DEPOSITS OF MANGANESE ORE IN NEW MEXICO.

By Edward L. Jones, Jr.

INTRODUCTION.

HISTORY.

Manganiferous iron ores have been mined for many years in New Mexico. In the early days they were used as flux in smelters at El Paso, Tex., and Silver City, Hillsboro, Kingston, and Socorro, N. Mex. Since 1916 such ores have been shipped in large quantities from the Silver City district to the Colorado Fuel & Iron Co. at Pueblo, Colo., and to furnaces in Chicago for the production of spiegeleisen. Production of high-grade manganese ore began with the shipment of a few tons in 1916. The high prices for manganese ore that prevailed in 1917 and the summer of 1918 and the necessity for the production of domestic ores, brought about by the curtailment of imports, led to the discovery of many deposits in the west-central and southwestern parts of the State and to the investigation of old silver mines as producers of manganese ores. Production was begun in July, 1917, from the Water Canyon deposit, in Socorro County, followed in September by the Lake Valley mines, and later, in 1917, by deposits near Rincon. In addition to the ore obtained from these deposits a small output was made in 1918 from scattered deposits in Socorro, Luna, Grant, and Sierra counties.

PRODUCTION AND ECONOMIC FACTORS.

The total production in New Mexico of ores containing 35 per cent or more of manganese to December 31, 1918, was approximately 5,500 tons. A few deposits in the State are capable of yielding several thousand tons each of high-grade ore, but most of the deposits are small, containing from a few tons to several hundred tons of high-grade ore. In view of the scanty developments on most of the deposits a close estimate of the ore reserves is not possible. The ores were shipped to furnaces in Chicago and other furnaces east of Mississippi River. The minimum freight rate to Chicago is about $8 a long ton; the charges for mining and wagon transportation are high, and even at the high prices for manganese ores that prevailed during the summer of 1918 little profit was made. With a return of pre-war prices of manganese ores, probably none of the deposits can be profitably worked.

FIELD INVESTIGATIONS.

The examination of the manganese deposits in New Mexico was begun by the United States Geological Survey in 1917, when J. B. Umpleby visited the Silver City district and the writer examined the deposits of Hillsboro, Kingston, and Lake Valley, in Sierra County; near Rincon, Dona Ana County; near Fierro, Grant County; and in the north end of the Magdalena Mountains, Socorro County. A short description of the Silver City deposits by Mr. Umpleby was published by the mining press in the fall of 1917.[1] The discovery of many deposits in Arizona, southeastern California, southern Nevada, and New Mexico after the 1917 field work had been completed made necessary the extension of these investigations, and they were continued by the writer from April 20 to July 10, 1918. A week in July was spent by him in examining deposits near Socorro, Socorro County. A press bulletin on the scattered deposits of manganese ore was issued in the fall of 1918. Other deposits were examined by E. H. Wells, of the State School of Mines, Socorro, who has kindly collaborated in the work of the Geological Survey by supplying the data on these deposits. The results of his work have been published.[2]

The present report deals mainly with the deposits examined by the writer, but the description of one deposit of a type unusual in New Mexico (that at Hot Springs) is taken from the report by Mr. Wells, and data with regard to the Silver City manganese deposits, from observations by Mr. Umpleby and Mr. Wells, are incorporated in this report. The locations of all the deposits examined are shown on the accompanying map (fig. 1).

GEOLOGIC RELATIONS.

ASSOCIATED ROCKS.

The deposits of manganese ore in New Mexico occur in both sedimentary and igneous rocks, which present a wide range in geologic age. The sedimentary rocks comprise Paleozoic limestones in the Silver City, Lake Valley, Kingston, Hillsboro, and Fierro districts, sandstone of Tertiary age near Rincon, and sandstone and gravel deposits of probable Pleistocene age near Hot Springs. The igneous rocks are andesitic or basaltic lava intercalated in sandstone of probable Tertiary age in La Plata Canyon, Socorro County, and rhyolite

[1] Umpleby, J. B., Manganiferous iron deposits at Silver City, N. Mex.: Eng. and Min. Jour., vol. 104, p. 931, 1917.

[2] Wells, E. H., Manganese in New Mexico, New Mexico State School of Mines Bulletin, 1918.

and rhyolite tuff of Tertiary age in the Magdalena and Socorro mountains, Socorro County.

TYPES OF DEPOSITS.

The deposits may be classified as (1) veins and brecciated zones, (2) stratiform (mainly replacement) deposits, and (3) placer de-

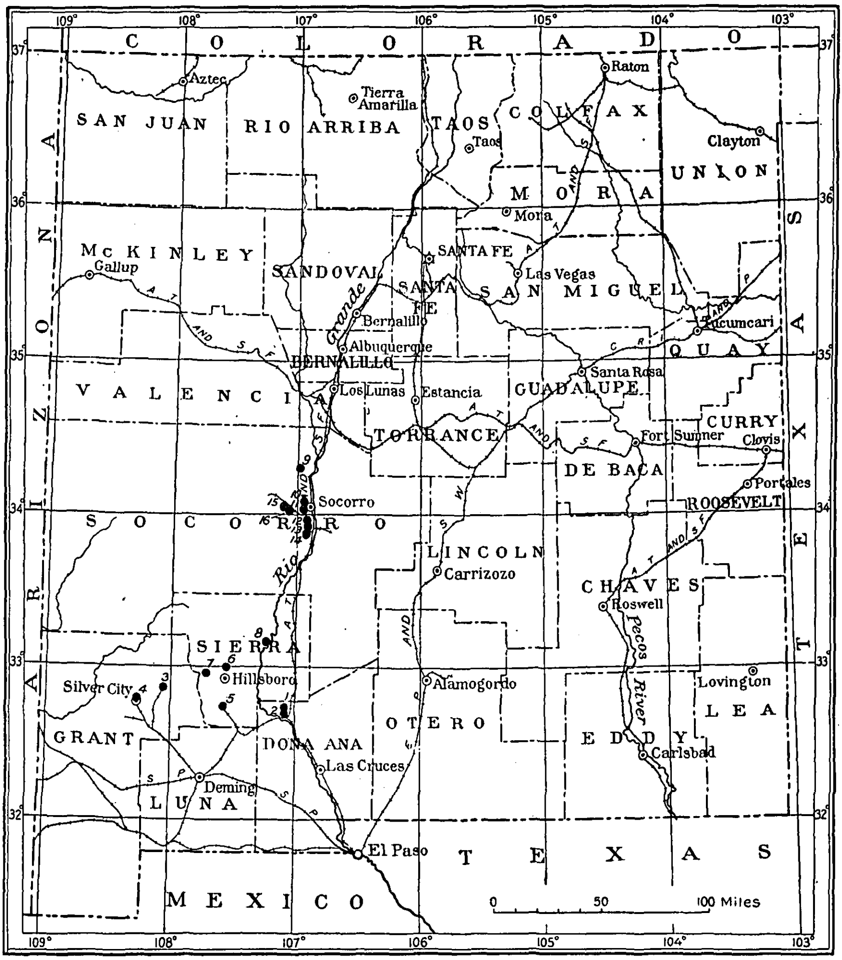

FIGURE 1.—Map showing location of manganese ore mines and prospects in New Mexico.

posits derived from the disintegration of the other types. Some of the deposits represent both types 1 and 2, for the manganese minerals in part are deposits in open fissures and in part replace the wall rocks. The deposits may also be divided into those in which the manganese oxides are relatively free from accompanying metalliferous minerals and those in which the oxides are associated with iron oxides and occur as the gangue minerals of silver ores.

The deposits in veins and brecciated zones that are valuable only for manganese occur particularly in the Tertiary lavas of Socorro County, but the deposits in sandstone near Rincon and a few veins in limestone in the Hillsboro and Fierro districts are of this type. The manganiferous iron ores of the Silver City district for the most part are reported to contain only small quantities of silver. These ores occur as stratiform replacement deposits in limestone and as lode deposits. Veins and metasomatic replacement deposits in which the manganese minerals form the gangue of silver-bearing minerals occur in limestone in the Lake Valley, Kingston, and Hillsboro districts. Near Hot Springs sandstone beds have been replaced by manganese oxides along the bedding planes. In the Rincon district manganese ore has accumulated in placer deposits from the disintegration of numerous manganese-bearing veins.

MANGANESE MINERALS.

Both the oxidized and primary minerals occur in some of the manganese deposits of New Mexico, but only the oxides have been mined. In other deposits the manganese oxides alone have been found. Psilomelane, pyrolusite, manganite, and wad are the oxides. Psilomelane occurs abundantly in the outcrops of veins in Tertiary lavas and in veins in sandstone near Rincon, but it is scarce in the oxidized gangue minerals of silver deposits and is generally not abundant in other non silver-bearing manganese deposits in limestone. At Lake Valley and Fierro long fibrous crystals of manganite occur. Pyrolusite occurs in all the deposits as a soft amorphous powder or in stubby wedge-shaped crystals that are regarded as pseudomorphously developed after manganite. In the Hillsboro districts the manganese oxides are without crystalline structure and are termed "wad."

The primary manganese minerals are rhodochrosite, rhodonite, manganiferous calcite, manganiferous siderite, ankerite, and alabandite. The metasomatic replacement deposits in some of the silver mines of the Kingston district contain rhodochrosite and rhodonite, and according to E. H. Wells the deposit in the Lady Franklin mine of that district carries alabandite, the manganese sulphide. In the Kingston district bodies of manganese ore derived from the decomposition of the primary manganese minerals are nowhere extensive, and the oxidized zone is shallow. The source of the manganese oxides in the Lake Valley mine is thought to be ankerite, a carbonate of lime, iron, and manganese, which was noted in the ore by geologists at the time the mine was being worked in the eighties. Manganiferous calcite was observed by the writer in veins in limestone in the Hillsboro district. The manganiferous iron ores of the Silver City district are believed to have been largely derived from manganiferous carbonates, of which manganiferous siderite has been identified.

ASSOCIATED MINERALS.

The primary manganese minerals of the Kingston and Lake Valley districts are associated with quartz and metallic sulphides, some of which contain silver. In the Hillsboro district some of the deposits in limestone contain large, well-developed crystals of the lead molybdate, wulfenite, and the lead vanadate, vanadinite, in a gangue of soft manganese oxides. Iron oxides are associated with the manganese oxides of the silver deposits and occur in most of the deposits in limestone but can rarely be detected in the manganese deposits of Tertiary rocks. Barite accompanies psilomelane abundantly in veins in sandstone near Rincon, and calcite also occurs in these veins, though less abundantly than barite. Calcite is the dominant mineral accompanying the manganese oxides in veins and brecciated zones in the Tertiary lavas, where it has been deposited as a secondary mineral. The prevalence of calcite in these veins suggests that manganiferous calcite is the primary mineral of these deposits below the zone of oxidation. Some of the manganiferous iron ores of the Silver City district are associated with veins carrying barite and quartz.

MINES AND PROSPECTS.

DONA ANA COUNTY.

1.[1] *Morgan group.*—The Morgan group of 10 claims is about a mile north of Rincon, on the Atchison, Topeka & Santa Fe Railway. The claims were located in 1914 and 1915, but with the exception of a sample lot no ore had been shipped from the property to August, 1917, when the deposits were examined. Production began shortly afterward, however, and by December 31, 1918, several hundred tons of ore which contained more than 35 per cent of manganese had been shipped. The numerous small veins on the property have been exploited by open cuts and several shafts, the deepest of which is 66 feet deep. A wagon road with a gentle down grade leads from the principal workings to Rincon. The freight rate to Chicago is about $8 a long ton.

The climate is arid, and the low hills support only sparse growth of cactus and small shrubs.

The deposits occur in low hills at the south end of the Sierra de los Caballos at an altitude of approximately 4,350 feet above sea level, and 200 feet above the Rio Grande valley at Rincon. The summits of the highest hills in the vicinity are 500 feet above the

[1] Black-face figures refer to corresponding figures on the map (fig. 1).

deposits. Shallow arroyos drain southward to Rio Grande, but they contain no water except after storms. Water level was not reached in the workings.

Red sandstone, agglomerate, and conglomerate beds in which the pebbles are principally of volcanic origin, are the inclosing rocks of the manganese deposits, but toward Rincon gray sandstones and clays with interbedded gypsum deposits compose some low knolls which rise above detrital material. These rocks are of Tertiary age. The beds strike in general north and dip about 20° E. The sandstones in the vicinity of the manganese deposits are cut by several faults which strike N. 10°–50° W. In places these faults are marked by sandstone scarps several feet high, with slickensided walls, but probably in none of them is the displacement great.

The manganese ore occurs in numerous fissures, some of which are small faults and others are minor fractures parallel to the faults. No less than ten of these veins have been prospected for manganese ore. The veins strike from N. 10° to 50° W. and dip steeply southwest or are vertical. The ore bodies are small, no ore shoot having been traced more than 50 feet along the strike of the vein, and they range in thickness from that of a knife blade to 20 inches. Their extent in depth is not known; one vein was observed at a depth of 20 feet, and another vein was reported to persist to the bottom of a 66-foot shaft. Generally the veins are well defined, but in places the sandstone is brecciated and cemented with manganese oxides. The vein material consists of manganese oxides, barite, and calcite. The principal manganese mineral is psilomelane, which occurs generally as mammillary crusts several inches thick. Some masses of the mineral weigh 50 pounds or more. In other places psilomelane occurs as nodular aggregates, in which the nodules range from the size of a pin head to half an inch in diameter and have concentric structure. The interstices between the nodules are filled with barite, into which project minute filaments of a black manganese mineral with a velvet-like surface. This mineral may be manganite, but it could not be identified. Barite is common in the veins and occurs in places in coarse crystals several inches thick attached to the sandstone walls. The manganese oxides were deposited later and formed in the center of the vein on the projecting surfaces of barite crystals.

The origin of the manganese oxides is obscure, but apparently both the barite and manganese oxides have been deposited in the fissures from ascending solutions.

2. *Placer claims.*—Some manganese claims that extend for half a mile southeast of the Morgan group lie along the course of an arroyo and include some low hills on either side of it. The detrital material, which in places in the arroyo is many feet thick, contains pebbles and masses of psilomelane that have undoubtedly been derived from

the decomposition of the manganese-bearing veins to the north. The concentration of the placer manganese ore was undertaken by means of a four-compartment jig which was set up in the arroyo. A well was sunk near by and the water pumped to the jig. Apparently the results were unsatisfactory, for much barite was mixed with the psilomelane concentrates. At a number of other places the detrital material was jigged by hand and the concentrates sacked. An analysis of these concentrates is reported to show manganese 45.2 per cent, iron 3.69 per cent, silica 3.26 per cent, phosphorus 0.02 per cent, sulphur 0.04 per cent, and barium oxide 10.29 per cent.

GRANT COUNTY.

3. *Gold Quartz and Lost Treasure groups.*—The Gold Quartz and Lost Treasure manganese claims, owned by Hodges & Dowell, are 2½ miles northeast of Fierro, the terminus of a branch line of the Atchison, Topeka & Santa Fe Railway from Whitewater. They lie along two parallel veins about a quarter of a mile apart which strike east. These deposits were discovered many years ago, and they were prospected by a few shallow holes and a shaft 35 feet deep. In 1914 and 1915 the deposits were relocated as a possible source of manganese ore. At the time of visit, August 13, 1917, no ore had been shipped, and the recent development work consisted of a number of open cuts and 10-foot holes.

The Gold Quartz group is accessible from Fierro by a fair wagon road, and the Lost Treasure group can be reached by building a road half a mile beyond the Gold Quartz group.

The Gold Quartz vein crops out on a gently sloping surface about 7,150 feet above sea level; the Lost Treasure vein cuts across the bottom of a small canyon at an altitude of 6,800 feet, giving a local relief of 350 feet. A few peaks in the vicinity are approximately 7,500 feet in altitude. The region is sufficiently high to insure a moderate rainfall, and the soil supports a good growth of piñon, cedar, oak, walnut, and other trees.

The Lost Treasure vein crops out in a canyon that drains northeastward to Mimbres River. The canyon contains no perennial stream at this point, but a small spring issues a short distance north of the claims. Hanover Creek heads in the divide a short distance south of the deposits and flows southward through Fierro and Hanover to its junction with Whitewater Creek. The workings have not reached water level, the depth to which is not known.

The geology and ore deposits of the Santa Rita and Hanover districts have been described in previous reports.[1] The dominant rocks near the manganese deposits are massive blue-gray limestones of

[1] U. S. Geol. Survey Prof. Paper 68, pp. 305–317, 1910; Geol. Atlas, Silver City folio (No. 199), 1916.

Carboniferous age, which, on the Lost Treasure group, are abundantly fossiliferous. West of the claims a large northerly fault separates the Carboniferous limestones from quartzites and shales of Cretaceous age. A weathered dike rock crops out near the west end of the Gold Quartz group. It is probably an offshoot of an intrusive mass of granodiorite that crops out along Hanover Creek. Near the manganese deposits the limestones dip about 15° SE., but along Hanover Creek they are domed above the intrusive granodiorite and dip to the east on the east side of the creek and to the west on the west side.

The commercial-ore bodies of the Hanover district are contact-metamorphic deposits of iron, zinc, and copper ores. They occur at the contact of the granodiorite with limestone and are associated with garnet, pyroxene, and epidote.

The manganese deposits are fissure veins that are probably a considerable distance from the main mass of the granodiorite. The limestones in which they occur are not metamorphosed, but the abundance of silica in the veins indicates that they were deposited from hot waters that were no doubt connected with igneous intrusion. The Gold Quartz vein strikes N. 70° E., and the Lost Treasure vein strikes N. 50° E. Both have steep dips to the southeast.

The ore is a mixture of manganese and iron oxides. The manganese oxides are chiefly wad and pyrolusite, in which are crusts of slender prismatic crystals of manganite. Some of the manganite has a fibrous structure similar to asbestos. No other manganese minerals were noted, although in a shaft there is some coarsely crystalline carbonate that is undergoing decomposition to iron and manganese oxides, and may be mangano-siderite. Limonite is abundant in the veins. The depth to which the oxides extend has not been determined, but it is not believed to average more than 50 feet.

The veins are persistent and can be traced for several thousand feet by means of float and outcrops. They range from a few inches to 10 feet in width and probably average 3 feet. The ore shoots are not coextensive with the veins, and only one shoot on each vein has thus far been discovered. On the Gold Quartz group a shoot of ore 200 feet long has been found, and on the Lost Treasure group the ore shoot is 500 feet long. In each vein the tenor of the ore is low. The manganese content is probably not more than 20 per cent in the Gold Quartz vein, but may be higher in the Lost Treasure vein. By screening and sorting out the crusts of oxides the manganese content could be raised to 40 per cent or more.

4. *Silver City district.*[1]—Numerous deposits of manganiferous iron ore occur adjacent to Silver City in an area 15 miles long and

[1] Data on the manganiferous iron ore deposits of the Silver City district were compiled from reports by J. B. Umpleby and E. H. Wells.

from 1 to 3 miles wide. Among the properties which have produced ore or in which it occurs are the Nineteen Sixteen, Cansland, Silver City Manganese & Development Co., Kirchman & Crawford, and Stevens. Since January 1, 1916, many thousand tons of manganiferous iron ore has been mined from the Kirchman & Crawford and Stevens properties, on Boston Hill, and in 1918 a small quantity of high-grade ore was mined from the Nineteen Sixteen mine. The manganiferous iron ore contains about 16 per cent of manganese, 35 per cent of iron, 6 per cent of silica, and 0.01 per cent of phosphorus.

The manganiferous iron deposits crop out on the hill southwest of Silver City and extend westward and northward along the south and west sides of Chloride Flat. Most of them are stratiform replacement deposits in Ordovician limestone, but some are fissure fillings and replacement deposits in limestone and porphyritic igneous rocks.

In the stratiform replacement deposits "the ore-bearing beds dip eastward at low angles, and in the immediate vicinity of Silver City they are cut off by a mass of quartz monzonite porphyry. Several normal faults which cross the range offset the beds westward. Parallel to these larger displacements are innumerable other faults that are too small to be traced at the surface. The ore bodies are irregular replacements, most of them of lenticular outline and oriented parallel to the bedding. The largest mass developed is on the Stevens group of claims. It is exposed throughout the extent of an open cut 6 feet deep and 300 feet long, which crosses beds dipping 15° E. Smaller openings show that ore continues for 300 feet farther west and 200 feet farther east. Ore crops out at the surface on the slope above the line of open cuts to an elevation 60 feet higher. It seems safe to estimate that in this mass more than 500,000 tons of ore, apparently of a grade similar to that already shipped from the area, is available. Several other parts of the district show surface exposures of comparable extent and quality, but the work on them is less advanced, and an estimate of the quantity of ore available is more hazardous. Evidently, however, a very large quantity of ore suitable for making spiegeleisen can be easily mined in the Silver City area."

The ore ranges in color from dark red to black, and the ore minerals are mainly pyrolusite, manganite, and limonite.

The replacement deposits in igneous rocks "occur near the Boston Hill fault, but they possibly have a wider distribution. Manganiferous iron ores have replaced a fine-grained felsite which was intruded along the contact of the limestone and the underlying porphyry and which formed sills in the limestone beds. The ore consists of the usual iron and maganese oxides, together with a notable quantity of carbonates. The carbonates are coarsely crystalline calcite and manganiferous siderite, and some rhodochrosite may be present. They appear to some extent at the surface in the lowest outcropping beds. Both the carbonates and the oxides have retained the original flow structure of the rock to a remarkable degree in many places. The replacement process has been so complete that much of the ore contains only scattered specks of unreplaced felsite, and even these may be lacking. The deposits of this class extend along the Boston Hill fault for a third of a mile and up the hill to the south for 100 feet or more. The deepest workings at the time the property was visited did not permit the ore bodies to be examined at a depth of more than 15 feet.

"The fissure deposits are of subordinate importance. They are numerous in the northeastern part of the hill, and in that vicinity have been worked to some extent. In width they vary from a few inches to 5 feet. The walls are well defined and are but slightly replaced with ore. The vein filling consists mainly of manganese and iro oxides, but small amounts of quartz and barite are present. Some good silver assays have been secured from this ore."

The ores are believed to have been derived from the decomposition of manganiferous carbonates which were deposited from ascending hot solutions.

SIERRA COUNTY.

The manganese deposits of Sierra County that were visited by the writer are in the Lake Valley, Hillsboro, and Kingston districts. In addition to these deposits, one in the Hot Springs district, on Rio Grande, was examined by E. H. Wells. The Lake Valley mine is the only producer of manganese ore in the county, but years ago manganiferous iron ore was mined and used as flux in smelters at Hillsboro and Kingston.

5. *Lake Valley mines.*—The property of the Lake Valley Mines Co., at Lake Valley, the terminus of a branch line of the Atchison, Topeka & Santa Fe Railway, is a consolidation of the three principal mining groups of the district, which lie adjacent. The properties were famous producers of silver in the early eighties, and to 1893 are said to have yielded approximately 5,000,000 ounces of silver. Since that date the work has been desultory and the production small, but in the summer of 1917 the workings were being reopened and the dumps sorted, chiefly for their manganese ore, but with the probability of disclosing new bodies of silver ore in the mine development. The ore deposits were mined from 10 or more shafts, the deepest of which is said to be 150 feet deep. Most of the workings were inaccessible at the time of visit, on August 20, 1917. The old mine dumps cover a large area, and contain several hundred thousand tons of material from which it would be possible to sort by hand and concentrate several thousand tons of manganese ore. The ore is hauled or trammed about a quarter of a mile to the railroad.

The principal shafts are driven on a gently sloping surface about 5,400 feet above sea level. The low hills in the vicinity of the deposits rise 150 feet above them. Porphyry Hill, a prominent peak west of Lake Valley, is 1,000 feet higher than the town.

There are no perennial streams in the vicinity of Lake Valley. Several gulches and arroyos trend eastward and southeastward to a bolson valley. Water level is reported at a depth of 150 feet in the mine shafts. The climate is arid and supports only a growth of shrubs and grasses.

The geology and ore deposits of Lake Valley are described by Gordon,[1] and many of the data with regard to manganese in the ore deposits were obtained from this publication. The sedimentary rocks of the Lake Valley district are of Paleozoic age, ranging from Ordovician limestone at the base to the Mississippian Lake Valley limestone at the top. The sedimentary strata dip in general 20° SE., although there are local folds in the beds. The differential weathering of these beds, in which the shale members have eroded faster than the limestone, has left the harder rocks as reefs that extend for several miles north of Lake Valley.

Extensive flows of andesite covered by rhyolite constitute the surface rocks of the region. In many places erosion of these rocks has exposed the underlying Paleozoic strata, as at Lake Valley. Porphyry Hill is composed of rhyolite. Small patches of the andesite that covers a large area east of Lake Valley are found near the ore deposits.

Several faults are reported in the mine workings, but they have not seriously displaced the ore bodies.

The ore deposits constitute pockets, chambers, or pipes in the lower beds of the Lake Valley limestone, locally known as the "Blue limestone." The ore-bearing beds are overlain by shale. The deposits of iron and manganiferous iron oxides are much more widespread than the ore that was commercially valuable for silver. Large deposits of these oxides, containing only a few ounces of silver, are said to have been left in the mine. Bodies of ore of this type several feet thick were noted in some of the accessible workings. The deposition of ore was accompanied by extensive silicification, and much of the silicified limestone has the appearance of flint or chert.

The manganese oxides are manganite, pyrolusite, and wad. Manganite in slender well-developed prismatic crystals half an inch long is commonly found on fragments of flint or silicified limestone and as crusts in the masses of soft ore composed of pyrolusite, wad, and

[1] Gordon, C. H., The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, pp. 276–282, 1910.

limonite. Cerargyrite, embolite, galena, cerusite, vanadinite, quartz, calcite, and ankerite are reported from these deposits[1] in addition to the manganese and iron oxides.

The maximum depth to which oxidation extends is not known, but in most places it reaches the water level, about 150 feet beneath the surface. Mine explorations ceased at the water level.

The origin of the ore deposits is ascribed by Lindgren to hot waters that ascended along the bedding planes of the Lake Valley limestone and deposited their minerals. The solutions probably emanated from some igneous mass near by.

The source of the manganese oxides is believed to be manganiferous carbonates, of which ankerite, a carbonate of lime, iron, and manganese, was observed by Silliman[1] in the ores being mined in 1882.

To June 1, 1918, when work was suspended, the Lake Valley mines had produced 3,009 tons of manganese ore. The ore which was shipped first was largely sorted from the dumps, but most of the ore of later shipments was mined. Assays of two carloads, that represent the best and poorest ore shipped up to September, 1917, are as follows: Iron, 12.27 and 14.48 per cent; phosphorus, 0.053 and 0.061 per cent; silica, 6.90 and 11.09 per cent; manganese, 39.16 and 35.11 per cent; moisture, 3.68 and 6.01 per cent. These shipments consisted of hand-sorted ore from the old dumps, and they probably represented the best grade that can be profitably made by this method.[1]

Bodies of silver ore in the several workings are reported to have contained from 12 to 30 per cent of manganese.

Probably much of the material on the mine dumps is amenable to some methods of concentration. At the time of visit tests were being made on the ore to improve the grade, but no method had yet been installed.

6. *Hillsboro district.*—Several low-grade manganese deposits 2½ to 3½ miles northeast of Hillsboro were briefly examined August 18, 1917. They are in a district that has produced much silver and gold ore and have long been known, but they are low in manganese and in precious metals, and as soon as this became apparent development work on them ceased. The workings consist of a few short tunnels and open cuts and have disclosed several hundred tons of manganiferous ore containing not over 25 per cent of manganese. Ore of this character is said to have been used as a flux in an old smelter now dismantled at Hillsboro. The deposits are accessible by wagon road from Hillsboro, but the nearest shipping point is Lake Valley, 18 miles south of Hillsboro.

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[1] Gordon, C. H., op. cit., p. 279.

The region, though high, is of moderate relief and is characterized by plateaus and gently rounded hills in which the streams have cut channels in places a few hundred feet deep. Some of the summits rise a few hundred feet above the plateau, whose general altitude is about 5,400 feet. The flatness of this upland surface is due partly to erosion and partly to basaltic lava flows which overlie old gravels. The Hillsboro district is drained by Percha Creek, which flows toward Rio Grande. Water level was not reached in the manganese prospects.

The climate is arid. A few trees grow along the watercourses, but the uplands support only grasses and a few small shrubs.

The geology and ore deposits of the Hillsboro district are described in the report already cited.[1] The sedimentary rocks consist of Ordovician and Silurian limestones, the Percha shale (Devonian), the Lake Valley limestone (Mississippian), and the Palomas gravel (Pleistocene). The igneous rocks are intrusive monzonite porphyry and effusive andesite, rhyolite, and basalt. The basalt is the youngest formation in the district and overlies the Palomas gravel. The sedimentary rocks are generally flat bedded.

Several types of ore deposits occur in the district, but only those containing manganese will be considered here. The manganese deposits are replacement bodies along fissures in the Ordovician limestones, and partial fillings of solution cavities in limestone. They are small and but little development work has been done on them. The Nichols & Lannon and McPherson claims were visited. The Miner's Dream claim, owned by Nichols & Lannon, is 2½ miles northeast of Hillsboro, at an altitude of 5,500 feet. This claim is developed by a shaft 40 feet deep. Another deposit owned by Nichols & Lannon, 1 mile east of the Miner's Dream, is developed by a tunnel 150 feet long, which gains a depth of 50 feet at its face. Midway between these deposits and half a mile to the north lie the McPherson claims. Here a tunnel 50 feet long has been driven in sheared limestone near the contact with an east-west dike of monzonite porphyry.

The ore is a soft brownish-black mixture of manganese and iron oxides. No crystalline manganese oxides were observed. Calcite is abundantly associated with the ore, and in the fissure on the Miner's Dream claim some coarse black crystals contain finely disseminated manganese oxides. On the Miner's Dream claim the most noteworthy minerals of the fissure are the orange-colored crystals of lead vanadate, endlichite, and yellow tabular crystals, some 1 inch wide, of lead molybdate, or wulfenite. Cerusite also occurs in the fissure. Several tons of the oxidized material containing these crystals

[1] U. S. Geol. Survey Prof. Paper 68, pp. 272–276, 1910.

has been mined, but the quantity of manganese ore in the deposits is negligible. The other deposit owned by Nichols & Lannon contains a few hundred tons of soft brown ore in small irregular veins and masses in limestone. The ore is of low grade and probably does not contain more than 20 per cent of manganese and is high in iron. The tunnel on the McPherson claims shows an irregular vein of soft manganiferous ore from 2 to 6 feet wide. About 500 tons of this material is in sight. It probably contains 25 per cent of manganese ore and considerable iron ore.

In view of the low manganese content of the material and the distance from centers of consumption, these deposits have little value. The material can not be concentrated by ordinary wet gravitational methods of concentration, because the iron and manganese oxides are soft and are intimately mixed.

7. *Kingston district.*—In the Kingston mining district, 9 miles west of Hillsboro, a number of the old mines that were chiefly valuable for their silver ores contain low-grade manganese deposits. The manganiferous ores have not been utilized except for a small quantity used many years ago as flux in a smelter at Kingston. The deposits are too low in grade and too remote from the railroad to be valuable. Kingston is 27 miles from Lake Valley, the nearest railroad station. A weekly stage runs between Hillsboro and Kingston.

The climate is mild and the rainfall is moderate. The mountain slopes are covered with a good growth of piñon and cedar.

Kingston lies on the eastern slope of the rugged Black Range at an altitude of 6,300 feet. In the vicinity of the town the ridges rise about 1,000 feet above it, but the summits of the main range attain over 9,000 feet. The Kingston district is drained by Percha Creek and its tributaries. Middle Percha Creek, which flows through Kingston, is a small perennial stream. The old mines of the district are mostly inaccessible, and the depth to water level was not learned.

The geology and ore deposits of the Kingston district are briefly described by Gordon.[1] Quartzites, shales, and limestone are the dominant rocks along the eastern flank of the Black Range. They range in age from Cambrian to Pennsylvanian. The core of the Black Range a few miles west of Kingston is composed of granites and schists of pre-Cambrian age. The limestone near Kingston is intruded by a few dikes of monzonite porphyry. The sedimentary rocks dip in general to the east, but local folds in them appear to have controlled somewhat the deposition of the ore bodies.

The ore deposits of the Kingston district occur along fractures in the Ordovician limestones beneath the Percha shale. The most productive deposits were found along fractures that strike northwest and at the intersection of these with other fractures, elsewhere barren of

[1] Gordon, C. H.. op. cit., pp. 268–270.

ore, that strike east and northeast. The ore bodies are in the form of pockets and pipes of irregular size. Of the old productive silver mines, the Comstock, Lady Franklin, and Iron King were partly examined, but most of the old workings are now inaccessible, and knowledge of their ores was gained by an inspection of the dumps.

The manganese oxides are wad and pyrolusite. They are formed along the fissures in the oxidized zone and result from the decomposition of the primary manganese minerals in the deposits. In the Comstock mine they have been found to a depth of 150 feet, but commonly unoxidized ore is found within a few feet of the surface. Nowhere do the manganese oxides form workable deposits in the Comstock mine, but in shallow tunnels on the Iron King bodies of impure manganese oxide several feet wide were noted. These were mined and used as flux in the smelter at Kingston. In the unoxidized vein matter of the Comstock mine rhodochrosite, rhodonite, calcite, and quartz are the gangue minerals of the metallic sulphides. Fractures in beautiful pink rhodonite are filled with manganese oxides, which also extend in fernlike growths into the rhodonite. The rocks of the mine dumps are coated with a black film of manganese oxides, but when broken they show a crystalline matrix of quartz, carbonates, and white to pink rhodonite, in which fine-grained sulphides are disseminated. According to E. H. Wells,[1] alabandite, the sulphide of manganese, occurs in the Lady Franklin mine, associated with lead and copper sulphides.

It is impossible to estimate the quantity of low-grade manganiferous material in these mines, but undoubtedly the deposits that contain 15 per cent or more of manganese amount to many thousand tons. Under present conditions these deposits have no value, but possibly methods of treating such ores will be devised.

8. *Hot Springs district.*—The following description is quoted from Wells:[2]

The Hot Springs district is adjacent to the town of Hot Springs and lies to the northwest. Hot Springs is on the Rio Grande 7 miles below Elephant Butte dam, and by wagon road is 18 miles southwest of Engle, on the Atchison, Topeka & Santa Fe Railway, the nearest railroad station. The geology of the region is simple. This part of the Rio Grande valley is made up of nearly horizontal beds of only slightly consolidated sand and gravel. The age of the beds is undetermined, but geologically they are evidently quite recent. The sedimentary beds rise to an elevation of about 200 feet above the level of the river. They are dissected by numerous arroyos leading into the river bottom. The deposits are included in an area that extends N. 30° W. from the town limits a distance of a mile or more and has a maximum width of 500 feet.

Ellis claims.—This is the only property that has been located. The claims take in the more promising part of the manganese-bearing sandstone, an area

[1] Wells, E. H., Manganese in New Mexico: New Mexico State School of Mines Bull. 2, p. 68, 1918.

[2] Idem, pp. 61–63.

1,200 feet long and 200 feet wide on the average. The best ore is found less than half a mile from the town of Hot Springs.

The manganese mineralization is apparently confined to the upper sandstone beds of the district, and its maximum thickness seems to be about 30 feet. These beds are terminated on each side by two roughly parallel arroyos which have cut down through the lowest ore-bearing strata. The highest grade of ore occurs at or very close to the surface, and the lower beds contain a much smaller manganese content. A sample taken across the bottom manganiferous beddings where exposed by one of the two short tunnels on the property gave 6.5 per cent of manganese. A sample of the surface ore freed of the loose sand in which it was originally embedded contained 24.2 per cent manganese, and some sorted ore would undoubtedly contain a still higher percentage.

Psilomelane is evidently the most abundant manganese mineral, though wad may exist in considerable quantities where the ore is farthest from the surface. The psilomelane forms both a replacement of the individual sand grains and a cementing material. Due to these changes the soft, incoherent sandstone has been altered to a hard and compact rock that is with difficulty affected by weathering. The superior ability of the ore strata to resist erosion probably accounts in part for their preservation to the present time. Unfortunately the replacement of the grains of sand has seldom been complete. The result is that no great quantity of sorted ore can be obtained that will contain more than 30 per cent of manganese, and the silica content of the best ore is liable to be high.

These deposits represent a type that in New Mexico is rather unique. Fissuring in the ore beds is not apparent, and no evidence of vein or fracture filling characteristic of other manganese deposits could be found. The replacement process has progressed along innumerable small passageways in the sandstone, leaving the intervening material unaffected. Weathering results in the loosening of the unreplaced sand grains and their removal from the ore, which then may resemble a closely packed aggregate of icicles having a parallel or slightly radial structure. Ore of this character from which the loose sand has been removed is of better grade than the average of the ore that has not been weathered.

Near the surface in a number of areas where the best grade of ore occurs the solution passageways radiate outward and upward from numerous approximately vertical pipes, some of them being at least a foot in diameter. These passageways in some places are parallel to the stratification planes and in others are oblique or perpendicular to them. In fact, the stratification does not seem to have played an important part in determining the courses of the moving solutions. The resulting structure is slightly suggestive of giant cauliflowers, possibly 40 or 50 feet in diameter, embedded in the sand beds, with the tops partly planed off by erosion. Lower down in the ore beds the above-described structure gives way to an impregnation and slight replacement that follows the bedding to a great extent.

At the southeast end of the manganiferous beds hot springs, from which the town is named, issue from the limestone underlying the sandstone. In view of the structure of the ore and the presence of the springs at one extremity of the mineralized section, it seems highly probable that these deposits have been due to manganese-bearing solutions rising upward through the pipes and conduits and entering an oxidizing environment which caused the deposition of the manganese in an oxide form.

The development work on the property is too slight to justify any but very general estimates of the tonnage and grades of ore reserves. It is thought that there are at least 100,000 tons of ore that will contain 5 to 15 per cent manganese, and 15,000 tons that will contain 15 to 40 per cent manganese, though the average grade of the latter tonnage would be nearer to 15 per cent than to 40 per cent. When visited in August, 1918, the property was idle.

SOCORRO COUNTY.

LOCATION OF DEPOSITS.

The manganese deposits of Socorro County that were examined by the writer are in the northeastern part of Magdalena Mountains and in foothills bordering the Rio Grande valley and from 3 to 6 miles distant, from a point opposite San Acacia to a point opposite San Antonio. Of these deposits the Myers mine, at the mouth of Water Canyon, is the only one that has produced ore in large quantity. Most of the deposits contain only a few tons of ore, and the main interest attached to them is in their geologic occurrence.

The Myers mine shipped ore from Water Canyon station on the Atchison, Topeka & Santa Fe Railway, which is 6 miles distant by wagon road.

The deposits in the foothills west of the Rio Grande valley are accessible from San Acacia, Socorro, and San Antonio, towns on the Atchison, Topeka & Santa Fe Railway. A few deposits near the base of Socorro Peak about 3 miles west of Socorro, are readily accessible, but the deposit west of San Acacia is 10 miles distant by the circuitous road and trail leading to it, and the shipment of ore would entail considerable expense. Several deposits west of San Antonio are reached by a wagon road 6 miles long.

GEOGRAPHY.

The Rio Grande valley near Socorro is at an altitude of approximately 4,600 feet. It is bordered on its west side by a gently sloping gravel-covered mesa several miles wide, which flanks the Socorro, Lemitar, and Polvadera mountains, all in alinement and in reality a single range. West of the Socorro Mountains and separated from them by a high plateau are the rugged Magdalena Mountains. The manganese deposits in the slopes and outlying hills of the mountains bordering the Rio Grande valley are at altitudes of 5,100 to 5,400 feet above sea level; those on the northeasterly slope of the Magdalena Mountains are 6,200 to 6,900 feet above sea level.

The deposits bordering the Rio Grande valley, except for those which lie at the base of Socorro Peak, are in areas of moderate relief. Socorro Peak is 7,226 feet high, and the deposits near its easterly base and in Blue Canyon, 2 miles to the south, are, respectively, at altitude of 5,100 and 5,200 feet. The Myers mine, in Water Canyon, is at an altitude of 6,900 feet, about 250 feet above the creek and several hundred feet below an outlier of the Magdalena Mountains, whose highest point stands more than 10,000 feet. Other claims are on Sixmile Creek at a point where the stream emerges from the Magdalena Mountains and enters the bench land that flanks them on the east and northeast.

Numerous arroyos enter the Rio Grande valley from the west, but only a few of them that head in the higher mountains contain water in their upper courses. On entering the bench land bordering Rio Grande their channels are dry, except for periods following heavy storms. Socorro Canyon, which is traversed by the branch line of the Atchison, Topeka & Santa Fe Railway from Socorro to Magdalena, heads in the foothills of the Magdalena Mountains, flows eastward, and marks the limit of the main mass of the Socorro Mountains on the south. Water Canyon Creek heads in the Magdalena Mountains and flows northwestward around the main part of the Socorro Mountains on the north. La Plata Canyon is a tributary of Salado River and joins it several miles north of the Smith manganese property.

The climate is arid, except in the higher mountains, where there is a moderate rainfall. The slopes of the Magdalena Mountains are covered with a good growth of piñon, cedar, and pine, and cottonwoods grow along the streams. The high bench lands are covered with grasses and a few shrubs, but the vegetation of the hills and bench land bordering the Rio Grande valley is scant.

GEOLOGY.

The manganese deposits of Socorro County are contained dominantly in Tertiary rhyolite and rhyolite tuff. One deposit in La Plata Canyon, however, occurs in a flow of fine-grained vesicular basalt which lies between sandstone and clay beds that are regarded as of Tertiary age. Manganese oxides also occur in some silver deposits near the base of Socorro Peak, which were worked years ago, but the extent of these deposits is not known, as the workings are inaccessible.

Most of the deposits in rhyolite and rhyolite tuff are breccias in which veinlets of manganese oxide are the cementing substance of the rock fragments, but some deposits are due to the replacement of tuff beds, and in La Plata Canyon the manganese oxides occur as seams and nodules in brecciated basalt.

The managanese oxides are psilomelane, manganite, pyrolusite, and wad. Psilomelane is the dominant mineral in the outcrops of manganese deposits in the rhyolite and rhyolite tuff. In the Myers mine a tuff bed is replaced by manganese oxides which are thought to be wad and pyrolusite. Psilomelane, manganite, and pyrolusite occur in the deposit in La Plata Canyon.

MANGANESE DEPOSITS.

The manganese deposits of Socorro County will be described in order, beginning at the north and extending southward in the foothill belt bordering the Rio Grande valley on the west, ending with the deposits on the slopes of the Magdalena Mountains.

FOOTHILL BELT OF RIO GRANDE VALLEY.

9. *La Plata Canyon.*—The manganese deposit in La Plata Canyon is included in the Sevilleta de la Joya Grant. It is under bond and lease to H. W. Smith. The deposit is about 2 miles north of San Lorenzo Springs and several miles from the junction of La Plata Canyon with Salado River. The highest peak of Sierra Ladrone, north of Salado River, bears N. 25° W. from the crest of the hill above the deposit. Access to the deposit is gained by a wagon road that goes westward from San Acacia and by a newly made road that connects with the old one and follows the sandy bed of La Plata Canyon for about 2 miles.

Work was begun on the deposit in the spring of 1918, and was continued through the summer. The development work consists of an open cut 70 feet long and 15 feet wide and another 20 feet long and 15 feet high in steep exposures of basalt near its contact with the overlying sandstone, and half a mile south of these workings a shaft 30 feet deep sunk on a fissure in the basalt. A small quantity of ore containing more than 40 per cent of manganese was shipped. Plans were being made at the time of visit in July, 1918, to erect a small concentration plant in La Plata Canyon to treat the low-grade ore. Water can be obtained from the arroyo at shallow depths.

The deposit consists of nodules and seams of manganese oxides in a zone of brecciation in basalt. The basalt is a flow several hundred feet thick that is inclosed in clay and sandstone beds. It is a fine-grained dark-gray vesicular rock that shows no prominent phenocrysts. It is more resistant to weathering than the sedimentary rocks and in consequence forms a pronounced ridge trending north, that can be followed for several miles. The altitude of the top of the ridge above the manganese deposits is 5,450 feet, and that of the bottom of La Plata Canyon opposite is 5,050 feet. The sedimentary series with the included flow of basalt and basalt breccia strikes north and dips 30°–60° W. West and northwest of La Plata Canyon the sedimentary rocks of this series cover a large area in the Salado River basin, where coal beds are reported to occur. The sediments are considered to be of Tertiary age. The sandstone bed immediately overlying the basalt contains at its base many fragments of basalt derived from the weathering of the underlying flow.

The contact of the basalt with the sandstone, which dips 60° W., is marked by several north-south faults and brecciated zones in the basalt. In places the sandstone beds are eroded to the level of the canyon floor. Several springs issue along this fault zone.

Manganese oxides as fissure fillings and nodules occur more or less plentifully for a mile or more in a zone of brecciation along the west side of the basalt flow near the contact with the overlying sandstone. The zone has been explored in two places half a mile apart, where it was thought that the manganese oxides occurred in deposits of commercial size. Where explored by the open cuts the brecciated and decomposed basalt contains manganese oxides through an area about 300 feet long and 30 feet wide. These particles of ore are cobbed from the great mass of basalt that is broken down in the open cuts. The deposit as a whole was judged to contain about 10 per cent of manganese. The ore consists of hard masses of manganese oxides that could be readily separated from the decomposed basalt by concentration, although it is believed that the manganese content of the deposit is not high enough or the ore reserves large enough to justify the building of a concentration mill. Psilomelane is the dominant manganese oxide. It occurs in nodules of irregular shape, and much of it is cavernous, the cavities being lined with rounded surfaces of small wedge-shaped manganite crystals and a soft, black, velvety film of pyrolusite. The manganese oxides are remarkably free from accompanying minerals. The sorted ore is judged to contain about 45 per cent of manganese, and the quartz, iron, alumina, etc., in it are due to the fragments of decomposed basalt which adhere to it. The depth to which the manganese oxides extend in the basalt is not known, but it is believed to be shallow. In the surface cuts the manganese oxides occur in the decomposed basalt, which in most places extends only a few feet beneath the surface, but in the shaft half a mile south of the open cuts manganese oxides extend to a depth of 30 feet. The source of the manganese oxides is obscure, but the explanation which appears most probable to the writer is that the basalt itself has yielded small quantities of manganese oxides from the decomposition of its minerals, and these oxides have been deposited in the zones of brecciation that favored the circulation of waters. No analyses of the fresh basalt have been made, however, to determine its manganese content.

10. *Mountain View group.*—The Mountain View group of seven claims, owned by J. P. Woods, lies at the eastern base of Socorro Peak 3 miles west of Socorro, at an altitude of 5,200 feet. No ore has been shipped from the property, and little development work has been done.

Many kinds of rocks are exposed on the east slope of Socorro Peak, but the writer made no attempt to map or classify them except those inclosing the manganese deposits, which are rhyolite and rhyolite tuff.

The most promising deposit of manganese ore is in a shear zone in rhyolite and tuff which strikes east and dips 50° S. It is known to contain manganese oxides for 100 feet on the strike of the vein. An inclined shaft 30 feet deep has been sunk in the shear zone and shows 3 to 4 feet of material containing manganese oxides. These consist principally of psilomelane with some pyrolusite, in vesicular and botryoidal masses associated with kaolinized rhyolite. An assay of sorted ore is said to have yielded 41 per cent of manganese, 6 per cent of silica, and 2 per cent of phosphorus. The manganese oxides are apparently free from iron oxides and other minerals.

11. *Sanchez deposit.*—The Sanchez deposit is on the south side of Blue Canyon 3 miles west of Socorro, at an altitude of 5,200 feet. It is developed by a tunnel 60 feet long. A small shipment of ore was made from this deposit. It occurs in a shear zone in light-colored kaolinized rhyolite tuff, which strikes N. 40° W. and dips 45° NE. The shear zone, as shown in the tunnel section, is about 2 feet wide, and in it stringers of manganese oxides a few inches wide replace the kaolinized material. The ore is mostly amorphous black manganese oxides which here and there contain small nests of manganite crystals. Most of the ore, however, is so intimately mixed with tuff and kaolinized material that the separation of a high-grade product would prove difficult. The ore is said to be high in phosphorus content.

12. *Jim Crow and Cactus claims.*—The Jim Crow and Cactus claims, owned by F. Fischer and B. F. Van Pelt, are in the foothills of Socorro Mountains 6 miles west of San Antonio, at an altitude of 5,200 feet. They are accessible from San Antonio by a road that traverses the broad gravel-covered mesa on the west side of Rio Grande valley to a point at the mouth of a gulch, about a quarter of a mile distant, and by a trail from the end of the road. When visited in July, 1918, development work consisted only of holes 10 feet deep on each claim, and no ore had been shipped, but later a small shipment was made by H. W. Smith, who had a bond and lease on the claims. The hills are composed principally of a red rhyolite in which quartz forms the dominant phenocrysts.

The deposits consist of narrow veins that have been traced for only a few feet along their strike. On the Jim Crow claim a flat-lying vein about 2 feet thick disclosed by the 10-foot hole is composed principally of calcite, but a little psilomelane has been found in it. The discovery hole of the Cactus claim is sunk on a vein 1 foot wide, which strikes north and is vertical. The vein is composed of 2 or 3 inches of psilomelane, calcite, and fragments of rhyolite. Some of the calcite is black, from the presence of disseminated manganese oxides. There is little evidence that the ore will extend more than a few feet below the shaft, and the small tonnage in sight does not warrant further development.

13. *Black Jack claim.*—The Black Jack claim, owned by B. D. Wilson and Ed Dodd, adjoins the Cactus claim on the east. It lies on the summit of a small hill about 5,300 feet in altitude. The development work consists of an inclined shaft 50 feet deep, sunk on a fissure that strikes N. 20° W. and dips 60° W., and by drifts 30 feet long at the bottom of the shaft. The fissure is a shear zone 2 feet wide in rhyolite. Near the surface seams of psilomelane as much as an inch thick traverse the sheared material, but in depth the manganese oxides are soft wad and pyrolusite, the ore generally becoming poorer in grade than at the surface. As a whole the vein matter is of low grade, and the lumps and seams of high-grade ore can not be profitably sorted from it. Calcite is abundant in the gangue, with a little secondary quartz.

14. *Iron Mountain claim.*—The Iron Mountain claim adjoins the Black Jack claim on the east and lies near the base of the easterly slope of the hill, where it merges into the mesa. The claim is owned by G. A. Adams and Alva Adams. An open cut 30 feet long and 5 feet deep at the face explores a brecciated zone in rhyolite which strikes north and is vertical. The brecciated zone is several feet wide and consists of fragments of hard reddish rhyolite cemented together with seams of manganese oxides, most of which are less than a quarter of an inch thick. In this zone the seams are widely spaced on the whole, but in places they are a network of closely spaced seams, the manganese oxides about equal to half the volume of rock fragments that they bind. Psilomelane is the dominant manganese oxide, and it is deposited successively in laminae on each wall of the fissure. It adheres strongly to the rock fragments, from which it is separated with difficulty. In places coarse crystals of calcite occur in the center of the psilomelane veinlets. The manganese oxides probably extend to depths of less than 25 feet from the surface.

The quantity of ore-bearing material in sight is small, and the building of a concentrating plant is not justified.

Other claims.—Several other claims have been located in the foothills west of San Antonio, in similar geologic surroundings to those already described and having deposits of the same type. The development work is said to consist merely of discovery holes, and no ore was shipped from them.

MAGDALENA MOUNTAINS.

15. *Water Canyon manganese mine.*—The manganese mine in Water Canyon, on the northeast side of the Magdalena Mountains, is 5½ miles from Water Canyon station, on the Magdalena branch of the Atchison, Topeka & Santa Fe Railway from Socorro. The deposit was discovered by Billy Myers in December, 1916, but it was not exploited until the following year, when L. C. Butler purchased an interest. This property was examined by the writer

September 22, 1917, and by E. H. Wells during the summer of 1918. Ore was first shipped in June, 1917, and by July 1, 1918, the mine had produced several hundred tons of high-grade ore. At the time of the writer's visit the deposit was explored by an inclined shaft sunk at an angle of 40° to a vertical depth of 27 feet and from the bottom of the shaft by drifts whose aggregate length was 150 feet. At 70 feet below the mouth of the shaft a lower tunnel was driven S. 40° E. for 140 feet but at the time of examination had encountered no ore. In 1918 Mr. Wells reported that the ore body had been found in the lower tunnel at a distance of 180 feet from its portal and the ground had been further explored by two winzes 30 and 40 feet deep sunk below the tunnel level and by drifts aggregating 125 feet from the bottoms of these winzes.

The mine is accessible by a fair wagon road from Water Canyon station. The freight rate to Chicago, where shipments were sent, is about $8 a long ton.

The deposit lies at an altitude of 6,900 feet, about 250 feet above Water Canyon Creek. The ridge above the deposit is several hundred feet higher, and the highest point in the Magdalena Mountains is more than 10,000 feet above sea level, a maximum relief of over 3,000 feet. Water level has not been reached in the mine workings. The mountain slopes support a good growth of piñon, cedar, and pine, and cottonwoods grow sparingly along the creek. The high bench lands bordering the mountains are covered with grasses and a sparse growth of shrubs.

Red and chocolate-colored rhyolite and rhyolite tuffs compose the hill on the south side of Water Canyon in which the deposit occurs. On the north side of the canyon granite is the principal rock. The rhyolites are flow banded, with a gentle inclination to the west, and at a distance they have the appearance of red sandstone. The rhyolite is of Tertiary age. In the vicinity of the workings the rhyolite is traversed by a number of fissures that strike from N. 40° E. to N. 10° W. and have steep dips.

The ore deposit was formed by the replacement of a block of rhyolite and rhyolite tuff that is bounded largely by faults. Its outcrop consists of a rhyolite breccia in which psilomelane is the cementing substance. A short distance below the surface the main ore body was cut, and it was followed southwest for 60 feet to a well-defined fault that strikes N. 20° E. and dips 80° W. As exposed in September, 1917, the deposit extended 60 feet along this fault plane and was in bedded form and from 2 to 8 feet thick. In places irregular masses extended above the top of the bed, and the depth or thickness of the deposit below the floor of the drift was not known. In 1918 Mr. Wells reported: "The stope as it now stands is an irregular lens-shaped opening which dips to the south at an angle of about 30°. In horizontal dimensions it is about 40 by 55 feet, and it has a maximum height of 20 feet." The ore is soft and granular for the most part and is readily mined without blasting. A crust of psilomelane from 2 to 8 inches thick occurs above the soft granular material and is sorted for high-grade ore. It is somewhat cavernous, and the cavities are lined with small, shotlike masses of psilomelane. The granular ore consists chiefly of wad and pyrolusite in which there are thin crusts of psilomelane. Streaks of red clay and fragments of rhyolite are frequently found in the soft ore, and clay gouge is abundant along the fault. The texture of the ore suggests that the deposit has replaced a tuff bed. Calcite accompanies the ore but is generally most abundant in a crust immediately overlying the deposit and consisting of banded layers of coarse white crystals. In places this crust is 2 feet thick. The banded structure is due to streaks of thin clay gouge and manganese oxides adhering to the layers of crystals. This would indicate that the crust has grown by the deposition from time to time of layers of calcite crystals from solutions that rose through the deposit; though the evidence is not clear as to what caused each layer of crystals to become detached from its base. The ground swells and is subject to caving, making the use of timbers necessary. No unoxidized ore from which the manganese oxides could have been derived was observed. The abundance of calcite, however, suggests that the manganese oxides were derived from the decomposition of manganiferous calcite. The hard ore is said to contain 46 per cent of manganese, 0.92 per cent of iron, and 0.02 per cent of phosphorus. The soft ore contains about 41 per cent of manganese, 1.2 per cent of iron, and from 8 to 22 per cent of silica. Most of the high-grade ore had been removed from the deposit in July, 1918, but at that time plans were being made to build a concentration mill for the treatment of low-grade material.

16. *Garst claims.*—The Garst claims are near the mouth of Sixmile Canyon about 4 miles southeast of the Water Canyon mine and 5½ miles south of Water Canyon station. The deposit consists of numerous seams of manganese oxides distributed for several hundred feet along the walls of the canyon. The seams are from a fraction of an inch to 3 inches wide. They strike in general N. 20° W. but also branch in all directions. The country rock is chocolate-colored rhyolite. A few shallow holes and a 15-foot tunnel were dug at points where the seams were most numerous, and these workings disclosed that the seams persist for only a few feet along their strike, and they pinch out at shallow depths. Psilomelane is the chief manganese oxide and was deposited as lamellar and botryoidal crusts along the walls of the fissures. A little calcite is associated with the psilomelane.