DEPOSITS OF MANGANESE ORE IN SOUTHEASTERN CALIFORNIA.

By EDWARD L. JONES, Jr.

INTRODUCTION.

A reconnaissance examination of the manganese deposits of southeastern California, embraced in an area bordering Colorado River in San Bernardino, Riverside, and Imperial counties, was made by the writer in June, 1918. This examination was the outgrowth of similar examinations in 1917 and earlier in 1918 of widely scattered manganese deposits in southwestern Arizona, for the purpose of making estimates of the quantity and grade of ore that the region is capable of producing. The deposits that were examined in California extend from the mouth of Whipple Wash on Colorado River southward to the eastern part of the Chocolate Mountains, as shown on the accompanying map (Pl. IX). Most of the deposits within this zone that were reported to the United States Geological Survey were visited by the writer, whether producing or not, but a few remote deposits from which no production has been made were not examined. From north to south these deposits are the McDowell claims, near the mouth of Whipple Wash; the Red Cross and Hidden Treasure groups, in the Monumental district of the Whipple Mountains; the Dioxide group, in the Maria Mountains; the Black Jack, Social, and Melville groups, in the Ironwood Mountains; the Lugo claims, in the Palo Verde Mountains; and the Everharty, Tolbard, and Curley M. groups, in the Paymaster district of the Chocolate Mountains. Most of these deposits are recent discoveries, and their exploitation dates from the beginning of the war demands for the production of domestic manganese ores early in 1917. The Black Jack deposit, in the Ironwood district, however, has long been known, and attempts were made to mine it prior to 1917.

ECONOMIC FACTORS.

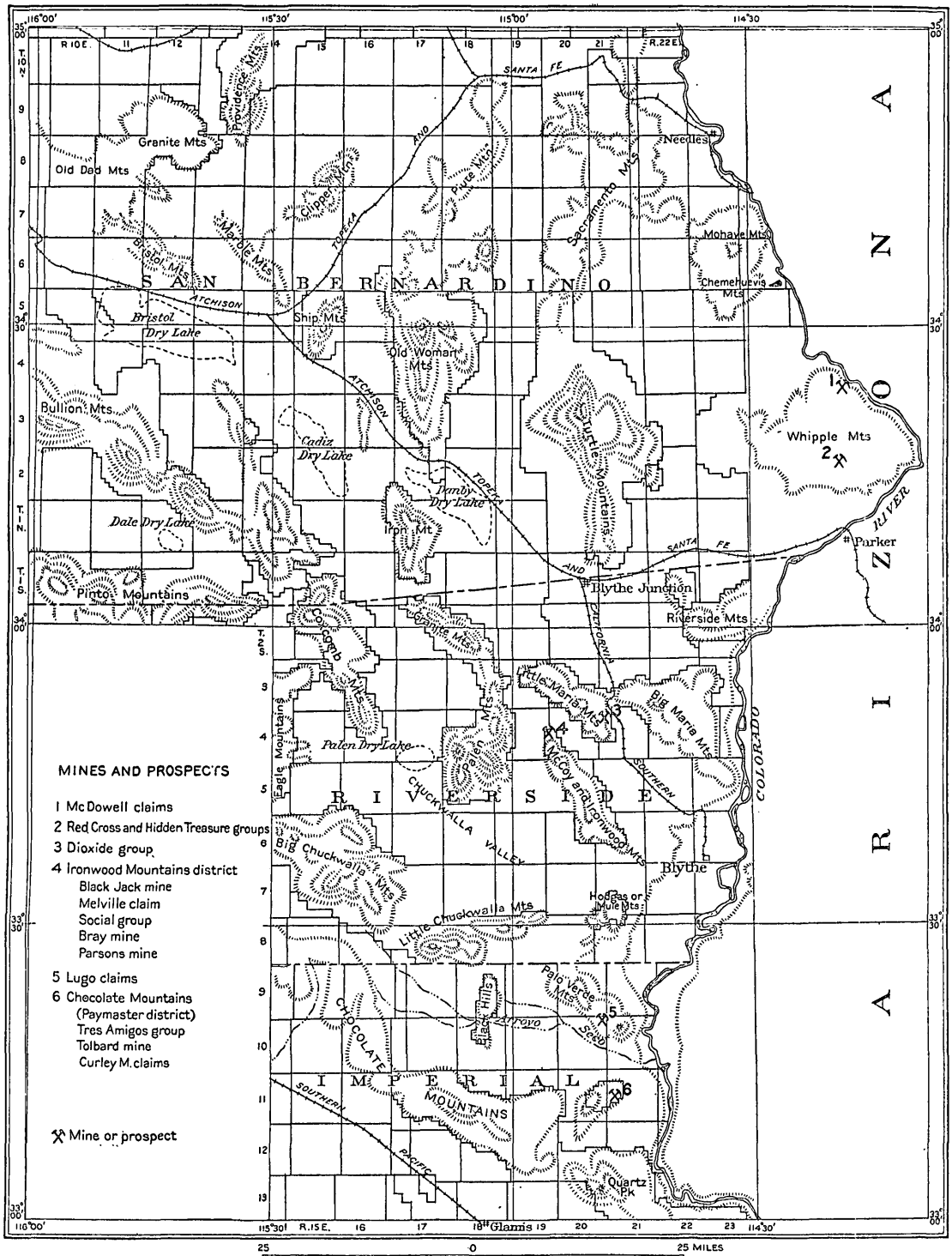
The possibility of commercial production of manganese ore in this region is determined by the accessibility of the deposits and the cost of transportation and mining. The northern part of the region is served by the Parker branch of the Atchison, Topeka & Santa Fe

Railway; the central part by the California Southern Railroad, which extends from Blythe Junction on the Parker branch to Blythe; and the southern part by the Southern Pacific Railroad. The McDowell claims are best reached by boat on Colorado River from Parker, Ariz., about 40 miles distant; the Red Cross and Hidden Treasure groups are 11 miles north of Drennan, a station opposite Parker. The deposits in the Maria and Ironwood mountains are from 3 to 12 miles west of English and Brown sidings, on the California Southern Railroad. The Lugo claims are about 35 miles north of Glamis, on the Southern Pacific Railroad, and the deposits in the Chocolate Mountains about 32 miles from Glamis. Auto trucks are used in hauling the ore to the railroad. Transportation costs are unduly large because of the poor condition of the roads, the expense of repairing which is largely borne by the operators. Truckage charges are not less than 50 cents per ton-mile, and from some deposits the rate is higher. The ore is shipped to furnaces east of Mississippi River, and the freight charges range from $11 to $15 a long ton. Water and fuel must be hauled to the camps. All the mining is done by hand, and the mining costs are high. Some of the shafts are equipped with small gasoline hoists. Development work is nowhere extensive, and none is done in advance of the extraction of ore. The ore is sorted by hand or screened in order to bring it to the required grade. Although the ore appears to be well adapted to mechanical concentration by wet gravity processes, the lack of water near the deposits precludes the installation of such machinery on the ground, and the expense of hauling the crude ore for considerable distances to water would probably not be justified.

Manganese deposits can be readily found in the desert region. All the deposits crop out and on distintegration most of them yield masses and pebbles of the hard manganese oxide, psilomelane, which can be easily traced to their sources on hill slopes generally devoid of vegetation. The deposits occur in rocks of all ages but are most abundant and widespread in Tertiary lavas and associated rocks.

PRODUCTION.

The early records of production from these deposits are incomplete, but from January 1, 1917, to October 1, 1918, they yielded over 6,000 tons of high-grade ore. The incomplete development of the deposits and the variability of range in depth of the oxides preclude any close estimate of ore reserves, but at a minimum 30,000 tons of high-grade ore is available. Much of the ore that was shipped contained over 40 per cent of manganese, less than 6 per cent of silica, and 2 per cent of iron. It was used largely in making ferromanganese.



INDEX MAP SHOWING MANGANESE DEPOSITS IN SOUTHEASTERN CALIFORNIA.

With the resumption of imports of high-grade foreign ores it is highly probable that these deposits can not be worked profitably unless a market can be found much closer to the deposits than the furnaces which now use the ores.

GEOGRAPHY AND TOPOGRAPHY.

The region in which the manganese deposits occur is characterized by many irregular mountain masses and short ranges separated from one another by areas of detrital deposits or bolson valleys from a few miles to many miles wide. The mountains rise from a few hundred to several thousand feet above the surrounding plains, and the range in altitude of occurrence of the known manganese deposits is from 600 feet on the McDowell claims, near Colorado River, to 2,300 feet in the Red Cross and Hidden Treasure groups, in the Whipple Mountains. In the Maria, Ironwood, Palo Verde, and Chocolate mountains the deposits lie near the base of the hills, at altitudes of 1,000 to 1,500 feet above sea level. Colorado River, which forms the eastern boundary of this region, is narrowly confined in places between steep walls of solid rock; elsewhere it is bordered by flood-plain areas of bottom lands, of which Palo Verde Valley, the largest, is about 30 miles long and has a maximum width of 12 miles. The bottom lands are generally bounded by a well-defined bench from 50 to 100 feet high. In favorable places the bench land may form a flat-topped mesa many miles wide, or it may merge into a gently inclined plain built up by the accumulation of outwash deposits from the mountains.

Except Colorado River there are no perennial streams in the region, and in the mountains springs and watering places are very scarce. The mountains, however, are deeply dissected by numerous arroyos and gulches which carry to the surrounding valleys the detritus-laden flood waters that follow heavy storms.

The climate is extremely arid; the probable average annual rainfall for the region is less than 5 inches, and most of it occurs in midsummer. The heat is intense in summer and often interferes with outside work, but from October 1 to the following June the climate is generally mild and dry. A few cottonwood trees grow along Colorado River, and mesquite, willow, and arrowweed are abundant in the bottom lands. The mountain slopes and mesas support a scattering growth of the typical desert vegetation of cactus, ironwood, palo verde, and other shrubs.

ORE DEPOSITS.

The manganese deposits occur in veins and brecciated zones in sedimentary and igneous rocks ranging in age from pre-Cambrian to probably Quaternary. On the McDowell claims manganese deposits

occur in pre-Cambrian granitic rocks and in sandstones and basalt of Tertiary or later age. The deposits on the Red Cross and Hidden Treasure groups are in limestones, sandstones, and shales that are probably of Tertiary age, closely associated with volcanic breccias and lavas. Massive Paleozoic limestone and quartzite are the inclosing rocks of the Dioxide deposit, and in the Ironwood Mountains the deposits are contained in a sheared quartz-bearing porphyritic rock whose age is not known. In the Chocolate Mountains the veins containing the manganese deposits cut lavas of Tertiary age and conglomerate that is probably Quaternary.

The deposits vary greatly in size. Some of the veins in the Chocolate Mountains can be traced for several thousand feet, but the longest ore shoot so far developed in them is about 400 feet long and has a maximum width of 3 feet. In the Ironwood Mountains most of the developed ore shoots are less than 100 feet long, but in some of them the ore is 8 feet wide. The deposits on the Dioxide group of claims consist of veinlets traversing limestone and sandstone and small replacement deposits in limestone distributed irregularly for several thousand feet in a wide zone of brecciation. Many small lenticular bodies from a few feet to 25 feet long and as much as 6 feet wide are found on the Red Cross and Hidden Treasure claims.

The age of the manganese deposits in the Chocolate Mountains is believed to be Quaternary, as the veins cut conglomerate beds that are probably of Quaternary age. In the Ironwood district there is no criterion on which to base an age assignment, but in the Whipple Mountains the deposits are post-Tertiary. Although the deposits occur in rocks that differ widely in age it appears probable that the deposits themselves are all of the same age, because of their similarity in type and mineral composition, and if this assumption is correct all the deposits are probably Quaternary.

The manganese ore consists of the oxides, of which psilomelane, pyrolusite, and manganite have been determined. Psilomelane is the dominant oxide in all these deposits. It occurs in many forms but most commonly in laminae deposited along the walls of fissures. Massive, mammillary, and botryoidal forms are not unusual, but more rarely it occurs in rodlike or stalactitic forms in cavities in the ore. Psilomelane is more abundant in the surficial ores of the deposits; with increasing depth the softer oxides, pyrolusite and manganite, become increasingly abundant. Psilomelane has been found, however, to depths of 70 feet in the Black Jack mine and of 40 feet in the deepest workings of the Tolbard mine. Manganite in small wedge-shaped crystals commonly occurs interbanded with psilomelane, but it has an unusual occurrence in small fibrous crystals developed in cavities in massive psilomelane. Pyrolusite is regarded solely as the decomposition product of manganite, and it is nowhere

abundant. The sooty films on specimens of other oxides are largely pyrolusite. Associated with the manganese oxides are calcite and subordinately iron oxides. Calcite is universally present in the ores, though it varies largely in quantity. In some deposits it occurs as veins and veinlets traversing the ore, and in others it partly fills cavities in the ore. Some of it is of primary origin, but probably most is secondary. In the Tolbard mine veins of a white sugary calcite as much as 6 inches wide occur on one or both walls of the ore body. Iron oxides are scarce in most of these deposits, but in some of the veins that cut Tertiary lavas they are abundant. The deposits in the Whipple Mountains are generally incased in a shell of soft red hematite, although iron forms only a small percentage of the ore itself. Quartz was nowhere observed as a primary constituent of the manganese deposits, although the ore generally carries a small quantity of silica from the inclusion of fragments of siliceous wall rock. No manganese mineral other than oxides was recognized in any of these deposits, but none of the workings had passed through the oxidized zone.

The manganese deposits of southeastern California examined in this reconnaissance are similar in type and mineralogy to the deposits in southwestern Arizona, but in each locality the source of the manganese oxides is obscure. However, it seems probable that the manganese oxides are the decomposition product of manganiferous calcite deposited by rising hot solutions in the fissures, or that they were deposited with calcite in the fissures by meteoric waters which obtained the oxides from the decomposition of manganiferous minerals of the surrounding rocks. The evidence for either hypothesis is not conclusive, and definite proof can probably not be obtained until the deposits are explored below the zone of oxidation.

MINES AND PROSPECTS.

SAN BERNARDINO COUNTY.

McDOWELL CLAIMS.

Several claims owned by H. W. McDowell lie at the lower end of Little Chemehuevis Valley, about a mile north of a point opposite the property of the Arizona Manganese Co. on the Arizona side of Colorado River. The claims extend from the river about 1 mile westward. They are accessible only by boat from Parker, Ariz., which by the circuitous water route is said to be 44 miles south of the claims. The claims have recently been located, and no ore has been produced from them.

The bottom lands of Colorado River adjacent to the deposits are about 400 feet above sea level, and from them hills 200 feet high extend a mile or more back from the river. Colorado River is the only

water supply in the vicinity of the deposits. The climate is arid, and except on the bottom lands, where mesquite is abundant, the soil supports only a sparse growth of desert shrubs.

Igneous and sedimentary rocks ranging in age from pre-Cambrian to late Tertiary or Quaternary occur in the vicinity of these claims. In a small area along the river granitic rocks of pre-Cambrian age crop out and form the old complex on which sandstone and interbedded limestone of Tertiary age were deposited. The sediments strike in general about east and dip 60° S. In some places the sandstone is intruded by dikes of black vesicular basalt, and in others basalt flows overlie the sandstone. The basalt is probably of Quaternary age.

Manganese oxides occur in several places on the claims in small seams and in deposits formed by impregnation from fissures, but rarely do the deposits of manganese oxides attain a width of 3 inches, and they persist only for a few feet. Small veins of psilomelane that strike east were noted in diorite and granite near the river. A short distance west of the older rocks on the river bank small seams of psilomelane cut across beds of brown sandstone. The sandstone is impregnated with manganese oxides for a few inches from the fissures, but the seams are too small to be mined.

About a mile west of the river a dike or flow of vesicular basalt about 100 feet wide lies between beds of sandstone that strike east and dip 60° S. In a small area the basalt is cut by seams of psilomelane as much as 3 inches wide, but the seams are too widely spaced to be mined profitably, and it is probable that they persist only to depths of a few feet. Psilomelane is the dominant oxide in these deposits, but some pyrolusite was also observed. Calcite occurs in the seams with the manganese oxides.

RED CROSS AND HIDDEN TREASURE GROUPS.

Location.—The Red Cross group of 16 claims and the adjoining Hidden Treasure group of 8 claims are owned by Fred W. Hall and Mrs. Maude Washbish, of Parker, Ariz. The claims are in the Whipple Mountains about 11 miles north of Drennan, Calif., a siding on the Parker branch of the Atchison, Topeka & Santa Fe Railway, on the bank of Colorado River opposite Parker. They are included in the Monumental district. The claims lie about 2½ miles northwest of Monument Peak, a prominent landmark which forms the northernmost point of the Colorado River Indian Reservation.

The claims are accessible from a wagon road which goes northward from Drennan to Copper Basin, a few miles northeast of the manganese deposits. There is a well near this road, and from it a new road leads westward for about a mile to the manganese camp. Beyond the camp the manganese deposits are reached by a trail half a

mile long. The deposits are said to have been discovered early in 1917, but to the time of visit on May 21, 1918, only a small quantity of ore had been shipped.

Geography.—The Whipple Mountains constitute an irregular mountain mass covering approximately 200 square miles, which occupies an area in a great bend of Colorado River. In places the mountains approach the river, but for the most part they are flanked by broad areas of outwash and gravel beds. The deposits lie at altitudes ranging from 2,100 to 2,300 feet above sea level. The mountains adjacent to the deposits rise to a maximum of 1,000 feet above them, and the bottoms of the washes are about 1,000 feet below the deposits. Monument Peak is 2,446 feet high. The mountains are intricately and deeply dissected by many washes and arroyos. Some of the mountain summits are flat-topped or gently sloping; others are in castle-shaped and spirelike forms. In the vicinity of the deposits washes or arroyos drain north, east, and south to Colorado River. Whipple Wash drains north and joins Colorado River at the lower end of Little Chemehuevis Valley.

The manganese claims cover a large part of two mountains and a low pass at the heads of two washes or arroyos which lie between them. One wash drains into Whipple Wash, and the other into a wash that leads southward to Colorado River. Springs are found here and there in the washes of the Whipple Mountains, and Whipple Wash contains several, but the flow of water from them is not abundant enough to carry water for more than a few feet. In addition to the springs, a few natural rock reservoirs or "tanks" occur in the beds of arroyos, and some of them contain potable water throughout the year. The nearest water to the manganese deposits, however, is along the road 1½ miles east of them, but its quality is poor, and water for domestic purposes is hauled from Colorado River at Drennan.

The climate is extremely arid, the weather records at Parker, Ariz., indicating a mean annual precipitation of 5 inches. The gravel-covered bench lands and mountain slopes support several varieties of cactus, including the prickly pear, the sahuaro, and cholla, and the larger arroyos contain sparse growths of palo verde, ironwood, and mesquite.

Geology.—The Whipple Mountains are composed of igneous and sedimentary rocks that range from pre-Cambrian to Quaternary in age. Gneiss, granite, hornblende schist, and included masses of metamorphosed sedimentary rocks of probable pre-Cambrian age are the basal rocks of the mountains. Overlying them unconformably in ascending order are conglomerate and red and brown sandstone with interbedded shale and limestone members of probable Tertiary age. These are closely associated with and succeeded by andesite and basalt breccias and tuffs and finally by basaltic flows, which form the

summits of some of the flat-topped mountains. Some of the later lava flows may be of Quaternary age. The bench lands that flank the Whipple Mountains on the east are composed of gravel, sands, and outwash deposits, intercalated in which are a few thin basalt flows. The sand and gravel deposits are believed to be the equivalent of the Chemehuevis gravel, named and described by W. T. Lee,[1] which is of late Quaternary (Recent) age.

Gneiss, granite, and schist are exposed for several hundred feet above the bottoms of the washes that head near the manganese deposits. Overlying them unconformably are red and brown sandstone and shale, with some interbedded or gradational red to gray limestones, then volcanic breccia succeeded by dark-colored lava flows. The sediments are at least several hundred feet thick, and they may be much thicker. They have been greatly faulted and distorted since their deposition. Several faults that strike about N. 40° W. and dip steeply southwest correspond rather closely in attitude with the sediments near the manganese deposits.

Manganese deposits.—The deposits of manganese ore occur as lenticular and irregular masses in the sandstone, limestone, and volcanic breccia of the younger rock series. Some of the ore bodies are clearly connected with northwesterly fissures along bedding planes, but others have no apparent connection with fissuring. There are many outcrops of ore on the claim groups, but only a few of them have been exploited. At a number of places the ore was being mined from widely distributed lenticular bodies. One deposit that is inclosed in volcanic breccia is 25 feet long and 4 feet wide in its widest part. At two other places ore was being mined from fissures in limestone. The bodies were 8 feet wide in their widest part and not over 25 feet in length. The depth of these deposits has not been determined; the deepest work is only 25 feet below the surface. At many places small knobs and pipes of high-grade ore project above the weathered surfaces of limestone and sandstone. Float ore of high grade is widely distributed over the surface, and in places it is abundant enough to make its gathering profitable. Exploitation of the many scattered deposits may lead to the discovery of large ore bodies, but the largest of the bodies so far exploited is estimated to contain not more than 200 tons. The aggregate of ore in the numerous deposits, however, is probably several thousand tons.

The manganese ore consists dominantly of massive psilomelane, but as shown in a polished section a little pyrolusite is present and veinlets of calcite are abundant in it. The lenticular masses of ore are inclosed in crusts of soft red hematite, but the iron oxides are not mixed with the psilomelane. Iron oxides are more abundant in

[1] Lee, W. T., Reconnaissance of a part of western Arizona: U. S. Geol. Survey Bull. 352, p. 18, 1908.

deposits in volcanic breccias than in limestones and sandstones. The ore is of high grade, and an analysis of a sample from a carload shipment is said to have yielded 46 per cent of manganese, 4 per cent of silica, 2 per cent of iron, and 0.04 per cent of phosphorus. No manganese minerals other than the oxides were noted, and the source of the manganese oxides is not apparent.

RIVERSIDE COUNTY.

GENERAL FEATURES.

Manganese deposits occur in a small area in the northern part of the Ironwood Mountains and in the west end of the Maria Mountains, in Riverside County, both areas in the Ironwood district. The deposits in the Ironwood Mountains are included in the Black Jack, Melville, and Social claim groups. The Melville group has been separated and was being worked under three ownerships at the time of visit. In the Maria Mountains ore has been produced only from the Dioxide group, but adjoining it are some undeveloped claims. A group of claims of the United States Gypsum Co. lies northwest of the Dioxide group. The deposits are accessible by roads that lead from Brown's siding and from English Siding, points on the California Southern Railroad, where loading platforms have been built. The deposits in the Ironwood Mountains are about 10 miles west of Brown's siding; those in the Maria Mountains are 5 miles northwest of Brown's siding and 3 miles west of English siding. The roads lead over soft, unconsolidated material, and under the traffic deep ruts are worn, so that unless they are repaired frequently travel is slow and difficult.

The manganese deposits of the Ironwood district were examined on June 16 and 17, 1918, by the writer, who studied only the geology of the country on the way to the deposits and in their immediate vicinity.

It is reported that manganese ore was first produced in the Ironwood district from the Black Jack mine in 1916. In 1917 C. E. Groce shipped ore from one of the claims of the Melville group; in 1918 P. H. Bray and H. M. Parsons shipped ore from other claims of this group, and in January, 1918, H. N. Mabery began shipping ore from the Dioxide group. To October, 1918, the district had produced about 3,000 tons of manganese ore. Most of the ore shipped in 1918 contained over 40 per cent of manganese, from 0.5 to 2 per cent of iron, and from 3 to 8 per cent of silica.

The deposits are mined by hand from open cuts, shafts, and tunnels. Some of the ore was shipped without sorting, but most of the vein material requires hand sorting or screening. The low-grade ore is well adapted to mechanical concentration, but there is no water

near the deposits available for the purpose. Water is hauled from the tanks at the railroad platforms to the mines. These tanks are replenished every few days from the tank cars of the California Southern Railroad. The ore is hauled to the railroad at a cost of $5 to $7.80 a long ton. Most of the ore is shipped to furnaces in Illinois and Pennsylvania, the freight rates to which range from $11 to $12.50 a short ton.

GEOGRAPHY.

The Ironwood Mountains form a short, narrow range trending northwestward, surrounded by desert valleys that lie between it and other isolated ranges. One of these valleys, several miles wide, lies between the Ironwood and Maria mountains. The deposits in the Ironwood Mountains lie at their north end near the base of the northerly slope, at altitudes ranging from 1,050 to 1,500 feet above sea level. South of the deposits the mountains attain a relief of 1,500 feet or more above the surrounding plain.

The Maria Mountains are an irregular mass with no well-defined trend. A low detritus-filled pass in them, traversed by the California Southern Railroad, separates a group of low hills west of the railroad, locally known as the Little Maria Mountains, from the Maria Mountains east of the railroad. The manganese deposits are in the Little Maria Mountains about 3 miles west of the railroad, at an altitude of 1,000 feet, only a few feet above the detrital deposits.

Numerous arroyos drain from the Ironwood and Maria mountains to the surrounding desert flats, but they contain no water except for brief periods after the infrequent rains. The annual precipitation is probably less than 5 inches. Notwithstanding the lack of moisture a fair growth of ironwood, palo verde, greasewood, cactus, and several other shrubs is found in places on the desert flats and part way up the mountain slopes.

GEOLOGY.

The manganese deposits of the Ironwood Mountains are contained in veins or shear zones that cut a sheared and schistose intrusive igneous rock. The veins strike within a few degrees of due north and have steep dips. The Ironwood Mountains are probably composed of rocks of several kinds, but in the area examined only the intrusive rock inclosing the manganese deposits is exposed. The intrusive is a medium-grained grayish rock made up of quartz, feldspar, and biotite. Some of the quartz and feldspar crystals are slightly larger than their neighbors and give the rock a porphyritic aspect. The rock is sheared and somewhat altered, for sericite is developed along the planes of shearing. Biotite occurs rather abundantly throughout the rock. No thin sections of the rock were made

for microscopic study, but it would probably be classified as granite porphyry or quartz monzonite porphyry.

The manganese deposits in the Little Maria Mountains are contained in a wide zone of brecciation in massive limestone and in fine-grained gray sandstone or quartzite. The limestone ranges in color from a gray rock to one composed of white and pink bands. No igneous rocks were noted near the workings, but intrusive rocks are reported to occur a short distance west of the Dioxide group. Extensive beds of gypsum occur a short distance northwest of the Dioxide group, and they are apparently overlain by or interbedded with limestone. The zone of brecciation strikes about N. 60° W. and approximately marks the crest of a fold in limestone, which dips to the northeast at low angles.

MANGANESE DEPOSITS.

The manganese deposits consist of the oxides psilomelane, manganite, and pyrolusite. Psilomelane is dominant near the surface and persists to a depth of 70 feet in the shaft on Black Jack No. 3 claim, but in all the deposits the softer oxides become increasingly abundant as depth is attained. The oxidized zone has not been penetrated in any of the workings, and the depth to which the ore extends is not known, but it seems probable that in places it extends at least 100 feet beneath the surface.

Most of the ore has been deposited in open fissures, though some of it has replaced fragments of country rock. In larger masses of clean ore deposited in open fissures the manganese oxides are in laminae of various thicknesses in different shades of steel-gray, brown, and black. The laminae range from some a quarter of an inch thick to those of microscopic size. They are composed dominantly of psilomelane, but manganite and perhaps pyrolusite are interbanded with the psilomelane. Some of the laminae consist of prismatic crystals an eighth of an inch long; in others the crystals are of minute size. The ore is hard and brittle. It breaks most readily along the planes on which the crystalline oxides have been deposited. In other places in the veins the ore is nodular, and the manganese oxides are deposited in concentric layers about fragments of country rock. The prevalence of psilomelane in the ores near the surface is the basis for the supposition that psilomelane is an alteration product of the softer oxides, although no horizontal gradation from crystalline to amorphous oxides was observed. Calcite occurs in all the deposits in the Ironwood Mountains, but it is more abundant in some of the veins than in others. It is a secondary mineral deposited as white crystals in veinlets or as vugs in the ore. Iron oxides occur very sparsely in the ore, the analyses indicating from a trace to 2 per cent of iron

Analyses of the ore also show as much as 8 per cent of silica, but this content is due to fragments of country rock that have not been separated from the manganese oxides.

In the Dioxide group the manganese deposits occur in a wide shear zone in limestone and subordinately in sandstone interbedded with limestone. This zone may be traced for more than half a mile, but the ore occurs as irregular bodies in it—as small veins, as replacement deposits along the bedding planes, and as a breccia. Ore has been extracted at several places along this zone through a distance of 800 feet. The deepest workings at the time of visit were only 15 feet beneath the surface. Psilomelane is the dominant manganese oxide, but pyrolusite and manganite also occur.

CLAIMS.

BLACK JACK GROUP.

The Black Jack Mining Co.'s group of five claims lies near the base of the northerly slope of the Ironwood Mountains at altitudes ranging from 1,050 to 1,500 feet above sea level. E. E. Shellenger is said to have located the claims in January, 1916, but the deposits had been worked and abandoned previous to that time. Since 1916 the property has been operated intermittently by the company and by several lessees who paid royalty on the ore. At the time of examination the company had been working the deposit since March, 1918, with M. Clark in charge. A considerable quantity of ore had been shipped which contained from 42 to 47 per cent of manganese, less than 2 per cent of iron, and about 6 per cent of silica. Ore has been mined from several deposits on the claim group, but on June 16, 1918, only one deposit, that on claim No. 3, was being worked. The mine is accessible by a wagon road 10 miles long from Brown's siding, on the California Southern Railroad.

Black Jack No. 3 claim is developed by a tunnel 60 feet long from which a winze 43 feet deep was sunk. At the bottom of the winze are drifts north and south to a total length of 117 feet.

Black Jack No. 1 claim is located over a vein parallel to the vein on No. 3 claim and about 400 feet west of it. It is developed by a tunnel 85 feet long which gains a depth of 45 feet. Black Jack No. 2 claim is south of No. 1 and on the same vein, but no ore bodies have been exploited on it. Black Jack No. 5 claim, which is southwest of No. 1, is located over two veins, from which there is abundant float of psilomelane ore, but the veins are undeveloped.

The veins in this group strike nearly parallel; that of No. 3 strikes N. 20° W. and dips 65° W., and that of No. 5 strikes N. 15° W. and dips 70° W. The ore shoot on No. 3 is from 60 to 70 feet long, and the vein matter is from 1 to 12 feet wide; on No. 1 the ore shoots are

85 feet long, with an average width of 5 feet. The veins on No. 5 are undeveloped, but ore shoots in them may prove to be of considerable size, as is shown by the occurrence of pieces of psilomelane float that weigh as much as 50 pounds.

The vein material is in part a fissure filling and in part a breccia. In places there are solid masses of ore several feet thick made up of concentric laminae of manganese oxides that clearly have been deposited at different stages in open fissures. In other places the ore is a breccia of the quartzose intrusive rock cemented and partly replaced by manganese oxides. The rock fragments range from less than a quarter of an inch to 1 foot in diameter. The depth to which the ore extends has not been determined, although it has been found 70 feet below the surface in the shaft on claim No. 3. Because of the character of the oxides found at that depth, which are largely psilomelane, it appears probable that the ore will be found here to a depth of 100 feet below the surface.

Psilomelane is the dominant manganese oxide in ores from the Black Jack group. It extends from the surface to the bottom of the shaft on claim No. 3. Here and there crystalline needles of manganite are interlaminated with the psilomelane. As psilomelane is regarded as an altered product from manganite or pyrolusite, it is believed that pyrolusite and manganite will prove to become more abundant below the 70-foot level and to pass gradually into the original manganese mineral from which the oxides were derived. Iron oxides were not observed in ores from the Black Jack, although analyses of the ore are said to yield as much as 2 per cent of iron. Calcite commonly accompanies the manganese oxides as white crystals in seams and lining cavities in the ore. It is evidently of secondary origin. Quartz does not occur in the ore except as it may be included in fragments of country rock.

SOCIAL GROUP.

The two claims of the Social group are south of Black Jack claim No. 5. They were located in December, 1917, and the owners are Floyd Brown, Jim Harrington, Harry Powers, and Frank Goldsberry. The development work consists of a tunnel driven southward for 160 feet on one vein and an open cut on another vein 75 feet to the east. The portal of the tunnel is on a hill slope at an altitude of 1,225 feet above sea level and about 250 feet above the detrital slope at the base of the hill. A road on the Black Jack group is about half a mile from the tunnel. No ore had been shipped from the property to June 16, 1918.

The vein on which the tunnel is driven strikes north and dips 65° W. In the tunnel section the granite porphyry country rock is brecciated along the vein, but little ore shows in it. On the surface

about 50 feet above the tunnel the deposit is exposed for 50 feet along the strike of the vein, and it consists of a breccia 3 feet wide, composed of porphyry fragments cemented together with psilomelane. The vein 75 feet east of that prospected by the tunnel strikes N. 20° W., and is mineralized with manganese oxides for 150 feet along its strike. Here a shallow open cut shows brecciated vein matter about 3 feet wide in which is a vein of ore 8 inches wide composed mainly of psilomelane.

MELVILLE NOS. 1 AND 5.

Claims Nos. 1 and 5 of the Melville group were purchased from C. E. Groce by P. H. Bray. They lie a few degrees west of south across a ridge from Black Jack claim No. 3. The ridge is about 300 feet above the Melville shaft, which is at an altitude of 1,200 feet. The deposit is developed by a shaft 46 feet deep and by drifts aggregating 150 feet. The fissure strikes N. 15° E. and dips 75° W. The vein or breccia material ranges in width from 2½ to 10 feet. The ore shoot is known to be 150 feet long, but its limits in length and depth have not been determined. In parts of the fissure bodies of manganese oxides 2 feet thick occur, but the dominant vein matter is a breccia of granite porphyry and manganese oxides cut by veinlets of calcite.

Psilomelane predominates, but pyrolusite and manganite are relatively more abundant than in the veins of the Black Jack group. The ore is hand sorted and screened. The harder lumps constitute the high-grade ore, and the soft material which passes the screen the low-grade ore.

Considerable ore was produced between January 21 and October 1, 1918. Most of the ore contained about 49 per cent of manganese, 1 per cent of iron, and 7 per cent of silica, but a quantity of low-grade ore that was shipped contained only 32 per cent of manganese.

MELVILLE NO. 2.

The Melville No. 2 and an adjoining claim comprising 45 acres were purchased from C. E. Groce by H. M. Parsons. The principal workings are about 600 feet east of the shaft on the Melville claim No. 1, owned by P. H. Bray. Beginning in November, 1917, Mr. Groce produced a quantity of high-grade ore from the deposit before it was acquired by Mr. Parsons. In June, 1918, the first carload was being mined by Mr. Parsons, and to October 1, 1918, a few hundred tons had been shipped, containing 46 per cent of manganese, 1.45 per cent of iron, and 6 per cent of silica.

The workings comprise a shaft 44 feet deep, with drifts 80 feet long at a depth of 29 feet and drifts 35 feet long at the bottom.

The vein strikes about north and dips 80° W. The ore shoot as disclosed underground is about 60 feet long and on the intermediate

level is from 1 to 3 feet wide. Between the intermediate and the bottom levels the ore shoot attains a width of 5 feet but has been explored for 35 feet only. The ore is chiefly psilomelane, with some manganite and pyrolusite. Approximately 500 tons of high-grade ore is in sight, but more development may disclose a much larger quantity.

MELVILLE.

A short distance north of the shaft on Melville claim No. 2 a shaft is being sunk on another claim of the Melville group, owned by C. E. Groce. The shaft was about 25 feet deep at the time of visit, but no ore had yet been found.

DIOXIDE.

The Dioxide group of 12 claims lies along the southeastern part of the Little Maria Mountains about 3 miles west of English siding. The claims are owned by H. N. Mabery and Charles E. Brown, and they were located in March, 1915, July, 1917, and February, 1918. The active development of the property began in January, 1918, and the first carload of ore was shipped February 1. The property was actively productive during the first nine months of 1918. The greater part of the ore that was shipped contained about 43 per cent of manganese, less than 2 per cent of iron, and about 3 per cent of silica, but some shipments contained only 38 per cent of manganese, 2 per cent of iron, and 6 per cent of silica. Eight men are employed on the property, and at the time of visit ore was being taken out at the rate of 80 tons a month.

The developments for 800 feet along the mineralized zone consist of a number of open cuts and tunnels and a glory hole. The greatest depth attained in these workings is 15 feet.

The manganese deposits occur along a zone of brecciation in massive limestone and quartzite or sandstone. The zone strikes about N. 60° W., and manganese ore crops out here and there over an area about 3,500 feet long and several hundred feet wide. The limestone is gently folded and the brecciated zone follows the crest of the fold. The beds dip at low angles northeast. They are gray, white, and pink. At one place the limestone is altered to a white marble. Manganese deposits occur in the brecciated limestone and quartzite as veins and stringers, as irregular replacement deposits along the bedding planes, and as the cementing substance of breccia. The deposits from which the ore has been mined have not been fully exploited, and their extent can only be surmised. Most of the ore has been obtained from the glory hole, an excavation about 30 feet in diameter and 10 feet deep. Many tons of ore that required little sorting was mined from this deposit, but that which remains is in

small veins and breccia from which the limestone and sandstone must be removed in order to make a marketable product. Ore has also been mined from two short tunnels that follow irregular veins and masses in the bedding planes. Several promising outcrops, particularly some in the northwest end of the group, had not been prospected at the time of visit. A considerable tonnage of high-grade manganese ore as float is widely scattered over the claims.

The manganese oxides are dominantly psilomelane, with minor quantities of pyrolusite. A specimen of the breccia shows fragments of quartzite cemented together with shells of psilomelane about one-eighth of an inch thick. The quartzite itself has been attacked only slightly by the solutions that deposited the manganese oxides. In parts of the specimen the interstices between the fragmental material are partly filled with manganese oxides, and the exposed surface is filmed over with a sooty substance that is probably pyrolusite. The shells of psilomelane are apparently homogeneous, except for the sooty film.

The source of the manganese oxides is not known. Except for a little calcite and iron oxides the manganese oxides are free from accompanying minerals.

The development has nowhere passed through the oxidized zone, and the depth to which the oxides extend is not known. In view of the fact that the ore occurs largely in shattered limestone the oxides may extend to considerable depths in places. Several thousand tons of ore could be won from these deposits, even if the ore extends only to depths of 25 feet from the surface, and if development proves a greater depth the estimate of ore reserves will be enlarged correspondingly.

At the northwest end of the Dioxide group some claims were located by Howser & Cheeseborough on June 17, 1918. These claims are said to be in conflict with some of the claims of the Dioxide group. Very little development work had been done on them, and no ore had been mined. The claims are located over some promising outcrops of psilomelane as stringers and irregular masses in shattered limestone.

IMPERIAL COUNTY.

PALO VERDE DISTRICT.

T. LUGO CLAIMS.

Several manganese claims owned by T. Lugo are located in the Palo Verde Mountains about 5 miles west of the wagon road between Palo Verde and Glamis. Access to them is gained by a newly made road 5 miles long that leads from the Palo Verde-Glamis road to a point within half a mile of the deposits, and from that point by a trail suitable to pack animals. A small quantity of ore is reported to

have been shipped from the deposits early in 1918, but when they were examined, June 19, 1918, no work was being done on the property.

The Palo Verde Mountains are a mass of deeply eroded volcanic flows extending from the vicinity of Colorado River 8 miles south of Palo Verde northwestward for about 20 miles. On the west the mountains are bounded by a broad desert valley that lies between them and the Chocolate Mountains. On the east they are flanked by a bench land which extends nearly to Palo Verde, where there is a steep descent of 75 feet to the bottom lands of Colorado River. The relief in the vicinity of the deposits is about 400 feet. Most of the deposits are at the bases of hills at altitudes of 1,000 feet above sea level.

Numerous gulches and arroyos drain from the Palo Verde Mountains, but they contain water only after heavy rains. Mesquite, ironwood, and palo verde grow in the arroyo bottoms, and several varieties of cactus are abundant on the hill slopes.

The manganese deposits are contained in a number of short veins or shear zones that cut basic lava flows. Three of these veins are opened in five places by open cuts and short tunnels. The veins strike about N. 65° E. and are vertical.

The vein material is from a few inches to a few feet wide and consists of fragments of basalt cemented together with manganese and iron oxides and cut by veinlets of calcite. The ore shoots are but a few feet long, and at depths of 6 to 10 feet the material becomes much poorer than at the surface. Psilomelane is the principal manganese oxide, but it is more or less mixed with iron oxides and calcite. No clean masses of ore were observed, and in order to obtain a marketable product the material must be broken up and hand sorted.

PAYMASTER DISTRICT.

GENERAL FEATURES.

Deposits of manganese ore occur in the Paymaster district in an outlying spur from the southeastern part of the Chocolate Mountains, in Imperial County. Colorado River is about 4 miles east of the deposits. The known deposits are encompassed in an area of about 1 square mile and are in the Tolbard, Everharty or Tres Amigos, and Curley M. groups of mining claims. They are accessible from Glamis, on the Southern Pacific Railroad, by a wagon road about 32 miles long. Very little maintenance work is done by the county on the roads in this sparsely settled area, and for most of the distance to Glamis the roads are in poor condition. Ore is hauled to the railroad in 5-ton motor trucks. These deposits were examined by the writer on June 18 and 19, 1918. Water for domestic purposes is hauled

from Glamis or from local wells, two of which are within a few miles of the properties.

Manganese ore is reported to have been first mined in this district by J. J. Everharty early in 1917 from the Black Mountain claim of the Everharty group. Later the deposits on this group were worked by the Tres Amigos Co., of Los Angeles, and Suffern & Co., of New York. A few months after Everharty began work O. S. Tolbard located some claims adjacent to the Black Mountain claim, and he has worked some of the manganese deposits continuously since. From the date of the discovery of manganese deposits to September 30, 1918, the district produced more than 3,000 tons of high-grade ore, and the incomplete development of the deposits indicates many thousand tons in reserve.

The deposits are worked from open cuts, tunnels, and shafts. All the drilling and most of the hoisting are done by hand, although one shaft is equipped with a gasoline hoist. The ore is hand sorted or screened to make a high-grade product. Mining costs are reported to range from $6 to $15 a long ton. Most of the ore is shipped to eastern furnaces. Transportation charges, comprising the truckage and railroad freight, are not less than $25 a long ton, and it is obvious that only high-grade ores can be shipped profitably.

GEOGRAPHY.

The Chocolate Mountains extend northwest from the vicinity of Colorado River for about 75 miles. The main range west of the manganese deposits is well defined, but its eastern part is irregular, and numerous spurs trend at diverse angles from it. The deposits are situated in an outlying spur of the range having a northeasterly trend. This spur is not more than half a mile wide, and it is flanked on either side by broad areas of detrital deposits. The relief is about 400 feet, and the altitudes range from 900 to 1,300 feet above sea level. The workings in the manganese deposits are at altitudes of 1,000 to 1,200 feet.

Numerous arroyos or gulches are carved in the Chocolate Mountains and drain to the desert flats. The large arroyo that is traversed by the road leading to the deposits heads along the south flank of the spur but turns and cuts directly across the spur, draining to the valley north of it. This arroyo marks a change in the rock formations. West of it the rocks are lavas and volcanic breccias, and east of it the rocks are flat-bedded conglomerate and loosely consolidated sandstones. The difference in character of the rocks gives rise to contrasted erosional forms; the lavas are intricately eroded into rather jagged peaks and sharp ridges, whereas the conglomerates are flat-topped or gently rounded, though they present steep slopes to the detrital deposits that flank the range.

The climate is extremely arid, as the annual precipitation is probably less than 5 inches. No springs or water holes are near the manganese deposits, but a well a few miles south of the Tolbard camp supplies water for the camp, and there is another well about 8 miles west of the manganese deposit, near the main road between Glamis and Blythe. The hill slopes are bare of vegetation except for a few low shrubs. In the arroyos and on the flats a sparse growth of ironwood, greasewood, palo verde, and a few varieties of small shrubs are found.

GEOLOGY.

The volcanic rocks on the northwest side of the arroyo traversed by the wagon road are reddish andesite and andesite breccia. The andesite is a porphyritic rock in which phenocrysts of an altered white feldspar are rather abundantly distributed in a dense reddish matrix. The breccia consists of a fragmental andesite in a matrix of the same material.

South of the arroyo the dominant rocks are flat-bedded conglomerates and sand, which are several hundred feet thick, as indicated by the relief. The conglomerates are composed mainly of pebbles and angular rock fragments of small size, but some of them are several inches in diameter. Locally there are sand beds from a few inches to a few feet thick in the conglomerate. The pebbles of the conglomerate have been derived from the volcanic rocks north of the arroyo. The beds lie flat or have very low dips. In places on the hillsides slabs of conglomerate more firmly cemented than the beds in general project for several inches, but for the most part the surface covering of the beds is a mass of loose pebbles and sand.

The lavas and breccias are probably Tertiary, on the assumption that they are of the same age as other lavas in the desert region whose relations have been fully established. The conglomerates and sandstones are later than the lavas, and they may be as recent as Quaternary, one feature in favor of the later age being that they are loosely consolidated and only slightly distorted.

MANGANESE DEPOSITS.

The deposits of manganese ore are contained in fissure veins that cut both the sedimentary and igneous rocks. The veins strike from N. 10° W. to N. 50° E. Most of them strike about N. 25° E. Some of the veins can be traced for 1,500 feet, but others are less than 300 feet long. The veins dip from 65° E. to vertical. The longest veins are in the conglomerate beds, and more ore has been mined from them than from veins in the lavas. The ore shoots are not coextensive with the veins but are tabular bodies from 1 to 3 feet thick, the longest of which so far exploited is one 385 feet long on the Tolbard

claims. Other developed ore shoots in the Everharty claims are 200 feet long, and there are several undeveloped ore shoots whose dimensions are not known. The greatest depth to which ore has been mined is 40 feet, in the Tolbard mine, where a tunnel was driven under a small hill. The ore probably extends a few feet below the tunnel level under the crest of the hill. A shaft 50 feet deep was sunk in a gulch near the portal of the tunnel, but it was reported that the ore became too poor to work below 25 feet. A vein in andesite breccia on the Everharty group contains an ore shoot 200 feet long and 3 feet wide, but the maximum depth of the ore was only 30 feet. The ore appears to extend deeper in the veins in conglomerate than in the veins in lavas and volcanic breccias, and this condition may be due to the fact that the veins in conglomerate are for the most part large simple fissures, while those in the volcanic rocks are poorly defined zones of brecciation. Oxidation of the original manganese-bearing minerals of the veins was effected by surface waters, and therefore large steeply dipping fissures with well-defined walls would be much more favorable for oxidizing conditions than small fissures with poorly defined walls or fissures that dip at lower angles.

The ores consist of the oxides psilomelane, manganite, and pyrolusite. These oxides are of course secondary minerals, and for the most part they have been deposited in open fissures, but to a slight extent they have replaced fragments of wall rock, pebbles, and boulders included in the vein. Psilomelane predominates in the ore, and it has been deposited in several forms. Its most common form is in narrow layers or laminae parallel with the walls of the fissure, alternating with generally narrower laminae of manganite or pyrolusite. It also occurs in massive mammillary growths, in which, however, there are small seams of manganite with concentric structure and small cavities lined with cellular and small stalactites of psilomelane. Cavernous and cellular psilomelane was found in the Tolbard shaft near the limit of the ore. Manganite and pyrolusite are not readily distinguished from each other, except that a soft black sooty substance frequently found on pieces of ore as a thin coating is definitely known to be pyrolusite. Manganite occurs generally in prismatic crystals in laminae deposited between layers of psilomelane. Some pieces of ore taken from the Tolbard shaft near the limit of the ore show cavities in massive psilomelane that are lined with a black finely fibrous mineral that is believed to be an unusual form of manganite or pyrolusite, pseudomorphous after manganite. The fibers are short, and the mineral is somewhat like asbestos, but on being rubbed between the fingers the mineral breaks down to a soft black powder.

Calcite and iron oxides are the only recognizable minerals that accompany the manganese oxides. Calcite occurs abundantly on

the walls of the ore bodies and in fissures traversing the ore. It is in both coarsely crystallized and fine-grained aggregates. The coarse-grained crystals are in veinlets in the ore and they fill interstices in the manganese oxides. The finely granular aggregates were noted along the walls of the ore bodies in the Tolbard mine and in places are 6 inches thick. The aggregates look like lump sugar, though more porous. The crystals are probably of secondary origin and were introduced after the vein filling of manganese oxides had been shattered, for the calcite incloses or partly surrounds angular pieces of psilomelane.

Iron oxides occur very sparsely in veins in the conglomerate beds and can only occasionally be recognized, but in veins in lava they are abundant in places. The original mineral from which the manganese oxides were derived was not observed in any of the veins.

The manganese deposits are believed to be of Quaternary age, for the veins cut volcanic rocks of known Tertiary age and conglomerate that is composed largely of volcanic pebbles derived from the disintegration of the Tertiary rocks.

CLAIMS.

EVERHARTY.

The Everharty group of four claims, also known as the Tres Amigos claims, are on both sides of the arroyo that dissects the ridge. Two of the claims lie east of the arroyo, along the northwest side of the well-defined hill composed of conglomerate; the other two claims cover deposits in volcanic breccias west of the arroyo. The claims are said to have been discovered by Tom Clark and L. L. Morse. They were acquired by J. J. Everharty, who began development on the Black Mountain claim in 1917 and to June 30 produced a considerable quantity of high-grade ore. No production was made in the last half of 1917. The property was leased to the Tres Amigos Co., of Los Angeles, and a small production was made early in 1918. It was then subleased to Suffern & Co., of New York, who operated the property until August, 1918, and then relinquished it to Mr. Everharty. The greater part of the ore contained more than 40 per cent of manganese and less than 8 per cent of silica. The ore was hauled by motor trucks to Glamis, 32 miles distant, on the Southern Pacific Railroad, and shipped to furnaces in Pennsylvania and Illinois.

Several veins occur on the four claims of the group. One vein on the Black Mountain claim strikes N. 10° W. and dips 80° E. It is explored for 150 feet by two tunnels, the upper one 40 feet above the lower one. A considerable tonnage of ore was mined from the upper tunnel, but in the lower tunnel the vein contains little ore. The vein

here cuts conglomerate beds, and the ore was a filling by manganese oxides about pebbles of the conglomerate. The vein was traced southward from the Black Mountain tunnel for 1,300 feet to another tunnel being worked by Suffern & Co. Between these tunnels several croppings of ore of good grade from 1 to 4 feet wide were observed, but in most places the ore is in thin streaks about pebbles and is of too low grade to work. The tunnel that was being worked by Suffern & Co. at the time of visit is driven about 50 feet north. The vein is about 2 feet wide and is composed largely of psilomelane. The size of the ore body had not been ascertained.

A shear zone 10 feet wide, which cuts volcanic breccia, occurs on the southwest side of the arroyo. It is explored by a tunnel 40 feet long. The shear zone contains numerous veinlets and seams of psilomelane for 100 feet along its strike, but in the material on the dump the crusts of psilomelane appear to be too narrow and too sparsely distributed to yield a profit by hand sorting. The material could be concentrated readily if water were available.

A quarter of a mile south of this shear zone a fissure vein inclosed in andesite breccia strikes N. 50° E. and dips 75° SE. The vein is explored on the surface by an open cut about 150 feet long and by a tunnel 50 feet long, which is driven southwest under the east end of the open cut and gains a depth of 35 feet. In the open cut the ore is about 3 feet wide, and the walls of the vein are well defined, though fragments of wall rock are generally included in the vein material. Good ore was found at the portal of the tunnel, but at its face, where a vertical depth of 35 feet was attained, the ore is a breccia in which soft manganese oxides occur sparsely. Near the surface the ore is hard and psilomelane predominates in it, but with increasing depth the ore becomes softer and manganite and pyrolusite become more abundant. In the open cut a crust of psilomelane adheres strongly to both walls of the vein. Ore was being mined from this open cut at the time of visit.

CURLEY M.

The Curley M. claims lie south of the west end of the Everharty group and inclose a small area of conglomerate that flanks the volcanic rocks on the south. The development work consists only of a few shallow holes and a short tunnel, and no ore has been produced from the property. Several veinlets that strike from north to northeast cut the conglomerate and dip at steep angles. They are apparently of no great persistence, and the greatest width of ore observed was 6 inches. The manganese oxides consist of psilomelane and the softer oxides, which inclose pebbles of the conglomerate. They fill some of the open spaces and replace some of the cementing substance of the conglomerate.

TOLBARD MINING CO.

The Tolbard Mining Co. owns three claims on the hill east of the arroyo and on the southeast side of the north end of the Tres Amigos claims. The claims were located, it is said, in 1917 by O. S. Tolbard. Operations are said to have been begun on the Tolbard group in June, 1917, and to the end of the year a large quantity of ore was shipped which contained 46 per cent of manganese, 0.5 per cent of iron, and 2.5 per cent of silica. Considerable ore was produced in the first nine months of 1918, although poor roads, shortage of labor, and high mining and transportation costs largely curtailed the production. The principal development work is on the Black Sheep claim of the group. It consists of four tunnels, two on each of two veins, driven toward each other on either side of a low bridge, and a shaft in a gulch near the portal of one tunnel. These workings aggregate more than 500 linear feet. Work on the two other claims of the group consists only of shallow open cuts.

Three veins, which for convenience will be designated No. 1, No. 2, and No. 3, crop out on the Black Sheep claim. Veins Nos. 1 and 2 have been partly explored, and all the ore shipped has been mined from them. Vein No. 3 has been opened by a shallow cut. These veins can be traced for about 1,200 feet, but ore has been mined from them in two ore shoots only, the longer of which is 400 feet long. Other veins are known on the claim group, but they have not been explored. The easternmost vein, No. 1, strikes N. 40° E. and is vertical. It is developed by a tunnel driven northeastward for 165 feet to a point under the apex of a hill, where it gained a depth of 40 feet. A shaft 50 feet deep was sunk on vein No. 1 in the gulch bottom near the portal of the tunnel. On the north side of the hill a tunnel 220 feet long was driven southwestward under the end of the tunnel that enters from the south side, with which it is connected by a raise of 12 feet. The vein pinches and swells and is from 2 inches to 4 feet wide. A considerable part of the vein has been removed above the tunnel level. Vein No. 2 is 50 feet northwest of the south portal of the tunnel on vein No. 1. It strikes N. 25° E. and dips 65° SE. A tunnel is driven northeastward from the gulch for 105 feet and gains a depth of 40 feet. The vein is composed of high-grade psilomelane ore from 3 inches to 1 foot wide, and it has partly been stoped above the tunnel level. About 600 feet northeast of this tunnel, on the other side of the hill, another tunnel on vein No. 2 is driven southwestward for 75 feet. Extending from the portal of the tunnel for 50 feet the vein is 1 foot wide, but toward the face it pinches out. No ore has been stoped from this tunnel.

A shallow open cut on vein No. 3 is 150 feet northwest of the portal of the south tunnel on vein No. 2. Vein No. 3 strikes N. 30° E.

and can be traced for 1,200 feet. About 2 feet of high-grade ore is exposed in the open cut.

The manganese oxides are dominantly psilomelane, though with increasing depth the softer oxides, manganite and pyrolusite, become more abundant. In veins Nos. 1 and 2 the manganese oxides occur in paying quantities to depths of 40 feet under the apex of the hill, but it is not known how far they extend below the tunnel levels at this point. In the shaft near the portal of the tunnel on vein No. 1 the ore extended only to a depth of 25 feet, below which the vein matter was reported to be sandy material and calcite. In vein No. 1 calcite occurs on one or both walls of the ore body as a white granular aggregate in a deposit that is in places several inches thick. Calcite also occurs in veinlets of coarse crystals that are of primary origin, traversing the ore. Quartz does not accompany the manganese oxides, but silica is present in the ore from the inclusion of pebbles and fragments of wall rocks.