History and geology of the precious metal occurrences in Socorro County, New Mexico

Robert M. North

1983, pp. 261-268. https://doi.org/10.56577/FFC-34.261

in:

Socorro Region II, Chapin, C. E.; Callender, J. F.; [eds.], New Mexico Geological Society 34 th Annual Fall Field Conference Guidebook, 344 p. https://doi.org/10.56577/FFC-34

This page is intentionally left blank to maintain order of facing pages.

HISTORY AND GEOLOGY OF THE PRECIOUS METAL OCCURRENCES IN SOCORRO COUNTY NEW MEXICO

ROBERT M. NORTH
New Mexico Bureau of Mines and Mineral Resources
Socorro, New Mexico 87801

INTRODUCTION

Precious metals, in varying degrees of importance, have been reported from 21 mining districts in Socorro County (fig. 1). Most of these occurrences have little or no reported production, but all are included to present a complete overall picture of the occurrence of precious metals in the county. Space limitations preclude an exhaustive discussion of each occurrence here; however, comprehensive references are given.

For the purpose of this discussion, an "occurrence" of precious metals is defined as a deposit (no size restriction) with precious metal contents of at least 100 times average crustal abundance. The average crustal abundance of gold is approximately 0.005 ppm (0.00015 oz/ton) and silver approximately 0.070 ppm (0.0020 oz/ton). No platinum or platinum-group metals are known to occur in the county. Since no complete geochemical study of the county has been made, the occur-

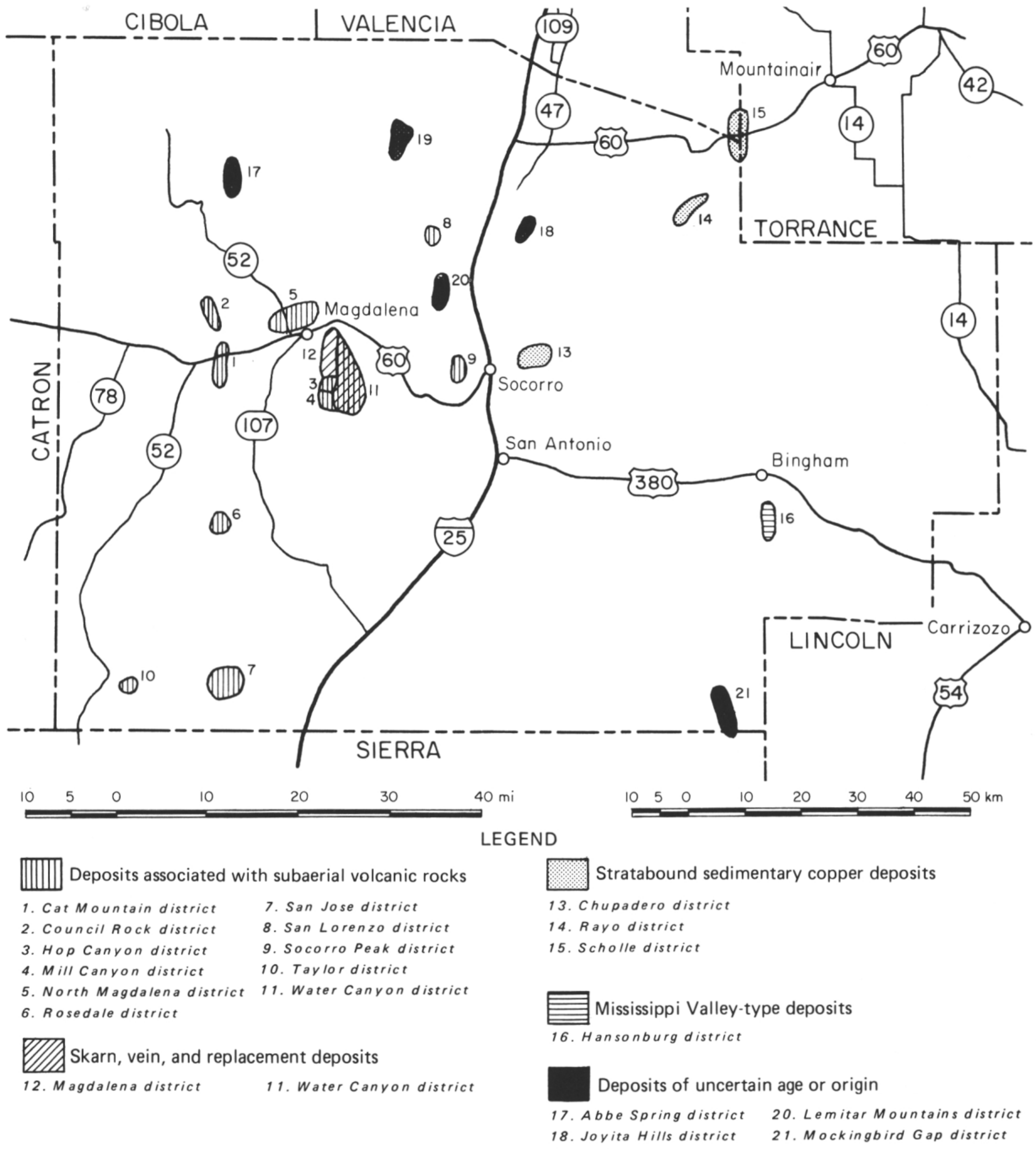

Figure 1. Precious metal occurrences in Socorro County.

rences discussed are limited to areas that have been previously prospected or mined for base or precious metals.

The precious metal occurrences of the county can be separated into four groups: (1) veins associated with Tertiary subaerial volcanic rocks; (2) replacement, vein, and skarn deposits associated with Tertiary intrusive rocks; (3) deposits in Paleozoic sedimentary rocks that are not obviously associated with igneous activity; and (4) deposits of uncertain age or origin.

DEPOSITS ASSOCIATED WITH SUBAERIAL VOLCANIC ROCKS

Much of western Socorro County is covered by a thick accumulation of Tertiary volcanic and associated sedimentary rocks. Recent studies have delineated a number of cauldrons and have defined the volcanic stratigraphy of the area (Osburn, this guidebook; Chapin and others, 1978; Elston, 1978; Osburn and Chapin, 1983). The volcanic pile contains tuffs (commonly welded), volcaniclastic sediments, and flows which are locally cut by veins and breccia zones containing precious metals.

Cat Mountain District

The Cat Mountain district (#1, fig. I) was first prospected in the early 1870's with little success. In the early 1900's, the Socorro Gold Mining Company acquired a group of 14 claims and in 1902 built a 20-stamp amalgamating mill with a cyanide circuit to process tailings (Jones, 1904). The company did some development work on the veins and had a small amount of production in 1903. Low grade of ore coupled with poor recovery is presumed to have caused the district's demise (Lasky, 1932).

The only other known production from the district was by S. S. Thurmond and E. E. Cobb, who in the early 1950's shipped 356 tons (323 mt) of ore from the Sixty prospect to the El Paso smelter. The ore was low grade, averaging 0.81 percent copper and 3.01 oz/ton (103 ppm) silver (Wilkinson, 1976).

The veins are concentrated along fissures in the Spears Formation (Oligocene) and the Abo(?) Formation (Permian). The veins are dominantly white quartz and black, manganese-stained calcite with minor barite, fluorite, pyrite, and galena. Oxidation products include cerussite, mimetite, wulfenite, and anglesite (Wilkinson, 1976). The gold is presumed to be fine-grained native gold, possibly disseminated in pyrite. Wilkinson reported that no silver was detected in the black calcite and presumed the silver to be contained in the galena.

The Sixty prospect, while mainly a copper prospect, has produced some silver. The mineralization consists of quartz, pyrite, chalcocite, chalcopyrite, malachite, azurite, chrysocolla, tenorite(?), cuprite, hematite, and mottramite disseminated through the Rock House Canyon Tuff (Tuff of Nipple Mountain) of the Datil Group (Wilkinson, 1976; Osburn and Chapin, 1983). The silver, while probably present in chalcopyrite and chalcocite, may also be contained in the mottramite (a lead-copper vanadate of the descloizite family).

Council Rock District

Mineralization in the Council Rock (Iron Mountain) district (#2, fig. 1) was discovered in 1881 by Messrs. Hill and Bowles (Las Vegas Mining World, 1882). The mines were worked in the early 1880's for lead and silver, and perhaps a little gold (Lasky, 1932). No production is known for the district, but the area probably produced at least a small amount, given the extent of workings (about 240 m reported by Jones [1904] for the Old Boss mine). An early report claims that evidence of Spanish mining, including mining tools, abandoned smelters, and slag was found by early workers in the district (Las Vegas Mining World, 1882).

The ore deposits of the district are in veins along faults in the Spears Formation (Oligocene). Chamberlin (1974) reported vein trends of N 10°-45° W, and N 30°-60° E, with the major workings at the intersections of veins. The veins range in thickness from a few centimeters to 1.5 m and contain quartz with minor barite, siderite, hematite, calcite, malachite, and fluorite (Chamberlin, 1974). In addition, Lasky (1932) reported cerussite and gold, and an early newspaper account reports galena and chlorargyrite (Las Vegas Mining World, 1882).

Hop Canyon District

The Hop Canyon mining district (#3, fig. 1) was prospected from about 1880 to 1920. The first report of activity was by Burchard (1883) who mentions the work of the Mountain Queen Mining Company in "Hope Canyon" (Hop Canyon?). A considerable amount of activity was reported by Gordon in 1905 (Lindgren and others, 1910) by the Hop Canyon Mining Company which resulted in the production of 20 tons (18 mt) of ore yielding 258 oz (8,025 g) of silver and 2,813 lbs (1,277 kg) of copper in 1915 (Loughlin and Koschmann, 1942). The Calumet and New Mexico Mining Company had a group of 10 claims surveyed for patent (MS 1436) in 1911, which were subsequently patented in 1914. Lasky (1932) reported there was no activity during his visit in 1929. No other production is known for the district, although it is quite possible that a small amount was produced during development work.

The mineralization in the Hop Canyon district occurs in veins cutting the Hells Mesa Tuff and the Sawmill Canyon Formation; although some prospects are also in the Lemitar Tuff and an overlying andesite, all of Oligocene age (Allen, 1979; Osburn and Chapin, 1983). Some of the prospects are along extensional faults and silicified shear zones that parallel faults trending from N 30° W to N 20° E (Allen, 1979). Prospecting also occurred along a shear zone trending N 10° W, dipping 70° southwestward (Lindgren and others, 1910). The veins contain weak copper mineralization with small amounts of silver and gold. Ore minerals include copper sulfide and copper carbonates in a gangue of quartz (Lasky, 1932).

Mill Canyon District

The Mill Canyon district (#4, fig. 1) was first prospected in the late 1800's. The earliest activity was reported to be near the crest of the range on the Crestone group (MS 1241) of C. T. Brown and Copper Lode claim (MS 1313) of Addie Driscoll. These claims were located in the mid-1890's and patented in the early 1900's; but no production is known. Attempts to work the Crestone Group in the early 1980's failed. The lower Mill Canyon area which includes the Iron Cap vein, Wheel of Fortune (Cuprite) mine, and Old Soldier vein was largely developed by August Riviere. A small amount of copper, lead, silver, and gold production is reported from the area (Laughlin and Koschmann, 1942, p. 86). Attempts were made to further develop the Old Soldier mine in the late 1940's (McKinley and Clipinger, unpub., 1947) and again in the late 1970's (Allen, 1979), but no further production is reported.

The deposits of the Mill Canyon district are veins in shear zones or along the margin of a white rhyolite dike that intrudes the Hells Mesa Tuff near the crest of the Magdalena Range (Allen, 1979). Very fine-grained gold is reported by Allen (1979) in limonite casts after pyrite within the white rhyolite. Krewedl (1974) reports gold in quartz-filled fractures in the dike. Stahl (1971; unpub.) reports visible gold both in place and on the dump of the Crestone lode. Assays reported for the Crestone by Stahl (1971; unpub.) indicate, in general, a relatively high gold/silver ratio (about 1: I) and copper of approximately one percent. Allen (1979) reports that no mineralization was visible on the dumps of the Copper lode. The Iron Cap vein is along a northeast-trending mafic dike which intrudes the Hells Mesa Tuff (Allen, 1979). Lasky (1932) reports traces of pyrite, chalcocite, covellite, and malachite in an adit below the outcrop of the vein. The Wheel of Fortune and Old Soldier veins are in north to northwest trending shear zones in porphyritic andesite in the Sawmill Canyon Formation (unit of Six-mile Canyon) (Allen, 1979). Ore minerals reported at the Wheel of Fortune by Lasky (1932) are chalcocite, covellite, malachite, chrysocolla, and galena in a gangue of black calcite. Galena, chalcopyrite, and black calcite were found by Allen (1979) on the dump of the Old Soldier mine.

North Magdalena District

The first ore discovery in the North Magdalena district (#5, fig. 1) was in 1863, with active prospecting for silver ores reported in the late 1860's (Jones, 1904). The district was the focus of considerable interest in the 1880's and there are many newspaper accounts of activity in the area during this period. Little is known of the production in these early years. The only report found of early production was for the Sophia mine, which shipped 200 sacks of ore to the Billing smelter in 1885 (Socorro Bullion, 1885). Other mines in the district doubtless shipped sacked ore to this and other smelters in the immediate area during this period. Lasky (1932) reports that a stamp mill in Pueblo Canyon treated ore from the district, but gives no dates of operation.

In 1919 the Copper Belt Silver and Copper Company filed 13 claims east of Silver Hill and proceeded with development work consisting mostly of small cuts and shallow shafts on outcropping copper-silver mineralization (Lasky, 1932). This work resulted in the production of 3 tons (2.7 mt) of ore containing 149 oz (4,634 g) of silver and 1,138 lb (515 kg) of copper (Loughlin and Koschmann, 1942). The district has been worked sporadically since the 1920's for lead, silver, vanadium, copper, and barite. The most recent activity, an attempt to produce barite in the late 1970's, resulted in little if any production.

The ore deposits of the district are veins in shear zones and faults in the La Jara Peak Basaltic Andesite (late Oligocene—early Miocene). The mineralogy of the deposits varies, with lead and vanadium high toward the east (Pueblo subdistrict) and copper more abundant toward the west (Silver Hill subdistrict). In the Silver Hill area, Simon (1973) reports generally northwest vein trends that range between N 70° W and N 35° E. The mineralogy of the veins is interesting, with recent discoveries of some rare species. The veins contain chrysocolla, malachite, chalcocite, covellite, galena, sphalerite, argentite, vanadinite, quartz, calcite, and barite (Simon, 1973). In addition, fomacite ((Pb,Cu), ((Cr,As)0_4)2OH), duftite (PbCu(Asat)OH), conichalcite

($CaCu(AsO_4)OH$), descloizite, willemite, mimetite, and apatite have recently been identified from the Silver Hill area. In the eastern portion of the district, the veins are generally north to northwest trending. Galena is more abundant than to the west, and the veins also contain locally abundant vanadinite with barite, calcite, quartz, anglesite, mottramite, and descloizite. Lasky (1932) also reports minor fluorite, cerussite, and chalcopyrite.

Rosedale District

The Rosedale district (#6, fig. 1) is one of the most important gold-producing districts in Socorro County. Gold was discovered in December, 1882 by Jack Richardson, creating a rush to the area (Jones, 1904). The only properties developed to any extent are the Rosedale and Bell mines. The W. H. Martin Company first developed the Rosedale mine from about 1887 to 1905 (Batchelder, 1910 unpub.). The Martin Company built a 10-stamp mill in 1891 and a cyanide plant in 1900 (Marshall, 1915 unpub.). The company produced about 8,200 troy ounces (255,020 g) of gold (Table 1). The Rosedale Mining and Milling Company assumed control in 1909 and produced almost 1400 troy ounces (43,450 g) of gold before the mill burned in August 1910 (Batchelder, 1910 unpub.). The mine remained inactive until the mid 1930's, when the Black Bear Mining Company and Rosedale Gold Mines Ltd. produced for a short period (Table 1). The most recent prospecting for precious metals, drilling programs in the 1970's, has not resulted in production (Neubert, 1983).

The Bell mine is located about 1.5 km southwest of the Rosedale mine. The Bell vein doubtless has a prospecting history roughly paralleling that of Rosedale. The mine produced a small amount in the early 1900's and was patented in 1930. The foundation of a small crushing plant stands just to the east of the Bell adit, but the history of operation is unknown.

The ore deposits of the Rosedale district are in veins of quartz-rich breccia along faults cutting the South Canyon Tuff of Oligocene age (G. R. Osburn, 1983, oral commun.). The Rosedale mine workings are along a I-3-m-wide fault zone striking N 20° W and dipping 80° eastward (Lindgren and others, 1910). Prospects are located along this fault both north and south of the Rosedale workings, but are not of any consequence. The Bell mine is in a steeply dipping silicified fault breccia in the upper South Canyon Tuff approximately parallel to the Rosedale fault. Some breccia-vein samples collected on the dump of the Rosedale mine contained tuff clasts with a lower phenocryst content than the outcropping South Canyon Tuff of the mine area. Both have quartz and altered feldspars in roughly the same ratio. The low phenocryst material

Table 1. Reported production of the Rosedale mine, 1896–1941. Sources: Batchelder (1910, unpublished report); compilation by W. Clark, New Mexico Bureau of Mines and Mineral Resources.

YEAR	ORE Tons	(metric tons)	GOLD Troy Oz	(g)	SILVER Troy Oz	(g)	OWNER-OPERATOR
1896	-		47.2	(1,468)	-		W.H. Martin Company
1898	2,003	(1,817)	510.5	(15,878)	-		W.H. Martin Company
1899	4,731	(4,292)	1,367.3	(42,527)	-		W.H. Martin Company
1900	5,995	(5,439)	2,188.2	(68,060)	-		W.H. Martin Company
1901	3,406	(3,090)	984.3	(30,615)	-		W.H. Martin Company
1903	912	(827)	485.2	(15,091)	-		W.H. Martin Company
1904	5,471	(4,963)	1,800.0	(55,985)	-		W.H. Martin Company
1905	3,252	(2,950)	994.2	(30,923)	-		W.H. Martin Company
1909	4,561	(4,138)	1,397.0	(43,451)	-		Rosedale Mining & Milling Co.
1934	58	(53)	13.0	(404)	115	(3,577)	Black Bear Mining Co.
1935	2,972	(2,696)	158.0	(4,914)	147	(4,572)	Rosedale Gold Mines, Ltd.
1936	18,262	(16,567)	1,631.0	(50,729)	2,682	(83,418)	Rosedale Gold Mines, Ltd.
1937	30,005	(27,220)	1,665.0	(51,786)	2,291	(71,257)	Rosedale Gold Mines, Ltd.
1941	200	(181)	35.0	(1,089)	128	(3,981)	Rosedale Gold Mines, Ltd.
	81,828	(74,218)	13,275.9	(412,920)	5,363	(166,805)	

probably belongs to the lower South Canyon Tuff; however, the depth at which it was encountered is unknown.

The veins of the Rosedale district contain fine-grained native gold in a gangue of quartz, tuff clasts, manganese, and iron oxides. The quartz is occasionally pale amethyst. A small amount of deep purple fluorite was found on the Rosedale dump. Relatively little silver was found with the gold (Table I) and no evidence of base metal mineralization was found in the dump material or in the Bell mine. Sulfides and base metals occurred below the water level (Lindgren and others, 1910).

San Jose District

In 1900, a local prospector named Johnson discovered the veins of the San Jose district (#7, fig. 1; Ballmer, 1932, unpub.). However, this discovery was not deemed important until a high-grade streak was discovered on the Pankey vein by Tom Hillyer in 1931. The Springtime Mining Company developed the Pankey vein from 1934 to 1937 and constructed a mill in 1935 (Henderson and Martin, 1936). The district produced in the 1930's and early 1940's (Table 2) from the Pankey, Burbank, Republic, Victorio, and El Porvenir properties.

Veins in the San Jose district occur along faults cutting the Spears Formation and the Vicks Peak Tuff, both of Oligocene age (G. R. Osburn, 1983, oral commun.). The major vein is the Pankey which fills a fault breccia striking N 10°-30° E. Vein minerals include native gold, argentite (Ballmer, 1932 unpub.), native silver, chlorargyrite, a trace of malachite, and stephanite(?) in a gangue of quartz, and pyrite (Lasky, 1932).

San Lorenzo District

The San Lorenzo district is located in the southwest corner of the Sevilleta Land Grant, about 2.1 km north of San Lorenzo spring (#8, fig. 1). The largest prospect in the district, the Jerome, was located by Mark Thomas in 1901 (Jones, 1904). The district is reported to have shipped a few sacks of ore (Lasky, 1932), presumably copper-silver ore, although gold was mentioned in early reports (Mining and Scientific Press, 1903).

The ore deposits of the San Lorenzo district occur as fracture fillings along faults in andesite. The andesite is grayish-red to bright red where highly oxidized in the permeable fault zones. Some outcrops contain vesicles up to 10 mm, typically filled with calcite near the faults. The Jerome prospect is located along a fault zone in andesite striking north-south to N 10° E and dipping 55° eastward. Near the prospect, the fault zone is nearly 50 m wide but it thins both to the north and south. A shallow shaft about 400 m southeast of the Jerome was sunk along a fault striking N 40° W and dipping 73° northeastward. Mineralization consists of chrysocolla filling fractures with some calcite. No native copper was found. A fault zone about 100 m west of the Jerome strikes N 33° E, dips 50° northeastward, and contains calcite fracture filling. Copper and precious metal mineralization was not detected. A shaft about 5 m deep has been sunk on this vein.

Table 2. Reported production of the San Jose mining district. Sources: U.S. Bureau of Mines Minerals Yearbooks. (1) Test shipment made prior to 1932 (Ballmer, 1932, unpublished report); (2) mill clean up.

YEAR	ORE Tons (metric tons)	GOLD Troy Oz (g)	SILVER Troy Oz (g)
____[1]	156 (142)	74.6 (2320)	1624 (50,511)
1934	396 (359)	139.3 (4333)	1748 (54,368)
1935	1330 (1206)	312.0 (9704)	4842 (150,600)
1936	2175 (1973)	146.9 (4569)	2790 (86,777)
1937	43[2] (39)	96.8 (3011)	861 (26,780)
1938	52 (47)	29.2 (908)	93 (2,893)
1939	495 (449)	68.0 (2115)	928 (28,864)
1940	2[2] (2)	5.0 (156)	3 (93)
1941	52 (47)	16.0 (498)	28 (871)
TOTAL	4701 (4264)	887.8 (27,614)	12,917 (401,757)

The mineralogy of the San Lorenzo area is unusual. The major ore mineral at the Jerome prospect is native copper in calcite veins filling the andesite fault breccia. The native copper is often along the edges of the calcite veins or along the edges of andesite clasts caught up in the calcite. The copper has been altered to cuprite, crysocolla, and a small amount of malachite. Selected dump samples assayed as much as 1.8 oz/ton (62 ppm) silver. The average grade of ore would doubtless assay much less. Native copper separated from dump material contained as much as 295 ppm (8.6 oz/ton) silver.

Socorro Peak District

The Socorro Peak district (#9, fig. 1), was an important silver producer in the 1880's. The district was heavily prospected in the late 1860's, and may have been known to the Spanish much earlier (Jones, 1904). An early newspaper account (Longuemare, 1883) reports work on the Merritt mine in 1842 by the father of Don Estanislao Montoya. The ore was supposedly carried to Socorro and smelted in an adobe smelter. Burchard (1883, p. 606) reports: "The Merritt is an old Spanish mine, having been worked over two hundred years ago in the rude gopher style of the time." The accuracy of these two reports is uncertain, but it is likely that the area was prospected by the Spanish because of its close proximity to Socorro, which was settled in the late 1500's.

The most active period in the district was during the 1880's when the Torrence, Merritt, and Socorro Tunnel were actively mined. The Torrence Company built a 10-stamp mill in 1881 to handle its ores (Burchard, 1882). In 1884, the Cabinet Consolidated Mining Company of Saint Paul, Minnesota, purchased the Torrence mine and mill and the Merritt mine (Burchard, 1884) and operated them under the supervision of A. D. Coon until 1889 (Socorro Bullion, 1889). The Socorro Tunnel Mining Company of Las Vegas, New Mexico, operated the Socorro (Woods) Tunnel and other prospects from 1881 to the early 1890's (Socorro Bullion, 1891). Smaller scale operations were doubtless carried out in the district during the 1880's, taking advantage of the nearby Billing smelter (later the Rio Grande Smelting Works). Activity in the district slowed considerably by 1890 and was completely halted by the silver crash of 1893. The last activity in the district was in the 1920's (Lasky, 1932). Total production is estimated to be between $760,000 and slightly more than $1,000,000 but little profit was derived (Lasky, 1932). However, newspaper accounts and reports by the Director of the Mint (Burchard, 1881, 1882, 1883, 1884) indicate that the district was more profitable than Lasky's (1932) estimates.

The major ore deposits of the Socorro Peak district occur as veins along faults in the Socorro Peak Rhyolite (late Miocene) and the underlying Popotosa Formation. They are the youngest known lode precious metal deposits in the county and are younger than the main mass of the Socorro Peak Rhyolite which has been dated at 12 to 10 m.y. (Chamberlin, 1980, p. 492). The Socorro (Woods) Tunnel veins cut the Madera and Sandia Formations of Pennsylvanian age (Chamberlin, 1980). The mineralized faults generally strike north with variable dips, some as low as 38° (Chamberlin, 1980, plate 1). The major ore mineral of the district is chlorargyrite which contains significant bromine. A small amount of galena is present with gangue minerals including barite and quartz and minor amounts of fluorite, calcite, and manganese oxides (Lasky, 1932). Lasky reported the best ore was associated with fluorite. Oxidation of the small amount of base metals present produced mimetite, wulfenite, hemimorphite, willemite, anglesite, and mottramite (Moats and Queen, 1981).

PRECIOUS METAL OCCURRENCES

Taylor District

The Taylor (Ojo Caliente #2) district is located on the southwest side of the San Mateo Mountains (#10, fig. 1). Published accounts give erroneous locations of the Taylor prospect. The actual location, as given by the patent plat (MS 2174) and confirmed by field investigation, is NE1/4 SW1/4 sec. 5, T9S, R7W. The prospect is shown accurately on Hillard's (1969) map but the wrong section number is given in his text. The area was prospected prior to 1930 and Lasky (1932) reported 110 m of workings but no production. The May Day #1 and #2 claims were surveyed for patent (MS 2174) in 1952 and patented in 1956. The Taylor prospect is located on the May Day #2 claim. No production is known from this later activity.

The Taylor prospect is in a vein along a shear zone that is as much as 3 m wide, strikes N 60° E, and dips steeply northward. The vein is in an andesite-latite flow of Oligocene age in an intensely altered area (Hillard, 1969). The vein contains cerussite, malachite, crysocolla, and hemimorphite in a gangue of quartz and iron and manganese oxides. A small amount of fluorite was detected by x-ray diffraction. The ore contains small amounts of silver. The silver values, given the oxidized nature of the vein, may be as halides but none were detected. Lead was the major metal in the upper portion of the vein and copper dominates at the bottom of the shaft (Lasky, 1932). Widespread alteration consists of montmorillonite, kaolinite, alunite, and silicification (Hillard, 1969).

Water Canyon District

The Water Canyon district (#11, fig. 1) encompasses a large area on the northeast side of the Magdalena Mountains. At least three types of deposits are found in the district; (1) veins associated with volcanic rocks, (2) vein, replacement, and skarn deposits in limestone, and (3) veins along faults between Paleozoic and Precambrian rocks. The vein deposits in volcanic rocks are located in South Canyon, approximately 1.5 km east of Timber Peak. These veins were discovered in the mid 1890's and worked by Louis and Lee Terry who amalgamated the ore and supposedly sent a small amount of bullion to the Denver Mint prior to 1900 (Stendel, 1936, unpub.). In 1898, the Terry brothers sold the property to the Timber Peak Mining Company who built an ill-advised 150-ton-per-day (136 mt) mill (Stendel, 1936, unpub.). The mill failed and the venture resulted in little, if any, production (Collins, 1899, unpub.). Roy Stendel obtained the property in 1933 and produced a gravity concentrate from the open-cut mine until 1939 (Stendel, 1936, unpub.; Table 3). The South Canyon area was prospected for uranium in the 1950's (McLemore, this guidebook).

The ore deposits are veins in a structurally complex area near the north rim of the Sawmill Canyon cauldron and are associated with white rhyolite dikes emplaced along faults (Petty, 1979). The major workings are along the intersection of north-south faults with the east-trending South Canyon fault of Krewedl (Petty, 1979, plate 1; Krewedl, 1974, fig. 4). Krewedl (1974) reported that mineralization was restricted to the north side of the South Canyon fault in the Hells Mesa Tuff and in white rhyolite dikes. However, Petty (1979) reported mineralization was also found in andesites of the Unit of Six-Mile Canyon (now Sawmill Canyon Formation; Osburn and Chapin, 1983) on the south side of the fault. The mineralization is in quartz veinlets associated with the white rhyolite dikes. The dominant sulfide is pyrite (at places altered to limonite) with minor amounts of chalcopyrite, galena, and sphalerite. Barite occurs as small veins along joints and the rhyolite-host rock contact (Petty, 1979).

SKARN, VEIN, AND REPLACEMENT DEPOSITS ASSOCIATED WITH TERTIARY INTRUSIVE ROCKS

Precious metals, especially silver, have been produced in Socorro County as by-product of lead, zinc, and copper production from replacement, skarn, and to a lesser extent, vein deposits in Paleozoic limestones. The deposits are of similar age and tectonic environment as gold-silver vein deposits in volcanic rocks. The relationships between deposits is unknown.

Table 3. Reported production from the Water Canyon district. Types of deposits: (1) veins in volcanic rocks, (2) veins in faults, (3) veins and replacements in Kelly Limestone, (4) breccia pipe at fault intersection. Sources: (a) Loughlin and Koschmann, 1942; (b) Krewedl, 1974; (c) Lasky, 1932, (d) U.S. Bureau of Mines Mineral Yearbooks.

YEAR	MINE	ORE TONS (metric tons)	GOLD TROY Oz (g)	SILVER TROY Oz (g)	COPPER POUNDS (kg)	LEAD POUNDS (kg)	TYPE OF DEPOSIT	SOURCE
1905	Wall Street	60 (54)	16 (498)	10 (311)	-	-	3	a
1917	Silver Mt. Mining Co.	13 (12)	1 (31)	219 (6,812)	896 (406)	4,480 (2,032)		a
1917	Buckeye	53 (48)	1 (31)	148 (4,600)	5,904 (2,680)	-	3	b
1927	Maggie Merchant	2 (2)	2 (62)	27 (840)	48 (22)	2,145 (974)	3	c
1927		23 (21)	-	49 (1,524)	164 (74)	3,833 (1,739)		a
1928	Gold King(Maggie Merchant)	9 (8)	0.1 (3)	32 (995)	148 (67)	6,029 (2,735)	3	a
1929	Gold King(Maggie Merchant)	23 (21)	0.2 (6)	36 (1,120)	181 (82)	9,870 (4,477)	3	a
1929	Ellis Canyon (Queen?)	2 (2)	-	12 (373)	-	2,218 ( )	3	c
1930	Gold King(Maggie Merchant)	6 (5)	0.3 (9)	19 (591)	-	3,417 (1,550)	3	a
1932	Gold King(Maggie Merchant)	21 (19)	8.1 (252)	121 (3,763)	175 (79)	8,627 (3,913)	3	a
1933	Gold King	14 (13)	.72 (22)	45 (1,400)	106 (48)	4,568 (2,072)	3	a
1933	Stendel-Open Cut	4 (4)	6 (187)	3 (93)	-	-	1	a
1934	Open Cut	5 (5)	2.3 (72)	2 (62)	-	-	1	a
1934	Gold King(Maggie Merchant)	2 (2)	-	21 (653)	27 (12)	1,847 (838)	3	a
1935	Queen	17 (15)	.7 (22)	85 (2,644)	194 (88)	12,413 (5,630)	3	a
1935	Open Cut	240 (218)	20.4 (635)	15 (467)	6 (3)	9 (4)	1	a
1936	Queen	59 (54)	5.9 (184)	306 (9,518)	1,429 (684)	41,477 (18,814)	3	a
1937	Balakohna	4 (4)	.1 (3)	6 (187)	-	1,536 (697)	3	a
1937	Open Cut	13 (12)	6.5 (202)	12 (373)	13 (6)	91 (41)	1	a
1937	Queen	6 (5)	13.6 (423)	6 (187)	6 (3)	-	3	a
1938	Bullet	4 (4)	0.9 (28)	2 (62)	3 (1)	-		a
1938	Rose Quartz	67 (61)	17.5 (544)	12 (373)	74 (34)	21 (10)	2	a
1939	Open Cut	30 (27)	21.8 (678)	25 (778)	36 (16)	104 (47)	1	a
1939	Rose Quartz	62 (56)	43.2 (1,344)	248 (7,714)	2,811 (1,275)	2,801 (1,271)	2	a
1939	Plata	20 (18)	-	16 (498)	156 (71)	2,498 (1,133)		
1941	Open Cut; Springtime	103 (93)	14 (435)	14 (435)	-	-	1	d
1946		30 (27)	6 (187)	2 (62)	-	-		d
1947	Love Bug #7	42 (38)	-	44 (1,369)	-	3,800 (1,724)		d
1952	Sunset	95 (86)	-	53 (1,648)	600 (272)	9,800 (4,445)	4	d
1953	Buckeye; Sunset	129 (117)	8 (249)	461 (14,339)	2,400 (1,089)	4,300 (1,950)	3; 4	d
1956	Queen	3 (3)	-	13 (404)			3	d
	TOTAL	1,161 (1,053)	196.32 (6,106)	2,064 (64,197)	15,377 (6,981)	125,884 (57,151)		

Magdalena District

The Magdalena district (#12, fig. 1) is the largest producer of silver in Socorro County (present boundaries). From 1904-1957 the district produced over 1.5 million ounces (46 million g) of silver and 3129 ounces (97,321 g) of gold (Howard, 1967). Production of lead and silver prior to 1904 was valued at $8.7 million (Jones, 1904). The district was a lead-silver producer from about 1870 to 1900 and dominantly a zinc producer after 1900, although it still produced considerable lead, copper, and silver with a little gold. The history of the district is discussed briefly by Eveleth (this guidebook) and in detail by Loughlin and Koschmann (1942). The geology and ore deposits were studied exhaustively by Loughlin and Koschmann (1942) and the area was remapped by Blakestad (1978).

Water Canyon District

As discussed earlier, the ore deposits of the Water Canyon district include some skarn, vein and replacement deposits associated with Tertiary intrusive rocks, as well as some deposits in faults between the Precambrian and Paleozoic rocks. Known production of the district is given in Table 3. The deposits of the middle part of the district (Copper Canyon, North Fork Canyon) are replacement deposits in Paleozoic limestone. The deposits in the northern end of the district are along faults between Paleozoic rocks and Precambrian rocks. In places, Tertiary dikes are associated with both types of deposits.

The replacement deposits were prospected in the late 1800's and doubtless experienced peak activity after it was discovered that the Kelly Limestone (Mississippian), host to large orebodies on the west side of the range, cropped out on the east side as well. The most active properties in the central part of the district were the Minerva group (Hall-Lytton properties) and the Buckeye mine (Lasky, 1932). The most recent activity was an attempt by Vernon F. Foy in the 1940's and 1950's to develop the Buckeye mine. This resulted in a small amount of production (Table 3) but was not profitable. The El Tigre mine was operated by the El Tigre Mining Company at least as late as 1952 (Martin, 1952). The ore deposits of the central Water Canyon district are skarn, replacement, and vein deposits in limestone, typically near the contact with Precambrian rocks. The ore deposits are generally along faults; Tertiary dikes are common in the mineralized areas. The only large intrusive body that crops out in the district is the Water Canyon stock which has been dated at about 30 m.y. (Sumner, 1980). A small skarn composed of diopside, andradite garnet, quartz, allophane, galena, sphalerite, pyrite, and minor chalcopyrite occurs in Kelly Limestone near the head of North Fork Canyon at the North Baldy mine. The only exposed igneous rock in the area is a white rhyolite dike which is apparently older than the mineralization (Krewedl, 1974). A concealed stock is inferred to have caused the mineralization.

Vein and replacement deposits containing dominantly zinc and lead with minor copper are found at the El Tigre mine, Minerva group, and Maggie Merchant claim (Krewedl, 1974; Lasky, 1932). Similar mineralization is found near the head of Ellis Canyon (Queen claim) at the extreme northern end of the district (Lasky, 1932). The ore deposits are replacements of limestone or fillings in fault breccia. The chief ore mineral is galena with sphalerite and minor chalcopyrite in a gangue of quartz and barite. Deposits are found in both the Kelly Limestone and the Madera Formation (Krewedl, 1974; Lasky, 1932). Silver was found in small to moderate quantities (Table 3). At the Buckeye mine, the dominant mineralization is copper. The ore deposits are in faults and as replacements in the Kelly Limestone and in faults between the limestone and Precambrian argillite. Lasky (1932) reports pyrite, chalcopyrite, chalcocite, cuprite, malachite, azurite, and native copper in silicified limestone. Silver is found in small quantities with the copper (Table 3).

In the northern part of the Water Canyon district two areas have been prospected for precious metals—the Rich Hill area (located about 0.5 km west of the Strozzi Ranch) and the Papa claims (located near the head of Jordan Canyon). The area west of the Strozzi Ranch has been claimed under many names. Those known are Silver Lode and Silver Streak groups (Gualtieri, 1968, unpub.); Sunset group (Benjovsky, 1947, unpub.), and Wagon Wheel group. Production is shown in Table 4 (Sunset group). The mineralized area is a small knob rising about 20 m above the surrounding alluvial apron. The rocks were mapped by Sumner (1980) as Precambrian metasediments intruded by Tertiary diorite. Both rock types are brecciated on the eastern half of the hill. The mineralization occurs as breccia filling at the intersection of an east-west fault and a northwest-trending, range-bounding fault (Sumner, 1980). The major ore minerals of the area are malachite, azurite, and cerussite, with minor sphalerite, galena, and chalcopyrite (Benjovsky, 1947, unpub.; Gualtieri, 1968, unpub.).

The Papa properties are located near the crest of the range at the head of Jordan Canyon. Victor Papa discovered gold in the area in 1937 while mining limestone replacement deposits at the Queen claim (Aiken, 1938, unpub.). The gold is in quartz gangue that fills fault zones between the Kelly Limestone and the Precambrian. Gold is visible in places, making the deposit quite impressive, but production has been small because of narrow and discontinuous mineralization. Silver, copper, and lead have also been produced from the property (Table 3).

DEPOSITS IN PALEOZOIC SEDIMENTARY ROCKS NOT OBVIOUSLY ASSOCIATED WITH IGNEOUS ACTIVITY

Stratabound Sedimentary Copper Deposits

Stratabound sandstone copper deposits ("red bed" copper deposits) are found in three areas in Socorro County (#13, 14, and 15, fig. 1). These deposits typically contain a small amount of silver. The Scholle district produced 8,148 oz (253,428 g) of silver between 1915 and 1961 (Soule, 1956; Hatchell and others, 1982). Typically the copper is in bleached sandstones, siltstones, and limestones in red-bed sequences. The silver content of these deposits averages about 0.5 oz/ton (17 ppm).

Mississippi Valley-type Deposits

Hansonburg district

Silver has been produced as a by-product of lead-barite-fluorite mining in the Hansonburg district (#16, fig. 1). The ore deposits are in Pennsylvanian limestones overlying Precambrian rocks in an uplifted, east-dipping fault block in the northern Oscura Mountains. The dominant silver-bearing mineral is galena, although small amounts of halides may be present. The district is discussed in detail by Putnam and Norman (this guidebook).

DEPOSITS OF UNCERTAIN AGE OR ORIGIN

Abbe Spring District

The Abbe Spring district, as here defined, is a large area of prospects west of Abbe Spring Canyon (#17, fig. 1). Two areas contain mineralization, the area south of the Hot Spot coal mines and the area northwest of Abbe Springs. Mayerson (1979) reports "a short chalcocite vein . . . along a fault south of the Hot Spot mine within the Baca Formation (SW i/4 NW i/4 sec. 18, TIN, R5W)." An attempt to locate this vein was unsuccessful; however, clay gouge from a shallow prospect along a fault in the Baca Formation in the area assayed 1.9 oz/ton (65 ppm) silver. A second sample, taken to the north along the same fault, assayed 0.34 oz/ton (12 ppm) silver. The area shows no visible mineralization and the samples assayed essentially nil in copper, lead, and zinc.

A second area of mineralization is along a north-trending fault between the Chinle Formation (Triassic) and Dakota Sandstone (Cretaceous) located in section 5, TIN, R5W and section 32, T2N, R5W. The mineralization is malachite, chalcocite, and barite in quartz veins filling the fault. Selected vein samples contained as much as 5.6 oz/ton (192 ppm) silver. Several shafts and open pits have been sunk along the fault. No production or history is known, but this may be the area from which Wheeler (1875) took samples of "copper ore from Springhill district, New Mexico." His samples assayed 46.56 percent "copper glance" (chalcocite), 3.52 percent "silicate of copper" (chrysocolla), 0.28 percent silver (82 ounces/ton), and 49.05 percent quartz gangue (Wheeler, 1875, p. 636). Analyses of selected vein material showed 2.0 percent copper and 2.85 oz/ton (98 ppm) silver; however, the average tenor would doubtless be less. A high-grade chalcocite sample could conceivably assay as high as those collected by the Wheeler Survey.

No large igneous intrusions crop out in the Abbe Spring vicinity; however, numerous mafic dikes and sills have been intruded into the sediments of the area (Chapin and others, 1979). La Jara Peak Basaltic Andesite, La Jencia Tuff and Vicks Peak Tuff, crop out about 3 km to the east of the prospects (G. R. Osbum, oral commun., 1983). The veins, which fill Tertiary faults, are hydrothermal in origin. The mineralized area falls along the Tijeras lineament, a transverse shear zone proposed by Chapin and others (1979, fig. 3-2).

Joyita Hills District

Prospecting in the Joyita Hills district (#18, fig. 1) was active as early as 1880 (Las Vegas Mining World, 1880), presumably for base and precious metals. A small mill was constructed in the area and an attempt about 1915 to market a galena concentrate failed due to the loss of the galena slimes (Lasky, 1932). Later the area was prospected for fluorite (Arendt, 1971). The mineralization occurs in fissures in the Precambrian gneiss and along the fault contacts between the Precambrian and younger rocks. The rocks to the west include a sequence of Permian and Pennsylvanian sediments (Wilpolt and others, 1954), while to the east are Tertiary volcanic rocks (Spradlin, 1975). The ore minerals are fluorite, barite, galena, chalcopyrite, bornite, and malachite in quartz gangue (Arendt, 1971) with low values of precious metal (Lasky, 1932).

Ladron District

Prospecting for precious metals in the Ladron district (#19, fig. 1) began in the late 1860's and was active through about 1900 (Socorro County Courthouse records). Prospecting peaked during two periods; 1879-84 and 1895-97. The second period of activity may have resulted from a New Mexico Bureau of Immigration report (1896) of the discovery of ". . . a vein of lead ore . . . eight feet wide . . . containing . . . 40 percent lead and $12 in gold per ton." While this and other exaggerated reports led to predictions of prosperity for the district, little production resulted. It is possible, however, that small amounts of sacked ore were sent to the smelters in Socorro during the 1880's and 1890's.

The mineralization in the Ladron district occurs mostly in veins in Precambrian rocks on the east flank of the Ladron Mountains. In general, the veins are steeply dipping (60°-90°) with variable strike. Samples were collected in 1982 as part of the Ladron wilderness evaluation (Chamberlin, 1982). Samples from the Lawrence lode claim (MS 631) contained minor malachite and galena in a gangue of quartz and iron-stained calcite and assayed as much as 1.5 oz/ton (51 ppm) silver. Sorted dump material from the Silver King shaft, (SW1/4 sec. 3, T2N, R2W) assayed 10.0 oz/ton (343 ppm) silver. The samples contained galena, chalcopyrite, and sphalerite in a gangue of quartz and limonite with minor calcite and hematite (Chamberlin, 1982, Appendix I). Both the Silver King vein and the Lawrence vein cut the Precambrian Capirote granite (Chamberlin, 1982, fig. 2). Several prospects are dug on oxidized calcite veins cutting Precambrian metasediments (sec. 27, T3N, R2W). Samples from these veins showed small amounts of silver (up to 1.0 oz/ton, 34 ppm).

Samples showing copper mineralization taken along the low-angle fault at the Jeter mine assayed only as high as 0.3 oz/ton (10 ppm) and commonly showed no silver. The Jeter fault is between Precambrian Capirote granite and Tertiary Sierra Ladrones Formation. The fault is mineralized with uranium and copper and has produced high-grade uranium ore (McLemore, this guidebook).

Lemitar Mountains District

Prospecting in the Lemitar Mountains district (#20, fig. 1) began about 1880 (Burchard, 1881, p. 341). The production is unknown, but the proximity of the smelters in Socorro in the 1880's and 1890's may well have prompted the production of a small amount of sacked lead-silver ore during this period. Mineralization in the district occurs in Precambrian rocks and along the contact between Precambrian and Paleozoic rocks. Base and precious metal mineralization is found in three areas: Corkscrew Canyon, the Jackpot prospects, and the Western Silver and Gypsum Company prospects (McLemore, 1982).

Prospects are located along the contact between Precambrian rocks and Paleozoic sediments north and south of Corkscrew Canyon (Cañoncito del Puertecito del Lemitar, sections 7 and 18, T2S, R1W). The mineralization occurs along the unconformable contact and consists of galena and malachite in a gangue of quartz, barite, fluorite, and calcite. The deposits partially replace the limestone (McLemore, 1982) and contain some silver.

The Jackpot prospects (sections 5 and 6, T2S, R1W) are along Precambrian mafic dikes, Ordovician carbonatite dikes, and in a fault block of Paleozoic limestone. The mineralization in limestone consists of barite, galena, chalcopyrite, pyrite, calcite, fluorite, and sphalerite in veins and as replacements. The deposits along the dikes contain barite, galena, and pyrite (McLemore, 1982). The silver content in the Jackpot area is unknown.

The Western Silver and Gypsum prospects are located on the northeast side of the Lemitar Mountains (sections 29, 30, and 31, T1S, R1W). The mineralized areas are associated with Precambrian mafic dikes and Paleozoic carbonatite dikes. Barite was the major commodity of interest in most of the prospects. The mineralization is in veins containing barite, quartz, fluorite, and galena. Small amounts of wulfenite and vanadinite have been identified from one prospect in the area (McLemore, 1982). Selected dump samples high in galena assayed 1.48 oz/ton (51 ppm) silver (McLemore, 1982, Table 11).

The deposits of the Lemitar Mountains district are hydrothermal veins filling areas of high permeability. The deposits are probably Tertiary in age and related to igneous activity. Some small Tertiary mafic dikes occur in the area; however, no large Tertiary intrusive rocks are exposed near the deposits. The veins are generally thin and discontinuous.

Mockingbird Gap District

The Mockingbird Gap district (#21, fig. 1) is located within the White Sands Missile Range. The area was prospected about 1900 and may have produced small ore shipments during this period. Shipments recorded in 1934, 1938, and 1941 totaled 833 tons (755 mt) of ore yielding 117 troy ounces (3639 g) of silver and 71,200 pounds (32,325 kg) of lead (U.S. Bureau of Mines Minerals Yearbooks). The ore is in veins filling faults between Precambrian and Paleozoic rocks. Lasky (1932) reported the mineralization at the Mockingbird Gap mine as malachite, azurite, chrysocolla, cuprite, and small amounts of chalcocite and native copper in a fluorite, limonite, hematite, and calcite gangue. To the south, at the Independence mine, the primary mineralization is galena and sphalerite in a quartz, calcite, and barite gangue. Oxidation has resulted in the formation of cerussite, anglesite, and smithsonite (Lasky, 1932).

ACKNOWLEDGMENTS

The author gratefully acknowledges the assistance of G. R. Osburn with volcanic stratigraphy and offers thanks for sharing his compilations of geologic maps of the county. Lynn Brandvold supervised chemical analyses and delivered speedy results. Robert H. Weber, Robert W. Eveleth, Virginia T. McLemore, and David Menzie provided many helpful discussions. Virginia T. McLemore critically read the manuscript.

REFERENCES

NOTE: Unpublished reports cited in the text are available from the New Mexico Bureau of Mines and Mineral Resources for a per-page copy charge. Many of the theses cited are also available as open-file reports.

Allen, P., 1979, Geology of the west flank of the Magdalena Mountains south of the Kelly mining district, Socorro County, New Mexico [M.S. thesis]: Socorro, New Mexico Institute of Mining and Technology, 116 p.

Arendt, W. W., 1971, Geology of the La Joyita Hills [M. S. thesis]: Albuquerque, University of New Mexico, 75 p.

Blakestad, R. B., 1978, Revised geology of a portion of the Kelly mining district, Socorro County, New Mexico [M.S. thesis]: Boulder, University of Colorado, (New Mexico Bureau of Mines and Mineral Resources Open-file Report 43), 149 p.

Burchard, H. C., 1881, Report of the Director of the Mint upon the statistics of the production of precious metals in the United States: Washinigton, D.C., U.S. Treasury Department, 765 p.

, 1882, Report of the Director of the Mint upon statistics of the production of the precious metals in the United States: Washington, D.C., U.S. Treasury Department, 873 p.

, 1883, Report of the Diretor of the Mint upon statistics of the production of precious metals in the United States: Washington, D.C., U.S. Treasury Department, 858 p.

, 1884, Report of the Director of the Mint upon statistics of the production of precious metals in the United States: Washington, D.C., U.S. Treasury Department, 644 p.

Chamberlin, R. M., 1974, Geology of the Council Rock district, Socorro County, New Mexico [M.S thesis]: Socorro, New Mexico Institute of Mining and Technology, 143 p.

, 1980, Cenozoic stratigraphy and structure of the Socorro Peak volcanic center, central New Mexico [Ph.D. thesis]: Golden, Colorado School of Mines, (New Mexico Bureau of Mines and Mineral Resources Open-file Report 118), 532 p.

, 1982, Preliminary evaluation of the mineral resources potential of the Sierra Ladrones wilderness study area, Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-file Report 179, 168

Chapin, C. E., Chamberlin, R. M., Osburn, G. R., and others, 1978, Exploration framework of the Socorro geothermal area, New Mexico, *in* Chapin, C. E. and Elston, W. E., eds., Field guide to selected cauldrons and mining districts of the Datil-Mogollon volcanic field, New Mexico: New Mexico Geological Society Special Publication no. 7, p. 114-129.

Chapin, C. E., Osbum, G. R., Hook, S. C., Massingill, G. L., and Frost, S. J., 1979, Coal, uranium, oil and gas potential of the Riley-Puertecito area, Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-file Report 103, 38 p.

Elston, W. E., 1978, Mid-Tertiary cauldrons and their relationship to mineral resources, southwestern New Mexico: a brief review: *in* Chapin, C. E. and Elston, W. E., eds., Field guide to selected cauldrons and mining districts of the Datil-Mogollon volcanic field New Mexico: New Mexico Geological Society Special Publication no. 7, p. 107-114.

Hatchell, W. 0., Blagbrough, J. W., and Hill, J. W., 1982, Stratigraphy and copper deposits of the Abo formation, Abo Canyon area, central New Mexico: New Mexico Geological Society Guidebook 33, p. 249-260.

Henderson, C. W. and Martin, A. J., 1936, Gold, silver, copper, lead, and zinc in New Mexico: U.S. Bureau of Mines Minerals Yearbook, 1936, p. 311-321.

Hillard, P. D., 1969, Geology and beryllium mineralization near Apache Warm Springs, Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 103, 16 p.

Howard, E. V., 1967, Metalliferous occurrences in New Mexico: Phase 1, state resources development plan: Santa Fe, New Mexico State Planning Office, 270 p.

Jones, F. A., 1904, New Mexico mines and minerals: Santa Fe, The New Mexican Printing Co., 346 p.

Krewedl, D. A., 1974, Geology of the central Magdalena Mountains, Socorro County, New Mexico [Ph.D. thesis]: Tucson, University of Arizona, (New Mexico Bureau of Mines and Mineral Resources Open-file Report 44), 128 p.

Lasky, S. G., 1932, The ore deposits of Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 8, 139 p.

Las Vegas Mining World, 1880, Manzaneras district: v. 1, #2, 10/1880, p. 12.

______ , 1882, Old Boss mine: v. 2, #14, 4/20/1882, p. 203.

Lindgren, W., Graton, L. C., and Gordon, C. H., 1910, The ore deposits of New Mexico: U.S. Geological Survey Professional Paper 68, 361 p.

Longuemare,-C., 1883, History of Socorro: Socorro Bullion, 9/1/1883, p. 3.

Loughlin, G. F. and Koschmann, A. H., 1942, Geology and ore deposits of the Magdalena mining district, New Mexico: U.S. Geological Survey Professional Paper 200, 168 p.

Martin, A. J., 1952, The mineral industry of New Mexico: U.S. Bureau of Mines Minerals Yearbook, v. 3, Area Reports, p. 628-652.

Mayerson, D. L., 1979, Geology of the Corkscrew Canyon-Abbe Springs area, Socorro County, New Mexico [M.S. thesis]: Socorro, New Mexico Institute of Mining and Technology, 133 p.

McLemore, V. T., 1982, Geology and geochemistry of Ordocivian carbonatite dikes in the Lemitar Mountains, Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-file Report 158, 104 p.

Mining and Scientific Press, 1903, Mining news, 8/29/1903, p. 139.

Moats, W. P. and Queen, L. D., 1981, Minerals of the Socorro Peak district [abs.]: New Mexico Geology, v. 3, no. 1, p. 16.

Neubert, J. T., 1983, Mineral investigations of the Apache Kid and Withington Wilderness areas, Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-file Report, 5-83.

New Mexico Bureau of Immigration, 1896, The mines of New Mexico: Santa Fe, New Mexican Printing Company, Santa Fe, 80 p.

Osburn, G. R. and Chapin, C. E., 1983, Nomenclature for Cenozoic rocks of northeast Mogollon-Datil volcanic field, New Mexico: New Mexico Bureau of Mines and Mineral Resources Stratigraphic Chart 1.

Petty, D. M., 1979, Geology of the southeastern Magdalena Mountains, Socorro County, New Mexico [M.S. thesis]: Socorro, New Mexico Institute of Mining and Technology, 174 p.

Simon, D. E., 1973, Geology of the Silver Hill area, Socorro County, New Mexico [M.S. thesis]: Socorro, New Mexico Institute of Mining and Technology, 107 p.

Socorro Bullion, 1885, Pueblo district: v. 3, #2, p. 4.

, 1889, Socorro, NM: v. 7, #18, 7/30/1889, p. 3.

, 1891, The Socorro Tunnel Company: v. 9, #22, 9/1/1891, p. 3, 7.

Soule, J. H., 1956, Reconnaissance of the "red bed" copper deposits in southeastern Colorado and New Mexico: U.S. Bureau of Mines Information Circular 7740, 74 p.

Spradlin, E. J., 1975, Geologic map and sections of the Joyita Hills area, Socorro County, New Mexico [M.S. thesis]: Albuquerque, University of New Mexico, 73 P.

Sumner, W., 1980, Geology of the Water Canyon-Jordan Canyon areas, Socorro County, New Mexico [M.S. thesis]: Socorro, New Mexico Institute of Mining and Technology, 152 p.

Wheeler, G. M., 1875, Geographical and geological explorations and surveys west of the 100th Meridian, v. 3, Geology: Washington, D.C., U.S. Government Printing Office, 681 p.

Wilkinson, W. H., 1976, Geology of the Cat Mountain-Tres Montosas area, Socorro County, New Mexico [M.S. thesis]: Socorro, New Mexico Institute Mining and Technology, 169 p.

Wilpolt, R. H., MacAlpin, A. J., Bates, R. L., and Vorbe, G., 1954, Geologic map and stratigraphic sections of Paleozoic rocks of Joyita Hills, Los Pinos Mountains and northern Chupadera Mesa, Valencia, Torrence, and Socorro Counties, New Mexico: U.S. Geological Survey Oil and Gas Investigations Preliminary Map 61.