, Ariz. In the late 1930's and early 1940's, Mowry Exploration Co. performed considerable underground exploration near the old workings; reports indicate that 1 carload of silver-lead ore was shipped. In 1954 and 1955 Southwest Metallurgical Industries did underground work in the East End shaft.

The first manganese ore (206 tons containing 33.6 percent manganese)[46/] was shipped during World War I. Production was resumed in World War II when, according to Karl Peterson, about 10 carloads, or 500 tons of ore averaging about 30 percent manganese, was mined. The ore was shipped to the Metals Reserve Company's stockpile in Deming, N. Mex. From 1952 through 1954, after the Deming purchasing depot was reopened by the General Services Administration, manganese mining again was resumed, and a total of 6,797 long tons of ore averaging 24.3 percent manganese was shipped to the depot. Of this quantity, 6,600 tons or more was shipped by lessee Rupert Beyerle, 144 tons by owner Karl Peterson, and the balance by lessee Willis Lovelace. Virtually all the ore was mined from an opencut about 1,200 feet east of the center of the old lead-silver workings. No work was in progress when the property was visited in June 1957.

Most of the lead-silver and manganese deposits on the property occur as replacement bodies localized in places along a fault contact between Paleozoic limestones and quartz monzonite. This contact, known as the Mowry fault, trends eastward, dips 75° to 80° N., and has a traceable length of about 4,000 feet. The limestones, being the principal host rocks, occur on the north or hanging-wall side of the contact and the monzonite, on the south side. In a few places near the contact, the limestone has been invaded by irregular bodies of gabbro.

The old lead-silver workings are near the west end of the contact where they extend for a strike length of about 900 feet. Much caving and subsidence has taken place in the limestone overlying the former stopes. The old productive sections of the workings are inaccessible. Considerable manganese accompanies the lead-silver ore bodies. The following has been quoted from Schrader's description of these deposits as they appeared in 1909:[47/]

> The croppings, consisting mainly of oxides of manganese and iron, kaolin, and some argentiferous galena, extend interruptedly along the contact fissure for half a mile or more and continuously along the

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45/ Schrader, F. C., and Hill, J. M., Mineral Deposits of the Santa Rita and Patagonia Mountains: Geol. Survey Bull. 582, 1915, p. 296.

46/ Wilson, E. D., and Butler, G. M., Manganese Ore Deposits in Arizona: Arizona Bureau of Mines Bull. 127, 1930, p. 94.

47/ Work cited in footnote 45, pp. 302-303.

600-foot stretch now occupied by the mine openings, being especially prominent over the ore bodies.

The ore consists mainly of the argentiferous ore minerals, cerussite, coarse galena, anglesite, and bindheimite, all contained in a manganiferous and ferruginous gangue consisting principally of psilomelane and massive pyrolusite and hematite. The manganese and iron together are said to form about one-fifth of the ore body in volume.*** The ore is said to become less manganiferous and more siliceous with increasing distance from the gabbro dike.

At a depth of about 235 feet the limestone gives way to gabbro.*** The vein or ore body in general narrows downward from this depth and seemingly deteriorates in value.

The manganese of the gangue*** continues from the surface to the bottom of the mine*** (500 feet). The 400-foot level in general is characterized by an abundance of calcite and kaolin in addition to the usual manganese and iron minerals.

At about the 150-foot level occur several veins or sheets of manganese, which in one place unite and form a large ore body with a corresponding increase in the amount of good ore.

*** The abundance and purity of the pyrolusite in the gangue suggest that this mineral may prove a useful byproduct.

Along the contact immediately east of the old workings, recent exploratory work, consisting largely of stripping, has disclosed a manganiferous zone in the sheared and altered monzonite adjacent to the limestone. The zone strikes eastward parallel to the contact, has an exposed length of about 150 feet, and is as much as 20 feet wide. It contains a network of thin seams, narrow veinlets, and small irregular bunches of manganese oxides impregnating the shattered part of the monzonite. Some sorted ore has been shipped from the zone, but the bulk of the material is said to average less than 15 percent manganese.

Most of the manganese ore shipped from the property has come from a deposit in the limestone along the monzonite contact about 1,000 feet east of the last-mentioned zone. The ore body follows the contact, which in this area strikes N. 60° E. and dips 75° NW. The deposition on the surface is in a roughly lenticular area ranging from a few feet to 30 feet in width and 200 feet in length, with its long dimension parallel to the contact. The better ore in the deposit appears to have been localized in overlapping bands or lenses up to 10 feet wide that follow well-defined shear planes along the footwall adjacent to the monzonite. In the wider sections of the deposit, the minerals spread into the fractured hanging-wall limestone where they form various-size bunches and irregular replacement masses of ore separated by lean or unreplaced limestone.

The chief manganese minerals, wad and pyrolusite, occur in a calcareous gangue with small amounts of iron and oxidized lead minerals.

Most of the ore was mined from an opencut about 130 feet long, 10 to 30 feet wide, and up to 20 feet deep. The ore decreased in width at the east end of the opencut, but some ore was mined underground farther east in a 40-foot drift. On the surface along the contact, manganese occurred sporadically for some 60 feet beyond the face of the drift. Near the west end of the opencut the ore also decreased in width and terminated on the surface a few tens of feet farther west. Near the west end of the opencut a shaft, said to be over 100 feet deep, had been sunk and some drifting completed. The shaft was caved when the property was visited. According to Rupert Beyerle, who did the shaft sinking and drifting, the ore persisted to the depth of the shaft. However, little ore was mined as the ground was heavy, requiring much timber, and the cost of mining from the shaft was such that little, if any, profit could be realized.

About 700 feet east of these workings, other manganiferous deposits are exposed along the Mowry fault near the East End shaft. In this area the fractured limestone is manganiferous in places for 200 feet or more along the monzonite contact. The deposits, as exposed in a few scattered trenches, seldom exceed 2 feet in width and a few tens of feet in length. As far as is known no manganese ore has been produced from the area, although some manganiferous lead-silver ore has been shipped from the East End shaft. This shaft, sunk many years ago, is about 130 feet deep and has three levels, which extend westward along the contact zone 150 feet or more. The shaft was rehabilitated and further underground exploration was performed in 1954 and 1955 by Southwest Metallurgical Industries, an affiliate of Ventures, Ltd., of Canada. The results of the work are not known.

Bullwhacker

The Bullwhacker deposits are on a fractional patented claim, known as the Golden Gate, which adjoins the northeast end of the Mowry group in the central part of approximate sec. 15, T. 23 S., R. 16 E., unsurveyed (figs. 21 and 22, pp. 158 and 159). The property is accessible over a northerly trending road about 0.8 mile long that branches left from the Mowry road 0.6 mile east of the Patagonia-Washington Camp road.

The claim is said to have been located and operated on a small scale as a silver mine as early as 1880. The first manganese ore was produced in World War I, when 5 carloads or more of handsorted ore, containing about 40 percent manganese, reportedly were shipped. In 1941, when the manganese resources of the district were appraised, the deposits on the claim were mapped and sampled by the Bureau of Mines. Fifty-six samples were taken from the principal surface and underground workings. The samples contained from a few percent to 28 percent manganese, and in the 15 samples assayed for silver the silver content ranged from 0.8 to 7.4 ounces per ton.

In 1942, while under lease to H. Woodruff, several carloads of manganese ore were shipped to the Metals Reserve Company's stockpile in Deming, N. Mex. The exact tonnage and grade of the lots are unknown.

Subsequently, the claim was purchased from the estate of A. S. Henderson by the present owner, Karl Peterson, of Nogales, Ariz., and production of manganese was resumed in 1952. About 200 long tons of ore, averaging 18.9 percent manganese, was shipped by Peterson to the Government purchasing depot in Deming, N. Mex. Some of the lots were not amenable to concentration by flotation as prescribed by the depot, so the shipper was notified that further shipments would not be accepted. Operations were discontinued, and no further work had been attempted up to the time the claim was visited in June 1957.

Manganese oxides occur on the claim in several disconnected areas along fractures in limestone. The mineralized areas are several hundred feet north of the Mowry fault contact and are strung about 500 feet along a northwesterly trending belt. Near the southern end of the belt and the south end of the claim, a shallow trench exposes a mineralized zone about 100 feet wide. The zone is composed of stringers, veinlets, and small irregular bunches of manganese oxides largely oriented along steeply dipping fractures striking about N. 45° W. The wider masses of ore are separated by lower grade material or unreplaced limestone of various widths. Except near the trench, overburden obscures any extension of the ore along the strike. Grab samples, taken from the material broken in the trench, averaged about 11 percent manganese.

For some 200 feet southeast of this work and into the adjoining claim of the Mowry group, several shallow pits show spots of scattered manganese minerals. Likewise, for 350 feet or more to the northwest, between the trench and the main Bullwhacker workings, a few shallow cuts expose small, widely spaced manganiferous deposits associated with minor fractures in the limestone.

In the northernmost deposit, which has yielded virtually the entire production, the ore occurs in three rather closely spaced fracture zones, oriented in various directions within an irregular surface area roughly 150 feet square. Two of the fractures strike northwest and dip moderately northeast, and the other trends north-northeast and dips steeply northwest. The steeply dipping fracture cuts the limestone beds, whereas in places the others appear to follow bedding planes in the limestone. The largest occurrence and the one from which the bulk of the ore was mined is an irregular lenticular body striking N. 60° W. and dipping about 40° NE. On the surface it has an exposed length of some 60 feet and ranges in width from a few feet at each end to 10 feet or more in the center. The higher grade ore in the body occurs erratically as various-size bunches and masses surrounded by lower grade material. In places prongs of ore extend outward from the main mass into the walls of the enclosing limestone. This deposit has been mined on and near the surface in an opencut and from inclined underground workings that in places follow down the dip of the ore about 130 feet. A few tens of feet north of the opencut, a vertical shaft said to be over 100 feet deep passes through the deposit on the 35-foot level. The shaft is inaccessible but evidently continues into the underlying limestone.

About 40 feet northwest of the shaft, some ore has been mined from a narrow fracture striking N. 30° E. and dipping steeply northwest. It is exposed in places about 100 feet along its strike by shallow surface cuts and underground workings. The higher grade deposits occur erratically along the

fracture in small widely separated lenses. The best ore has been found in the north drift on the 35-foot level.

The third occurrence, about 100 feet northeast of the shaft, is exposed in a 40-foot incline that follows the dip of a fracture striking N. 40° W. and dipping about 60° NE. The manganese deposit is 8 feet wide but is exposed only a few tens of feet along the strike. Near the surface the occurrence is well mineralized, but two samples taken in the bottom of the incline contained less than 3 percent manganese.

Other manganiferous occurrences have been found west and northwest of the productive deposits. The principal one is exposed in a shallow trench 200 feet west of the vertical shaft. The trench follows a northeasterly trending fracture for about 80 feet. Six samples taken along the central part of the trench, across widths of 2 to 3 feet, had an average manganese content of 14.6 percent.

The chief ore minerals in the deposits are wad and pyrolusite. The gangue is composed of siliceous limestone, iron oxides, and calcite. Small amounts of lead accompany the ore.

Bench-scale sink-and-float, flotation, and sulfur dioxide leaching tests were made on a composite of five grab samples of broken ore from the mine dumps on the Golden Gate claim. The composited sample weighed about 350 pounds and assayed 15.7 percent Mn, 42.3 percent $CaCO_3$, and 0.03 percent Cu. The ore was a fine-grained intergrowth of calcite and wad with some pyrolusite, quartz, and variegated iron oxides, such as limonite and hematite. The limonite, wad, and pyrolusite contained traces of lead, zinc, and barium. The bulk of the manganese was wad intergrown with the calcite. Grinding to pass minus-200-mesh was required for good liberation of the manganese minerals.

Sink-and-float concentration of the ore failed to yield a metallurgical-grade manganese product. Fractionation of ore crushed to pass minus-5/8-inch yielded a sink product assaying 25 percent Mn and gave a manganese recovery of 43 percent.

Bulk and selective flotation of the ore was investigated. Bulk flotation of the manganese and calcite with oil-emulsion collector from minus-100- and minus-200-mesh charges of the ore failed to yield acceptable manganese concentrates owing to dilution of the froths by the calcite and silicate gangue. Selective flotation of the calcite followed by oil-emulsion flotation of the manganese also gave manganese concentrates containing less than 40 percent Mn. For example, in a typical test 77.6 percent of the manganese was recovered in a flotation froth that assayed 34.3 percent Mn. The wad is inherently low grade, which accounts for its inability to yield a metallurgical-grade concentrate despite good rejection of the calcite and gangue minerals.

Good extraction of the manganese was obtained from the ore by either agitation or percolation leaching of fine- and coarse-ore charges with sulfur dioxide. Agitation leaching of minus-100-mesh charges of the composite with a 10-percent sulfur dioxide-air mixture in pulps of about 20-percent solids

extracted 96 percent of the manganese in a 3-hour leach. The sulfur dioxide consumption was 4.1 pounds per pound of manganese extracted. Dithionate formation was 1.8 pounds per pound of manganese dissolved, which was more than ample to compensate losses that would be incurred in the manganese hydroxide product and in washing the leach residues if the leaching solutions were treated for recovery of the manganese.

The percolation leaching tests were made on minus-1/4- and minus-1/2-inch charges of the ore. Alternate upward passage of sulfur dioxide through the moist agglomerated charges and downward percolation of wash solutions to remove the solubilized manganese extracted 87 percent of the manganese from the 1/4-inch feed in a 16-day leach. About 70 percent of the manganese was extracted from the 1/2-inch ore in the same time. Sulfur dioxide consumption in treating the ore was 10 pounds per pound of manganese recovered, and dithionate formation was 2 pounds per pound of manganese extracted. The excessive sulfur dioxide consumption by the ore is attributed to the high calcite content.

The Golden Gate ore is not amenable to treatment by gravity concentration or flotation. Good extraction of the manganese can be obtained by agitation or percolation leaching with sulfur dioxide, but the sulfur dioxide requirement is excessive because of the high calcite content of the ore. Of the treatment methods tested to date, agitation leaching is best for recovering a metallurgical-grade manganese product.

Bender

The Bender property, formerly known as the Fernando, comprises a group of five unpatented claims situated some 10 miles by road south-southeast of Patagonia and about 2 road miles south-southwest of the village of Harshaw. The group lies in the central part of approximate sec. 9, T. 23 S., R. 16 E., unsurveyed, on the northeastern slope of American Peak at an altitude of 5,600 feet. The property can be reached from Patagonia by following the graded Washington Camp road south 8.5 miles to a faint road that branches left a few hundred yards south of the settlement of Harshaw. This branch is followed south 1.8 miles to the property. (See fig. 22, p. 159.)

The claims were prospected and mined for silver as early as 1880. Attention first was directed to the manganese ore in World War I when a small, but unknown, amount of the ore is said to have been shipped. The property was active again in World War II when it was optioned to Patagonia Metal Co., headed by G. T. Humphries. This company completed several hundred feet of underground work and reportedly mined a few thousand tons of manganese ore which was concentrated in a small gravity plant erected near Patagonia; the tonnage and grade of the ore is not known.

In 1941, a preliminary investigation of the deposit was made by the Bureau of Mines and the Geological Survey in connection with an appraisal of the manganese resources of the district. A total of 179 samples was taken on the Bender property from both surface exposures and the mineralized sections of accessible underground workings. The individual samples ranged from a few

percent to 40 percent manganese and from less than 1 to as much as 5 ounces of silver per ton. Sizable, but extremely irregular, mineralized areas containing 10 to 20 percent manganese were indicated.

The property remained idle from about 1944 to 1952, meanwhile passing into the possession of the present owner, Grover Marsteller, of Nogales, Ariz. At that time, locations of the original Bender claims were amended and recorded under the name of the Mina Prieta group. From 1952 through the early part of 1955 the property was operated intermittently, and 3,892 long tons of ore averaging 20.1 percent manganese was shipped to the Government purchasing depot in Deming, N. Mex. Some 2,000 tons was shipped by Grover Marsteller and the balance, by three lessees, E. L. Cleveland, Rupert Beyerle, and the Still Bros. Mining Co. When the district was visited in June 1957, all equipment had been removed and the property was idle.

The ore occurs as irregular replacement bodies distributed erratically in a highly fractured zone of siliceous limestone (fig. 23). The limestone is bounded on the north and east by volcanic rocks and has been completely silicified in an uneven band as much as 80 feet wide along the contact with the volcanics. Between this band of dense massive silica and the unaltered limestone to the south and west is an extremely irregular zone of partly silicified and brecciated limestone containing the manganese deposits. Numerous ore bodies have been found in this zone in an area extending roughly 200 feet to the northwest and 100 feet to the northeast. The ore bodies, ranging from small pods to irregular masses several tens of feet in greatest dimension, are oriented in different directions and separated by various-size bodies of lean or barren limestone. The zone appears to dip steeply northward and has been explored to a maximum depth of 250 feet. Selected samples at that depth compare favorably in manganese content with samples found near the surface. However, the deeper workings are limited in extent, and the amount of ore at this depth has not been indicated.

Most of the manganese ore produced in 1952-55 was mined from opencuts situated largely along the northern and southern margins of the zone, whereas the bulk of the ore mined in the early 1940's is said to have come from adit workings as much as 140 feet below the surface.

On the northern side of the outcrop, five opencuts had been excavated in an area about 180 feet long and 60 feet wide. The cuts were 10 to 40 feet long, 6 to 30 feet wide, and up to 25 feet deep. Some inaccessible underground workings extended below the floor of the easternmost opencut. Doubtless, this work connected with sublevels driven from raises above the adit level.

About 100 feet to the southeast, ore had been mined along the southern margin of the outcrop in a series of shallow opencuts that followed an easterly trending fissure zone about 130 feet. In places in this area the manganese mineralized zone was about 20 feet wide. Farther west along its trend, the zone passed into unaltered limestone, in which the ore occurred in short disconnected lenses ranging from 1 to 3 feet in width.

The portal of the adit level is down the steep hillside a few hundred feet north of the outcrop and about 150 feet vertically below the opencuts.

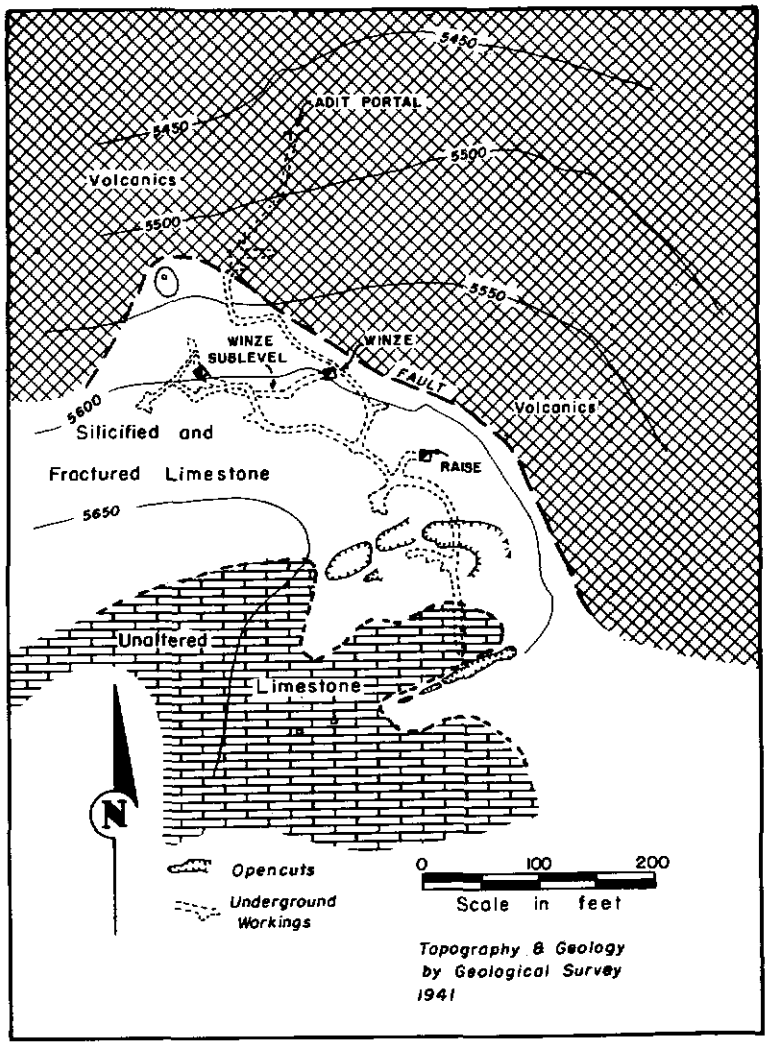

FIGURE 23. - Bender Manganese Deposit, Santa Cruz County, Ariz. *(Topography and Geology by Geological Survey, 1941.)*

The adit workings comprise more than 1,000 feet of crooked drifts and crosscuts, a sublevel from the bottom of a 100-foot-deep winze, and two raises extending to the surface. The manganese ore produced in World War II came largely from several stopes above the adit level near the inclined raise. The stopes were inaccessible when the property was visited, and their extent is not known.

A composite of five grab samples of broken ore from low-grade ore dumps at the Bender deposit was treated by sink and float, flotation, and sulfur dioxide leaching. The composited sample weighed about 350 pounds and assayed 17.3 percent Mn, 0.6 percent $CaCO_3$, 0.14 percent Pb, 0.42 percent Zn, and 0.06 percent Cu. The ore was dense and hard and comprised pyrolusite and wad associated with quartz, chalcedonic silica, limonite, hematite, and sporadic grains of clay and feldspars. Spectroscopic analysis showed weak spectral lines of barium, aluminum, and iron. Grinding the ore to pass 200-mesh was required to liberate most of the pyrolusite from the gangue.

Concentration of the ore by sink and float yielded an enriched manganese sink product but did not give a metallurgical-grade concentrate. The ore was crushed to minus-5/8-inch and screened on a 10-mesh sieve for the test. Separation of the minus-5/8-inch, plus-10-mesh fraction in a heavy medium of 2.94 specific gravity yielded a sink product analyzing 35.8 percent Mn and accounting for a manganese recovery of 49.4 percent; 22.2 percent of the manganese was lost in the float product, which assayed 7.6 percent Mn. The remainder of the manganese reported to the minus-10-mesh fraction. Sink-and-float concentration of minus-1/4-inch feed gave about the same results. Heavy-medium concentration might be useful for preconcentrating the Bender ore but would yield a low manganese recovery.

Bulk flotation of the manganese with oil-emulsion collector from minus-150-mesh and 270-mesh charges of the ore failed to yield metallurgical-grade manganese concentrates. In a typical test on 150-mesh material, 93.7 percent of the manganese was recovered in a concentrate assaying 41.9 percent Mn, 20.2 percent SiO_2, 1.0 percent Al_2O_3, 2.6 percent Fe, 0.36 percent Pb, 0.96 percent Zn, and 0.06 percent Cu. Flotation of an ore charge ground to pass 270-mesh reduced the silica content to meet specifications for ferrograde manganese and gave a concentrate assaying as high as 44 percent Mn, but the lead and zinc content still exceeded minimum requirements. Subsequent fuming tests at 1,250° C. on nodules prepared from a mixture of 90 percent concentrate and 10 percent coke reduced the combined lead, zinc, and copper to less than 1 percent. However, the roasting treatment resulted in a weight loss, yielding a product which exceeded manganese specifications for combined silica and alumina. The nodules produced by this procedure assayed 53.8 percent Mn, 14.2 percent SiO_2, 2.0 percent Al_2O_3, 5.8 percent Fe, 0.05 percent Pb, 0.11 percent Zn, and 0.14 percent Cu.

Good manganese extractions were obtained from the sample by either agitation or percolation leaching of fine- or coarse-ore charges with sulfur dioxide. Agitation leaching of minus-100-mesh charges of the sample with a 10-percent sulfur dioxide-air mixture extracted 98 percent of the manganese during a 90-minute leach. The sulfur dioxide consumption was 1.7 pounds per pound of manganese extracted, and dithionate formation was 0.4 pound per pound of manganese dissolved. Although formation of dithionate from the ore was low, the quantity was ample to assure successful recovery of manganese hydroxide from the pregnant solutions by the dithionate process.

Good manganese extractions were obtained from minus-1/4- and minus-1/2-inch charges of the ore by percolation leaching with SO_2, but the SO_2 and the leaching time required were excessive. The hard, dense nature of the ore was not conducive to good percolation leaching. In tests on the 1/2-inch feed, 95 percent of the manganese was extracted in a leaching period of 14 days. Treatment of the minus-1/4-inch feeds extracted 98 percent of the manganese in the same leaching period. About 6 pounds of sulfur dioxide was consumed per pound of manganese recovered, and 1.2 pounds of dithionate ion was produced per pound of manganese extracted.

The batch laboratory tests demonstrated that the Bender ore was not amenable to concentration by flotation and nodulizing, as the manganese concentrates failed to meet metallurgical-grade specifications. The ore responded readily to agitation leaching with sulfur dioxide. An excellent manganese recovery was obtained with a nominal consumption of sulfur dioxide. Percolation leaching of coarse feeds with sulfur dioxide also gave satisfactory manganese extractions, but sulfur dioxide consumption was high. Of the methods tested to date, agitation leaching has most merit for treating the Bender ore.

Black Eagle

The Black Eagle group of three unpatented claims is about 2 miles by road south-southwest of Harshaw in the north-central part of approximate sec. 9, T. 23 S., R. 16 E., unsurveyed. (See fig. 22, p. 159.) The claims adjoin the

Bender, or Mina Prieta, group on the north and west and lie along the upper end of Hardshell Gulch at an altitude of about 5,400 feet. The deposit can be reached from the Bender workings by continuing westward down a steep, winding hillside road about 0.3 mile.

The deposit is said to have been discovered in the late 1880's but was not worked extensively until World War I. Reports[48/] indicate a production of 66 tons of ore containing 44.8 percent manganese during that period. Subsequently, the deposit was operated as a silver mine; in the next few years production totaled about 3,200 tons of manganiferous silver ore averaging about 28 ounces of silver per ton, 19.9 percent manganese, 0.9 percent lead, and 0.18 percent copper. This ore was shipped to custom smelters, and the manganese was not recovered.

In 1941 the accessible mine workings were sampled by the Bureau of Mines in connection with an investigation of the manganese resources of the district. Fifty-seven samples were taken on the Black Eagle property, largely from the deeper underground workings. They represented as nearly as possible the grade of the ore remaining in the deposit. The samples averaged 8.3 percent manganese, and individual samples contained 2 to 24 percent manganese. Twelve samples were assayed for silver and contained 0.8 to 10.8 ounces of silver per ton.

In the late 1940's the claims were purchased by the present owner, Grover Marsteller, of Nogales, Ariz.

In 1952, after the Government manganese purchasing depot was opened in Deming, N. Mex., the property again was operated by lessees. In 1953 a total of 82 long tons of sorted ore averaging 19 percent manganese was shipped to the Deming depot. No work was in progress when the property was visited in June 1957, and most of the underground workings were inaccessible.

The ore occurs as irregular lenticular bodies along a fracture zone roughly parallel to the bedding planes of a silicified limestone. The zone strikes northeast, dips 30° to 40° NW., and ranges from 2 to 8 feet in thickness. It is exposed for 400 feet or more along the strike and in this distance contains three disconnected oreshoots which have yielded the past production.

On the surface the main or central oreshoot had a strike length of about 100 feet. It was developed and exploited from an adit and an inclined shaft which was caved and inaccessible, and only parts of the adit were safe to enter at the time the property was visited. Old reports and maps indicate that the shaft reached a depth of about 180 feet as measured on the dip. The bulk of the ore was mined in open stopes in the upper 100 feet of the workings. Below that depth the oreshoot decreased in size, and the higher grade bodies were more widely separated than those in upper parts of the deposit.

48/ Wilson, E. D., and Butler, G. M., Manganese Ore Deposits in Arizona: Arizona Bureau of Mines Bull. 127, 1930, p. 95.

About 200 feet west of the shaft, some ore was mined in inclined workings from irregular ore bodies that were stoped in places for 60 feet along the strike and 30 feet on the dip. The greatest depth attained by the workings in this area was less than 100 feet.

For approximately 200 feet northeast of the main shaft the mineralized zone had been explored by several shallow opencuts and an inclined adit about 60 feet long. Some ore had been mined from small stopes in this area. Most of the manganese ore shipped to the Deming depot in 1953 was mined from relatively shallow shaft workings a short distance farther northeast.

The chief manganese minerals are wad and pyrolusite. The gangue consists of quartz, unreplaced limestone, and manganiferous calcite.

Hardshell

The Hardshell mine, an old producer of substantial amounts of lead-silver and some manganese ore, is 1.5 miles south-southwest of the village of Harshaw. (See figs. 21 and 22, pp. 158 and 159.) The property at present consists of a contiguous group of 19 unpatented claims covering part of approximate secs. 4 and 9, T. 23 S., R. 16 E., unsurveyed. The principal workings are in Hardshell Gulch at an altitude of 5,150 feet. They may be reached by an access road about 0.7 mile long, which branches left from the Patagonia-Washington Camp road about 0.8 mile southwest of Harshaw.

The first claim locations, comprising part of the present group, were made in 1879 by David Harshaw and Jose Andrade. Later, they were purchased by R. R. Richardson who discovered the main productive deposit in 1895.[49/] The mine has since worked intermittently by several operators and up to 1921 is credited with a total production of 5 million pounds of lead and 250,000 ounces of silver.[50/] All the lead-silver ore was manganiferous.

The first manganese ore was shipped during World War I, when production[51/] totaled about 500 tons of ore and 500 tons of concentrates, both containing over 40 percent manganese. As far as is known this is the only manganese ever shipped from the property, although some lead-silver ore is said to have been produced in the early 1940's.

The Hardshell claims are owned by Gold Canyon Mining Co., of New York, and are presently held under a lease by American Smelting & Refining Co. Since the inception of the lease in 1944, the latter company has further explored the property from time to time, largely by diamond drilling in search of lead-silver deposits.

Virtually all the manganese ore produced on the property has been found in association with the lead-silver ore bodies in the main underground

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49/ Schrader, F. C., and Hill, J. M., Mineral Deposits of the Santa Rita and Patagonia Mountains: Geol. Survey Bull. 582, 1915, p. 266.

50/ Elsing, M. J., and Heineman, R. E., Arizona Metal Production: Arizona Bureau of Mines Bull. 140, p. 100.

51/ Work cited in footnote 48, p. 91.

workings. These deposits occur as irregular oreshoots in a broad shear zone cutting beds of quartzite and silicified limestone which have been intruded by sills of rhyolite. The shear zone ranges from 10 to 60 feet in width, strikes N. 60° E., and dips about 30° NW.

When the property was visited in June 1957, the underground workings were largely inaccessible, and the following description of the deposit has been taken from the reports of F. C. Schrader[52/] and E. L. Jones, Jr.[53/]

The mine workings comprise an inclined shaft, which follows the dip of the shear zone for 600 feet, and several levels, which extend about 200 feet east of the shaft and 75 feet west of it. The levels, consisting of several thousand feet of lateral work, are connected in places with irregular stopes, some of which attain heights of 30 feet or more as measured at right angles to the dip. The workings reach a vertical depth of 250 feet. Water stands at an inclined depth of 300 feet or more below the collar of the shaft.

Much of the better manganese ore appears to have been localized in lenticular bands resting upon a hard, impervious rhyolite that forms the footwall of the deposit. Above the footwall, the manganese was deposited in various-size irregular bunches and stringers distributed erratically in a matrix of crushed rock. In some places the larger manganiferous masses are said to have been as much as 6 feet wide and fairly persistent for several tens of feet along both the strike and dip. Most of the manganese ore is hard, consisting chiefly of pyrolusite, psilomelane, and braunite, which occur in a siliceous gangue. These minerals are reported to have persisted to the lowest level of the mine workings.

Other manganiferous outcrops are found on the property in an area extending 2,000 feet or more south of the main shaft. These outcrops are relatively small and scattered and appear associated with poorly defined fracture and brecciated zones in quartzite and limestones. In the southernmost and largest outcrop, the manganese oxides occur in numerous seams and stringers in a zone of brecciated limestone about 300 feet long and as much as 100 feet wide. The more promising sections of the zone have been explored by a few shallow pits and an old shaft estimated to be about 50 feet deep.

Salvador

The Salvador, a single patented claim, lies across Hardshell Gulch about 0.5 mile below the Black Eagle group in the northeastern part of approximate sec. 9, T. 23 S., R. 16 E., unsurveyed (fig. 21). It may be reached from Harshaw by traveling west 0.8 mile on the Washington Camp road, then left or southeast on a side road 0.4 mile to a right-hand branch. This branch is followed south a quarter of a mile to the Hardshell inclined shaft. Beyond this point the road was washed out when the property was visited, and access to the Salvador deposit was gained on foot by following the old road southward up the gulch about 0.75 mile beyond the Hardshell shaft. (See fig. 22, p. 159.)

52/ Work cited in footnote 49, pp. 266-268.

53/ Jones, E. L., Jr., and Ransome, F. L., Deposits of Manganese Ore in Arizona: Geol. Survey Bull. 710; pt. I, 1920, pp. 93-184.

The claim was located in 1877 and was operated for several years in the early 1880's as a silver mine by Hermosa Mining Co. At that time it is reported to have produced about 1,000 tons[54/] of ore containing 30 ounces of silver per ton. This ore was mined from a vein in volcanic rocks situated several hundred feet east of what is now known as the Salvador manganese deposit. In the late 1930's, this deposit was partly explored and worked by lessees for its silver content. According to A. R. Byrd, who held an option on the property in 1941, about 50-odd carloads, or some 2,000 tons of manganiferous silver ore had been shipped from the deposit before 1941. The shipments were made to various Arizona copper smelters and were reported to have averaged about 15 ounces of silver per ton. Only 18 lots were assayed for manganese, and they contained about 19 percent manganese. Although some work may have been done after 1941 there are no records of further production. Whether any manganese ore as such has ever been shipped from the deposit is not known, although reports indicate that a few shipments of hand-sorted manganese ore may have been made during World War I.

In 1941 the area was mapped by the Geological Survey and the deposit sampled by the Bureau of Mines. Fifteen samples contained 6 to 22 percent manganese and 6 to 11 ounces of silver per ton. In 1944, a 10-ton sample was taken for metallurgical tests by the Bureay from the faces of the principal workings. This sample contained 13.5 percent manganese, 0.12 percent copper, 1.1 percent lead, 1.3 percent zinc, 1.9 percent iron, 67.4 percent silica, and 10.7 ounces of silver per ton. About a year later, another 15-ton sample was taken for the same purpose. It assayed 15.2 percent manganese, 11.3 ounces of silver per ton, and about the same in base metals as the 10-ton lot. The samples were tested on a semi-pilot-plant scale in the Salt Lake City laboratory of the Bureau by the dithionate process of sulfur dioxide leaching to extract the manganese and cyanidation of the leached residue to recover the silver. The results of this test work[55/] on both samples showed an extraction of more than 90 percent of the manganese and a recovery of about 90 percent of the silver by cyanidation after the manganese was removed. Tests made on the raw ore by flotation and cyanidation failed to show a satisfactory recovery of the silver.

The Salvador manganese deposit, like the Bender, is composed of various-size replacement bodies occupying a fracture zone in a block of silicified limestone. The limestone covers a surface area about 900 feet long and 200 to 300 feet wide, which is completely surrounded by volcanic rocks (fig. 24). Although small amounts of manganese minerals are present in the limestone, the principal deposits crop out along the west side of Hardshell Gulch near the southwest end of the limestone block. The better deposits in the area are exposed about 180 feet to the north and, as shown in some of the workings, extend west some 50 feet. Ore is still present in the west face of these openings, and its further extent in that direction has not been revealed. Past operations have been confined entirely to mining the higher grade ore bodies. Not enough exploratory work has been done to indicate the attitude of

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54/ Work cited in footnote 49, pp. 272-275.

55/ Romslo, T. M., and Ravitz, S. F., Arizona Manganese-Silver Ores: Bureau of Mines Rept. of Investigations 4097, 1947, p. 13.

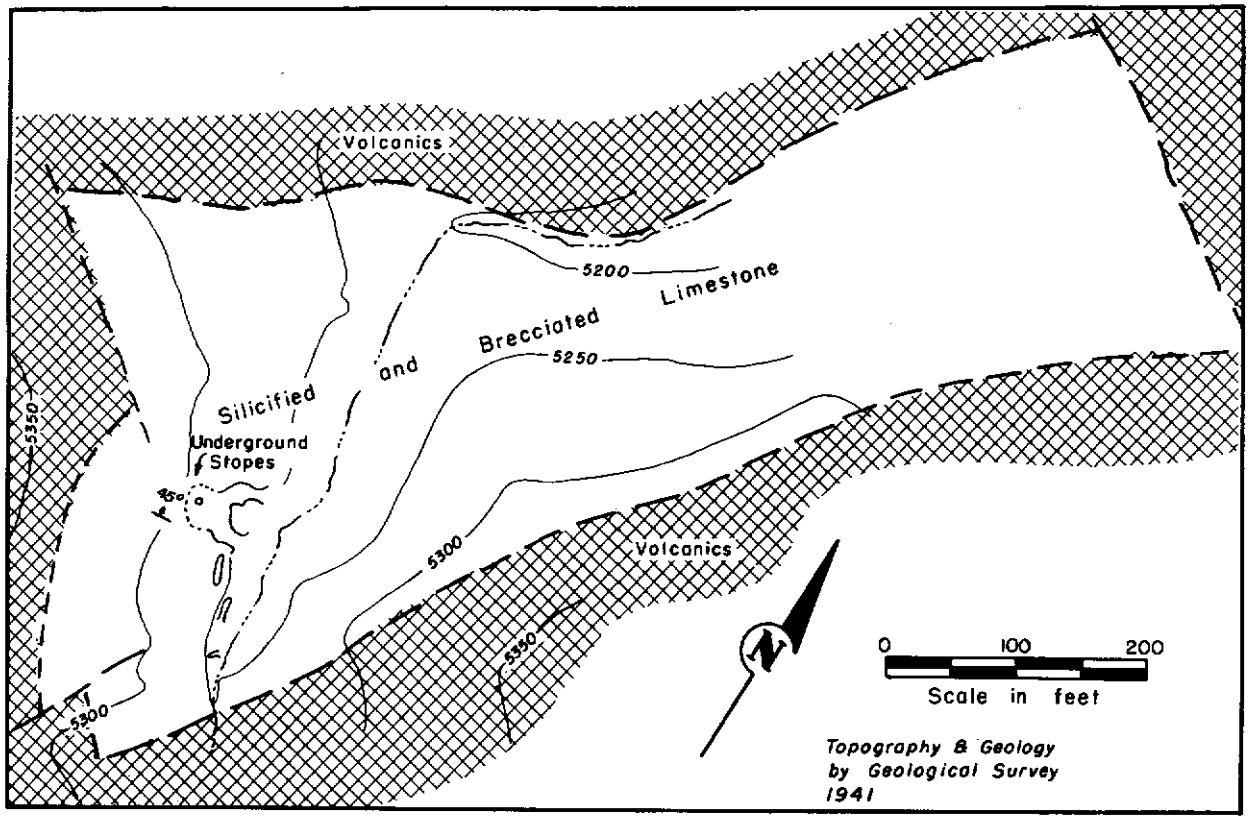

FIGURE 24. - Salvador Manganese Deposits, Santa Cruz County, Ariz.
(Topography and Geology by Geological Survey, 1941.)

the deposit as a whole. In some places the ore bodies appear to follow the bedding planes of the limestone, which strike westward and dip about 35° N. In other places the ore seems to be associated with an irregular fracture zone striking northward across the limestone beds in general conformance with the long dimensions of the outcrop.

The ore bodies range from small high-grade bunches to average-grade masses a few tens of feet in length and several feet in width. These are separated by various-size bodies of lower grade material or by barren siliceous limestone.

The ore minerals are chiefly pyrolusite and wad occurring in a highly siliceous gangue with small amounts of iron, copper, lead, and zinc minerals.

The workings consist of a few shallow opencuts scattered along the outcrop and two 50-foot adits driven westward into the hillside from the outcrop. The portal of the adits are about 45 feet apart and are connected underground by an open stope 35 feet long, up to 20 feet wide, and as much as 20 feet high. The north adit is inclined downward and terminates in an underhand stope, reaching a maximum depth of some 20 feet below the outcrop--the deepest point reached by the workings. A sample cut across the west end of the underhand stope contained 16.7 percent manganese. The property was idle when the area was visited in June 1957.

Black Rose

The Black Rose, a single unpatented claim, is about 1 mile directly south of Harshaw in the east-central part of approximate sec. 9, T. 23 S., R. 16 E., unsurveyed. (See figs. 21 and 22, pp. 158 and 159.) The workings are accessible by 0.8 mile of winding road that branches left from the Bender mine road about 1.3 miles south of its intersection with the main Patagonia-Washington Camp road (fig. 22).

When the property was visited in June 1957, a location notice showed that the claim had been relocated in April 1954 by Richard Hale, whose address is not known. The age of some of the workings indicated that the claim had been located and prospected for silver much earlier than 1954. As far as is known no manganese ore has been shipped from the property.

Minor amounts of manganese minerals, largely in the form of narrow stringers and stain, are quite widespread along fracture zones in the rhyolite country rock covering the claim and in areas to the west along the Bender mine road.

The principal deposit on the property consists of a lenticular body of soft manganese oxides ranging from 2 to 8 feet in width and having an exposed length of some 20 feet. The fracture zone in the rhyolite, along which the lens of ore is localized, strikes N. 15° W. and dips steeply northeast. Beyond the exposure to the northwest the fracture zone is covered with overburden. Southeast along the projected trend of the occurrence, the overburden has been stripped by recent bulldozer work. Only a few widely spaced stringers and small irregular bunches of manganese oxides are exposed in this stripped area.

The other workings consisted of an old partly caved pit about 8 feet in diameter and 10 feet deep which had been sunk in the wide central part of the main lens of ore. A few tens of tons of ore, estimated to contain 15 to 20 percent manganese, had been sorted from the material broken in the pit and placed in a pile nearby.

Pollywog

The Pollywog group of three unpatented claims is about 14 miles by road south and a little east of the town of Patagonia in approximate sec. 27, T. 23 S., R. 16 E., unsurveyed. (See fig. 22, p. 159.) The Patagonia-Washington Camp road crosses the claims about 1 mile southeast of the Mowry mine.

The earlier history of the property is not known. In 1941 the claims were known as the J and E group and were held by George T. Killim and R. M. Carter. In 1953 they were relocated by the present owners, Manuel Heredia and Jim Nations, of Patagonia, Ariz. Although some manganiferous silver ore may have been produced in the past, apparently no ore chiefly valuable for its manganese content has been shipped from the property.

The deposit lies along the south side of a wash a few hundred feet northeast of the main road at an altitude of about 5,400 feet. The area is almost completely covered with alluvium and detrital overburden, and only a few outcrops of the underlying rocks are evident. Limestone appears to be the prevailing bedrock in the area and is the host of the manganese ore. Manganiferous material is present on the dumps of several old caved pits that are scattered within an area roughly 60 feet east-west and 150 feet north-south.

The only minerals in place are exposed in an old 18-foot vertical shaft at the north end of the area. The shaft penetrates a body of soft wad-type manganese oxides replacing the limestone. The ore along the west end of the shaft lies adjacent to a well-defined fracture striking north and dipping almost vertically. Along the strike of the fracture the ore has an exposed length of about 12 feet; its further extent is obscured by overburden. As exposed in a short crosscut near the bottom of the shaft, the mineralized zone is at least 10 feet wide normal to the strike of the fracture. Because other exposures are lacking it is impossible to compare the ore in the shaft with that in the other inaccessible openings nearby, the dumps of which contain manganese minerals. The deposit may consist of several disconnected irregular ore bodies following the limestone beds, or the ore bodies may occur along a steeply-dipping, northerly-trending fracture zone, such as is exposed in the shaft.

A sample taken in the shaft and crosscut over a width of 8 feet contained 21 percent manganese and 8.4 percent iron.

Blue Bird

The Blue Bird group, comprising two unpatented claims, is about 21 miles by road east-southeast of the town of Patagonia in SE1/4 sec. 5, T. 23 S., R. 18 E. (See fig. 21, p. 158.) The claims lie along the west slope of the Canelo Hills at an altitude of about 5,200 feet. The property can be reached from Patagonia by traveling south on the Harshaw road 6.3 miles, then east on a left-hand branch 9.6 miles to a right-hand fork leading to the Cherry Creek Dam. This fork is followed east 4.8 miles to a faint access road branching left, which continues north several hundred feet to the principal workings.

The claims are said to have been located first in World War I, and a small amount of hand-sorted ore was shipped in 1917. The claims have since been abandoned and relocated several times. In the early 1940's they were held by R. L. McKenney, and in 1952 they were relocated by Avelino De La Osa, of Patagonia. In 1953 De La Osa and lessee S. J. Lemas, Jr., shipped 23 long tons of sorted ore containing about 42 percent manganese. Part of this ore was trucked to the Government purchasing depot in Wenden, Ariz., and part to the depot in Deming, N. Mex. The property was idle when visited in July 1957. Location notices were found at the time, showing that the claims had been relocated in May 1957 by Joe V. Quinlan, of Tucson, Ariz.

The manganese minerals occur along a steeply dipping fracture and in a brecciated zone in volcanic rocks. The zones are about 300 feet apart and diverge in strike. The eastern fracture, from which the ore has been produced,

trends N. 50° E. and is virtually vertical in dip. It is as much as 8 feet wide and has an exposed length of about 200 feet. To the southwest, the outcrop is covered with overburden. To the northeast, where exposed in a short adit, the ore zone ends against a transverse fracture. Hard manganese oxides, consisting chiefly of psilomelane, occur along this zone in narrow stringers and in a series of short, disconnected lenticular pods. The pods range from 6 inches to 2 feet in width and are seldom more than a few feet long.

The workings on the eastern fracture consist mainly of a small vertical shaft, two opencuts, and a 10-foot adit. The shaft is about 18 feet deep, and some 20 feet of drifting has been done on the fracture at that depth. The principal opencut, situated northeast of the shaft, is about 50 feet long and up to 8 feet deep.

The west brecciated zone, situated about 300 feet northwest of the east-zone workings, strikes almost due north and dips about 75° E. It is 4 feet wide and has an exposed length of 150 feet. In this zone the manganese oxides are confined largely to narrow stringers and thin films surrounding the brecciated fragments of the country rock. The workings consist of a shallow opencut about 20 feet long.

Black Butte

The Black Butte group of two unpatented claims, formerly known as the Blue Bird or Carico property, is some 4 miles by road west of the town of Patagonia in the east-central part of approximate sec. 9, T. 22 S., R. 15 E., unsurveyed. (See fig. 21, p. 158.) The deposit can be reached from Patagonia by traveling 3 miles southwest on State Highway 82, then north across Sonoita Creek on a dirt road branching to the right. This branch is followed north-northwest about 1 mile. From this point the deposit is reached by a northward trending foot trail 0.5 mile long.

The claims were located in the early days of the district as silver prospects. Since that time they have been abandoned and relocated several times. In the 1940's they were held by P. W. Carico. The present owner, Avelino De La Osa, of Patagonia, relocated the group in 1952.

The first manganese ore was produced in 1953. In 1953-54, 34 long tons of sorted ore averaging about 25 percent manganese was shipped to the Government purchasing depots in Wenden, Ariz., and Deming, N. Mex. About 12 tons of this ore was produced by the owner and the balance by lessee Robert R. Hathaway. No work was in progress when the area was visited in July 1957.

Soft manganese oxides occur on the property along a vertical fracture in rhyolite. The fracture strikes N. 60° E., ranges from 2 to 4 feet in width, and is mineralized in disconnected areas about 400 feet along the outcrop. The ore minerals, consisting of pyrolusite and wad, occur in narrow parallel stringers and occasionally as lenticular masses as much as 10 feet long and 2 feet wide.

The ore produced came from the most highly mineralized part of the outcrop, where several of the larger lenses occurred in an area along the fracture about 60 feet long. The workings in this area comprised a small vertical shaft some 20 feet deep and an adjacent opencut 18 feet long and as much as 9 feet deep. A shallow trench about 30 feet northeast of the shaft exposed a short lens of ore 2 feet wide. Although some manganiferous float was present farther northeast, the trench appeared to mark the exposed limits of any appreciable amount of mineralization in that direction.

Minor amounts of manganese minerals were exposed in places along the outcrop of the fracture for 300 feet or more southwest of the shaft. The more promising spots had been explored by several shallow opencuts, but apparently no ore had been mined in this part of the fracture.

Iron oxide and quartz are the chief gangue minerals accompanying the pyrolusite and wad. Samples assaying about 20 percent manganese usually contain approximately 10 percent iron.

Sorillo

The Sorillo group, consisting of two unpatented claims, is about 10 miles by road northeast of Nogales, Ariz., in SE1/4 sec. 18, T. 23 S., R. 15 E. (See fig. 21, p. 158.) The deposit is accessible over some 2 miles of dirt road that branches right from State Highway 82 about 0.7 mile northeast of the entrance to the Nogales airport.

The claims, although located much earlier for silver, have been held since 1953 by Robert R. Hathaway, of Nogales, Ariz. As far as is known no manganese ore as such has ever been shipped from the property. When they were visited in June 1957, one man was employed in rehabilitating part of the caved workings.

The manganese minerals occur in disconnected lenses along a vein cutting granitic rocks. The vein trends N. 60° E., dips about 55° SW., and ranges from a fraction of an inch to 4 feet in width. It is exposed in places for several hundred feet along the strike, where it crops out along the top of the bluffs bordering the southern side of Cañada de la Paloma Wash. The manganiferous lenses range from a few inches to 2.5 feet in width and from 4 to 10 feet in length. In places they are closely spaced, and in other parts of the vein they are separated along the strike by several tens of feet of barren or sparsely mineralized vein matter.

The chief manganese minerals are wad, pyrolusite, and some psilomelane. The gangue is composed largely of clay gouge, quartz, and brown jasper.

The principal workings consist of a 175-foot crosscut adit that intersects the vein about 60 feet below the surface. From the face of the adit, a drift extends along the vein about 30 feet to the southwest and 10 feet to the northeast. The southwest drift was largely caved and inaccessible when the property was visited.

Loma de Manganese

The Loma de Manganese claim is one of a group of five unpatented claims in SE1/4 sec. 1, T. 23 S., R. 11 E., some 36 miles by road northwest of Nogales, Ariz. (See fig. 21, p. 158.) It can be reached from that town by traveling north on U.S. Highway 89 about 7 miles to a graded dirt road branching left, known as the Ruby-Arivaca Road. This branch is followed west-northwest 27.3 miles, then the Warsaw Canyon Road is followed left or southward 1.8 miles. At this point the manganese deposit is reached by a short access road branching left.

The property is now owned by Edward A. Sheeny, of Nogales, Ariz. The first manganese ore of record was produced in 1953 and 1954 by lessees Frank Otero and E. M. Hunter. At that time 44.8 long tons of sorted ore averaging 47 percent manganese was shipped to the Government purchasing depot in Deming, N. Mex. Previously, shipments of high-grade copper-silver ore had been made from time to time from claims adjoining the one containing the manganese deposit. No work was in progress when the property was visited in July 1957.

The manganese ore occurs in irregular lenticular masses along a fissure in rhyolitic rocks. The fissure ranges from 2 to 3 feet wide, strikes N. 25° E., and dips about 50° SE. Overburden covers much of the surface along the trend of the fissure, but bulldozer stripping both to the northeast and southwest indicates that the bulk of the manganese minerals are limited to a strike length of 100 feet. As exposed in the workings, the better ore appears to be confined to a strike length of some 50 feet. In this area the higher grade ore lenses range from a few inches to 1.5 feet in width and are up to 10 feet long. In places the lower grade material, separating or surrounding the high-grade ore, is as much as 3 feet in width.

The chief manganese minerals are psilomelane and pyrolusite, which occur in a gangue of manganiferous calcite and small amounts of iron oxides.

The workings consist of a 35-foot inclined shaft with 18 feet of drifting and an opencut immediately northeast of the shaft. Small irregular stopes extend upward from the drift on both sides of the shaft. The opencut is about 30 feet long and as much as 6 feet deep.

A headframe constructed of 2-inch pipe is the only equipment remaining on the premises.

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