Mineralization of the Luis Lopez epithermal manganese deposits in light of fluid inclusion and geologic studies

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MINERALIZATION OF THE LUIS LOPEZ EPITHERMAL MANGANESE DEPOSITS IN LIGHT OF FLUID INCLUSION AND GEOLOGIC STUDIES

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INTRODUCTION

Manganese minerals are common in hydrothermal deposits. In association with sulfide minerals, manganese occurs in reduced form (Mn+) as a carbonate, silicate, or sulfide: the most common forms are rhodochrosite, rhodonite, and alabandite.

Psilomelane, the principal manganese mineral in the Luis Lopez deposits (Hewitt, 1964; Farnham, 1961), generally occurs in surficial environments or in the shallow, low-temperature part of veins or in thermal spring deposits (Roy, 1981). The possibility that the Luis Lopez district might be the surface expression of an extensive hydrothermal system, with possible economic mineralization at depth, is suggested by the size of the district, the common occurrence of manganese oxides high in hydrothermal systems, the report of anomalous Ag and W in the deposits (Hewitt, 1964; Willard, 1973) and the recognized association of manganese with gold-silver and molybdenum-tungsten mineralization. Because of the possibilty of other mineralization at depth, as well as because there have been few studies of hydrothermal Mn-oxide deposits, the Luis Lopez deposits were studied to determine the nature of the mineralizing system.

Six major occurrences of manganese mineralization (fig. 1, Eggleston and others, this guidebook) were studied by fluid inclusion methods and the paragenesis of the deposits determined.

MANGANESE DEPOSITS

The geology and alteration of the Luis Lopez manganese district is discussed in Eggleston and others (this guidebook) and will not be repeated here. The major manganese deposits in the Luis Lopez district

occur on the periphery of a 2 X 3 km area of volcanic rocks distinctly reddened by hydrothermal alteration (fig. 1, Eggleston and others, this guidebook). Scattered within the central altered zone, and between the major deposits, are at least thirty minor manganese shows and prospects. Mineralization is remarkably similar in all the deposits. It occurs as open-space fillings in fault breccias and fault openings. The mineralogy is manganese oxides, calcite, hematite, quartz, and rhodochrosite with rare barite and fluorite.

Manganese minerals occur as banded and fibrous, black to dark steel-gray incrustations of oxides coating breccia fragments and as massive, banded vein fillings. Rhodochrosite was observed only in the MCA mine as 1 to 3 mm bands interlayered with bands of calcite and manganese oxides. X-ray diffraction of manganese oxide samples listed in Table 1 yielded diffuse diffraction patterns of hollandite (BaMn8016). Similar results were reported by Modreski (1983). X-ray diffractometry, electron microprobe, and chemical analysis of individual bands in oxide specimens (Modreski, 1983; Hewitt, 1964) indicate that bands each contain varying proportions of the end-member minerals hollandite (BaMn8016), romanechite (BaMn90,6(OH).), coronadite (PbMn80.6), cryptomelane (KMn8016), and ramsdellite (Mn0₂). Turner and Buseck (1979) have shown, using transmission electron microscopy, that fibrous manganese oxides from the Luis Lopez district are composed of a mixture of unit-cell layers of romanechite randomly distributed with a crystal lattice of mostly hollandite. We, like Modreski (1983), Roy (1981), and Burns and Burns (1977), prefer the use of the old name psilomelane for manganese oxides like those in the Luis Lopez district which are poorly crystalline and are of variable composition with a general formula (Ba, K, Mn, Pb, Co)Mn₅0,₀ x H₂0).

Hematite occurs in all deposits, but only in major amounts in the Upper Tower and US 60 mines. It is generally fine-grained although there is minor specularite. Calcite occurs in both white and black forms. Black calcite occurs interlayered with manganese oxides. Miesch (1956) reports that dissolution of black calcite in acid yields a residue of fine-grained psilomelane. White calcite occurs interbanded with manganese
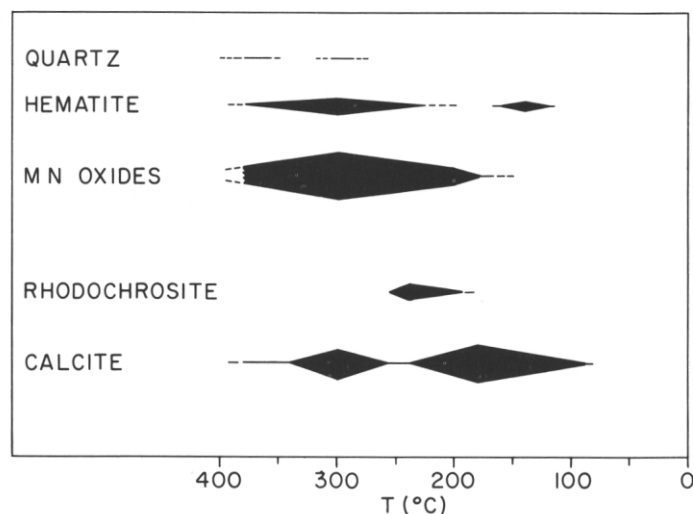

Figure 1. Paragenesis of the manganese deposits in the Luis Lopez district. Temperatures were determined from measurement of fluid inclusion homogenization temperatures (T_h).

Table 1. Partial chemical analyses of manganese oxide samples from the six occurrences studied in the Luis Lopez district. The US 60 deposit is also known as the Bursum and the MCA deposit is also known as the Red Hill.

Sample Location	Mn (%)	Pb (%)	Zn (%)	Cu (ppm)	Ag (ppm)	W (ppm)	Be (ppm)
Black Canyon	41.6	0.44	0.60	906	14.	1000	60
US 60	47.8	4.9	0.48	145	12.	2000	48
Tower	42.6	0.62	0.24	69	ND	410	28
Upper Tower	50.6	1.95	0.04	110	ND	1000	38
Nancy	46.5	0.47	0.40	776	ND	1200	52
MCA	4.0	0.04	0.03	<20	9.	ND	13

oxides and as clear crystals lining vugs. Quartz occurs as fine-grained layers and microveins in the manganese oxides and as a thin, crypto-crystalline layer coating manganese oxides in vugs. Alteration of wall rocks along veins is minimal. At most there is a 1 mm bleached zone on volcanic rocks coated with manganese and iron oxides.

The manganese content and concentration of base metals, Ag, W, and Be were determined by wet chemical analysis for one sample of manganese oxide from each of the deposits studied (Table 1). Even though the samples selected for analysis appeared megascopically to be mostly manganese oxides, the analyses (Table 1) indicate the black manganese oxides are not pure. Stoichiometic hollandite has 52.8% manganese, romanechite, 51.8% Mn, cryptomelane, 59.8% Mn, and coronadite, 48.7% Mn. Only the Upper Tower sample is >95% Mn oxides. Examination of polished thin sections of oxide samples showed them to include considerable calcite, quartz, and hematite which ex-plains the low Mn content of samples analyzed. The specimen from the MCA deposit was mostly black calcite, hence the very low Mn content.

There is considerable Pb in most of the samples, but the oxides analyzed are not pure coronadite which has 23% Pb. All samples have anomalous zinc and the Black Canyon and Nancy samples have anom-alous copper. Silver occurs in measurable quantities in three of the samples. The lithopile elements W and Be are approximately 1000 x and 10 x , respectively, their normal abundance in rhyolite, except in the MCA sample.

PARAGENESIS

The paragenesis for the six deposits studied was identical. Faulting and brecciation preceded mineralization and continued during hydro-thermal deposition. All deposits show evidence of brecciation and re-cementation of early deposited minerals. Early mineralization was quartz, hematite, Mn-oxides, and calcite (fig. 1). With time, the proportion of calcite to Mn-oxides increased. This was followed by decrease in calcite mineralization with rhodochosite being deposited in the MCA mine. Manganese mineralization continued so there was a second period of dominantly manganese deposition. Manganese oxide precipitation ceased and last deposited was hematite and clear-white calcite.

FLUID INCLUSIONS

A minimum of six polished sections were prepared from each deposit. Three types of inclusions were observed: liquid-rich, liquid-vapor in-clusions; vapor-rich, liquid-vapor inclusions; and three-phase inclusions with two liquids and vapor. The most common type of inclusions in all samples, except late calcite, was the vapor-rich type. These were about 80 percent of the inclusions and are interpreted as trapped vapor which was generated by boiling of the mineralizing fluids.

Three-phase inclusions were rare and none were measured. When heated, they decrepitated, and freezing generated hydrates which melted above 0°C. The second liquid disappeared when heated to 30°C indi-cating that it was liquid CO_2.

Freezing point and homogenization temperatures were determined for 398 inclusions in quartz and calcite. The average freezing temper-atures for all inclusions measured was — 0.1°C with a standard deviation of ± 0.16°C. Mineralizing waters were nearly pure water. A freezing point depression of 0.1°C is equivalent to 1800 ppm NaCl. Since the precision of measuring the freezing point depression is ± 0.2°C we are confident that the mineralizing solutions for the occurrences studied had a very low salinity, but can only say the salinity was 2000 ± 2000 ppm.

Homogenization temperatures (T_h) ranged from 139 to 402°C (fig. 2). The lower temperatures were measured in late calcite and the higher temperatures in calcite and quartz intergrown with manganese oxides.
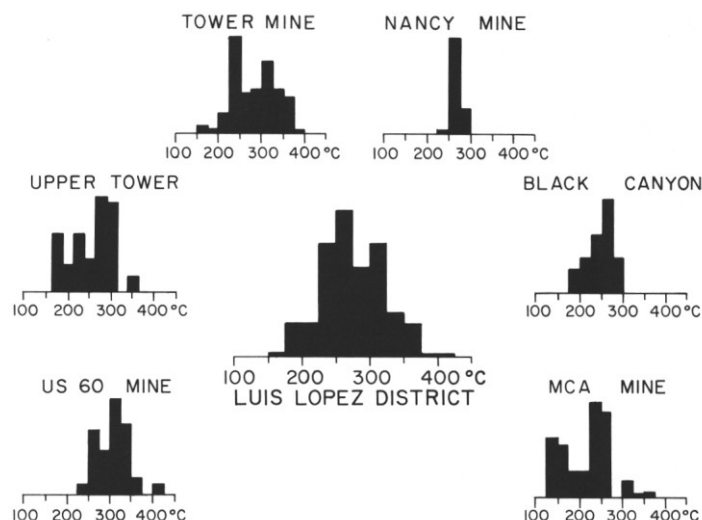

Figure 2. Homogenization temperatures for the individual deposits studied, and in the center of the figure, the combined data for the Luis Lopez district. Since the hydrothermal fluids were boiling, no pressure correction is required and the homogenization temperatures should accurately indicate the temperatures of the mineralizing fluids.

Calcite and quartz associated with manganese mineralization had T_h ranging from 197 to 402°C. Individual samples had a wide range in T_h with no apparent relation of T_h of an inclusion to its location in a crystal. High- and low-filling-temperature inclusions were randomly distributed within individual crystals. All deposits had a maximum in T_h between 225 and 275°C. In the Nancy and Black Canyon deposits, no temper-atures >300°C were measured, whereas in the other occurrences tem-peratures to 400°C were common with a second maximum in T_h between 300 and 325°C. The bimodal distribution in T_h is evident in the combined fluid inclusion data for the Luis Lopez district (fig. 2). Late calcite had T_h ranging from 139 to 252°C with most temperatures between 150 and 200°C.

Gases in inclusion fluids were analyzed for two samples of calcite associated with manganese mineralization (Table 2). Gases were re-leased by thermal decrepitation using methods described by Norman (1977). The principal gases were CO2, N2, H2, Ar, and He. The gas-to-water ratio is very high, but typical of analyses of inclusion gases with a high percentage of vapor-filled inclusions. Inclusion gases an-alyzed in boiling zones do not yield a good analysis of the volatiles in the fluids prior to boiling. Such analyses include a high percentage of gases from vapor-filled inclusions and for the most part simply indicate the species of gases in the geothermal fluids. The actual amount of CO_2 in the hydrothermal fluids must have been less than 3 weight percent. Above 3 wt.% CO_2, liquid CO_2 can readily be observed when inclusions are cooled and this was only observed in the rare three-phase inclusions. The three-phase inclusions are interpreted as containing both liquid and some of the CO_2-rich vapor which was released during boiling. The

Table 2. Analyses of gases in fluid inclusions in calcite.

Analysis	MCA	Tower
Co_2 (%)	98.1	95.0
N_2 (%)	1.8	4.8
Ar (%)	0.051	0.18
He (%)	0.000045	0.00010
H_2 (%)	0.0081	0.15
gases/water × 100	8.4%	12.8%

amount of H_2, N_2, Ar, and He are in greater concentration versus $CO2$ than in the original fluid. These gases partition to a vapor phase by a factor of 10 to 100 times greater than CO_2 (Ellis, 1979). Because the analyses sampled both vapor and liquid inclusions, the amount of these gases is misleadingly high. The actual amount of $N2$ in the ore-fluids below the boiling zone was —0.01%, Ar and $H2$ —0.001%, and He — 10 ppb.

DISCUSSION

Depth of Mineralization

Since the mineralizing solutions were boiling, the depth and pressure of mineralization can be estimated. Gas analysis suggests that "boiling" was principally CO, effervescence. But CO_2, if not more than 5 percent of the fluids, effervesces from thermal waters in the 250°C range in temperatures and pressures just below the boiling temperature and pressure of pure water (Takenouchi and Kennedy, 1964). Hence, boiling point curves for water (Haas, 1971) can be used to determine the depth and pressure during manganese mineralization. Boiling between 225 and 275°C, which was characteristic of every deposit in the district, would occur at depths of 300 to 700 m below the water table in a hydrostatically pressured system and at a pressure of 20 to 50 bars. The boiling which occurred in some of the deposits at temperatures between 300 and 325°C would occur at a pressure of 70 to 90 bars and boiling to temperatures of 375°C would imply a pressure up to 150 bars.

The district-wide boiling at —250°C implies an average depth of 500 m beneath the water table at the time of mineralization at a pressure of 30 bars in a hydrostatically pressured system. Closing of the channelways to the surface would result in the pressure increasing to lithostatic pressure in the order of 84 bars, or even to an over-pressured system.

The temperature of the fluids at depth must have been at least 375°C as indicated by T_h data. Hence, as fractures filled and the pressure increased, higher temperature fluids could come nearer the surface before boiling. The wide range in T_h indicates the pressure of the mineralizing system was continually changing during mineralization with pressure increasing then decreasing, probably as a result of fault movements reopening fractures. The two maximums in T_h correspond nicely to mineralization occurring both in a hydrostatically pressured system and a closed, lithostatically pressured system. Open, vuggy veins like the MCA rarely saw high pressures, hence rarely saw high-temperature fluids. The US 60 and Tower mines, which are tightly mineralized with few vugs, were repeatedly mineralized by high-temperature fluids. Since high-temperature fluids deposited more Mn than calcite (fig. 1), the deposits with the more massive ores deposited at higher temperatures have the highest grade mineralization. The Upper Tower deposit was mineralized by cooler fluids, in general, than the lower parts of the vein, indicating that the upper part of the vein saw lithostatic pressure during mineralization less frequently than lower parts of the vein.

Source of Fluids

The hydrothermal waters of the Luis Lopez district are similar in respect to their gas chemistry and low salinity to the Lightning Dock geothermal system, Animas Valley, New Mexico, which has an estimated reservoir temperature of 260-290°C (Logsdon, 1981; Norman and Bernhardt, 1982). The Lightning Dock waters are heated meteoric waters as is the case in most geothermal systems. The low salinity of the fluids in the Luis Lopez district would argue against their being basin brines or magmatic waters and the $8_{18}0$ of the fluids is not typical of magmatic waters (Eggleston and others, this guidebook). Hence, the

Luis Lopez hydrothermal solutions were most probably heated meteoric waters.

In most geothermal systems, H_2S is a principal gas and the fluids have a higher salinity than the Luis Lopez mineralizing fluids with the solute dissolved from the host rock. No H_2S in the gas analysis and the lack of any sulfide mineralization indicates that the Luis Lopez fluids had no reduced sulfur. Whether this resulted from sulfur-poor source rocks or some other factor is not clear.

There are several enigmas about the mineralizing system. The low salinity of the fluids would argue for a short residence time of waters in the geothermal system, or limited water-rock interaction. However, the SRO of fluids of +9 to +13 permil argues for extensive water-rock interaction. Interaction of the fluids with sedimentary rock could explain the high $6_{18}0$ of the fluids (Eggleston and others, this guidebook). However, interaction of the mineralizing fluids with sedimentary rocks is not indicated. Organic compounds in fluid inclusions have proven to be an excellent indicator of interaction of hydrothermal waters with sedimentary rocks (Norman, 1983), but gas analysis indicated no organic compounds in the Luis Lopez ore fluids.

Type of Deposit

The Luis Lopez deposits possess all the characteristics of an epithermal deposit in the modern sense. Mineralization is fine-grained and banded; it was deposited at shallow depths by boiling meteoric waters at temperatures >200°C; mineraliztion is open-space filling in pre-existing fractures; and similar mineralization occurs over an extensive district. The Luis Lopez district differs from typical precious-metal, epithermal deposits in its oxidized nature with Mn" oxides and hematite rather than sulfide mineralization. Epithermal systems can probably vary from reduced to highly oxidized. The Luis Lopez district represents deposition from an oxidized geothermal system.

Potential for Other Mineralization

Rather than the near-surface, hot-spring zone of a geothermal system as first thought, the Luis Lopez manganese minerals were deposited in the high-temperature boiling zone of an epithermal system. This is the level in a reduced geothermal system where precious metal mineralization occurs (Buchanan, 1981). The possibility of a Ag-Au-sulfide deposit at depth is very low, since the present exposed mineralization is at the level one would expect to find Ag-Au-sulfide mineralization, but there is no evidence that other than oxides were deposited. Gas analysis of inclusion liquids from quartz in barren mineralization up to hundreds of meters above ore shoots in epithermal deposits shows them to contain high amounts of organic compounds and H_2S (D. Norman, unpublished data). The lack of H_2S and organic compounds in Luis Lopez fluid inclusions further indicates a poor possibility of Ag-Au-sulfide mineralization at depth.

The best possibility for potentially economic mineralization under the Luis Lopez veins would be a deposit like the Hardshell deposit of southern Arizona (Koutz, 1978). The Hardshell deposit contains cryptomelane-coronadite with as much as 30 wt.% Pb, 10% Zn, 3% Cu, 2% Sb + As and 1% Ag in the manganese oxides. Fluid inclusion data indicates that mineralization occurred below the boiling zone. In most epithermal systems, the base metals (albeit sulfides) are deposited deep in the system below the boiling zone (Buchanan, 1981). Hence, there is a chance of finding base-metal-rich, Ag-bearing manganese oxides at depth. Whether such a deposit would be economic would depend on whether the metallurgical problem of separating Ag from manganese oxides is solved. To date, the Hardshell deposit has not been exploited because of this problem.

The lack of sulfides in the deposit, the lack of H_2S in the mineralizing fluid, and the lack of intense alteration would argue against there being

a porphyry molybdenum deposit under the Luis Lopez district. Porphyry molybdenum deposits are sulfur-rich and generally capped by intense alteration. Some Sn-W deposits are associated with hematite rather than pyrite. But Sn-W mineralization is associated with fluorine minerals and the lack of significant topaz or fluorite in the Luis Lopez deposits is certainly not a good indicator of a Sn-W deposit. On the other hand, beryllium is associated with W mineralization in New Mexico and there is both beryllium and significant W in the manganese deposits. But tungsten is a common constituent of epithermal deposits and the tungsten in the Luis Lopez deposits can be explained by the epithermal nature of the deposit, rather than the manganese being the top of a tungsten deposit. Most likely, the amount of W will decrease with depth in the Luis Lopez veins. If there is any other type of mineralization in the district resulting from the same system which deposited the manganese oxides, the high fluid-inclusion-homogenization temperatures indicate that some of that mineralization should be exposed. There is really no favorable indication for other than manganese-oxide mineralization in the district.

Geochemistry

Psilomelane occurs in surficial environments under atmospheric conditions, but fluid inclusion data from calcite and quartz intergrown with psilomelane in the Luis Lopez district indicates psilomelane was co-deposited with calcite and quartz at temperatures of 200 to 375°C. There is no evidence for significant supergene mineralization. An f_{o_2}-temperature diagram (fig. 3) was constructed to determine the f_{o_2} of psilomelane-depositing hydrothermal fluids. No thermodynamic data exists for psilomelane, romanechite, cryptomelane or coronadite. Since these minerals contain mostly oxidized Mn in the 4 + state, and because some MnO_2 occurs in the Luis Lopez deposits, the diagram was calculated for MnO_2 and Mn_2O_3 (which would be a mineral indicating more reducing conditions than psilomelane). The diagram indicates that psilomelane would only be deposited under very oxidizing conditions; very mild reducing conditions would favor the deposition of rhodochrosite or rhodonite. That is why rhodochrosite and rhodonite are the common manganese minerals in most hydrothermal deposits.

The f_{o_2} of geothermal waters is controlled by the oxidation of Fe^{2+} to Fe^{3+}. The hematite-magnetite equilibria can be considered to be an upper bound on the oxidation state of most geothermal waters, hence it was included in Figure 3. If the manganese-depositing fluids were in equilibrium with average crustal rock, the f_{o_2} would have been such that only Mn^{2+} minerals would have been deposited.

Obviously the mineralizing system had a high f_{o_2}. The red alteration zone, which we consider to be the heart of the manganese-depositing hydrothermal system, is typified by alteration of iron-bearing minerals to hematite plus clays and micas and the vein mineralization is hematite and psilomelane.

Chemical Model

Manganese occurs in igneous rocks in the reduced (2 +) state. The data of Eggleston and others (this guidebook) strongly suggest that the manganese in the Luis Lopez deposits was leached from volcanic rocks in the zone of red alteration and distributed radially to the several deposits. In this process most of the manganese was oxidized to the 4+ state and most of the reduced iron in the central zone was oxidized.

Free oxygen is required to oxidize manganese in any quantity and we can think of three possible ways this could have happened. First, the mineralization could have occurred in a very shallow geothermal system where surficial waters with free oxygen rapidly flowed through volcanic rocks, oxidizing the iron and manganese, leaching the manganese, and depositing it in veins. There are two objections to this model. The oxygen-isotope data do not indicate mineralization by meteoric waters rapidly cycling through the volcanic rocks (Eggleston and
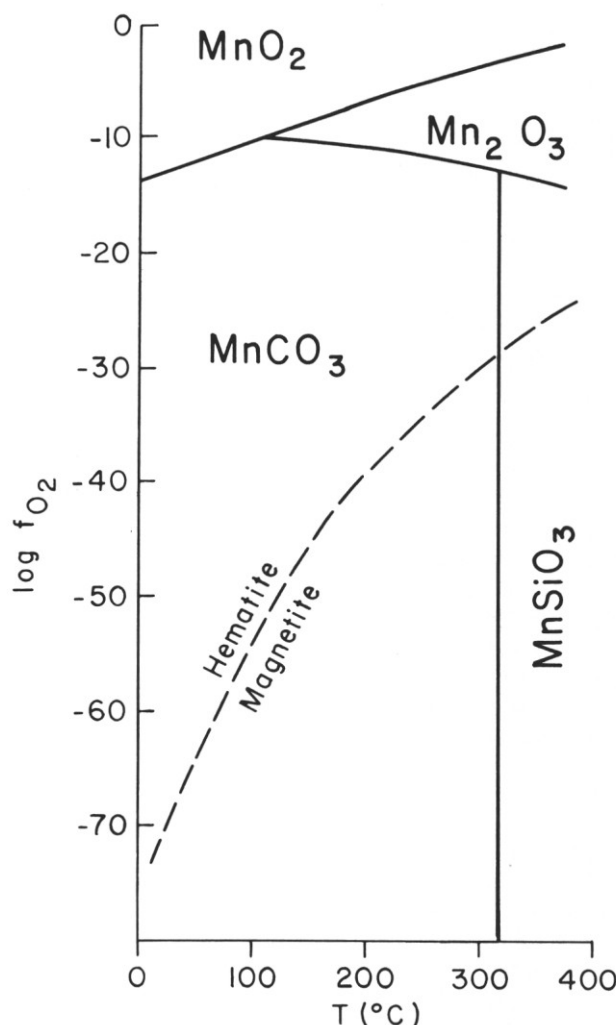
Figure 3. Diagram showing stability fields of the principal manganese minerals versus f_{o_2} and temperature. Because there are no thermodynamic data for psilomelane, romanechite, hollandite, coronadite, or cryptomelane, the stability fields of these minerals could not be calculated. However, since the manganese in the cryptomelane-psilomelane groups of minerals is mostly in the 4+ state, their stability fields should be little different than MnO_2 and Mn_2O_3. A CO_2 concentration of 1 mole percent was assumed.

others, this guidebook) and measurements of gases in geothermal waters have not detected free oxygen (Norman and Bernhardt, 1982; Ellis, 1979).

A second method would be to introduce oxygen into the hydrothermal waters at the site of deposition by mixing with cool, oxygenated waters. In the Creede epithermal-Ag deposit, manganese was deposited in a zone of mixing (Robinson, 1981; Robinson and Norman, 1983). However, the influx of cooler waters resulted in a temperature drop of approximately 100°C and cessation of boiling in the zone of mixing. We saw no evidence in the fluid inclusion data for an influx of cool waters, but we can not reject this possibility.

Hydrothermal manganese oxide deposits are quite common in New Mexico and always occur in association with volcanic rocks, mostly the felsic type. This implies some genetic relationship between volcanic rocks and manganese deposits. Manganese is readily leached from volcanic rocks (Ellis and Mahon, 1964; Seyfried and Bishoff, 1977). This suggests that most of the manganese in volcanic rocks is in the

groundmass or interstitial sites where it is readily leached. We suggest that much of this readily leachable Mn in the felsic volcanic rocks in the Luis Lopez district was oxidized either during or shortly after eruption. Manganese in the 4+ state was later leached from the volcanic rocks by geothermal waters and deposited near the surface in veins as a result of cooling, pH change due to boiling, and decrease in pressure. The f_{oe} of the solutions was buffered by Mn"-Mn$^.$ or Mn$_4$+-Mn" equilibria and was highly oxidizing. This solution would have oxidized Fe" in the rock. However, there is so much hematite in the red alteration zone that there probably was not enough Mn in solution to account for all the hematitic alteration. Water at 300 to 400°C can readily oxidize iron by the process

2FeO (in oxides and silicates) + H_2O = Fe_2O, + (clays and micas) + H2

(The reason this mechanism will not work for Mn is that minute amounts of H. will stop the reaction). The gas analysis indicated H, among the gases so this process was undoubtedly going on. Equilibrium was never reached in the above reaction because the f_o. of the fluids would have been near the hematite-magnetite equilibria and Mn$_2$' minerals would have been deposited.

This process, mobilizing Mn$_4$+ with oxidation of Fe+ by water in a nonequilibrium process, does not occur in all geothermal systems. If the water comes to equilibrium with the rock, the f_{o2} will be buffered by Fe" -Fe+ and manganese will be reduced and perhaps much of it precipitated as MnSiO, or $MnCO_3$. We therefore think that Mn deposits like those in the Luis Lopez district require, in addition to readily leachable Mn$_4$+ in volcanic rocks, a fast-acting geothermal system. A mature geothermal system, with extensive water rock-interaction, would result in reduced fluids buffered by Fe" -Fel+ , fluids with significant salinity, reduction of SO, to H_2S, and possibly a sulfide-bearing, AgAu epithermal deposit. A youthful or fast-acting system would be oxidizing, buffered by Mn$_4$+-Mn" , have low salinity fluids, and deposit mostly oxides. Since oxidizing solutions can readily transport base- metals and silver in solution, the oxide deposits, like Hardshell, can have significant quantities of these metals.

CONCLUSIONS

The Luis Lopez manganese deposits were deposited by boiling hydrothermal solutions at a depth of approximately 500 m and at temperatures from 150 to 375°C. Deposition temperature fluctuated in response to changes in pressure. The temperature of the hydrothermal fluids was a minimum of 375$^.$C.

The manganese deposits, rather than being the near-surface, hot-spring zone of a geothermal system, were deposited in the heart of an oxidizing epithermal system. There is little likelihood for sulfide deposits under the district, but there is potential for Pb-Zn-Cu-Ag-bearing manganese oxides deeper in the veins.

Oxidized manganese in felsic volcanic rocks was leached and transported by a fast-acting geothermal system of very low salinity which did not extensively react with the volcanic rocks. The hydrothermal waters oxidized reduced iron in the volcanic rocks, depositing hematite, but were never in equilibrium with the rocks. Manganese was deposited on the periphery of the geothermal system in fractures near the surface where the solutions were cooling and boiling.

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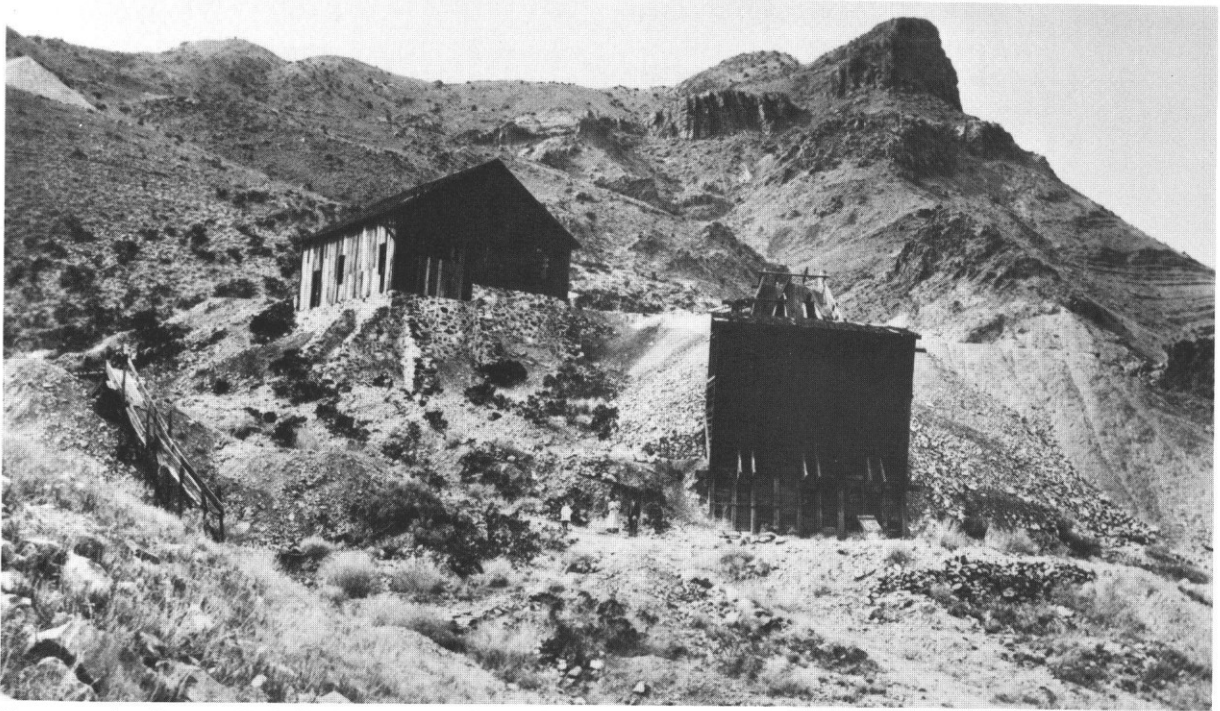
Torrance mine, Socorro Peak district, Socorro County, New Mexico, ca 1895. This mine was the principal producer of silver ores in the district, the Merritt being the only other property of any significance. Together they produced most of the $760,000 total production credited. The Torrance stamp mill was located on present day Cuba road in Socorro, and just south of the New Orleans and La Joya (later Graphic) smelting works. Both mine and mill were closed by the silver crash of 1893 and would never again operate on the grand scale of the 1880's. Photo by Joseph E. Smith, courtesy Ed Smith; New Mexico Bureau of Mines and Mineral Resources collection.
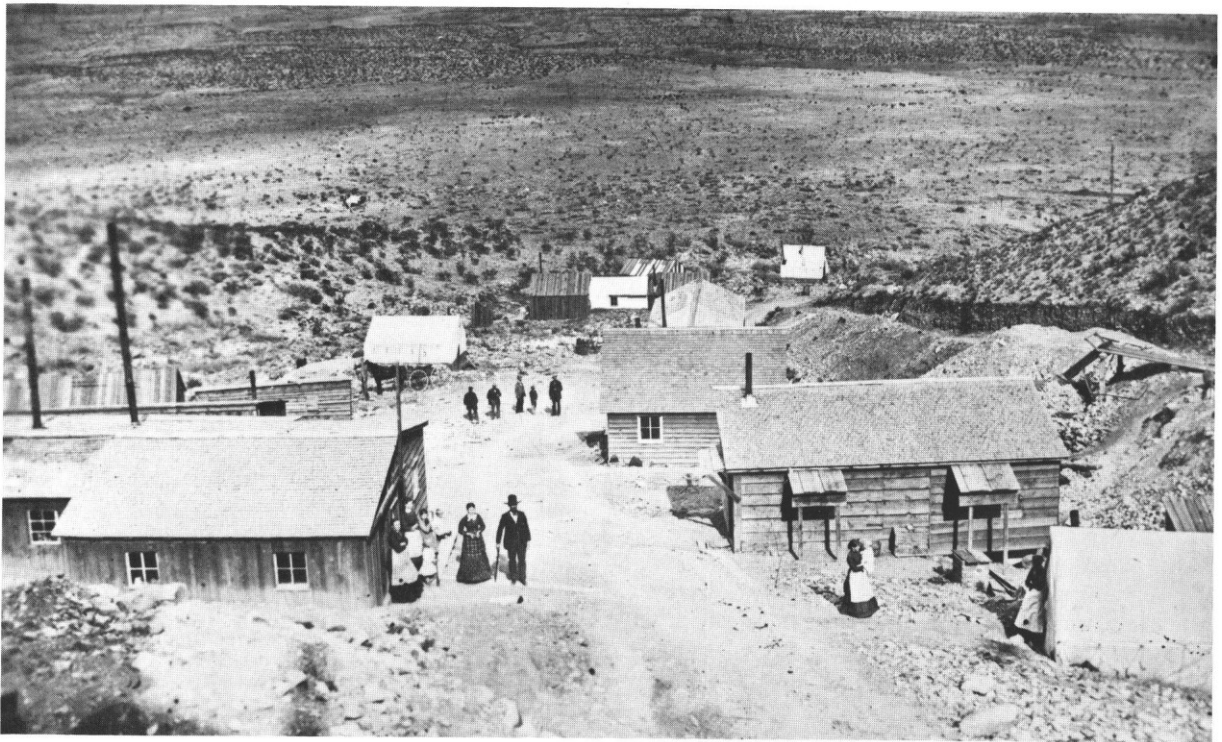
Merritt Camp at the foot of Socorro Peak, ca 1885. The Merritt mine, second in prominence only to the Torrance, experienced a brief flurry of excitement when, during 1884–85, it was operated by the Cabinet Consolidated Mining and Milling Company and produced during the latter year ". . . Silver, $100,300; gold, $1700 . . ." Note the treeless Rio Grande in the distance, the wood having been completely scavenged for domestic and boiler fuel. Socorro is barely visible at upper right. Photo by Joseph E. Smith, courtesy Ed Smith; New Mexico Bureau of Mines and Mineral Resources collection.