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Summary of the mineral resources in the San Andres Mountains, south-central New Mexico

V. T. McLemore

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New Mexico Geological Society Guidebook, 53rd Field Conference, Geology of White Sands, 2002, p. 339-352.

MINERAL RESOURCES OF THE NORTHERN AND CENTRAL SAN ANDRES MOUNTAINS, WHITE SANDS MISSILE RANGE, NEW MEXICO

VIRGINIA T. McLEMORE

New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, NM 87801, ginger@gis.nmt.edu

ABSTRACT.—There are four types of deposits in northern and central San Andres Mountains (Rio Grande rift (RGR), copper-silver (± uranium) vein, vein and replacement deposits in Proterozoic rocks, and Proterozoic talc deposits) in five districts: Mockingbird Gap, Salinas Peak, Grandview-Sulfur Canyons, San Andrecito-Hembrillo, and San Andres Canyon districts. All of these districts are on the White Sands Missile Range and have been withdrawn from mineral entry since the 1940s. It is estimated that <$53,000 worth of Au, Ag, Cu, Zn, Pb, Bi, W, Fe, barite, fluorite, and talc were produced from the five districts in 1900–1948.

INTRODUCTION

The San Andres Mountains are in south-central New Mexico and cover portions of Socorro, Sierra, and Doña Ana Counties. Mineral deposits are scattered throughout the mountain range, but have not been active since the withdrawal from mineral entry in the 1940s to create the White Sands Missile Range. This paper summarizes the geology, geochemistry, and mineral production of the mineral deposits in five mining districts in the northern and central San Andres Mountains (Fig. 1, Table 1). Detailed geology and stratigraphy of the districts are described elsewhere in this volume and in cited references. This work is part of ongoing studies of mineral deposits in New Mexico that include updates and revisions of prior work by Lasky (1932), Dunham (1935), North and McLemore (1986, 1988), McLemore (1988, 1994, 1998, 2001), McLemore et al. (1996), and Bartsch-Winkler (1997).

Mineral production since the late 1800s is listed by district in Tables 1, 2, and 3. Mining and production records are generally poor, particularly for the earliest times and many early records are conflicting. These production figures are the best data available and were obtained from published and unpublished sources (New Mexico Bureau of Geology and Mineral Resources, NMBGMR file data). However, production figures are subject to change as new data are obtained.

METHODS

The first step in this project was to inventory and compile data, both published and unpublished, on existing mines and mills within the northern and central San Andres Mountains, including a literature search and compilation of unpublished file data. Mineralized areas were examined and sampled in 1994–1996; sample locations and descriptions are listed in Appendix 1.

TYPES OF DEPOSITS

There are four types of deposits in northern and central San Andres Mountains: 1) Rio Grande rift (RGR), 2) copper-silver (± uranium) vein, 3) vein and replacement deposits in Proterozoic rocks, and 4) Proterozoic talc deposits. A brief description of each type is in Table 4; more detailed descriptions are by Cox and

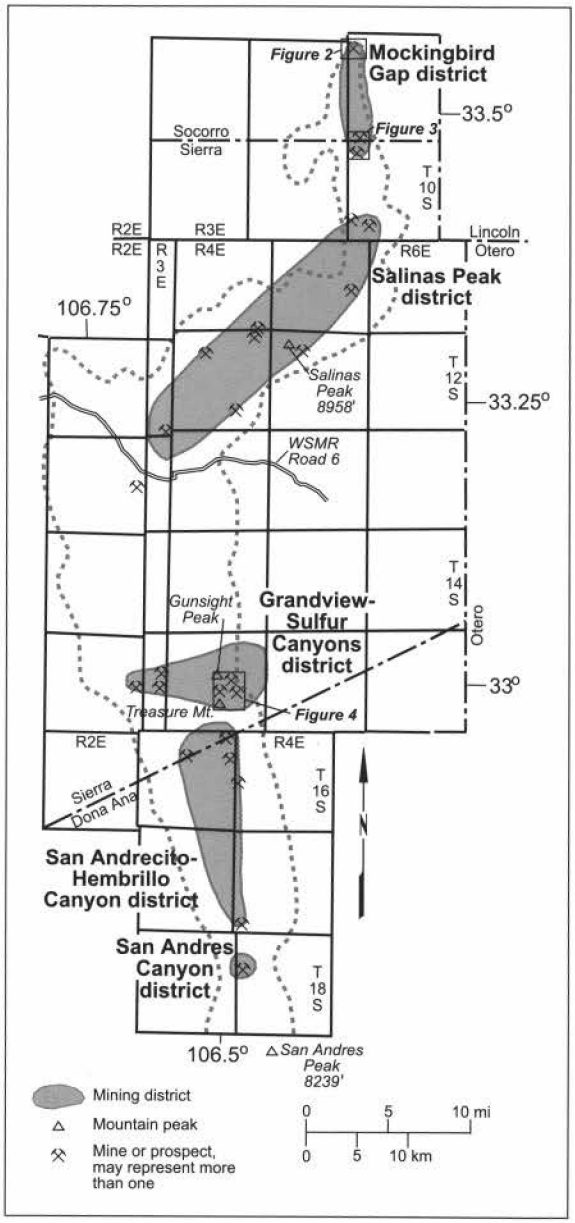


FIGURE 1. Mining districts in the northern and central San Andres Mountains.

TABLE 1. Mining districts in the northern and central San Andres Mountains, New Mexico. Names of districts are after File and Northrop (1966) wherever practical, but many districts have been combined and added. Estimated value of production is in original cumulative dollars and includes all commodities in the district, except aggregate (sand and gravel) and dimension stone. Type of deposit after North and McLemore (1986, 1988) and McLemore (2001). Production data modified from Lindgren et al. (1910), Anderson (1957), McLemore (1994), McLemore et al. (1996), U. S. Geological Survey (1902–1927), U. S. Bureau of Mines (1927–1990), and New Mexico State Mines Inspector (1912–1982).

District or coal field (aliases)	Year of discovery	Years of production	commodities produced (present)	Estimated cumulative value of production (in original dollars)	Type of deposit
Mockingbird Gap	1900	1934–1941	Ag, Pb, Ba, F (Cu, Zn)	4,000	Rio Grande Rift, veins and replacements in Proterozoic rocks, copper-silver veins
Salinas Peak (Good Fortune Creek, Bearden Canyon)	1655	1935–1948	Au, Ag, Cu, Pb, Zn, F (Mo, Bi, Ba)	<5,000	Rio Grande Rift
Grandview-Sulphur Canyons	1896	1907–1920	Au, Ag, Cu, Zn, Pb, Bi, W, Fe (Mo,Mn)	<20,000	veins and replacements in Proterozoic rocks, Rio Grande Rift
San Andrecito-Hembrillo (Membrillo, Capital Peak, Red Rock, Green Crawford)	1890s	1914, 1915, 1918,1920–1930	Cu, Ag, Pb, talc (Ba, F, Fe, W?)	23,000	Rio Grande Rift, veins and replacements in Proterozoic rocks, talc
San Andres Canyon (Capital Peak)	1900	1900–1904	Cu, Pb (Ag, Ba, F)	<1,000	Rio Grande Rift

TABLE 2. Reported and estimated base and precious metals production by district in the northern and central San Andres Mountains, New Mexico. — no reported production. W withheld or not available. ( ) estimated data. Production data modified from Lindgren et al. (1910), Anderson (1957), McLemore (1994), McLemore et al. (1996), U. S. Geological Survey (1902–1927), and U. S. Bureau of Mines (1927–1990).

District	Years of production	Ore (short tons)	Copper (lbs)	Gold (oz)	Silver (oz)	Lead (lbs)	Zinc (lbs)	Estimated value ($)
Mockingbird Gap	1934–1941	833	—	—	117	71,200	—	3,949
Salinas Peak	1935–1948	530	100	1	308	72,700	10,000	<5,000
Grandview-Sulphur Canyons	1907–1920	—	W	W	17	W	—	<20,000
San Andrecito-Hembrillo	1914 –1930	—	(<10,000)	—	(<100)	W	—	10,000
San Andres Canyon	1900–1904	—	(<10,000)	—	—	W	—	<10,000

TABLE 3. Other mineral production by district in the northern and central San Andres Mountains, New Mexico.

District	Mine	Years of production	Production	Reference
Salinas Peak	Lava Gap	1926	25 tons fluorite	Williams (1966), McAnulty (1978)
Grandview-Sulphur Canyons	Pioneer	1908, 1911, 1918	1,500 lbs 70.2% Bi	Lasky (1932)
Grandview-Sulphur Canyons	Pioneer	1907–1920	20,000 lbs tungsten	Dale and McKinney (1959), Hobbs (1965)
Grandview-Sulphur Canyons	St. Lawrence	1913	62.6 tons of 28.8–48% Fe	
San Andrecito- Hembrillo	Hembrillo Canyon	1920–1930 1942–1945	10,000 tons of talc 2,602 tons of talc	Chidester et al. (1964), Fitzsimmons and Kelly (1980)

TABLE 4. Descriptions of types of mineral deposits found in the northern and central San Andres Mountains, New Mexico.

Type of deposit	Description	Mineralogy	Perceived age (Ma)	References
Rio Grande Rift (RGR)	Low temperature, open-space fillings with little or no replacement and are not obviously associated with any magmatic activity. Found within or near the Rio Grande rift.	barite, fluorite, galena, local silver, copper, zinc, vanadium and molybdenum minerals	late Miocene to Pliocene	McLemore and Barker (1985), McLemore and Lueth (1996), McLemore et al. (1998)
Copper-silver (± uranium) vein deposits	Veins formed at low temperatures, near the surface, and along Tertiary faults, possibly as a result of dewatering of rift basins and may be similar in origin as the Rio Grande Rift deposits (formerly called supergene-copper-uranium (silver) deposits by North and McLemore (1986)).	Variable, but malachite, azurite, other copper minerals, iron oxides, calcite, silver minerals, and quartz are common to most deposits. U, Pb, Zn, Co, Ni, Ge minerals and minor amounts of Au found locally in small quantities.	late Miocene to Pliocene	North and McLemore (1986), McLemore (1999, 2001)
Vein and replacement deposits in Proterozoic rocks	Vein and replacement deposits are found along faults, fractures, shear zones, and contact zones within Proterozoic granitic and metamorphic rocks.	Malachite, chalcopyrite, chalcocite, azurite, gold, silver minerals, iron oxides, quartz common to most deposits.	Proterozoic or younger	North and McLemore (1986), Williams and Bauer (1995)
Proterozoic talc	Lenticular masses of talc and talc-quartz-phyllite hosted by metamorphic rocks.	Talc, quartz	Proterozoic	Chidester et al. (1964), Fitzsimmons and Kelly (1980)

Singer (1986), North and McLemore (1986, 1988), McLemore and Lueth (1996), Bartsch-Winkler (1997), McLemore et al. (1998), and McLemore (2001).

DESCRIPTION OF MINING DISTRICTS

Mockingbird Gap district

The Mockingbird Gap district is in the northern San Andres range in Sierra and Socorro Counties (Fig. 1). The Mockingbird Gap district, discovered about 1900, contains three types of deposits: RGR, copper-silver veins, and vein and replacement deposits in Proterozoic rocks. Reported production from the district in 1934–1941, amounts to 833 short tons of ore containing 117 oz Ag and 71,200 lbs Pb from RGR barite-fluorite-galena deposits (Table 5; North, 1983).

The majority of the deposits in the Mockingbird Gap district are RGR barite-fluorite-galena (± silver and copper) deposits along north-trending faults and as stratabound deposits in limestones. They are typically small, low grade, and uneconomic. Past production generally involved hand-sorting mining methods. Numerous undeveloped occurrences of barite, fluorite, galena, and malachite are found locally along silicified faults (Bachman, 1968), but typically are small and low grade. Gangue minerals include quartz, calcite, and iron oxides.

TABLE 5. Production from the Mockingbird Gap district, Socorro and Sierra Counties (from U. S. Geological Survey, 1902–1927, U. S. Bureau of Mines, 1927–1990).

Year	Ore (short tons)	Silver (oz)	Lead (lbs)	Value $
1934	4	6	4,500	170
1939	18	18	10,100	487
1941	811	93	56,600	3,292
TOTAL	833	117	71,200	3,949

TABLE 6. Chemical analyses of samples from the Mockingbird Gap district, Socorro and Sierra Counties. Selected samples are located in Figures 2 and 3. Analyses of Cu, Pb, and Zn by FAAS (after *aqua regia* digestion) and Ag, Sb, and As by ICP and Au by INNA. —no data.

Sample No.	Mine	Au ppb	Ag ppm	Mo ppm	Cu (ppm)	Pb (ppm)	Zn (ppm)	Sb ppm	As ppm
MG1	Independence	47	19	7	49	47,185	36,000	15	<0.5
NMG1	Independence	9	11	7	46	41,605	38,000	14	<0.5
NMG2	Independence	21	<5	14	47	10,731	34,000	2.5	3.2
MG3	Independence	5	<5	<1	19	474	10,500	0.9	1.3
NMG3	Independence	10	<5	<1	18	5928	430	1.4	<0.5
MG4	Independence	45	6	<1	87	19,049	2500	3.3	<0.5
NMG4	Independence	19	30	7	39	37,669	17,000	4.7	<0.5
MG18	Independence	<70	<0.7	—	20	39,000	9800	—	—
MG5G	Mockingbird Gap	57	<5	54	10,000	487	640	8.2	63
MG5W	Mockingbird Gap	21	<5	<1	6786	33	22	0.5	3
NMG5	Mockingbird Gap	25	<5	<1	>10,000	335	430	4.9	22
MG6	Mockingbird Gap	5	<5	4	1590	182	57	1.1	1
NMG6	Mockingbird Gap	<2	<5	<1	534	41	120	0.5	2.2
MG7	Mockingbird Gap	<2	<5	<1	2471	34	260	0.2	<0.5
NMG7	Mockingbird Gap	<2	<5	4	2977	448	110	0.3	0.8
MG8	Mayday	13	<5	26	590	250	23	0.2	1
MG11	5, T10S, R5E	7	<5	<1	5113	1347	1200	1	14
MG12	Wildhorse	12	<5	10	82	2869	3400	4.7	24
MG13	Wildhorse	3	11	3	419	49,378	2500	11	2.5
MG14	33, T8S, T5E	<70	<0.7	—	1900	13,000	230	—	—
MG15	33, T8S, T5E	<70	<0.7	—	140	67,000	2200	—	—
MG16	4, T9S, R5E	<70	<0.7	—	3200	150	47	—	—
MG19	Unknown (25, T9S, R4E)	<70	<0.7	—	630	330	32	—	—
MG20	Unknown (25, T9S, R4E)	68	9.6	—	130	1600	2000	—	—

Two styles of RGR mineralization are found at the mines in district: fault-controlled and stratabound deposits. Deposits along the northern San Andres Mountains, including the Independence mine, occur along the main north-trending range fault between brecciated granite and limestones of the Yeso Formation (Fig. 2). The fault-controlled deposits at the Independence mine are developed by two shafts, 114 and 80 ft deep, 2 short adits, and several pits. The main shaft has drifts at 50-ft levels, with underground development totaling 175 ft (Lasky, 1932). The fault strikes north-south and dips 65–75°E. Only the limestone is mineralized and contains barite, fluorite, galena, and sphalerite, in a gangue of calcite, quartz, and iron and manganese oxides. Galena and sphalerite have been oxidized to cerussite, anglesite, and smithsonite (Lasky, 1932; North, 1983). The mineralized zone is approximately 4–20 ft wide and as much as 500 ft long. At least three pods or lenses of mineralized and brecciated limestone are exposed along an arroyo in a downdropped block of Yeso Formation (Fig. 2). The northern dump contains abundant barite, sphalerite, galena, cerussite, anglesite, and trace fluorite in a gangue of calcite and quartz. Barite is the predominant mineral in the southern pods. Silicification of the limestone is common. The pods are approximately 10–30 ft wide and at least 50–100 ft long. Two carloads of ore were shipped about 1920 that assayed 2% Pb, 10% Zn, 343 ppm Ag, and a trace of gold (Lasky, 1932). Sample assays are in Table 6. Holes drilled in 1986–1987 indicate that lead is more prominent at the surface, whereas zinc is more prominent at depth (Table 7). The drill data indicate a resource of 353,426 short tons of 0.67% Pb, 0.9% Zn, 2.06 ppm Ag, and 23.8% $BaSO_4$ to a maximum depth of 120 ft (C. T. Smith, unpublished report, 1987).

Farther east in section 4, T9S, R5E, and section 33, T8S, R5E a 30-ft shaft and trenches have exposed brecciated Madera Group limestone that contains a small pod of coarsely crystalline barite, galena, and fluorite with quartz and calcite. This RGR deposit is approximately 6 ft thick, 10 ft wide, and 20 ft long. Barite blades are as much as 3 inches long and galena and fluorite cubes are as much as 1 inch across. An inclined shaft at least 50 ft deep developed a second pod. Material on the dump contains abundant malachite, azurite, brochantite, barite, and fluorite in a gangue of calcite and quartz. Galena is rare in this pod. A sample assayed 3 ppb Au, 11 ppm Ag, and 49,378 ppm Pb (Table 6, #MG14–17). Silicification of the limestone is common.

The Mayday deposits, west of the Mockingbird Gap mine in Johnson Park Canyon, consists of a 100 ft shaft, short adits, and numerous pits along north-trending faults between Lead Camp Limestone and Sandia Formation (Fig. 3). This RGR deposit consists of barite, fluorite, azurite, malachite, and chalcocite in

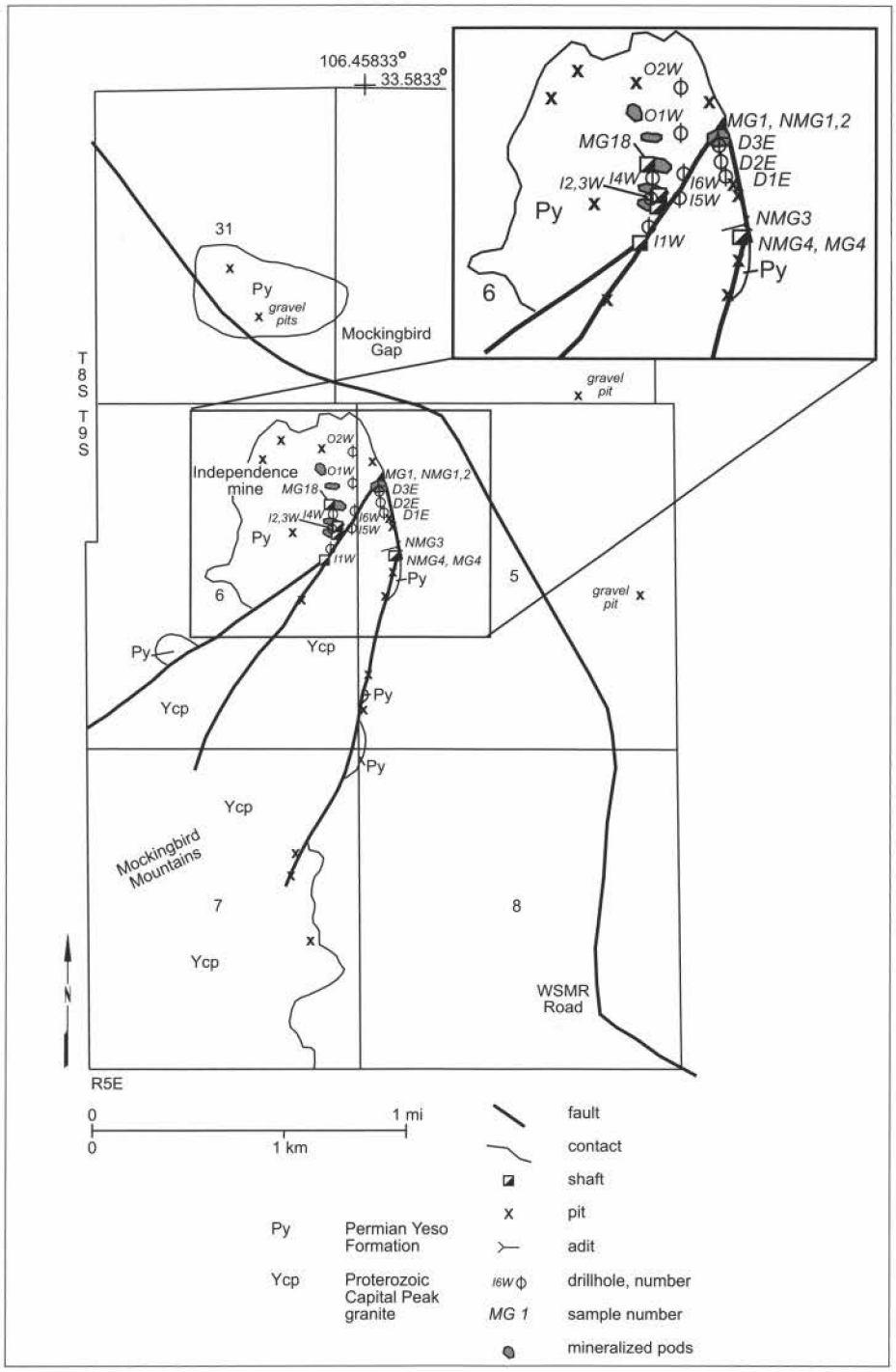


FIGURE 2. Mines, drillholes, and geology at the Independence mine area, northern Mockingbird Gap district, San Andres Mountains. Geology modified from Bachman (1968) and Condie and Budding (1979). Drillhole data is in Table 7.

a gangue of calcite, quartz, and clay. The zone strikes N10°E, dips steeply, is 5–9 ft wide, and is at least 100 ft long. A sample assayed 90.6% Ca F_2 and 1% $BaSO_4$ (Williams, 1966). A sample collected in 1996 contained 13 ppb Au and low metals (Table 6, #MG8). Additional RGR deposits are found scattered throughout the district, but are small, low grade, and discontinuous (Table 6, #MG19–20, Wildhorse—MG12–13).

Copper-silver veins at the Mockingbird Gap mine, the largest mine in the district and approximately 8-km south of Mockingbird Gap proper, are fault-controlled and found along and at the intersection of two faults and the unconformity between the Proterozoic granite and Bliss Sandstone (Fig. 3). These deposits were previously considered Proterozoic deposits (North and McLemore, 1986), but the mineralized zones clearly extend into the overly-

TABLE 7. Summary of drillhole data from the Independence claims, Mockingbird Gap district (Smith, C. T., unpublished report, 1987). Not all assay data are shown. nd—not detected. Au and Ag were by fire assay and Pb, Zn, and Ba were by FAAS. Drillhole locations shown in Figure 2.

Drill hole no.	Collar Elevation (ft)	Total Depth (ft)	Bearing	Inclination	Interval (ft)	Au (ppb)	Ag (ppm)	Pb%	Zn%	$BaSO_4$%
D1E	5135	259	109°	-60.5°	174–182	6.8	94.6	0.99	0.89	3.5
D2E	5131	203.7	235°	-30.5°	163.7–172	nd	nd	1.14	5.91	24.1
D3E	5130	92	255°	-42°	85–90	3.4	1.4	0.12	0.36	15.0
O1W	5164	159	74°	-37.5°	122–135	—	1.7	0.14	0.45	13.7
O2W	5151	85	61°	-38.5°	76–81	—	2.7	0.80	0.47	7.2
O2WA	5152	285	56°	-55°	71–73	—	3.4	0.11	0.47	11.0
I1W	5234	170	79°	-54°	70.5–74	—	1.0	0.55	0.37	12.3
I2W	5222	71	90°	-56°	—	—	—	—	—	—
I2WA	5222	47	90°	-56°	125–136.7	—	8.6	0.30	0.55	13.0
I2WB	5222	118.4	124°	-50°	104–108	—	19.5	0.09	0.3	18.7
I3W	5212	140	130°	-44°	122.5–126.3	—	36.0	0.66	2.07	13.7
I4W	5194	142	127°	-55°	12–17	—	1.7	0.09	0.58	15.0
I5W	5189	157.9	72°	-30°	89–99	nd	0.3	0.14	0.13	15.3
I6W	5187	176.5	74°	-30°	169–175	—	4.1	0.20	0.56	12.3

ing Bliss Sandstone. Workings consist of a 150-ft adit, two 50-ft shafts, and several pits. Production is unknown. The mineralized fault strikes N15–25°W and dips 60–85°E and is intersected by a second, unmineralized fault, which strikes N0–10°E, with a vertical dip. The unconformity between the brecciated Proterozoic granite and hematite-bearing Bliss quartz sandstone is exposed at the portal of the adit. The sandstone strikes N5°W and dips 25°W. Ore minerals include malachite, azurite, chrysocolla, fluorite, barite, and chalcocite in a gangue of quartz, calcite, and iron and manganese oxides. Native copper and cuprite have been reported (Lasky, 1932; North, 1983). The mineralized zone is 4–10 ft wide and approximately 200 ft long. A selected sample assayed 82.9% CaF_2 (Williams, 1966). Samples collected in 1996 assayed as much as 57 ppb Au and >10,000 ppm Cu (Table 6, #MG5G, 5W, 6–7, NMG5–7). Thin zones (less than a foot thick) of glauconitic sandstone and shale in the Bliss Sandstone are unmineralized, in contrast to the Bliss-hosted deposits at the Virginia mine in the Bent district, Otero County (McLemore, 2001).

Veins and replacements in Proterozoic rocks are found scattered throughout the Proterozoic granite in the Mockingbird Gap Mountains. The deposits are small and were developed by shallow pits and short adits with little, if any production. The deposit in section 26, T9S, R4E consists of a mineralized shear zone and quartz veins that strike N35°E and dip steeply. Prospect pits (3–10 ft deep) have exposed the mineralized shear zone that contains predominantly quartz, chlorite, and iron oxides with trace amounts of pyrite, malachite, and chalcopyrite. Cuprite and native copper are reported (Lasky, 1932). The zone is less than 5 ft wide and 50 ft long.

Salinas Peak mining district

The Salinas Peak district includes the area from Capital Peak southward to Rhodes Canyon (Fig. 1) and was first prospected in 1655 (File and Northrup, 1966), but recorded production wasn't until 1935–1948. During 1935–1948, 530 tons of ore containing 100 lbs Cu, 1 oz Au, 308 oz Ag, 72,700 lbs Pb, and 10,000 lbs Zn was produced (Table 2). All of the deposits within this district are RGR barite-fluorite-galena deposits.

Several adits have developed small mineralized pods containing barite, fluorite, galena, azurite, malachite, and anglesite in a gangue of quartz, calcite, and iron oxides at the Salinas Peak mines. Many of the mineralized pods follow a series of en echelon faults that strike N85ºE–N80ºW and dip 55–45ºN. Some mineralized pods are along bedding planes. A selected sample assayed 0.3 ppm Ag, 0.41% Pb, 7.83% CaF_2, and 77.04% $BaSO_4$ (L. S. Clemmer and B. Sibbet, unpublished report, 1974); additional assays are in Table 8 (#SP1–7).

The Good Fortune mine consists of a 20 ft shaft, a 60 ft shaft, and several pits. A rhyolite sill intruded the Paleozoic limestones near the mine, but the RGR mineralization occupies breccia that cuts the sill and is, therefore, not related to the intrusive activity. One sample assayed 138,000 ppm Zn (Table 8, #GF1–2).

The Lava Gap (Baso Four) mine consists of a 60-ft shaft and shallow trenches that expose a fissure replacement deposit containing fluorite, barite, and calcite in cherty limestone. The deposit is 2–5 ft wide and approximately 3000 ft long. A sample assayed 86.1% CaF_2, 8.4% $BaSO_4$, 3% $CaCO_3$, and 0.4% SiO_2 (Johnston, 1928); additional assays are in Table 8. In 1926, 25 tons of fluorite was produced from the mine (Table 3).

The Sam Hall claims (NE9, T12S, R5E) consist of pits, trenches, an 80-ft vertical shaft, and two inclined shafts that expose a 3-ft wide vein in Proterozoic granite. The vein contains galena, fluorite, and sphalerite in a gangue of quartz and Fe oxides. Assays range from undetectable to 0.3 ppm Au, 8.2 to 111 ppm Ag, 0.37 to 16.7% Pb, undetectable to 0.11% Cu, and 2.35 to 16.2% Zn (John Goldstein, unpublished report, March 15, 1973).

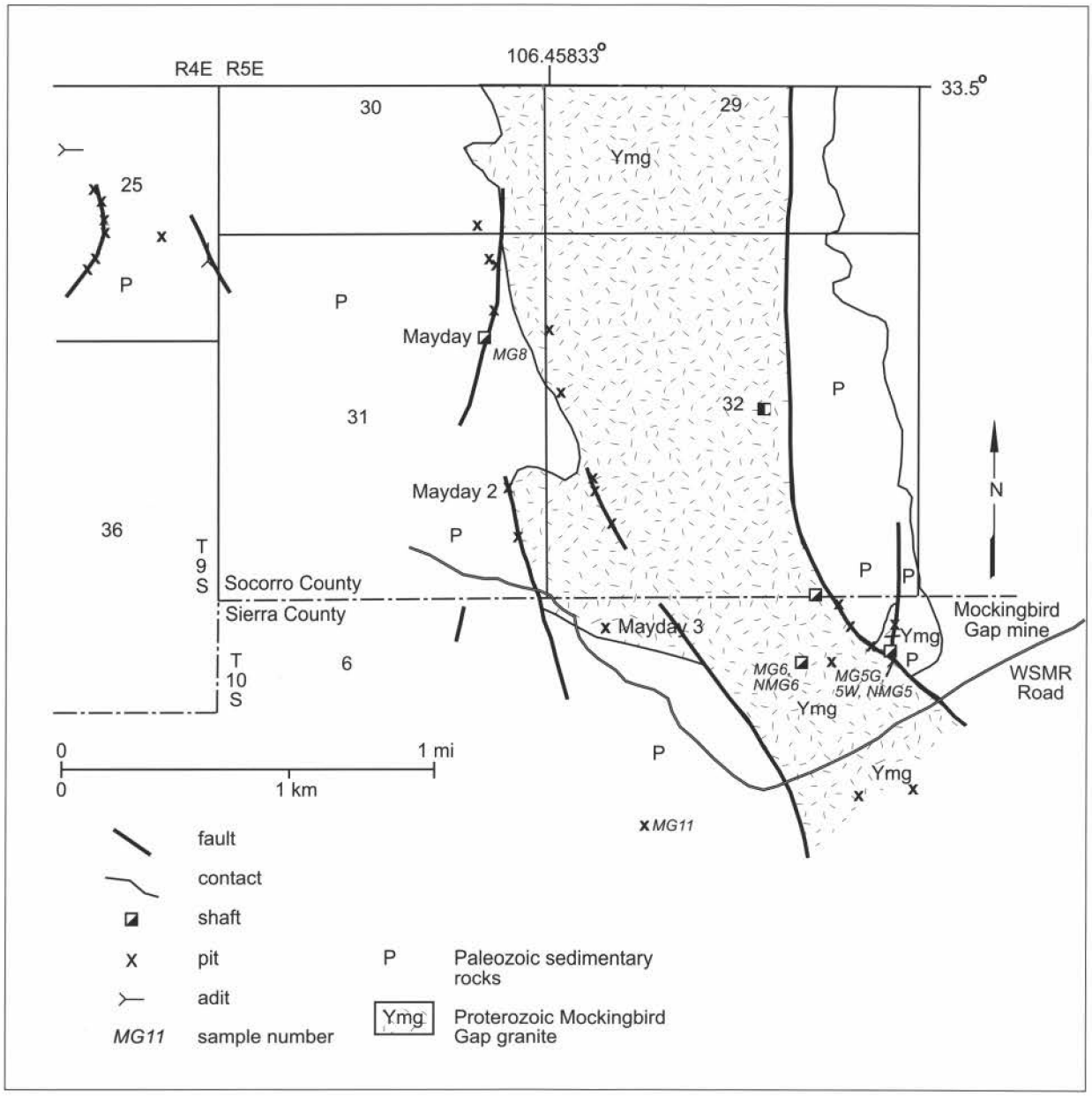


FIGURE 3. Mines and simplified geology at the Mockingbird mine, Johnson Park Canyon, southern Mockingbird Gap district, San Andres Mountains. Geology modified from Bachman (1968) and Condie and Budding (1979).

Small RGR deposits are found in Bear Den Canyon, including the Black Bear deposit. Lens or pod shaped mineralized bodies of barite, fluorite, galena, anglesite, and malachite in a gangue of quartz, calcite, and pyrite are found along bedding planes in Paleozoic limestone. Silicified limestone surrounds the mineralized bodies. Samples assayed as much as 127 ppb Au, 13 ppm Ag, and 46,313 ppm Pb (Table 8, #BB1–4).

Additional small RGR barite-fluorite deposits are found scattered throughout the district. A shallow pit exposes a small bedded barite-galena pod near Capital Peak; assays are low (Table 8, #CP5). At the Section 29 prospect, barite-fluorite-galena deposits are found along a fault that strikes N25°E and dips 50°W; one sample contained 14,649 ppm Cu (Table 8, #CP1–2). Molybdenite and ferrimolybdite are reported to occur in Taylor Canyon (Northrop, 1959; Schilling, 1965).

Grandview–Sulphur Canyons mining district

Proterozoic vein and replacement and RGR barite-fluorite-galena deposits are found in the Grandview-Sulphur Canyons district, which includes Grandview, Sulphur, Ash, and Workman Canyons in the San Andres Mountains (Fig. 1). Although the district was discovered in 1896 (Lasky, 1932), total production from the district has amounted to less than $20,000 of copper, gold, silver, lead, tungsten, and bismuth. Approximately 20,000 lbs of tungsten was produced from Grandview Canyon in 1907–1920

TABLE 8. Chemical analyses of samples from the Salinas Peak district, Sierra County. Analyses of Cu, Pb, Zn, Ag, Mo, and As by ICP and Au by INNA.

Sample No.	Mine	Au ppb	Ag ppm	Mo ppm	Cu (ppm)	Pb (ppm)	Zn (ppm)	As ppm
SP1	36 ,T11S, R4E	13	37	<1	829	41,053	4600	7.7
SP2	36 ,T11S, R4E	9	12	51	6330	49,481	210	7.3
SP2	36 ,T11S, R4E	12	34	4	2018	43,050	190	7
SP3	36 ,T11S, R4E	80	<5	43	299	4340	58,000	4.3
SP4	36 ,T11S, R4E	<2	<5	12	126	944	1700	4.8
SP4	36 ,T11S, R4E	<2	42	6	569	39,600	410	0.7
SP5	36 ,T11S, R4E	10	<5	31	252	4422	10,000	13
SP6	Salinas Peak	123	62	<1	297	40,924	490	2.5
SP7	Salinas Peak	10	8	120	127	30,417	2100	16
SP7	Salinas Peak	10	7	89	151	28,869	2000	14
CP1	Capital Peak	<2	<5	28	5709	11,532	170	6.9
CP1	Capital Peak	<2	<5	26	13,895	2180	170	11
CP2	Capital Peak	7	<5	<1	86	612	<50	2
CP3	Capital Peak	<2	<5	9	14,649	548	330	1.6
CP5	7, T9S, R5E	<2	<5	27	258	727	64	1.6
GF1	Good Fortune	<2	7	26	21	44,621	1070	1.6
GF1	Good Fortune	18	<5	<1	11	42,170	5600	2.3
GF2	Good Fortune	<2	<5	<2	28	14,825	138,000	<0.5
GF2s	Good Fortune	16	16	<1	23	40,826	2900	<0.5
BB1	Black Bear	9	<5	5	339	16,420	3300	1.7
BB1	Black Bear	5	<5	0.6	304	16,497	4700	1.4
BB2	Black Bear	<2	<5	22	217	7438	20,000	1.8
BB2	Black Bear	17	<5	14	361	39,296	3500	3.2
BB3	Black Bear	119	<5	19	1330	5880	280,000	10
BB4	Black Bear	127	13	18	2096	46,313	94,000	2.1
BB4	Black Bear	152	<5	<1	2988	1518	170,000	<0.5

from vein and replacement deposits in Proterozoic rocks (Dale and McKinney, 1959). In 1918, 1,500 lbs of ore containing 70.2% WO_3 and some gold and silver were shipped from the Pioneer claim (Lasky, 1932). In addition, George Stone produced mineral specimens of bismutite from the claims in the early 1900s.

Tungsten and bismuth are found in Grandview Canyon at the Pioneer, Greenback, Grandview, Pioneer Junior mines and other minor prospects (Fig. 4; Lasky, 1932). Minor replacements, thin mineralized veins and seams, and fracture coatings are found along faults and shear zones occur in Proterozoic granite and schist along contacts with amphibolite dikes. The mineralized bodies consist of malachite, bornite, chalcopyrite, chalcocite, scheelite, powellite, bismutite, bismuthinite, pyrite, and quartz (Lasky, 1932; Clemmer and Holstein, 1974; NMBGMR files). Chlorite, biotite, pyrite, epidote, talc, jarosite, and iron oxides are common alteration minerals. Quartz veins and mineralized seams are typically less than a few inches wide and locally cut across the metamorphic foliation; several veins and seams occur locally in a zone up to 5 ft wide and several hundred feet long. Pods of mineralized veins and seams surrounded by unmineralized, but altered host rocks are common within these zones. The zones are steeply dipping and strike predominantly N70°W. The veins appear to thin and pinch out with depth. Assays as high as 60 ppm Ag, 6.3% Cu, 2.9% WO_3, 1.3% Bi, and no gold are reported (Clemmer and Holstein, 1974). Samples collected in 1994 assayed as much as 200 ppb Au and 11,000 ppm Bi (Table 9, #Pion 1–4). The deposits are probably Proterozoic because of the contact relationship with amphibolite dikes.

At the St. Lawrence claims in eastern Sulfur Canyon, a 70-ft shaft and 30-ft incline developed a mineralized zone containing pyrite, malachite, chrysocolla, chalcocite, and azurite (Lasky, 1932). The vein occurs in fractured and sheared Proterozoic biotite schist, strikes N20°W, dips 65°SE, is 4–10 ft wide, and is approximately 100 ft long. Three cars of ore were shipped in May–June 1913 amounting to 62.6 short tons of 178–261 ppm Ag, 9.1–18% Cu, and 28.8–48% Fe. Samples collected in 1996 assayed as much as 383 ppb Au and 260 ppm Ag (Table 9, #SC1–4). Quartz veins in Proterozoic amphibolite are found in Workman Canyon; samples assayed as much as 2 ppb Au and 12 ppm Ag (Table 9; #WORK1–2). Similar veins are found in Proterozoic rocks in Ash Canyon.

RGR deposits are found scattered throughout Paleozoic limestone in the western portion of the district in Sulfur and Hole-in-the-Wall Canyons. The deposits contain barite, fluorite, and

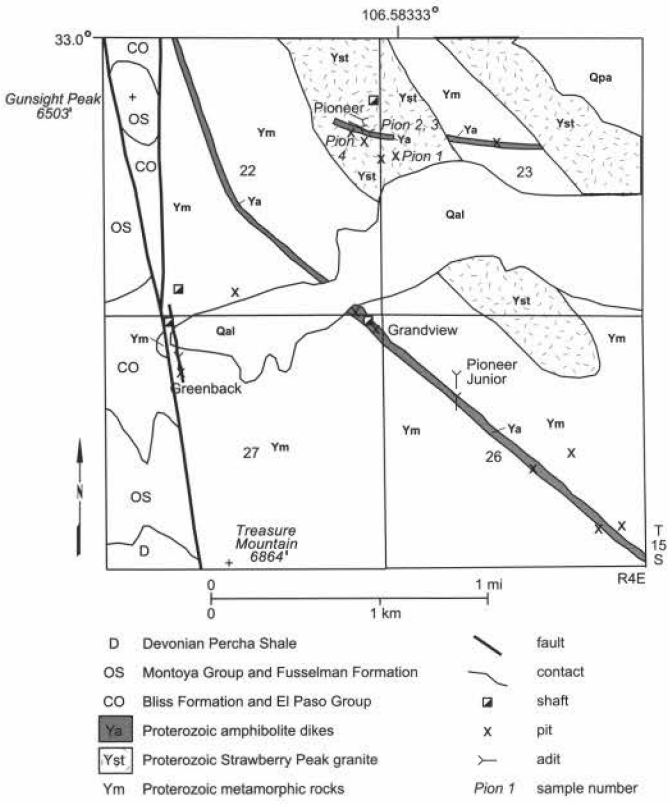


FIGURE 4. Mines in the Grandview Canyon area, Grandview–Sulphur Canyons district, San Andres Mountains. Geology modified from Seager (1994), Bachman and Harbour (1970), and Condie and Budding (1979).

varying amounts of chalcopyrite, chalcocite, galena and silver and are small and low grade. Mineralized faults, approximately 1 mi long, in sections 13, 14, and 24 T15S R3E, between Sulphur and Hole-in-the-Wall Canyons, including the American mine, contain numerous mineralized pods of barite, fluorite, galena, pyrite, malachite, and smithsonite in a gangue of quartz, calcite, and pyrite. Some fluorite cubes are as much as 2 inches in diameter. One sample assayed 496 ppb Au and 40,700 ppm Zn (Table 9, #Sul3–7, 10–12).

San Andrecito-Hembrillo mining district

Proterozoic vein and replacement, RGR, and talc deposits are found in the San Andrecito-Hembrillo district, which includes the San Andrecito, Deadman, Lost Man, Hembrillo, and Hospital Canyons (McLemore, 1994). Very little information exists on the discovery, history, or production of these small deposits. The Green Crawford and Hembrillo Canyon prospects were worked in the late 1890s or early 1900s. Additional production occurred from the Green Crawford during 1920–1930 and from the Hembrillo Canyon prospects in 1914, 1915, and 1918 (Anderson, 1957; NMBGMR file data). Total metal production from the district amounts to less than $10,000 worth of copper (<10,000 lbs), lead, and silver (<100 oz) (Dunham, 1935; NMBGMR file data). Total talc production from 1920 to 1945 was approximately 12,062 short tons (Table 3; Chidester et al., 1964; Fitzsimmons and Kelly, 1980).

The RGR barite-fluorite-galena deposits are small, but all of the reported metal production has come from them. RGR barite-fluorite-galena deposits occur in the Pennsylvanian Lead Camp Limestone and Ordovician limestones. The most extensive development is at the Green Crawford mine (NW31, T17S, R4E) and Hembrillo Canyon prospects (SE9, T16S, R3E). Prospects also are found in Hospital Canyon (SW18, T16S, R4E). Additional prospect pits are reported along veins in Lost Man Canyon (Dunham, 1935; The Mining World, April 23, 1910, p. 868).

The Green Crawford mine, in San Andrecito Canyon, consists of two adits, several prospect pits, and shallow shafts on opposite sides of the canyon. The north adit is approximately 130 ft long with a 30-ft winze and a raise. Prospect pits and a shaft also develop portions of the north vein upslope from the adit. The south adit is less than 70 ft long with a 30 ft raise. Prospect pits and trenches also expose portions of the south vein.

The deposit consists of a silicified zone, less than 3 ft wide and 100–300 ft long, which lies along two north-trending faults that cut sandstones of the Bliss Formation and limestones of the El Paso and Montoya Groups (Seager, 1994). The vein north of the canyon has a strike of N55°E and a dip of 80°E; whereas the vein south of the canyon has a strike of N25°E and a dip of 87°E. Additional veins may be present in the area, but are covered by talus material. The veins are simple fissure-fillings that consist of covellite, chalcocite, chalcopyrite, cuprite, malachite, and azurite in a gangue of quartz, calcite, iron oxides, and a trace of barite. Chalcanthite coats some walls along the adits. The host rocks have been silicified and replaced by iron oxides adjacent to the veins. A sample of ore reportedly assayed no gold, trace of silver, and 27.93% Cu (Dunham, 1935); one sample assayed 168,000 ppm Cu (Table 10, #A–F).

The Hembrillo Canyon prospects in Hembrillo Canyon consist of two shafts, 12 and 75–100 ft deep, and two shallow prospect pits. The RGR deposits may be part of the Lot OM-69 prospect described by Williams et al. (1964); however, Williams et al. (1964) places the Lot OM-69 prospect in section 10, T16S, R3E instead of section 9. The Hembrillo Canyon prospects consist of thin veins and small replacement bodies in limestones within a faulted block of Lead Camp Limestone (Seager, 1994). The deposit is less than 300 ft long and consists of galena, barite, quartz, calcite, iron oxides, and possibly traces of wulfenite. A sample of the Lot OM-69 prospect reportedly contained 77.8% $BaSO_4$, 14.8% SiO_2, and 0.3% $CaCO_3$ (Williams et al., 1964). One sample assayed 13 ppm Ag and 37,000 ppm Zn (Table 10, #Hembrillo 1, 2, VM013R, 014R).

The Proterozoic talc deposits are the most extensive deposit type in the district, they include the largest talc deposit in New Mexico, and are found in Proterozoic granite and metamorphic rocks in Hembrillo Canyon along the Sierra-Doña Ana County line (Chidester et al., 1964; Fitzsimmons and Kelly, 1980). The deposits are lens shaped and approximately 100 ft long and 8–12 ft wide. Fitzsimmons and Kelly (1980) report a reserve of 6500 short tons. Development consists of adits and pits. The central portion of the talc lenses consists predominantly of relatively pure talc. The outer part is 2–3 ft wide and consists of talc, carbonate minerals, and chlorite. The talc grades into banded quartz-

TABLE 9. Chemical analyses of samples from the Grandview-Sulphur Canyons district, Sierra County. Selected samples are located in Figure 4. Analyses of Cu, Pb, Zn, Ag, W, and Bi by ICP and Au by INNA.

Sample No.	Mine	Au (ppb)	Ag (ppm)	W (ppm)	Bi (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)
SC-1	St. Lawrence	141	40	440	92	70,550	45	170
SC-2	St. Lawrence	42	<5	51	30	31,848	38	600
SC-3	St. Lawrence	360	260	820	161	81,312	11	100
SC-3	St. Lawrence	383	260	790	158	81,215	38	110
SC-4	St. Lawrence	45	<5	93	<5	64,210	20	1000
WORK-1	Workman Canyon	2	<5	3	11	121	918	<50
WORK-1	Workman Canyon	<2	12	16	49	66	5415	<50
WORK-2	Workman Canyon	<2	<5	7	115	87	384	<50
WORK-2	Workman Canyon	<2	<5	7	185	146	1098	<50
Pion 1	Pioneer pit	<2	<2	0.5	<10	9300	29	34
Pion 2	Pioneer adit	4	<2	1.5	<10	530	26	33
Pion 3	Pioneer adit	200	9	0.15	11,000	840	140	24
Pion 4	Pioneer shaft	150	5	1.5	30	11,000	33	33
SUL01	Sulphur Canyon	5	49	<1	<5	107,365	66	<50
SUL02	Sulphur Canyon	7	50	<1	<5	119,711	7	55
SUL03	Sulphur Canyon	43	<5	<1	<5	620	2819	4890
SUL04	Sulphur Canyon	8	<5	<1	<5	501	7649	23,700
SUL05	Sulphur Canyon	9	<5	<1	<5	577	6559	30,400
SUL06	Sulphur Canyon	85	<5	<1	<5	519	15,875	21,000
SUL07	Sulphur Canyon	18	<5	<1	<5	207	2039	1910
SUL10	Sulphur Canyon	41	<5	<1	<5	101	4365	3820
SUL11	Sulphur Canyon	160	<5	9	<5	220	16,147	1550
SUL12	Sulphur Canyon	496	<5	<1	13	523	6371	40,700

chlorite phyllite and schist. Foliation of the talc is subparallel to foliation of the metamorphic rocks, indicating a Proterozoic age.

Quartz-calcite veins and replacement deposits cut Proterozoic amphibolite and are developed by prospect pits and a 15 ft shaft in SW18, T16S, R4E in Hospital Canyon. Alteration consists of hematite and local sericite. Trace amounts of malachite are present on the dump; a sample assayed no detectable gold, 16 ppm Ag, and 2600 ppm Cu (Table 10, #Hos 4). An adit was reportedly driven along a copper vein in Hospital Canyon (The Mining World, April 23, 1910, p. 868), but was not found in 1994.

Additional veins of copper and barite are reported to occur in the San Andrecito-Hembrillo district. The Kendrick copper prospect is reported to occur on the east slope of the mountains between San Andrecito and Deadman Canyons (Dunham, 1935).

San Andres Canyon mining district

The San Andres mine in the San Andres Canyon district (SE18, T18S, R4E; Fig. 1), was discovered and developed in 1900. It is developed by a 100-ft open cut, 550-ft adit with a 130-ft drift and a winze, and several pits and shafts (Dunham, 1935; Smith, 1981), but all are caved and inaccessible in 1993. A mill and smelter were erected in 1900–1904. Capacity was expected to be 100 tons per day. However, the mill and smelter were built before any reserves were delineated and the entire operation failed with very little lead and copper production (Dunham, 1935). Only the foundations are left. Approximately 10,000–12,000 short tons of ore containing 10% Pb and some copper were produced prior to construction of the mill.

The RGR deposits are small, irregular replacement bodies in Fusselman dolomite adjacent to a N15°W-trending fault that dips steeply to the west (Dunham, 1935; Bachman and Myers, 1963, 1969; Smith, 1981). The deposits are approximately 200 ft long and up to 20 ft wide (Dunham, 1935) and contain barite, quartz, minor galena, calcite, fluorite, Fe oxides, and clay. A sample assayed 2.2 ppm Ag, 170 ppm Cu, 24,000 ppm Pb, and 31 ppm Zn (McLemore et al., 1996). The deposits are characteristic of RGR deposits elsewhere in New Mexico (McLemore and Barker, 1985; North and McLemore, 1986).

SUMMARY

The Rio Grande rift (RGR), copper-silver (± uranium) vein, vein and replacement deposits in Proterozoic rocks, and Proterozoic talc deposits in five districts (Mockingbird Gap, Salinas Peak, Grandview–Sulfur Canyons, San Andrecito-Hembrillo, San Andres Canyon) in the northern and central San Andres Mountains are small, discontinuous, low grade, and uneconomic. The

TABLE 10. Chemical analyses of samples from the Green Crawford, Hospital Canyon, and Hembrillo Canyon mines. Analyses of Cu, Pb, Zn, and Hg by FAAS (after *aqua regia* digestion), Hg by cold vapor AA, and As and Ag by ICP. —no data. Gold was less than 20 ppm in all samples.

Sample No.	Mine	As (ppm)	Ag (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Hg (ppm)
A (VM001R)	Green Crawford	190	<4	11,000	68	48	<0.10
B (VM002R)	Green Crawford	240	<4	5100	31	18	<0.10
C (VM003R)	Green Crawford	200	<4	20,000	14	7	0.78
D (VM004R)	Green Crawford	260	12	163,000	52	28	0.44
E (VM005R)	Green Crawford	<20	<4	3200	34	29	0.15
F (VM006R)	Green Crawford	<20	22	178,000	68	49	<0.10
Hos 2	Hospital Canyon	11	<2	<50	310	61	<0.02
Hos 3	Hospital Canyon	12	<2	<50	89	100	<0.02
Hos 4	Hospital Canyon	12	16	2600	1200	280	—
Hospital	Hospital Canyon	<20	<4	<50	14	<50	—
Hembrillo 1	Hembrillo Canyon	—	13	1400	37,000	79	—
VM013R	Hembrillo Canyon	<20	<4	580	42,000	<50	—
Hembrillo 2	Hembrillo Canyon	—	<2	1600	16,000	1700	—
VM014R	Hembrillo Canyon	<20	<4	250	35,000	80	—
SA009R	Hembrillo Canyon	<20	11	2200	152,000	85	—

mineral-resource potential of these deposits is low and they will not be developed in the foreseeable future, because they are on the White Sands Missile Range and withdrawn from mineral entry.

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APPENDIX 1. Sample location and description.

Sample No.	Latitude	Longitude	Mine	Sample description
MG1	33.56476	106.458279	Independence	dump
NMG1	33.56476	106.458279	Independence	dump
NMG2	33.56476	106.458279	Independence	dump
MG3	33.56175	106.456834	Independence	dump
NMG3	33.56175	106.456834	Independence	dump
MG4	33.56182	106.457081	Independence	dump
NMG4	33.56182	106.457081	Independence	dump
MG18	33.564151	106.460402	Independence	limestone, dump
MG5G	33.477841	106.442629	Mockingbird Gap	dump
MG5W	33.477841	106.442629	Mockingbird Gap	dump
NMG5	33.477841	106.442629	Mockingbird Gap	dump
MG6	33.47762	106.446765	Mockingbird Gap	dump
NMG6	33.47762	106.446765	Mockingbird Gap	dump
MG7	33.478251	106.442799	Mockingbird Gap	dump
NMG7	33.478485	106.443377	Mockingbird Gap	dump
MG8	33.490096	106.461321	Mayday	5 ft chip
MG11	33.47132	106.453751	5, T10S, R5E	road cut
MG12	33.4412	106.4660	Wild Horse	limestone, outcrop
MG13	33.4412	106.4660	Wild Horse	pod of galena, fluorite
MG14	33.5716	106.4322	33, T8S, T5E	limestone, dump
MG15	33.5688	106.4320	33, T8S, T5E	limestone, 6 ft chip
MG16	33.5677	106.4317	4, T9S, R5E	limestone, dump
MG19	33.503284	106.487630	Unknown (25, T9S, R4E)	granite, dump select
MG20	33.502968	106.488199	Unknown (25, T9S, R4E)	granite, dump select
SP1	33.3131	106.5513	36 ,T11S, R4E	dump
SP2	33.31234	106.55215	36 ,T11S, R4E	dump (McLemore)
SP2	33.31234	106.55215	36 ,T11S, R4E	dump (Marsh)
SP3	33.31358	106.54983	36 ,T11S, R4E	grab of rib
SP4	33.31358	106.54983	36 ,T11S, R4E	shale along rib
SP4	33.31358	106.54983	36 ,T11S, R4E	rib (Marsh)
SP5	33.31358	106.54983	36 ,T11S, R4E	clay below ore
SP6	33.30825	106.56596	Salinas Peak	dump
SP7	33.30825	106.56596	Salinas Peak	5 ft chip
SP7	33.30825	106.56596	Salinas Peak	5 ft chip (duplicate)
CP1	33.404655	106.442442	Capital Peak	3 ft chip
CP1	33.404655	106.442442	Capital Peak	dump
CP2	33.405347	106.442003	Capital Peak	dump
CP3	33.405347	106.442003	Capital Peak	dump
CP5	33.42408	106.44747	7, T9S, R5E	limestone, 4 ft chip
GF1	33.29016	106.61810	Good Fortune	grab of dump (McLemore)
GF1	33.29016	106.61810	Good Fortune	dump
GF2	33.28954	106.61783	Good Fortune	4 ft chip
GF2s	33.28954	106.61783	Good Fortune	select
BB1	33.223441	106.663386	Black Bear	dump
BB1	33.223441	106.663386	Black Bear	5 ft chip
BB2	33.224291	106.664097	Black Bear	140 ft chip
BB2	33.223441	106.663386	Black Bear	dump (Marsh)

BB3	33.223441	106.663386	Black Bear	dump
BB4	33.224291	106.664097	Black Bear	dump (McLemore)
BB4	33.219218	106.660609	Black Bear	dump (Marsh)
SC-1	33.02383	106.59896	St. Lawrence-Sulphur Canyon	select dump sample
SC-2	33.02383	106.59896	St. Lawrence-Sulphur Canyon	grab of dump
SC-3	33.02383	106.59896	St. Lawrence-Sulphur Canyon	select of dump (McLemore)
SC-3	33.02383	106.59896	St. Lawrence-Sulphur Canyon	grab of dump(Marsh)
SC-4	33.02383	106.59896	St. Lawrence-Sulphur Canyon	chip of rib
WORK-1	33.08706	106.567681	Workman Canyon	dump sample (McLemore)
WORK-1	33.08706	106.567681	Workman Canyon	dump sample (Marsh)
WORK-2	33.08917	106.56768	Workman Canyon	dump (Marsh)
WORK-2	33.08917	106.56768	Workman Canyon	dump (McLemore)
Pion 1	32.9938	106.5834	Pioneer pit	grab sample of dump
Pion 2	32.99457	106.58514	Pioneer adit	4 ft chip across back
Pion 3	32.99457	106.58514	Pioneer adit	select dump sample
Pion 4	32.99509	106.58608	Pioneer shaft	select dump sample
SUL01	33.03438	106.69215	Sulfur Canyon	dump sample
SUL02	33.03436	106.69153	Sulfur Canyon	dump sample
SUL03	33.00459	106.66947	Sulfur Canyon	10 ft chip sample across jasperoid
SUL04	33.00459	106.66947	Sulfur Canyon	dump sample
SUL05	33.00355	106.66588	Sulfur Canyon	dump sample
SUL06	33.00065	106.66588	Sulfur Canyon	dump sample
SUL07	33.99533	106.66401	Sulfur Canyon	dump sample
SUL10	32.99579	106.66418	Sulfur Canyon	10 ft chip sample across jasperoid
SUL11	32.99976	106.66608	Sulfur Canyon	dump sample
SUL12	32.99980	106.66603	Sulfur Canyon	dump sample
A (VM001R)	32.789213	106.575629	Green Crawford	select dump sample, north adit
B (VM002R)	32.789213	106.575629	Green Crawford	1 ft chip across north vein
C (VM003R)	32.789213	106.575629	Green Crawford	1.5 ft chip sample across back north vein
D (VM004R)	32.789213	106.575629	Green Crawford	select dump sample, north vein
E (VM005R)	32.786954	106.574898	Green Crawford	3 ft chip sample across south vein
F (VM006R)	32.786954	106.574898	Green Crawford	select dump sample, south vein
Hos 2	32.91714	106.56748	Hospital Canyon	chip across 15 ft quartzite
Hos 3	32.9173	106.5755	Hospital Canyon	chip across 10 ft face in pit
Hos 4	32.91656	106.57311	Hospital Canyon	grab sample of dump at pit
Hospital	32.9161	106.5644	Hospital Canyon	chip of quartzite
Hembrillo	32.9319	106.6417	Hembrillo Canyon	grab sample of dump of south pit
VM013R	32.9319	106.6417	Hembrillo Canyon	grab sample of dump
Hembrillo	32.9319	106.6417	Hembrillo Canyon	grab sample of dump of north pit
VM014R	32.9319	106.6417	Hembrillo Canyon	grab sample of dump of north pit
SA009R	32.9319	106.6417	Hembrillo Canyon	select of dump, north pit