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GEOLOGICAL SURVEY

Economic geology of some selected mines in the Hillsboro and San Lorenzo quadrangles, Grant and Sierra Counties, New Mexico

By

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

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INTRODUCTION

The purpose of this open-file report is to present the results of geologic mapping in the various mining districts of the Hillsboro-San Lorenzo quadrangles (figs. 1 and 2). The report is largely dependent on past mining records, on the interpretation of older mine maps, and the remapping of various mine areas. The region encompasses the following mining districts: (1) Hillsboro district and the adjacent Las Animas placer district, (2) Kingston district, (3) Tierra Blanca district, (4) Carpenter (Swartz) district, and (5) small segments of the Lake Valley, Georgetown, and Santa Rita (San Juan) districts. Most of these mining districts were developed in several stages. In the first period, from 1880 to 1893, the rich, near-surface, oxidized silver ores in the Kingston and Tierra Blanca districts were developed and in the Hillsboro district both gold placer and gold fissure veins were exploited. During the second period, in the early 1900's, precious metal mining was less intensive and the base-metal deposits of the Kingston and Carpenter districts were mined. After the price of gold rose from $20.67 to $35.00 an ounce in 1933, many of the precious metal mines were reopened between 1934 and 1942. The precious metal production did not match that of the 1880-1893 period, however. With the wartime demand for manganese in 1943 and 1944 the numerous small manganese deposits of the Kingston district were developed along zones of silver-bearing fissure veins and bedded replacement deposits; the production was small, about 5,000 tons of ore. A fourth period of development began with the drilling of the porphyry copper deposit of Copper Flat near Hillsboro in 1952. This period reached its culmination with the open-pit mining of the Copper Flat orebody in 1982. This open-pit mining activity was of short duration owing to the depressed prices for copper in the 1980's. The most recent episode of mining activity began with the sudden increase of precious metal prices beginning in the mid-1970's. As a consequence of the increased prices for gold and silver many mine dumps, shallow workings, and placers were exploited for their precious metals, e.g. the Opportunity mine, the numerous mine dumps in the Georgetown district, the placers near Gold Dust, and the Ingersoll, Virginia, and Black Colt mines in the Kingston district.

Previous work

This compilation is largely a resume of previous work; it includes numerous previously unpublished mine maps and maps that have been open-filed by the U.S. Geological Survey. Map credits are placed in the lower left and right corners of the maps, stating the date and any modifications that have been made by the author.

For the Hillsboro and Las Animas districts the principal publications have been those of Harley (1934), Kuellmer (1955), Dunn (1982, 1984), and Segerstrom and Antweiler (1975). The work in the district is supplemented by enlarged geologic maps that were prepared by the author as an outgrowth of the geologic mapping of the Hillsboro and San Lorenzo quadrangles in the early and mid-1970's (Hedlund, 1977a).

For the Kingston district there has been very little published information. Perhaps the best data is that provided by Roy Tirey, a claim owner in the district, who provided claim maps and a topographic base showing the outline of mine workings on a rudimentary geologic map (pl. 3). The

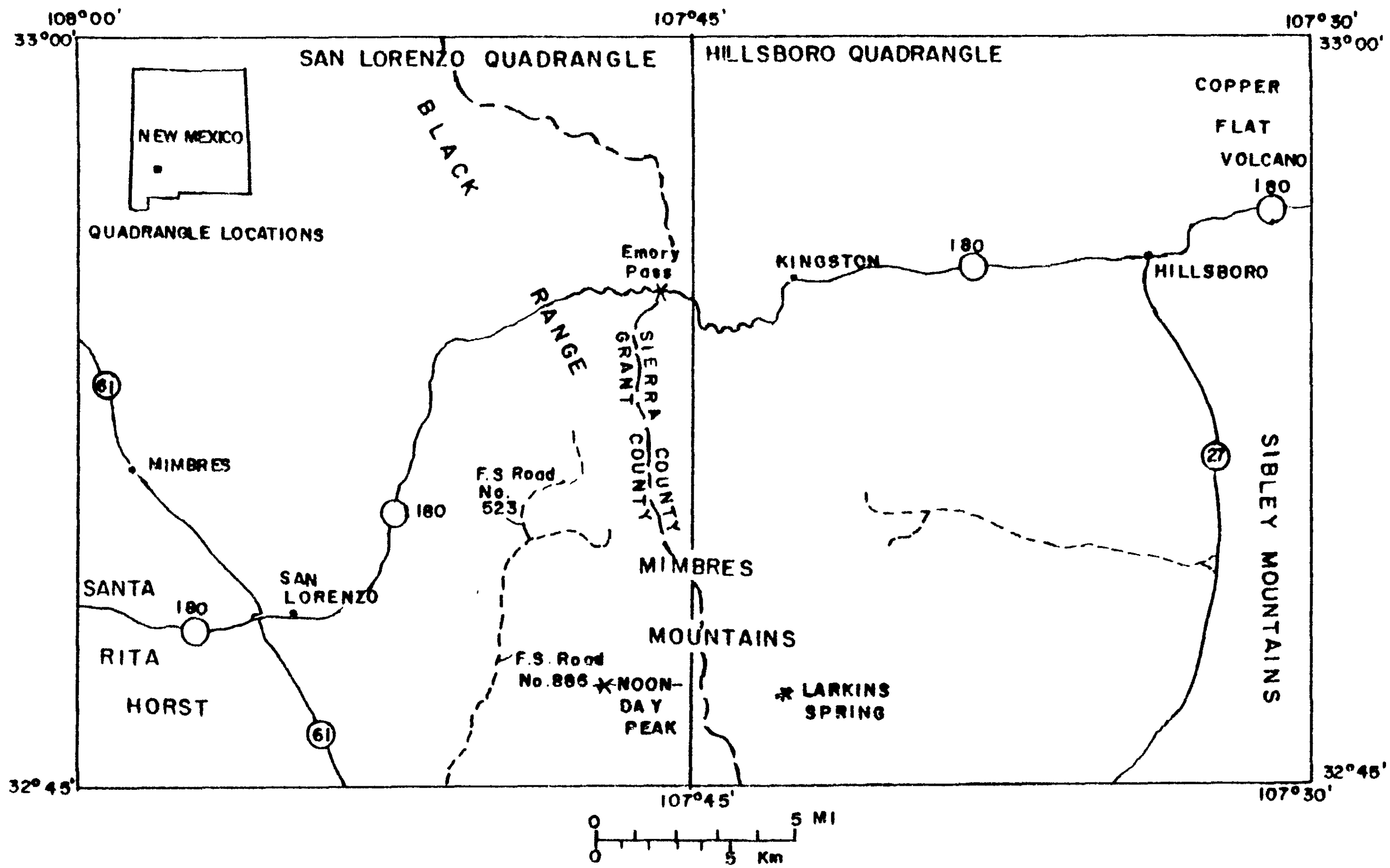

Figure 1.--Index map of the Hillsboro and San Lorenzo 15' quadrangles, Sierra and Grant Counties, New Mexico, showing the major physiographic elements, highways, and secondary U.S. Forest Service (F.S.) access roads

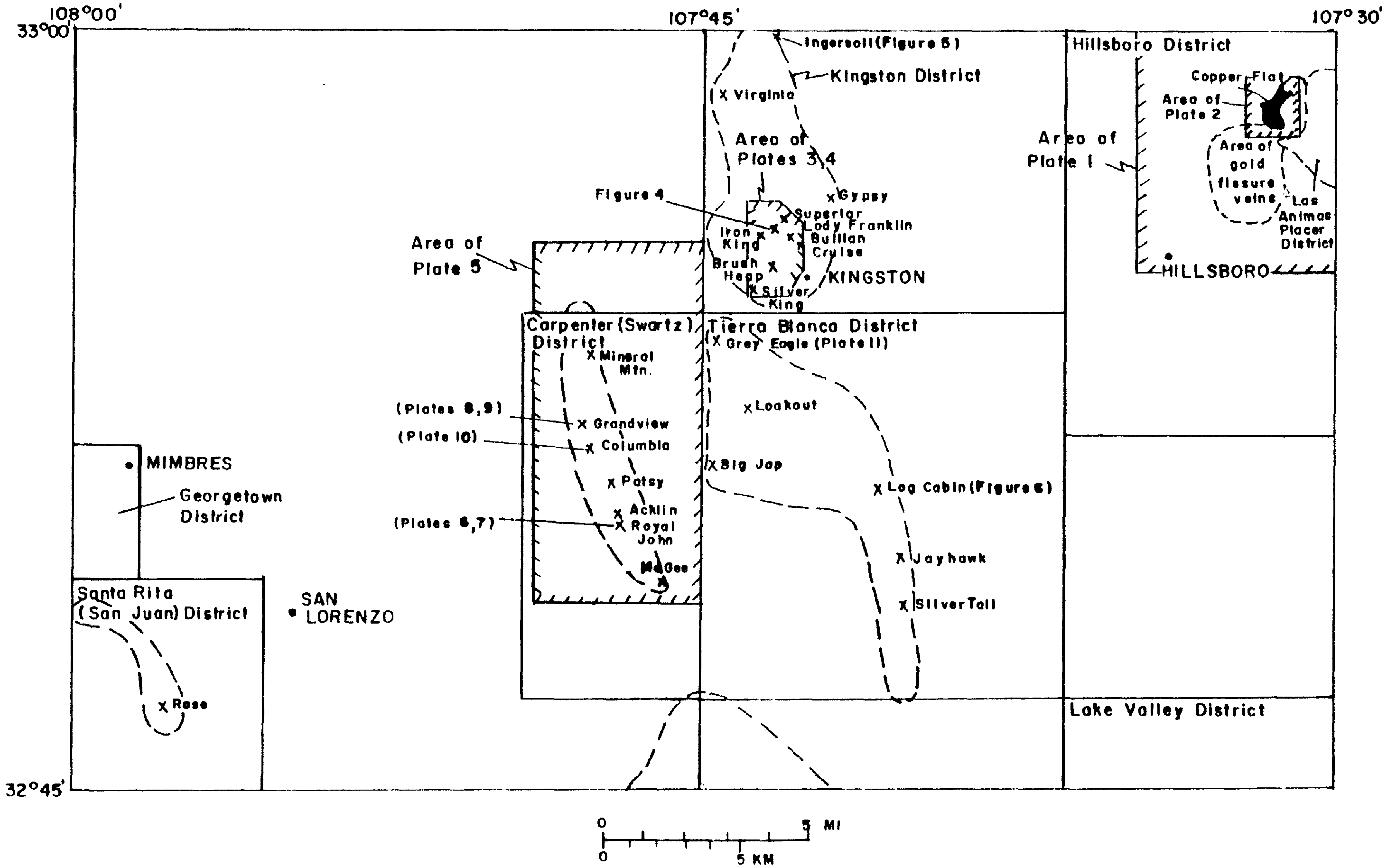

Figure 2.-- Index map showing the boundaries of mineral districts (solid lines) within the Hillsboro and San Lorenzo quadrangles, Sierra and Grant Counties, New Mexico. Dashed lines enclose and identify potentially favorable mineral resource areas and mines within the various districts.

geology as revised by the author is shown on plates 3 and 4. An outline of the mine workings of the Black Colt mine (fig. 4) is from a survey done by Scott Gould in 1967. A map of the mine workings of the Ingersoll mine at the north end of the Kingston district (fig. 5) was provided by E. H. Hale, Jr., and represents the geology done by C. A. Appledorn. Other mine maps are those of L. L. Farnham (1961) who studied the manganese deposits of the district.

In the Tierra Blanca district a sketch map of the Log Cabin mine and the Hornet claim area (fig. 6) was provided by Don Fingado of Truth or Consequences. The Grey Eagle mine, near the border with the Kingston district, was mapped by R. L. Griggs and S. P. Ellison in 1943 (unpublished maps in the files of the U.S. Geological Survey) (pl. 11).

The various mines of the Carpenter (Swartz) mining district were mapped in detail by members of the U.S. Geological Survey (R. L. Griggs, S. P. Ellison, H. C. Wagner, A. E. Weissenborn, and D. M. Kinney) and by members of the U.S. Bureau of Mines (J. H. Soule and R. S. Hill) from 1943 to 1950. This work was supplemented by core drilling which provided valuable subsurface information. Much emphasis was placed on the fault control of the base-metal deposits despite the fact that skarns are present throughout the mineralized area. Most of the maps were open-filed, as well as a report by D. M. Kinney (1944) on the geology and ore deposits of the Royal John area. The U.S. Bureau of Mines published some maps together with text in their Report of Investigations Series No. 3904 and 4748 (Soule, 1950; Hill, 1946).

MINING DISTRICTS

Hillsboro District

Geology

The Copper Flat volcano is the dominant geologic feature (pl. 1) of the Hillsboro district and various aspects of the geology in this district have been previously described by Harley (1934), Kuellmer (1955), Hedlund (1977a), and Dunn (1982, 1984). The volcano is about 4 mi (6 km) in diameter and is readily apparent on Landsat photographs. The core of the volcano is intruded by a quartz monzonite stock (pl. 2) that occupies an area of about 0.4 mi^2 (1.0 km^2) and is the source of porphyry copper deposits and peripheral gold-bearing veins and gold placers. The quartz monzonite has been dated by K-Ar methods (biotite) as 75.1±2.5 m.y. (R. F. Marvin, H. H. Mehnert, and Violet Merritt, U.S. Geological Survey, written commun., 1974). The andesite flows that comprise the eroded volcanic carapace are of a similar but slightly older age and have not been radiometrically dated. The radial dikes about the quartz monzonite stock, and the localized great thickness (>2,700 ft, 825 m) of andesite flows intruded by the stock support a volcanic origin and suggest that the original volcanic superstructure has been eroded to a depth of about 3,000 ft. A reconstruction of the volcano is made difficult by the sparsity of flow banding and layering in the andesite flows to the north and south of the stock; however, east-dipping (25^o-30^o) flows occur along and near Animas Peak and west-dipping (20^o-30^o) flows occur in sec. 28 west of the Copper Flat stock (pl. 1). This field data supplemented by fluid inclusion data from quartz veins in the stock reported by P. G. Dunn (oral commun., 1981) suggests that the quartz monzonite was intruded at a depth of about 1,500 to 2,000 m.

Andesite.--The andesite flows of Copper Flat are dark greenish gray to medium gray and slightly porphyritic with commonly 5 to 10 percent phenocrysts of sodic andesine (An_{32-37}) in a cryptofelsitic to pilotaxitic groundmass;

highly porphyritic flows are of minor extent. Pale-green clinopyroxene phenocrysts up to 2 mm across are commonly twinned and zoned, and some of the pyroxene grains are marginally replaced by bluish-green hornblende. Accessories are chiefly magnetite and apatite.

The andesite flows are of considerable thickness. Drill hole IDC-20.31 near the El Oro mine (pl. 1) is reported to have penetrated andesite to a depth of 2,732 ft (832 m) and did not reach Paleozoic strata. An EXXON drill hole southeast of Empire Peak reportedly cut at least 2,300 ft (700 m) of andesite and andesitic breccias and still did not penetrate Paleozoic rocks. During underground mining at the Snake shaft, Paleozoic limestones were present at 2,200 ft (670 m) below ground level.

Propylitic alteration of the andesite is only locally present marginally to the Copper Flat stock and is more extensive along radial veins about the stock. With intensive alteration the andesite is bleached light-greenish-gray and the groundmass is commonly chloritized; the plagioclase phenocrysts are altered to white mica, epidote, and chlorite; hornblende and pyroxene are completely replaced by clinozoisite, calcite, and iron oxides.

Quartz monzonite.--The quartz monzonite stock of Copper Flat occupies a topographic depression surrounded by andesites that form low hills about the stock; the altitude difference is as much as 800 ft. The stock has a lobate outcrop pattern to the southwest and an extended northeast-trending apophysis (pl. 2). Large xenoliths of andesite locally occur along this apophysis and suggest partial stoping during intrusion. Although Kuellmer (1955) suggests that the quartz monzonite has inward-dipping contacts and is funnel-shaped, more recent drilling suggests steep to outward-dipping walls (sec. C-C′, pl. 2).

Compositionally the quartz monzonite varies from dominantly porphyritic to medium grained, hypidiomorphic-granular. A cryptocrystalline or felted groundmass is generally absent except for some of the contact facies. Most rock types are characterized by 45-60 percent pinkish-gray orthoclase phenocrysts 1-2.2 cm across that are set in a fine- to medium-grained matrix consisting of 20-30 percent calcic oligoclase (An_{28-30}), 5-17 percent anhedral quartz, 2-8 percent biotite, 0-8 percent blue-green hornblende, and accessory sphene, epidote, apatite, and chlorite. Some of the drill cores have revealed fine-grained pegmatitic phases and xenoliths of quartz diorite.

Dikes.--The radial dikes about the Copper Flat stock are chiefly oriented N. 45°-55° E. and N. 40°-50° W., and as many as 34 dikes have been mapped in the surrounding andesite. The dikes are of quartz latite and low-silica rhyolite (69.4 percent SiO_2) and represent late stage differentiates of the quartz monzonite (60.5 percent SiO_2). A few dikes cut the quartz monzonite stock, and latitic dike fragments are present in the brecciated phases of the stock. The dikes are as much as 125 ft (38 m) thick and 5,200 ft (1.6 km) long. Most dikes are light gray but weather pinkish gray, and, where cut by a later vein system, are brecciated, reddened, and locally mineralized.

The latitic dikes consist of a felted groundmass containing alkali feldspar microlites and minor interstitial quartz grains. Coarse orthoclase phenocrysts, up to 1.5 cm long, have secondary overgrowths of potassic feldspar and comprise about 5 percent of the rock. Most of the orthoclase phenocrysts display Carlsbad twinning and some have highly resorbed pitted cores. Euhedral oligoclase (An_{24-26}) phenocrysts comprise about 15-18 percent of the latite, and some phenocrysts have alkali feldspar overgrowths. Hornblende phenocrysts comprise about 3 percent of the latite, and in most dikes the hornblende is partially chloritized. Resorbed, pitted, and rounded quartz phenocrysts generally form less than 1 percent of the latite.

Accessories are sphene, iron oxides, clinopyroxene, epidote, apatite, sericite, and biotite. The dikes near vein systems are highly altered to sericite, calcite, epidote, and chlorite.

Magnetic expression.--The principal aeromagnetic anomaly in the Hillsboro quadrangle is the circular magnetic high of +270 gammas located just south of the Copper Flat stock and over the andesite flows (Wynn, 1978; Wynn and Dansereau, 1978; and Hedlund and others, 1979). This strong positive anomaly may be over a small buried pluton that is 984 to 1,968 ft (300 to 600 m) below the ground surface and may represent an apophysis of a larger body that is subjacent to the Copper Flat and Warm Springs composite pluton. Skarn deposits within buried Paleozoic limestone beds may have also enhanced the value of the anomaly.

Ground magnetic surveys over the Copper Flat stock indicate higher magnetic values along the south margin of the pluton and lower magnetic values over the altered parts of the stock, such as near the Quintana Incline site (pl. 2). The low anomalies in the areas of alteration are indicative of magnetite destruction by late-stage hydrothermal fluids.

Structure.--The Copper Flat volcano is bounded by faults (pl. 1)--the Snake fault and Ready Pay Gulch faults to the south, the Berenda fault to the west, a fault complex in the Tank Canyon and Animas Gulch area, and a largely unmapped concealed fault bounding the Rio Grande Trough to the east. Most of these faults are of Pliocene-Miocene age, although the faults in the Tank Canyon area are of probable Late Oligocene age. Some of the northwest-striking faults in the Ready Pay Gulch area pre-date the andesite of Copper Flat which is of Late Cretaceous age.

Mining history

The Hillsboro district encompasses gold-bearing quartz veins and associated placers which radiate from a quartz monzonite stock that is the central intrusive of the Copper Flat volcano and the porphyry copper deposits of the central stock. The gold deposits of this district were discovered in 1877 along the fissure veins that radiate outward from the Copper Flat stock (pl. 1). Placer gold deposits were first developed along the Snake and Wicks Gulches in the same year, and placer mining subsequently extended into the vicinity of Golddust Camp (pl. 1) and along the intermittently flowing tributaries of the Rio Grande such as Grayback, Hunkidori, and Greenhorn Gulches which head into or drain the Copper Flat volcanic center. Gold production up to 1931 was about $7 million, using the prices at the time of production (Harley, 1934). The fissure veins yielded about 51,000 oz of gold (Harley, 1934) and the placer deposits about 110,000 oz (Segerstrom and Antweiler, 1975). This indicates that prior to 1931 about one-third of the former production came from the quartz-gold fissure veins. Most of the underground mining was done prior to 1893. After the price of gold rose from $20.67 to $35.00 an ounce in 1933, there was renewed mining activity and the placer deposits yielded 15,200 oz of gold from 1932 to 1943 (Segerstrom and Antweiler, 1975). Many of the tailings from this operational period are still visible. In the mid-1970's various attempts were made to exploit the placers and dump material from the various older workings; these efforts were short-lived owing to low grade and the problems of beneficiation.

At Copper Flat, the Sternberg mine produced about 200 tons of copper ore between 1911 and 1934 (Harley, 1934) from the oxidized cap of the quartz monzonite stock. The stock was first explored by drilling for disseminated copper in 1952 when Newmont Mining Company drilled six inclined holes totaling

3,369 ft (Kuellmer, 1955). In 1958 and 1959, Bear Creek Mining Company drilled 20 holes for a total of 9,346 ft and discovered a mineralized breccia pipe within the stock (P. G. Dunn, oral commun., 1981). Inspiration Consolidated Copper began drilling at Copper Flat in 1967, and by 1973 had drilled an additional 28 holes for a total of 23,046 ft (E. F. Burke, oral commun., 1981). Quintana Minerals Corporation leased the property from Inspiration in 1974, and between 1974 and 1976 drilled 127 holes for a total length of 94,097 ft (P. G. Dunn, oral commun., 1981). In 1980 Quintana Minerals Corporation began construction at the site and open-pit mining commenced in late 1981. The indicated copper reserves at Copper Flat have been placed at 65 million tons of ore averaging 0.45 percent copper (P. G. Dunn, oral commun., 1982). About one-half of the copper reserves are in the breccia pipe. The grade of the ore outside of the breccia pipe is lower, generally most analyses plot from 0.15 to 0.25 percent copper (fig. 3).

Porphyry copper of Copper Flat

Introduction.--Although gold mining preceded the development of the copper deposits in the Hillsboro district, the porphyry copper deposit is described first because both the gold veins and the disseminated copper are related in origin to the subvolcanic quartz monzonite intrusion. The quartz monzonite stock has an outcrop area of about 0.4 mi^2 (1.04 km^2), but only an area of about 0.1 mi^2 (0.26 km^2) is mineralized. The surrounding andesite is not appreciably mineralized with copper, although one sample near the contact with the quartz monzonite had 300 ppm copper. The deposit shows very little supergene enrichment, but some faults, such as the Hunter (pl. 2), locally contain chalcocite and turquoise.

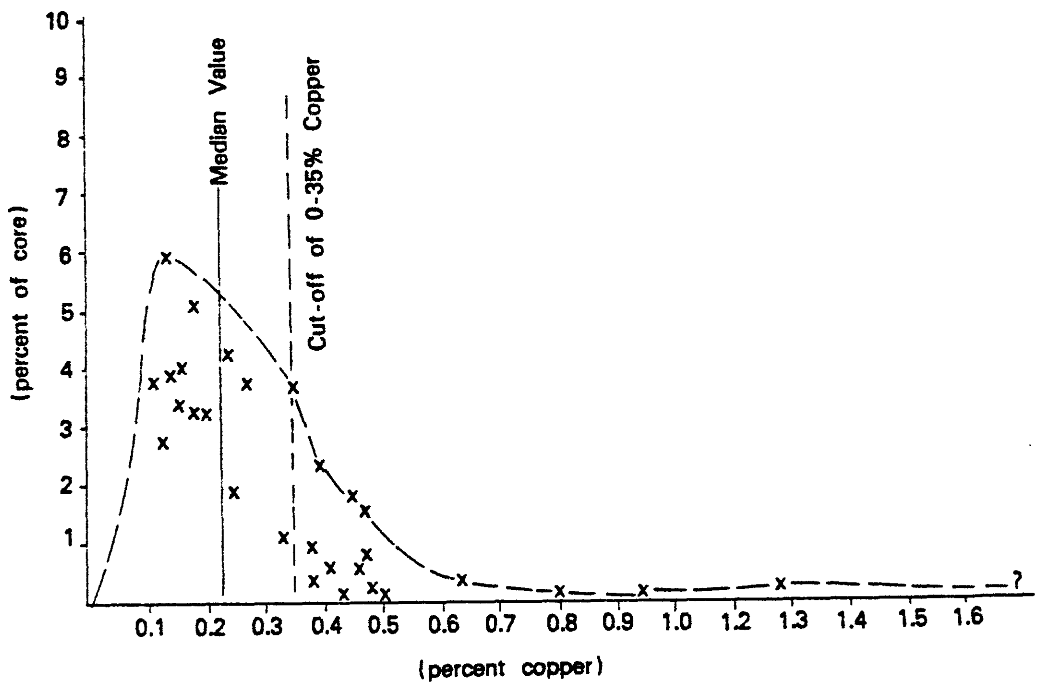

Figure 3.--Monomodal distribution of average assay values for copper in 17,830 ft of drill core and sludge samples taken from Copper Flat. Sludge samples have been analyzed at mineralized intervals within 29 different drill holes. (Analytical data furnished by Inspiration Development Co. Holes IDC-1 to IDC-29)

Ore minerals.--Pyrite, chalcopyrite, very minor sphalerite, and galena are the chief ore minerals. Locally, at the periphery of the mineralized area, there are a few grains of bornite intergrown with chalcopyrite. Magnetite is locally abundant but is commonly replaced by hematite. In some magnetite grains there is selective hematitic replacement of certain growth zones. Molybdenite is sporadically distributed in the biotite breccia zone of the breccia pipe, and P. G. Dunn (oral commun., 1981) has observed relatively high molybdenum values (0.15 percent Mo) along the weathered, oxidized parts of faults within the stock. Generally the molybdenum content is relatively low elsewhere, 0.008 to 0.012 percent Mo.

Breccia pipe.--The breccia pipe is largely concealed by colluvium, although small outcrops of highly fractured quartz monzonite occur near the Alhuten shaft. Dunn (1984) has described the breccia pipe in detail and has suggested that one-half of the total copper reserves are within the pipe.

The breccia pipe is elongate west-northwest and is about 1,300 ft (395 m) long and 600 ft (185 m) wide. It extends about 985 ft (300 m) below ground level, and the upper part of the pipe has sharp contacts with the quartz monzonite, whereas the lower part has gradational contacts. The best mineralized zones are at the top of the pipe where the sulfides, chiefly chalcopyrite, occur as masses up to one-half meter across. Dunn (1984) mapped three breccia types: (1) breccia containing chiefly rotated and altered fragments of quartz monzonite; (2) biotite breccia in which coarse (3-5 mm) secondary biotite plates occur along veinlets with abundant quartz. This breccia contains considerable high-grade chalcopyrite ore; and (3) quartz-feldspar breccia which contains a vuggy matrix of comminuted feldspar Fragments, fluorite, quartz, and apatite.

As based on fluid inclusion data, P. G. Dunn (oral commun., 1981) presented evidence that the breccia pipe formed by hypogene, hydrothermal fluids that boiled at about 350°C, 4,900 to 6,500 ft (1,500 to 2,000 m) beneath the surface.

Alteration.--The alteration is most intensive within the breccia pipe and is chiefly a potassic and biotitic type of alteration. Secondary biotite and K-feldspar occur in the breccia matrix as large crystals and also replace the monzonitic rock fragments.

Sericitic alteration is widespread throughout the mineralized zone but is most intensively developed in the breccia pipe where two periods of sericitization, pre- and post-brecciation, have been recognized by P. G. Dunn (oral commun., 1981). The first period of sericitic alteration was accompanied by pyrite and chalcopyrite deposition, whereas the second period was accompanied by the deposition of pyrite, galena, and sphalerite. During the first period of sericitization the plagioclase as well as the K-feldspar are sericitized with some cores of the plagioclase more intensively altered. Radial aggregates of white mica are common about the opaque minerals and the biotite shows various stages of chloritization. Calcite veinlets cut the opaque minerals as well as the silicates. In the second stage of sericitization the early pyrite and chalcopyrite grains tend to be rounded; the quartz monzonite is highly bleached; there is abundant quartz, some of which is locally associated with chloritized biotite to form myrmekitic intergrowths; and limonite staining is locally common.

Structure.--The preferential orientations of the dikes, i.e. N. 50°-60° E. and N. 30°-60° W. within the andesite, and the lobate-neck outcrop pattern of the stock all indicate that there was considerable structural control during emplacement of the stock. Moreover, there is evidence that the stress conditions during emplacement continued after the intrusion and consolidation of the stock. Numerous joint readings (67) within the quartz monzonite indicate two preferred orientations: N. 45°-55° E. and N. 60°-65° W. (pl. 2). Dunn (1982) noted a somewhat similar orientation but reported a strongly preferred N. 35° E. direction for most joints (162). This N. 35° E. direction is parallel to the Hunter fault (pl. 2) and elongate apophysis of the stock. The Hunter fault is post-ore and shows evidence of right-lateral strike slip movement.

Reserves.--The copper reserves of the Copper Flat stock have been established by closed-spaced core drilling by the Quintana Minerals Corp. as 55 to 60 million tons of ore, averaging 0.43-0.45 percent copper at a cut-off grade of 0.25 percent copper. The molybdenum content is commonly 0.008 to 0.012 percent in the mineralized rock but is as much as 0.15 percent in parts of the weathered breccia pipe. One analysis of sulfide concentrate representing a composite sample of ore from various parts of the mineralized stock yielded 0.1 oz of gold and 3 oz of silver per ton of ore (table 1). P. G. Dunn (oral commun., 1982) estimated 0.2 to 0.3 oz of gold and 5 oz of silver per ton of ore.

Analytical data from 29 drill holes provided by Inspiration Development Company are plotted in figure 3. This plot showed a monomodal distribution with most analyses plotting from 0.15 to 0.25 percent copper.

Vein deposits

Very little can be added to the original descriptions of the vein deposits in the Copper Flat area that were published by Harley (1934). Most mines were inaccessible at the time of mapping in the 1970's, and as a consequence it is necessary to rely on the original studies by Harley for tonnages and grade of ore removed.

There are about 26 major veins in the district (pl. 1) and all of the veins are younger than the quartz latite dikes that are roughly radial to the central quartz monzonite stock. The veins also have a radial distribution but are generally clustered in the southwest, east, and northeast quadrants about the Copper Flat intrusion. The veins are as much as 5,000 ft (1,500 m) long, 3-8 ft (0.9-2.4 m) thick, and have a marginal propylitic type of alteration. The propylitized light-greenish-gray andesite is chloritized and partially replaced by calcite, sericite, and zoisite. Anastomosing and en echelon quartz veins within the altered andesite contain pyrite, chalcopyrite, bornite, bismuthinite, tetradymite, sphalerite, galena, and free gold. About 51,800 troy ounces of gold were extracted from the veins at Hillsboro (Harley, 1934) between 1877 and 1943, but no data are available on the past production of other metals. The descriptions of the veins are largely summations of the work of Harley with supplemental field descriptions by the author.

Wicks vein.--The Wicks vein strikes N. 5° E. and can be followed for about 6,500 ft (2000 m) within the andesite (pl. 1). Two shafts, one 300 ft (90 m) deep and the other 200 ft (60 m) deep, and numerous pits are aligned along the vein and along a subsidiary vein about 40 ft (12 m) east of the main vein. The main Wicks vein has a 3 to 7 in. (7.5-17.8 cm) pay streak which contains quartz, pyrite, bornite, chalcopyrite, and free gold. The total production has been about $150,000 or about 7,140 oz of gold.

Ready Pay vein.--The Ready Pay vein is located in Ready Pay Gulch where it has been intensively mined and trenched over a length of about 5,000 ft (1,500 m). The vein strikes N. 15°-20° E. and is an anastomosing fracture zone 10-15 ft (3-4.6 m) thick that contains abundant quartz veins. Pyrite,

Table 1.--Semiquantitative-spectrographic and modal analyses of mineralized quartz monzonite from Copper Flat and of gold-bearing veins from the Chance mine with supplemental atomic absorption analyses for gold and gravimetric analyses for silver

[Spectrographic analyses by L. A. Bradley, 1973, atomic absorption (A.A.) analyses for gold and gravimetric silver analyses (Chem.) by A. W. Haubert and Claude Huffman, Jr., 1974. Values reported in parts per million to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.15, and so forth. Elements determined but not reported here are: Na, K, Ga, and Zr. L, detected but below limit of determination; N, not detected; G, greater than 10 percent]

	1	2	3	4
Rock type----	Sulfide concentrate, vein material, Chance mine, Copper Flat	Vein material from the Chance mine, Copper Flat	Sulfide concentrate, quartz monzonite, Copper Flat	Mineralized quartz monzonite from Copper Flat
Field No.----	HL-23-71	HL-23-71A	HL-24-71	HL-24-71B
Lab No.------	D161386	D161399	D161387	D161400
Analyses (ppm)				
Be	1.5	N	L	5
Mg	100	300	500	3,000
Ca	1,000	3,000	2,000	20,000
Sr	15	300	15	300
Ba	150	1,500	30	500
Zn	10,000	N	N	N
Pb	5,000	150	30	30
Cd	100	N	N	N
Cu	20,000	200	G	10,000
Ag	150	50	70	5
Ag (Chem.)	(300)	(50)	(100)	(20)
Au	30	N	N	N
Au (A.A.)	(38)	(0.5)	(3.5)	(0.2)
As	N	N	N	N
Sb	N	N	N	N
Bi	70	30	50	N
Fe	G	70,000	G	20,000
Mn	200	100	150	500
Ti	1,500	1,500	10,000	2,000
Zr	30	100	300	150
Ni	30	L	50	L
Co	300	100	70	10
Cr	150	2	15	3
Mo	20	150	70	50
V	20	20	150	70
Nb	15	L	70	10
Sc	15	5	15	10
La	L	N	300	70
Nd	N	N	700	70
Yb	N	N	N	3
Y	20	15	100	30
Modal analyses (volume percent)				
Points counted	211	325	917	125
Pyrite	50	98	46	9
Chalcopyrite	30	1	42	66
Bornite	0	0	0.7	16
Magnetite	0	0	9	9
Hematite	0	1	2.3	Tr
Molybdenite	0	Tr	Tr	0
Sphalerite	14	0	0	0
Galena	6	Tr	0	0
Totals	100	100	100	100

bornite, chalcopyrite, and free gold have been reported to occur in the subsurface at the Ready Pay shaft. Minor amounts of placer gold have been mined from the south end of Ready Pay Gulch.

Sherman vein.--The Sherman vein is west of Ready Pay Gulch and strikes N. 45° E. The vein is slightly mineralized over a distance of about 4,000 ft (1,200 m) and is about 2-4 ft (0.6-1.2 m) thick. Numerous small stringers of vein quartz follow thin fracture zones within the andesite; oxidized pyrite was the only ore mineral observed on the outcrop.

McKinley (Caballero) vein.--The McKinley vein is between Snake Gulch and Ready Pay Gulch. Two tunnels have been opened along the vein. The lower tunnel is 500 ft (150 m) long and is connected with an upper tunnel and lower workings through a raise and some old stopes. The vein strikes N. 45° E. and cuts off the Opportunity vein to the southwest. The vein is about 4,000 ft (1,200 m) long and 3-4 ft (0.9-1.2 m) wide. In the lower tunnel an andesite breccia is along the footwall and andesite along the hanging wall. The vein consists of soft and altered andesite gouge traversed by calcite-quartz-pyrite veins that contain about 0.2 oz per ton of gold. The oxidized vein in the upper workings produced gold that averaged about 2.7 oz per ton of gold, and the ore is reported to have been in shoots 15-30 ft (4.6-9.1 m) long and 10-20 ft (3-6.1 m) thick (Harley, 1934).

Opportunity vein.--The Opportunity vein, east of Snake Gulch, strikes N. 10° E. and is about 200 ft (60 m) long. The main Opportunity shaft and associated pits and adits are located along the south end of the vein on the shoulder of a low ridge. Farther north the vein is splayed and is cut off by the McKinley vein. The vein is about 2,500 ft (750 m) long and strikes N. 30° E. At the time of this study the dump material of this mine was being worked for gold-bearing pyrite concentrates. The mineralogy of the vein is relatively simple, chiefly quartz and pyrite.

Snake vein.--The Snake or Rattlesnake vein in Snake Gulch is about 7,000 ft (2100 m) long, strikes N. 20°-25° E., and is 4-10 ft (1.2-12.0 m) wide. South of the main Snake shaft the vein splits into several branches which end at the Snake fault. Two of the branches of the main vein have been extensively worked. North of the Bobtail shaft a latite porphyry dike in the footwall of the vein strikes N. 48° E.; the dike is highly sheared at the contact with the vein. Quartz veins in shoots up to 100 ft (30 m) long and up to 1 ft (0.3 m) thick contain pyrite, sphalerite, bornite, and free gold. Oxidized ore extends to the 500 ft (152 m) level in the Rattlesnake mine. Past production figures for the Rattlesnake mine indicate 72,500 oz of gold has been mined with a value of about $1,500,000.

The Snake fault at the south end of the Rattlesnake vein extends S. 20° E. to near BM-5236 at the entrance of The Box on Percha Creek. Near the bench mark there are reddish-brown jasperoids at the fault contact of the El Paso Limestone with the Santa Fe Group. These jasperoids have been thoroughly studied by T. G. Lovering of the U.S. Geological Survey (written commun., 1975), and he has identified cerussite, jarosite, plumbojarosite, and descloizite in thin sections. Spectrographic analyses indicate anomalous amounts of lead, zinc, barium, mercury (0.9 to 4.4 ppm), silver (35 to 115 ppm), and gold (0.55-0.58 ppm) within the jasperoids.

Bonanza vein.--The Bonanza vein, west of Snake Gulch, is about 5,000 ft (1,500 m) long, strikes N. 37° E., and in places consists of a fracture zone 2-8 ft (0.6-2.4 m) wide. The vein has been prospected by three tunnels, one of which extends through the mountain for a distance of 3,500 ft (1065 m). The vein in most places resembles a bleached shear zone in which the ore is localized in en echelon fractures as much as 80 ft (24 m) wide. The primary ore minerals are pyrite, chalcopyrite, sphalerite, galena, acanthite, and free gold; secondary minerals include chalcocite and limonite. From 1904 to 1905 the value of the gold and silver production was $34,721, and the total production from the vein may have been as much as $700,000.

Richmond vein.--The Richmond vein, also known as the Bigelow vein, is about 6,300 ft (1,900 m) long and is developed by two principal mines, the Bigelow and Richmond. The vein intersects and closely parallels a quartz latite dike on and to the east of Empire Peak. Faulted segments of this dike or possibly another dike are found in the subsurface of the Bigelow mine. The Bigelow mine, along the southwest segment of the Richmond vein is developed by a 400-ft tunnel at an elevation of about 5,600 ft. The vein is up to 12 in. thick and the ore is massive to finely disseminated chalcopyrite, bornite, pyrite, gold, silver, and chalcocite. Very minor amounts of sphalerite, limonite, and marcasite are also present. Some gold values have fluctuated between 2.32 and 3.9 oz per ton, whereas the silver values have averaged about 26 oz per ton (Reeves, 1963). The Richmond mine is developed along the northeast segment of the Richmond vein and the workings consist of several tunnels and a shaft that are along a quartz vein that follows a quartz latite dike. The vein is from 3-8 ft (0.9-2.4 m) thick and cuts highly fractured and propylitized andesite; in places the quartz latite dike forms the footwall of the vein. The primary ore minerals at the Richmond mine are pyrite, chalcopyrite, sphalerite, galena, and free gold. Harley (1934) estimated the total ore production as 670,000 tons averaging about 1 oz of gold per ton of ore. The reserves were estimated to be 51,720 tons.

Butler vein.--The Butler vein, also known as the Garfield-Butler vein, strikes N. 55° E. on the southwest side of Empire Peak and extends for a distance of about 3,000 ft (900 m) in the andesite. Quartz veins within the altered and fractured andesite contain pyrite, chalcopyrite, galena, sphalerite, and free gold. A brecciated, discontinuous latite porphyry dike locally displaced by the vein. In the oxidized zone along the fault gouge in the Jackpot Tunnel, Reeves (1963) reported assays of 0.36 oz of gold, 1.3 oz of silver, and 0.25 percent copper per ton. Numerous trenches, shafts, tunnels, and prospect pits are localized along the vein, but the names for these workings are not well known. Harley (1934) has estimated the total production at $40,000 from 1877-1931.

Empire vein.--The Empire vein, also known as the Empire-Bickford vein, strikes N. 85° E. along the north side of Empire Peak and can be traced for about 3,000 ft (900 m) along the outcrop. The mineral deposits are small and the oxidized pyrite-quartz veins have yielded only about $1,000 or about 50 oz of gold (Harley, 1934). The Empire shaft is the only appreciable development within the old Empire-Bickford claims.

Grayback vein.--The Grayback vein strikes N. 80° E. along the northwest side of Empire Peak and can be traced for about 3,500 ft (1,100 m). The oxidized vein is only slightly mineralized with quartz and pyrite and no visible workings were noted along the vein.

Homestake-Tripp vein.--The Homestake-Tripp vein crops out to the north of Copper Flat, strikes N. 10° E., and has subsidiary veins that are both older and younger than the principal vein; the subsidiary veins strike N. 80°-85° W. The Homestake-Tripp vein is about 4,000 ft (1,200 m) long, 4-5 ft (1.2-1.5 m) thick, and has been developed by several adits that intersect the vein from the east. Harley (1934) estimated the total gold production as $50,000 (2,420 oz) from 1877 to 1931.

Little Jewess-El Oro veins.--The El Oro shafts and the adit of the Little Jewess mine are along veins that strike N. 50°-55° E. along the south side of Dutch Gulch. The parallel veins are as much as 3,500 ft (465 m) long, 4-5 ft (1.2-1.5 m) thick, and contain pyrite, chalcopyrite, galena, bismuthinite, tetradymite, and free gold. Harley (1934) estimated that the total production of gold ore between 1877 and 1931 had a value of about $200,000 and represented about 9,670 oz of gold. The El Oro shaft is one of the deepest in the district and reaches a depth of about 500 ft (152 m).

Sweetwater veins.--The Sweetwater vein is on the east side of Animas Peak where the vein strikes N. 60° E. and is joined by a conjugate east-striking fault that approximately merges with the Little Jewess vein to the north. The vein is 2,000-3,000 ft (600-900 m) long, 3-5 ft (0.9-1.5 m) thick, and the anastomosing quartz veins are within propylitized andesite. The vein is developed by an adit and several prospect pits. No production values are known.

Chance veins.--The Chance group of veins are located along Grayback Gulch east of Copper Flat. At least five different but parallel veins strike N. 55° W., and are as much as 3,500 ft (465 m) long. The veins are 3-5 ft (0.9-1.5 m) thick and contain pyrite, chalcopyrite, bornite, and chalcocite. The shaft at the Chance mine is at least 400 ft (122 m) deep. Harley (1934) states that the production value of the gold ore was about $6,000 (representing 290 oz of gold) between 1877 and 1931.

Gold placers of Golddust Camp

The gold placers of Golddust Camp (pl. 1) have been among the most productive in New Mexico and are chiefly found along the drainage out of Copper Flat and along the dry gulches that radiate off the andesite flows surrounding Copper Flat. Some of the chief sources of placer gold have been the alluvium along Grayback, Hunkidori, Gold Run, Little Gold Run, Greenhorn, and Dutch gulches. A secondary source has been some of caliche-cemented gravel interbeds within fan debris along the interfluves. The absence of surface water along the dry stream courses has hindered placer operations, and water has either been transported into the area from nearby wells or the placer operations have been confined to seasonal rainy periods. In 1975 El Oro Mining, Ltd., commenced dry-dredge operations near Golddust Camp and an unknown quantity of placer gold was extracted from the dry washes.

The total amount of placer gold mined between 1887 and 1943 has been about 113,200 troy ounces which represent about two-thirds of the total gold production in the district. A detailed study of the placer gold deposits by Kenneth Segerstrom and John C. Antweiler III (1975) suggests that the reserves of placer gold in 52 acres along Grayback Gulch total about 7,000 troy ounces, the 13 acres along Hunkidori Gulch have about 1,000 troy ounces, and the 6.8 million yds^3 of tailings at Golddust Camp are estimated to contain about 20,000 oz of gold. Thus the total reserves of near-surface placer gold are about 28,000 oz which represents about one-fourth of the past production.

The gold placers of Golddust Camp have been chiefly derived from the gold-bearing vein systems that radiate outward from the quartz monzonite stock of Copper Flat. Since the quartz monzonite stock, dike, and vein systems have an age of about 75.1±2.4 m.y., it is probable that weathering and erosion of the subvolcanic structure began in the Late Cretaceous but was interrupted by periods of volcanic cover during most of the Oligocene and parts of the Pliocene. Segerstrom and Antweiler (1975) have shown that the placer gold occurs in four gravel units that range in age from the latest Miocene(?) to the Holocene. They determined that some of the oldest placer gold occurs within gravel beds belonging to the upper part of the Santa Fe Group (Pliocene-Miocene?) and suggest that some of the more recent placer gold may have been derived from the erosion and reworking of these older conglomerates.

Kingston District

Mining history

The discovery of silver ore in 1880 and the organization of the Black Range mining district[1] in 1881 was followed by intensive mining of near-surface oxidized ores in 1883. During the period of peak development from 1883 to 1893 an estimated 6 million oz (186,000 kg) of silver was produced from about 27 mines in the district. From 1883 to 1904 production was valued at $6,250,000, most of which was from silver (Jones, 1904). From 1934 to 1957 the total silver produced was 67,940 oz (2,113 kg), whereas the gold production amounted to only 124 oz (3.8 kg), or only about 0.18 percent of the total precious metal production (Howard, 1967, p. 129, 130). During the early years very little effort was made to recover the base metal ores, but from 1930 to 1949 base metal ores accounted for most of the production and most shipments were to El Paso, Tex., or to the lead smelter at Hanover, N. Mex.

The first mines in the district were the Iron King, Empire, and Brush Heap, and much of the early production was from the Andy Johnson, Bullion-Superior group, Brush Heap, Black Colt, Comstock, Lady Franklin, United States, Illinois, and Black Eyed Susan mines. Most of these mines are clustered in an area of about 36 mi^2 (93.2 km^2) just north of Kingston and along Ladrone Gulch (pl. 3 and 4). Generally the orebodies were developed less than 460 ft (140 m) below the surface in the oxidized zone of supergene enrichment. The ore minerals were chiefly cerargyrite, native silver, polybasite, and argentiferous galena. Cerargyrite nodules as much as 3 in. across, though rare, can still be found along some of the major washes. The depression of 1893 greatly curtailed mining activity, but from 1934 to 1945 there was a brief resurgence of mining and some of the important mines were the Iron King (1937); Percha (1942-1945); Keystone, Miners Dream, Smiling Jane (1934-1936); and the Virginian, Southern Cross, Independence, and Morris (1938-1941). Shipment of precious- and base-metal ores virtually ceased after 1952.

The history of manganese mining in the district has been described by Farnham (1961). Most of the mining for manganese was in 1943, 1944, and from 1952 to 1959, and a total of 5,689 tons of manganese ore averaging 32 percent manganese was shipped from the district.

Geology

Most of the silver-bearing base-metal deposits are along fissure veins coincident with major faults such as the Bullion, Iron King, Ladrone Gulch, Ladrone, and Middle Percha Creek faults (pl. 3). Minor bedding-replacement type deposits are also present and tend to occur in the Fusselman Dolomite near the contact with the overlying Percha Shale. Presumably the shale acted

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[1]Black Range mining district later became the Kingston mining district in 1883.

as a barrier to the upward migration of the mineral-bearing hydrothermal fluids and may have supplied minor amounts of sulfur to the ore fluids. At some localities, such as near the Lady Franklin mine, the andesite sills within the Percha Shale also acted as barriers to the upward migrating ore-fluids, and the sills are propylitized as well as slightly mineralized. The lateral movement of the andesitic magma placed the underlying Fusselman Dolomite under stress that probably propagated numerous small fractures. These fractures provided further access for the ore fluids. There is ample evidence that the mineralizing fluids were forming synchronously with the faulting and are of late Oligocene age. For example, the Middle Percha Creek fault displaces both the Pollack Quartz Latite (28.1 m.y.) and the Kneeling Nun Tuff (33.4 m.y.) and strikes north-northwest similar to the other major faults in the district. It is still uncertain whether the Middle Percha Creek fault represents the caldera margin of the Emory caldera in this part of the Hillsboro quadrangle.

Some of the veins, such as those along the Bullion fault, have been mined over a length of 3,000 ft (915 m), and the mines located along or near this fault include the Bullion and Superior Groups. Along the west side of Ladrone Gulch, fault breccias along the Ladrone fault are mineralized at the United States, Illinois, and Andy Johnson mines (pl. 3). Most of these mines are along the fault contact of the Fusselman Dolomite with the Percha Shale and Lake Valley Limestone. The Iron King, Miner's Dream, and Tall Pine mines are located along the Iron King fault that has displaced the Magdalena Group downward on the west against the Fusselman Dolomite and Montoya Group.

The ore minerals of the veins and bedding-replacement deposits of the district include pyrite, sphalerite, galena, polybasite, acanthite, cerargyrite, and wire silver. The galena is argentiferous and electron microprobe studies indicate as much as 1,300 ppm silver. Alabandite is present in the Lady Franklin ores and plumose manganite is observed in the ore from the Black Colt mine. Polybasite in the Brush Heap mine is a late hypogene mineral and is typically copper-poor. An electron microprobe analysis of the polybasite indicates 70 percent silver, 6 percent antimony, 5 percent copper, 13-15 percent sulfur, and 0.12-0.65 percent selenium. The gangue minerals are quartz, rhodochrosite, very minor rhodonite, and various manganese oxides as coatings on quartz crystals. Modal analyses of ores from various mines (table 2) indicate that the ores are rich in zinc minerals, relatively poor in copper minerals, and contain moderate amounts of galena. Pyrite is ubiquitous and occurs early in the paragenetic sequence.

Atomic absorption, semiquantitative spectrographic, and gravimetric analyses of ores from the Black Colt, Blackie, Iron King, Brush Heap, Grey Eagle, and Gypsy mines are shown in table 2. In the relatively unoxidized ores the silver content is about 450 ppm (12.7 oz/t), whereas in the oxidized ores the silver content can be as much as 2,650 ppm (76 oz/t). The gold values are low, generally 0.1 to 21 ppm. Antimony and arsenic are present in the ores from the Brush Heap and Gypsy mines. Barite and fluorite were not observed in the veins, and the Ba values are low, 3 to 30 ppm.

Veins and bedding-replacement deposits

Black Colt mine.--Silver and base metal mining on the Black Colt claim began in 1887 and closed with the depression of 1893. Mining activity has been sporadic in recent years with some manganese mined from open cuts in 1952 and 1953, and some silver extracted from lower grade ores in 1959. Past production records indicate that an estimated $350,000 of manganese and silver

Table 2.--Semiquantitative spectrographic and modal analyses of ore samples from the Kingston mining district with supplemental atomic absorption analyses for gold and gravimetric analyses for silver

[Spectrographic analyses by L. A. Bradley, 1973, atomic absorption (A.A.) analyses for gold and gravimetric silver analyses (Chem.) by A. W. Haubert and Claude Huffman, Jr., 1974. Values reported in parts per million to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.15, and so forth. Elements determined but not reported here are: Na, K, Ga, and Zr. L, detected but below limit of determination; N, not detected; G, greater than 10 percent]

	1	2	3	4	5	6	7	8
Rock type---	Base metal ore Black Colt	Base metal ore Black Colt	Base metal ore Blackie	Base metal ore Iron King	Base metal ore Brush Heap	Base metal ore Gray Eagle	Base metal ore Gypsy	Sulfide concentrate from vein Ingersoll mine
Field No.---	Hb-90-73	Hb-1-BC	Hb-93-73	HL-7-73	Hb-73-73	Hb-131-73	HI-46-72	HS-68-72
Lab No.------	D161388	D161389	D161390	D161397	D161391	D161394	D161393	D161392
				Analyses (ppm)				
Be	N	N	N	N	N	N	N	N
Mg	500	1,500	10,000	1,500	3,000	1,000	7,000	70
Ca	3,000	20,000	30,000	50,000	7,000	1,500	1,500	150
Sr	N	7	7	N	N	N	N	N
Ba	5	10	5	7	5	30	3	7
Zn	G	G	30,000	7,000	G	70,000	5,000	G
Pb	G	30,000	5,000	3,000	50,000	100,000	1,000	30,000
Cd	1,000	1,500	150	N	1,500	150	N	2,000
Cu	5,000	10,000	1,000	300	10,000	5,000	500	10,000
Ag	300	300	150	70	500	200	1,500	20,000
Ag (Chem.)	(660)	(790)	(130)	(60)	(740)	(250)	(2,650)	(17,800)
Au	N	N	N	N	N	N	N	N
Au (A.A.)	(1.4)	(0.7)	(0.2)	(0.1)	(0.3)	(0.8)	(21)	(11)
As	N	N	N	N	N	N	G	1,500
Sb	N	N	N	N	1,500	N	7,000	10,000
Bi	N	N	N	N	N	N	N	N
Fe	G	G	15,000	15,000	70,000	G	G	70,000
Mn	10,000	20,000	20,000	20,000	3,000	1,500	700	500
Ti	100	1,000	150	30	200	150	150	30
Zr	N	30	N	N	N	N	30	N
Ni	70	20	7	L	7	70	70	15
Co	30	15	N	N	N	20	15	15
Cr	500	100	50	1	3	300	700	2
Mo	15	30	7	7	30	3	15	30
V	30	15	10	L	N	30	50	N
Nb	N	N	N	10	L	L	L	L
Sc	N	N	N	N	N	N	N	N
La	N	N	N	N	N	N	N	N
Nd	N	N	N	N	N	N	N	N
Yb	N	N	N	N	N	N	N	N
Y	L	L	N	L	L	15	15	N
Ce	N	N	N	N	N	N	N	N
				Modal analyses (volume percent)				
Points counted	130	596	53	—	572	234	61	214
Pyrite	19	18	34	—	41	Tr	95	23
Sphalerite	62	80	55	—	45	82	1	64
Galena	17	2	9	—	11	16	1	9
Chalcopyrite	2	0	2	—	1	2	0	1
Argentite	0	0	0	—	0	0	0	0
Polybasite	0	0	0	—	1	0	3	3
Corellite	0	0	0	—	0.4	0	0	0
Totals	100	100	100		99.4	100	100	100

ore has been extracted from veins and bedding-replacement bodies to depths as much as 200 ft (60 m).

A mine map prepared in 1967 by Scott Gould (fig. 4) shows the Black Colt shaft is 200 ft (60 m) deep, with lateral workings on the 130 and 200 ft levels. At least nine slanted drill holes within the mine have penetrated mineralized rock. Although the shaft is collared in mineralized Fusselman Dolomite, it is highly probable that some of the mineralized dolomite beds belong to the Montoya Group. In the vicinity of the mine the beds strike N. 10° E., dip 30°-35° east, and the ore deposits are localized along faults that strike N. 70°-80° E.

The ore typically contains 60-80 percent sphalerite, 18-20 percent pyrite, 2-18 percent galena, up to 2 percent chalcopyrite, and very minor amounts of acanthite. Two chemical analyses of vein material show 660 and 790 ppm (19 and 22 oz/t) of silver and 0.7 and 1.4 ppm (0.02 and 0.04 oz/t) of gold (table 2). Fracture fillings of manganese oxides are especially abundant in the silver ores from this mine and the nearby Blackie mines to the west. Some manganese ore averaged 40 percent Mn and was shipped to Deming, N. Mex., during World War II. The manganese orebodies were developed to depths of 75 ft below the surface.

Comstock mine.--The principal workings on the Comstock claim are the Canfield and West Tunnels which are about 800 ft north of the Black Colt shaft (pl. 3). The Comstock operated from 1886 to 1892 and briefly in the 1920's. About $230,000 worth of ore containing up to about 20 oz of silver per ton was produced in the 1800's. A detailed sampling of the Canfield Tunnel by the U.S. Bureau of Mines (Farnham, 1961) indicated that the silver content of the ore ranged from 0.4 to 20 oz per ton and averaged about 3.7 oz per ton.

The deposit is mostly a bedding replacement type and is localized in the upper part of the Fusselman Dolomite. The dolomite beds strike N. 10° W., dip 10-15 degrees east at the mine portal, and the ore deposit can be followed about 300 ft (90 m) down-dip. The width of the deposit is about 40-80 ft (12-24 m), but the richest part of the vein is only 2-8 ft (0.6-2.4 m) thick. Calcite, quartz, minor rhodochrosite, and sparse amounts of rhodonite are the common gangue minerals below the depth of weathering, and the ore minerals are sphalerite, galena, pyrite, minor chalcopyrite, and traces of acanthite.

Lady Franklin mine.--The group of mines on the Lady Franklin claim (pl. 4) were the largest producers of high-grade silver ore in the Kingston district from 1880 to 1893, and the ores averaged as much as 15 oz of silver per ton. Not much is known of the subsurface geology since the mine workings are presently inaccessible. Old mine maps indicate that mining was done on the 137- and 460-ft levels and that about 13 shafts were located on the claim (pl. 4). Many of the workings are interconnected with tunnels from the nearby mines, and the 137-ft level was continuous with the Bullion Tunnel. Most of the ore is in fractures and faults within the dolomite beds of the Montoya Group, but bedding-replacement bodies are also present. Most of the faults strike N. 75° E. and N. 35° W., with the N. 35° W.-striking faults offsetting the older N. 75° E. faults. At various places underground andesite sills, termed "porphyry" by the miners, were emplaced along the contact of the Percha Shale with the underlying Fusselman Dolomite.

The ores typically contain sphalerite, galena, pyrite, minor chalcopyrite and alabandite, and very minor amounts of acanthite that forms micro-veins which cut other base metal sulfides. Epidote and white mica are observed in

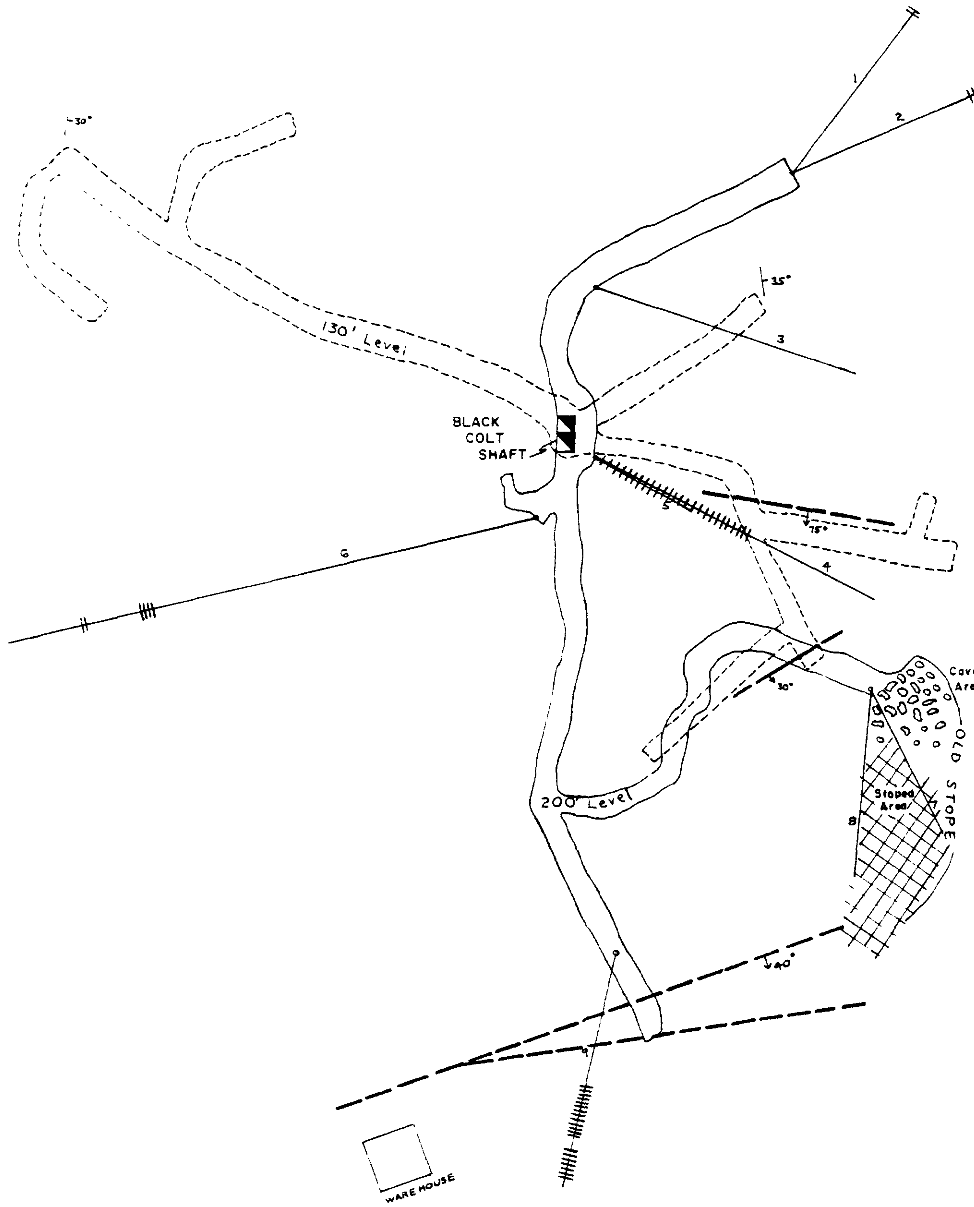

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FIGURE 4

UNDERGROUND WORKINGS BLACK COLT PATENT No. 618

SIERRA COUNTY, NEW MEXICO

0 10 20 30 40 50 FEET
0 5 10 15 METERS

EXPLANATION

Fault, dashed where projected

Mine workings, dashed where projected

Shaft

Inclined drill hole; slashed where mineralized

Traced from survey by Scott Gauld
(Chapman, Wood and Griswold
Drawing No. 732; November, 1967)

the dolomite beds marginal to the veins and some rhodochrosite is probably present, although it was not positively identified.

Superior mine.--Numerous shafts (nine) and adits within the Superior claim join underground workings that connect with the Lambert Shaft, Savage Tunnel, Yorin-Superior Tunnel, and lower and upper Superior Tunnels (pl. 4). Past production records are not available, but the Superior mine is reputed to have been one of the largest silver producers in the district. The ore deposits are primarily along faults that strike N. 70^{o}-75^{o} E. and N. 30^{o}-35^{o} W. The Bullion fault extends N. 35^{o} W. through the west side of the claim but may be offset by a N. 75^{o} E.-striking fault. Bedding-replacement deposits are also present within dolomite beds of the Fusselman Dolomite and Montoya Group.

Bullion-Chance mines.--The Cruise Shaft, Bullion Tunnel, and Bullion-Discovery Shaft are located on the Bullion claim (pl. 4), and the workings extend westward into the Last Chance claim. The ore deposits are chiefly along the Bullion fault (pl. 3) which strikes N. 35^{o} W. along the east side of the district. High grade silver-bearing base metal ores have been mined from faulted dolomite beds of the Fusselman Dolomite and Montoya Group. Rhodochrosite is a gangue mineral in some of the vein and bedding replacement deposits.

Iron King mine.--The underground workings of the Iron King mine are inaccessible and past mine records are few. Several shafts on the property indicate that most of the ore deposits were along a N. 5^{o}-10^{o} W.-striking fault that displaced older, numerous N. 70^{o}-80^{o} E.-striking fractures. Most of the deposits are confined to the faulted dolomite beds of the Fusselman Dolomite and to bedding-replacement deposits in zones 4-8 ft thick (1.2-2.4 m) marginally to the faults. Rhodochrosite and minor rhodonite are present as gangue minerals, and in some open cuts on the Iron King claim (pl. 3) as much as 1,684 tons of manganese ore was mined from the oxidized protore. As in other parts of the district sphalerite, pyrite, galena, and minor chalcopyrite are the dominant ore minerals and alabandite is locally abundant. Some of the ore is reported to have averaged 12 oz of silver per ton. One chemical analysis indicated 60 ppm (1.7 oz/t) of silver and 0.1 ppm (0.03 oz/t) of gold (table 2).

Brush Heap mines.--Underground workings of the Brush Heap mine are inaccessible and past mining records are not available. A shaft, collared in the Percha Shale, and numerous adits within the Fusselman Dolomite at the contact with the Percha Shale are located along the east side of Ladrone Gulch (pl. 3). The ore deposits appear to be both stratigraphically and fault-controlled with strong N. 20^{o}-30^{o} W.-striking faults and fractures probably providing access for the ore-forming fluids which were ponded below the impermeable Percha Shale. The ores were especially rich in silver, and it is estimated that at least 500,000 oz of silver were mined from the various mines within the claim.

Ore samples from the various dumps indicate the presence of about 40-50 percent sphalerite, 10-40 percent pyrite, 10 percent galena, 1 percent chalcopyrite, 1-2 percent polybasite, and trace amounts of covellite. The polybasite occurs as grains 0.3 mm across that mantle older sphalerite grains and replace pyrite and chalcopyrite. Chemical analysis of the ore indicates 740 ppm (21 oz/t) of silver and 0.3 ppm (0.01 oz/t) of gold (table 2).

Illinois and United States mines.--Extensive underground workings on the Illinois 452 and adjoining United States 620 claim indicate that large tonnages of ore were removed from these mines from 1880 to 1893 (pl. 3). Since many of the shafts are in the Percha Shale along extensions of the

N. 25° W.-striking Ladrone fault (pl. 3), it is inferred that most orebodies are bedding-replacement deposits in the upper part of the Fusselman Dolomite.

Ingersoll mine.--The Ingersoll mine (fig. 5) was opened in 1879 or 1880 and closed about 1893[1]. Some renewed mining activity took place in 1917 and from about 1968 to 1972, when E. W. Hale, Jr., of Hillsboro, shipped small tonnages of ore. The total production is not known but is probably about 100 to 150 tons. One shipment of 14.7 tons averaged 17.7 oz of silver per ton and had a copper content of 0.18 percent (E. H. Hale, Jr., written commun., 1974). Other analyses indicate 0.7-4.0 percent lead, 3.2-7.2 percent zinc, and 0.11 percent silver.

The Ingersoll vein is about 0.5 to 0.8 ft (15-24 cm) thick and can be traced for about 1,500 ft (457 m) in Precambrian granite. The vein strikes N. 85° W. to N. 80° E., dips 80° north, and is locally offset by north-striking faults. The vein follows the dominant joint direction in the granite, and the granite is highly sericitized in a zone about 3 ft thick on each side of the vein. The main adit, at an elevation of 6,840 ft, is about 225 ft (68 m) long and connects with an inclined winze which joins the main adit at the 105-ft (32-m) level and a lower abandoned 200-ft (60-m) level (fig. 5).

The vein is locally banded with a 1-2 mm thick crenulated marginal layer of pyrite and a core zone of sphalerite, pyrite, galena, chalcopyrite, chalcocite(?), and polybasite. Some vugs in the surrounding granite wall rock also contain wire silver. Sphalerite comprises about 65-70 percent of the sulfides and is generally free of exsolution blebs of chalcopyrite. Brecciated grains of pyrite (about 20-25 percent) in a sphalerite host are common, and the pyrite is partially replaced by the sphalerite. Galena comprises 8-10 percent of the sulfides and is locally intergrown or veined by polybasite. Chalcopyrite constitutes 1 percent or less of the ore minerals and is commonly present as rounded inclusions in the galena. In every paragenesis the polybasite is a late mineral and occurs most commonly as late veins cutting all the other sulfides. Electron microprobe studies (table 3) indicate possibly two types of polybasite: a copper-rich type with 16.3-17.8 percent copper and 55.1-55.8 percent silver, and copper-poor type with 4.7 percent copper and 69.9-70.9 percent silver; the antimony content in both types is relatively constant at 6.1-7.4 percent.

Gypsy mine.--The Gypsy mine is located along the south side of Sawpit Canyon near Mud Springs (fig. 2). The main adit is almost at road level and trends due south for almost 100 ft (30 m) along a small fault within the Lake Valley Limestone. Larger faults that strike N. 5° E. have repeatedly displaced the Percha Shale and have brought the limestones of the Lake Valley Limestone and Magdalena Group into contact with the Fusselman Dolomite-Montoya Group dolomite beds. It is these large faults which served as channelways for the mineralizing fluids. Sphalerite, galena, pyrite, acanthite, and polybasite are the most common sulfide minerals, and pyrargyrite has also been reported (Harley, 1934). The mine is reported to have produced about $200,000 of high grade silver ore. Some composite grab samples of rich ore from the mine dump contain 2,650 ppm (~75 oz/t) of silver and 21 ppm (0.6 oz/t) of gold (table 2).

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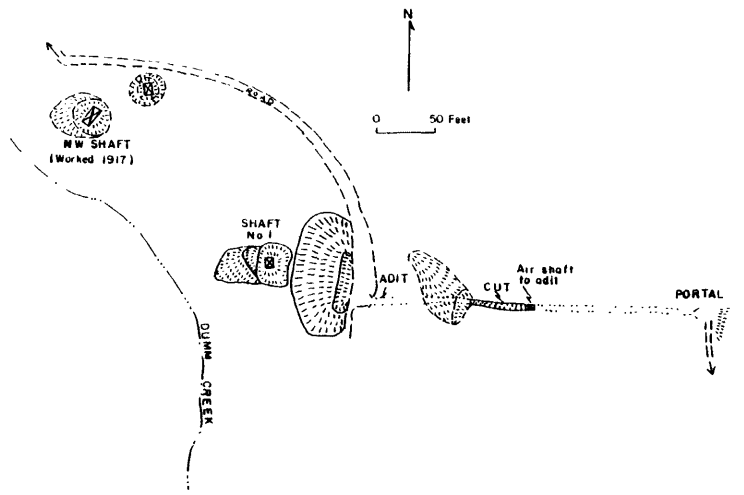
[1]The Ingersoll mine location is not shown on plate 3, but the approximate location is shown on figure 2. Mine is near head of Dumm Canyon; 6,840 ft elevation; latitude 32°59'54"; longitude 107°43'22".

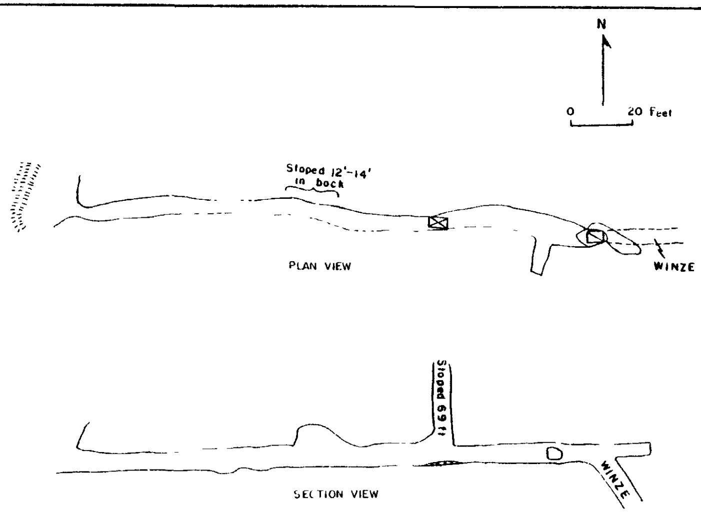
FIGURE 5: WORKINGS OF THE INGERSOLL MINE, NORTH KINGSTON DISTRICT, SIERRA COUNTY, NEW MEXICO

EXPLANATION

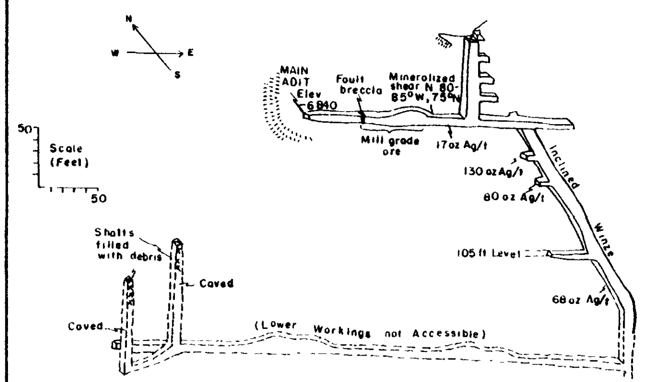
Geology by C.A. Appledorn; Maps released to U.S.G.S. by E H Hale, Jr., owner (1974)



SURFACE WORKINGS OF THE INGERSOLL MINE



PLAN AND SECTION VIEW OF THE UPPER WORKINGS OF THE INGERSOLL MINE



ISOMETRIC PROJECTION OF THE UNDERGROUND WORKINGS OF THE INGERSOLL MINE

Table 3.--Electron microprobe analyses of sphalerite, galena, polybasite, and an unidentified silver-antimony-copper sulfide or sulfosalt

[Field sample numbers in parentheses. All values in weight percent except those for silver which are in parts per million. Analyses by R. H. Heidel and D. C. Hedlund, 1974]

Electron microprobe analyses of sphalerite

Mine locality	No. of analyses	Mean ZnS	Mean FeS	Mean MnS	Mean CdS	Total
Royal John (SL-3-RJ)	4	94.2	3.77	1.03	1.19	100.2
Grey Eagle (SL-148-73)	9	95.5	2.40	1.31	1.53	100.7
Brush Heap (HB-73-73)	10	93.2	1.91	2.53	1.26	98.9
Big Jap (SL-283-73)	5	93.3	4.13	1.12	1.46	100.0

Partial electron microprobe analyses of galena

Locality	No. of analyses	Mean Ag (ppm)
Grey Eagle (SL-148-73)	4	850±40
Big Jap (SL-283-73)	4	850±40
Royal John (SL-5-RJ)	4	>500
(SL-3-RJ)		n.d.
Grandview (SL-152-A-73)	5	3,100±300
Brush Heap (HB-73-73)	4	1,300±100
Ingersoll (HB-69-72)	4	700±40

Partial electron microprobe analysis of polybasite (Cu-rich)

Locality	No. of analyses	Ag	Sb	Cu	S	Se
Brush Heap (HS-69-72)	4	55.8±2.8	7.4±0.4	16.3±1.9	20.5	n.d.
Brush Heap (HS-69-72)	4	55.1±3.33	6.1±0.48	17.8±2.3	21.0	n.d.

Partial electron microprobe analyses of an unidentified silver-antimony-copper sulfide

Locality	No. of analyses	Ag	Sb	Cu	S	Se
Brush Heap (HS-69-72)	5	69.9±6.0	6.45±0.43	4.7±0.2	13.4±0.40	0.12
Gypsy (HI-46-72)	8	70.9	n.d.	n.d.	13.2	0.49
Log Cabin (HB-81-72)	8	70.3	n.d.	n.d.	14.93	0.65

Virginia mine.--The Virginia mine is about 3 mi north of the main part of the Kingston district near the head of the North Fork of Percha Creek. The mine is developed by an adit and shaft near creek level. The mine is along a strong fault that strikes N. $0^{\circ}-5^{\circ}$ W. and displaces Precambrian granophyre. The granophyre is intensively sericitized in a zone about 1 m thick along each side of the vein, and the vein extends discontinuously for about 2,000 ft (600 m) north of the adit. The ores are dominantly pyritic with minor amounts of sphalerite, galena, acanthite, and cerargyrite. Some of the more oxidized ore is reported to have contained as much as 60 oz of silver per ton.

Manganese deposits

The manganese deposits of the Kingston district have previously been described by Farnham (1961), whose detailed report describes the individual occurrences and gives production figures for each of the mines. Most of the mining of manganese ore was in 1943, 1944, and from 1952 to 1959, and a total of 5,687 long tons of manganese ore with an average grade of 30 percent manganese was shipped from the district. Most of the manganese ore occurs in small pods, shoots, and replacement bodies along fractures and faults within dolomite of the Fusselman Dolomite and Montoya Group. The manganese minerals consist chiefly of pyrolusite and wad that have formed through the weathering and oxidation of rhodochrosite, alabandite, and manganite. Generally the manganese oxides have formed at depths less than 75 ft (23 m) below the present surface. According to L. L. Farnham (1961) the principal manganese producing mines are as follows:

Years	Mine	Long tons of manganese ore	Average grade (wt. percent Mn)
1943-1944 and 1950's	Iron King	2,650	34
1957-1958	Tall Pine	1,003	37
1952-1953, 1958	Black Colt	765	37
1954, 1957-1958	Miners Dream	516	40
1950's	Black Sheep	285	25
1952, 1958	Blackie	148	34
1954-1955	Wagon Wheel and Prospect Group	98	25
1955	Dove Group	78	31
1954	Superior Group	56	22
1953	Viola	45	23
1954	Pine Group	21	22
1954	Silver King	14	33
1954	Black Magic	8	33
Totals		5,687	Avg. grade 30%

The total value of this ore is about \$13,100 as based on a value of \$2.30 per long ton of metallurgical grade manganese ore in 1951.

Tierra Blanca District

Mining history

The Tierra Blanca district (fig. 2) encompasses several subdistricts including the Bromide, Grey Eagle, South Percha Creek, and Pierce Canyon. Most of the mines were discovered in the late 1880's and have been principally silver-bearing base metal deposits. Probably the three most important mines have been the Log Cabin, Lookout, and Grey Eagle mines (fig. 2). Of less importance have been the Bi-metallic, Silver King, Silver Bell, Victorio, Silver Tail, Jayhawk, and Jap-Upton mines. The early mining history is obscure and the current ownership is unknown.

Log Cabin mine.--Rich silver-bearing base metal deposits have been mined from the Log Cabin and Hornet group of claims (fig. 6). An estimated 200 tons of ore valued at about $75,000 has been extracted from brecciated and talcose veins within the Fusselman Dolomite. The largest production came between 1911 and 1931, and operations from late 1971 to 1972 resulted in very small production.

In the vicinity of the mine the bedding in the Fusselman Dolomite strikes N. 30° W., dips 25° SW., and the dolomite is traversed by numerous small quartz veins that strike N. 0°-35° W. The quartz veins contain sphalerite, galena, pyrite, and acanthite, and the wall rocks have been altered to a mixture of talc and secondary calcite. The acanthite commonly mantles the sphalerite and galena grains or follows the intergrain boundaries of calcite and quartz. One grab sample of ore contained 1,420 ppm (~40 oz/t) silver and 6 ppm (0.17 oz/t) gold (table 4).

Lookout mine.--The Lookout mine is along the south side of Trujillo Creek about 1 mi northwest of Seven Brothers Mountain (fig. 2). The mine has been described by Harley (1934) who estimated that the total production of the silver-rich ores had a value of $100,000. The mine is developed by an inclined shaft and about 2,400 ft of inaccessible workings. The inclined shaft is along the contact of the Bliss Sandstone with the El Paso Formation, and the ore deposits are closely associated with a rhyolite dike and sill that has been intruded along the contact of quartzite with a shaly limestone. A strong fault that strikes N. 10° W. has caused thinning of the quartzite. The silver tellurides, calaverite, and hessite, have been recognized as important ore minerals that occur with pyrite, sphalerite, and galena.

Grey Eagle mine.--The Grey Eagle mine along South Percha Creek (shown only on figure 2) is included in the Tierra Blanca district, although earlier reports consider it to be within the South Kingston district. As much as 2,855 tons of ore has been mined from the various workings of the Grey Eagle group and the mine was noted for its high-grade pockets of silver-rich ore that contained as much as 14 oz of silver per ton of ore. The past known production figures are cited from Hill (1946). The average grade of the ore is as follows: lead, 5.5 percent; zinc, 8.1 percent; copper, 1.8 percent; and silver, 13.5 oz/t.

Years	Tons of ore	Lead (lbs)	Zinc (lbs)	Copper (lbs)	Au (oz)	Ag (oz)
1919-1920	319	41,878	51,069	--	9.2	8,049
1943-1944	2,536.7	276,709	412,986	92,784	64.2	30,768
Total	2,855.7	318,487	464,055	92,784	73.4	38,817

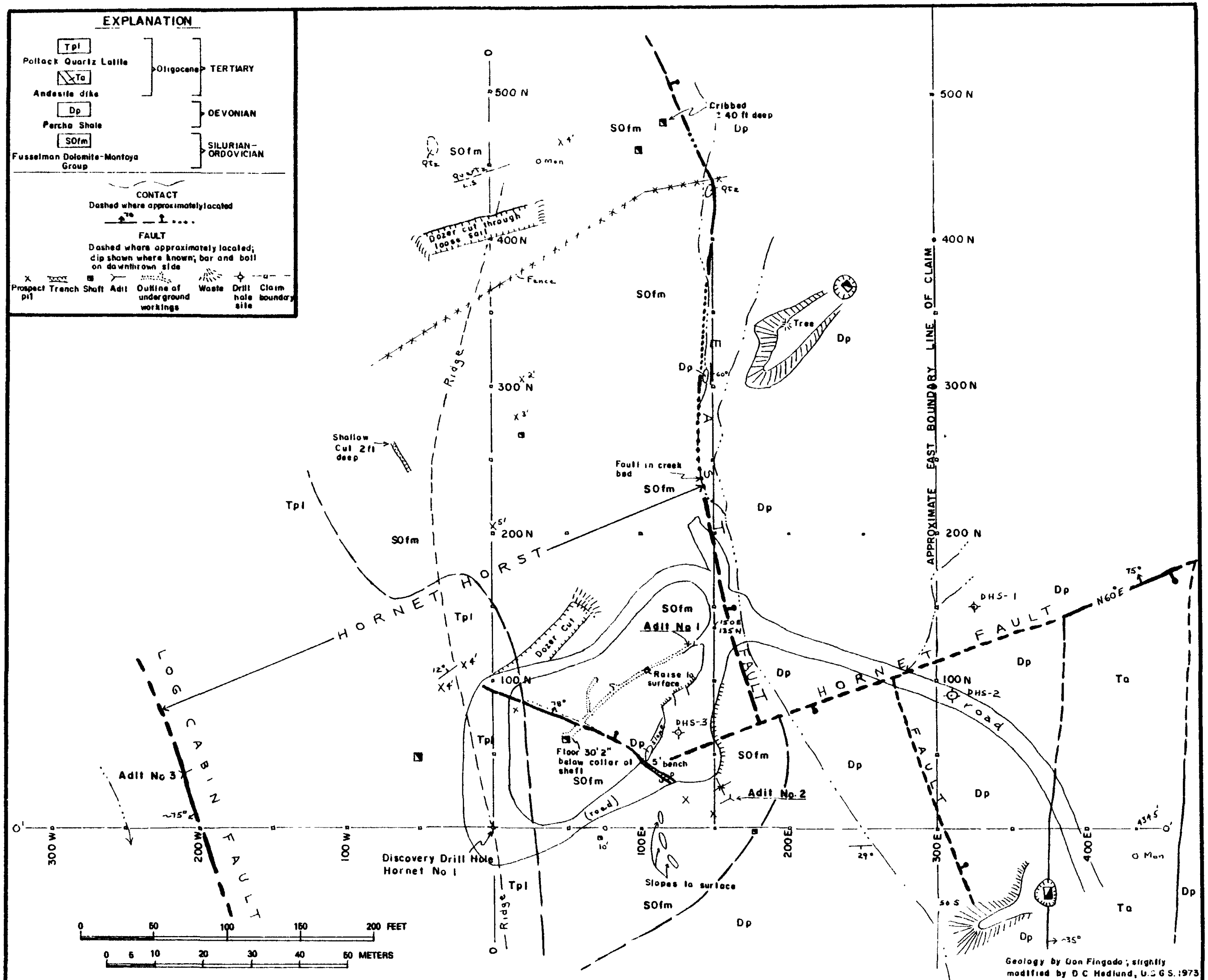


FIGURE 6--GEOLOGIC SKETCH MAP OF THE LOG CABIN MINE AND HORNET CLAIM AREA, TIERRA BLANCA DISTRICT, SIERRA COUNTY, NEW MEXICO

Table 4.--Semiquantitative spectrographic and modal analyses of ore samples from the Jap and Log Cabin mines with supplemental atomic absorption analyses for gold and gravimetric analyses for silver

[Spectrographic analyses by L. A. Bradley, 1973; atomic absorption (A.A.) analyses for gold by A. W. Haubert and Claude Huffman, Jr., 1974; gravimetric silver analyses (Chem.) by A. W. Haubert, G. D. Shipley, and Claude Huffman, Jr., 1974. Values reported in parts per million to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.15, and so forth. Elements determined but not reported here are: Na, K, Ga, and Zr. L, detected but below limit of determination; N, not detected; G, greater than 10 percent]

Rock type---	Vein sample Jap mine	Sulfide concentrate from vein Jap Mine	Vein sample Log Cabin mine
Field No.---	S1-283-73	SL-1-JAP	Hb-81-72
Lab No.-----	D163861	D161396	D161398
Analyses (ppm)			
Be	2	N	N
Mg	3,000	700	10,000
Ca	30,000	10,000	30,000
Sr	30	N	15
Ba	30	2,000	15
Zn	G	G	300
Pb	G	70,000	1,500
Cd	700	2,000	N
Cu	50,000	30,000	100
Ag	300	1,000	1,000
Ag (Chem.)	(230)	(1,430)	(1,420)
Au	N	N	N
Au (A.A.)	(n.d.)	(0.05)	(6)
As	N	N	N
Sb	N	N	N
Bi	N	2,000	N
Fe	70,000	50,000	1,000
Mn	1,500	2,000	1,000
Ti	1,500	200	30
Zr	30	N	N
Ni	30	20	L
Co	30	150	N
Cr	10	20	2
Mo	50	500	7
V	50	L	1
Nb	N	L	L
Sc	7	N	N
La	70	N	N
Nd	100	N	N
Yb	7	N	N
Y	70	L	N
Ce	200	N	N
Modal analyses (volume percent)			
Points counted	698	217	220
Pyrite	19	0	5
Sphalerite	51	89	5
Galena	12	5	80
Chalcopyrite	18	6	5
Covellite	0	tr	0
Polybasite	0	0	0
Native silver	0	0	1
Argentite	0	0	4
Totals	100	100	100

The map of the underground workings at the Grey Eagle mine was prepared by R. L. Griggs and S. P. Ellison (U.S. Geological Survey open-file maps, 1943) (pl. 11), and the mapping was followed by a drilling program conducted by the U.S. Bureau of Mines in 1944. Seven exploratory drill holes disclosed only small bodies of ore. Five of the holes were drilled underground and two were from the surface, and the total length of core or cuttings was 848.8 ft (259 m) (Hill, 1946).

The ore deposits are chiefly along breccia zones marginal to rhyolite dikes that strike N. 5^{o}-10^{o} W. within the El Paso Limestone. The ore minerals consist of 80 percent sphalerite, 10-16 percent galena, 3 percent chalcopyrite, and minor amounts of pyrite. A chemical analysis of dump material indicates 250 ppm (7.1 oz/t) of silver and 0.8 ppm (0.02 oz/t) of gold (table 2). The galena is argentiferous and contains 850 ppm silver, as indicated by electron microprobe analyses (table 3).

Jayhawk mines.--Numerous small adits and prospect pits are located along Armstrong Canyon on the south side of Tierra Blanca Mountain in the southern part of the Tierra Blanca district (fig. 2). Most of these small mines are located along talcose quartz veins that strike N. 0^{o}-30^{o} W. The host rock is recrystallized sugary Fusselman Dolomite and the ore minerals include sphalerite, galena, pyrite, chalcopyrite, and acanthite. The dolomite is brecciated in places along a large fault that strikes N. 15^{o}-20^{o} E. and displaces rhyolite in contact with dolomite.

Jap-Upton mines.--The Jap mines along the east side of Seven Brothers Mountain have produced as much as 140 tons of ore and were intermittently operated by Jack Upton in 1970. The largest mine, the Big Jap (fig. 2), operated briefly in 1970 and was developed by an adit 55 ft (16 m) long that trends N. 70^{o}-75^{o} W. in Bliss Sandstone and joins a shaft 65 ft (20 m) deep that was collared in the El Paso Limestone.

Several analyses of ore shipments from the Big Jap mine had the following values: zinc 8.8-10.2 percent, lead 6.0-8.7 percent, copper 2.2-4.0 percent, silver 10.5-23.75 oz/ton, and gold 0.04 oz/ton. Some vein samples in the quartzite contain relatively large amounts of chalcopyrite (35-40 percent) and pyrite (22 percent); the galena content is about 6 percent and the sphalerite about 34 percent. A chemical analysis of composite vein samples indicated 230 ppm silver (~7 oz/ton) and a similar analysis of sulfide concentrates showed 1,430 ppm silver (~40 oz/ton) and 0.05 ppm gold (table 4). An electron microprobe analysis of the argentiferous galena showed the presence of 850 ppm silver (table 3).

Carpenter (Swartz) District

Introduction

The Carpenter district is on the west slope of the Black Range within rugged pine-forested land in the Gila National Forest. Most of the mines in the district can be reached from the junction of New Mexico State Highway 180 with State Highway 61 at San Lorenzo by traveling about 7 mi (11.3 km) south along Highway 61 to the Royal John road turnoff and then by dirt road 12 mi (19.3 km) east to the Royal John mine. The Forest Service Silver Creek Road 523 leads to the Grandview, Columbia, and other mines from the junction with Forest Service Road 886 about 9 mi (14.5 km) east of New Mexico Highway 61 (fig. 1).

History

Base metal ores were discovered in the district in 1880, and in 1891 the first patented claim, the Comanche, was located. Some of the earliest mining operations were probably along the Discovery workings in the Royal John mine area. This property was acquired in 1914 by Albert Owen and the Black Range Mining Company which shipped about 160 tons of lead-zinc ore during WW I. In 1917 the Mimbres Mining Company purchased the property and nine churn drill holes were drilled to the north of the Sunshine Cut (pl. 6). The Royal John mines were operated by the American Smelting and Refining Company from 1927 to 1929 and about 20,534 tons of ore were shipped. Mining operations ceased in 1929 owing to a decline in metal prices and did not resume until early 1942 when Albert Owen reacquired the property. A lease-option arrangement with the Peru Mining Company in 1943 led to the drilling of 12 cored holes; the deepest hole, No. 1, bottomed at 708 ft (pl. 6). During the spring and summer of 1943 the U.S. Geological Survey mapped the Carpenter district, and some mines in the north part of the district were mapped in detail. An area was recommended to the U.S. Bureau of Mines for exploratory drilling, and project 15-115 was begun at the Grandview mine in September 1943. The U.S. Bureau of Mines later requested that the Royal John mines be mapped, and this work was accomplished in 1944 by A. E. Weissenborn and others of the U.S. Geological Survey. In 1948, the U.S. Bureau of Mines conducted a drilling program and 38 holes were drilled in the district (Soule, 1950). In 1964 the G. F. and G. Mining Company shipped 1,592 tons of ore before the Diversified Corp. and Joplin Industries acquired the property. An additional four holes were cored in September and October, 1973, on the Royal John property by Oliver Reese, representing the FROBEX Company. The U.S. Geological Survey was permitted to examine this core and the logs are shown in Appendix B.

Production

The total ore production from the Royal John, Columbia, Grandview, and Mineral Mountain mines has been about 58,000 tons, and it is estimated that another 2,000 tons has been taken from the Patsy, Acklin, McGee, and various other small mines in the district. The 60,000 tons of ore is estimated to have an average grade of about 7.6 percent zinc, 3.6 percent lead, 0.13 percent copper, and 1-3 oz silver/ton.

Geology

Most of the zinc-lead vein and bedded-replacement deposits occur within the El Paso Limestone of Lower Ordovician age and the Fusselman Dolomite and Montoya Group dolomitic beds of Ordovician and Silurian ages. The dominant structural feature in the Carpenter district is a gently west-dipping homocline in the central and southern part of the district and a north-striking doubly plunging anticline of low amplitude with a core of Precambrian granite in the vicinity of Rustler Canyon and the Grandview mine (pl. 5). Most of the veins are fault controlled but the strata-bound bedded-replacement orebodies are within skarns that are especially well developed in the upper cherty beds of the El Paso Limestone.

The faults in the district mainly strike north to N. 25° W. Some of these faults are pre-ore but many are post-ore, e.g. the Sunshine and Discovery faults in the Royal John mine area (pl. 6). Many faults have been mapped underground by Griggs and Ellison (1943), where the complexity of the faulting is more evident than at the surface.

From north to south the important mines of the district are the Mineral Mountain, Grandview, Columbia, Patsy, Acklin, Royal John group, Sunshine, and McGee (pl. 5). Most of these mines are located along or near the Grandview and Owens fault system that strikes N. 20^{o}-30^{o} W. through this region. Within the southern part of the district these faults bound a horst that brings older Paleozoic strata into fault contact with limestones of the Magdalena Group and with Tertiary volcanic rocks (pl. 5). To the north the horst is less well defined with numerous cross faults and splayed branch faults. In the Royal John area the Grandview and Owens fault have important parallel subsidiary faults such as the Discovery-Workings and Sunshine faults (pl. 6). All of these post-ore faults displace the strata-bound layers.

Ore genesis

The hydrothermal ore deposits of the Carpenter district are clearly related to rhyolitic plutons of Oligocene age (34.8±1.2 m.y., Hedlund, 1977a) that were emplaced in the ring fracture zone of the Emory caldera. These epizonal intrusives were probably intruded to depths of about 3,300-5,000 ft (1,000-1,500 m) below the surface as based on the thickness of volcanic rocks present at the time of intrusion. Some of the plutons do not crop out, as in the Royal John mine area and near the Grandview mine where drill holes 3 and 5 (pl. 8) penetrated a rhyolite pluton at a depth of about 200 ft (60 m) beneath the present surface. The plutons intrude the Kneeling Nun Tuff, the ash-flow tuff fill of the Emory caldera, and the underlying pre-caldera Paleozoic carbonate formations, where most of the ore deposits occur in the resulting skarns.

Vein and skarn deposits

Distribution.--The distribution of skarns is discontinuous along the outcrop of Paleozoic carbonate strata that extends from the McGee mine on the south to the Mineral Mountain mines on the north, a distance of about 5 mi (8 km) over a width of about 0.5 mi (0.8 km) (pl. 5). In the southern and central parts of this belt the skarns reflect proximity to buried Mid-Tertiary silicic plutons, and in the vicinity of the Columbia, Grandview, and Mineral Mountain mines to the north these plutons and dikes crop out within 3,000 ft (915 m) of the skarn deposits.

The aeromagnetic map of Wynn (1978) shows an elongate (~8 mi long and about 0.5 to 2 mi wide) magnetic high of +50 to +80 gammas over the district, that roughly corresponds to the outcrop of silicated and mineralized Paleozoic carbonate strata. The high aeromagnetic anomaly is narrow in the vicinity of the magnetite-bearing skarns but fans outward at both the north and south ends where there is an abrupt change of lithology to volcanic rocks. The aeromagnetic high is relatively even and smooth although the magnetite occurrences in outcrop are of limited extent and are chiefly confined to the vicinity of the Patsy and Columbia mines.

The skarns are especially well developed in the cherty limestone beds in the upper part of the El Paso Limestone but also occur to minor extent in the carbonate strata of the Fusselman-Montoya, Lake Valley, and Magdalena formations. Some of the dark-brown-weathering silicated layers of ferrian dolomite of the El Paso Limestone can be traced for hundreds of meters along cherty horizons in the limestone.

Fissure vein deposits are common throughout the district and are especially localized along N. 5^{o}-30^{o} W.-striking faults of late Oligocene age. Some veins, especially in the Columbia mine area (pl. 10), are locally contiguous with rhyolite dikes; other veins clearly post-date the skarn deposits and follow intergrain surfaces and fractures in garnet, diopside, and other skarn minerals.

Paragenetic sequence of skarn minerals.--There are numerous skarn minerals within the Carpenter district, and those listed in figure 7 represent only the principal minerals or mineral groups identified in petrographic studies. Undoubtedly a more intensive study of the mineralogy would reveal additional skarn minerals. In general terms the silicates and iron oxides are early-formed minerals; the sulfides are intermediate to late; and the fluorite-helvite assemblage is still later. A vertical zonation of the ore minerals is not readily apparent but needs further study.

The early phase of metasomatism was characterized by the presence of abundant iron, as shown by the presence of ferroan dolomite (N_o = 1.697-1.705) replacement bodies in the cherty limestone within the upper part of the El Paso Limestone. With further metasomatism magnetite and specularite formed, especially in the skarns of the Grandview, Patsy, and Columbia mines. At the Patsy mine magnetite occurs as small pods that are veined by grossular garnet; in other skarns the magnetite selectively replaced certain beds or seams in the limestone; and in some skarns the magnetite displays a crude net-texture and the magnetite is intergrown with granular diopside. The distribution of the magnetite-specularite-rich skarns can be determined by ground magnetic studies as shown on the geologic map (pl. 5).

Closely following or nearly concurrent with the iron-rich phase of metasomatism there was an extensive silication of the limestone and dolomite beds, which in the field is first shown by the occurrence of white tremolitic reaction rims on black chert nodules within the El Paso Limestone. Other silicates formed during this silication phase are andradite-grossularite garnet, diopside, epidote, wollastonite, zoisite, and clinozoisite. Zoned andradite-grossularite is especially abundant and commonly has birefringent rims that may be of hydrogrossular. In some grains sphalerite has selectively replaced zones within the garnet and also filled the interstices of the garnet aggregates. Some skarns, such as that at the Royal John mine contain abundant granular aggregates of diopside and epidote with sparse porphyroblasts of wollastonite. Clinozoisite, with anomalously blue pleochroism, partially replaces the epidote. At the Royal John, Patsy, and Mineral Mountain mines tremolite is especially abundant as matted aggregates about chert nodules and as clusters interstitial to the magnetite granules. During this silication phase the chert nodules became fragmented and bleached.

The zinc-rich sulfides of the ore-forming phase are interstitial to the diverse silicate minerals and also fill fractures and brecciated parts of the skarn. Minor amounts of muscovite, phlogopite, and chlorite are closely associated with the sulfides. The muscovite and phlogopite replace diopside, epidote, and other skarn minerals and the sulfides follow the cleavage and grain boundaries of the mica. The micas are especially localized along veins and shear surfaces that cut the magnetite-ilmenite skarns; commonly secondary calcite and quartz are associated with the micaceous minerals.

The late stages of mineralization are best developed at the Grandview, Patsy, and Columbia mines where fluorite and traces of helvite are in vug-fillings and quartz-bearing fractures that cut the sulfide-bearing skarns. Some of the quartz displays growth zoning and locally contains abundant deep-red acicular inclusions of hematite. The helvite at the Grandview mine has been described by Weissenborn (1948), and some of the ores of this mine contain as much as 150 ppm Be (table 5).

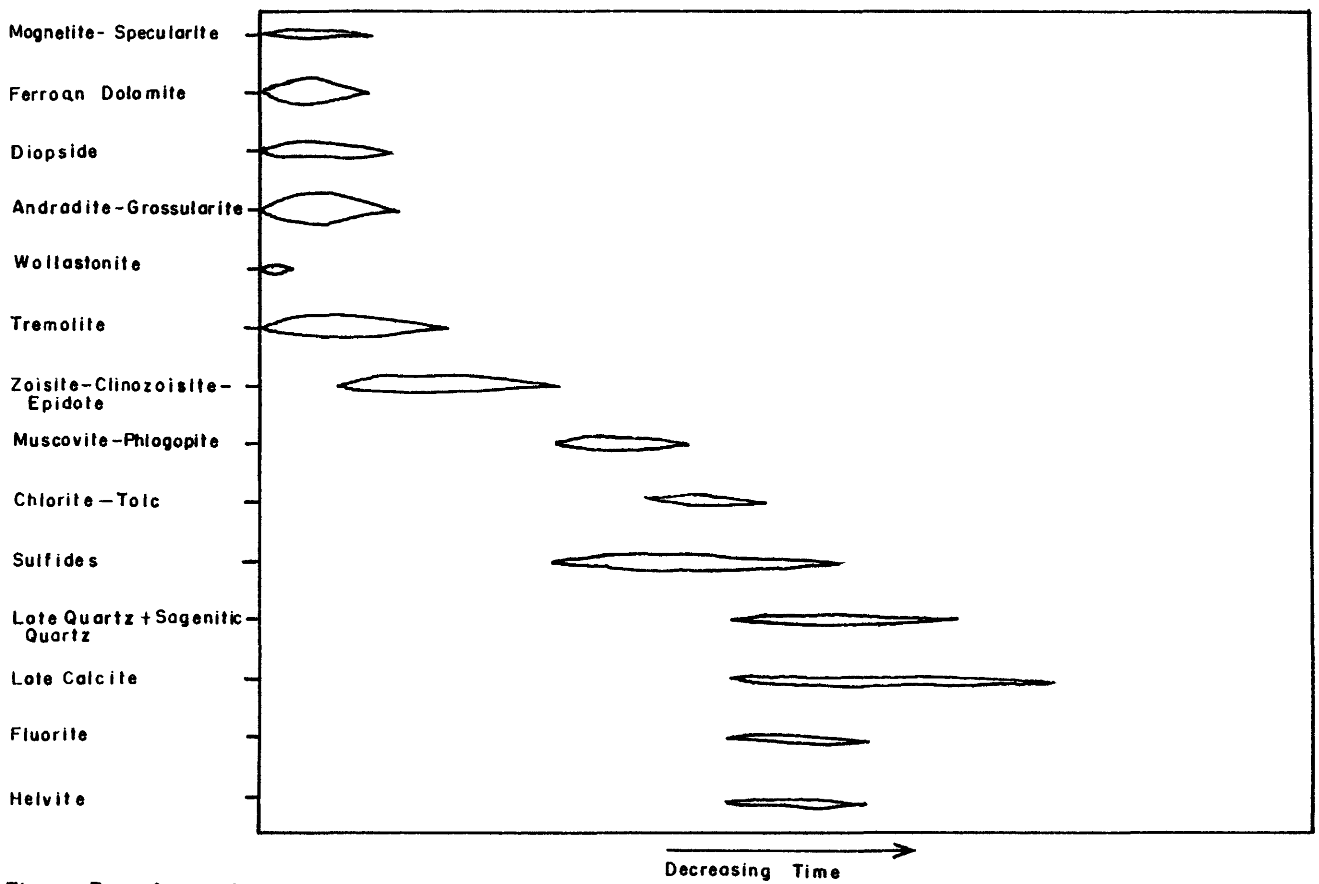


Figure 7.-- Approximate paragenetic sequence of skarn minerals and sulfides from the Carpenter mining district, San Lorenzo quadrangle

Table 5.--Semiquantitative spectrographic and modal analyses of ore samples from the Carpenter (Swartz) mining district with supplemental gravimetric analyses for silver

[Spectrographic analyses by J. C. Hamilton and L. A. Bradley, 1973; gravimetric silver analyses (Chem.) by G. D. Shipley and Claude Huffman, Jr., 1974. Values reported in parts per million to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.15, and so forth. Elements determined but not reported here are: Na, K, Ga, and Zr. L, detected but below limit of determination; N, not detected; G, greater than 10 percent]

	1	2	3	4	5	6
Mine locality-	Royal John	Acklin	Patsy	Columbia	Grandview	Mineral Mountain
Field No.-----	SL-5-RJ	SL-143-73	SL-179-73	SL-167-73	SL-152-73	SL-303-73
Lab No.-------	D161395	D163856	D163857	D163858	D163859	D163860
			Analyses (ppm)			
Be	N	N	5	10	150	2
Mg	3,000	2,000	20,000	7,000	20,000	5,000
Ca	30,000	30,000	G	G	70,000	G
Sr	15	15	15	70	15	700
Ba	5	20	3	10	5	3
Zn	G	7,000	5,000	10,000	G	70,000
Pb	G	7,000	3,000	2,000	G	70,000
Cd	1,500	L	N	L	700	300
Cu	700	15,000	7,000	1,500	2,000	15,000
Ag	100	300	50	7	150	30
Ag (Chem.)	---	(185)	---	---	(93)	---
Au	N	N	N	N	N	N
As	N	N	N	N	N	N
Sb	N	N	N	N	N	N
Bi	N	300	300	20	200	N
Fe	50,000	70,000	G	G	10,000	70,000
Mn	10,000	3,000	5,000	20,000	20,000	20,000
Ti	150	150	1,500	200	700	30
Zr	N	N	30	20	30	N
Ni	20	7	10	L	10	10
Co	70	70	70	5	10	7
Cr	70	3	30	5	15	7
Mo	10	7	150	7	70	N
V	10	N	150	70	30	70
Nb	L	N	10	N	N	N
Sc	N	N	7	N	N	N
La	N	N	50	N	N	N
Nd	N	N	N	N	N	N
Yb	N	N	N	N	N	N
Y	N	N	50	N	10	10
			Modal analyses (volume percent)			
Points counted	1,372	433	84	1,388	172	87
Pyrite	12	95	4	9	20	1
Sphalerite	74	4	96	90	54	95
Galena	13	tr	tr	1	25	tr
Chalcopyrite	1	1	0	tr	tr	3
Argentite	0	0	0	0	0	0
Polybasite	0	0	0	0	0	0
Totals	100	100	100	100	99	99

Paragenesis of ore minerals.--As indicated, the sulfide minerals are clearly a post-metamorphic assemblage that occurs along intergrain contacts of the silicate minerals and locally followed faults, fractures, and breccia zones within the skarns. Amber sphalerite containing 3.77 mole percent FeS (table 3) constitutes 60-95 percent of the sulfides; galena 3-15 percent; pyrite 5-30 percent; and chalcopyrite generally less than 3 percent. Chalcopyrite chiefly occurs as exsolution-type blebs along the margins of the sphalerite grains and locally alters to trace amounts of covellite. No silver minerals were identified in the 12 polished sections examined, although most silver values for the analyzed ores range from 7 to 185 ppm (0.2 to 5.3 oz/t) (table 5). However, as determined by electron microprobe, argentiferous galena contains as much as 500 ppm silver. Pyrite is an early mineral in the paragenetic sequence and some pyrite inclusions in the sphalerite have smooth anhedral outlines that suggest some replacement by sphalerite. Most pyrite and sphalerite grains are veined by galena.

Study of the ore minerals is made difficult by the inaccessibility of the numerous mine workings in the district. Many of the orebodies have been worked out and a vertical zonation of the ores can only be inferred by observing the ore assemblages along fissure veins that are stratigraphically lower in the section, e.g. at the Patsy mine near outcrops of the Bliss Sandstone, and comparing these assemblages with those stratigraphically higher, e.g. at the Grandview and Royal John mines. Generally there is a higher lead content, as galena, in the upper levels; a lower pyrite content at the lower levels; and a greater abundance of amber sphalerite at the higher levels (table 5).

Description of selected mines

Royal John mines.--Numerous small mines comprise the Royal John group; these include the West Cut, East Cut, Wilson Cut, Royal John, Mill adit, and Sunshine adit (pl. 6). A geologic map of the Royal John property was first published by the U.S. Bureau of Mines (Hill, 1946), and the results of the drilling activity and early mining history were described in detail by Soule (1950).

The past production figures for the Royal John group of mines are summarized from Hill (1946):

Years	Tons of ore	Lead (lbs)	Zinc (lbs)	Copper (lbs)	Silver (oz)	Gold (oz)
1916-1949	31,322	1,913,257	3,160,526	18,270	41,378	9.4
1956-1969	1,780	206,500	363,200	--	3,899	--
Total	33,102	2,119,757	3,523,726	18,270	45,288	9.4

The average grade of ore is as follows: zinc, 5.3 percent; lead, 3.2 percent; copper, 0.027 percent; and silver, 1.4 oz/t. The reserves remaining on the Royal John property are difficult to assess owing to the absence of complete drilling records. However, some of the core remaining from the U.S. Bureau of Mines drilling program and from the more recent FROBEX Project were available for inspection and the logs of these holes are presented in Appendix B and in the cross sections of plate 6. A projection of favorably mineralized skarns between the West Cut and the Royal John mine and New Cut (secs. A-A′ and B-B′, pl. 6) suggests that there is probably less than 20,000 tons of ore remaining in this area.

On the Royal John property bedding-replacement-type ore deposits are common in the upper silicated cherty limestone beds of the El Paso Limestone. The dark-brown-weathering silicated layers can be traced for hundreds of meters along a cherty horizon that is 20-75 ft (6.1-22.9 m) below the lowest dolomite bed of the Montoya Group (pl. 6). The mineralized outcrops are in a small erosional window surrounded by younger nearly flat-lying Paleozoic carbonate strata.

The area of mineralized rock is within the horst bounded by the Owens and Grandview faults which strike N. 10°-25° W. Within this horst parallel subsidiary post-ore faults such as the Discovery and Sunshine faults have displacements as much as 400 to 600 ft (120-180 m). The Owens fault is pre-ore, but it is uncertain whether the Grandview fault predates the mineralization. The Discovery fault has a throw of about 115 ft (35 m) and has displaced two mineralized zones downward on the east to the 7,740-ft level and the 7,655-ft level (sec. B-B′, pl. 6). The Owens fault has a throw of about 1,350 ft (411 m) and places limestones of the Magdalena Group in fault contact with the Fusselman-Montoya Dolomites. The displacement on the Grandview extension fault is probably 750 to 800 ft (230-245 m) as based on formational thickness and cross section C-C′ (pl. 6).

Contact metamorphic effects are pervasive in the dolomitic beds of the Montoya Group and in the underlying cherty beds of the El Paso Limestone. Among the metamorphic minerals are ferrian dolomite, talc, tremolite, diopside, epidote, grossularite, and wollastonite. With increasing silication the cherty limestone becomes greenish gray, pinkish gray, and finally olive green, and the chert becomes more bleached and fragmented. Drill core that was examined from the FROBEX holes revealed that the dolomite beds in the overlying Montoya Group showed evidence of solution and replacement by yellowish-gray fine-grained calcite. The presence of white clay and secondary calcite veinlets suggests that this replacement of dolomite may have been caused by the downward percolation of groundwater.

Acklin mine.--The Acklin mine, across Wilson Canyon, northwest of the Royal John mine (pl. 6), has been developed in a tactite zone in cherty limestone within the El Paso Limestone. In proximity to the mine adit the El Paso Limestone is repeated by the Grandview fault and the ore horizon is displaced upward about 750 ft (230 m) on the east side of the fault. Epidote, diopside, clinozoisite, and granular garnet aggregates are the chief minerals in the tactite and pyrite; sphalerite, galena, and chalcopyrite are the principal sulfides. One composite sample from the ore dump contained 300 ppm (~8 oz/t) of silver (table 5).

Patsy mine.--There are numerous trenches, open cuts, and several adits along the steep canyon walls of upper Little Gallinas Canyon (pl. 5). The main adit is at creek level at an elevation of 8,200 ft and trends N. 50° E. into mineralized beds of the El Paso Limestone. An open cut along the north side of the canyon and about 150 ft (45 m) west of the main adit is in a mineralized fault within the El Paso Limestone near the contact with the Bliss Sandstone. Along the south side of the canyon about 100-150 ft (30-45 m) above stream level there are several small prospect pits and adits in bedding-replacement bodies within cherty limestone beds of the El Paso Limestone, just below the contact with dolomite of the Montoya Group. The total ore production from this group of workings is not known but is estimated between 300 and 500 tons.

The El Paso Limestone is locally marmoritized and silicated in areas of bedding-replacement deposits. The thermally metamorphosed limestone contains magnetite, specular hematite, chlorite, phlogopite, muscovite, diopside, wollastonite, grossular garnet, and helvite. Vug fillings of specular hematite and fluorite are locally common. The ore minerals are dominantly amber sphalerite (90-95 percent) with minor amounts of pyrite, galena, and chalcopyrite. One semiquantitative spectrographic analysis of a composite ore sample showed only 50 ppm (1.4 oz/t) of silver (table 5).

Columbia mine.--The early history of the Columbia mine is poorly known. The first recorded shipment of ore was in 1924, and about 1,400 tons of ore were mined during World War II. Past production figures for the mine are summarized from Hill (1946):

Years	Tons of ore	Lead (lbs)	Zinc (lbs)	Copper (lbs)	Ag (oz)	Au (oz)
1924	1,709	207,627	369,888	6,480	2,307	--
1943-1944	1,375	64,000	266,000	--	1,603	--
Total	3,084	371,627	635,888	6,480	3,910	--

The average grade of the ore is 10.3 percent zinc, 6.0 percent lead, 0.11 percent copper, and 1.2 oz/ton of silver.

The Columbia mine is only partially accessible and this description is based on the mine map of R. L. Griggs and H. C. Wagner (U.S. Geological Survey open-file map, 1963) (pl. 10). This map shows development on two levels from adits which trend S. 70° E. and S. 50° E. The lower level is 360 ft (110 m) long and a crosscut at 210 ft (64 m) follows the vertical contact of a rhyolite porphyry dike for about 250 ft (76 m) along a N. 10°-15° E. strike. The El Paso Limestone is silicated and mineralized marginally to the dike. In the upper level the rhyolite dike is absent, but there is a mineralized zone along a fault that strikes N. 30° E. The El Paso Limestone at the mine entrance contains some silicated cherty beds that strike N. 10°-20° E. and dip 30° W. A ground magnetic survey (pl. 5) indicates that the highest magnetic anomalies occur in an elongate area over the Columbia and Patsy mines.

Minerals that are commonly present in the tactite are magnetite, phlogopite, chlorite, diopside, epidote, and grossular garnet. The sulfides follow boundaries of the diopside, garnet, and epidote grains and locally replace selective zones (hydrogrossular zones?) in the garnet (fig. 8). The sulfides are later than the magnetite as well as the silicates, and include sphalerite, 10 percent; pyrite, 8 percent; galena, 1 percent; and chalcopyrite, 1 percent. Sphalerite commonly contains exsolution blebs of chalcopyrite and also rounded inclusions of pyrite. Some of the more euhedral pyrite is intergrown with magnetite. Silver-bearing minerals are absent and a semiquantitative analysis indicates only 7 ppm (0.2 oz/t) silver in composite grab samples of the ore (table 5).

Grandview mine.--The early history of the Grandview mine is largely unknown prior to the middle 1930's. In 1937, D. B. Leake of San Lorenzo shipped about 110 tons of ore from about 15 claims covering the Grandview mine area. Later the Black Range Development Co. leased the property and operated the mine for a period of about 7 years during which about 19,000 tons of ore was shipped (Hill, 1946). Mining operations ceased in 1945 when the lease to

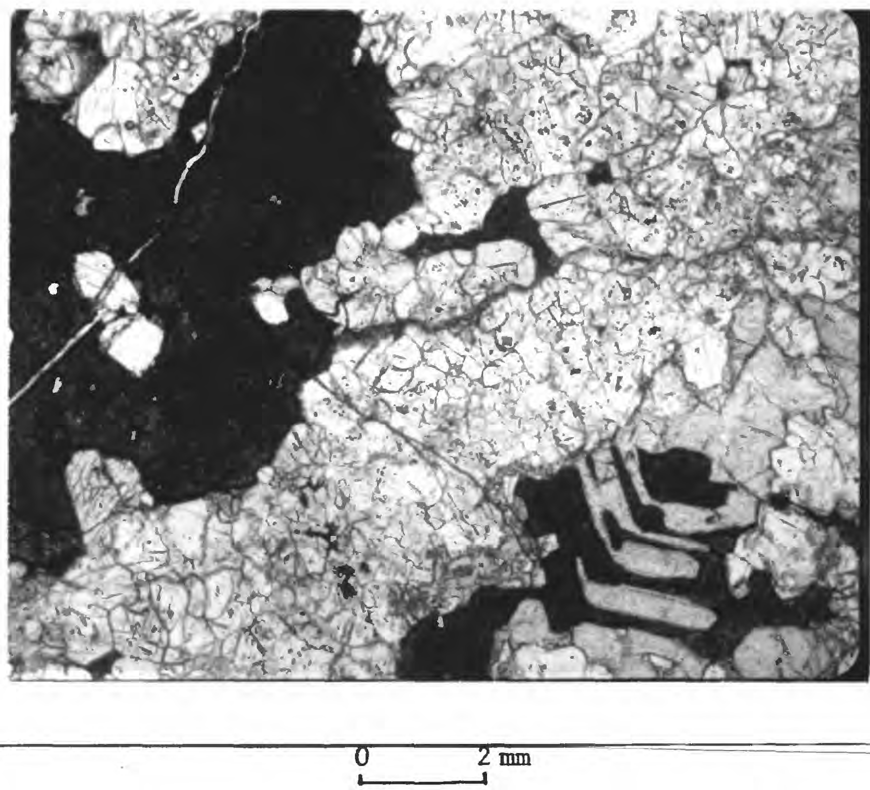


Figure 8.--Photomicrograph of tactite from the Columbia mine. Specimen contains granular intergrowth of diopside (white) and zoned andradite garnet (gray with high relief) with interstitial sphalerite (black). Note how the sphalerite has replaced zones in the garnet and filled interstices between the diopside grains.

the Black Range Development Co. was terminated. Past production figures for the Grandview mine are summarized from Hill (1946):

Years	Tons of ore	Lead (lbs)	Zinc (lbs)	Copper (lbs)	Silver (oz)	Gold (oz)
1938	80	35,662	39,862	--	--	--
1938-1944	18,869	1,722,828	3,214,223	92,999	13,963	15.34
Total	18,949	1,758,490	3,254,085	92,999	13,963	15.34

The average grade of the ore is as follows: zinc, 8.5 percent; lead, 4.7 percent; copper, 0.24 percent; silver, 0.73 oz/ton; and gold, 0.08 oz/ton.

The Grandview mine has been mapped by R. L. Griggs and S. P. Ellison (U.S. Geological Survey open-file map, 1943). The mine is now largely inaccessible and the middle level adit is now collapsed into a small glory hole or pit at road level. As shown by Griggs and Ellison, the mine is developed by lower, middle, and upper workings, as shown in plate 9. There are two adits that trend about N. 70° E. and intersect mineralized faults that strike N. 0°-10° W. Four inclined holes and one vertical hole were drilled by the U.S. Bureau of Mines along the 5,000 N. coordinate at the surface and four of the holes intersected mineralized limestone (pl. 8). One vertical hole (No. 5) and one inclined hole (No. 3) intersected rhyolite porphyry at a depth of about 150-200 ft (45.7-60.9 m) (pl. 8).

The tactite at the Grandview mine contains magnetite, diopside, grossular garnet, helvite, and fluorite. Fluorite, helvite, and quartz are present as vug fillings and appear to be later than the silicates and iron oxides. There is commonly abundant vein quartz and calcite associated with the ore minerals. The Devonian Percha Shale outcrop just to the north of the mine area along Rustler Canyon (pl. 5) is converted to bleached flinty hornfels, which suggests proximity to a concealed intrusive in this area.

The sulfides are clearly later than the silicates and follow intergrain surfaces and fractures in the garnet and diopside. Sphalerite is present in variable amounts, 3-55 percent, and commonly contains exsolution blebs of chalcopyrite. Euhedral pyrite is an early formed mineral and the pyrite content varies from 20-90 percent. Galena commonly replaces pyrite and sphalerite and comprises 5-25 percent of the sulfides. The galena is argentiferous and contains as much as 3,100 ppm silver (table 3). One semiquantitative spectrographic analysis of ore showed 150 ppm (4.2 oz/t) silver, and other elements of significance were beryllium, 150 ppm, and cadmium, 700 ppm (table 5). The relatively high beryllium content indicates appreciable helvite in some of the sulfide-tactite bedding-replacement deposits.

Mineral Mountain mines.--A series of four small adits are developed in metamorphosed Lake Valley Limestone and limestones of the Magdalena Group at the end of the Forest Service Road 523 and along the north side of Rustler Canyon at an elevation of about 8,000 ft (pl. 9). The earliest recorded shipment of ore from the Mineral Mountain group of mines is 1924 and any later mining activity is not recorded. Past production figures from the Mineral Mountain mines are summarized from Hill (1946):

Years	Tons of ore	Lead (lbs)	Zinc (lbs)	Copper (lbs)	Silver (oz)	Gold (oz)
1924	46	6,800	--	3,282	220	231

The average grade of the ore is as follows: lead 7.4 percent, copper 3.5 percent, silver 6 oz/ton, and gold 6.6 oz/ton.

The mineralized zones are largely bedding-replacement deposits that extend for about 30 ft (9 m) along marmoritized and cherty limestone beds of the Tierra Blanca Member of the Lake Valley Limestone. Some mineralized faults and dike margins contain minor amounts of galena and amber sphalerite; generally galena is more abundant than sphalerite and pyrite. The deposits are small and are locally fault controlled with N. 30° W.- and N. 30° E.-striking faults most prominent.

GEOCHEMISTRY

The results of the extensive geochemical sampling program in the Hillsboro-San Lorenzo quadrangles have been published in various U.S. Geological Survey Miscellaneous Field Study Maps by Alminas and Watts (1978); Alminas, Watts, Siems, and Kraxberger (1978a,b,c,d); Watts, Alminas, and Kraxberger (1978); and Watts, Alminas, Nishi, and Crim (1978a,b,c). Most of these data pertain to a select group of 31 elements as determined in panned concentrates along the drainage systems within these quadrangles. Additional analyses of diverse rock types, vein systems, and bedding-replacement deposits that have been determined by the U.S. Geological Survey in the course of this study are presented in this open-file report.

The Copper Flat porphyry copper stock has been extensively sampled and has yielded anomalous gold, bismuth (as tetrahedrite and bismuthinite), molybdenum (molybdenite), nickel, and cobalt values, as well as copper, lead, and zinc concentrations (Alminas and Watts, 1978). Streams draining across the andesite surrounding this highly eroded Laramide volcano have yielded panned concentrates that contain anomalous amounts of silver, gold, boron, and fluorite (Alminas and Watts, 1978). Electron microprobe analyses of pyrite and chalcopyrite grains from fracture-fillings in the quartz monzonite central intrusive of the volcano show as much as 0.2-0.4 weight percent Ni and 0.14-0.4 weight percent Co. The boron (30-50 ppm) occurs in tourmaline along some of the vein systems in the southeast quadrant of the Copper Flat volcano (K. C. Watts, written commun., 1975). Molybdenite occurs in veins along the south and southwest margins of the stock. Silver and gold values are especially high along the veins in the andesite along the south and southeast quadrants of the volcano, and silver values are especially high along the quartz latite dikes that radiate outward from the central quartz monzonite intrusion. Detrital fluorite is present in stream-sediment concentrates that were analyzed in areas marginal to the known base- and precious-metal deposits. Along Tank Canyon anomalous amounts of scheelite occur in panned concentrates in areas of tactite. Some of the jasperoids just south of Ready Pay Gulch have yielded anomalous amounts of mercury (0.9-4.4 ppm Hg) as well as plumbojarosite (T. G. Lovering, written commun., 1978). Along the west

Partial electron microprobe analyses of chalcopyrite and pyrite from the Copper Flat Stock

[Analyses by R. H. Heidel and D. C. Hedlund, 1975; all values in weight percent]

Locality[1]	No. of analyses	Mean FeS_2	Mean Zns	Ni	Co	As	S
Electron microprobe of chalcopyrite							
HL-24"-71	4	70.2	1.51	0.424	0.40	0.046	35.7
Electron microprobe of pyrite							
HL-24"-71	5			0.20	0.20	0.039	--
				0.19	0.14	0.051	--

[1]Prospect pit: NE1/4 NE1/4 sec. 35, T. 15 N., R. 7 W., Hillsboro quadrangle. Polished section contains 65 percent chalcopyrite, 8-10 percent pyrite, 15 percent bornite, and 8-10 percent magnetite (in volume percent).

side of the Copper Flat volcano in the vicinity of Warm Springs Canyon the stream sediments have been notably barren of Cu, Au, Ag, and base metal concentrations.

The silver-bearing base metal veins of the Kingston district contain anomalous amounts of antimony, arsenic, cadmium, copper, and manganese (table 2). The high antimony (as much as 10,000 ppm) and arsenic (as much as 10 percent) in some veins can be attributed to the presence of polybasite in some ores from the Brush Heap, Ingersoll, and Gypsy mines. Cadmium, in amounts as much as 1,000 to 2,000 ppm, is an ubiquitous element in some of the sphalerite-rich ores. Anomalous amounts of Cu, Pb, and Ag are found in panned stream concentrates along Ladrone Gulch, Mineral Creek, and Carbonate Creek.

The zinc-rich base metal skarn, vein, and bedding-replacement deposits of the Carpenter district have anomalous silver (1-3 oz/ton), bismuth, beryllium, tungsten, fluorine, and cadmium values (table 5). The beryllium values are especially high (150 ppm) in the skarns from the Grandview mine and can be attributed to the presence of helvite. Sporadic amounts of fluorite occur in the ores of the Patsy, Columbia, and Grandview mines. Stream-sediment concentrates have especially high values of lead and bismuth in the vicinity of the Columbia mine, and tungsten anomalies are found in the nonmagnetic fractions throughout the skarn belt. Anomalous lead, zinc, and silver values are found in stream-sediment concentrates throughout the Carpenter district with silver anomalies of 10 to 500 ppm most common in the vicinity of the Royal John group of mines.

The silver vein and bedding-replacement deposits in the Tierra Blanca district, along Pierce Canyon and extending northward into the vicinity of Tierra Blanca Mountain, are characterized by anomalous values of Pb, W, and Mo, as well as silver. The Silver Tail mines produced appreciable amounts of tungsten from molybdenum-bearing scheelite, according to Dale and McKinney (1959, p. 66, 67). High molybdenum values are also reported from panned stream concentrates in the vicinity of the Jayhawk mines (fig. 2) near Tierra Blanca Mountain. At the Grey Eagle mine, and extending southward to the vicinity of Seven Brothers Mountain in the Carpenter mining district, stream-sediment concentrates contain anomalous amounts of silver and molybdenum. Stream sediments along South Percha Creek near the Grey Eagle mine contain as much as 10,000 ppm Ag in panned concentrates and near the Lookout mine stream concentrates contain 500 ppm silver (Alminas and others, 1978a). Molybdenum anomalies are well represented in this area.

The Rose mine area west of the Mimbres Valley and about 3.5 mi southwest of San Lorenzo (fig. 2), has anomalous values for Mo, Cu, Pb, Zn, and Ag. High lead values are especially concentrated in jasperoids and limonite cappings with as much as 700 ppm Pb reported.

Anomalous concentrations of tin and fluorine are associated with rhyolite domes in the south-central part of the Hillsboro-San Lorenzo composited quadrangles. Panned stream sediments in the vicinity of Noonday Peak (fig. 1) have yielded detrital cassiterite, and detrital fluorite occurs in panned stream concentrates near Larkins Springs (fig. 1).

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APPENDIX A

Analytical data and composition of diverse plutonic and extrusive rocks of Laramide and Tertiary ages

Location and description of samples

1. Quartz monzonite, Copper Flat stock: NW1/4NE1/4NE1/4 sec. 35, T. 15 S., R. 7 W., Hillsboro quadrangle. Light-pinkish-gray, medium-grained porphyry with scattered orthoclase laths up to 15 cm long. Contains 60-70 percent orthoclase, 8-21 percent oligoclase (An_{25-27}), 10 percent quartz, 5 percent biotite, and 4-5 percent magnetite. Accessories are sphene, apatite, zircon, and sericite. Very slight sericitization with some radiating and fibrous "bow-tie" sericite about the granules of magnetite.
2. Altered quartz monzonite, Copper Flat stock: Composite drill core samples from IDC-25, 27, and 28 (Inspiration Development Co.), S1/2 sec. 26, T. 15 S., R. 7 W., Hillsboro quadrangle. Very light pinkish gray, fractured quartz monzonite with very thin (<1 mm) fracture-fillings of pyrite and quartz. Porphyritic with euhedral orthoclase laths up to 1 cm long. Moderately sericitized orthoclase but relatively non-altered oligoclase (An_{25-27}). Micro-quartz veins account for silica increase. Biotite is bleached and has ragged margins; the hornblende is slightly chloritized. Some secondary orthoclase.
3. Quartz latite porphyry dike, peripheral to the Copper Flat stock: Center, NE1/4NW1/4 sec. 1, T. 16 S., R. 7 W., Hillsboro quadrangle. Very light gray to light-pinkish-gray quartz latite porphyry with orthoclase laths up to 2 cm long set in a cryptocrystalline groundmass. The groundmass shows varying degrees of alteration to carbonates, epidote, sericite, and chlorite. The phenocrysts include orthoclase (5-6 percent), oligoclase (An_{28-30}) (14-21 percent), and chlorite pseudomorphs after hornblende (3 percent).
4. Quartz monzodiorite, Warm Spring Canyon stock: SE1/4SE1/4NW1/4 sec. 10, T. 16 S., R. 7 W., Hillsboro quadrangle. Medium-light-gray, hypidiomorphic-granular, medium-grained rock containing 1-15 percent orthoclase, 54-76 percent sodic andesine (An_{30-32}), 9-13 percent quartz, 6-12 percent hornblende, 2-3 percent biotite, and accessory amounts of iron oxides and apatite.
5. Leucogranite, Warm Spring Canyon stock: NW1/4NE1/4NW1/4, sec. 10, T. 16 S., R. 7 W., Hillsboro quadrangle. Light-pinkish-gray, hypidiomorphic- to xenomorphic-granular, medium-grained rock containing 28 percent orthoclase, 43 percent oligoclase (An_{25-28}), 22 percent quartz, 2 percent biotite, 2 percent hornblende, 2 percent epidote, and accessory sphene, iron oxides, and apatite.
6. Andesite of Copper Flat: NW1/4SE1/4NW1/4 sec. 36, T. 15 S., R. 7 W., Hillsboro quadrangle. Dark-gray, slightly propylitized andesite with about 8 percent andesine phenocrysts. Minor amounts of hornblende and traces of biotite. Moderate chloritization of the cryptocrystalline groundmass. Accessories are apatite, quartz, and iron oxides. Sparsely disseminated pyrite in parts of andesite.
7. Hornblende andesite, Rubio Peak Formation: Road cut 0.4 mi (0.64 km) south of Emory Pass at an elevation of 8,100 ft, San Lorenzo quadrangle. Medium-gray (N 5) andesite with sparse phenocrysts of plagioclase. A sugary microbrecciated groundmass shows varying degrees

of replacement by calcite and chlorite. Some plagioclase fragments are highly sericitized. Very small angular inclusions of andesite contain abundant iron oxides.

8. Hornblende latite sill within the Percha Shale: About 300 ft (91 m) south of the Black Colt mine, Kingston District, and in draw at an elevation of 7,040 ft, Hillsboro quadrangle. Medium-light-gray (N 6), slightly propylitized latite with about 10 percent andesine (An_{30-32}) phenocrysts up to 3 mm across. The plagioclase grains show incipient sericitization. The felted groundmass is slightly altered to calcite and chlorite. Former hornblende phenocrysts are largely replaced by calcite, chlorite, and iron oxides.
9. Crystal-rich welded tuff, Kneeling Nun Tuff: Berrenda Mountain, Center, NE1/4NW1/4 sec. 7, T. 18 S., R. 7 W., Hillsboro quadrangle. Pale-pinkish-gray, densely welded, ash-flow tuff with strong eutaxitic texture. Contains about 37 percent fragmented phenocrysts of sanidine, oligoclase (An_{27-30}), quartz, and biotite. Accessories are sphene, apatite, and iron oxides. The quartz phenocrysts show strong resorption embayments and pitting.
10. Rhyolite porphyry plug, Dry Gallinas Canyon Campground: Coordinates: N. 36, 4200, E. 2, 33600, San Lorenzo quadrangle. White to very light gray rhyolite with about 55 percent phenocrysts. Felted groundmass shows areas of patchy recrystallization. Contains 24 percent sanidine, 16 percent albite, 14 percent quartz, and 1 percent biotite phenocrysts. Accessories are apatite, sphene, iron oxides, and white mica. Sanidine phenocrysts display a satiny schiller or chatoyancy.
11. Rhyolite, Mimbres Peak Formation: NE1/4NW1/4SW1/4 sec. 14, T. 16 S., R. 8 W., Hillsboro quadrangle. White to very light gray rhyolite with about 2 percent phenocrysts of sanidine and quartz. The groundmass shows patchy recrystallization with some spherulitic textures. Strong flow folding in outcrop.
12. Hornblende latite, Pollack Quartz Latite: Center, SW1/4NW1/4 sec. 18, T. 16 S., R. 7 W., Hillsboro quadrangle. Reddish-brown porphyritic lava containing about 10 percent phenocrysts set in a pilotaxitic groundmass. Phenocrysts include about 8 percent sodic andesine (An_{30-32}), 1 percent oxyhornblende, and 0.5 percent biotite. Accessories are clinopyroxene, iron oxides, and apatite. Probably two generations of plagioclase, an older partially resorbed labradorite (An_{50-53}), and a younger unaltered twinned andesine.
13. Andesite, Bear Springs Basalt: Stitzel Canyon, SE1/4NE1/4NE1/4 sec. 14, T. 16 S., R. 11 W., San Lorenzo quadrangle. Dark-gray to grayish-black andesite chill facies. Pilotaxitic groundmass consisting of alkali-feldspar and andesine microlites with interstitial iron oxides, and clinopyroxene. Less than 1 percent andesine (An_{36}) phenocrysts.
14. Alkali basalt, Santa Fe Formation: NE1/4NE1/4NE1/4, sec. 9, T. 16 S., R. 7 W., Hillsboro quadrangle. Medium-bluish-gray basalt with minor vug-fillings of calcite. Texture is pilotaxitic with microlites of andesine (An_{35}) and interstitial grains of clinopyroxene, olivine, and iron oxides. About 8 percent large phenocrysts of andesine (An_{40-45}) which have thin marginal poikilitic overgrowths of more sodic plagioclase. Sporadic oxyhornblende(?) phenocrysts are highly altered to ferric oxides.

Table A-1.--Chemical analyses, normative and modal compositions of Laramide intrusive rocks

[Analyses by rapid-rock method by P. L. D. Elmore, Hezekiah Smith, and Lowell Artis, U.S. Geological Survey, 1973, 1975, 1976]

	1	2	3	4	5
Rock type------	Quartz monzonite (Copper Flat)	Altered quartz monzonite (Copper Flat)	Quartz latite porphyry dike (Copper Flat)	Quartz monzo-diorite (Warm Springs Canyon)	Leuco granite (Warm Springs Canyon)
Field No.------	HL-24-71	IDC-25, 27, 28	HI-47-A-75	HI-28-72	HI-23-72
Lab No.--------	W182947	W182948	D174683W	W160467	D160466W
Sp Gr (powder)-	2.60	2.60	2.56	2.76	2.71
Analyses (weight percent)					
SiO_2	60.5	66.6	69.4	58.7	67.4
Al_2O_3	16.0	14.9	15.1	16.4	15.0
Fe_2O_3	4.7	2.0	1.3	3.6	2.0
FeO	2.8	1.1	0.20	4.0	2.0
MgO	1.4	0.67	0.29	2.6	1.2
CaO	2.2	1.4	2.3	5.6	3.0
Na_2O	4.1	3.2	3.4	3.4	3.4
K_2O	5.7	6.6	4.4	2.7	4.0
TiO_2	0.63	0.56	0.21	0.82	0.46
P_2O_5	0.30	0.16	0.11	0.51	0.26
MnO	0.02	0.01	0.03	0.20	0.09
H_2O^+	0.38	0.41	1.6	1.0	0.93
H_2O^-	0.38	0.39	0.60	0.29	0.17
CO_2	0.20	0.91	1.2	0.08	0.03
Total	99.31	98.91	100	99.90	99.94
Norms (weight percent)					
Q	9.3	20.0	31.5	13.6	24.3
or	33.7	39.0	26.0	15.9	23.6
ab	34.6	27.0	28.7	28.7	28.8
an	7.9	4.2	3.2	21.3	13.2
C	0.0	0.9	3.5	0.0	0.2
en	3.5	1.7	0.7	6.5	3.0
hy	0.2	0.0	0.0	3.1	1.3
wo	0.0	0.0	0.0	1.2	0.0
mt	6.8	2.0	0.0	5.2	2.9
il	1.2	1.1	0.4	1.5	0.9
hm	0.0	0.6	1.3	0.0	0.0
ap	0.6	0.4	0.2	1.1	0.6
tn	0.0	0.0	0.0	0.0	0.0
cal	0.4	2.1	2.7	0.2	0.1
Total	98.2	99.0	98.2	98.3	98.94
Modes (volume percent)					
Groundmass	0	0	70-76	0	0
Orthoclase	65	56	5-6	12	27
Oligoclase	15	30	14-21	64	43
Quartz	10	8	0	13	22
Hornblende	0	2	0	6	0
Biotite	6	2	0	3	1
Chlorite	Tr	Tr	3	Tr	2
Epidote	0	0	0.5	0	3
Sphene	0.6	0.2	0.7	0	0.4
Apatite	0.2	Tr	Tr	Tr	Tr
Iron oxides	3	2	0.5	1	0
Total	99.8	100.2	100	99	98.4

Table A-2.--Semiquantitative spectrographic analyses of Laramide intrusive rocks

[Values are reported in parts per million to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.015, and so forth. G, greater than 10 percent; N, not detected at limit of detection; L, detected, but below limit of determination. Analyses by H. G. Neiman and M. W. Solt, U.S. Geological Survey, 1974, 1975]

	1	2	3	4	5
Rock type------	Quartz monzonite (Copper Flat)	Altered quartz monzonite (Copper Flat)	Quartz latite porphyry dike (Copper Flat)	Quartz monzo-diorite (Warm Springs Canyon)	Leuco granite (Warm Springs Canyon)
Field No.------	HL-24-71	IDC-25, 27, 28	HI-47-A-75	HI-28-72	HI-23-72
Lab No.--------	D165994W	D165995W	D174683W	D160467W	D160466W
Fe	30,000	20,000	30,000	70,000	30,000
Mg	5,000	3,000	7,000	20,000	10,000
Ca	10,000	7,000	20,000	50,000	30,000
Ti	2,000	1,500	2,000	5,000	3,000
Mn	150	200	1,000	1,000	700
Ba	1,000	1,000	2,000	1,500	1,500
Be	3	3	3	2	2
Co	N	N	7	15	7
Cr	1	1	10	10	10
Cu	100	200	15	20	3
La	70	50	L	L	50
Nb	L	10	10	L	L
Ni	N	N	7	7	7
Pb	10	10	30	15	20
Sc	7	5	7	15	10
Sn	10	N	N	N	N
Sr	1,500	700	3,000	1,500	1,000
V	70	50	70	150	70
Y	30	20	30	50	30
Zr	100	100	150	200	200
Ga	20	20	30	20	20
Yb	3	2	3	5	3
Nd	70	L	N	N	N

Table A-3.--Chemical analyses, normative and modal compositions of late Cretaceous andesite and Tertiary intrusive and extrusive rocks

[Analyses by rapid-rock method by P. L. D. Elmore, Hezekiah Smith, and Lowell Artis, U.S. Geological Survey, 1973, 1975]

	6	7	8	9	10	11	12	13	14
Rock type--	Andesite of Copper Flat	Hornblende andesite (Rubio Peak Formation)	Hornblende latite sill	Ash-flow tuff (Kneeling Nun Tuff)	Rhyolite porphyry plug	Rhyolite (Mimbres Peak Rhyolite)	Hornblende latite (Pollack Quartz latite)	Basaltic andesite (Bear Springs Basalt)	Alkali Basalt (Santa Fe Formation)
Field No.--	HL-23-71	SL-42A-75	HB-90A-73	HB-5-71	SL-57-73	HL-13-73	HL-8b-71	SL-136-73	HI-19-72
Lab No.----	D160465W	D174681W	D174680W	D160464W	W182949	D160463W	D160462W	W182950	D160468W
Sp gr------	2.64	2.60	2.60	2.50	2.56	2.43	2.58	2.64	2.92
Analyses (weight percent)									
SiO_2	53.7	56.3	62.4	72.0	72.0	76.5	62.1	60.0	48.0
Al_2O_3	14.7	16.4	15.5	14.6	14.6	12.6	17.0	16.5	16.3
Fe_2O_3	4.1	4.0	1.3	1.0	1.7	0.65	4.4	1.7	5.5
FeO	4.7	2.2	3.6	0.76	0.36	0.20	0.60	4.1	6.4
MgO	3.2	3.8	1.8	0.38	0.31	0.12	1.2	3.2	6.1
CaO	5.4	5.2	1.9	1.2	1.6	0.29	4.1	5.2	8.0
Na_2O	2.6	3.8	4.9	3.4	3.4	3.3	3.8	3.9	3.6
K_2O	4.3	1.5	3.2	4.8	4.4	4.5	3.2	2.8	1.3
TiO_2	0.95	0.90	0.59	0.28	0.56	0.14	0.80	0.75	2.0
P_2O_5	0.56	0.30	0.35	0.10	0.13	0.01	0.32	0.30	0.57
MnO	0.16	0.08	0.09	0.04	0.01	0.03	0.06	0.06	0.20
H_2O^+	2.4	3.2	2.2	0.96	0.42	1.2	1.3	0.06	1.2
H_2O^-	0.21	0.83	0.25	0.44	0.98	0.39	0.65	0.18	0.52
CO_2	3.0	1.7	1.1	0.05	0.09	0.02	0.03	0.02	0.08
Total	99.98	100	99	100.01	100.56	99.95	99.56	99.31	99.77
Norms (weight percent)									
Q	10.7	17.1	16.4	31.1	32.3	39.4	18.2	10.4	0.7
or	25.4	8.9	18.9	28.4	26.0	26.5	18.9	16.6	7.7
ab	22.0	32.1	41.4	28.8	28.8	27.9	32.2	33.0	30.5
an	15.4	13.3	0.5	4.13	6.1	1.4	18.4	19.0	24.2
C	0.0	3.6	3.7	2.3	2.0	1.7	0.4	0.0	0.0
en	8.0	9.5	4.5	0.9	0.8	0.3	3.0	8.0	15.2
hy	3.7	0.0	5.5	0.6	0.0	0.0	0.0	4.9	4.0
wo	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	5.0
mt	5.9	4.5	1.9	1.5	0.0	0.3	0.0	2.5	8.9
il	1.8	1.7	1.1	0.0	0.8	0.3	1.3	1.4	3.8
hm	0.0	0.9	0.0	0.0	1.7	0.4	4.4	0.0	0.0
ap	1.2	0.7	0.8	0.2	0.3	0.02	0.7	0.6	1.2
tn	0.0	0.0	0.0	0.7	0.4	0.0	0.0	0.0	0.0
cal	4.1	3.9	2.5	0.1	0.2	0.0	0.1	0.0	0.2
Total	98.2	96.2	97.2	98.7	99.4	98.2	97.6	98.5	101.4
Modes (volume percent)									
Groundmass									
devitrified				63	43	98			
felted	81	95	82				86	68	85
Orthoclase	0	0	0	13	18	1.5	0	0	0
Plagioclase	8	1	10	16	27	0	8	18	7.5
Quartz	0	0	0.4	6	9	0.5	0	0	0
Olivine	0	0	0	0	0	0	0	0	7
Pyroxene	0	0	0	0	0	0	1	10	0.5
Hornblende	0	Tr	6	0	0	0	1	3	0
Biotite	0	0	0.7	1.5	2	0	0.3	0	0
Chlorite	10	1	0.2	0	0	0	0	0	0
Sphene	0	0	0	Tr	Tr	0	0	0	0
Iron oxides	1	3	0.9	0.6	0.8	0	3	1.5	Tr
Apatite	Tr	Tr	0	Tr	Tr	0	Tr	Tr	Tr
Total	100	100	100.2	100.1	99.8	100	99.3	100.5	100

Table A-4.--Semiquantitative spectrographic analyses of late Cretaceous andesite and Tertiary intrusive and extrusive rocks

[Values are reported in parts per million to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.015, and so forth. G, greater than 10 percent; N, not detected at limit of detection; L, detected, but below limit of determination. Analyses by M. W. Solt, U.S. Geological Survey, 1973, 1975]

	6	7	8	9	10	11	12	13	14
Rock type--	Andesite of Copper Flat	Hornblende andesite (Rubio Peak Formation	Hornblende latite sill	Ash-flow tuff (Kneeling Nun Tuff)	Rhyolite porphyry plug	Rhyolite (Mimbres Peak Rhyolite)	Hornblende latite (Pollack Quartz latite)	Basaltic andesite (Bear Springs Basalt)	Alkali Basalt (Santa Fe Formation)
Field No.--	HL-23-71	SL-42A-75	HB-90A-73	HB-5-71	SL-57-73	HL-13-73	HL-8b-71	SL-136-73	HI-19-72
Lab No.----	D160466W	D174681W	D174680W	D160464W	W182949	D160463W	D160462W	W182950	D160468W
Analyses (ppm)									
Fe	70,000	50,000	50,000	15,000	15,000	7,000	50,000	50,000	70,000
Mg	30,000	50,000	20,000	5,000	3,000	1,500	10,000	20,000	70,000
Ca	50,000	50,000	30,000	10,000	7,000	2,000	50,000	30,000	70,000
Ti	3,000	5,000	3,000	1,500	2,000	1,000	5,000	5,000	15,000
Mn	1,000	700	1,000	500	200	300	500	500	1,500
Ba	1,500	1,500	2,000	1,000	1,000	70	2,000	1,500	1,000
Be	2	L	1.5	3	2	3	1.5	1	1.5
Co	30	30	15	5	N	N	15	15	50
Cr	20	300	30	3	1	1	30	50	150
Cu	300	30	15	3	1.5	1.5	20	30	50
La	L	L	50	70	50	L	70	70	L
Mo	N	N	N	3	N	N	N	N	N
Nb	L	10	L	15	15	20	10	N	30
Ni	15	70	15	L	N	N	20	30	100
Pb	15	15	10	20	15	20	20	15	N
Sc	20	20	20	L	L	N	15	15	20
Sn	N	N	N	N	N	N	N	N	N
Sr	1,500	2,000	1,000	300	200	15	1,500	1,000	1,500
V	300	200	150	30	30	10	150	150	200
Y	30	15	30	20	15	20	20	15	20
Zr	200	150	150	150	70	200	200	200	150
Ga	20	30	30	20	20	20	30	20	20
Yb	3	--	5	2	1.5	2	1.5	1.5	1.5
Nd	N	N	N	N	N	N	N	70	N

APPENDIX B

Miscellaneous drill logs from the Royal John mine area

Drill hole No. 1 (FROBEX)

Coordinates: N. 10,600
E. 10,650
Collar elevation: 7,914 ft
Total depth: 252.0 ft

Formation: Montoya Group and El Paso Limestone
Inclination: Vertical
Date: September 1973
Logged by D. C. Hedlund

Interval (feet)	Feet	Description
0.0-8.0	8.0	No core recovered
8.0-11.0	3.0	Limestone, medium-light-gray, aphanitic
11.0-83.0	72.0	Dolomite, medium-light-gray to medium-gray,, aphanitic, replacement of dolomite by calcite from 30.0-32.0 ft Breccia zone from 35.5-36.0 ft Thin fractures dip 60-90^{o} from 38.0-47.0 ft Strong joint at 48.2 ft dips 60^{o} Strong joints at 56.5 ft dip 55^{o} and 60^{o} Strong joint at 75 ft dips 60^{o}
83.0-85.0	2.0	Brecciated dolomite, with light-brown dolomite cementing the medium-gray dolomite fragments Strong slickensides at 82.5 ft
85.0-93.6	8.6	Dolomite, medium-gray to medium-light-gray, aphanitic
93.6-99.5	5.9	Dolomite, partially replaced by white fine-grained calcite and clay, medium-gray dolomite has a mottled texture
99.5-109.0	9.5	Dolomite, medium-gray to dark-gray, aphanitic
109.0-121.5	12.5	Dolomite, dark-gray replaced by white calcite which has a swirl-textured pattern From 115.0-116.0 ft abundant white clay associated with secondary calcite
121.5-150.0	28.5	Calcite rock, represents 80-90 percent replacement of dolomite with very minor residual dark-gray dolomite; white clay closely related to calcite replacement process
150.0-158.0	8.0	Dolomite, medium-light-gray to medium-gray, aphanitic From 155.2-156.2 ft highly fractured dolomite with abundant white calcite fracture-fillings
158.0-169.0	11.0	Dolomite, medium-gray, aphanitic, minor fracture-fillings of calcite

Interval (feet)	Feet	Description
169.0-172.0	3.0	Dolomite, medium-dark-gray, aphanitic, moderately abundant fracture-fillings of white calcite
172.0-173.0	1.0	Calcite rock, represents 80-90 percent replacement of dolomite
		(Contact of dolomite of Montoya Group with El Paso Limestone)
173.0-189.5	16.5	Limestone, penecontemporaneous breccia with curls and blebs of light-gray limestone in a medium-dark-gray limestone matrix; fragments up to 4 cm across Sparse sulfides 176.8-177.0 ft and in intervals at 179.5-179.7 ft and 186.5-186.8 ft Laminations from 189.0-189.5 ft dip 10^{o} and contain minor sulfides
189.5-194.0	4.5	Limestone, light-medium-gray alternating light-gray, laminated
194.0-195.5	1.5	Dolomite, very light gray, medium crystallinity, cherty
195.5-202.0	6.5	Limestone-chert breccia, abundant, very light gray chert fragments
202.0-204.5	2.5	Limestone-breccia, light-gray limestone fragments up to 7 cm across; fragments are tightly cemented From 202.0-202.5 ft sparse amounts of pyrite interstitial to limestone fragments
204.5-213.0	8.5	Limestone, very light gray, penecontemporaneous breccia with curls, balls, and disrupted laminae Olive-green silicated limestone from 206.3-207.0 ft Sparse sulfides from 210.8-211.0 ft
213.0-213.3	0.3	Limestone, olive-green, silicated; sparse sulfides
213.3-216.8	3.5	Limestone, very light gray, penecontemporaneous breccia
216.8-225.0	8.2	Fault breccia, abundant secondary calcite and quartz; minor greenish-gray clay; chiefly limestone fragments
225.0-232.5	7.5	Limestone, very light gray, penecontemporaneous breccia; minor chert
232.5-233.0	0.5	Limestone, white, marmoritized with medium-coarse crystallinity

Interval (feet)	Feet	Description
233.0-242.0	9.0	Limestone-chert-tremolite rock, abundant fragmental white to very light gray chert; sulfides at 233.2 ft are closely associated with tremolite
242.0-252.0	10.0	Limestone-chert-tremolite rock, minor light-gray chert fragments in slightly marmoritized limestone; minor amounts of tremolite Strong fault breccia development from 244.0-245.0 ft
		(Bottom of hole)

Drill hole No. 2 (FROBEX)

Coordinates: N. 10,675
E. 10,515
Collar elevation: 7,930 ft
Total depth: 323.0 ft

Formation: Montoya Group and El Paso Limestone
Inclination: Vertical
Date: October 1973
Logged by D. C. Hedlund

Interval (feet)	Feet	Description
0.0-9.0	9.0	No core recovered
9.0-16.5	7.5	Dolomite, light-gray, aphanitic to very finely crystalline; brecciated from 11.5-12.0 ft and 12.5-16.5 ft; sparse sulfides at 15.0 ft
16.5-25.0	8.5	Dolomite, light-medium-gray, aphanitic; secondary calcite veins at 18.0 ft and 18.2-18.4 ft; sparse sulfides 24.0-24.3 ft
25.0-26.0	1.0	Dolomite breccia, medium-light-gray; sparse sphalerite along breccia zone; some secondary calcite veins
26.0-28.0	2.0	Dolomite, light-medium-gray, aphanitic; slightly brecciated
28.0-46.0	18.0	Dolomite, medium-light-gray, aphanitic; sparse sulfides 33.7-34.0 ft, 35.5-36.0 ft, and at 36.5 ft
46.0-55.0	9.0	Dolomite, medium-light-gray, aphanitic, white spherules 2-3 mm across; sparse sulfides along fractures at 53.0 and 54.3 ft
55.0-79.0	24.0	Dolomite, medium-light-gray, aphanitic; fault breccias at 61.0-62.0 ft, 67.0-69.0 ft, and 71.0-71.5 ft
79.0-90.4	11.4	Dolomite, medium-dark-gray, aphanitic; replacement textures with white to light-greenish-yellow calcite replacive after dolomite--about 10 percent of the original dolomite remains
90.4-97.2	6.8	Dolomite, medium-dark-gray, aphanitic; strong joints dip 70° at 94.7 ft and 70° at 96.5 ft (green clay films along joints)
97.2-125.2	28.0	Dolomite, medium-dark-gray, aphanitic; replacement textures with pale-greenish-yellow calcite replacive after dolomite--about 5-10 percent of the original dolomite remains, a swirl-patterned replacement texture

Interval (feet)	Feet	Description
125.2-145.0	19.8	Dolomite, medium-light-gray to medium-gray, aphanitic; fracture fillings of calcite at 135.3-136.0 ft; sparse sulfides at 131.2 ft
145.0-190.0	45.0	Dolomite, medium-dark-gray, aphanitic; laminations dip 15°; Highly broken core 148.0-149.0 ft--fault with clay slickensides Sparse sulfides at 151.0 and 152.0 ft Calcite vein dips 75° at 157.0 ft Fracture-fillings of calcite common from 175.0-179.0 ft Fault zone with gouge at 178.5-179.0 ft--dips 75° Breccia zone from 181.5-182.5 ft Split taken for analysis from 188.0-190.0 ft
		(Contact of Montoya Group and El Paso Limestone)
190.0-194.5	4.5	Limestone, medium-dark-gray, laminated, aphanitic
194.5-198.0	3.5	Limestone, medium-dark-gray with very light gray recrystallized calcitic pseudomorphs after ropy algal casts
198.0-201.0	3.0	Limestone, medium-dark-gray, with disrupted laminations of more silty limestone
201.0-207.5	6.5	Limestone, very light gray; light-greenish-gray clay films along bedding surfaces Small fault breccia at 204.8 ft with secondary calcite Sparse pyrite associated with light-greenish-gray clay at 206.3-206.5 ft
207.5-213.5	6.0	Limestone chert breccia, light-gray chert fragments common; abundant tremolite Sparse sulfides 208.0-209.0 ft
213.5-216.3	2.8	Limestone, white with thin films of light-greenish-gray clay, medium crystallinity; sparse pyrite associated with clay
216.3-220.5	4.2	Limestone-chert breccia, white to very light gray chert fragments
220.5-226.0	5.5	Limestone, medium-dark-gray to very light gray, medium crystallinity Healed breccia zone from 225.0-226.0 ft--secondary calcite

Interval (feet)	Feet	Description
226.0-227.0	1.0	Limestone, white to very light gray, medium crystallinity
227.0-236.5	9.5	Limestone, medium-dark-gray, very finely crystalline, white recrystallized fossil fragments are abundant, incipient styolite development Light-gray chert from 234.5-234.8 ft Clay-calcite seam 235.5-235.9 ft
236.5-255.5	19.0	Limestone, medium-dark-gray, very finely crystalline, abundant fossil detritus with coral at 238.0-238.4 ft within chert bed; also abundant fossils from 246.0-249.0 ft Calcite-filled breccia from 239.7-240.3 ft White recrystallized limestone from 241.7-242.2 ft Calcite veins from 244.0-246.0 ft Sparse sulfides from 254.0-254.5 ft
255.5-274.0	18.5	Limestone, white to very light gray, medium crystallinity Sparse sulfides 255.5-257.5 ft (split taken for analysis from 255.5-261.5 ft) Strong joint with clay film dips 60° at 262.6 ft Healed penecontemporaneous breccia from 269.8-270.0 ft Crenulated laminations from 270.0-271.0 ft Healed slump fault 270.7-272.0 ft Penecontemporaneous breccias from 273.2-274.0 ft
274.0-276.0	2.0	Limestone, medium-light-gray to medium-dark-gray, very finely crystalline, penecontemporaneous breccias common
276.0-285.0	9.0	Limestone, medium-dark-gray, aphanitic, laminated with laminae dipping about 20°; incipient styolite development
285.0-311.5	26.5	Limestone, medium-dark-gray, aphanitic, laminated with black clay films along lamination surfaces; abundant fracture-fillings of secondary calcite Fault slickensides at 295.0 ft
311.5-321.0	9.5	Limestone, black, aphanitic, laminated with black clay films along lamination surfaces that dip 20° Abundant fracture-fillings of calcite from 311.5-312.5 ft

Interval (feet)	Feet	Description
321.0-323.0	2.0	Limestone, black, crenulated laminations with clay films, aphanitic
		(Bottom of hole)

Chemical analyses of core splits[1]
(weight percent for Zn, Pb, and Cu; oz/t for Ag)

Interval (feet)	Zn	Pb	Cu	Ag
187.0-192.5	2.12	0.75	0.08	1.48
255.5-257.4	0.25	0.25	n.d.	2.4
257.4-258.8	1.25	1.2	0.17	3.6
258.8-261.0	0.75	0.25	0.21	0.80

[1]Analyses furnished by Oliver Reese, consultant, Silver City, New Mexico.

Drill hole No. 3 (FROBEX)

Coordinates: N. 10,320
E. 10,136
Collar elevation: 7,780 ft
Total depth: 64.0 ft

Formation: El Paso Limestone
Inclination: Vertical
Date: October 1973
Logged by D. C. Hedlund

Interval (feet)	Feet	Description
0.0-13.0	13.0	No core recovered; drill rig collared in ore zone
13.0-51.0	38.0	Limestone, medium-light-gray, crenulated and laminated aphanitic; chert nodules 24.0-32.0 ft and ropy chert from 44.7-51.0 ft; about 3 cm spacing between chert plates and nodules
51.0-57.0	6.0	Limestone-chert, medium-dark-gray limestone; chert beds 1-2 cm thick
57.0-60.0	3.0	Limestone, medium-light-gray, laminations dip 15°; aphanitic
60.0-64.0	4.0	Limestone, white, alternating medium-light-gray, discontinuous crenulated laminae 1-2 cm thick
		(Bottom of hole)

Drill hole No. 4 (FROBEX)

Coordinates: N. 11,499
E. 10,250
Collar elevation: 7,835 ft
Total depth: 254.0 ft

Formation: El Paso Limestone
Inclination: Vertical
Date: October 1973
Logged by D. C. Hedlund

Interval (feet)	Feet	Description
0.0-10.0	10.0	No core recovery
10.0-10.7	0.7	Chert layer in silicated limestone, medium-gray
10.7-14.5	3.8	Limestone, medium-dark-gray, aphanitic Fault from 13.0-14.0 ft with slickensides that plunge 50°; fault dips 55°-70°
14.5-46.0	31.5	Limestone-chert, very light gray, abundant tremolite adjacent to chert nodules; some chert laminae from 30.5-39.5 ft are brecciated; chert layers dip about 20°; some secondary quartz near brecciated chert; medium-crystalline limestone
46.0-49.0	3.0	Limestone, medium-light-gray, sugary-textured; slightly marmoritized; no chert
49.0-50.5	1.5	Limestone breccia, slickensides plunge 45°
50.5-58.5	8.0	Limestone, medium-dark-gray, sugary-textured; healed breccia at 57.5 ft is cemented by secondary calcite; slickensides at 61.5 ft
58.5-65.5	7.0	Limestone, medium-light-gray, sugary-textured; fault slickensides at 61.5 ft
65.5-67.5	2.0	Limestone, very light pinkish gray to very light greenish gray; sparse sulfide disseminations in the greenish-gray limestone
67.5-68.5	1.0	Limestone, pale-green to light-pinkish-gray; sparse disseminated sulfides
68.5-69.2	0.7	Limestone, pale-greenish-yellow, partly silicified and silicated
69.2-76.5	7.3	Limestone, white to very light gray, sugary textured, marmoratized in part to coarsely crystalline rock

Interval (feet)	Feet	Description
76.5-82.5	6.0	Limestone, white to very light gray, medium crystallinity Strong joints at 79.5 and 80.5 ft have sparse sulfide coatings
82.5-86.5	4.0	Limestone, medium-light-gray to very light gray, disrupted and crenulated laminations common in darker gray limestone
86.5-200.0	113.5	Limestone, medium-dark-gray to dark-gray, laminated with crenulated laminae showing varying degrees of disruption White, coarsely crystalline limestone layer 2 inches thick at 135.6-135.8 ft Chert nodules at 145.2, 147.2, and 153.0 ft From 153.0-156.0 ft black clay films along lamination surfaces Highly disrupted laminae from 168.5-170.0 ft Round pelletal limestone at 117.0 ft Abundant lensoid limestone bodies at 174.3-175.0 ft
200.0-209.5	9.5	Limestone, medium-dark-gray from 200.0-204.0 ft and very light gray from 204.0-209.5 ft, sugary-textured, penecontemporaneous breccia from 203.0-203.5 ft
209.5-219.0	9.5	Limestone, very light gray, massive, a black clay seam at 210.2 ft with sparse pyrite; a chert nodule at 215.0 ft
219.0-229.0	10.0	Limestone, very light gray, weakly laminated, sugary-textured, very fine grained, discoid-shaped segregations common in a more coarse-grained matrix Minor sulfides 219.0-219.7 ft
229.0-238.5	9.5	Limestone, light-gray, aphanitic to sugary-textured, weakly laminated, penecontemporaneous deformed laminae dip about 30°
238.5-248.0	10.0	Limestone, very light gray to mottled dark-gray, sugary-textured, disrupted laminae common, minor lensoid limestone bodies common 243.7-244.5 ft
248.0-254.0	6.0	Limestone, medium-light-gray alternating medium-dark-gray, mottled, weakly developed laminae are disrupted, finely crystalline
		(Bottom of hole)

Chemical analysis of core split[1]
(Weight percent for Zn, Pb, and Cu; oz/ton for Ag)

Interval (feet)	Zn	Pb	Cu	Ag
67.6-68.8	1.3	0.25	0.25	1.16

[1]Analysis furnished by Oliver Reese, consultant, Silver City, New Mexico.

Drill hole 15-240-1
U.S. Bur. of Mines Project
Coordinates: N. 12,104
E. 10,836
Collar elevation: 7,843 ft
Total depth: 428.8 ft

Formation: Magdalena Limestone
Inclination: 65°, N. 67 E.
Date: August 1948-June 1949
Logged by D. C. Hedlund (2/25/74)

Interval (feet)	Feet	Description
0.0-13.1	13.1	Andesite, reddish-brown fragments--probably float
13.0-35.0	22.0	Limestone, medium-gray, aphanitic Fault breccia 27.2-27.5 ft Black, laminated limestone from 34.5-35.0 ft
35.0-56.0	21.0	Limestone, dark-gray to black, with white coarsely crystalline fossil casts, commonly laminated
56.0-65.0	9.0	Limestone, medium-gray, aphanitic, penecontemporaneous ball and bleb texture 57.0-61.3 ft
65.0-78.0	13.0	(No core available)
78.0-86.2	8.2	Limestone, dark-gray to black, aphanitic
86.2-94.0	7.8	Limestone, medium-dark-gray, aphanitic; fine calcarenite from 93.1-93.8 ft
94.0-112.0	18.0	Limestone, medium-dark-gray to dark-gray, fine calcarenite intervals at 96.4-96.6 ft; bedding dips 55°; penecontemporaneous breccia at 101.5-101.8 ft; limestone pebble conglomerate at 102.5-102.7 ft
112.0-123.0	11.0	Limestone, dark-gray to black; calcarenite 117.4-118.4 ft; abundant calcite fracture-fillings 118.4-119.4 ft laminated 121.7-123.0--dip 35°
123.0-139.5	16.5	Limestone, dark-gray to black, laminated with dips of 45°; penecontemporaneous breccias 127.6-128.4 ft; abundant calcite fracture-fillings 134.0-134.5 ft
139.5-172.5	33.0	Limestone, medium-gray to medium-light-gray, aphanitic; white calcitic spherules or pellets 159.0-159.5 ft
172.5-183.0	10.5	Limestone, medium-light-gray, aphanitic
183.0-205.0	22.0	Limestone, medium-light-gray, aphanitic; white spherules 193.5-193.6; calcite fracture fillings 198.0-200.9 ft

Interval (feet)	Feet	Description
205.0-224.0	19.0	Limestone, medium-light-gray, aphanitic to very finely crystalline, white spherules 213.0-213.5; calcitic fracture fillings 206.0-210.0 ft
224.0-233.0	9.0	Limestone, medium-gray to medium-light-gray, aphanitic; penecontemporaneous breccia 226.6-227.6 ft
233.0-238.0	5.0	Limestone, very light gray, aphanitic
238.0-246.0	8.0	Limestone, medium-gray, aphanitic; abundant disseminated pyrite 240.6-241.6 ft
246.0-251.0	5.0	Limestone, white to very light gray, aphanitic
251.0-274.0	23.0	Limestone, medium-light-gray, aphanitic
274.0-295.0	21.0	Limestone, medium-dark-gray, aphanitic
295.0-318.0	23.0	Limestone, medium-light-gray, sugary-textured; calcarenite 295.2-298.0 ft
318.0-359.5	61.5	Limestone, light-gray, sugary-textured; brecciated from 356.6 to 357.0 ft
359.5-369.0	9.5	Limestone, medium-gray, laminated with dips of 20^{o}; cherty from 360.1-360.2 ft
369.0-390.1	21.1	Limestone, light-gray, sugary-textured
390.1-391.5	1.4	Limestone, medium-dark-gray, laminated with dips of 10^{o}
391.5-392.0	0.5	Limestone, dark-gray to black, aphanitic
392.0-400.5	8.5	Limestone, medium-light-gray, very finely crystalline
400.5-428.8	28.3	Limestone, dark-gray to black, fossil casts 405.4-405.6 ft, at 416.4-417.0 ft and crinoid columnal at 426.6 ft
		(Bottom of hole)

Drill hole 15-240-2
U.S. Bur. of Mines Project
Coordinates: N. 12,104
E. 10,836
Collar elevation: 7,843 ft
Total depth: 262 ft

Formation: Magdalena Limestone
Inclination: 82°, S. 67° W.
Date: August 1948-June 1949
Logged by D. C. Hedlund (2/25/74)

Interval (feet)	Feet	Description
0.0-15.0	15.0	Andesite blocks and float
15.0-56.0	41.0	Limestone, medium-dark-gray, aphanitic; sparse white fossil casts at 50.0 ft
56.0-81.0	25.0	Limestone, medium-dark-gray to dark-gray, aphanitic; algal casts at 57.1 ft; penecontemporaneous breccia 62.0-62.9 ft; oolites at 72.7 ft in 2 in. zone
81.0-89.0	8.0	Limestone, medium-dark-gray to dark-gray, aphanitic; penecontemporaneous breccia at 89.0 ft
89.0-110.0	21.0	Limestone, medium-light-gray to light-gray, medium coarsely crystalline
110.0-115.0	5.0	Limestone, dark-gray, aphanitic
115.0-189.5	74.5	Limestone, medium-dark-gray, medium-gray, aphanitic; strong joint at 119.3 ft dips 65°--clay films
189.5-195.0	5.5	Limestone, very light gray, aphanitic, brecciated in part
195.0-210.0	15.0	Limestone, medium-light-gray, aphanitic, laminated; fault breccia 209.5-210.0 ft
210.0-229.0	19.0	Limestone, medium-light-gray, medium crystallinity; strong crenulation of laminae up to 1 cm thick; fault breccia 229.0-229.5 ft
229.0-262.0	33.0	Limestone, medium-dark-gray, silty laminae are common; secondary crystalline calcite at 257.0 ft
		(Bottom of hole 262.0 ft?)

Drill hole 15-240-3
U.S. Bur. of Mines Project
Coordinates: N. 12,228
E. 10,108
Collar elevation: 7,940 ft
Total depth: 111.8 ft

Formation: El Paso Limestone
Inclination: -50^{o}, N. 24^{o} E.
Date: August 1948-June 1949
Logged by D. C. Hedlund (2/25/74)

Interval (feet)	Feet	Description
0.0-23.0	23.0	Limestone, medium-dark-gray, aphanitic; abundant ropy chert from 22.4-22.8 ft
23.0-42.0	19.0	Limestone, medium-gray, aphanitic; numerous fractures at 34.5 ft dip 60^{o}
42.0-45.0	3.0	Limestone, medium-light-gray, aphanitic
45.0-67.0	22.0	Limestone, medium-dark-gray, aphanitic
67.0-89.0	22.0	Limestone, medium-light-gray, abundant limestone blebs and plates from 79.0-83.5 ft Abundant chert at 79.8-80.0 ft and at 88.3 ft
89.0-98.0	9.0	Limestone, medium-light-gray, abundant chert from 89.0-94.0 ft and from 96.5-97.5 ft; silicated in part with diopside present Abundant fracture-fillings of galena and sphalerite from 89.0-98.0 ft
98.0-107.0	9.0	Limestone, medium-light-gray, abundant, very light gray chert
107.0-111.8	4.8	Limestone, light-gray, chert nodules abundant from 110.0-111.8 ft but also cherty at 108.3-110.0 and 107.6-108.3 ft Sparse sphalerite at 108.8 ft
		(Bottom of hole)

Drill hole 15-240-4
U.S. Bur. of Mines Project
Coordinates: N. 12,228
E. 10,108
Collar elevation: 7,940 ft
Total depth: 83 ft

Formation: El Paso Limestone
Inclination: -75°, N. 24° E.
Date: August 1948-June 1949
Logged by D. C. Hedlund (2/25/74)

Interval (feet)	Feet	Description
0.0-12.0	12.0	No core available
12.0-25.9	13.9	Limestone, medium-light-gray, aphanitic
25.9-33.0	7.1	Limestone, medium-dark-gray, aphanitic
33.0-53.0	20.0	Limestone, medium-gray, aphanitic
53.0-63.0	10.0	No core available
63.0-73.0	10.0	Limestone, medium-light-gray, cherty zones at 67.6 ft have sparse amounts of sphalerite; other cherty zones at 69.8-69.9 ft and from 71.0-71.5 ft; limestone is variegated medium light gray to white within the cherty intervals
73.0-83.0	10.0	Limestone, very light gray to white, medium crystallinity, disseminated sulfides in zone from 79.2-79.5 ft
		(Bottom of hole)

Drill hole 15-240-5
U.S. Bur. of Mines Project
Coordinates: N. 12,228
E. 10,108
Collar elevation: 7,940 ft
Total depth: 76 ft

Formation: Montoya Group and El Paso Limestone
Inclination: -57°, N. 81° W.
Date: August 1948-June 1949
Logged by D. C. Hedlund (2/25/74)

Interval (feet)	Feet	Description
0.0-26.0	26.0	Dolomite, medium-light-gray, aphanitic
26.0-30.1	4.1	Dolomite, light-gray, sugary-textured
30.1-41.3	11.2	Limestone, medium-dark-gray, aphanitic; some argillic alteration from 39.8-41.0 ft; chert zone from 41.0-41.3 ft
41.3-51.8	10.5	Limestone, light-brown, mineralized interval from 41.4-51.8 ft with sphalerite and galena common; some manganese oxides especially abundant in zone from 44.5-45.8 ft; fracture fillings of galena are especially common
51.8-53.8	2.0	Limestone, medium-gray, silicified strata
53.8-55.0	1.2	Limestone, medium-gray, aphanitic
55.0-55.5	0.5	Limestone, medium-gray, silicified
55.5-55.7	0.2	Quartzite, white, some disseminated sulfides
55.7-61.5	5.8	Quartzite, white, medium-grained
61.5-61.6	0.1	Quartzite, sulfides present--chiefly sphalerite
61.6-64.0	2.4	Quartzite, white to light-brownish-gray
64.0-69.6	5.6	Limestone, white to pinkish-gray, sugary-textured
69.6-71.0	1.4	Limestone, light-brownish-gray, abundant fracture-fillings of galena
71.0-74.0	3.0	Limestone, light-brownish-gray to medium-light-gray, laminae dip 30°
74.0-76.0	2.0	Limestone, medium-gray, weakly laminated
		(Bottom of hole)

Drill hole 15-240-6

U.S. Bur. of Mines Project

Coordinates: N. 9,435
E. 11,280

Collar elevation: Mill adit in mine, 7,590 ft

Total depth: Unknown--may be 22 ft

Formation: El Paso Limestone

Inclination: +53°, S. 37° E.

Date: August 1948-June 1949

Logged by D. C. Hedlund (2/26/74)

Interval (feet)	Feet	Description
0.0-10.2	10.2	Limestone, medium-light-gray, abundant angular white to very light gray chert fragments; some disseminated sulfides from 3.8-4.0 ft
10.2-22.0	11.8	Limestone, medium-dark-gray, penecontemporaneous breccias commonly present
		(Bottom of hole?)

Drill hole 15-240-7
U.S. Bur. of Mines Project
Coordinates: N. 9,435
E. 11,280
Collar elevation: Mill adit in mine, 7,590 ft
Total depth: 83 ft

Formation: El Paso Limestone
Inclination: +20°, S. 37 1/2 ° E.
Date: August 1948-June 1949
Logged by D. C. Hedlund (2/26/74)

Interval (feet)	Feet	Description
0.0-12.1	12.1	Limestone-chert, medium-light-gray, with abundant very light gray chert
12.1-15.5	3.4	Limestone, medium-light-gray, sparse sphalerite at 14.0 ft--2 in. thick
15.5-22.6	7.1	Limestone-chert, medium-light-gray, abundant angular very light gray chert fragments; sparse sulfides at 15.5 ft
22.6-24.5	2.1	Limestone, medium-gray, very finely crystalline
24.5-25.7	1.2	Limestone-chert, medium-gray, abundant angular chert fragments
25.7-26.0	0.3	Limestone, medium-gray, abundant secondary calcite in solution cavities several cm across
26.0-34.0	8.0	Limestone-chert, medium-light-gray, abundant angular white chert fragments
34.0-35.0	1.0	Limestone, medium-gray, aphanitic
35.0-35.4	0.4	Limestone-chert, white to very light gray
35.4-42.0	6.6	Limestone, dark-gray, aphanitic
42.0-44.0	2.0	Limestone, medium-dark-gray, penecontemporaneous breccias and some white gastropod shell casts
44.0-54.0	10.0	Limestone, medium-dark-gray with medium-light-gray swirl-replacive textures and disrupted laminae
54.0-73.0	19.0	Limestone, medium-light-gray, swirl-replacive textures, and penecontemporaneous breccias
73.0-83.0	10.0	Limestone, medium-light-gray, aphanitic
		(Bottom of hole)

Drill hole 15-240-8
U.S. Bur. of Mines Project
Coordinates: N. 9,435
E. 11,280
Collar elevation: Mill adit in mine 7,590 ft
Total depth: 272.8 ft

Formation: El Paso Limestone
Inclination: +8°, S. 37 1/2° W.
Date: August 1948-June 1949
Logged by D. C. Hedlund (2/26/74)

Interval (feet)	Feet	Description
0.0-25.0	25.0	Limestone-chert, light-gray with abundant very light gray angular chert fragments; sparse sulfides from 3.0-3.2 ft are interstitial to the chert fragments
25.0-28.4	3.4	Limestone, white to very light gray, coarsely crystalline
28.4-30.7	2.3	Limestone-chert, very light gray, silicified
30.7-35.0	4.3	Limestone, white, sugary-textured, recrystallized penecontemporaneous breccia
35.0-70.0	35.0	Limestone-chert, medium-gray, abundant very light gray chert fragments Abundant sphalerite and galena from 68.0-69.8 ft
70.0-89.0	19.0	Limestone, medium-gray to dark-gray, aphanitic; trace of sphalerite at 78.0-78.1 ft
89.0-108.0	19.0	Limestone, medium-light-gray, aphanitic Fault breccia 102.0-102.5 ft--abundant secondary calcite and white clay Abundant fossil casts at 94.0 ft--chiefly brachiopods
108.0-118.0	10.0	Limestone, medium-light-gray, aphanitic Abundant disseminated pyrite at 117.0-118.0 ft--also includes some fracture-fillings of sulfides
118.0-126.0	8.0	Limestone, medium-light-gray, commonly includes some penecontemporaneous breccias Disseminated pyrite at 125.3 ft--thickness less than 3 in.
126.0-136.0	10.0	Limestone, medium-gray to dark-gray, aphanitic; secondary fracture-fillings of calcite at 127.2 ft
136.0-145.0	9.0	Limestone, medium-dark-gray, aphanitic; fractures with black clay films at 138.4 ft dip 60°; secondary quartz and black clay breccias at 142.3 and 142.7 ft
145.0-160.0	15.0	Limestone, medium-dark-gray, fractures with black clay films at 149.0-150.0 ft dip 65°

Interval (feet)	Feet	Description
160.0-173.0	13.0	Limestone, medium-gray, aphanitic; abundant anastomosing calcite fracture-fillings 166.7-173.0 ft
173.0-202.0	29.0	Limestone, medium-dark-gray, aphanitic, anastomosing calcite veins from 173.0-174.5 ft; clay along fractures at 191.0 ft that dip 80°
202.0-211.0	9.0	Limestone, medium-gray, aphanitic
211.0-240.0	29.0	Limestone, medium-dark-gray, aphanitic
240.0-250.0	10.0	Limestone, medium-light-gray, aphanitic
250.0-253.0	3.0	Limestone, medium-dark-gray, aphanitic
253.0-253.3	0.3	Argillized limestone, white, abundant clay
253.3-254.2	0.9	Silicified limestone, very light gray, hard
254.2-265.8	11.6	Argillized limestone, white, chalky in texture
265.8-272.8	7.0	Limestone, medium-light-gray, sugary-textured
		(Bottom of hole)

Drill hole 15-240-9
U.S. Bur. of Mines Project
Coordinates: N. 12,228
E. 10,108
Collar elevation: 7,940 ft
Total depth: 95.1 ft

Formation: El Paso Limestone
Inclination: -60°, N. 24° E.
Date: August 1948-June 1949
Logged by D. C. Hedlund (2/25/74)

Interval (feet)	Feet	Description
0.0-32.0	32.0	Limestone, medium-gray, aphanitic
32.0-62.0	30.0	Limestone, medium-gray to medium-dark-gray, aphanitic
62.0-64.0	2.0	Limestone, light-gray, some chert nodules
64.0-74.0	10.0	Limestone, medium-gray to medium-light-gray, penecontemporaneous breccias common
74.0-84.0	10.0	Limestone, very light gray, sugary-textured, beds dip 15°, penecontemporaneous breccias locally present
84.0-86.4	2.4	Chert breccia, silicified
86.4-89.0	2.6	Cherty limestone, slightly mineralized with sphalerite, galena, and pyrite
89.0-93.0	4.0	Chert breccia, silicified
93.0-95.1	2.1	Chert breccia, silicified, strong fractures 94.7-95.1 ft--probable fault
		(Bottom of hole)

Drill hole 15-240-10
U.S. Bur. of Mines Project
Coordinates: N. 9,435
E. 11,280
Collar elevation: 7,580 ft
Total depth: 235.5 ft

Formation: El Paso Limestone
Inclination: +8°, S. 65° E.
Date: August 1948-June 1949
Logged by D. C. Hedlund (2/25/74)

Interval (feet)	Feet	Description
0.0-12.4	12.4	Limestone-chert, light-gray
12.4-18.0	5.6	Limestone, white to very light gray, recrystallized medium coarse crystallinity
18.0-18.9	0.9	Limestone-chert, very light gray, silicified
18.9-21.6	2.7	Limestone, white to very light gray, recrystallized
21.6-25.0	4.4	Limestone-chert, silicified breccias
25.0-26.0	1.0	Limestone, white, chalky textured
26.0-31.0	5.0	Limestone-chert, abundant angular chert fragments
31.0-35.0	4.0	No core available
35.0-46.0	11.0	Limestone-chert, very light gray, abundant angular chert fragments
46.0-52.0	6.0	Limestone, white, coarsely crystalline
52.0-59.7	7.7	Limestone-chert, very light gray, abundant angular chert fragments
59.7-62.5	2.8	Limestone-chert, sparse sulfides present at 60.5 ft
62.5-67.5	5.0	Limestone, white, chalky textured
67.5-70.0	2.5	Limestone-chert, abundant angular chert fragments
70.0-160.5	90.5	Limestone, medium-gray, aphanitic Abundant secondary calcite fracture fillings from 81.0-85.0 ft Strong shear foliation from 81.2-81.8 ft Abundant fossil detritus from 131.7-132.0 ft Secondary calcite fracture fillings 132.8-133.8 ft
160.5-181.0	20.5	Limestone, medium-dark-gray, aphanitic, secondary vug-filling of calcite at 162.8 ft
181.0-190.5	9.5	Limestone, medium-gray, aphanitic

Interval (feet)	Feet	Description
190.5-200.7	10.2	Limestone, dark-gray to black, black clay films along lamination surfaces
200.7-213.0	12.3	Limestone, medium-gray, aphanitic, abundant secondary calcite veins from 203.5-204.0 ft
213.0-215.0	2.0	Limestone, medium-gray, aphanitic, fault at 213.0 ft
215.0-235.5	20.5	Limestone, very light gray to medium-light-gray, sugary-textured, laminae dip 10° to 45°--some crenulation of the laminae
		(Bottom of hole)

Drill hole 15-240-11
U.S. Bur. of Mines Project
Coordinates: N. 10,294
E. 9,434
Collar elevation: 7,697 ft
Total depth: 269 ft

Formations: Rubio Peak Andesite, Lake Valley Limestone
Inclination: -35°, S. 88° W.
Date: August 1948-June 1949
Logged by D. C. Hedlund (2/27/74)

Interval (feet)	Feet	Description
0.0-65.2	65.2	Andesite, medium-dark-gray
65.2-82.0	16.8	Limestone, medium-light-gray, medium crystallinity
82.0-82.8	0.8	Ferruginous limestone, chalcopyrite and malachite are present
82.8-85.8	3.0	Limestone, medium-light-gray, ferruginous zone 85.0-85.8 ft
85.8-94.0	8.2	Limestone, medium-light-gray, sugary-textured
94.0-96.0	2.0	Limestone-chert, light-gray, silicified
96.0-102.6	6.6	Limestone, medium-light-gray, sugary-textured
102.6-106.6	4.0	Limestone-chert, light-gray
106.6-117.0	10.4	Limestone, light-gray, sugary-textured, marmoritized
117.0-120.0	3.0	Limestone-chert, light-gray
120.0-128.0	8.0	Limestone, medium-light-gray, aphanitic to sugary textured
128.0-140.0	12.0	Limestone, white to very light gray, recrystallized, red calcite at 137.7 ft; especially altered from 138.0-140.0 ft--weak argillic to silicic type
140.0-153.1	13.1	Limestone, white to very light gray, laminated; minor white clay and chert from 152.7-153.1 ft
153.1-162.2	9.1	Limestone, white to very light gray, recrystallized, laminated to massive and chalky-textured, secondary calcite veins dip 50° at 158.0 ft
162.2-176.0	13.8	Limestone, very light gray to medium-light-gray, sugary-textured from 163.0-169.2 ft--elsewhere aphanitic
176.0-193.0	17.0	Limestone, very light gray to white, silicified in part

Interval (feet)	Feet	Description
193.0-203.0	10.0	Limestone, white to very light gray, recrystallized, medium-coarse crystallinity
203.0-215.0	12.0	Limestone, medium-light-gray, pelletal from 213.0-213.5 ft; calcite veins 206.0-210.0 ft
215.0-248.0	33.0	Limestone, white to very light gray, very finely crystalline although coarsely crystalline from 218.0-219.0 ft
248.0-253.0	5.0	Limestone, medium-dark-gray, aphanitic
253.0-269.0	16.0	Limestone, very light gray, very finely crystalline
		(Bottom of hole)