Geology and Ore Deposits of
the Orogrande Mining District
Otero County, New Mexico
Robert M. North, NMBM&MR
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INTRODUCTION

The Orogrande (Jarilla, Silver Hill) mining district, located in the Jarilla Mountains (T 21, 22, S., R. 8E., Otero County, Fig. 1) is a past producer of gold, silver, copper, lead, iron and turquois. The ore deposits with the exception of turquoise occur as late-stage veins and limestone replacement deposits in skarns associated with the intrusion of a Tertiary monzonite-quartz monzonite stack complex. The turquoise was formed during the supergene alteration of the stock.

Physiography

The Jarilla Mountains are a small range of desert mountains rising some 1200 feet above the surrounding Tularosa Basin. The highest point is an unnamed peak which rises to 5295 feet above sea level along a ridge between Water Canyon and the Ohaysi Valley. The range is roughly four miles wide (east-west) and ten miles long (north-south) cut deeply by Monte Carlo Gap, three miles from the northern end of the range. There are no springs or wells in the Jarilla Mountains.

The surrounding Tularosa basin is a large intermontane valley of the Basin and Range phisiographic province. The basin is bounded on the west by (from north to south) the San Andres mountains, the Organ mountains, and the Franklin Mountains. The eastern boundary of the Tulurosa Basin is the Sacramento mountains on the north and the Hueco Mountains on the south. Two prominant recent geologic features are found within the Tularosa Basin; the gypsum white sands, about 25 miles north of the Jarilla Mountains, and the Quaternary Carrizozo lava flow (malpais), which terminates about 60 miles north of the Jarilla Mountains and runs north to northeast about 50 miles to its source.

Previous Work

The Orogrande district is mentioned in newspaper accounts as early as 1883 (Rio Grande Republican, 1883), but the first detailed disscussion of the geology and ore deposits is by Jones (1904). L.C. Graton (Lindgren, and others, 1910) describes the geology and some of the mine workings to ca. 1908. Production data and brief geologic discussions are subsequently given by Finlay (1922), Laskey and Wootton (1933), Anderson (1957), and Howard (1967). The history of the district and a detailed account of the iron mines is given by Kelley (1949). The placer gold deposits and production are discussed by Johnson (1972). The turquoise deposits are mentioned by Hidden (1893) and Weber (1975). The geology of the Jarilla Mountains has been mapped by Seager (1961), Schmidt (1962), and Schmidt and Craddock (1964). A general overview of the geology and base metal mineralization is given by Beane and others(1975). Jaramillo C (1973) studied the alteration and mineralization of the district. The contact metamorphism in the district was studied by Bloom (1975) and the stratigraphy worked out by Strachan (1976). In addition, reports by private consultants and the U.S. Bureau of Mines, and numerous newspaper accounts have concentrated on the Orogrande deposits through the years (NMBM&MR file data).

HISTORY

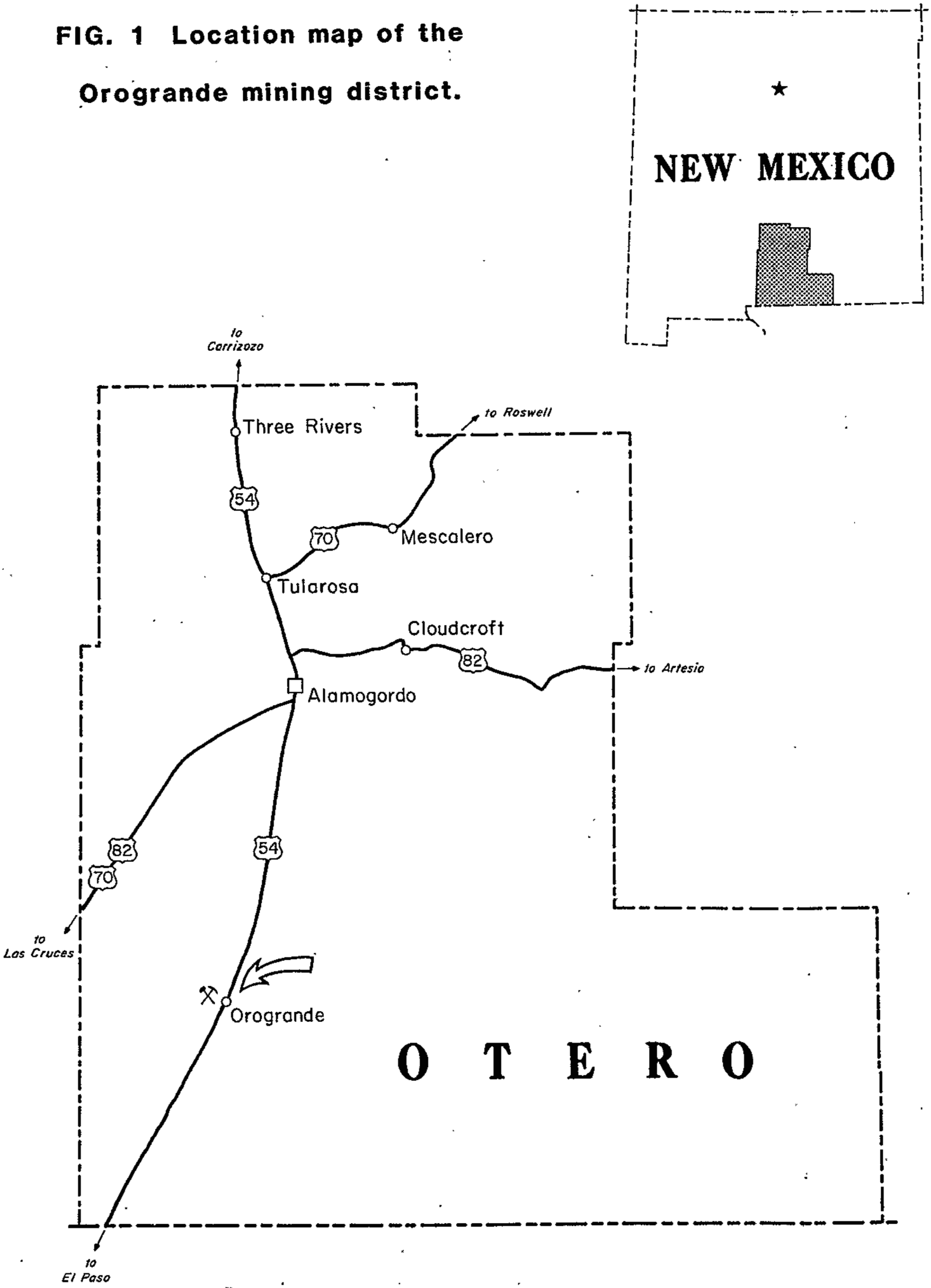
The first mining in the Jarilla Mountains was by Indians who worked shallow turquoise pits in the area. These workings were rediscovered in the early 1890's (Hidden, 1893) and worked by Amos J. De Meules, a dealer in turquoise and precious stones. Large scale turquoise mining was suspended soon after De Meules was killed in 1898, but doubtless has continued intermittently to the present on a small scale.

J.M. Perkins is credited as the earliest white prospector in the Orgrande district, arriving in 1879 (Jones, 1904). By 1883, the district was the site of considerable activity, with several shallow shafts and cuts developing outcropping mineral showings, the deepest shafts reported at 50 feet (Rio Grande Republican, 1883). A number of prospectors and mining companies were by now interested in the district which reportedly had ores of copper, gold, lead (cerussite and galena), silver, and iron. One mine, the Refugia, (exact location unknown) was reported to have "a rich copper vein, also a galena and carbonate vein which at a depth of 18 feet assays 160 ozs. silver; "(Rio Grande Republican, 1883). While these early newspaper accounts are of questionable accuracy, it is worth noting that even at this early date the Orogrande area was thought to be a potential bonanza, with only the lack of water preventing development. Water for the camp, at this time, was collected by earthen tanks during the rainy season and reportedly could be sold for $3 a barrel, an enormous price for 1883 (Rio Grande Republican, 1883).

Mining activity had reached such proportions in the late 1890's that a branch line to Brice, a now abondoned settlement in the Jarilla Mountains (Fig. 2), was completed by the El Paso and Southwestern Railroad. This line was extended further north in 1916 to accomadate iron mining in the district (Myrick, 1970). The extention passed through Ohaysi (Fig. 2) to its' northern terminis, Zora, a loading facility and mining community at the base of the tram to the Iron Duke and Cinco de Mayo mines (Kelley, 1949).

Events in 1904 and 1905 eventually led to the predicted rapid growth, and even significant production, albeit, doubtless,

FIG. 1 Location map of the Orogrande mining district.



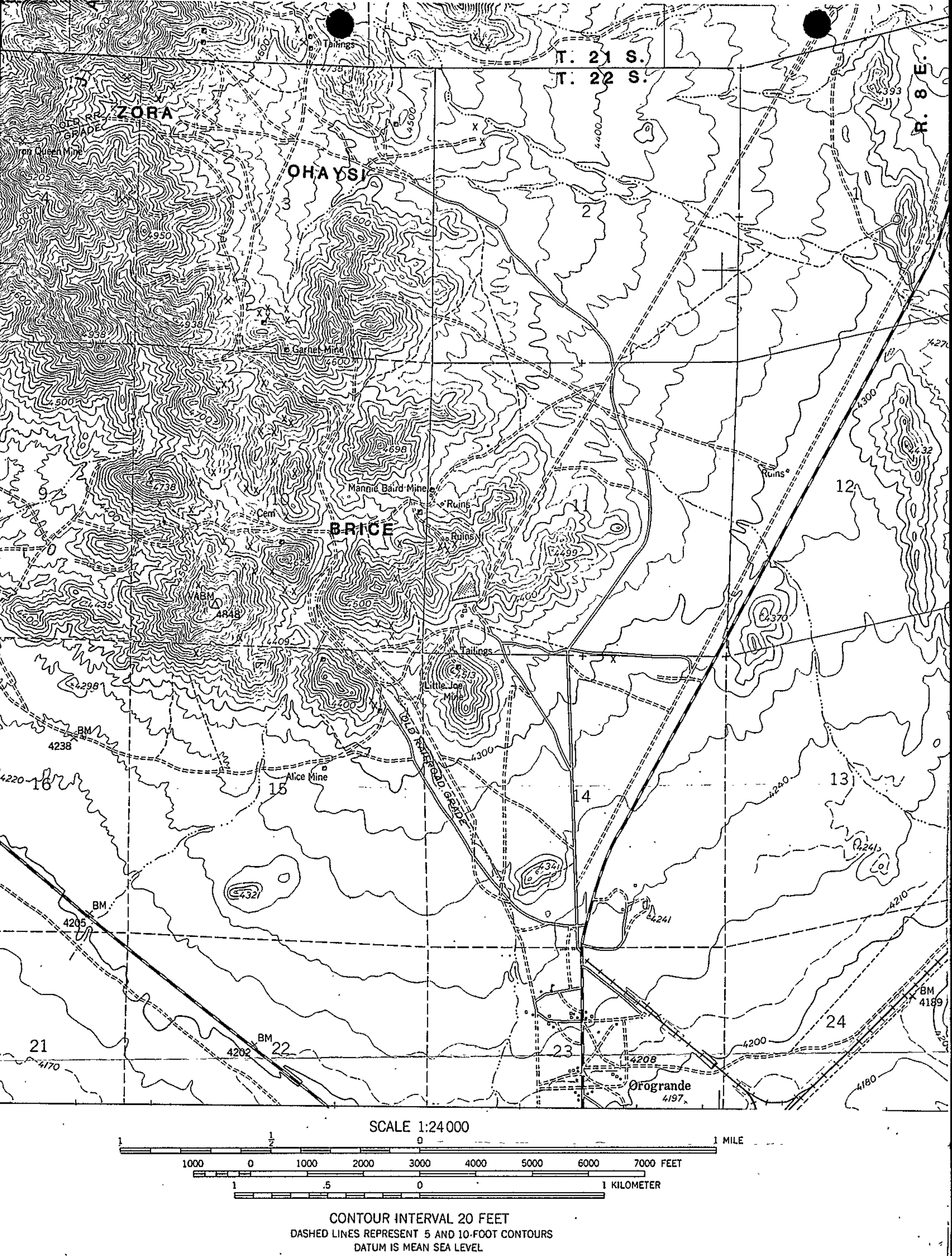


FIG. 2 Topographic map of the Orogrande mining district

considerably less than predicted by many. In June, 1904 a 6 1/2 ounce gold nugget was found during the dry washing operation on the Little Joe Claim of the Electric Mining and Milling Company (Jones, 1904). It was this discovery, dubbed by a newspaperman as "oro grande" (big gold) that would give the town and district its' name and contribute to its biggest boom (Jenness, 1964). Equally important in the sudden growth of the district was the work of the Southwestern Smelting and Refining Company.

The Southwestern Smelting and Refining Company was organized under the laws of the Territory of New Mexico on December 5, 1904 with offices at Orogrande and St. Louis, Mo. (Stevens, 1906). The company reportedly was orginally interested only in building a smelter, and later decided to aquire mining claims (Mining Reporter, 1905). The company built a pipeline to the Sacramento River, some 50 miles distant, to supply water to the mining community. The pipeline, completed in 1907, finally brought large amounts of much needed water to the area, (around 500,000 gallons/day) causing peaked interest by miners and investors (Stevens, 1908). The pipeline still brings water to the district today.

The SWS&R Co. also planned and built a smelter. The smelter, with one 250 ton furnace operating and one planned, was blown in on November 6, 1907 causing further interest in the district (Mining World, 1907). At this time, the company operated the largest mines in the area (purchased from the Jarilla Mining Company), including the Lucky, Nannie Baird, Iron Mask, and Garnet mines. The smelter operated for six months, but sufficent ore was not produced to keep it operating. The smelter was shut down in May, 1908, and George J. Green, the former company president, was appointed receiver (Stevens, 1908). The smelter was sold on January 6, 1909 and the company was reorganized as the Orogrande Smelting Company (Stevens, 1911), and operated until 1910 (NMBM&MR File data).

Base metal mining didn't die with the Orogrande Smelting Company nee Southwest Smelting and Refining Company, and significant production continued until 1918 (Table 2). Work in the district has been sporadic since then with peaks of interest in the depression, the mid 50's, the late 60's, and most recently, the late 70's (NMBM&MR File data).

Production

Mineral production (exclusive of iron ore) for the Orogrande district is summarized in Table 2. Iron ore production for the district is estimated at $500,000 (Kelley, 1949). Finlay (1922) reports the production of 6,656 tons of tungsten ore from the district in 1916. The approximate value of metals produced from the district from 1904 to present is: copper-$1,105,000; gold-$355,000; silver-$29,000; lead-$12,000, total (excluding iron)-$1,501,000.

Table 1

Mineral Surveys in the Orogrande Mining District

NAME	SURVEY #	PATENT DATE	OWNER AT TIME OF SURVEY
Grizzly Bear Lode	534	3/13/1890	Jarilla Mining Company
Cinnamon Bear Lode	535	6/ 6/1890	" " "
Brown Bear Lode	536	6/ 6/1890	" " "
James Fisk Lode	591	9/ 4/1891	Southwestern Mining & Smelting Co.
Iron Duke	592	8/19/1891	" " " " "
Providence	593	9/ 4/1891	" " " " "
Lone Star	594	3/19/1891	" " " " "
Lucky Group	984	11/26/1906	J.R. Burton
Alabama	1089	6/15/1903	Alabama Gold and Copper Mining Co.
Nannie Baird Group	1170	5/16/1905	Jarilla Mining Company
Annie Rooney Lode	1171	no application	" " "
Little Annie Lode	1172	" "	" " "
Garnet Group	1180	1905	St. Louis United Copper Mining Co.
Garnet Lode	1244	1/16/1908	Jarilla Mining Company
Emma Lode	1245	6/22/1907	" " "
Parallel Lode	1246	6/22/1907	" " "
Iron Queen Lode	1247	6/22/1907	" " "
Pasadena Lode	1248	6/22/1907	" " "
Fannie Lode	1249	6/22/1907	" " "
Adah Lode	1250	10/25/1907	" " "
Iron King	1251	12/ 5/1907	" " "
Macon Group	1252	2/ 3/1908	" " "
Copper King Group	1253	1/16/1908	" " "
Seven Come Eleven	1254	1/16/1908	" " "
Little Joe Group	1269	5/21/1907	Electric Mining & Milling Co.
Little Bear Lode	1333	5/26/1910	Jarilla Copper Co.
Raton Lode	1363	6/29/1911	Minna Dieter
Charleston Mine Philadelphia Mine }	1434	10/ 1/1914	Jarilla Copper Co.
Horse Shoe Lode	1435	7/21/1915	" " "
Copper Hill Mont Alto }	1498	5/ 6/1913	Copper Hill Mines Co.
Contact	1714	———	W.H. Parrott
Iron Duke Lode	1720	8/20/1926	Burro Mountain Copper Co.
Luara Lode	1721	12/16/1926	" " " "
Mary H. Fraction	1805	not patented	Wm. L. Rutherford
Cinco de Mayo	1815	———	Oro Iron Co.
Iron Drone Lode	1816	———	" " "
Virginia Group	1915	9/27/1925	J.H. Parker, W.H. Winter

GEOLOGY

The Jarilla Mountains are composed of mostly upper paleozoic limestone, sandstone, and shale intruded and domed by Tertiary igneous intrusions. The ore deposits are in contact metasomatic zones (skarns) in carbonate rocks (Fig. 3).

Paleozoic Sedimentary Rocks

Percha (?) Shale

A small patch of shale in the NW 1/4, NW 1/4, Sec. 14, T. 22S., R. 8E., is mapped by Strachan (1976) as Devonian Percha (?) shale (Fig. 3). This is a possible interpretation as up to +100' of Percha shale is encountered in a drill hole in the Orogrande district (Strachan, 1976). Another possible interpetation is that the outcrop represents an unusually thick shale acculululation in the Laborcita formation.

Gobbler Formation

At least 1600 feet of Pennsylvanian Gobbler formation is exposed in the Orogrande district. The entire exposure in the district is Desmoinesian age. The Gobbler Formation is dominantly limestone and cherty limestone with lesser amounts of sandstone and arkose (Strachan, 1976). The limestone beds of the Gobbler formation commonly are host rocks of metasomatic ore deposits in the district.

Laborcita Formation

The Laborcita formation in the Orogrande area is composed of sandstone shale, limestone, and conglomerate. Over 2000 feet of Laborcita formation is exposed in the Jarilla mountains. Strachan (1976) has shown the Laborcita formation to be latest Virgilian (upper Pensylvanian) to early Wolfcampion (lower Permian) in age. The Laborcita formation, like the Gobbler formation is contact metamorphosed in places by the intrusion of Tertiary igneous rocks.

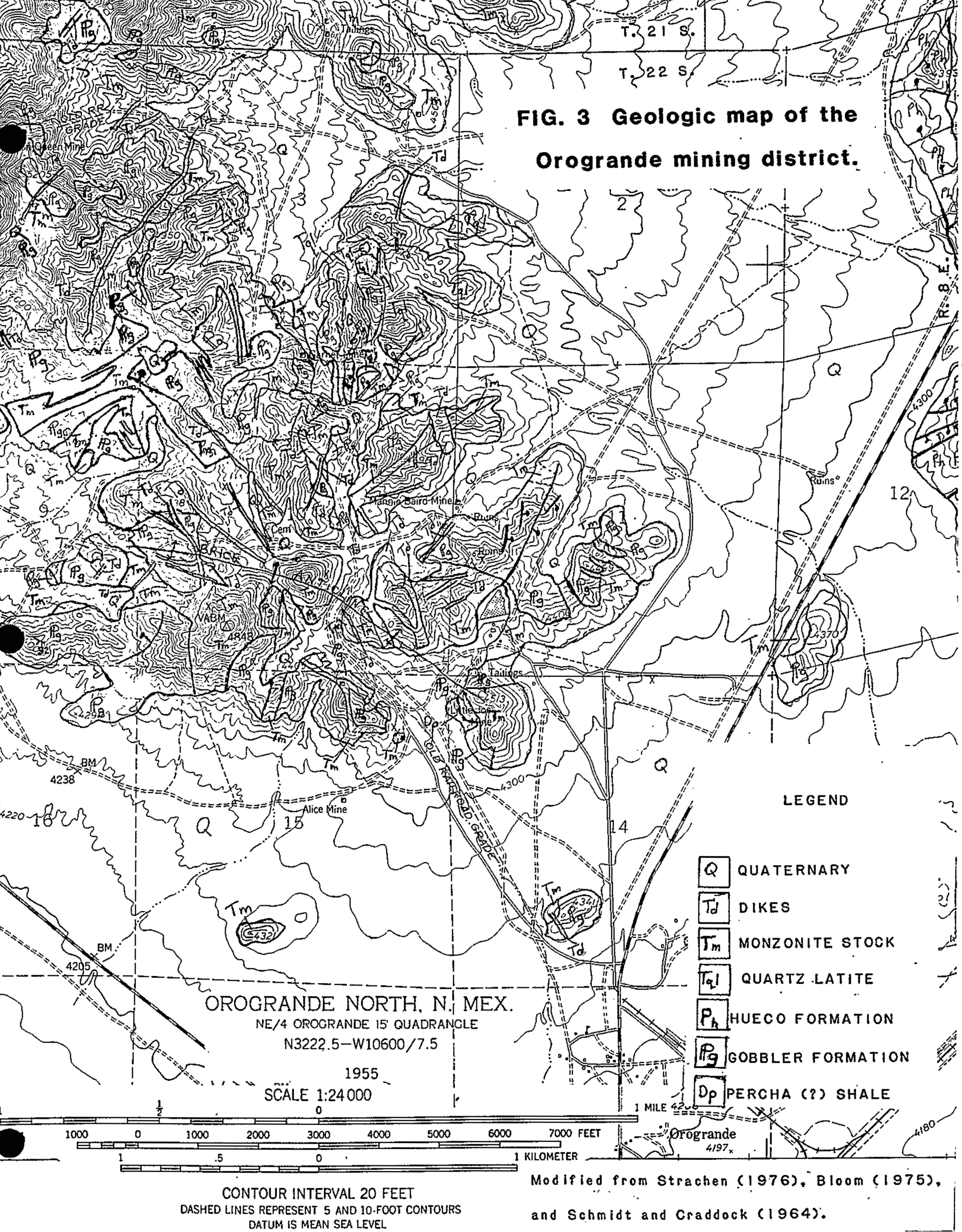
Hueco Formation

The lower Permian (Wolfcampian) Hueco formation crops out in the northern Jarilla Mountains and in the small hills to the east. Strachan (1976) described 3 members totaling 1040 feet. The upper and lower units are limestone separated by 163' of clastic rocks of the "distal Abo tounge." The Hueco formation has not served as a host rock for large ore bodies in the district.

Igneous Rocks

The oldest igneous rocks in the Orogrande mining district are quartz latite and granodionite. Exact age relationships of the two rock types can not be observed, as they are intruded and

FIG. 3 Geologic map of the Orogrande mining district.



Modified from Strachen (1976), Bloom (1975), and Schmidt and Craddock (1964).

thus separated by a later monzonite-quartz monzonite stock. The granodionite has been dated at 47.1 + 1.8 m.y. using the potassium-argon method on a biotile concentrate (Beane and others,1975). The intrusives are cut by later dikes and sills. The granodiorite and quartz latite are probably from a diffentiated common source (Beane and others, 1975). Descriptions and intrusive relations are summarized here mostly from accounts and maps by Bloom (1975), Strachan (1976), and Schmidt and Craddock (1964).

Granodiorite

Granodiorite crops out in the central and northwestern Jarilla Mountains. The intrusive has sharp contacts with the surrounding rocks and shows skarn development where it intrudes carbonate sediments of the Hueco and Laborcita Formation (Beane and others, 1975). No important ore mineralization was formed, however.

The granodiorite is a dark-gray, fine- to medium-grained equigranular rock composed of plagioclase, orthoclase, biotite, hornblende and quartz with minor amounts of augite, magnetite, pyrite, epidote , apatite, and sphene (Jaramillo C, 1973). Schmidt and Craddock (1964) described this rock type as biotite syenodionite.

Quartz Latite

Quartz latite crops out only in the southeastern part of the Jarilla Mountains. The rock is very fine grained (aphanitic) with some local phenocrysts of quartz and plagioclase. Schmidt and Craddock (1964) report the mineralogy as K-feldspar, quartz, and plagioclase with minor sericite, biotite, calcite and pyrite. Marbleization has taken place where the quartz latite cuts limestone of the Gobbler formation (SW 1/4, SE 1/4, Sec. 3, T. 22S., R. 8E.) but no true skarn is develped (Beane and others, 1975). The monzonite-quartz monzonite has been shown by all workers to intrude the quartz latite. Schmidt and Craddock (1964) describe the rock as leucorhyolite.

Monzonite-Quartz Monzonite Stock

The largest intrusive body in the Jarilla Mountains is a suite of monzonitic to quartz monzonitic rocks doubtless of common origin. The texture and mineral composition of the stock varies conciderably, but four phases have been recognized by recent workers (Beane and others, 1975; Strachan, 1976); Hornblende monzonite; quartz monzonite; orthoclase quartz monzonite and biotite-hornblende monzonite. All four rock types are more or less porphyritic containing varing amounts of orthoclase, plagioclase, quartz, hornblende, and biotite with accessary apatite, sphene, and zircon. Hornblende monzonite is the most common igneous rock in the district and is most often associated with the formation of the skarn ore deposits.

Dikes

A number of dikes cut both the igneous and sedimentary rocks of the Orogrande district. The biotite-hornblende monzonite commonly occurs as dikes cutting hornblende monzonite and palezozic sediments. Similarly, hornblende monzononite cuts the sediments as dike-like apotheses. Later andesite and diabase dikes cut both all phases of the monzonite stock complex and the paleozoic sediments. These are thought by Beane and others, (1975) to be related to an extrusive basalt at the northern-most end of the Jarillas.

Structure

Broadly, the Jarilla Mountains are a dome caused by the forcefull injection of the monzonite stock body. Faulting in the range is limited to a number of high-angle normal faults of 150' or less displacement in the northern part of the range and a small horst, bounded by vertical faults intruded by monzonite in the southern part of the range (Strachan, 1976). Strachan also defined by detailed mapping a doubly-plunging, broad anticline which he named the Brice anticline. The axis of the Brice anticline runs North 60-65^{o} west crossing the Jarilla Mountains just south of the old Brice townsite (Fig. 3). This feature, which roughly parallels Laramide age compressional structures at Otero Mesa (Black, 1975), and in Trans-Pecos Texas (Woodward, et al., 1975), is thought to also be Laramide age, predating the intrusion and doming.

Contact Metamorphism

Contact metamorphism is pervasive in the Orogrande mining district, occurring at both monzonite and grandionite contacts. Especially significant are the hornblende monzonite-limestone contacts, where the largest volume and best grade ores of copper, gold, and iron were found in contact metasomatic deposits (skarns). Where limestone has been intruded by monzonite the skarn shows a distinct zoning of mineral assembledges radiating away from the contact. The zones from the igneous contact into the limestone are: 1) epidote-clinozoisite-calcite, 2) garnet-calcite, 3) pyroxene, and 4) marble (Bloom, 1975). The first zone is classified as endoskarn (within the intruding rock), the last three, exoskarn (in the host rock). The following descriptions of these metamorphic zones is taken from Bloom (1975). Descriptions of metamorphism by the granodionite are largely from Beane, et al., (1975) and Schmidt and Craddock (1964).

Skarn Associated with Granodiorite

The injection of granodiorite in the central and northern portions of the Jarilla Mountains resulted in considerable contact metamorphism of the Hueco and Laborcita formations. Near the contact with limestone (within 100 feet) the mineralogy has been changed to dominantly coarsely crystalline andradite garnet and diopside with lesser, finer-grained calcite, scapolite, epidote and chlorite. The entire original character of the host rock has been changed. Alteration becomes less intense away from the contact with similar mineralogy, though finer grained, with the addition of some wollastonite and pyrite. Schmidt and Craddock (1964) showed the thermal effects as far away as 2400 feet in siltstone beds and 1600 feet in limestones. No ore deposits are known to be associated with these skarns.

Skarn Associated with Monzonite

The intrusion of the monzonite stock resulted in contact metamorphism of the Paleozoic sediments, most notably, the limestones of the Gobbler formation. The effects are not as extensive as those of the granodiorite intrusion, with silicate alteration (metasomatism) extending only some 60 feet from the contact and the thermal effects (marblaization) extending only another 60 feet, at most (Schmidt, 1962). This is probably due to the lower temperature of intrusion that would be expected for a monzonite as opposed to a granodiorite. Nevertheless, all important ore deposits in the district were mined from skarns associated with the monzonite stock. Four contact metamorphic zones were formed radiating away from the intrusive.

Clinozosite-Epidote-Calcite Zone The skarn zone nearest relatively unaltered intrusive contains medium- to coarse-grained clinozosite, epidote, and calcite. The zone is within the outer edge of the intrusive (i.e. the igneous side of the contact) and is hence termed endoskarn. The contacts with the relatively unaltered intrusive and the exoskarn zones are gradational.

Andradite-Grossularite-Calcite Zone The nearest-contact exoskarn zone (i.e. within the host rock, usually limestone in this case) contains fine- to coarse-grained andradite, grossularite, and calcite. Accessory minerals include medium- to fine-grained hematite, wollastonite, diopside and epitote. The mineralogic composition of the zone varies considerably in response to variations in the original character of the host rock which were interbedded impure limestones and calcareous shales. This zone may grade through a pyroxene zone or directly into the marble zone.

Pyroxene Zone An irregular zone of very fine-grained needles of wollastonite and diopside may be present between the andradite-grossolarite-calcite zone and the marble zone. These needles usually are found replacing former chert nodules, and Schmidt (1962) reports nodules as large as six inches in diameter which show cores of chert surrounded by wollastonite needles with minor diopside veinlets.

Marble Zone The furthest effects of metamorphism from the contact is the thermal recrystalization of limestone into marble. The marble is medium- to coarse-grained, with no evidence of

TABLE 2

Mineral Production of the Orogrande Mining District

Year	Ore Tons	Gold (ounces)	Silver (ounces)	Copper (Pounds)	Lead (Pounds)	Value $	Major Producing Mines
1904	170	126.7	164	14,400	-	$4,557	
1905	20	51.1	93	3,600	-	1,696	Nannie Baird, 3 Bears
1906	78	20.5	163	11,166	-	2,689	Garnet
1907	11,319	716.5	1,829	555,580	-	127,134	Nannie Baird; 3 bears
1908	21,901	1,726.7	4,205	710,780	-	131,742	Nannie Baird; Lucky
1909	143	12.4	29	6,354	-	1,098	Delusion; Cuprite
1910	536	415.1	2,007	38,858	5,841	14,857	Nannie Baird; 3 Bears
1911	770	325.0	680	10,406	739	8,412	Maggie; Nannie Baird
1912	2,553	630.8	1,011	119,740	-	33,418	Nannie Baird; 3 Bears; Garnet
1913	15,822	2,411.6	6,444	597,580	1,911	146,448	Nannie Baird; 3 Bears; Garnet
1914	11,009	1,860.6	5,376	387,211	2,027	93,010	Nannie Baird; 3 Bears; Garnet
1915	14,930	2,659.6	6,150	853,257	-	207,412	By Chance; Garnet; Nannie Baird; 3 Bears
1916	20,195	1,925.9	7,403	1,077,492	638	309,787	Garnet; By Chance; Delusion; Verde
1917	15,558	1,172.8	4,514	731,894	-	227,768	By Chance; Garnet; Nannie Baird; 3 Bears
1918	6,210	246.5	2,048	253,405	-	69,735	Garnet; Nannie Baird; 3 Bears
1919	205	3.6	25	4,382	-	917	Lincoln
1920 *							
1921	500	253.0	32	-	-	5,262	
1922 *							
1923	68	17.7	190	666	14,286	1,620	
1924	499	1.0	397	4,046	129,286	11,160	
1925	217	34.6	75	13,300	-	2,656	
1926 *							
1927	372	19.2	60	7,847	-	1,458	By Chance
1928	2,753		559	70,368	-	14,564	By Chance
1929	4,927	357.7	1,285	127,192	-	30,464	By Chance
1930	490	19.6	89	12,230	246	2,042	By Chance; Molly Gibson; Cuprite
1931 *							
1932	11	2.61	-	-	-	54	Nannie Baird; Lee #1
1933	3	197.4	20	-	-	4,088	Small Placer Operations
1934	-	130.0	11	-	-	4,584	Small Placer Operations
1935	-	259.0	18	-	-	9,067	Small Placer Operations
1936	-	94.0	9	-	-	3,304	Small Placer Operations
1937	-	66.0	13	-	-	2,334	Small Placer Operations
1938	-	12.0	1	-	-	407	Small Placer Operations
1939	37	9.0	25	3,742	-	629	Garnet; Harvey Group
1940	86	29.0	173	13,900	-	3,640	
1941-1946 *							
1947	998	28.0	291	21,272	2,685	5,749	Delusion; Providence Garnet
1948-1952 *							
1953	1,136	-	-	32,738	-	9,428	Providence; Garnet
1954	-	11.0	4	1,000	-	684	
1955-1956 *							
1957	4	1.0	5	3	2	41	
1958-1959 *							
1960	11	1.0	3	657	-	248	
1961-1965 *							
1966	288	-	76	10,000	-	3,715	Shay
1967-1981 *							
TOTAL 1904-1981	136,816	15,847	45,477	5,695,066	157,661	$1,497,878	

* No production

Source: U.S. Bureau of Mines Mineral Yearbooks material added from the intrusion. The recrystalization effects can be traced up to 60 feet past the last detectable metasomatism (addition of silicate material) after which the limestone is unaltered (Schmidt, 1962).

ORE DEPOSITS

Placer Deposits

Placer gold can be found in small quantities in many of the dry washes of the Jarilla Mountains. The earliest placer operations were concentrated in the NW 1/4 section 14 and the SW 1/4 section 11, near the Little Joe Mine, and in the center of the W 1/2 section 10, T. 22S., R. 8E., near the Nannie Baird Mine. In general, the gold was found near the surface (Johnson, 1972), making commercial operations somewhat limited.

The gold is presumed to have eroded from the skarn deposits of the district.

Lode Deposits

Base and Precious Metal Deposits

The copper-silver-gold-lead-zinc deposits of the Orogrande district are contact metasomatic (skarn) deposits formed from late-stage mineralizing solutions associated with the intrusion of the monzonite stock. Field relations show the ore mineralization to be later than the formation of the calc-silicate sharn (Bloom, 1975). While contact metamorphic zones are present at the contact of the earlier granodiorite with limestone, no significant ore deposits were formed. The ore zones are limited to replaced limestone beds near the contact, as the metasomatic effects generally extend less than 60 feet into the limestone (Bloom, 1975).

The skarns fall nicely into the copper calcic skarn deposit catagory of Einaudi and Burt (1982). This type of deposit typically is associated with the intrusion of a stock of granodiorite to quartz monzonite composition, ranging in size from 1 to 100 million tons of 1-2% copper ore. Chalcopyrite is usually the most important ore mineral, with molybdenum, zinc, and tungsten as common associates (Einaudi and Burt, 1982). In relative terms, the Orogrande deposit is small, doubtless less than 1 million tons, probably less than 500,000 tons. The ore produced was about 2% of copper, which is typical of ore deposits of this type. The gold and silver values varied conciderably (Schmidt and Craddock, 1964, p. 43).

Mineralogy The most important primary ore mineral of the deposits is chalcopyrite. Native gold is locally important. The silver values are probably as concentrations in chalcopyrite and possibly pyrite. Galena is a minor ore mineral, and wulfenite and sphalerite are reported from the district (Northrup, 1959; NMBM&MR file data).

Oxidation is common, especially at the Lucky Mine (Labeled "Garnet Mine" on the Orogrande 7 1/2' quadrangle) where attractive specimens of malachite and chrysocolla coated with drusy quartz have been found. A black copper-bearing mineral is also present here, which is probably maganese- and/or iron-rich chrysocolla. This material could, however, be tenorite.

Gangue minerals include quartz, andradite, grossularite, calcite, wollastonite, scheelite (Moore, 1956), diopside, epidote, clinozoisite, tremolite, magnetite, and specular hematite.

Iron Deposits

The iron deposits of the Orogrande district are also skarn deposits associated with the monzonite stock. Field relations show the iron mineralization is also later than the calcic skarn formation (Kelley, 1949). These deposits have some of the characteristics of iron calcic skarns in the classification scheme of Einaudi and Burt (1982).

The iron ores range in composition from 54-62% of iron, trace to 0.3% of manganese, and trace to 0.11% of copper (Kelley, 1949) and show some gold, which is characteristic of the iron calcic skarn type deposits. However, the ores are relatively high in sulfur, (~1%), which is not generally the case with iron calcic skarn deposits (Einaudi and Burt, 1982).

Mineralogy Fine-grained magnetite and hematite are the iron ore minerals of the Orogrande district. The ore occurs in a skarn ore gangue of garnet, calcite, pyrite, actinolite, quartz and fluorite (Kelley, 1949). The Iron Mask and Iron Queen produced small amounts of gold, silver, and copper (NMBM&MR file data) probably from argentiferous chalcopyrite, native gold, and auriferous-argentiferous pyrite.

Turquoise Deposits

Turquoise is found in the SE 1/4 section 3, T. 22S., R. 8E., as veinlets in altered monzonite. Turquoise is formed by the supergene alteration of alminous igneous rocks with phosphorous presumably supplied by the breakdown of apatite and copper from chalcopyrite. The turquoise is blue to blue-green in color, occassionally weathering out as small nuggets. The turquoise is associated with kaolinite, limonite, gypsum, jarosite and pyrite (Weber, 1975).

Discussion

Formation of the Ore Deposits

An exact classification of the Orogrande ore deposits is somewhat problematical. The ore mineralization has been shown to be later than the calcic skarn formation (Bloom, 1975) but the deposits are not true vein deposits. Lindgren (Lindgren, and others, 1910, p. 56), thought the deposits were transitional between true contact metasomatic ore deposits, where ores are emplaced at relatively high temperatures and pressures near the intrusive contact, and vein deposits, where the ores are deposited by hydrothermal emanations at lower temperatures and pressures at some distance from the intrusion. Regardless of classification, the geologic setting of the ores is well documented, that is they were deposited as replacements and veins in limestone near the top (roof) of a relatively shallow igneous intrusion of monzonitic-to quartz monzonitic composition. Limestone roof pendants are common in the monzonite and made good host rocks for mineralization.

Problems arise, as with many mineral deposits, in attributing the metals to a source. In this case, it seems obvious, upon preliminary examination, that the metals came from the mozonitic magma. Any base or precious metals present in the magma would tend to be concentrated in the late-stage fluids, since they are not easily incorporated into the early crystalizing silicate phases such as amphiboles, micas, and feldspars. However, recent work has cast some doubt on concept that magmas are the source of metals in hydrothermal ore deposits. It has been found by a number of workers, using stable isotope data, that the metals in ore deposits, in most cases are deposited by hydrothermal solutions dominated by meteoric water (Taylor, 1973; O'Neil and Silberman, 1974; Taylor). The metals, in some cases, are thought to be leached from the surrounding host rock by metoric water, and are not from a magmatic source (Casadevall and Ohmoto, 1977). However, it has been demonstrated by O'Neil and Baily (1979) that while a gold-bearing jasparoid in Utah was deposited by waters of a much dominant metoric component, the pyrite (with which the gold is associated) had sulfur isotope values which indicate a magmatic source. This is doubtless the case at Orogrande, that is, the ores are deposited by hydrothermal fluids of a large metoric componet, but the metals are supplied by the magma.

The monzonite stock of the Orogrande district was emplaced at a relatively shallow depth, certainly less than 5000 feet, and probably nearer 1000 feet. The country rock, dominantly limestone, was altered to calc-silicate skarns by contact metamorphism. The ores were emplaced after the skarn formation as veins and replacement deposits, but probably are associated with their formation and were formed very near the skarns in both time and space. Doubtless the ores represent the final stage of skarn formation.

Although no stable isotopic data is available on the ores of the district, it is reasonable to assume that the ore-forming solutions had a large meteoric component, given the near-surface environment of formation. However, the metals were supplied by the magma, not leached from the host rocks. Indirect evidence of this is supplied by the fact that no ore deposits are associated with the intrusion of the granodiorite. If leaching of host rocks were the source of metals, with the magma suppling only heat, it is reasonable to expect some ore mineralization associated with the granodiorite. It also seems unlikely that enough rock would be available for leaching, given the fact the magma was intruded at shallow depth, and assuming the leaching was done by meteoric water heated by the magma. The evidence, in total, is compeling that the metals were indeed contributed by the magma.

Another interesting aspect of the district is the association of iron and copper-gold-silver mineralization. Both types of mineralization are associated with the intrusion of the monzonite stock, just as is the case with the intrusion of the Fierro granodiorite pluton in Grant County, NM. Skarns are also developed at Fierro, with associated (but again, somewhat later) copper, iron, and zinc mineralization (Jones and others, 1967). At Orogrande, the deposits show a crude zoning, with iron deposits in the northwest part of the district, through copper-gold in the central portion (Lucky mine), to gold at the Little Joe mine in the southeast. More study is needed to further deliniate this zoning in detail.

Future Potential

Copper-Gold-Silver Deposits Howard (1967) reported no nonferrous reserves for the district. The known reserves are small, but some potential may exist. The district shows alteration characteristic of porphery-type copper deposits (Beane and others, 1975) and may have potential as a large, low-grade copper deposit. However, Anaconda Copper Company showed some interest in the district in the 1950's (Moore, 1956) and probably did explore for porphery-type mineralization. Anaconda has not produced from the district.

Recently, the district was examined by New Cinch Uranium Company Ltd. of Canada for potential as a large, low-grade gold-silver prospect (Stamper, 1980). After a flurry of activity, work has slowed, but intrests are still held in the district by Triple S Development Company of Albuquerque, presumably still investigating the possibilities of a low-grade gold-silver deposit.

The placer deposits of the district have potential mostly for recreational panning. The best deposits have been worked intermittently since the early 1900's and are presumed essentially exhausted. However, the district is a good spot for amatures to pan for weekend entertainment. The most productive areas, however, are patented claims, and thus require the owner's permission to pan on the property.

The best procedure to determine potential in the district is judged to be making a detailed study of the zoning of the skarn deposits. From this study, it may be possible to predict a "target area" of deposits under the alluvial cover, especially to the east and northeast of the Nannie Baird mine. The major drawback of any deposits remaining (presumably hidden) is that they will be relatively small and discontinous, as the already mined deposits were. The overall copper-gold-silver potential of the district is estimated to be small.

Iron Ore Deposits Reserves of iron ore are given by Howard (1967) as 216,000 tons, indicated and 116,000 tons inferred ore averaging 40-50% of iron. Owing to the relatively high sulfur content of the ores (Kelley, 1949), it is doubtful that these deposits will be economic for many years to come.

Turquoise Deposits The turquoise deposits, like the placer gold deposits, are best thought of as a recreational resource. Lapidarists and mineral collectors should be able to find turquoise for their jewelry and collections for many years to come. However, as with the placers, the turquoise deposits are under claim, and it requires permission to collect. The small veins, inconsistant quality, and present low price of turquoise should prevent future commercial operations.

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APPENDIX: Minerals Reported from the Orogrande Mining District

Actinolite	$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$
Andradite	$Ca_3Fe_2(SiO_4)_3$
Apatite	$Ca_5(PO_4)_3F$
Augite	$(Ca,Na)(Mg,Fe,Al,Ti)(Si,Al)_2O_6$
Biotite	$K(Mg,Fe)_3(Al,Fe)Si_3O_{10}(OH,F)_2$
Calcite	$CaCO_3$
Cerussite	$PbCO_3$
Chalcopyrite	$CuFeS_2$
Chlorite	$(Mg,Al,Fe)_{12}(Si,Al)_8O_{20}(OH)_{16}$
Chrysocolla	$(Cu,Al)_2H_2Si_2O_5(OH)_4$
Clinozosite	$Ca_2Al_3(SiO_4)_3(OH)$
Diopside	$Ca_2MgSi_2O_6$
Epidote	$Ca_2(Al,Fe)_3(SiO_4)_3(OH)$
Fluorite	CaF_2
Galena	PbS
Gold	Au
Grossularite	$Ca_3Al_2(SiO_4)_3$
Gypsum	$CaSO_4 \cdot 2H_2O$
Hematite	Fe_2O_3
Hornblende	$Ca_2(Fe,Mg)_4Al(Si_9Al)O_{22}(OH,F)_2$
Jarosite	$KFe_3(SO_4)_2(OH)_6$
Kaolinite	$Al_4Si_4O_{10}(OH)_8$
Magnetite	Fe_3O_4
Malachite	$Cu_2(CO_3)(OH)_2$
Microcline	$K\ AlSi_3O_8$
Montmorillonite	$(Ca,Na)_{0.33}(Al,Mg)_2Si_4O_{10}(OH)_2 \cdot nH_2O$
Orthoclase	$K\ AlSi_3O_8$
Plagioclase	$(Na,Ca)_3Al(Al,Si)Si_2O_8$
Pyrite	FeS_2
Quartz	SiO_2
Rutile	TiO_2
Scapolite	$(Na,Ca,K)_4Al_3(Al,Si)_3Si_6)_{24}(Cl,CO_3SO_4OH)$
Scheelite	$CaWO_4$
Sericite	$K_2Al_4Si_6Al_2O_{20}(OH,F)_4$

Sphalerite	ZnS
Sphene	$CaTiSiO_5$
Tenorite(?)	CuO
Tremolite	$Ca_2Mg_5Si_8O_{22}(OH)_2$
Turquoise	$CuAl_6(PO_4)_4(OH)_8 \cdot 5H_2O$
Wollastonite	$CaSiO_3$
Wulfenite	$PbMoO_4$
Zircon	$ZrSiO_4$

Year	Ore Tons	Gold (ounces)	Silver (ounces)	Copper (Pounds)	Lead (Pounds)	Value $	Major Producing Mines
1904	170	126.7	164	14,400	–	$4,557	
1905	20	51.1	93	3,600	–	1,696	Nannie Baird, 3 Bears
1906	78	20.5	163	11,166	–	2,689	Garnet
1907	11,319	716.5	1,829	555,580	–	127,134	Nannie Baird; 3 bears
1908	21,901	1,726.7	4,205	710,780	–	131,742	Nannie Baird; Lucky
1909	143	12.4	29	6,354	–	1,098	Delusion; Cuprite
1910	536	415.1	2,007	38,858	5,841	14,857	Nannie Baird; 3 Bears
1911	770	325.0	680	10,406	739	8,412	Maggie; Nannie Baird
1912	2,553	630.8	1,011	119,740	–	33,418	Nannie Baird; 3 Bears; Garnet
1913	15,822	2,411.6	6,444	597,580	1,911	146,448	Nannie Baird; 3 Bears; Garnet
1914	11,009	1,860.6	5,376	387,211	2,027	93,010	Nannie Baird; 3 Bears; Garnet
1915	14,930	2,659.6	6,150	853,257	–	207,412	By Chance; Garnet; Nannie Baird; 3 Bears
1916	20,195	1,925.9	7,403	1,077,492	638	309,787	Garnet; By Chance; Delusion; Verde
1917	15,558	1,172.8	4,514	731,894	–	227,768	By Chance; Garnet; Nannie Baird; 3 Bears
1918	6,210	246.5	2,048	253,405	–	69,735	Garnet; Nannie Baird; 3 Bears
1919	205	3.6	25	4,382	–	917	Lincoln
1920 *							
1921	500	253.0	32	–	–	5,262	
1922 *							
1923	68	17.7	190	666	14,286	1,620	
1924	499	1.0	397	4,046	129,286	11,160	
1925	217	34.6	75	13,300	–	2,656	
1926 *							
1927	372	19.2	60	7,847	–	1,458	By Chance
1928	2,753		559	70,368	–	14,564	By Chance
1929	4,927	357.7	1,285	127,192	–	30,464	By Chance
1930	490	19.6	89	12,230	246	2,042	By Chance; Molly Gibson; Cuprite
1931 *							
1932	11	2.61	–	–	–	54	Nannie Baird; Lee #1
1933	3	197.4	20	–	–	4,088	Small Placer Operations
1934	–	130.0	11	–	–	4,584	Small Placer Operations
1935	–	259.0	18	–	–	9,067	Small Placer Operations
1936	–	94.0	9	–	–	3,304	Small Placer Operations
1937	–	66.0	13	–	–	2,334	Small Placer Operations
1938	–	12.0	1	–	–	407	Small Placer Operations
1939	37	9.0	25	3,742	–	629	Garnet; Harvey Group
1940	86	29.0	173	13,900	–	3,640	
1941–1946 *							
1947	998	28.0	291	21,272	2,685	5,749	Delusion; Providence Garnet
1948–1952 *							
1953	1,136	–	–	32,738	–	9,428	Providence; Garnet
1954	–	11.0	4	1,000	–	684	
1955–1956 *							
1957	4	1.0	5	3	2	41	
1958–1959 *							
1960	11	1.0	3	657	–	248	
1961–1965 *							
1966	288	–	76	10,000	–	3,715	Shay
1967–1981 *							
TOTAL 1904–1981	136,816	15,847	45,477	5,695,066	157,661	$1,497,878	

* No production

Source: U.S. Bureau of Mines Mineral Yearbooks