Bulletin No. 2 Mineral Resources Survey

BULLETIN OF THE
NEW MEXICO STATE SCHOOL OF MINES
A. X. ILLINSKI, PRESIDENT

MANGANESE IN NEW MEXICO

BY
E. H. WELLS
PROFESSOR OF GEOLOGY AND MINERALOGY

SOCORRO, N. M.
1918

CONTENTS.

BOARD OF REGENTS.

OFFICERS OF THE BOARD.

PUBLICATIONS OF THE MINERAL RESOURCES SURVEY OF NEW MEXICO.

Bulletin No. 1.	The Mineral Resources of New Mexico, Fayette A. Jones, 1915.
Bulletin No. 2.	Manganese in New Mexico, E. H. Wells, 1918.

LETTER OF TRANSMITTAL.

SOCORRO, N. M., Nov. 15, 1918.

HON. W. E. LINDSEY,
Governor of New Mexico,
Santa Fe, N. M.

DEAR SIR:

I have the honor to submit for publication as Bulletin No. 2 of the Mineral Resources Survey of the NEW MEXICO STATE SCHOOL OF MINES a report on Manganese in New Mexico by E. H. Wells. This bulletin should be of value to those who are interested in manganese properties in the state.

Very respectfully yours,
A. X. ILLINSKI,
President, State School of Mines.

MANGANESE IN NEW MEXICO.

BY E. H. WELLS.

INTRODUCTION.

THE MANGANESE SITUATION.'

The present unprecedented demand for the subordinate metals used in the steel industry is due to the war. Mananese is one of the most important of these, and vigorous efforts are being made by the Government to stimulate its production. The War Industries Board has been given the power to commandeer mines and equipment if the necessity arises, but such action is hardly to be expected.

Manganese is one of the few metals that was not produced in large amounts in the United States prior to the war. The deposits of Virginia, Georgia, Arkansas, and California yielded

---

'Note—The manuscript of this bulletin was practically completed before the armistice was declared which virtually ended the war. Inasmuch as the manganese situation is now quite different from what it was during September and October it has been, thought advisable to add the following information regarding the present and future status of the industry. This information was supplied by Mr. D. F. Hewett and Mr. E. F. Burchard both of the United States Geological Survey. However, no absolutely dependable forecast can be given at this time.

The schedule of prices approved by the War Industries Board, which appears in this bulletin, is theoretically still in force (Dec. 10, 1918), but during the first month since the armistice became effective little or no manganese ore has been sold according to its stipulations. This schedule of prices may possibly be abandoned in the near future. Sufficient manganese ore, ferromanganese, and spiegeleisen are now on hand to supply the steel industry for about nine months at the rate of production which was attained during the closing months of the war and for a proportionately longer period if the rate of production decreases.

Manganese-ore prices are liable to decline in the near future, but probably will not fall below two-thirds of the schedule quotations before the spring of 1919. Prices may continue to decline for some time, though they may not return to pre-war levels during the next two years.

a fairly large amount of ore from 1885 to 1904, but from that time until the war began very little ore was mined. The low prices paid for manganese ores and the high freight rates rather discouraged the working of the known western deposits.

In 1913 the total production of high-grade manganese ore in this country was 4,048 tons, and the imports amounted to 345,090 tons. The tonnage required has increased enormously since the war began. The United States Geological Survey estimated that 800,000 tons of high-grade ore is needed by the industries of the country during 1918. The establishing of a price scheduled for manganese ores and greater activity in prospecting for new deposits and in the working of old and new properties has materially increased the domestic output. Since 1913 the production has been as follows : 1914, 2,635 tons ; 1915, 8,708 tons ; 1916, 26,997 tons ; 1917, 114,000 tons. For 1918 it is expected to be at least 215,000 tons.

It *is* especially advisable to obtain as much of the necessary tonnage as possible in this country because the remainder of the required supply must be imported. This requires the use of shipping that is badly needed for the transportation of supplies to Europe. In 1913 the imported ore was obtained from Russia, India, and Brazil, Russia supplying the largest amount and Brazil the smallest. Now, of course, it must come almost entirely from Brazil.

PURPOSE AND SCOPE OF INVESTIGATION.

Prospecting for manganese in *New* Mexico has led to the discovery of numerous hitherto-unknown deposits. Some of them are of little value, but others have yielded sufficient ore for small shipments, and a few have become rather important producers. Some of the old silver-lead properties of the state have been reopened, and the ores high in manganese content and low in silver which were valueless in former times have been mined at a profit. Many of the recently located properties and prospects, however, are in new districts about which little or nothing is known. Manganese in ores is often not associated with the other valuable metals. Its deposits may have much in common with some of the copper, lead, or silver deposits, but in many respects they are very different and their peculiarities should be considered by those engaged in working them.

This bulletin was authorized by the board of regents of the New Mexico State School of Mines for the purpose of making available to mining men and others reliable information regarding the manganese properties and ore deposits of New Mexico. Under the direction of the board of regents the writer spent about two months in the field during the summer of 1918 and visited nearly all of the known manganese deposits of the state. The time that could be devoted to each individual property ranged from less than one hour to one and a half days and did not permit detailed examination to be made. Some of the properties merited more thorough study than the time which could be devoted to them permitted.

In writing the report an effort has been made to have it ready for distribution at the earliest date consistent with the reliable and reasonably comprehensive treatment of the subject. The identification of minerals and rocks is in part only approximately correct. The literature on the geology and various ore deposits of the state has been freely consulted, as have also the general articles on manganese, its ores, and its deposits. The publications of the United States Geological Survey have been exceedingly valuable sources of information, and pertinent sections have been quoted.

ACKNOWLEDGMENTS.

The writer acknowledges with pleasure his indebtedness to the various men who by their aid and advice have added greatly to the value of this report. The mine owners and operators, geologists of the United States Geological Survey and Bureau of Mines, and members of the faculty of the School of Mines are included in the list. Special thanks are due to the following; C. T. Brown, of the board of regents; E. L. Jones, Jr.,. associate geologist of the Geological Survey; Chas. E. van Barneveld, of the Bureau of Mines Experimental Station, Tucson, Ariz.; T. F. Donnelly, of the Suffern Co., Los Angeles, Calif.; John

McIntyre, San Antonio; Max Montoya, San Antonio; Nathan Hall, Water Canyon; Billie Myers, Water Canyon; R. E. Callow, Rincon ; T. P. Arnett, Socorro; Date Whitham, Kingston ; R. I. Kirchman, Silver City; Porterfield Bros., Silver City; Wm. Dorsey, Silver City; Wm. Lesdos, Deming; J. P. Porteus, Lords-burg; Frank Maloit, Kingston; T. B. Everhart, Socorro; the officials of the Empire Zinc Co., Hanover, N. Mex.; President A. X. Illinski and Professor B. *J.* Snyder of the School of Mines faculty. Analyses of samples were made by the chemistry department of the School of Mines.

PART I.
MANGANESE, ITS MINERALS, AND ORES.

M A N G A N E S E .

CHARACTERISTICS AND PROPERTIES.

Manganese is a white or grayish-white metal resembling cast iron in appearance but having a slightly reddish luster like bismuth. It is very brittle and is somewhat harder than steel. Its gravity, about 7.4, is nearly the same as that of iron. It has a marked affinity for oxygen *and* is never found in the metallic state in nature. Manganese is related to the halogens of which chlorine is the chief member. In certain chemical combinations it greatly resembles the halogens, but in others it shows strong affiliations with iron. As found in nature manganese has much in common with iron and is often associated with it.

USES.

Some of the minor *uses* of manganese are: *as* a decolorizer to remove the green color and also to give an amethystine color to glass; in dry batteries; in the manufacture of chlorine, oxygen, disinfectants, and certain paints. Certain alloys, as cupromanganese and manganese german silver, contain manganese in various quantities.

The chief economic products obtained from manganese ores are the manganese-iron alloys which are indispensable in the manufacture of steel. These alloys are known *as* spiegeleisen and ferromanganese, or less technically as "spiegel" and "ferro." Spiegeleisen consists approximately of manganese 20 per cent, iron 75 per cent, and carbon 5 per cent. Ordinary ferromanganese consists of manganese 80 per cent.. iron 12 per cent, and carbon 6 per cent. Both alloys contain small amounts of silicon and phophorous as impurities. Alloys of iron and manganese in any desired proportion can be produced but the two above-mentioned alloys have proved to be most satisfactory in steel-manufacturing practice.

Concerning the uses of spiegeleisen and ferromanganese in steel manufacture and the uses of manganese steel, Harder' says:

Spiegeleisen and ferromanganese are used in the manufacture of steel in the following ways: (a) As reducers of iron oxide formed in the final melting, the manganese oxide formed going into the slag; *(b)* as recarbonizers of steel, the alloys being used for their carbon as well as their manganese content; *(c)* for counteracting phosphorus and sulphur by the formation of manganese phosphide and sulphide; and (d) in the manufacture of manganese steel, used for railroad and street-car rails on curves, for burglar-proof safes, dredger pins, car wheels, shoes and crusher plates in gold mills, and for other puposes. The addition of small amounts of manganese gives to steel hardness, ductility, and strength.

(a) During the final melting the molten iron in the converter absorbs small quantities of oxygen from the blast, forming iron oxide, the presence of which makes the steel difficult to forge. When a small amount of manganese *is* added it absorbs the oxygen from the oxide of iron, forming manganese oxide, which combines with the slag to form a protosilicate. Small particles of slag that are disseminated through the molten metal also contain small quantities of oxygen. Though the presence of oxygen in this form is less objectionable, the removal of the slag particles is very desirable, and is largely accomplished by manganese. The manganese unites with the silicate of iron composing the slag particles and forms a double silicate of iron and manganese, the presence of which causes the coalescence of the slag particles from their disseminated condition. They rise and join the main body of the slag at the surface. It is not all removed, however, and even the best steels contain small particles of manganese silicate. Some of the manganese combines directly with the slag, some is volatilized, and some combines with other impurities, so it is difficult to determine what quantities of the ferromanganese or spiegeleisen should be added in each case to produce the desired result.

(b) On account of the extensive oxidation in the Bessemer con verter, all or nearly all of the carbon is oxidized, leaving the metal in the form of wrought iron instead of steel. To remedy this, ferromanganese or spiegeleisen, either solid or molten, is added during the final melting to restore the requisite amount of carbon and prevent further oxidation.

(c) Manganese neutralizes the effect of sulphur by forming a manganese sulphide, which probably goes partly into the slag and partly remains in the steel. All good steels contain sulphur in this form. It counteracts the effect of phosphorus by forming the phosphide, Mn_3P_2. Manganese tends to keep carbon from separating out as graphite, and to increase the power of carbon to combine with iron.

(d) Ferromanganese is used in the manufacture of manganese steel * * *. Manganese steel is used for many purposes, although its application is considerably restricted because of the difficulty of machining it. In a large number of articles for which it is used this difficulty is surmounted by so arranging the castings or forgings that they can be used without any tooling. The greater first cost is compensated by the saving of the cost of machining. Manangese steel has a considerable advantage in being almost free from blow holes or honeycombs, and in possessing greater fluidity than cast steel.

'Harder, E. C., Manganese deposits of the United States: U. S. Geol. Survey Bull. 427, pp. 250, 251, 256, 1910.

Manganese steel is used for dredger pins and other parts of dredging machines; for dipper teeth of steam shovels; for parts of crushing and grinding machinery, such as shoes and crusher plates in ore mills; for ore chutes and screens; for elevator links, especially where the wear and tear is heavy; for agricultural implements, as plow shares and plow points, cultivator fingers, and even shovels, spades, rakes, hoes, and forks; for wheels, tires, and axles on railway cars, street cars, and mining wagons; for cogwheels; for couplers between railway cars; for railroad and street-car rails on curves; for burglar-proof safes; and for many other purposes. One of its most important uses at the present time, on account of its nonmagnetic property and hardness, is for cover plates and coil shields in large electromagnets, such as are used for clutches in lifting pig and scrap iron at foundries.

The usual practice is to manufacture ferromanganese and spiegeleisen in blast furances. The charge consists of manganese ore, iron ore, coke, and limestone, in amounts depending on the chemical composition of the various ingredients and the product desired. The process in general is not unlike that pursued in pig iron manufacture, though a larger amount of fuel is required, and the capacity of the blast furnaces is less. The loss of manganese by volatilization is usually high. In ferromanganese manufacture it may reach 25 per cent or more, and some is also lost in the slag. In recent years the electric furnace has been successfully adapted to the manufacture of ferromanganese.

MANGANESE MINERALS.

Of the many minerals containing manganese as an essential or accessory constituent only a small number are of sufficient importance to require detailed description in this bulletin.

OXIDES.

PYROLUSITE.

Pyrolusite is manganese dioxide, MnO_2. Manganese 63.2 per cent. Oxygen 36.8 percent. Hardness 1.5 to 2.5, can be scratched with the finger nail. Specific gravity 4.8. Luster almost metallic or dull. Color iron-black to dark steel-gray, sometimes slightly bluish. Color of powder black or bluish black; may soil the fingers. Orthorhombic crystallization. Sometimes occurs associated with psilomelane in alternating layers. May be fibrous or in needle-like aggregates; or in a powdery form.

PSILOMELANE.

Psilomelane is manganese dioxide with small amounts of other oxides. MnO_2 + (MnO, BaO, K_2O, H_2O). Manganese content variable but less than 63.2 percent. Hardness 5 to 6, harder than the knife blade. Specific gravity 3.7 to 4.7. Color iron-black, steel-gray, or bluish gray. Luster almost metallic. Color of powder black or brownish black. Does not occur in crystals. Characterized by rounded surfaces that often have a similar appearance to bunches of grapes, and by a concentric structure. Fracture surfaces usually rounded. Percentages of barium oxide, potassium oxide, and water vary considerably in psilomelane from different localities. Barium oxide amounts to 10 per cent or more in some, varieties.

MANGANITE.

Manganite is hydrous manganese oxide, $Mn_2O_3.H_2O$. Manganese 62.4 percent. Hardness 4, or softer than the knife blade but too hard to be scratched with the finger nail. Specific gravity 4.2 to 4.4. Luster almost metallic. Color dark steel-gray to iron-black. Color of powder reddish brown to nearly black. Orthorhombic crystallization. Found in fibrous and needle-like masses, often radiating. Less commonly occurs in prismatic crystals with deeply striated vertical faces.

BRAUNITE.

Braunite is manganese oxide and silicate, $3Mn_2O_3.MnSiO_3$. Manganese 63.5 percent. Hardness 6 to 6.5, harder than the knife blade. Specific gravity 4.8. Color brownish black to steel-gray. Color of powder the same. Dull or semi-metallic luster. Tetragonal crystallization. May occur either massive or crystalline.

WAD.

Wad is a mixture of manganese oxides. May contain some iron. Percentage of manganese variable. Hardness 1 to 6, may be harder than the knife blade or soft enough to be scratched with the finger nail. Color of mineral black or brownish black. Color of powder the same. Is never crystallized. Usually soft and loose but may be earthly or even hard and compact. Soils the fingers when handled.

CARBONATES.

RHODOCHROSITE.

Rhodochrosite is manganese carbonate, $MnCO_3$. Manganese

47.6 per cent. Hardness 3.5 to 4.5, or between the knife blade and finger nail. Specific gravity 3.5. Luster vitrous to pearly. Translucent to subtranslucent. Color usually pink but when impure may be rose-red, brown, or fawn colored. Color of powder white. Rhombohedral crystallization. Occurs in crystals, in cleavable or granular masses, and compact.

MANGANIFEROUS CALCITE.

Manganiferous calcite is calcium carbonate with some of the calcium replaced by manganese, (Ca,Mn)Co3. Manganese is possibly present also as an oxide. Percentage of manganese variable and usually small. Luster vitreous or pearly. Hardness 3.5 to 4. Specific gravity 2.8 to 3.2. Color black but occasionally has a reddish or brownish tinge. Subtranslucent. Rhombohedral. Usually occurs in cleavable masses that show numerous plane faces along the fracture surfaces; subordinately *as* crystals, granular, compact, and massive.

MANGANIFEROUS SIDERITE.

Manganiferous siderite is iron carbonate with some of the iron replaced by manganese, (Fe,Mn) CO3. Manganese content ranges from a few per cent to 25 per cent. Hardness 3.5 to 4. or between the knife blade and finger nail. Specific gravity 3.6 to 3.8. Prevailing color brown and to a minor extent reddish brown or yellowish gray. Color of powder white or yellowish white. Translucent to substranslucent. Rhombohedral crystallization. Occurs compact and earthy, in cleavable masses, in crystals, and granular.

SILICATE.

RHODONITE.

Rhodonite is. manganese silicate, MnSiO3. Manganese 41.9 per cent. Hardness 5.5 to 6.5, or harder than the knife blade. Specific gravity 3.4 to 3.7. Luster vitreous. Usual color pink; it may be brownish red or flesh-red due to impurities. Color of powder white or light colored. Translucent: Triclinic crystallization. Commonly in cleavable or granular masses.

COMPARISON OF MANGANESE ORE MINERALS.

The exact identification of manganese minerals is often difficult or impracticable. This is especially true with the fine-grained, feathery, and hairlike varieties which in places constitute the bulk of the ore.

Of the oxides, pyrolusite and psilomelane may be nearly identical in chemical composition. Pyrolusite, the manganese dioxide, usually contains some impurities, and the impurities may include one or more of the oxides which in slightly greater amount are characteristic of/ psilomelane. Pyrolusite may be distinguished from psilomelane by its crystalline structure and inferior hardness. Pyrolusite is soft enough to be scratched with the finger nail, but psilomelane is as hard or harder than the knife blade. Braunite is the only other manganese oxide mineral besides psilomelane that will take the steel of the knife blade. Its hardness, non-crystalline and often banded structure, and rounded fracture surfaces make the identification of psilomelane easy.

Manganite and pyrolusite may show a close resemblance, for in color, streak, and crystalline structure they may be very similar. Indeed, some mineralogists believe that pyrolusite always develops pseudomorphously after manganite by dehydration, but oxidation must also occur. The incomplete state of the alteration readily accounts for the almost invariable intermixtures of the two minerals. In hardness manganite stands between pyrolusite and psilomelane. Manganite' does not contain available oxygen and in that respect differs from pyrolusite and psilomelane.

Limonite is the most abundant iron mineral in New Mexico manganiferous iron deposits. The chemical composition of manganite is very similar to the chemical composition of limonite, but it has a still greater similarity to that of the hydrated iron oxide, goethite, $Fe_2O_3.H_2O$. Manganite and goethite both crystalize in the orthorhombic system and have the same characteristic crystal development. Goethite undoubtedly occurs in these deposits. Hematite is also a constituent of some of the manganiferous iron ores. Evidently iron and manganese occur isomorphously in the oxide minerals to some extent as they do in the carbonates.

Much of the softer manganese ores can be spoken of as wad,

---

[1]Harder, E. C., Manganese deposits of the United States: U. S. Geol. Survey Bull. 427, p. 261, 1910.

whose chemical composition is given as a mixture of manganese oxides. A fine-grained aggregate of pyrolusite and manganite may be designated in this way. Psilomelane and wad are the two mineralogical names that can be used with greatest assurance in naming the manganese oxide minerals.

The manganiferous carbonates are much alike in hardness, specific gravity, and occurrence. Percentages of calcium, iron, and manganese are exceedingly variable in different specimens. The color is a good but not infallible indication of the mineral.

Rhodochrosite and rhodonite resemble each other, especially in color. Rhodonite is the harder of the two and is less liable to occur in cleavable masses.

QUALITATIVE TESTS FOR MANGANESE.

Field tests for manganese in a mineral or mineral aggregate are difficult for the ordinary prospector to make and require apparatus with which he is not usually supplied. One of the common methods of procedure in qualitative analysis is as follows : Dissolve some of the powdered sample in hydrochloric acid and a few drops of nitric acid, add ammonia to alkaline reaction, filter off any precipitate that has formed, and pass hydrogen sulphide through the clear filtrate. If manganese is present in the solution a pink precipitate of manganese sulphide will form. When the percentage of manganese present is small the precipitate comes down slowly and may have a faint milky color. Cobalt, nickel, and zinc, if present, will also be precipitated with the manganese, but' they are rare in manganese deposits.

Blowpipe determinations for manganese are quite satisfactory when the proper apparatus is at hand. Make a sodium carbonate bead in a platinum wire loop, and while the bead is molten bring it in contact with some of the powdered mineral so that a small portion adheres. Heat the bead in the oxidizing flame, gradually adding more of the material in the above manner. A green-colored bead while hot which changes to a bluish green when cold indicates the presence of manganese. A similar color may be obtained by fusing a small quantity of the sample in a platinum spoon or on platinum foil with a flux composed of three parts of sodium carbonate and one of potassium nitrate.

MANGANESE AND MANGANIFEROUS ORES.

Prior to 1916 the Geological Survey classified the ores and other materials valuable for their manganese content under four headings—manganese ores, manganiferous iron ores, manganiferous silver ores, and manganiferous zinc residuum. The first three of these classes include practically all of the important ores containing manganese in appreciable amounts, and the same classification may be applied with equal propriety to the deposits from which the ores are obtained. The three types of ore deposits are all represented in New Mexico. Manganiferous zinc residuum is produced from the unique ores consisting mainly of franklinite, zincite, willemite, and calcite which occur near Franklin Furnace, N. J. It is not obtained from New Mexico manganese ores. The description of the three classes of ores given below are by Harder.'

MANGANESE ORES.

The only forms of manganese occurring in nature in sufficient quantities to be of commercial value are the oxides, the carbonate, and the silicate. Most manganese ores are oxides, mainly psilomelane and pyrolusite. Other oxides of manganese are mined, but much less abundantly. The carbonate of manganese, rhodochrosite, is not found in sufficient quantities in this country to be commercially valuable, but is mined in several foreign countries, as Spain and Wales. Both the oxides and the carbonate are used In the manufacture of steel and for chemical purposes. The silicate of manganese, rhodonite, contains too much silica to be used for its manganese content, but is sometimes mined for ornamental purposes on account of its beautiful pink color. Other minerals of manganese are too rare to be of commercial value.

MANGANIFEROUS IRON ORES.

Manganiferous iron ores consist of a mixture of iron and manganese oxides in varying proportions. The iron is generally in the form of limonite as in the manganiferous iron ores of the Appalachian region, though frequently it occurs as hematite, as in the Lake Superior ores. The manganese is mostly in the form of psilomelane, though pyrolusite is often abundant. Rarely iron oxides and manganese carbonate are associated, as at Chevron, Belgium, and in Wales. The manganese and iron oxides may occur together as a coarse mixture easily separated, or they may be so closely associated as to be indistinguishable to the eye. In most deposits where the individual oxides may be recognized the manganese seems to have penetrated into the mass, while the iron is nearer the surface. Small masses of psilomelane are frequently found in the interior of limonite nodules and limonite is found lining cavir ties in manganese ores. The two oxides may be so intermixed, however, that there seems to be no definite relation between them. In some

---

'Harder, E. C., Manganese deposits of the United States: U. S. Geol. Survey Bull. 427, pp. 17, 24-25, 1910.

iron-ore deposits there are portions in which pockets of manganese ore occur, while the rest of the body may be pure iron ore. In many manganese deposits the upper portion is ferruginous, containing limonite as surface coatings or intimately mixed with the manganese ore.

The amount of metallic manganese in manganiferous iron ore varies from less than 1 per cent to 40 per cent or more. The high and medium grades of ore are used in the manufacture of spiegeleisen and ferromanganese, but the ore that contains only a small percentagle of manganese is not used for this metal, but for its iron, only. High-grade manganiferous iron ore is found in the Appalachian and New England regions; low-grade ore occurs in the same regions and also in the Lake Superior district and in Arkansas.

MANGANIFEROUS SILVER ORES.

Manganiferous silver *ores* occur abundantly *in* the oxidized portions of many of the silver deposits of western United States. They consist of manganese and iron oxides, carrying silver chloride and lead. carbonate. The iron and manganese are intimately associated, forming a black amorphous ore. The iron is probably in the form of limonite and the manganese in the form of wad. As a rule, iron oxide predominates over manganese oxide, though locally, as at Butte, it is almost entirely absent. The lead sometimes occurs partly as the unaltered sulphide.

The unoxidized ores from which these ores are derived consist of silver, lead, zinc, and iron sulphides in a gangue of quartz, which in some places, as at Butte, is mixed with manganese carbonate and silicate. In other places, as at Leadville, manganese minerals are altogether lacking in the unoxidized ore, though they are abundant in the oxidized product. Zinc is rarely present in the oxidized zone, being readily dissolved and carried downward. Gold occurs in small quantities locally.

With regard to use, manganiferous silver ores may be classed under three heads:

(1) Ores with a high percentage of silver and lead and used for these metals only. The manganese and iron oxides present are a valuable aid in fluxing, and such ores as contain considerable quantities of them draw higher prices than other silver ores with the same silver content.

(2) Ores that are low in silver and lead but contain a large quanti ty of iron and manganese are utilized in the manufacture of spiegeleisen and ferromanganese. Under this head there may be included as a subclass ores that are too low in manganese to be used as a source for iron-manganese alloys and that are used for their iron content only.

(3) Ores that are too low in silver and lead to be used directly as *a* source of these metals and too low in iron and manganese to be used for the manufacture of spiegeleisen and ferromanganese are sent to the smelters to be used for fluxing purposes on account of their content of iron and manganese oxides. The silver and lead present, however, are recovered during the smelting, while the iron and manganese pass into the slag and are lost.

PRESENT METHOD OF CLASSIFICATION.

Recently the method of classification' of manganese-bearing

'Hewett, D. P., Manganese and manganiferous ores in 1916: U. S. Geol. Survey Mineral Resources, pt. 1, pp. 733-734, 1918.

ores has been revised in order to indicate more accurately the manganese content. Under the new system three classes of ore are recognized : (1) Manganese ores containing 40 per *cent* or more of manganese, (2) ferruginous manganese ores containing 15 to 40 per cent manganese, and (3) manganiferous iron ores containing 5 to 15 per cent manganese. This method of classification has been followed in the table showing the recent production of manganese and manganiferous ores in New Mexico (p. 82).

MARKETING OF MANGANESE ORES.

MANGANESE ORE PRICES.[1]

On May 28, 1918, a schedule of prices for manganese ores containing 35 per cent or more of metallic manganese was adopted by the Ferro Alloys Committee of the American Iron and Steel Institute and approved by the War Industries Board. The prices quoted are per unit of metallic manganese per ton of 2240 pounds. New Mexico shippers are required to pay the freight charges to Chicago amounting to $7.00 per ton.

Prices for ore containing when dried at 212° Fahrenheit

35% to 35.99%	inclusive-	Metallic	Manganese--	$ .86	per unit.
36% " 36.99%	"	"	"	.90	"
37% " 37.99%	"	"	"	.94	"
38% " 38.99%	"	"	"	.98	"
39% " 39.99%	"	"	"	1.00	"
40% " 40.99%	"	"	"	1.02	"
41% " 41.99%	"	"	"	1.04	"
42% " 42.99%	"	"	"	1.06	"
43% " 43.99%	"	"	"	1.08	"
44% " 44.99%	"	"	"	1.10	"
45% " 45.99%	"	"	"	1.12	"
46% " 46.99%	"	"	"	1.14	"
47% " 47.99%	"	"	"	1.16	"
48% " 48.99%	"	"	"	1.18	"
49% " 49.99%	"	"	"	1.20	"
50% " 50.99%	"	"	"	1.22	"
51% " 51.99%	"	"	"	1.24	"
52% " 52.99%	"	"	"	1.26	"
53% " 53.99%	"	"	"	1.28	"
54% and over	"	"	"	1.30	"

Premiums and Penalties.—Above prices are based on ore containing 8.0% silica and 0.25% phosphorus. For each 1% of silica under 8% and down to and including 5% a premium of

[1]See note, page 9.

50c. per ton is paid. Below 5% silica the premium rate is $1.00 per ton for each 1%. If the ore contains from 8% up to and including 15% of silica there is a penalty of 50e. per ton for each 1% in excess of 8%. If the silica content is from 15% up to and including 20% there is a similar penalty of 75c. per ton for each 1% in excess of 15%. For ore containing in excess of 20% silica a limited tonnage can be used; but for each 1% of silica in excess of 20% and up to and including 25% there is a penalty of $1.00 per ton. Ores containing over 25% silica are subject to acceptance or refusal at the buyer's option but if accepted are paid for at the above schedule with the additional penalty of $1.00 per ton for each extra unit of silica. All premiums and penalties are figures in fractions.

For each 0.01% in excess of 0.25% of phosphorus there is a penalty against unit price paid for manganese of 1/2c. per unit figured to fractions. There may be no penalty for phosphorus so long as the, ore shipped can be used to advantage by the buyer.

Payments and other Stipulations.—It is understood that 80% of the estimated value of the ore (less moisture and freight from shipping point) based on actual railroad scale weights is to be payable against certificates of sampling and analysis of an approved independing sampling chemist. Balance is to be paid on receipt of ore by the buyer. Settlement is to be based on an analysis of ore sample dried at 212° Fahrenheit. The percentage of moisture in the ore sample as taken is to be deducted from the weight. Actual railroad scale weights are to govern in final settlement.

The above prices are net to the producer and expense such as salary or commission to the buyer's agent is to be paid by the buyer. The cost of sampling and analysis to be equally divided between the buyer and seller.

Concerning the price schedule for manganese ores and the methods of payment Mr. Hewett' says:

Strictly speaking, the War Industries Board did not fix the price of manganese ore. It approved a gentleman's agreement between those consumers that are members of the Iron and Steel Institute for ores with more than 35 per cent manganese. It is highly improbable that any members of the Institute or their agents will pay higher prices than the schedule provides, but any other ore buyers can pay the prices

---

'Hewett, D. F., Personal communication.

they consider satisfactory to get ore. At the present time, however, many buyers consider that the schedule is sustaining prices rather than holding them down.

There is no legal power to compel any buyers of ore, even those subscribing to the agreement of the members of the American Iron & Steel Institute to pay 80 per cent of the value of shipments after sampling. The consumers merely state their willingness to do so.

APPROXIMATE VALUE OF NEW MEXICO MANGANESE ORES.

The procedure adopted in arriving at the values of shipments of manganese ores differs in several particulars from that usually followed with ores of the other metals. Payment is made on the basis of the number of long tons of 2240 pounds instead of the more commonly used short tons of 2000 pounds, and no deduction is made for smelting charges on manganese ores. The freight rate of $7.00 is per short ton. Freight must be paid on the weight of the ore as shipped, which is made up of the moisture content plus the dry weight of the ore. Half of the cost of sampling and analysis is charged against the shipment. For New Mexico ores the average deduction from the gross value for freight, sampling, etc., may be considered to be about $8.25 per long ton.

If the shipment contains 4 per cent moisture and the railroad weight is 60,000 pounds or 30 tons, the weight of the moisture is .04 x 60,000 pounds or 2400 pounds. The dry weight of the ore is equal to the difference between 60,000 pounds and 2400 pounds or 57,600 pounds. This weight is converted into long tons by dividing it by 2240, giving a result of 25.71 long tons. The value of the shipment equals the net value per ton multiplied by 25.71. Assuming that the above 30-ton shipment contains 35 per cent manganese, 8 per cent silica, and 0.02 per cent phosphorus, the approximate value can be found as follows: The gross value of the ore per long ton equals the number of units of manganese multiplied by the price per unit according to the schedule (p. 22) or 35 x $ .86 which gives $30.10 per ton. It would not be subject to either premiums or penalties for silica or phosphorus. Subtracting $8.25 for freight sampling, etc., from $30.10 leaves $21.85 as the net value per ton. The value of the shipment is $21.85 multiplied by 25.71 which is $561.76.

In case a shipment of 30 tons has a moisture content of 4 per cent, and the dry ore contains 42 per cent manganese, 18 per cent silica, and 0.10 per cent phosphorus, the gross value of the ore is 42 times $1.06 or $44.52. The silica penalty is $ .50 per unit for 7 units between 8 and 15 per cent amounting to $3.50, and $ .75 per unit for 3 units between 15 and 18 per cent amounting to $2.25, so that the total silica penalty is $3.50 plus $2.25 or $5.75. This amount is deducted from the gross value of the ore, and the $8.25 for freight, sampling, etc., is also deducted, leaving a net value of 30.52. The total amount which the shipper receives is $30.52 multiplied by 25.71, the number of dry tons, or approximately $784.66.

The method given above does not follow strictly the one used by manganese consumers. New Mexico manganese ores rarely contain enough phosphorus to be penalized, and on that account no illustration is given of the phosphorus penalty.

SAMPLING AND ANALYSIS BY THE SCHOOL OF MINES AS THE BASIS OF SETLLEMENT.

In the past, one of the unsatisfactory features of the mining of manganese ore has been that as a rule the shipper was obliged to wait until a shipment reached its destination before the ore was sampled and payment was made. Because of the freight congestion cars of ore were often in transit for two months or more. The additional time required by sampling and assaying made the period intervening between the date of shipment and date of payment amount to three months in exceptional cases.

In order to take advantage of the stipulation that 80% of the value of a shipment may be paid against the railroad bill of lading with attached certificate of sampling and analysis, the shipper and buyer must agree on an independent sampling chemist to take the sample and make the necessary determinations of its contents. Mr. Hugh W. Sanford', chief of the chemicals division, ferro alloys section, of the War Industries Board, states that when the producer and consumer agree on a local sampler and assayer *as* an official basis of settlement, each should pay half of the sampling and analytical costs. If a certain consumer does not agree to the local sampling and analysis, the producer is at liberty to correspond with the other consumers until he

[1]Personal communication.

finds one that will abide by them. The basis of sampling and analysis must be agreed to by both parties in order to be binding.

The United States Bureau of Mines was asked for suggestions that might be utilized by the NEW MEXICO SCHOOL OF MINES in the sampling and analysis of shipments, and Mr. J. E. Spurr, executive of the War Minerals Investigation replied as follows:

The question of sampling and assaying shipments of ore has been the cause of a great deal of complaint and worry. East-bound shipments of ore from California have been passed through sampling plants in Nevada, but the results have not been ideal as regards eliminating complaints. Furthermore, the necessary crushing has increased the fines, and for that reason this method has not met with favor from purchasers. I have been told that one of the California steel companies makes settlements on the basis of sampling by a representative of any one of 4 or 5 reputable assayers in San Francisco. Another well-known company buys a very large proportion of the Georgia output of manganese ore and has its own man in the field who takes a sample from the railroad car at the mine jointly with the shipper, such sample thereupon being divided so that each party can have its own analysis made if desired. In other camps, steps have been taken to try and establish some reputable chemist who shall have the confidence of both buyer and seller, and on the basis of whose sample and analysis settlement shall be made.

This last seems to me the most feasible method and one to be encouraged wherever possible. In, your case, could not your School of Mines act as the intermediary for sampling and assaying shipments, the idea being to educate the buyer to make his 80% settlement on the basis of your returns as to quality and on railroad weights as shown in the bill of lading?

The best method of sampling must vary with the conditions under which the sample is taken and the nature of the material sampled. If it can be taken while the railroad car is being loaded, a grab sample taken out of each wheelbarrow, or every tenth or twentieth shovel thrown into the car, should give a reliable sample of the whole. If the car has already been loaded, it is difficult to get a representative sample unless the material is so fine that a pipe can *be* driven down through it at measured intervals. It is best, therefore, always to sample while the car is in process, of loading, if possible.

THE NEW MEXICO STATE SCHOOL OF MINES is prepared to handle the sampling and analysis of shipments and will be glad to correspond -with producers and buyers who may desire to avail themselves of this service. Charges will consist of the travelling expenses of the sampler; a nominal sum per day for the time he is away from the institution; and the cost of the analysis of the sample, which is $8.00 for manganese, iron, silica, and phosphorus. Additional determinations will be made at prices furnished on request. The total cost of sampling and analysis by the SCHOOL OF MINES necessarily will be greater than it would be at a regular sampling works in the east. Some producers who are not inconvenienced by the delay in receiving payment prefer to have the sampling done when the ore reaches its destination.

SPECIAL HIGH-GRADE ORES.

The schedule of prices approved by the War Industries Board as given in the preceding section does not apply to manganese ores which can be used in the manufacture of glass and dry batteries and for chemical purposes, and which must fulfill more rigid specifications than ores utilized in the manufacture of ferromanganese and spiegeleisen. In general it may be said that these specifications call for an ore carrying a minimum of 40 to 50 per cent of metallic manganese, a minimum of 60 to 75 per cent of manganese dioxide, a maximum of 1 to 2 per cent of iron, usually a maximum of 0.01 to 0.02 per cent of copper, and no arsenic, cobalt, or nickel. Ores that comes within these specifications may secure a higher price than ores suitable for ferromanganese and spiegeleisen manufacture, but the demand for them is rather limited. Ordinarily the manufacturers of ferromanganese do not care to accept ore that contains less than 40 per cent manganese. Producers who have ore suitable for chemical or special manufacturing purposes are advised to correspond with the purchasers of ore of this character. A list of such firms is published by the United States Geological Survey.

OTHER SALABLE ORES.

As is indicated by the schedule of prices most manganese ores containing 35 per cent or more of metallic manganese are salable at a fixed-price. The chief shortage at the present time is of ores containing 40 per cent or more of manganese. Ores containing less than that amount are utilized largely in the manufacture of spiegeleisen, and of such ores there is a much better supply. Manganiferous iron ores containing 50 per cent or more of combined iron and manganese and in which the manganese ranges from 15 to 25 per cent are abundant and bring such a low price that in the case of New Mexico deposits only those that can be mined very cheaply and occur close to a railroad shipping point can be expected to yield a profit.

Ores that contain 28 to 35 per cent of manganese and only a small amount of iron and silica may find a buyer, but the usual price paid is too low to leave any profit for the producer. No schedule of prices has been prepared to cover ores containing less than 35 per cent manganese, and, according to Mr. Hewett[1] none is likely to be established.

Ores of lower grade than those mentioned above are in nearly all cases valueless unless concentrated, and only rarely is the installation of *a* concentration plant advisable. If a manganiferous ore contains gold, silver, copper, or lead in small quantities it may be salable as a fluxing ore, but in that case the manganese remains in the slag and has only an indirect value.

PURCHASERS OF MANGANESE ORES.

The United States Geological Survey has issued a list of purchasers of manganese and manganiferous ores. This list also indicates the class of ore each purchaser will accept. Five classes of ore are designated as follows:

(a) Manganese ores with 40 per cent or more manganese and less than 2 per cent iron.

(b) Manganese ores with 40 per cent or more manganese and 2 per cent or more iron.

(c) Manganiferous ore with 15 to 40 per cent manganese.

(d) Manganiferous ore with 5 to 15 per cent manganese.

(e) Manganiferous ore with 5 to 20 per cent manganese and small quantities of gold, silver, lead, or copper.

Owners and operators having ore to sell are advised to obtain a copy of this list of buyers.

UTILIZATION OF LOW-GRADE ORES.

Methods of treatment by which a salable product may be obtained from low-grade manganese ores have been investigated by the metallurgical department of the University of California and at the Minnesota School of Mines Experimental Station. The results of these investigations appear in bulletins by Hersam[2] and Newton[3]. The United States Bureau of Mines, Wash-

[1]Hewett, D. F., Personal communication.

[2]Hersam, E. A., The possible treatment of manganese ores in California, Univ. of California Engineering Bull., Vol. 2, No. 1, 1918.

[3]Newton, Edmund, Manganiferous iron ores of the Cuyuna district, Minnesota, Univ. of Minnesota, School of Mines Exp. Sta. Bull.. No. 5, 1918,

ington, D. C., expects to issue in the near future a bulletin on the mining and metallurgy of manganese ores, and producers and owners desiring the most up-to-date information on these subjects are advised to obtain a copy of this bulletin. The brief treatment of methods of beneficiation given below is based in part on the works of Hersam and Newton already mentioned and includes information obtained from the Bureau of Mines by personal correspondcnce. The methods considered include hand picking, screening, jigging and table treatment, magnetic processes, flotation, and leaching.

Hand Picking.—This includes the sorting out of the fragments of waste that are associated with the ore or become mixed with it during mining operations, and the cobbing off of worthless gangue from the lumps of ore. It is sometimes advisable to consider as ore only the relatively pure lumps and discard all of the fine material. Hand picking obviously requires no outlay for equipment. It is the only method of beneficiation that may be used to advantage by all who are mining manganese ores. Coarsely crushed ores may be improved by hand picking.

Jigging and Table Treatment.—If the ore minerals are hard and pure and do not slime while being crushed, they may yield a high-grade concentrate by the various methods of gravity concentration. . Barite is very objectionable in an ore that is to be treated by jigs or tables, as it has the same specific gravity as some of the manganese oxides and will invariably appear in the concentrates. Small success has so far been attained in the gravity treatment of the fine manganese oxides.

Screening.—When the fine material passing through the screen is of better grade than the mixture of coarse and fine material screening may occasionally be advisable. If the fines are too low grade to be of value their removal from the mixed product from the mine may result in easier sorting of the larger fragments. Ores that may be improved to any marked extent by screening are not plentiful.

Magnetic processes.—Considerable progress has been made in magnetic processes of concentrating manganese ores, but, rather curiously, magnetic separation has not been used successfully in the separation of the iron and manganese oxides in manganiferous iron ores. According to the United States Bureau of Mines'[1], a magnetic concentrating plant is being installed to produce concentrates from manganese ore at Phillipsburg, Montana. It is a small plant but will probably be enlarged if it proves to be a success. The ore it is designed to treat consists chiefly of manganese oxides in a highly siliceous gangue. Some apparently successful magnetic concentration tests have been carried out on siliceous carbonate ores from the Butte district.

Flotation.—To date, experimental work in the treatment of manganese ores by flotation has yielded no encouraging results.

Leaching.—The chemical extraction of manganese from ores involves no insurmountable difficulties as far as the chemical processes are concerned. The main problem seems to be that of reducing the cost of treatment to a figure that allows the product to be disposed of at a profit. Experimental work is being conducted by the Bureau of Mines Experimental Station, Tucson, Ariz., and by the Phelps-Dodge Corporation at Tombstone, Ariz., but no information as regards the progress accomplished has been made public.

In speaking of chemical methods of extraction Hersam[2] says in part:

The results of the tests by extraction, on the whole, indicated that the dissolution of manganese from most of its ores occurs with readiness and rapidity. The solvents suitable are the mineral acids of low cost. With the mineral acid is required a reducing agent, but as is seen, the reduction can be effected with simple and low-cost chemical. The removal or recovery of the manganese from the acid solution, with the regeneration of the solvent to the greatest extent possible, is a matter which is by no means subordinate and that next require consideration.

The sulphate process, in situations where sulphurous acid can be produced at low cost, offers an attractive field for practical experimental operation. The manganese of most of the ores examined is observed to be extracted to a satisfactory extent by sulphuric acid solvents enforced with reducing agent such as sulphurous acid, for example. The evaporation or crystallization of the dissolved manganese is a process involving only ordinary procedure, and the decomposition of the manganese sulphate, so produced, requires only the ordinary appliances of metallurgy. The costs of such operation will vary with the locality, and the availability of supplies, but for the treatment of ore that is too low grade for shipment, or of tailings, the process is worthy of attention.

---

[1]Spurr, J. E., Personal communication.

[2]Hersam, E. A., Op. cit., pp. 36-37.

PART II.
NEW MEXICO DISTRICTS, PROPERTIES, AND ORE DEPOSITS.

GENERAL CHARACTERISTICS OF THE DEPOSITS.

CLASSIFICATION BASED ON SHAPE AND TYPE OF DEPOSITION.

The types of ore deposits occurring at the more important properties are stated in the detailed descriptions of the properties, and only a brief summary is given here. The ore bodies may be broadly classified as: (1) Deposits in breccia zones, sheeted zones, and fissures ; (2) replacement deposits ; and (3) sedimentary deposits. Many of the deposits illustrate combinations of various subdivisions of (1) and (2).

DEPOSITS IN BRECCIA ZONES, SHEETED ZONES, AND FISSURES.

These deposits have formed in various felsitic and porphyritic rocks such as rhyolites, latites, and andesites ; also in sandstones and limestones. Ore deposition has been accomplished by the filling of open spaces in the fissures and between the breccia fragments, and by replacement of the fissure walls and brecciated rock.

REPLACEMENT DEPOSITS.

The replacement deposits have formed in limestones, intrusive igneous rocks, shales, and incoherent sandstones. The ore characteristically is in irregular beds or sheets. In the sedimentary rocks the beds are usually parallel to the stratification planes, and in the igneous rocks they tend to follow along limestone contacts. Ore deposition has taken place simultaneously with the removal of the country rock by metasomatic interchange.

SEDIMENTARY DEPOSITS.

The sand and gravel deposits that have accumulated along the flanks of the hills and mountains in which the manganese districts are located undoubtedly contain a large amount of psilomelane derived from the eroded portions of the veins. The little work done on these deposits indicates that the manganese content is too low on the average to enable them to be worked *as* placer deposits but additional investigations might possibly give more encouraging results.

CLASSIFICATION BASED ON THE COMPOSITION OF THE ORES.

According to the chemical composition of their ores the manganese deposits of the state may be classified as (a) manganese deposits, (b) manganiferous iron deposits, and (c) manganiferous silver deposits. Each of these classes includes deposits that would come under classes (1) and (2) described above. The straight-manganese deposits usually are definitely separated from the manganiferous iron and manganiferous silver deposits, but the distinction between the manganiferous iron deposits and manganiferous silver deposits cannot be made so easily.

MANGANESE DEPOSITS.

The manganese deposits proper are most numerous but have produced a much smaller tonnage than either of the other classes. They are the exclusive or predominant type in the following districts : Rincon, Cap Rock Mountain, Cooks Range, Florida Mountains, Little Florida Mountains, Santa Fe, Hot Springs, Derry, Magdalena Mountains, San Lorenzo, Socorro Mountains, and Luis Lopez. The deposits of the Silver City and Hillsboro districts are in part straight-manganese deposits.

Because of the frequent occurrence of manganese oxides in the outcrops of silver-bearing veins and lodes, some of these deposits were prospected for silver before the manganese ores became valuable, but with small success. The shipments of manganese ore usually carry only a trace of silver to the ton. Samples from these deposits, especially if barite is present, may give assay returns of a few ounces of silver. It may be said that manganese deposits whose outcrops have manganiferous calcite associated with the manganese oxides and which contain no vein quartz and only traces of silver are not likely to contain important bodies of silver ores below the outcrops.

Nearly all of the manganese ores are to a slight extent ferruginous. The iron content ranges from 1 to 5 per cent. The important ore minerals are psilomelane, pyrolusite, manganite, and wad. Other vein minerals are manganiferous calcite, and smaller amounts of manganiferous siderite, barite, and calcite. The ore bodies also contain more or less of the enclosing rock formation.

MANGANIFEROUS IRON AND MANGANIFEROUS SILVER DEPOSITS.

A strictly consistent classification of the manganiferous deposits appears to be out of the question. In attempting to divide them into two groups according to whether they do or do not contain silver, it is found that they are as a rule either silver bearing to some extent or are genetically related to neighboring deposits which are important sources of silver ores. The deposits whose ores are high in manganese and iron but contain sufficient silver to make them more valuable for that metal than for manganese and iron are beyond the scope of this report. Some are discussed briefly but only because of their intimate relationship with the deposits which are utilized for their iron and manganese content.

The districts from which ores having a high total percentage of manganese and iron and little or no silver are obtained are: Silver City, Fierro, New Placers, Lake Valley, Hillsboro, and Kingston. At Silver City manganese constitutes about 15 per cent and iron about 35 per cent of the average ore, and at Lae Valley manganese amounts to about 35 per cent and iron 12 per cent. Ores from the other districts are mostly of an intermediate chemical composition. Some of the ore from the New Placers district, however, has only a small iron content and can be classed as a straight-manganese ore.

These deposits as a rule are replacement deposits in limestone. Limonite, psilomelane, pyrolusite, manganite, and wad are the important minerals in the ores. Various manganiferous carbonates are present in minor amounts. Other gangue minerals are quartz, partly silicified limestone, calcite, and in places small amounts of barite.

PRIMARY ORE DEPOSITS.

The slight depth at which the deepest workings of many of the properties have exposed the ore deposits and the brief time that could be devoted to the subject of ore genesis renders any but general statements regarding the origin and alteration of the ore deposits rather hazardous. Probably most of the original manganiferous iron and manganiferous silver ores were deposited from upward-circulating waters which brought them from some exterior though not necessarily far removed source. Some of the manganese deposits proper had a similar origin, but in some of them the original deposition may have been from downward-moving solutions. The main circulation channels of the mineralizing solutions were fractures, fissures, breccia zones, pervious beds, and contacts due to igneous intrusions.

Except at rather shallow depths practically all of the manganese and an important part of the iron were deposited originally *as* carbonates, the chief carbonate minerals being rhodochrosite, manganiferous calcite, manganiferous siderite, and ankerite. The relative amounts of these minerals varied greatly in the different deposits, but manganiferous calcite seems to have been most abundant in the manganese deposits and rhodochrosite was rare or absent in them. Manganese oxides may have been deposited in part as primary minerals by upward-circulating waters at the surface or at very shallow depths. Most of the primary manganiferous iron and manganiferous silver deposits contained varying amounts of sulphides such as argentite, galena, chalcopyrite and sphalerite. A small amount of the manganese was in the form of the sulphide, alabandite, in a few of the deposits.

ALTERATION AND ENRICHMENT OF PRIMARY DEPOSITS.

The primary carbonate ores of manganese and manganiferous iron deposits are invariably too low in manganese and iron to be of commercial value. Primary manganiferous silver ores have been mined quite extensively in the state, but their value has depended on their silver, gold, copper, and lead content, and only indirectly on the iron and manganese. Workable bodies of manganese and manganiferous iron ores are nearly all secondary deposits; that is, they have been formed by the alteration of primary ore, the process having resulted in the concentration of the metals.

As the surface of the country rock is lowered by erosion and the primary ore is brought into an oxidizing environment above the ground water level, these deposits probably undergo secondary enrichment which may resemble to some extent the secondary enrichment of copper, silver, and gold deposits. The change from carbonates to oxides and hydrated oxides results in some concentration but is of itself insufficient to account for all of the concentration and other alterations in the ore bodies. The oxides are in part dissolved in meteoric waters and carried downward. They replace primary carbonates with which they come in contact, replace the adjacent country rock and breccia fragments, and are deposited along joints and other open spaces.

Unlike copper and silver, iron and manganese do not ordinarily migrate downward in solution to the water level or below before they are deposited. The best ore of many of the straight-manganese deposits is within a few feet of the surface and much of the production has been obtained at depths of less than 25 feet. Oxides may continue in diminishing amounts to depths of 100 feet or more. Manganiferous iron and manganiferous silver deposits are usually oxidized and enriched to greater depths than are the manganese ore deposits, and the productive ore zone may extend to the water level or even below it. Not all of the oxidized iron and manganese ore minerals take part in the downward migration and enrichment, as is attested by the abundant psilomelane float in most of the districts, which has been derived from the outcrops of the deposits by weathering and erosion.

DONA ANA COUNTY.

RINCON DISTRICT.

LOCATION AND GEOLOGY.

The manganese deposits which in this bulletin are included in the Rincon district are in the vicinity of Rincon, a station on the Atchison, Topeka & Santa Fe Railway line between Albuquerque and El Paso. They are in the southern part of the Caballos Range which extends northward from Rincon for 30 miles. The range consists of sandstones, quartzites, shales, and limestones overlying a basal granite. Extensive movement along a north-south fault or fault zone located on the west side of the mountains Ms resulted in the elevation of the formations on the east side of the fault plane, and in tilting them to the east with the development of the monoclinal type of mountain range. Erosion has modified to some extent the westward-facing fault scarp.

The east slope is more gradual and regular and corresponds roughly with the stratification planes of the sedimentary beds. At least locally, minor folding accompanied the faulting movements on the west side of the range. A number of flows and intrusions of rhyolite, andesite, and basalt appear in the southern part.

PROPERTIES AND ORE DEPOSITS.

MORGAN GROUP.

The Morgan group is $1^1/_4$ miles northwest of Rincon in the southern foothills of the Caballos Range. The country rock consists of sandstones, in part grading into quartzites; and conglomerates. The sandstone is generally red and varies from medium to coarse grained. The conglomerate is made up largely of boulders of rhyolite and other igneous rocks, some of which are nearly a foot in diameter. In the vicinity of the mine workings the sedimentary beds strike east-northeast and dip to the south, but half a mile to the northeast the strike has changed to the north and the dip is to the east. Evidently the southern part of the range has been subjected to additional disturbances that do not accord with the main mountain-forming movements.

The established ore-bearing area of the property is 1800 feet long and 600 feet wide. Surface indications consist of prominent vein outcrops and abundant psilomelane float. A portion of the earlier shipments consisted of the larger float fragments collected from the surface. This ore was practically pure psilomelane. Ore deposition has followed a series of nearly vertical fissures having in general a northwest strike which is parallel to the greatest elongation of the mineralized area. The most productive fissure strikes N. 60° W. and dips 80° SW. It intersects several other well-defined fissures which vary in strike from N. 10° W. to N. 40° W. These fissures all show more or less manganese mineralization at the surface. Faulting movements have been small as a rule. Where most of the ore has been mined on the main ore-bearing fissure the foot wall is well defined, but on the hanging-wall side the vein matter gradually merges into the country rock through a distance of 4 to 6 feet. Considerable brecciation of the hanging wall next to the vein has taken place.

The ore is largely psilomelane replacing the brecciated quartitic sandstone along the fissures. It occurs in pockets some of which contain as much as ten tons. The larger pockets are found near the surface. They are in part located at the intersection of subordinate fractures with the main fissure, and certain beddings of the country rock seem to have been more susceptible to replacement than others. This vein has very little barite, but some of the subordinate veins carry a considerable amount of it. The barium content of the pure psilomelane is usually high. In the deeper workings psilomelane gives way to wad and manganiferous calcite.

The manganese oxides probably have been derived from primary manganiferous calcite which, like the barite, may have been deposited from ascending solutions. The presence of several per cent of iron in the ore indicates that the primary carbonates were also ferruginous. A sample of the barite contained 0.3 ounces of silver per ton.

The mine workings consist of open cuts, tunnels, stopes, and shafts distributed along the vein for 600 feet. Very little ore has been mined at a depth of more than 30 feet. Two shafts that have prospected the vein to a depth of 50 feet or more were too badly caved to permit an examination of them. A number of short tunnels and shafts have served to prospect some of the other veins.

The total production of the Morgan group prior to July 1, 1918, is given by the United States Geological Survey as 471 tons. Most of the tonnage shipped during 1918 has been mined by R. E. Callow operating under a short term lease. The average grade of the ore mined by him was manganese 38 per cent, iron 3.5 per cent, silica 5.5 per cent, and phosporus 0.025 per cent.

RINCON MINE.

The claims of the Rincon Mining Company are three-quarters of a mile north of Rincon. The geological formations are similar to those present at the Morgan group. The sandstones, quartzites, and conglomerates are badly warped and faulted, and a dome structure has been partly developed. A fissure zone about 100 feet wide traverses the claims in a northwest-southeast direction. Much of the rock included in this zone has been brecciated and cemented into a solid mass that has resisted erosion more successfully than the unaltered country rock on each. side. It has been erroneously called a dyke.

Several well-defined northwest-striking fissures in the breccia zone carry some manganese oxide and a small amount of barite. Black manganese stain is common but the amount of float is slight. When the property was looked at in July a tunnel 85 feet long following the most prominent vein showed ore consisting of psilomelane, wad, and limonite. The returns from a picked sample were manganese 43.9 per cent and iron 5.6 per cent. The vein was about 2 feet in width, and the high grade ore was 2 to 6 inches in width. Much of the vein along the tunnel shows very little high-grade ore.

LIGHTTOWER PROPERTY.

This property is located about 6 miles southeast of Rincon. Nothing is known of it except that the ore is reported to be high in iron. No shipments have been made.

SHERIFF MINE.

The Sheriff mine is about twelve miles northwest of Rincon and is on the west side of the Caballos Range. No information could be obtained regarding it.

COOK PLACER CLAIMS.

At the south end of the Caballos Range recent deposits of sand and gravel derived from the adjoining slopes occur, and farther to the south merge into the usual heterogeneous detrital material characteristic of the Rio Grande Valley. Three-quarters of a mile south of the Morgan group some of the sand and gravel beds contain considerable fragmental psilomelane which has doubtless constituted one of the erosion products from the manganese area to the north. The beddings carrying more than 5 per cent of manganese probably make up only a small fraction of the entire series and are as a rule not over 3 feet thick. The extent of the area occupied by them is not known.

The workings consist of a few shallow cuts and a well 120 feet deep. It is said that the latter did not expose much manganese more than 20 feet from the surface. A 4-compartment power jig has been installed near the well but has not been operated. Experimental work resulted in the production of less than a ton of concentrates which contained considerable barite. The total tonnage of low-grade ore on the property may be considerable but no estimate of its probable amount can be given.

GRANT COUNTY.

SILVER CITY DISTRICT.

LOCATION AND TOPOGRAPHY.

The Silver City manganese district is near the town of Silver City, the terminus of the Atchison, Topeka & Santa Fe Railway branch from Rincon. It is included in what is easily the greatest general metalliferous district in the state. Within a radius of 20 miles are located the gold, zinc, and lead deposits near Pinos Altos; the silver deposits of Chloride Flat, Fleming Camp, and Georgetown districts, now largely worked out; the iron- and zinc-bearing areas in the vicinity of Hanover and Fierro; the copper deposits of the Burro Mountains, and of the Chino Copper Co. near Santa Rita ; -and various others.

Manganese is present to a rather limited extent in the ores of a number of the mines near Silver City, but the manganese district proper as here defined extends from Bear Mountain in a southeast direction to Lone Mountain, and forms an area 15 miles long and 1 to 3 miles wide. The town of Silver City is adjacent to it on the northeast side almost midway between the* two mountains. Other elevations of note in the area are the Silver City Range and Boston Hill. The latter is a rounded hill having a maximum relief of about 400 feet and is in reality a southeast continuation of the Silver City Range. Concerning the topography of this locality Paige' says:

The range of mountains of moderate relief which trends northwestward from Silver City culminates in Bear Mountain, a peak 8050 feet high. These mountains are called * * * the Silver City Range. South of Bear Mountain the range, in a broad way, is asymmetric In form, the western slopes being far steeper than the eastern, which have assumed low angles in conformity with the dip of the sedimentary rocks that form them. * * * The southern part of the mountains is not rugged and merges gradually into the gravel at the south end; the northern part, however, especially in the canyons at the north end, is somewhat rugged. * * * Lone Mountain, another of

'Paige, Sidney, U. S. Geol. Survey Geol. atlas, Silver City folio (No. 199), p. 2, 1916.

the smaller groups, is in type a counterpart of the southern portion of the Silver City Range. Its steep side is on the southwest and its northeast slope is gentle. These hills rise but 400 feet above the gravel at their base.

GENERAL GEOLOGY.

ROCK FORMATIONS.

The descriptions of the rocks of the manganese district and the treatment of the general geology are largely condensations from those of Paige.[1]

Pre-Cambrian Rocks.—The pre-Cambrian rocks comprise granites and ancient sediments metamorphised to schistose and quartzitic masses. They are the basal formation of the district:

Bliss Sandstone.—The Bliss sandstone of Cambrian age rests upon the pre-Cambrian complex. A vitreous quartzite predominates at the base but grades into a calcareous sandstone higher up in the formation and then into an arenaceous limestone. The thickness is given as not more than 180 feet.

El Paso Limestone.—The El Paso limestone is a *gray* or grayish-blue limestone with some dolomitic beds. Chert appears in the upper part of the formation. It has been classified as lower Ordovician in age. Its thickness is 900 feet or less.

Montoya Limestone.—The Montoya limestone is made up of pink chert-banded limestone near the base, and of white and massive blue alternating beds in the upper part. Due to the presence of the closely spaced chert bands, the lower part of the formation has a very distinctive appearance which makes its field identification quite easy. It belongs to the Upper Ordovician and *is* about 300 feet thick. Below it occurs the El Paso limestone and above it the Fusselman limestone.

Fusselman Limestone.—The Fusselman limestone consists of gray, partially magnesian limestone 40 feet or less in thickness belonging to the Silurian period.

Percha Shale.—The Percha Shale is 500 feet in maximum thickness and is between the Fusselman limestone and the Fierro limestone. In age it is Devonian. The prevailing color is dark gray to black. Owing to its slight resistance to erosion it does not as a rule form prominent outcrops.

'Paige, Sidney, Op, cit., pp. 3-6, 8.

Fierro Limestone.—The Fierro limestone above the Percha shale is of Carboniferous age. It includes up to 800 feet of light-gray to dark-blue or purplish limestones that are cherty for the most part.

Beartooth Quartzite.—The Beartooth quartzite lies unconformably on the Fierro limestone and consists of about 100 feet of quartzite, conglomerate, and sandstone. It is Cretaceous.

Colorado Shale.—The Colorado shale consists of drab, olive-green, yellow, and brown calcareous and sandy shales and a small amount of sandstone. It rests upon the Beartooth quartzite and has a maximum thickness of 2000 feet. It is classified as Cretaceous.

Quartz Monzonite Porphyry.—At Silver City adjacent to the manganese district is an area of quartz monzonite porphyry about 1 by $1^1/_2$ miles in size which has its greatest extension to the north. It is of intrusive origin and cuts Colorado shales on the north and Fusselman limestone and Percha shale on the west. It is light colored and the phenocrysts are chiefly quartz and feldspar. A similar intrusive rock has penetrated the Fierro limestone at Lone Mountain.

STRUCTURE.

This district is for the most part a structural unit, the structure being the result of both faulting and folding. The crest line of the Silver City Range and Lone Mountain forms the western edge of a broad, shallow syncline extending to the northeast for some distance. The Silver City Range is a monoclinal block of the sedimentary rocks described above, and the dip of the formations is to the northeast. This block is bounded on the north, east, and west by faults, and has been elevated, at least relatively, by movements along the fault planes. The main faults are parallel to the range. The surface between Boston Hill, the southeast extremity of the Silver City Range, and Lone Mountain is covered with Quaternary sand and gravel deposits so that the structure of the underlying rocks is not definitely known. Lone Mountain has a close structural relationship with the Silver City Range, and probably the same structural conditions persist in the solid rocks throughout the length of the manganese area.

PROPERTIES AND ORE DEPOSITS EXCEPT AT BOSTON HILL.

NINETEEN-SIXTEEN MINE.

The Nineteen-sixteen mine is on the northeast side of the Silver City Range, 5 miles northwest of Silver City, and 1 mile east of Bear Mountain. The Continental Divide passes within a quarter of a mile of it. Limestone that should probably be designated as Fierro is the prevailing rock. The limestone beds. strike N. 30° W. to N. 45° W. and dip 25° to 40° NE. The limestone formation continues for some distance up the hill to the southwest, but below the property it soon gives way to a quartzite. The known ore-bearing area has a maximum dimension of less than 1000 feet.

The limestone has been intruded by an igneous rock that has. formed dykes and sills, usually of small thickness. The intrusive rock has been so thoroughly altered by circulating waters that little can be said of its original nature. The alteration has consisted of (a) silicification especially along the outcrops and (b) kaolinization below, although the kaolinized material may also appear at the surface. The original rock had a very prominent flow structure which is well preserved in the silicified product and to a lesser extent in the kaolinized derivative. The latter is very similar in appearance to the gouge which is often formed along fissures of considerable displacement.

The ore deposits are for the most part replacement deposits in the limestone immediately below the kaolinized sills, and have formed characteristically in the vicinity of fissures which may have controlled the courses of the mineralizing solutions. In one place the ore has made in the bedding at least 25 feet from the fissure, though as a rule it grades into unaltered limestone within 10 feet or less. The deposits are inclined to be pockety and the maximum thickness attained is about 7 feet. Ore also occurs along a vertical north and south fissure as a characteristic though narrow fissure deposit in the kaolinized rock, and to some extent has a tendency to make along the beddings.

The ore minerals are psilomelane near the surface and the various softer oxides underneath. Carbonates are present and consist mostly of manganiferous calcite and a brown calcite that carries only a small amount of iron and manganese. Carbonates form a larger percentage of the ore in the deeper workings and the size of the high-grade ore bodies decrease as depth is attained. Most of the ore was mined within 30 feet of the surface.

In addition to an open cut 10 feet deep and extending for 25 feet along the ore-bearing fissure, the underground workings consist of four inclines ranging in length from 12 to 100 feet, and following contacts between the talcy kaolin and the limestone. At the foot of the longest incline, which furnished 75 per cent of the ore shipped, a shaft connects with the surface 50 feet above. The various inclines are located at two or more separate ore horizons.

Shipments from the Nineteen-sixteen mine have totalled 716 tons to July 1, 1918. This ore contained on the average, according to reports, manganese 35 per cent, iron 4 per cent, silica 12 per cent, and a negligible amount of phosphorus. No mining operations were conducted during the summer of 1918.

CAUSLAND PROPERTY.

The Causland property is about 1 mile west of Lone Mountain and 5 miles southeast of Silver City. It is located on the northeast side of a rather inconspicuous hill, which includes the extreme western surface exposure of the Lone Mountain limestone series. The ore apparently occurs in the Montoya limestone both as a fissure filling and as a replacement of the limestone along particular beddings. It is largely limonite and wad and is very similar to the ore mined at Boston Hill. A mixed sample from a number of exposures gave returns of 18.8 per cent manganese and 35.4 per cent iron.

The ore bodies are seldom more than 3 feet thick. They are localized in a fissure zone at least 200 feet wide and are near the intersection of two porphyritic dykes. The close proximity of the dykes suggests that the primary ore deposition was to some extent related to the igneous intrusions.

Workings consist of open cuts and shallow shafts, one of which is 20 feet deep. Kirchman and Crawford worked the property under a lease agreement early in 1918, and shipped about 100 tons of ore of about the same grade as they obtain from the Boston Hill workings. No work has been done since they suspended operations.

SILVER CITY MANGANESE MINE.

The claims owned by the Silver City Manganese and Development Co. are in the western part of the Chloride Flat district about 4 miles northwest of Silver City. The country rock is limestone. The ore, consisting of iron and manganese oxides, is largely present as a fissure filling, and is associated with barite and some quartz. Carbonates are sparingly present. The outcrops and important surface workings expose only small irregular bodies of ore of good grade. The ratio between the iron and manganese content is probably about the same as it is in the average manganiferous iron ore of Boston Hill. In the days when silver mining was active in this district a 40-foot shaft was sunk on one of the veins of the property.

No manganese or manganiferous iron ore has been shipped from the property.

BOSTON HILL PROPERTIES AND ORE DEPOSITS.

GENERAL STATEMENT.

Boston Hill, the low, rounded elevation southwest of Silver City, has an area of nearly 1 square mile and a maximum relief of less than 400 feet. The highest point is about 6325 feet above sea level. The surface has generally a gradual slope and is without distinctive topographic features. Most of the known ore-bearing area is included in the holdings of Kirchman and Crawford and of the Stevens Estate. Inasmuch as the claims of these two properties are somewhat intermingled and their ore bodies are not sharply differentiated, it has seemed advisable to discuss under one head the geology and ore deposits of the entire hill.

HISTORY.

The first mining at Boston Hill took place in the early seventies at the time when Chloride Flat and Fleming Camp districts were active. The similarity of the Boston Hill ores to some of those found in the neighboring silver districts led to considerable prospecting for silver but very little was obtained. Copper in small amounts was found in the southern part of the hill, though not enough to have commercial value. A considerable quantity of fluxing ore was shipped to the Socorro and El Paso smelters in the early nineties. According to reports, Wm. Newcomb mined 80,000 tons of ore from the hill, most of which was used at the Silver City smelter. After the closing down of the smelter about 15 years ago very little mining took place until Moses and Kirchman began operations in April, 1916.

About 1910, W. A. Stevens began to acquire claims in the Chloride Flat district and at Boston Hill. Aside from a brief period of operations at the Silver Cross mine in 1916 little work was done on his holdings until the summer of 1918.

ROCKS AND STRUCTURES.

The chief sedimentary rocks of the Boston Hill area are Bliss sandstone, El Paso limestone, Montoya limestone, Fusselman limestone, and Percha shale, which outcrop from west to east in the order named. They have been tilted from their original position and now constitute a part of the Silver City Range monocline. On the west side of the hill the strata strike north-northeast and dip to the east, but in the northeastern part the strike varies from north to north-northeast and the dip is still east. The dip angle is seldom more than 25°. To the south and west the surface of the solid rock dips below the sand and gravel deposits. On the north side of the hill displacement along a major fault striking N. 60° E. and dipping to the northwest at a steep angle, or possibly along several rather closely spaced parallel faults has elevated, relatively at least, the country on the south side, so that the Paleozoic sedimentary rocks are in contact at the surface with Cretaceous shales on the north side. This fault is called the Boston Hill fault. A large intrusive mass of quartz monzonite porphyry bounds the sedimentary rocks along the east side of the hill. Another igneous intrusion is exposed very sparingly on the north side near the Boston Hill fault where erosion has removed the El Paso limestone above it. Alteration has been so thorough that little can be said definitely as to its original nature, 'except that it had a porphyritic texture. A fine-grained intrusive with well-developed flow structure appears to have followed along the contact between the porphyry and limestone above. It was probably a latite or rhyolite, but has been so greatly kaolinized and otherwise, altered that the general term felsite is applied to it. Aside from the Boston Hill fault the fissures of the hill are not especially numerous and the average displacement is small.

ORE DEPOSITS.

Outcrops of manganiferous iron ore are exceedingly abundant in this area, and there has been little occasion to doubt the existence of fairly extensive deposits of the same type of ore beneath them. Mining operations of rather *a* pretentious character which have been conducted at various times have confirmed their presence to shallow depths, but not until 1916 did the value of the ore become sufficiently high to enable operators to mine it at a profit. Many of the deposits are too narrow to work successfully, and some having good-sized outcrops decrease in size when followed below the surface, but one at least continues downward to a vertical depth of 75 feet with little change in size or in the character of the ore and promises to continue downward for some distance. Umpleby[1] has estimated that these deposits contain probably 500,000 tons and possibly 1,000,000 tons of ore similar to that already mined.

Extensive mineralization has occurred in the El Paso limestone along the Boston Hill fault and in the Montoya limestone near the intersection of the fault with the contact of the limestone and the quartz monzonite porphyry; also in the Fusselman and Montoya limestones west of the Percha shale. The ore bodies now being worked are confined to a V-shaped area on the north and east slopes of the hill. The deposits are classified as replacement deposits in limestone, replacement deposits in felsite, and fissure deposits.

Replacement Deposits in Limestone.—These deposits appear in the El Paso, Fusselman, and Montoya limestones, and are common in nearly, all parts of the hill. They form irregular bodies which usually conform with the stratification, but do not seem to favor any particular beddings. The thickness is often 6 or 8 feet, and the width may be 50 feet or more. The length of the continuous ore bodies is not known, as no development work has been extended more than 225 feet along the dip. The ore has a tendency to cut quite abruptly along the sides, and a

---

[1]Umpleby, J. B., Some western manganese deposits, U. S. Geol. Survey press bulletin.

transition zone from ore to unaltered country rock is usually thin or lacking. In part the replacement bodies are inclined to the stratification planes, or they may be offset with no discernible faulting having taken place. Fissuring, however, has had a marked influence on ore deposition, and the larger ore bodies are often localized near fracture planes of small average displacement.

The most extensive deposit of these replacement ores which have been mined is in the Kirchman and Crawford workings in the northeastern part of the hill. The ore is composed of iron and manganese oxides whose mineralogical composition is quite complicated. Near the outcrop small nodules make up an appreciable part of the ore. They have an exceedingly well developed radial structure and attain a diameter of 1 to 11/2 inches. A sample composed of these nodules contained 35.6 per cent manganese and 23.1 per cent iron, showing that in them some concentration of the manganese has been brought about. The same radiating nodules are incompletely developed in the lower workings. Feathery and acicular crystals are less common at the surface than at the bottom of the incline.

Carbonates, largely secondary calcite, appear below, but on the whole the ore has changed but little in tenor or in character in the length of the incline, which extends over 200 feet down the bedding and attains a vertical depth of 75 feet from the surface. The ore is usually dark chocolate-red and forms both hard and soft varieties. Practically none of the original rock structure has been preserved.

Near the south end of the productive area, another type of replacement deposit is illustrated in one of Kirchman and Craw-ford's underground workings. Here, also, the ore follows the beddings rather closely and forms bodies of irregular outlines. Nodules are not present, and the ore has preserved the structure of the limestone to some extent. Along the periphery the ore in places grades gradually into unaltered limestone. The color varies from dark red to black, the latter being characteristic of the best grade. The ore minerals seem to be mainly pyrolusite, manganite, and limonite. The composition of the ore agrees closely with that of the typical ore of the district and contains about 35 per cent iron, 16 per cent manganese, 8 per cent silica, and 0.01 per cent phosphorus.

Replacement Deposits in Igneous Rocks.—The ore bodies of this class constitute a rather unusual occurrence of manganiferous iron ore, and one that deserves a more thorough examination both in the field and the laboratory than the writer has found time to undertake. Additional investigations might serve to alter some of the conclusions reached, but it has been thought advisable to present them in an incompletely verified form rather than to omit them.

These deposits were located with certainty only in the vicinity of the Boston Hill fault, but they possibly have a wider distribution. They have replaced the 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 geologic conditions have been discussed briefly under "Rocks and Structure" (page 45). The areal exposure of the underlying porphyritic rock is too small to justify an opinion as to its size or structural nature. Its porphyritic texture and absence of flow structure seem sufficient to separate it petrologically from the felsite above it, which still retains evidence of flow structure and seems to have been very sparingly supplied with phenocrysts though greatly kaolinized and otherwise altered.

The ore consists of the usual iron and manganese oxides together with a notable amount 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 preservation of the minute details of the banding in the coarsely crystalline carbonate aggregates is especially noteworthy. 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 carbonate ores are brown or yellow.

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. Possibly only a part of the banded structure of the ore is due to flow structure in felsite which the ore replaced.

Fissure Deposits.—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 iron oxides, but small amounts of quartz and barite are present. Some good silver assays have been secured from this ore.

GENESIS OF THE ORES.

The evidence at hand does not justify a detailed discussion of the genesis of the Boston Hill ores. Probably the iron and manganese were transported from some deep-seated locality by hot ascending waters and were deposited largely as carbonates. These primary carbonates were deposited chiefly as metasomatic replacement bodies in felsite and in various strata of the limestone, and to a lesser extent in open fissures. By erosion and diastrophic movements the carbonates were brought near the surface and into an oxidizing environment where the iron and manganese carbonates were converted to oxides and rendered relatively insoluble, while the calcium carbonate was taken into solution by meteoric waters and carried below. The enrichment of the ore has been due both to the removal of the calcium carbonate and to the higher metallic content of the oxides as compared with the carbonates. Much of the high-grade ore in the outcrops has been carried away by erosion, but there seems to have been considerable migration of the oxides downward which has resulted in additional concentration.

Some of the iron and manganese may have been leached from the overlying shales, and according to Umpleby[1] these shales are the main source from which the ores were derived. The iron and manganese content of the limestones is not sufficiently great to justify considering them the source of the ores.

---

[1]Umpleby, J. B., Some western manganese deposits, U. S. Geol. Survey press bulletin.

KIRCHMAN AND CRAWFORD PROPERTY.

The claims of the Kirchman and Crawford property are on the east side of Boston Hill and extend from the Boston Hill fault nearly to the gravel deposits at the south end. Part of the ground is owned by Kirchman and Crawford, and part is held by them under bond and lease. The leased ground belongs to the Newcomb Estate and Theodore Carter.

The ore deposits are mainly manganiferous iron replacement deposits in limestone, and their characteristics already have been discussed under "Ore Deposits" (pp. 46-49). No replacement deposits in felsite were located with certainty, but numerous fissures are ore bearing.

Many cuts and pits, usually less than 15 feet deep, are scattered over the surface. A number of years ago they yielded a surprisingly large tonnage of fluxing ore. Most of the recent shipments have come from the main incline in the northeastern part of the hill. An open cut 75 by 100 feet attains a depth of 20 feet on the south side, and beyond the cut an incline follows the ore down the bedding for a distance of 175 feet in the direction S. 20° E. The width of the stope along the incline averages about 45 feet, and it is 20 feet high in places. The lower end is at least 75 feet below the surface. Ore still remains along the sides of the stope, but as a rule its thickness has decreased until it can no longer be mined profitably. The greatest concentration of ore appears to be connected with nearly vertical fractures striking northwest. At the south end of the property underground workings reach a vertical depth of 25 feet and follow the ore along the bedding about 50 feet. They have yielded a fairly large tonnage of ore, and a minor amount has been taken from various shallow workings.

From Jan. 1, 1916, to July 1, 1918, the production is given as 37,100 tons, and the average content of the ore was manganese 16 per cent, iron 35 per cent, silica 8 per cent, and phosporus 0.01 per cent. At first the property was known as the Moses and Kirchman property but later it became the Kirchman and Crawford property. It has also been called the Legal Tender mine.

STEVENS ESTATE HOLDINGS.

The ground owned by the Stevens Estate is located in various parts of Boston Hill and extends to the northwest into the Chloride Flat district. The most promising areas are on the north slope of the hill near the Boston Hill fault, and in the northeastern part close to the town of Silver City. All of the types of ore deposits described in the section entitled "Ore Deposits" (pp. 46-49) are represented.

The workings are numerous and consist of open cuts and shallow shafts. In August, 1918, an open cut in the ore along the Boston Hill fault just above the porphyry was being worked, with the expectation of obtaining a large tonnage of ore. Carbonates are more abundant in this locality than usual, and there is a possibility that they may increase in amount *as* greater depth is attained. A number of small workings near Silver City were also yielding a large daily tonnage.

Recent mining operations on the Boston Hill portion of the property did not begin until late in the spring of 1918. The Silver Cross mine, a part of the Stevens property in the Chloride Flat district, produced 1160 tons of manganese ore in 1916. The production was 140 tons per day during September, 1918.

FIERRO DISTRICT.

LOCATION AND GEOLOGY.

The Fierro district is located about 2 miles northeast of Fierro, the terminus of the Whitewater-Hanover-Fierro branch of the Atchison, Topeka & Santa Fe Railway. It is in the northern part of the elevated, rolling region between Hanover Creek and Shingle Canyon. The Fierro limestone, which is the country rock of the deposits, has an areal exposure of at least 25 square miles. A few dykes of granodiorite or allied rock have penetrated the limestone in the vicinity of the deposits.

PROPERTIES AND ORE DEPOSITS.

HODGES-DOWELL PROPERTY.

This property is the only one in the district. Two groups of claims have been located on a fissure that strikes N. 50° E. to N. 60° E. The fissure could not be traced continuously from one end of the property to the other, and possibly there are two instead of one. The workings of the southwest group of claims consist of a number of trenches and small open cuts and a shaft 20 feet deep. The vein has a maximum width of 20 feet and is quite regular both in strike and in width. Only a small proportion of the vein is ore bearing, the thickness of the ore being 2 to 4 feet. The rest of the vein is composed of shattered limestone. The ore is strictly a fissure deposit and has no apparent tendency to make in the sedimentary beddings. It consists of manganite, wad, limonite, and some manganiferous calcite. Some of the ore is quite siliceous. A sample from the bottom of the shaft contained 26.6 per cent manganese and 15.1 per cent iron.

The most extensive opening on the northeast group is a shaft combined with an open cut that attains 25 feet in depth. Several other smaller workings are located along the vein, which on the whole is narrower here though still well defined. The ore forms replacement bodies in the beddings in addition to constituting a regular fissure deposit. In the beddings the thickness of the ore is seldom over 2 feet. The fissure ore is very similar both in width and minerals to the ore found at the other end of the property.

The Silver City Manganese and Development Co. was operating the property during August, 1918, under a bond and lease. A small car of ore that was shipped is reported to have given returns of manganese 34.6 per cent, iron 16.1 per cent, and silica 8.4 per cent. This was sorted ore and not an average of the entire vein as mined.

CAP ROCK MOUNTAIN DISTRICT.

The Cap Rock Mountain district was not visited by the writer. Mr. James P. Porteus, mining engineer of Lordsburg, has kindly furnished the data used in the following description:

The district is about 20 miles north of Lordsburg in the vicinity of Cap Rock Mountain. Ore deposits occur in quartzite and Gila conglomerate as veins 2 feet or less in width. The ore is largely psilomelane and is usually accompanied by a thin seam of jasper gouge along the hanging wall. A sample of the ore contained 45 per cent manganese, 3 per cent silica, and 0.15 per cent phosphorus.

The greatest amount of mining work has been done on the groups of claims owned by T. Edwards, W. D. McKeeghan, and associates, of Duncan, Ariz. It consists of a shaft 40 feet deep and 75 feet of drifts and cuts along the vein which strikes slightly west of north. The Maple and Lisso Syndicate of Lordsburg was operating the property Oct. 1, 1918, under a lease and was employing a force of 20 men.

LUNA COUNTY.

COOKS RANGE DISTRICT.

LOCATION AND GEOLOGY.

The Cooks Range district occupies a small area in the southern part of Cooks Range. Mirage, on the Atchison, Topeka & Santa Fe Railway branch between Deming and Rincon, is 18 miles to the southeast and Deming is 7 miles to the southwest. Cooks Range extends north-northwest from the district a distance of 12 or 15 miles and farther to the north merges into the Mimbres Mountains of which it is genetically a pare. Cooks Peak with an elevation of 8300 feet is the highest peak of the range. The elevation attained by the foothills in the vicinity of the manganese deposits is only 5000 feet or roughly 500 feet above the level of the surrounding bolson plain. The rocks in this part of the range are andesite, quartz latite, and an *agglomerate* made up of fragmental material derived from them[2]. The agglomerate beddings are separated by numerous igneous flows and breccias. Quartzites occur in the low hills about a mile north of the manganese area.

PROPERTIES AND ORE DEPOSITS.

LIBERTY MANGANESE MINE.

The Liberty manganese mine, the only property of note in the district, is 2 miles northeast of Mirage. The ore deposits are found in the characteristic andesite, andesite breccia, and conglomerate. A series of quartz reefs, which are undoubtedly made up of andesite silicified in the vicinity of fissures by circulating solutions, serve as a partial boundary of the known pro-

---

[1]Lindgren, Waldemar, Graton, L. C., and Gordon, C. II. The ore deposits of New Mexico: U. S. Geol .Survey Prof. Paper 68, p. 287, 1910.

[2]Darton, N. H., S, Geol. Survey Geol. atlas, Deming folio (No. 207) p. 10, 1917.

ductive area. The ore occurs in fissures and in breccia zones in three ways: (1) As a true vein deposit, (2) as a replacement of andesite, and (3) as a cementing material of andesite breccia. Most of it is psilomelane. The occurrence of small amounts of fluorite in one of the workings is of interest. Manganiferous calcite is prevalent in places and is probably the original manganese mineral from which the oxides were derived.

Underground workings consist of several shafts and steep inclines, none of which are more than 20 feet in depth. A small hand jig has been constructed to treat the fine material containing more or less psilomelane float that in places covers the solid formation. Several tons of concentrates have been obtained in this way. To Sept. 1, 1918, about 35 tons of high-grade ore had been marketed by the owners of the property.

FLORIDA MOUNTAINS DISTRICT.

LOCATION AND GEOLOGY.

The Florida Mountains extend north and south approximately 10 miles and have an average width of half that distance. Deming is about 14 miles north-northwest from the center of the range. Granite, limestone, and agglomerate are the prominent rocks', the agglomerate forming the northern part and granite and limestone the central and southern parts. The limestone is in irregular patches that extend across the range from west to east and separate the granite area into two nearly equal divisions. Most of the contacts between the granite and limestone are faulted contacts. The manganese is in the El Paso, Fussleman, Montoya, and perhaps the Gym limestone beds far down on the east flank of the mountains. The geological structure is in general monoclinal, and the dip of the sedimentary beds in this locality averages 45° to the east.

PROPERTIES AND ORE DEPOSITS.

LESDOS PROPERTY.

The entire manganese area about half a mile square is within the boundaries of the Lesdos property. Manganese outcrops are numerous but as a rule are rather small. They are seldom as much as 25 feet long or more than 4 feet wide. The elongation

'Darton, N. H., S. Geol. Survey Geol. atlas, Deming folio (Np. 207). P. 9, 1917.

is usually parallel to the strata of the limestone. Manganiferous calcite is often the predominant mineral in the outcrops and appears to some extent in most of the ore. Psilomelane is also plentiful both as float and as a vein mineral, and wad occurs in subordinate quantities below the outcrops.

The workings consist of a tunnel 30 feet long, several shallow pits 10 to 15 feet deep, and a considerable number of small cuts. No well-defined fracture system seems to have influenced the mineralization. As indicated by the various shallow workings the ore occurs for the most part as a replacement of the limestone beds at various horizons and subordinately along irregular fractures. In the Montoya limestone the replacement has affected only the calcium carbonate layers, and the chert seams are unaltered. The ore bodies are quite pockety and tend to pinch out when followed downward. Manganiferous calcite is in the main so intimately mixed with the oxides that sorting is ineffective in securing a shipping product. About 35 tons of ore containing 15 to 35 per cent of manganese is lying on the various dumps.

Nearly all of the work on the property was done in 1905 and 1906 by Henry Lesdos. Near the granite contact to the west some zinc carbonate was mined which carried sufficient manganese oxides to impart a black color to it.

LITTLE FLORIDA MOUNTAINS DISTRICT.

The Little Florida Mountains are north of the main Florida Mountains and are separated from them by a pass less than a mile wide. The range is composed mainly of volcanic agglomerate. In the vicinity of Black Canyon 12 miles southeast **of** Deming and 7 miles from Mesa on the main line of the Southern Pacific Railway, manganese deposits have been recently worked. A description of the deposits is not permitted by **the** meager amount of information at hand.

SANTA FE COUNTY.
NEW PLACERS DISTRICT.

The New Placers district was not visited by the writer. The information here stated' has been obtained from published **ar**ticles and by correspondence.

LOCATION AND GEOLOGY.

The New Placers district embraces the Tuertos or San Pedro range of mountains in the southern part of Santa Fe County.

The general features of the district and neighboring areas are described by Yung and McCafferty[1] as follows:

In the southern part of Santa Fe County, New Mexico, there are three groups of mountains, each of which penetrates the Carboniferous and Cretaceous sedimentary strata as a unit, and presents, in the main, the same characteristics and appearance. They extend in a north and south line, and, in order from the north, are the Oritz, Tuertos, and South Mountains. * * * They resemble each other so closely in appearance and height that the question naturally arises: Are not the three in some way related geologically? To the north is the Oritz group, a cluster of sharp, cone-like peaks, formed by the breaking of the eruptive syenite-porphyry through the flat beds of limestone and sandstone of Carboniferous and Cretaceous age. These beds have been slightly lifted by the intrusion and slope away from the mountain with a gentle and even dip. Four miles to the south is the Tuerto or San Pedro group, the geology of the western portion of which is the one exception to the rule of this trio. This western part consists of the San Pedro mountain proper, the greater part of which is formed of tilted sedimentary beds, but the eastern part of the group, including Oroquai mountain, consists entirely of the eruptive syenite-porphyry, with its sharp topography similar to the Oritz group. * * *

Each group of mountains was once an enormous laccolith, but the sedimentary strata both above and around the intruded masses have been entirely eroded, so that now, with the exception of the western end of the Tuertos, there remains nothing but the igneous rock.

PROPERTIES AND ORE DEPOSITS.

COLLIER MINES.

The Collier mines are in the Tuertos Range midway between Los Cerrillos on the Atchison, Topeka & Santa Fe Railway and Stanley on the New Mexico Central Railway. Stanley is 13 miles distant. The Santa Fe Copper Co. undertook the first mining operations in the district during the early eighties and worked the San Pedro copper mine and the Lincoln-Lucky group. The ore from the latter property was valuable chiefly for its lead and silver content but also contained sufficient manganese to be an excellent fluxing ore. Much of it was treated at the old Los Cerrillos smelter.

According to Yung and McCafferty[2] the ore deposits of the district may be divided into four classes: (1) Contact deposits

---

[1]Yung, M. P., and McCaffery, R. S., The ore-deposits of the San Pedro district, New Mexico: Am. Inst. Min. Eng. Trans., vol. 33, pp. 350-352, 1903.

[2]Idem., pp. 355, 357.

of copper, (2) lead-silver chimneys, (3) gold veins, and (4) gold placers. Of these only the second is important as a source of manganese. The same authors' in describing the silver-lead chimneys say :

The second class of ore deposits, those of lead-silver in limestones, * * * consists of chimneys of ore which swell and pinch along a fractured zone in the limestone, which has become a channel for the circulation of underground waters. The ore consists of galena, sphalerite, alabandite, pyrite, and a small amount of chalcopyrite. There are also present cerussite, limonite, and oxidized manganese minerals. The best example of this type of deposit is the Lincoln-Lucky mine, which is on such a chute or chimney. The chute follows the dip of the limestone, and is more or less circular in cross-section and about 60 feet in diameter.

The Lincoln-Lucky ore body, now owned by the Collier Mines Co., has been followed on its dip about 2300 feet. The lower end is about 350 feet below the surface. A crust several inches to 3 feet thick composed of manganese oxides and smaller amounts of lead carbonate was left along the sides of the pipe when the mine was worked originally. The owners expect to obtain quite a large tonnage of shipping manganese ores from this crust.

What is probably another pipe of ore below the original one has been located during the course of recent development work. The two pipes contain the same minerals, and their directions seem to be approximately parallel. The newly discovered ore body may become an important producer of lead and manganese ores.

In addition to the main incline the mine is supplied with three old shafts. These can be retimbered and supplied with hoisting equipment to handle the expected output.

SANTA FE DISTRICT.

LOCATION AND GEOLOGY.

Manganese deposits are located on the western slope of the Santa Fe Range 4 miles northeast of Santa Fe. The sedimentary rocks consist mainly of sandstone and shales. Their areal exposure is reported to be about 2 square miles, and they rest upon schists containing abundant intrusions of granite and pegama-

'Yung, M. P., and McCaffery, R. S., op. cit., p. 357.

tite. Some coal has been mined from a small seam that is close to the manganese deposits.

PROPERTIES AND ORE DEPOSITS.

HILL PROPERTY.

The Hill property includes a part of the sedimentary area described above. The various shales and sandstones have in this locality a strike of N. 45° E. and dip about 30° SE. They contain numerous and often large-sized limestone boulders. The ore is largely in the soft shale beds as replacement bodies along the beddings. It has in part a nodular structure, and also forms irregular pockets that so far have not contained more than a few hundred pounds of ore. Less than a ton of ore has been obtained during the exploratory work. It is of excellent grade and consists chiefly of pyrolusite and psilomelane.

Workings consist of an incline extending into the hill from an open cut, by means of which the formation has been prospected to a depth of 40 feet. When examined the property was idle.

SIERRA COUNTY.

LAKE VALLEY DISTRICT.

LOCATION AND GEOLOGY.

The Lake Valley district is in the immediate vicinity of Lake Valley in the southern part of the Mimbres Range. A branch line of the Atchison, Topeka & Santa Fe Railway extends to the town of Nutt, 12 miles distant, on the Silver City branch of the same railway system.

The sedimentary formations consist of Mimbres limestone, Percha shale, and Lake Valley limestone which strike to the northeast and dip to the southeast at an angle of 10 to 25°. These formations outcrop over an area of several square miles just north of Lake Valley, the Mimbres limestone appearing in the northwestern part. According to Gordon' the Mimbres limestone has been brought to its present elevated position by movement along a fault to the west of the outcropping ridge. This sedimentary area is of very moderate relief, and the ridges and valleys are due to the unequal resistance to erosion of the

---

'Lindgren, Waldemar, Graton, L. C., and Gordon, C. H., The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, p. 277, 1910.

various beds. The Percha shale has been very readily affected by weathering agents. Rhyolite and andesite flows at one time covered the entire region and still remain as the surface rocks over much of the surrounding country.

PROPERTIES AND ORE DEPOSITS.

LAKE VALLEY MINES.

The Lake Valley mines adjoin the town of Lake Valley on the north. They yielded considerable silver ore during the eighties and nineties but were operated only in a small way from 1894 until 1905. From that time until manganese mining was started in 1917 the property was dormant. The production of silver' to 1893 has been given as 5,000,000 ounces, half of which came from the Bridal Chamber ore body.

The ore deposits occur in the Lake Valley limestones where they have formed irregular replacement bodies along the bed-dings. The high-grade ore was rather pockety even in the best stopes, some of which are several hundred feet long. The Bridal Chamber ore body was found just below a shale bed, but most of the others occurred entirely within the limestone. Ore deposition has been influenced to some extent by nearly vertical fissures of slight displacement. The limestone has been replaced by ore to varying distances from them, but in places the ore shoots twist about and widen or contract irrespective of apparent fissures and fractures.

The recently mined ore has come chiefly from the Bella and Columbia workings and a small amount has been taken from the Apache workings. This ore was exposed during the mining of the silver ores in the early days, but on account of the small silver content it could not be worked at a profit at that time. It follows the same beddings and is somewhat similar to much of the silver ore which adjoined it.

Clark[2] described some of the characteristic silver ores carrying considerable manganese as follows:

The Emporia Incline ore, when considered in carload lots, is a neutral ore, consisting of 30 per cent silica, 12 per cent iron, and 18 per cent manganese, the remainder being limestone. It is generally brownish black, with a tendency to brown, and frequently carries from 1 to

'Lindgren, Waldemar, Graton, L. C., and Gordon, C. H., op. cit., p. 282.
[2]Clark, Ellis, Trans. Am. Inst, Min. Eng., vol. 24, pp. 148-149, 1894.

5 per cent of lead in, the form of galena. Its contents in silver vary from 30 to 50 ounces to the ton.

The Bunkhouse workings have yielded several distinct varieties of ore from different parts of the mine. The ore from the central portion of the body, taken out shortly after its discovery, varied in silver from 200 to 500 ounces per ton and was basic, containing a considerable proportion of cerargyrite. Subsequent workings developed large bodies of chocolate-colored manganiferous ore, with an average composition of 8 per cent silica, 12 per cent iron, and 24 per cent manganese, the remainder consisting of limestone and gypsum. The silver contents were 20 to 30 ounces per ton. Overlying this ore were considerable bodies of what became known. as "fluxing ore" carrying 5 per cent silica, 10 per cent iron, and 30 per cent manganese, the remainder consisting of limestone. The silver contents were always low, increasing and diminishing with the silica contents and averaging 5 ounces per ton. The color of the fluxing ore was black.

The most abundant minerals in the manganiferous iron ore are manganite, psilomelane, wad, and limonite. Galena is present in the silver ore but other sulphides are rare. The original minerals which metasomatically replaced the limestone are believed to have consisted largely of manganiferous carbonates. Lead probably appeared originally as a sulphide and silver as an impurity in the galena and as argentite. When the ore-bearing strata were elevated and subjected to oxidization near the surface, the primary minerals were altered to those now present in the deposits.

The ore zone of the property trends northeast parallel to the strike of the sedimentary formations. The ore bodies have numerous outcrops along the northwest side of the ore zone and follow the dip of the limestone beds to the southeast. The maximum depth from which ore has been mined is not much more than 150 feet, where water was encountered. The thoroughly oxidized character of the ore at the water level indicates that it may extend some distance farther down the bed-dings. An appreciable amount of silver ore was mined in open cuts at the surface, and the deeper ore was worked through in-clines and shallow shafts.

Manganiferous iron ore of lower grade than that already mined still remains in the old workings, and prospecting might serve to open up new ore bodies. Ore is also exposed at the water level, but whether its amount and grade are sufficiently good to enable it to be mined at a profit is undetermined.

The United States Geological Survey gives the tonnage shipped in 1917 and 1918 as 3009 tons, part of which was sorted from the dumps. Manager Colin McIntosh states that 2000 tons of the ore averaged 35 per cent manganese, 12 per cent iron, 15 per cent silica, and 0.05 per cent phosphorus. The ore as mined had to be carefully sorted to bring it up to this grade. No mining operations were in progress during the summer of 1918.

ROPER GROUP MINE.

The Roper Group mine is 7 miles south of Lake Valley. It is essentially a silver-lead property, but some manganese ore has been developed on two of the claims. Several shallow workings constitute the development work. A sample of the ore indicates that psilomelane is the usual manganese mineral, and andesite or latite is the country rock. The silver and lead deposits are in limestone.

HOT SPRINGS DISTRICT.

LOCATION AND GEOLOGY.

The Hot Springs district is adjacent to the town of Hot Springs and lies to the northwest. Hot Springs is on the Rio Grande River 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.

PROPERTIES AND ORE DEPOSITS.

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 1200 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 sanstone 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, imbedded 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 impregnaiton 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.

DERRY DISTRICT.

LOCATION AND GEOLOGY.

The Derry district is on the west side of the Caballos Mountains and about equally distant from the two ends of the range. Derry is the nearest post office and is situated about 6 miles southwest from the district. Hatch, on the Rincon-Deming branch of the .Atchison, Topeka & Santa Fe Railway, is 23 miles to the south. The average elevation is about 300 feet above the Rio Grande River.

The general geology of the Caballos Range has been stated under the Rincon district. The typical monoclinical structure is modified in this locality by the presence of an anticline along the west boundary of the range. The axis of the anticline trends north, parallel to the elongation of the mountains. The manganese district extends along the anticline for about 2 miles and includes parts of both limbs. Limestone is the usual country rock.

PROPERTIES AND ORE DEPOSITS.

NEW STAR MINE.

At the north end of the district is located the New Star mine. Two well-defined fissure veins outcrop near the axis of the anticline and cross the property in a general north-south direction. The distance between the fissure walls is as much as 35 feet, though only a small part of this width is well mineralized. The outcrops contain manganiferous and ferruginous calcite, manganese oxides, and limonite. A few shallow cuts have exposed some shipping ore, but most of it is high in calcium carbonate. The ore leads proper are usually 1 to 3 feet in thickness. These veins decrease in width when followed to the south. They intersect on the adjacent property known as the Wildcat mine. Another prominent fissure striking N. 25° W. is a quarter of a mile west of the axis. A quarter of a mile still farther down the slope a strong fissure zone several hundred feet in width has a course about parallel to the above fissures. Psilomelane float of good grade is found at the surface, and the outcrops show fairly heavy mineralization.

About 40 years ago, according to reports, an inclined shaft was driven on one of the fissure on the east side of the fissure zone to a depth of 45 feet in quest of silver, and some manganese ore was obtained. The lower part of this shaft is now filled with caved material. A short distance to the west a tunnel extends 60 feet into the mountain, and would, if continued 200 feet farther, cut several veins at depths of 100 to 150 feet. Several fractures had been intersected by the tunnel when the property was visited in August, 1918, and 10 or 15 tons of ore had been mined. It was the intention of the owners at that time to continue the tunnel for about 200 feet farther in order to prospect the full width of the fissure zone showing on the surface. The primary ore is chiefly manganiferous and iron-bearing calcite constituting both a fissure filling and a replacement of the fractured limestone beds. Fragments of unaltered carbonate are found enclosed by the oxidized ore derived from them. A soft, friable ore that is pyrolusite and wad occurs in the main fissure. A sample of this material was found to have 46.0 per cent manganese.

WILDCAT MINE.

The property adjoining the New Star mine on the south is known as the Wildcat mine. Most of the veins on the New Star claims extend into the Wildcat ground and retain much the same character, although they have decreased somewhat in width and less manganese is to be seen at the surface. A strong east-west fissure cuts the north-striking fissures near the west boundary of the property, and some ore of fair grade has been mined near the intersections. Four or five cuts 10 feet or less in depth have been excavated during the development work. The owners were working the property on a small scale at the time the district was visited.

RUTH MINE.

The Ruth mine is south of the Wildcat mine. The formation and general geological conditions remain about the same as on the two properties to the north. East-west fissuring is almost as important as north-south fissuring, and the ore occasionally exhibits a tendency to follow the beddings as well as to make along the fissures. Numerous veins of rather pure calcium carbon ate crop out over the surface of the group. Manganiferous calcite appears abundantly and psilomelane fragments are common. A small amount of good ore has been mined in the two shallow prospect workings. No work was in progress during the summer of 1918.

HILLSBORO DISTRICT.

LOCATION AND GEOLOGY.

The manganese deposits of the Hillsboro district are 1 to 4 miles east and northeast of Hillsboro. Lake Valley, the nearest railroad station, is 17 miles to the south. The deposits are in or close to an area of Mimbres limestone whose bounding formations are consolidated Palomas gravel on the east and west and andesite on the north.

PROPERTIES AND ORE DEPOSITS.

McPHERSON CLAIMS.

The McPherson claims are about 3 miles northeast of Hillsboro. They are located on an andesite and Mimbres limestone faulted contact which extends east and west. To the north the andesite rises to several peaks of moderate height. A number of igneous intrusions have followed the fault plane, and the crustal movements have produced a sheeted zone in both andesite and limestone near the contact. On the south side of the contact for 25 feet or more the country rock consists of a talcose and kaolinized material arranged in irregular layers. The manganese minerals, consisting of soft pyrolusite and wad, form irregular lenses along the beddings. Some of the ore looks very much like lignite coal. A picked sample contained 53.3 per cent manganese, but the seams of this grade of ore are rarely more than 2 or 3 inches thick. A 20-foot shaft connects near the bottom with a tunnel 25 feet long that is nearly parallel with the main contact. Low-grade manganese ore appears in several beds 4 inches to 3 feet in thickness.

MINOR DEPOSITS.

About $2^1/z$ miles east of Hillsboro, and extending northward from the Percha River for a mile or more in the Mimbres limestone near the Palomas gravel and andesite contact, is a mineralized zone that has yielded some manganese and iron ore. None of the old workings except the open cuts and short tunnels were in a condition permitting an examination of them. A mile north of the river a tunnel 100 feet long, a shaft 50 feet deep, and several small open cuts are in a assure zone striking east. Solid unaltered limestone forms the south or foot wall, but the hanging wall is composed of ground-up and altered shale and line-stone. The manganese ore consists of streaks of soft black pyrolusite and wad sparingly disseminated in the vein breccia. Close to the surface the soft ore has altered to hard psilomelane. Manganiferous calcite and siderite are also present.

Half a mile northwest of the above-described workings an open cut 20 feet long and 12 feet in greatest depth has been excavated in a breccia zone. The ore, which Occurs in lenses less than two feet thick, is made up of hematite, limonite, and psilomelane. Nearly all of the work accomplished in this part of the district was done a good many years ago in an effort to uncover bodies of gold, silver, or lead ore. Some of the manganese ore obtained during the prospecting operations was utilized for flux at the Hillsboro smelter.

At several places in this district fissure veins containing the rather rare lead minerals, vanadinite and wulfenite, have been worked at various times in the past 40 years. The ores from these veins contain considerable vanadium and molybdenum, but present a rather difficult• metallurgical problem. Manganese oxides in varying amounts occur with the vanadinite and wulfenite. The amount of phosphorus in the manganese ores is said to be high and would be a serious detriment if they should be found in bodies of workable size.

KINGSTON DISTRICT.

The Kingston district is on the west slope of the Black Range about 9 miles west of Hillsboro, and extends northwestward from the town of Kingston. No ore suitable for ferromanganese or spiegeleisen manufacture is being produced. Manganiferous silver ore is mined in considerable amounts, and the deposits of this class are of sufficient interest to merit a brief description. The only property visited during the few hours the writer was in the district was the Lady Franklin mine.

According to Gordon', the ores of the district consist chiefly of lead and copper sulphides carrying silver and gold, and free silver. The ores occur in pockets and pipes in the Mimbres limestone below the Percha shale. Some of the important ore bodies are irregularly distributed along the west side of *a* prominent porphyry dyke and have a tendency to form at the intersection of two series of fractures. A thin layer of limestone us-

---

[1]Lindgren, Waldemar, Graton, C., and Gordon, C. B., The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper, 68, pp. 269-270, 1910.

ually separates the ore from the Percha shale, but the deposits seldom extend more than 100 feet below the contact.

In the Lady Franklin mine the ore is valuable chiefly for its silver content. The silver occurs as argentite, free silver, and in the sulphides of manganese, lead and copper. The manganese sulphide, alabandite, is probably a fairly common constituent of the fine-grained streaks of sulphides and in places forms rather pure crystalline aggregates as much as several inches in diameter. Its silver content is usually high. Alabandite is a rare mineral in New Mexico ore deposits. It was not identified in any of the other districts visited, but is said to occur in the Collier mines.

The manganese carbonate, rhodochrosite, is almost invariably associated with the sulphides. It forms extensive replacement bodies in the limestone and also constitutes a fracture filling. As a rule it contains only small amounts of silver. According to Superintendent Date Whitham of the Lady Franklin mine the shipments of ore contain 8 to 20 per cent manganese. By oxidation under favorable conditions the rhodochrosite deposits of the Lady Franklin mine would yield bodies of high-grade manganese ore.

North and west of the Lady Franklin mine some oxidized manganese ore has been mined along the outcrop of the Mimbres limestone. The deposits are irregularly distributed along the beddings and have been worked by a few open cuts. The ore is largely psilomelane associated with small amounts of lead carbonate and galena. Occasional pockets are said to have had a high silver content, but the average ore carried little silver. It was used as a fluxing ore at the old Hillsboro smelter. These deposits are on ground owned by the Empire Zinc Co. and by John Brochu. They were not examined by the writer, and information regarding them was obtained from Mr. Frank Maloit of the Empire Zinc Co. Other mines in this district which have been important silver producers in the past are the Kangaroo, Comstock, and Caledonia.

SOCORRO COUNTY.

MAGDALENA MOUNTAINS DISTRICT.

LOCATION AND TOPOGRAPHY.

The Magdalena Mountains occupy an area about 25 miles long and 12 miles wide. They are a short distance east of the center of Socorro County, aud the crest of the range, which trends north and south, is approximately 20 miles west of the Rio Grande River. The manganese-bearing area is in the southeastern part of the range. It is bounded on the north by Water Canyon and on the west approximately by a line extending across the range from the head of Water Canyon in a general south-southwest direction.

Magdalena, near the north end of the range, is the largest town in the immediate vicinity of the Magdalena Mountains. It is the terminus of the Atchison, Topeka & Santa Fe branch line extending westward from Socorro. Kelly is located on the west slope 3 miles southeast of Magdalena and in close proximity to the lead and zinc mines of the Empire Zinc Co., and the Ozark Smelting and Mining Co. No railway stations are located close to the manganese area. Water Canyon station, 4 1/2 miles east of the mouth of Water Canyon, on the Magdalena branch of the Santa Fe, serves as the shipping point for the mines and prospects of the northern part, and ore mined in the southern part must be hauled to San Antonio or San Marcial on the Albuquerque-El Paso line of the Santa Fe system. The haulage distance to Sau Marcial varies from. 18 to 25 miles.

The southeastern part of the Magdalena Mountains is furrowed with numerous canyons, all of which head in the vicinity of Timber Peak about 3 miles southeast of Old Baldy. From there they radiate to the east and south. Enumerated in order from north to south the important canyons are Water Canyon, South Canyon, Six-mile Canyon, Eight-mile Canyon, and Sawmill Canyon. They are all characterized by steep gradients and by the frequent development of almost vertical sides and deep, narrow gorges known as box canyons. Talus slopes are numerous and many of them are unusually extensive. The mountain slopes are as a rule very rough and are either bare or covered with only a thin layer of fragmental material. As the base of the mountain is approached the mountain proper merges into foothills. These in turn give way to a talus plain composed of the erosion products from the mountain. The talus plane has an average elevation where it borders the foothills of 6,000 feet.

GEOLOGY.

The portion of the Magdalena Mountains under consideration is composed almost entirely of Tertiary eruptive rocks. Latites and andesites are present in small amounts, and pitchstone occurs in several places. All of these are relatively unimportant when compared with the extensive flows of rhyolites, and rhyolite tuffs, and rhyolite agglomerates which constitute by far the larger part of the rock exposure.

The rhyolites vary in texture from fine-grained felsitic to coarsely porphyritic. The fine-grained varieties possessing few phenocrysts are subordinate in extent to the porphyritic varieties. The phenocrysts of the latter include quartz, feldspar which is chiefly sanadine, some biotite and a little hornblende. The sanadine is very glassy and is distinguished from quartz chiefly by its cleavage faces. The phenocrysts seldom have a maximum dimension of more than one-eighth of an inch. All of the flow rocks have a glassy groundmass characteristic of surface flows. The prevailing color is a chocolate-red or chocolate-pink. Flow structure is common and often prominently developed.

Rhyolite tuffs are rare in the northern part but quite common near the southern end of the range. Aside from their tuffaceous texture they are quite similar to the rhyolites associated with them. The rhyolite agglomerates are most abundant in the vicinity of Water Canyon. In some instances the rhyolite inclusions are remarkably numerous and of large size.

Careful microscopic examination and chemical analysis might indicate that some of the so-called rhyolites are really trachytes or latites. The andesites are inclined to be dark chocolate-red and to carry phenocrysts of plagioclase, feldspar, biotite, and hornblende. Pitchstone, which appears in the foothills to the south, is black or dark brown and entirely glassy.

The only distinctly sedimentary rocks occupy small areas in Six-mile Canyon and in the southern foothills. They consist of coarse- or medium-grained sandstone whose stratification is roughly parallel with the flow planes of the underlying and overlying rhyolite.

The series of acidic lava flows aggregating several thousand feet in thickness was erupted from vents in the vicinity of Big Baldy during Tertiary times, and flowed to the east aid smith over a land surface of which nothing is known, inasmuch as present cauyons have not yet succeeded in cutting through the extensive series of flow rocks to the underlying formations, Temporary lakes existed at various times in the southern part as is evidenced by the tuffs and sandstones, but no extensive dynamic process were in operation. The various flows were subjected to erosion during the intervening periods. Some time after the cessation of the igneous eruptions the region experienced moderately pronounced faulting and tilting. Very little igneous activity seems to have accompanied these movements. It is of interest to note that the tilting in the vicinity of Water Canyon has been to the west, but the southern part of the range has been tilted in the opposite direction.

PROPERTIES AND ORE DEPOSITS.

WATER CANYON MANGANESE MINE.

The Water Canyon manganese mine is on the east side of Water Canyon and about $1^1/_2$ miles above its mouth. Water Canyon station on the Socorro-Magdalena branch of the Atchison, Topeka & Santa Fe Railway is 6 miles to the northeast. The mine was located by Billie Myers in 1914. Little work was done, however, until the summer of 1917, when. L. C. Butler acquired a half interest in the property. The subsequent exploratory work resulted in the discovery of the ore body which has yielded practically the entire output of the property. For a short time a production of 50 tons per week was maintained, but during 1918 it has been much below that figure. According to the United States Geological Survey the total amount of ore shipped to July 1, 1918, was 854 tons. The shipments have averaged more than 40 per cent manganese and about 8 per cent silica.

In the spring of 1918 the Water Canyon Manganese Co. was organized, and plans were made for the erection of a mill to treat the low-grade ore. The construction of the mill, which was designed to have a 50-ton capacity, was begun in the fall of 1918. Concentration is to be effected chiefly by means of Wilfley tables having riffles specially designed for manganese ore. Sufficient low-grade ore is on hand to supply the mill for a brief period.

The original work was begun in the outcrop of a vein striking N. 40° E. and dipping 45° SE. An inclined shaft was sunk 25 feet on the vein and a drift extended 50 feet to the southwest before the big body of high-grade ore was found. After a large part of. the ore had been mined a tunnel 40 feet lower than the collar of the shaft was driven S. 40° E. about 180 feet to intersect the ore body. The total footage of drifting on the tunnel level is about 500 feet. Two winzes have been sunk below the tunnel level in the vicinity of the big stope, one of them being 40 feet and the other about 30 feet deep. From the bottom of these winzes drifts aggregating nearly 125 feet have served to prospect the formation.

The rock enclosing the deposit is a chocolate-colored rhyolite that is abundant throughout the manganese district. Flow structure is rather indistinct and inclusions are not common. A short distance above the mine the rock is a rhyolite agglomerate. In the vicinity of the workings the country is traversed by a number of fissures which vary in strike from N. 40° E. to N. 10° W. and dip to the east at steep angles. Movement along some of the fracture planes is indicated by slickenslides.

The ore body of the property occupied a brecciated zone produced at the intersection of a number on the important fissures by faulting action. 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 50 feet, and it has a maximum height of 20 feet. Not all of the material taken from the stope was of shipping grade. The ore cuts out rather abruptly on all sides. It is largely wad but also contains some psilomelane and manganiferous calcite. The lower grade ore that lines the stope in places carries numerous unreplaced kaolinized-rhyolite particles. Botryoidal surfaces are especially characteristic of the psilomelane, and the wad is largely cellular. A reddish kaolin has been deposited over much of the exposed surfaces of the ore and along innumerable tiny solution passageways.

The drifts on the tunnel level and at the bottom of the winzes have prospected various fissures and fissure zones in the vicinity of the stope, but so far no new ore bodies of importance have been encountered. The brecciated rhyolite in the fissures is in places coated with a sooty film of manganese oxides, but replacing action has been rather unimportant.

In contrast to the other producing manganese properties in the state the outcrop of the ore body was not prominent at the Water Canyon mine. This can be accounted for by the accumulation above it of the products of weathering from the relatively steeper slope that rises just to the southeast of the mine workings. The absence of high-grade ore in quantity nearer than 20 feet from the surface and the chambering development of the ore body, which is not unlike that found in limestone replacement deposits, are other unusual features.

That the ore deposit is chiefly a replacement of rhyolite and its kaolinized products admits of little doubt, but the nature of the original deposition is somewhat obscure. The presence of manganiferous calcite in the ore suggests that at least in part it was a primary ore mineral. Perhaps a fairly large part of the ore was deposited in the ore body in an oxide form.

KELLY PROPERTY.

The Kelly property is situated in a subordinate canyon between Six-mile and Eight-mile Canyons, and is about 4 miles above the Torreon ranch. It has a remarkable surface showing of ore. Solid stringers of psilomelane, some of which are 2 or 3 inches thick, crop out, and are found in numerous boulders lying on the surface. Much pure psilomelane float appears also. The mineralization has affected an area about 400 feet wide where it is crossed by the canyon and extends up the slopes on each side for a distance of 300 to 500 feet. The best showing is near the bottom of the canyon.

The ore deposition is doubtless connected with a series of fractures having a strike of N. 30° W. which are at right angles to the course of the canyon. A number of shallow surface cuts have been excavated on the various veins, and all show stringers of psilomelane ore.

Near the bottom of the gulch a tunnel 15 feet in length has prospected one of the best defined and most promising fissures. Though some soft ore of a fair grade is exposed in the surface of the tunnel, the hard psilomelane stringers so abundant above do not seem to have extended downward to the depth reached by the tunnel or about 15 feet.

NUNEZ CLAIMS.

The Nunez property is about 3 miles northwest of the Torreon ranch on the west side of Eight-mile Canyon. The country rock is the usual rhyolite of that vicinity. The vein whose strike is. N. 10° W. averages 31/2 feet in width, and contains pyrolusite, wad, limonite, and rhyolite breccia. Much of the ore is of the soft powdery variety, and the richest of it is localized along the foot wall of the vein. A general sample across the better portion gave returns of manganese 31.9 per cent, and iron 4.0 per cent. The width of the vein included in the sample was 2 feet. In contrast to most of the deposits in the southern Magdalena Mountains, the ore is better a few feet below than it is at the outcrop. Surface indications are rather insignificant. The development work consists of a 12-foot shaft which follows the vein.

GARST PROPERTY.

The Garst property is near the mouth of Six-mile Canyon. The Country rock, consisting of rhyolite, contains widely spaced seams of psilomelane ore usually less than 3 inches thick. Very little work has been done.

SURFACE INDICATIONS IN OTHER LOCALITIES.

Manganese deposits of undertermined value exist in many places in the southern Magdalena Mountains. The size of the area occupied by the Tertiary flow rocks prohibited any but very superficial examination of the minor deposits, and they can be discussed only in a general way.

In the northern part the manganese indications are rather poor. Southward from the Water Canyon manganese mine very little psilomelane float is found until Six-mile Canyon is approached. About 1 mile nearly due south of the Water Canyon property surface conditions rather suggest a manganese vein, and 1I/2 miles southwest of the mine a 6-foot vein of manganiferous calcite has been prospected by means of an 8-foot cut. This vein is well defined but contains very little oxides. The steep cliffs and box-canyon walls are in places stained with manganese, but solid psilomelane is on the whole rather rare. It should be borne in mind that in some places manganese deposits do not have prominent outcrops, as is illustrated by the Water Canyon manganese mine.

The area showing the greatest surface mineralization is located between Six-mile and Eight-mile Canyons and extends south nearly to the Torreon ranch. At least 10 localities were seen in this part of the mountains that show considerable psilomelane at the surface both as float and forming the outcrops of numerous thin veins in the rhyolite. The Kelly property has the most extensive outcrop of this group of deposits. Not many of them are liable to have workable ore bodies below the surface.

Well down in the foothills west of Eight-mile Canyon some manganese oxides appear and are usually associated with iron oxides. The grade of this ore is low.

SAN LORENZO DISTRICT.

LOCATION AND GEOLOGY.

The San Lorenzo manganese district in the La Joya Grant is 2 miles north of San Lorenzo Springs and 12 miles west-northwest of San Acacia. It is in the northern continuation of the Lemitar Mountains, here reduced to a series of low hills. Sandstone and a fine-grained vesicular rock that is an andesite or basalt are the most abundant rocks of the district- The sandstone is light colored and in places grades into a conglomerate. Its total thickness is several thousand feet. Most of the field evidence indicates that the igneous flows preceded the deposition of the sandstone. That the sandstone is younger is also indicated by the presence of pebbles of andesite or basalt in the lower conglomeratic beds of the sandstone. The stratification planes of the sandstone and the flow planes of the andesite are nearly parallel, and they dip to the west at an angle of 20° **or** more. Erosion has planed the region until the maximum local relief is 250 feet or less. The contact between the andesite and sandstone has been complicated by displacements along a northward-striking, rather narrow fault zone, which is parallel to the La Platta Arroyo and is situated a few hundred feet east of it. The sandstones extend for several miles west of the fault zone.

PROPERTIES AND ORE DEPOSITS.

BURSUM-ARNETT-GRULE PROPERTY.

The ore deposits of this property are confined to the vicinity of the sandstone-andesite contact along the east side of the La Platta Arroyo. The mineralized zone is at least 1 mile long but only a few hundred feet wide. The ore occurs (1) as *a* replacement deposit and a cementing material in irregular bodies of rather loose andesite conglomerate, and (2) in fissures in the solid andesite. At or just below the surface most of the ore is psilomelane of high manganese dioxide content, but as the depth increases the hard ore is replaced by the softer oxides.

Near the south end of the ore zone a shaft 30 feet deep exposes a vein 2 to 4 feet thick containing brecciated andesite and manganese oxides. The ore minerals are in small amounts, and the production from this opening is negligible. Most of the mining has been done in the andesite conglomerate located along a westward-facing bluff three-fourths of a mile farther north. The rather abundant and easily sorted psilomelane which occurred in the outcrops and in the weathered material accumulated at the base of the bluff has made up part of the shipments. The softer oxides present in the deeper workings have proved difficult to separate from the andesite boulders with which they occur. Most of the mining has been done in open cuts. Shipments to Sept. 1, 1918, amounted to about 40 tons carrying 40 per cent or more of manganese. The property at that time was operated by H. W. Smith under a bond and lease.

SOCORRO MOUNTAIN DISTRICT.

LOCATION AND GEOLOGY.

Socorro Mountain lies about 4 miles west of Socorro, which *is* on the branch of the Atchison, Topeka & Santa Fe Railway extending from Albuquerque to El Paso. It belongs to the first series of ranges west of the Rio Grande River. To the north the other ranges in order are the Polvadera Mountains and the Lemitar Mountains. A minor range to which no name has been given continues southward from Socorro Mountain. All of these Ranges have a north-south elongation.

The highest point on Socorro Mountain is Socorro Peak at an elevation of 7,200 feet. The east face of the mountain is precipitous for the most part, but the west slope is more gradual. Blue Canyon, the site of the main highway between Socorro and Magdalena, crosses it from the west 1 mile south of Socorro Peak.

In origin Socorro Mountain is essentially volcanic. It is composed mainly of andesites, latites, trachytes, and rhyolites. These various rocks are included in surface flows, volcanic necks, dykes, and other igneous forms. Volcanic tuffs and their alteration products are plentiful, and in the southern part remnants of recent basalt flows are common. In the eastern face of the mountain 1000 feet of Pennsylvania limestones and shales crop out.

Many of the tuffaceous flows and agglomerate beds have been extensively kaolinized and to a lesser extent silicified by circulating solutions.

PROPERTIES AND ORE DEPOSITS.

WOODS-VIGIL CLAIMS.

The Wood-Vigil claims consist of two separate groups; one east of Socorro Peak near the base of the mountain and three-fourths of a mile north of the old Torrance mine, and the other group half a mile southwest of Socorro Peak in the elevated part of the range.

The ore in the lower group occurs in rhyolite and in kaolin derived from rhyolite by solutions circulating along fissures. Most of the recent underground work has been done in a kaolinized zone 2 to 10 feet wide along a fissure that strikes east and dips 50° to the south. Half way down a 30-foot incliued shaft along the vein, a drift extends 75 feet to the west. Most of the ore, amounting to about 15 tons, was mined close to the shaft. It occurred in small pockets and in seams, and was largely psilomelane. In the next canyon to the north a small amount of work has been done in a brecciated zone in rhyolite, where the ore consists of psilomelane, wad, and small amounts of limonite. Most of it is too soft to be mined cleanly or sorted.

Manganese ore is exposed in several places in an old tunnel on the property that was driven 1600 feet into the mountain in an effort to locate lead or silver deposits. Near the mouth of the tunnel and just below a prominent manganese outcrop manganese oxides are associated with manganiferous siderite and calcite. The oxides have probably been derived from manganiferous carbonates. The better grade of this mixed ore carries 31.2 per cent manganese and 8.7 per cent iron. Several hundred feet from the mouth of the tunnel a fissure is intersected which carries some soft, cellular wad of high grade but only in small quantities. This group of claims was being operated Sept. 1, 1918, by H. W. Smith under a bond and lease.

Practically no work has been done on the upper group of claims. The veins are covered with loose mantle rock so that very little can be learned of their character and extent. Psilomelane float is abundant along several possible ore zones. Some of the float is very siliceous and may be related to braunite.

SANCHEZ PROPERTY.

The Sanchez property is on the south side of Blue Canyon a quarter of a mile from the highway and 1 mile above the mouth of the canyon. The underground workings have been extended about 75 feet from the portal of the tunnel and follow *a* fissure having a strike of N. 40° W. The country rock is a kaolinized rhyolite tuff in which the kaolinization has not proceeded far enough to entirely obliterate the original flow structure. The ore makes in small seams in the fissure and to a subordinate extent in the country rock on each side. Ordinarily the seams of solid ore are less than 2 inches thick and are composed of the various oxides. Some stoping has been done above the tunnel and 15 or 20 tons of ore containing less than 35 per cent manganese has been mined. No work was in progress Sept. 1, 1918.

LUIS LOPEZ DISTRICT.

LOCATION AND GEOLOGY.

The Luis Lopez district is in the low, rather narrow range of hills extending southward from Socorro Mountain nearly to San Marcial. It is five miles west of Luis Lopez, a small settlement on the Rio Grande River midway between Socorro and San Antonio. The mineralized area is about 5 miles long and 1 to 2 miles wide. Several small prospects that are nearly three miles to the west of the chief properties are also included in this district. Ore is hauled either to San Antonio or Socorro, the distance varying from 6 to 10 miles.

Igneous' rocks of Tertiary age that were largely extruded as surface flows constitute most of the areal rock exposure. They are mostly rhyolites but include smaller amounts of andesite. Faulting has taken an important part in determining the present topography. The important faults are parallel to the range and are closely associated with the ore deposition.

PROPERTIES AND ORE DEPOSITS.

FISCHER-VAN PELT CLAIMS.

The Fischer-Van Pelt claims are near the center of the district. Development work consists of a 12-foot shaft, and an open cut 30 feet long and 12 feet in greatest depth. The shaft penetrates a nearly horizontal bedded vein containing manganiferous calcite and small amounts of psilomelane in slightly consolidated rhyolite conglomerate. The open cut follows a well-defined fissure vein in the rhyolite which strikes nearly due north and dips steeply to the west. The ore is psilomelane, and with it is associated considerable manganiferous calcite. The psilomelane occurs as sheets and nodular masses that vary in thickness from a fraction of an inch to 6 inches. Early in September, 1918, the open cut was beiug worked by H. W. Smith under a bond and lease. The average daily production at that time was nearly $1^1/_2$ tons of shipping ore.

EVERHART-DODDS-WILSON PROPERTY.

This property includes two groups of claims located on two well-defined fissures, which lie to the east of the ground owned by Fischer and Van Pelt. The west fissure strikes N. 20° W. and dips to the west at an angle of 60°. The vein has a width of 2 $1/_2$ to 4 feet and *as a* rule has a clear-cut foot wall and hanging wall. It has been prospected by an inclined shaft 50 feet deep and by drifts from the bottom of the shaft which have a total length of 30 feet. Manganese minerals in varying quantities appear in the vein along the sides of the shaft. The ore in the outcrop is rather low grade, but a few feet below the surface psilomelane increases in amount. The softer oxides become relatively more abundant toward the bottom of the shaft, and in the lower part manganiferous calcite is rather plentiful. The rest of the vein matter consists of brecciated rhyolite and small amounts of calcite. The west fissure traverses a brecciated rhyolite and contains rather low grade ore. The workings are a 30-foot vertical shaft and a short drift.

No attempt was made to save the ore during the progress of the development work. Recently a few tons of high-grade pyrolusite and wad have been mined. The property was being operated Sept. 1, 1918, in a small way by Harry Lockhart.

ADAMS CLAIMS.

The Adams claims are between the two groups of the Everhart-Dodds-Wilson claims. Numerous narrow psilomelane stringers are exposed in an area that is roughly 200 by 350 feet. No well-defined ore-bearing fissures have been located by the development work consisting of an open cut 10 feet deep and 25 feet long.

SEDILLO CLAIM.

The Sedillo claim is 1$^1/_2$ miles north-northeast from the Fischer-Van Pelt property and is located in the gravel deposits extending eastward from the foot of the range of hills. Psilomelane occurs as a cement which has consolidated the gravel, and as a replacement along the surfaces of the fragments. The small sand grains are in part entirely altered to psilomelane. The best ore crops out at the bottom of an arroyo running east, and becomes poorer away from the arroyo bottom. Some of it contains about 20 per cent manganese.

LOCKHART CLAIMS.

The Lockhart claims are half a mile west of the Fisher-Van Pelt claims. It is said that the ore, which occurs in rhyolite, contains much manganiferous calcite associated with the oxides.

HAMMEL CLAIM.

Near the south end of the district a claim belonging to W. C. Hammel includes an area of conglomerate having a psilomelane filling between the fragments. No shipping ore has been found on the claim.

BUNTON-MILLER CLAW.

About three-quarters of a mile west of the Fisher-Van Pelt property a claim held by Bunton and Miller is located on a vein that contains manganiferous calcite and some psilomelane. Workings consist of a 10-foot shaft.

GOLDEN PROPERTY.

At the Golden property about three miles west of the Fisher-Van Pelt group, a rhyolite breccia carries considerable psilom-elane. According to reports a fairly large quantity of low-grade ore shows at the surface.

STURGIS-VAN PELT CLAIMS.

These claims are near the Golden property and the ore deposits of the two groups said to be quite similar.

Production[1] *of manganese and ferruginous manganese ores in New Mexico, Jan. 1, 1916, to July 1, 1918, in long tons.*

Property	District	County	Shipper	1916		1917		1918 First six months	
				Manganese 40% or more	Manganese 15 to 40%	Manganese 40% or more	Manganese 15 to 40%	Manganese 40% or more	Manganese 15 to 40%
Morgan Group	Rincon	Dona Ana	C. E. Morgan......	.....	.....	140	.....	.....	.....
Morgan Group	Rincon	Dona Ana	L. Worcester	.....	.....	.....	70	.....	.....
Morgan Group	Rincon	Dona Ana	R. E. Callow......	.....	.....	.....	.....	63	198
Sheriff Mine	Rincon	Dona Ana	Sheriff Mining Co..	.....	.....	100	.....	.....	.....
Nineteen-sixteen Mine	Silver City	Grant	W. M. Dorsey......	.....	506	90	.....	.....	120
Moses & Kirchman Property (Legal Tender)	Silver City	Grant	Moses & Kirchman	.....	14,900	.....	.....	.....	.....
Kirchman & Crawford Property	Silver City	Grant	Kirchman & Crawford	.....	.....	.....	15,900	.....	6,305
Stevens Property (Silver Cross)	Silver City	Grant	Porterfield Bros. ..	.....	1,168	.....	.....	.....	.....
Stevens Property (Boston Hill)	Silver City	Grant	C. A. Stevens......	.....	.....	.....	.....	.....	673
Lake Valley Mines	Lake Valley	Sierra ...	Lake Valley Mng. Co.	.....	.....	.....	1,400	.....	1,609
Water Canyon Manganese Mine (Billy Myers)	Magdalena Mts..	Socorro ..	L. C. Butler.......	.....	.....	803	.....	.....	.....
Water Canyon Manganese Mine	Magdalena Mts..	Socorro ..	Water Canyon M. Co.	.....	.....	.....	.....	51	.....
Total				.....	16,574	1,133	17,370	114	8,905

[1]Figures supplied by the U. S. Geological Survey.

Owners of New Mexico deposits[1].

Name of Property	Owners and Addresses	Location
Dona Ana County		
Morgan Group	C E. Morgan, Rincon..........................	near Rincon
	T. E. Bourbonia, Rincon........................	
	J. H. Jones, Rincon..............................	
Rincon Mine	T. E. Bourbonia, Rincon........................	near Rincon
	G. W. Sanders, Rincon..........................	
Lighttower Property	J. Lighttower, Rincon...........................	south of Rincon
Sheriff Mine	Sheriff Mining Co., El Paso, Tex................	north of Rincon
Cook Placer Claims............	T. E. Cook, Rincon..............................	near Rincon
Cook Property	T. E. Cook, Rincon..............................	near Rincon
Horton Property	B. F. Horton, Rincon............................	near Rincon
Grant County		
Kirchman and Crawford Property	R. I. Kirchman, Silver City......................	near Silver City
	E. P. Crawford, Silver City......................	
	Theodore Carter, Silver City	
	Newcomb Estate, Silver City.....................	
Stevens Estate Holdings.......	Stevens Estate, Silver City......................	near Silver City
Nineteen-sixteen Mine	W. M. Dorsey, Silver City.......................	near Silver City
	W. P. Dorsey, Silver City.......................	
Causland Property	S. Bixler, Silver City............................	near Silver City
	T. Mossman, Silver City.........................	
	C. W. Causland, Silver City......................	
Silver City Manganese Mine....	Silver City Manganese and Development Co., Silver City	near Silver City
Hodges-Dowell Property	Mrs. A. J. Hodges, Fierro........................	near Fierro
	Mrs. M. N. Dowell, Fierro.......................	
Edmonds Property	Tuck Edwards and associates, Duncan, Ariz......	Cap Rock Mountain
McKeeghan Property	W. D. McKeeghan and associates, Duncan, Ariz...	Cap Rock Mountain

[1]This list includes all the properties and owners known to the writer but is undoubtedly incomplete.

Owners of New Mexico deposits—Continued.

Name of Property	Owners and Addresses	Location
Luna County		
Liberty Manganese Mine	F. Kohlmeyer, Deming	near Mirage
	E. Copper, Deming	
	J. W. Blee, Deming	
Lesdos Property	Henry Lesdos, Deming	Florida Mts.
Warren Property	Dr. S. S. Warren, Lordsburg	Little Florida Mts.
	J. L. Hoagland, Deming	
	A. R. Stickney, Deming	
McClure Property	Rev. McClure, Deming	Little Florida Mts.
	J. S. Hoagland, Deming	
Santa Fe County		
Collier Mines	Collier Mines Co., Stanley	Tuertos Range
Hill Property	Milo Hill, Santa Fe	near Santa Fe
Sierra County		
Lake Valley Mines	Lake Valley Mining Co., Lake Valley	Lake Valley
Roper Group Mines	Roper Group Mining Co., Lake Valley	Lake Valley
Ellis Claims	Albert Ellis, Las Cruces	Hot Springs
New Star Mine	S. Montoya, Derry	near Derry
	J. Montoya, Derry	
Wildcat Mine	F. Rivera, Derry	near Derry
	E. Horcasitas, Derry	
	P. Hughes, Derry	
	A. Escobar, Derry	
Ruth Mine	Wm. Petters, Las Cruces	near Derry
	Ralph French, Las Cruces	
Lady Franklin Mine	Lady Franklin Mining Co., Kingston	near Kingston
Iron King Mine	Empire Zinc Co., Socorro	near Kingston
Brochu Property	John Brochu, Kingston	near Kingston
McPherson Property	Guy McPherson, Hillsboro	near Hillsboro

Owners of New Mexico deposits—Continued.

Name of Property	Owners and Addresses	Location
Socorro County		
Water Canyon Manganese Mine	Water Canyon Manganese Mng. Co., Water Canyon	Water Canyon
Kelly Property	Frank Kelly, Water Canyon.....................	Water Canyon
	J. B. Kelly, Water Canyon.......................	
	S. Tinguely, Water Canyon.....................	
Nunez Claims	Severo Nunez, Water Canyon...................	Southern Magdalena Mts.
Garst Property	S. O. Garst, Water Canyon......................	Southern Magdalena Mts.
Bursum-Arnett-Grule Property.	H. O. Bursum, Socorro..........................	near San Lorenzo Springs
	A. Grule, Palvadera.............................	
	T. P. Arnett, Socorro...........................	
	Hose Baca, Socorro.............................	
Woods-Vigil Claims	J. B. Woods, Socorro............................	Socorro Mountain
	Frank Vigil, Socorro............................	
Sanchez Property	M. Sanchez, Socorro............................	Socorro Mountain
Fischer-Van Pelt Claims.......	F. Fischer, Socorro.............................	Luis Lopez District
	B. F. VanPelt, Socorro..........................	
Everhard-Dodds-Wilson Property	T. B. Everhart, Socorro.........................	Luis Lopez District
	Ed Dodds, Socorro..............................	
	B. D. Wilson, Socorro...........................	
Adams Claims	G. A. Adams, Lemitar...........................	Luis Lopez District
	Alva Adams, Lemitar............................	
Sedillo Claims	Jacobo Sedillo, Socorro.........................	Luis Lopez District
Lockhart Claims	Harry Lockhart, Socorro........................	Luis Lopez District
Hammel Claim	W. G. Hammel, Socorro.........................	Luis Lopez District
Bunton-Miller Claim	Wm. Bunton, Socorro...........................	Luis Lopez District
	Geo. Miller, Socorro............................	
Golden Property	Geo. Golden, Water Canyon.....................	Luis Lopez District
Sturgis-Van Pelt Claims.......	Harry Sturgis, Socorro..........................	Luis Lopez District
	B. F. Van Pelt, Socorro.........................	