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GEOLOGY AND ORE DEPOSITS OF THE NORTHWESTERN ORGAN MOUNTAINS
DONA ANA COUNTY, NEW MEXICO

by

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THESIS

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DONA ANA COUNTY, NEW MEXICO

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ABSTRACT

The Organ Mountains are in mid-eastern Dona Ana County, New Mexico, thirteen miles (20 km) east of Las Cruces, New Mexico. The northern half of the mountains is composed of gravels and alluvium of Tertiary and Quaternary age, volcanic and intrusive igneous rocks of Tertiary age, and Paleozoic sedimentary rocks. Quartz monzonite of the Organ Mountain Batholith is the dominant rock type exposed. The southern half of the Organ Mountains is a caldera of Tertiary age. Flows, tuffs, and lahars of Orejon Andesite, Cueva Rhyolite, and Soledad Rhyolite occur in the caldera and dip toward the center of the structure. Three periods of faulting are recognized in the study area: caldera related faults, batholith intrusion related faults, and faults of the Torpedo-Bennett fault zone (Basin and Range).

Two stages of hydrothermal activity, related to the Organ Mountain Batholith, mineralized the Paleozoic sedimentary rocks and the batholith. The first stage produced pyrometasomatic deposits directly related to intrusion of the batholith (hypothermal). The second stage consisted of late stage hydrothermal deposition and replacement (mesothermal). Ore minerals deposited include chalcopyrite, galena, argentiferous galena, sphalerite, and fluorspar. The deposits occur in fissure veins, breccia zones, skarn zones, and replacement bodies.

Present activity in the area consists of limited exploration, primarily for fluorspar and porphyry copper. Additional exploration probably will discover other commercial deposits of minerals in the area.

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INTRODUCTION

LOCATION

The Organ Mountains are in mid-eastern Dona Ana County, New Mexico, 13 miles (21 km) east of Las Cruces, New Mexico (Fig. 1). The area may be reached by traveling east on U. S. Highway 70 to the town of Organ, New Mexico, which is located in the northern portion of the study area. An improved dirt road parallels the entire western edge of the area.

The study area includes all or part of sections 34, 35, 36, T. 21 S., R. 3 E., sections 1, 2, 3, 10, 11, 12, 13, 14, 15, 22, 23, 24, 25, 26, 27, 34, 35, 36, T. 22 S., R. 3 E., sections 1, 2, 3, 10, 11, 12, T. 23 S., R. 3 E., section 31, T. 22 S., R. 4 E., and sections 6 and 7, T. 23 S., R. 4 E., New Mexico Principle Meridian, Organ Quadrangle, 7.5 minute series, and Organ Peak Quadrangle, 7.5 minute series. The study area encompasses about 26 square miles (67 sq km).

Most of the land is Public Domain controlled by the Bureau of Land Management and leased to ranchers for grazing. About 6 square miles (16 sq km) of the study area is covered by deeded property, patented claims, state land, and military reservation.

PREVIOUS WORK

The first geological paper on the Organ Mountains was published by Thomas Antisell in 1856. His report summarized the Parker Expedition

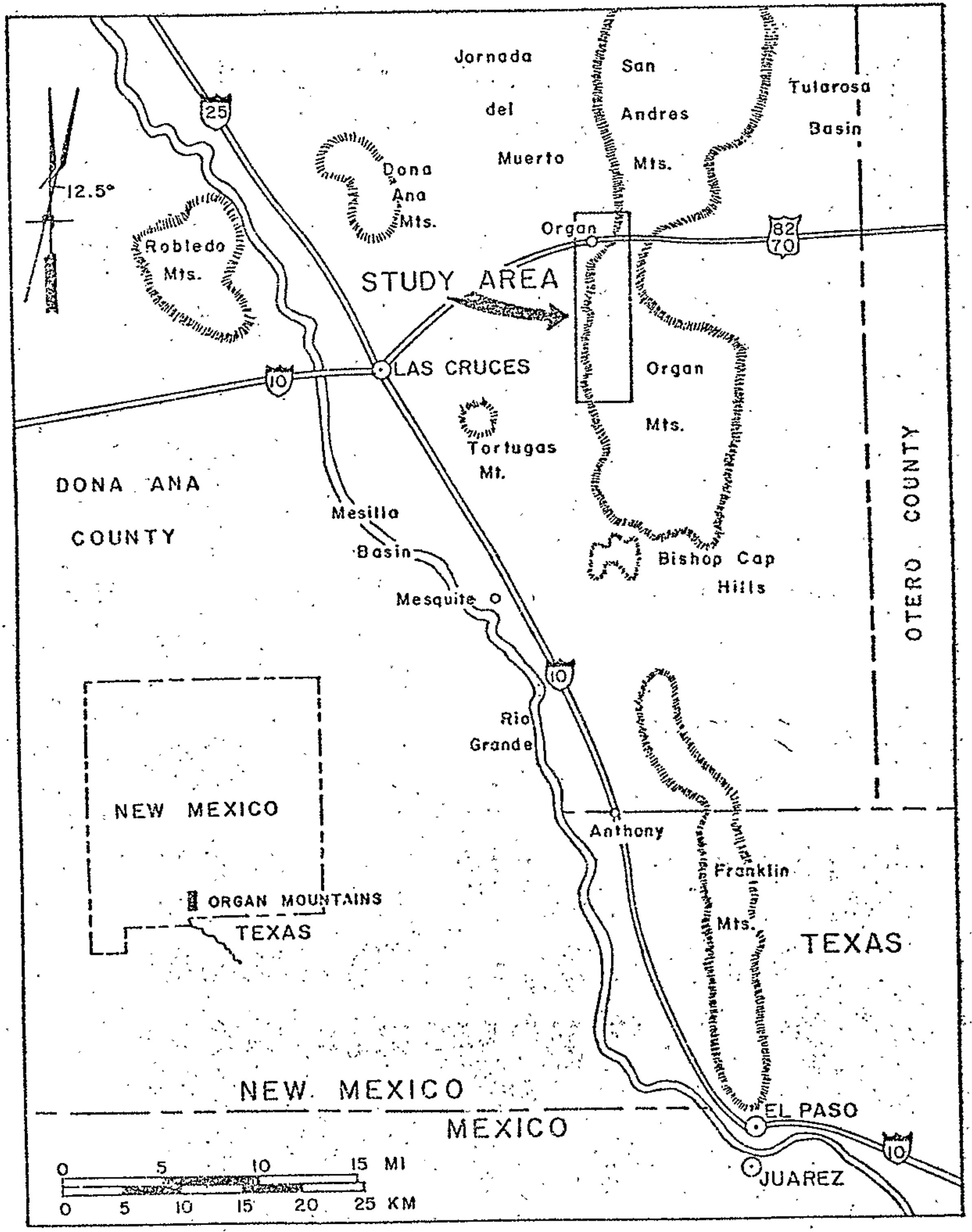


Figure 1: Index Map showing location of study area.

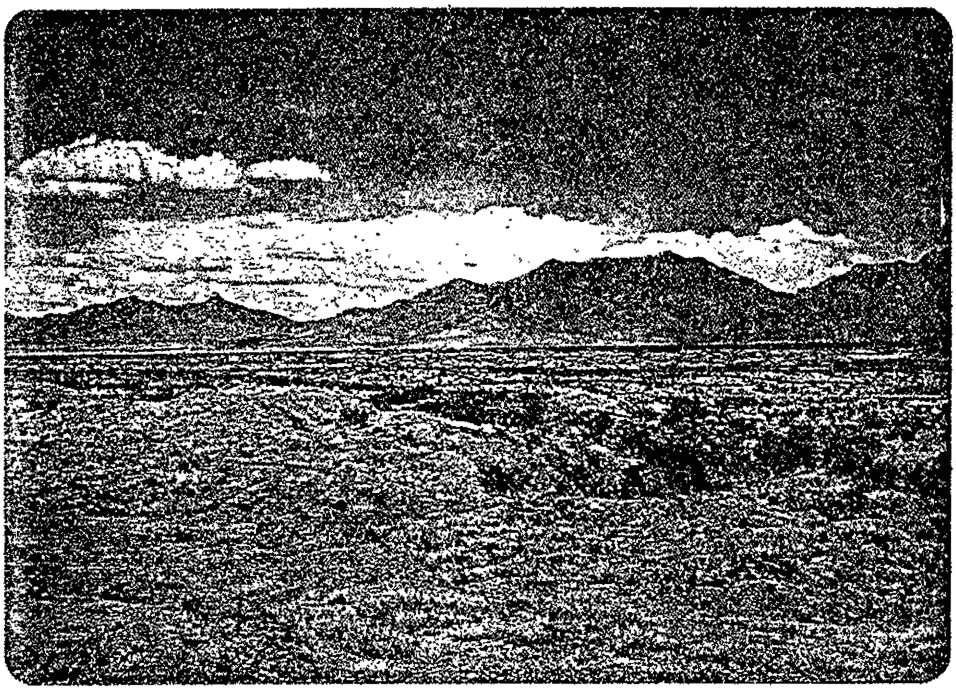


Plate IVa. Study area, northern half, showing Organ Mining District (left side) to Baylor Pass (right side). View looking to the east.

Plate IVb. Study area, southern half, showing Baylor Pass (left side) to Fillmore Canyon (right side). View looking to the east.

which was searching for a Pacific railroad route. In 1904, F. A. Jones published the first detailed description of the Organ Mining District, and in 1906 W. Lindgren and others published a brief description of the geology and ore deposits of the Organ Mountains.

Numerous short articles have been written on the general geology, stratigraphy, minerology, and mines in the Organ Mining District, but the only major work was published by K. C. Dunham in 1935. Dunham's paper covers the geology and mineral deposits of the Organ Mountains and Dona Ana County and contains several large scale maps of the geology and mines for selected small areas.

Dr. William Seager of New Mexico State University is presently mapping the Organ and Organ Peak Quadrangles for the New Mexico Bureau of Mines and Mineral Resources.

PHYSIOGRAPHY

The San Andres, Organ, and Franklin Mountains form a long north-trending mountain chain along the eastern edge of the Rio Grande basin. East of the Organ Mountains is the Tularosa Basin and west of the mountains are the Jornada del Muerto plains and the Mesilla Valley. The area is located in the southern part of the Basin and Range physiographic province known as the Mexican Highland Section (Fenneman, 1931). Maximum elevations in the district are in excess of 8,900 feet (2,713 m), with a surface relief of more than 4,000 feet (1,219 m). The terrain is very rugged and brushy.

The Rio Grande is the only through-flowing river in the county.

All streams draining the western Organ Mountains are intermitt tributary to the Rio Grande. The mountains are dissected by west-trending canyons and long washes with wide sandy bottoms.

The average annual precipitation is 9 inches (23 cm). Most rain falls during violent thunderstorms in July, August, and September, and there is light snowfall in the higher elevations of the mountains during December, January, and February. The average summer temperature is 80° F (27° C) and the average winter temperature is 62° F (17° C). Strong west winds, averaging 25 miles (40 km) per hour, usually occur in the spring (King _et al_, 1969).

Vegetation and animal life are typical of this part of the southwestern United States. Mesquite, scrub oak, pine, juniper, creosote, acacia, agave, sotol, tree yucca, ocotillo, sumac, prickly pear cactus, cholla, barrel cactus, grama and bear grasses are some of the flora in the study area. Common fauna include the rattlesnake, garter snake, racer, horned toad, jack rabbit, cottontail, coyote, fox, badger, skunk, bat, rat, mouse, pocket gopher, squirrel, turtle, deer, and numerous species of birds and lizards.

PURPOSE AND SCOPE

The purpose of this study was to map and interpret the geology and ore deposits of the northwestern Organ Mountains, with special attention being given to fluorspar.

Field work, done during the summers of 1974 and 1975, included geologic mapping on USGS topographic base maps (scale 1:24,000) with the aid of aerial photographs, construction of a detailed underground mine map (scale 1:233) and a surface plane table map (scale 1:1,010) of the Ruby (Hayner) mine area, and collection of rock samples for thin section study.

All rock color descriptions in the text are in accordance with the "GSA Rock Color Chart" (Goddard, chairman, 1948) and all igneous rocks are classified in accordance with "Classification of Rocks" (Travis, 1955).

ACKNOWLEDGEMENTS

I wish to thank Dr. W. N. McAnulty, Sr., chairman of my thesis committee, for his suggestions in the field, help in preparation of this thesis, and obtaining funds for this study. The New Mexico Bureau of Mines and Mineral Resources provided financial support for the field studies. I also wish to thank Dr. Jerry Hoffer for his help with thin section study and Professor H. P. Ehrlinger for information about the beneficiation of fluorspar.

Mr. William Tipton, Las Cruces Bureau of Land Management, helped greatly by supplying historical, claim, geological, and aerial photography information. Mr. Marvin Larson assisted with the surface and underground mapping of the Ruby mine area.

Dr. William Seager, New Mexico State University, furnished information about the area and Dr. David LeMone and Mr. Ron Simpson, University of Texas at El Paso, identified fossils from the Organ Mountains. Mr. Ben Schaberg, Cougar Fluorspar Corporation, furnished

information about the Ruby mine. I am thankful for the property access rights granted by Mr. W. A. Walters, Mr. Whitehall, Mr. David Ligon, and Mr. Robert Isaccks.

Special thanks to my typist, instrument "man", field assistant, draftsman, and critic -- my wife, Georgia.

GEOLOGY

GENERAL STATEMENT

The northern half of the Organ Mountains is composed of gravels and alluvium of Tertiary and Quaternary age, volcanic and intrusive igneous rocks of Tertiary age, and Paleozoic sedimentary rocks. Quartz monzonite of the Organ Mountain Batholith is the dominant rock type exposed. A north-trending andesite dike cuts the Paleozoic sedimentary rocks and parallels the batholith. Rocks flanking the western slopes of the range were faulted and uplifted by the quartz monzonite intrusion.

The southern half of the Organ Mountains may be a caldera of Tertiary age (Fig. 2). Flows, tuffs, and lahars of the Orejon Andesite, Cueva Rhyolite, and Soledad Rhyolite occur in the caldera and dip toward the center of the structure. Seager (1975) believes that Bishop Cap, Tortugas Mountain, and the central Organ Mountains may define the outer edge of the caldera. Fluorspar deposits are present in these areas.

Laramide and Tertiary age geologic structures are present in the study area. Most faults trend north, north-east, or east-west. Economic mineralization appears to be associated with north- to north-east trending faults.

STRATIGRAPHY

More than 4,170 feet (1,170 m) of sedimentary strata are exposed in the northwestern Organ Mountains. Lithologies of the Paleozoic strata include limestones, dolomites, sandstones, claystones, and shales. No Mesozoic sedimentary rocks are exposed.

Cambrian, Ordovician-Silurian, Devonian, and Mississippian rocks crop out only in the Stevenson-Bennett mine area (Fig. 6). As each exposure is small, altered, and faulted, the identification is based on gross lithologic similarities with known formations in the San Andres Mountains, Bishop Cap Hills, and the Franklin Mountains.

The volcanic sequence (Tertiary) includes more than 6,000 feet (1,829 m) of flows, tuffs, and lahars of andesitic and rhyolitic composition.

The stratigraphic sequence in the Organ Mountains is shown in Table 1.

CAMBRIAN STRATA

Bliss Formation

The oldest sedimentary rocks exposed in the Organ Mountains make up the Bliss Formation. As reported by Kottlowski et al (1952), the Bliss increases in thickness southward from the northern San Andres Mountains (8 feet (2 m) maximum) to the Franklin Mountains (240 feet (73 m) maximum). If the increase in thickness is consistant, as it appears to be, the

SYSTEM		FORMATION	THICKNESS FEET	THICKNESS METERS	CHARACTER OF ROCKS
Quaternary			0 to 200+	0 to 61+	Fan deposits, major valley fill units, and colluvium. Silt, sand, gravel, and boulders.
Tertiary	Pliocene				
	Miocene				Andesite dike, Organ Mtn. Batholith, quartz latite-quartz feldspar porphyry dikes and sills, granite, intrusive rhyolite.
	Oligocene				
	Eocene	Soledad Rhyolite	2500+	762+	Rhyolite tuff and lava flows.
		Cueva Rhyolite	950	290	Rhyolite tuff to boulder rhyolite tuff.
		Orejon Andesite	2600	792	Andesite-latite boulder conglomerates and breccias, tuffaceous mudstones and andesite-latite flows.
	Paleocene				
Cretaceous		Love Ranch Formation	0 to 50	0 to 15	Cobble and boulder conglomerates.
Jurassic					
Triassic					
Permian		Hueco Formation	3300	1006	Limestones, sandstones, shales, and claystones underlain by red claystone.
Pennsylvanian					
Mississippian		Lake Valley Formation	140	43	Massive blue limestone, a few interbedded crinoidal limestone units.
Devonian		Percha Shale	160	49	Gray to black thin shales.
Silurian		Fusselman? Montoya? El Paso?	500	152	Medium- to coarse- crystalline undifferentiated dolomite-dolomitic ls.
Ordovician					
Cambrian		Bliss Formation	20	6	Arkosic sandstone and quartzite.

Table 1: Composite stratigraphic section, northwestern Organ Mountains.

thickness of the formation in the northern Organ Mountains is approximately 150 feet (46 m). Two small outcrops near the Stevenson-Bennett mine (Fig. 6) are the only exposures in the study area, and each is less than 20 feet (6 m) thick. Faulting, minor post-Cambrian erosion, and alluvial covering of the outcrops probably account for the small thickness seen in the area.

The Bliss Formation probably was deposited on a nearly peneplained Precambrian surface, however, in the Stevenson-Bennett area the contact is not exposed. Rock in the outcrops is pale orange (10 YR 8/2) to light brown (5 YR 6/4) quartzite and arkosic sandstone which weathers moderate brown (5 YR 4/4). Clasts of subrounded, 0.5 to 3.5 mm, quartz and feldspar are embedded in a fine-grained quartz matrix. Minor amounts of hematite, glauconite, calcite, and biotite are randomly scattered throughout the rock. The rocks are non-fossiliferous.

ORDOVICIAN-SILURIAN STRATA

A thin sequence of Ordovician-Silurian dolomitic rock crops out in the Stevenson-Bennett mine area (Fig. 6). The total average thickness of the Ordovician-Silurian formations in the San Andres, Organ, and Franklin Mountain chains is in excess of 1,000 feet (305 m), but in the study area, only 400 to 500 feet (122 to 152 m) is exposed. The outcrop is bounded by high angle faults. The lower fault contact is with the Bliss Formation and Organ Mountain Batholith, and the upper fault contact is with Percha Shale. The exact age of the dolomites is problematic because there are no fossils present and both upper and lower contacts are faults.

Members of the El Paso and Montoya Groups (Ordovician) and Fusselman (Silurian) probably are present. Identification was made on the basis of gross lithologic similarities with formations of known age in the San Andres and Franklin Mountains.

The rock ranges from a medium- to coarse-crystalline dolomite and is dark gray (N3) to light gray (N7). It weathers light gray (N7) to brownish-gray (5 YR 4/1) and has a sugary texture in many outcrops. Its topographic expression is usually a slope.

The sequence is extensively mineralized, particularly in or near faults and shear zones. All of the lead-zinc-silver ore bodies of the Stevenson-Bennett mine are located in Ordovician-Silurian dolomites.

DEVONIAN STRATA

The single exposure of Devonian strata in the study area is in the Stevenson-Bennett mine area (Fig. 6). About 160 feet (49 m) of Percha Shale are exposed, but there may be some repetition of beds because of faulting.

The medium gray (N5) to black (N1) shale is thinly laminated. Individual beds seldom exceed 8 inches (20 cm). Weathering of the unit produces gentle, covered slopes. No fossils are present.

Almost no mineralization occurs in the Percha Shale except along a few faults and fractures. The formation may have blocked rising hydrothermal solutions, thus increasing the amount of mineralization in the underlying dolomites.

The Devonian strata are disconformably overlain by the Mississippian strata.

MISSISSIPPIAN STRATA

Lake Valley Formation

The Lake Valley Formation is represented by 140 feet (43 m) of thick-bedded, medium- to coarse-crystalline limestone. The only outcrop in the study area, near the Stevenson-Bennett mine, forms a gentle slope covered with colluvium. The limestone ranges in color from dark gray (N3) to greenish-gray (5 GY 6/1) and weathers light gray (N7).

Fossils are scarce except in a few thin-bedded crinoidal limestone units. The rock is usually moderately altered and the outcrop is truncated on one end by a silicified limestone breccia and fault zone. The formation is easily distinguished from other formations in the area because of its alteration and lack of fossils; its exact age cannot be determined. Identification was based on gross lithologic similarities with Lake Valley Formations in the Bishop Cap Hills. The Hueco Formation rests in fault contact on Mississippian strata.

PERMIAN STRATA

Hueco Formation

The Hueco Formation consists of approximately 3,300 feet (1,006 m) of interbedded limestones, silty limestones, sandstones, shales, and claystones. Dunham (1935) mapped the Hueco outcrops as Magdalena (Pennsylvanian); Kottlowski (1956) assigned them to the Hueco Formation.

Fossils, identified by LeMone (1975), indicate that the upper two-thirds of the sequence is Upper Wolfcamp.

In the southern half of the study area, the lower one-third of the formation is baked and altered and lacks fossils. In the northern half of the study area, the entire sequence is altered and contains no fossils. The lower units may be Pennsylvanian, but similarities in lithology with other Hueco strata in Dona Ana County suggest a Permian age. The lower contact of the section is with the Organ Mountain Batholith and/or Mississippian strata (fault contact). The Hueco Formation is unconformably overlain by the Love Ranch Formation and the Orejon Andesite.

Limestone beds making up the greater part of the sequence seldom exceed 10 feet (3 m) in thickness. The rocks vary greatly in character throughout the Hueco Formation, ranging from coarse- to fine-grained. Colors range from white (N9) to grayish-blue (5 PB 5/2) to grayish-black (N2). Chert is abundant and occurs in nodules and beds. Fossils collected in the southwest 1/4 of section 36, T. 22 S., R. 3 E., include the following:

Blue-green algae
Lophophyllid coral
Derbyia - brachiopod
Reticulariina - brachiopod
Squamaria moorei Muir-Wood & Cooper - gastropod
Bellerophon - gastropod
Knightites - gastropod
Omphalotrochus obtusispira (Shumard) - gastropod
Naticopsis - gastropod
Meekospira - gastropod
Nautiloid cephalopod
Echinoid remains

Thin-bedded claystones occur in the upper portion of the Hueco Formation and may represent interfingering of the Abo Group. The thickness of the Abo sequence is usually less than 4 feet (1 m) and it is composed of unfossiliferous claystones that range in color from dark reddish-brown (10 R 3/4) to white (N9). Baking of some of the beds leaves the Abo as a bleached, dense, hornfels type rock.

Six principal mines and numerous pits, trenches, and shafts are located in the Hueco Formation. Economic mineralization includes ore minerals of lead, zinc, silver, copper, and fluorine.

TERTIARY SYSTEM

Love Ranch Formation

Conglomerate along the western front of the Organ Mountains was first described by Dunham (1935) as a basal conglomerate overlying the Paleozoic sedimentary rocks. Kottlowski et al. (1956) described and tenatively correlated the formation with Love Ranch deposits in the San Andres Mountains.

An angular unconformity of approximately 20° separates the Love Ranch Formation from the underlying Hueco Formation. Kottlowski et al. (1956) consider the deposit to be early Tertiary in age; Seager et al. (1971) believe the deposit is an orogenic deposit that resulted from erosion of Laramide structures. The conglomerate ranges in thickness from 0 to 50 feet (0 to 15 m).

The conglomerate consists of about 50 percent cobbles and boulders, both angular and rounded, derived mostly from the underlying Hueco Formation. The matrix is white (N9) to medium gray (N5) calcareous sandstone and siltstone.

The Love Ranch Formation is unconformably overlain by the Orejon Andesite.

Orejon Andesite

The type locality for the Orejon Andesite is at the Orejon mine in the mouth of Fillmore Canyon (Dunham, 1935). The Palm Park Formation in northern Dona Ana County probably is time equivalent to the Orejon Andesite (Seager, 1975), and an andesite sequence similar to the Palm Park has been K-Ar dated at 43 m.y. (Kottlowski et al., 1969). Both the Love Ranch Formation and the Hueco Formation are disconformably overlain by the Orejon Andesite.

The type section of the Orejon Andesite consists of approximately 2,600 feet (792 m) of andesite-latite boulder conglomerates and breccias, tuffaceous mudstones, and andesite-latite flows which range in thickness from a few inches up to 75 feet (23 m). A laharic origin is suggested by the lithology of many of the deposits. The basal unit of the volcanics, at a few outcrops, is a distinctive white tuff and, although the formation was mapped as a separate unit by Dunham (1935), I consider it to be part of the Orejon sequence. Fragments of schist, gneiss, quartzite, and granite are present in the lower part of the unit.

The conglomerates and breccias contain boulders up to 6 feet (2 m) in diameter and are characteristically poorly sorted. The matrix consists of grains of plagioclase, quartz, vitric ash, and rock fragments less than 1 mm in size. Thin-bedded mudstones and flows have about the same composition as the conglomerate and breccia matrix, but are well sorted. Colors

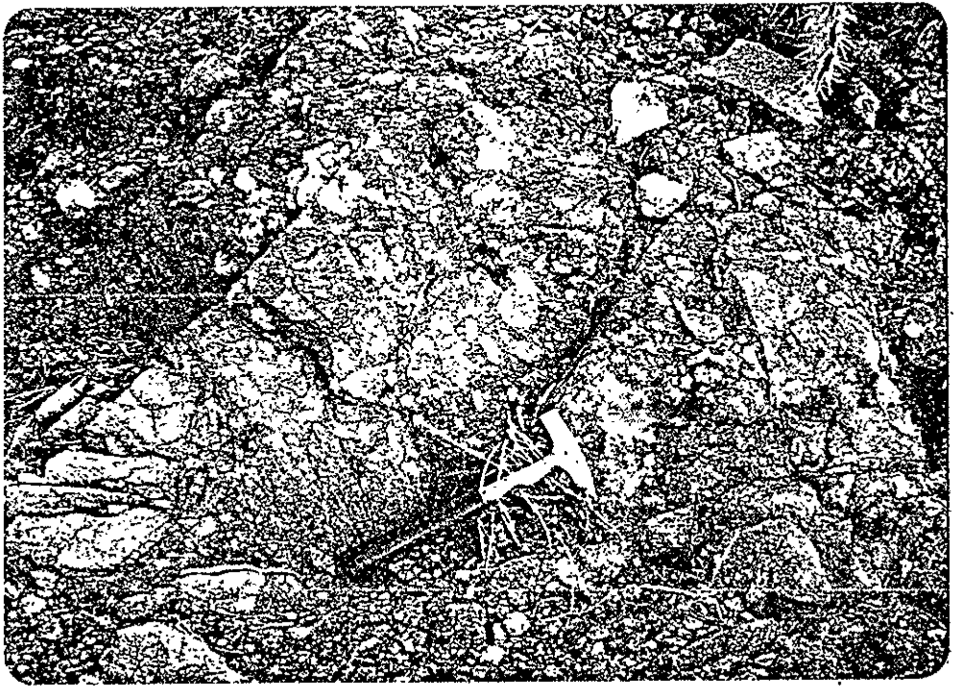


Plate V. Orejon Andesite, andesite-latite boulder breccia unit.

range from white (N9) to grayish-brown (5 YR 3/2) to very dark red (5 R 2/6).

A representative thin section (Slide 76) of one of the laharic units indicates that the rock is holocrystalline, porphyritic, and intensely altered. The essential minerals are andesine (An_{30}) and hornblende and accessory minerals include K-feldspar, sphene, and quartz. Phenocrysts are subhedral to euhedral and flow banding is common. The rock is a porphyritic hornblende andesite.

Alteration is intense in every sample studied. Alteration products identified include kaolinite, epidote, calcite, sericite, chlorite, magnetite, and iron oxides. Kaolinite and sericite are the most common plagioclase alteration products, however,near the Modoc mine, epidote cores are common in large phenocrysts of plagioclase.

Seager et al.(1971), in their study of similar andesites in the San Diego Mountain area, state:

> The percentage of altered fragments in the tuff breccia, the commonly altered matrix material, and the local matrix intrusions into clasts, suggests that much of the tuff breccia was erupted hot, plastic, and susceptible to hot water alteration.

Cueva Rhyolite

The type locality for the Cueva Rhyolite is in the southwestern 1/4 of section 1, T. 23 S., R. 3 E., near the mouth of Fillmore Canyon. It is named for an Indian dwelling (La Cueva) at the base of a weathered out, 250 foot (76 m) thick rhyolite tuff unit of the Cueva sequence. Seager (1975) believes that the Cueva Rhyolite is the time equivalent of the lower part of the Bell Top Formation (Oligocene) in the Sierra de las Uvas, Dona Ana County, New Mexico. Radiometric K-Ar dates of 34 m.y. and 35 m.y. have been established for the Tuff 5 member of the Bell Top Formation (Seager et al., 1973).

The Cueva Rhyolite disconformably overlies the Orejon Andesite. It is approximately 950 feet (290 m) thick at the type locality. A representative sample of the rhyolite has a cryptocrystalline groundmass with bands of pale brown glass. The fresh surface color is white (N9) to light brownish-gray (5 YR 6/1). Near the base of the sequence, the groundmass has a grayish-purple (5 P 4/2) tint. Large boulders of rhyolite up to 2 feet (61 cm) in diameter occur in the upper part of the formation.

In thin section, the rock is hypocrystalline and the essential minerals are K-feldspar, plagioclase, quartz, and brown glass. Lithic fragments and pumice are common in some units. Alteration products include sericite, calcite, kaolinite, and iron oxides. Dunham (1935) reported that spherulites occur in Cueva Rhyolite southeast of the study area.

The rock ranges from rhyolite tuff to boulder rhyolite tuff.

Small quantites of one of the white rhyolite units were quarried for use as building stone, however, the deposit is probably not large enough for a sizeable commercial operation.

Soledad Rhyolite

The Soledad Rhyolite forms the surface over most of the southern Organ Mountains, but the major portion of its outcrop is outside the study area. The sequence has an aerial exposure of more than 35 square miles (91 sq km). Dunham (1935) reported that it was composed of more than 2,500 feet (762 m) of rhyolite tuff and lava flows. The upper part of the Bell Top Formation (Oligocene) in the Sierra de las Uvas, Dona Ana County, probably is time equivalent to the Soledad Rhyolite (Seager, 1975).

The Soledad Rhyolite lies conformably on the Cueva Rhyolite, but the two formations are easily distinguished because of color differences; the Cueva Rhyolite is mostly white and the Soledad Rhyolite usually has a purplish tint. Individual units in the sequence range from 50 feet (15 m) up to possibly 500 feet (152 m) in thickness.

Representative samples of the rhyolite flows and tuffs range in color from light gray (N7) to grayish-red purple (5 RP 4/2). The rock is hypocrystalline and the groundmass is coarse and has a spongy texture. Common minerals present are quartz, K-feldspar, biotite, and plagioclase. Cristobalite, compressed pumice, vitric ash, and other rock fragments are also locally abundant. Alteration is less intense in the Soledad Rhyolite than in the Orejon Andesite. Common feldspar alteration products are kaolinite and sericite.

The rock is rhyolite to rhyolite porphyry.

TERTIARY AND QUATERNARY SYSTEMS

Alluvium and Colluvium

Pediment gravels, alluvial fans, and slope colluvium along the western front of the Organ Mountains make up the principal late Tertiary and Quaternary age sedimentary deposits.

Pediment gravels on the Organ Mountain Batholith are common north of the town of Organ. The deposits are unconsolidated and grains range in size from 2 to 10 mm. Thickness of the units ranges from 0 to 200+ feet (0 to 61+ m).

Alluvial fans occur at the mouths of most intermittent streams where they run out of the mountains and onto the lowland. They are composed of sand, pebbles, and boulders that are rounded and show strong weathering effects. Thickness ranges from 0 to 75 feet (0 to 23 m) and several of the larger fans cover an area of more than 1 square mile (3 sq km).

Slope colluvium occurs on many outcrops. The deposits range in thickness from 0 to 10 feet (0 to 3 m) and consist of unconsolidated sand to gravel size rock fragments.

INTRUSIVE IGNEOUS ROCKS

Andesite Dike

The oldest intrusive rocks exposed in the study area crop out southeast of the Ruby mine in sections 25 and 36, T. 22 S., R. 3 E. The dike (Ta) is approximately 7,000 feet (2 km) in length and up to 400+ feet (122 m) thick. The southern end of the dike is cut off by the Modoc fault and the northern end is covered by alluvium. The western contact with the Hueco Formation dips steeply to the west and the eastern contact with the Hueco Formation and quartz monzonite batholith dips steeply to the east. Geologic relationships in the area indicate that the emplacement of the dike predates volcano-tectonic collapse structures (Oligocene).

A representative sample of the andesite, taken east of the Ruby mine, is porphyritic and is composed of andesine, hornblende, quartz, K-feldspar, and alteration products. The fresh surface color is greenish-gray (5 GY 4/1) and the weathered surface color ranges from moderate yellowish-brown (10 YR 5/4) to dusky brown (5 YR 2/2).

In thin section (Slides E and 129) the major constituents are andesine, quartz, and hornblende: minor constituents are K-feldspar, pyrite, magnetite, and chalcopyrite (?). Alteration products include epidote, chlorite, magnetite, calcite, sericite, kaolinite, and iron oxides. The rock is holocrystalline and porphyritic and crystals range from anhedral to subhedral.

Andesine (An_{36-49}), occuring as phenocrysts and groundmass, makes up 70 to 85 percent of the rock. Phenocrysts range in size from 0.2 mm to 4.0 mm and groundmass grains average less than 0.1 mm in size. Alteration to kaolinite, sericite, and calcite is moderate to intense.

Quartz, as anhedral to subhedral phenocrysts and groundmass crystals, makes up 1 to 10 percent of the rock. The average size of the grains is 0.3 mm and many show undulatory extinction. Corrosion on the edges of large phenocrysts is common.

Hornblende makes up 1 to 15 percent of the rock and usually occurs as subhedral to euhedral phenocrysts. Crystal sizes range from 0.5 mm to 3.0 mm. Its alteration to magnetite, chlorite, and iron oxides is moderate to intense. Skeletons of magnetite are common in large phenocrysts.

Pyrite and chalcopyrite (?) occur as fine disseminations and tiny veinlets throughout the dike. Fluorite, calcite, and quartz are abundant along a fault that cuts the dike in the Ruby mine area.

The rock ranges from porphyritic andesite to hornblende andesite porphyry.

Organ Mountain Batholith

The Organ Needles, San Augustin Peak, Rabbit Ears, Baylor Peak, and Sugar Loaf Peak, the highest and most impressive group of peaks in the Organ Mountains, are developed on a large silicic intrusion of batholithic proportions. The batholith outcrop trends northeast, has an aerial exposure of approximately 60 square miles (155 sq km), and has a vertical exposure of more than 1,500 feet (457 m). The intrusion cuts the Paleozoic sedimentary rocks, the Orejon Andesite, and the andesite dike. Many blocks of both the andesite dike and the Orejon sequence, some up to 20 feet (6 m) in diameter, occur as xenoliths in the batholith. The intrusive contact is usually distinct and easily recognized in the field. The Organ Mountain Batholith has been radiometrically dated at 27 m.y. (Kottlowski _et al._, 1969).

Dunham (1935) classified the Organ Mountain Batholith as a multiple quartz monzonite intrusion. According to Dunham, Phase 1 of the intrusion is exposed along the eastern front of the Organ Mountains, but it does not crop out in the study area. Phase 2 constitutes the bulk of the batholith and Phase 3 crops out in the Organ Mining District.

Examination of Dunham's Phase 2 and Phase 3 intrusions showed that Phase 3 generally contained a higher percentage of biotite and is more intensely altered than Phase 2. Neither biotite percentage nor alteration intensity can be used to indicate phase changes as such lateral and vertical variations are common in large silicic intrusions. In this thesis, due to lack of mineralogical and field evidence in support of Dunham's classification, the Organ Mountain Batholith is considered as a single intrusion. Multiple silicic intrusions of Tertiary age are, however, common in the southwestern United States and it is possible that the batholith is a multiple intrusion. Future studies of the area should resolve the problem.

Fresh specimens of the batholith rock are commonly light gray (N7) to grayish-orange pink (5 YR 7/2); weathered surfaces are grayish-orange (10 YR 7/4) to pale brown (5 YR 5/2). The texture is equigranular with crystals up to 15 mm in length. Exfoliation is well-developed locally.

In thin section (Slides 10, 10a, 120, and 130) the major constituents are plagioclase, K-feldspar, and quartz. Minor constituents are biotite, amphibole, and sphene. Alteration products include magnetite, kaolinite, sericite, calcite, epidote, and iron oxides. The rock is holocrystalline and crystals are euhedral to anhedral.

Plagioclase makes up an average of 30 percent of the rock. Anhedral to subhedral grains average 1.5 mm in size and their compositions range from oligoclase (An_{19}) to andesine (An_{40}). Moderate to intense alteration to kaolinite, sericite, calcite, and epidote usually gives the crystals a clouded appearance.

Anhedral laths of K-feldspar range in size from 1 to 5 mm and perthites are common. The crystals make up 20 to 46 percent of the rock and are usually altered to kaolinite.

Quartz, occurring as anhedral grains and blebs in the matrix, makes up an average of 30 percent of the rock. Average grain size is 1.0 mm x 0.5 mm.

Reddish-brown biotite crystals constitute between 0.5 and 8 percent of the rock. They range in size from 0.5 mm to 1.5 mm and are slightly to moderately altered to iron oxides and chlorite. Small percentages of a highly altered, unidentified amphibole occur in some specimens.

The rock is a quartz monzonite to biotite quartz monzonite.

Mineralization in the Organ Mountain Batholith consists mainly of copper and silver minerals deposited in a fault breccia at the Torpedo mine. Contact metamorphic and contact metasomatic effects in rocks adjacent to the batholith consist mainly of baking, silicification, epidotization, garnetization, and marbleization.

Intrusive Quartz Latite - Quartz Feldspar Porphyries

Several silicic dikes and sills (Tds on Plate I) intrude the sedimentary and igneous rocks along the western front of the Organ Mountains. All of the dikes and sills appear to be similar in composition and texture, however, in the northern portion of the study area, intense sericitization has destroyed much of the original texture and primary mineral assemblage. Rock in the southern half of the study area has been classified as quartz latite porphyry, and rock in the northern half of the area has been classified as quartz feldspar porphyry. Emplacement of the dikes and sills may have occurred when fissures and shattering of the partly congealed batholith permitted a portion of the still fluid interior to escape.

Quartz Latite Porphyry

Two dikes and one sill of quartz latite porphyry crop out in the southern half of the study area. Moderate to weak alteration is present in most specimens.

A large dike along the Modoc fault in the eastern 1/2 of section 1, T. 23 S., R. 3 E., is more than 100 feet (30 m) thick and at least 2,300 feet (701 m) in length. The dike cuts the Hueco Formation, Orejon Andesite, and Soledad Rhyolite. If the dike is related to the Organ Mountain Batholith, then the batholith is younger than the Soledad Rhyolite (a questionable radiometric date on the Soledad Rhyolite indicated that the batholith was probably older than the Soledad). The fresh surface color is brownish-gray (5 YR 4/1).

In thin section (Slide 88), the rock consists of 50 percent andesine (An_{40}), 26 percent K-feldspar, and 18 percent quartz. Minor constituents are biotite, zircon, and magnetite. Alteration products include magnetite, calcite, sericite, and kaolinite. The rock is a quartz latite porphyry.

A small dike which cuts the Hueco Formation and the andesite dike in the southeastern 1/4 of section 25, T. 22 S., R. 3 E. is approximately 3,200 feet (975 m) long and 15 feet (5 m) thick. The fresh surface color of this dike rock is light olive gray (5 Y 6/1). In thin section (Slide 37) the major constituents are 45 percent plagioclase, 33 percent K-feldspar, and 15 percent quartz. Minor constituents are biotite, zircon, and magnetite. Alteration products include magnetite, kaolinite, calcite, and sericite. Appreciable pyrite is present in the dike rock and along the contact with the Hueco Formation. The rock is quartz latite porphyry.

A sill exposed in the southern half of the study area, in the southeast 1/4 of section 36, T. 22 S., R. 3 E., is 6 feet (2 m) thick and approximately 1,400 feet (427 m) long in the outcrop. The fresh surface color of the sill rock is yellowish-gray (5 Y 7/2). In thin section (Slide 53a) the major constituents are 57 percent albite (An_{12}), 28 percent K-feldspar, and 10 percent quartz. The rock is a quartz latite porphyry.

Quartz Feldspar Porphyry

At least three dikes and three sills are exposed in the northern half of the study area. Most of the dikes and sills are associated with ore mineralization in the Organ Mining District and may be a useful guide in exploration. Although alteration is very intense in every exposure, the texture and occurrences of the rock suggest a possible genetic relationship with unaltered dikes and sills of quartz latite porphyry in the southern half of the study area. The fresh surface color is white (N9) to pale yellowish-orange (10 YR 8/6) to dusky red (5 R 3/4). Thin section examination reveals that sericite, quartz, and iron oxides constitue 95 percent of the rock in some outcrops. Faint relic skeletons of feldspars and mafic minerals are present in some specimens. The rock is classified as quartz feldspar porphyry, but a better name for it may be quartz sericite hornfels.

Granite

In the eastern 1/2 of section 11, T. 22 S., R. 3 E., small bodies of granite (Tg on Plate I) intrude a block of the Organ Mountain Batholith which is bounded by two major faults of the Torpedo-Bennett fault zone. The age relationship between the granite and faulting is not known. Dunham (1935) mapped the fault block of quartz monzonite and granite as Precambrian granite. After careful field examination and thin section study, I believe the rocks are granite and quartz monzonite of Tertiary age and not Precambrian granite. Limited outcrops and faulting make an accurate evaluation difficult; future studies of large granitic bodies in the southern San Andres Mountains may help resolve the problem.

A representative sample of the granite east of the Stevenson-Bennett mine is medium-grained (1 to 2 mm) and equigranular. Xenoliths of the quartz monzonite batholith included in the granite can be seen at several outcrops. The fresh surface color is moderate brown (5 YR 3/4).

In thin section (Slide Pc), the essential minerals are K-feldspar, plagioclase, quartz, and biotite. Alteration products include magnetite, kaolinite, calcite, and iron oxides. The rock is holocrystalline and grains are anhedral to subhedral.

K-feldspar makes up 55 percent of the rock and occurs as anhedral to subhedral grains. Average crystal size is 1 mm and alteration to kaolinite is moderate to intense. Perthitic intergrowths are common.

Quartz constitutes 20 percent of the rock and occurs as 0.5 mm anhedral grains. The crystals show undulatory extinction and tourmaline needle inclusions are common in some specimens.

Anhedral biotite crystals have an average size of 0.4 mm and constitute 11 percent of the rock. Alteration to magnetite and chlorite is intense and many crystals have highly corroded edges.

Subhedral laths of platioclase make up 10 percent of the rock. Average size is 1 mm and alteration to kaolinite and calcite is moderate.

The rock is a biotite granite.

Intrusive Rhyolite

The youngest intrusive rocks in the study area are exposed in a dike one mile (2 km) north of the Memphis mine in the northern 1/2 of section 36, T. 21 S., R. 3 E. The outcrop of the dike is at least 2,500 feet (762 m) in length and approximately 5 feet (2 m) thick. Only a small portion of the dike is exposed in the study area. Its southern tip crosscuts the quartz feldspar porphyry feeder dike of the Homestake mine sill. According to Dunham (1935) there were at least three periods of rhyolite injection and numerous examples of each are exposed in the southern San Andres Mountains. Due to the mineralization, intense alteration, and crosscutting relationships, Dunham (1935) believed that "They represent the last residue of volatile-poor magma from deep down in the batholith".

A representative sample of the rhyolite from the northern part of the study area is fine-grained and consists of quartz and a minor amount of K-feldspar. The fresh surface color is very light gray (N8); the weathered surface color is yellowish-gray (5 Y 7/2).

In thin section, the major constituents are quartz and K-feldspar;

minor constituents are pyrite and an unidentified mafic mineral. Alteration products include kaolinite, sericite, calcite, and iron oxides. The rock is holocrystalline and crystals are anhedral. Small crosscutting veinlets of quartz occur locally.

The rock is a rhyolite.

STRUCTURAL GEOLOGY

General Statement

The Organ Mountains form the eastern margin of the Rio Grande depression in Dona Ana County, New Mexico. The Paleozoic and Mesozoic Eras, except during late Cretaceous or early Tertiary, were dominated by epeirogeny. During late Cretaceous and Tertiary times, orogenic activity dominated. Laramide (late Cretaceous - early Tertiary), volcano-tectonic (middle Tertiary), and Basin and Range (Miocene) structures are visible in the study area.

The core of the mountain range is an igneous intrusion of Tertiary age. Faulted and tilted igneous and sedimentary rocks of the Paleozoic and Cenezoic ages flank the western slope of the Organ Mountains. Mineralization and alteration appear to be associated with north- to northeast-trending faults.

Tilting and Folding

An angular unconformity of approximately 20° separates the Love

Ranch Formation and Orejon Andesite from the underlying Hueco Formation. The unconformity indicates that there was a slight southwestward tilting of the Permian strata prior to early Tertiary volcanism. Seager (1971) states that "The bouldery talus and fan deposits of the Love Ranch Formation most probably represent the erosional products of the deformation and thus constitute evidence that the deformation is late Cretaceous to Eocene in age (Laramide)". The small plunging anticline and syncline in the southwestern 1/4 of section 36, T. 22 S., R. 3 E., probably are Laramide structures in as much as they are partially cut off by the Love Ranch - Hueco unconformity.

Drag folds are associated with the thrust fault and a few of the major north-trending high-angle faults. Small folds with less than 6 inch (15 cm) wavelengths occur in shales southwest of the Ruby mine and probably are the result of compressional stresses during tilting of the Hueco Formation.

Volcano-Tectonic Structure

The Orejon Andesite, Cueva Rhyolite, and Soledad Rhyolite volcanic sequence probably was erupted between 43 m.y. and 34 m.y. ago. The flows and tuffs were deposited in the southern Organ Mountains area, but the source vents have not been located. Ejection of possibly 40 cubic miles (164 cu km) of igneous material and the resulting removal of support at depth caused subsidence of collapse of the volcanic sequence into the magma chamber. The structure appears to be elongate northwest 10 to 20 miles (16 to 32 km) in diameter. Formation of the caldera probably occurred during middle to late Oligocene time.

Seager (1975) believes that Bishop Cap, Tortugas Mountain, and the central Organ Mountains may define the outer edge of the caldera (Fig. 2). Fault and topographic trends in each of the areas appear to conform with the idea.

FAULTING

Faulting in the study area can be grouped into three major catagories: (1) faults related to the caldera, (2) faults related to intrusion of the Organ Mountain Batholith, and (3) Basin and Range faults of the Torpedo-Bennett zone. Evidence of Laramide faulting is lacking, however, it is possible that some faults in the area originated during the Laramide Orogeny and were reactivated in middle to late Tertiary time.

Most of the faulting in the northwestern Organ Mountains probably occurred during Oligocene and Miocene (?) time. All of the faults probably are high-angle and normal, with the exception of one thrust fault in the southern portion of the study area. The great number of normal faults probably indicated tensional release or vertical compression in the area. Stratigraphic displacement of the rocks could be determined at only a few places. Economic mineralization appears to be associated with north- to northeast-trending faults.

Caldera Related Faults

Small faults exposed in sections 1 and 11, T. 23 S., R. 3 E., and

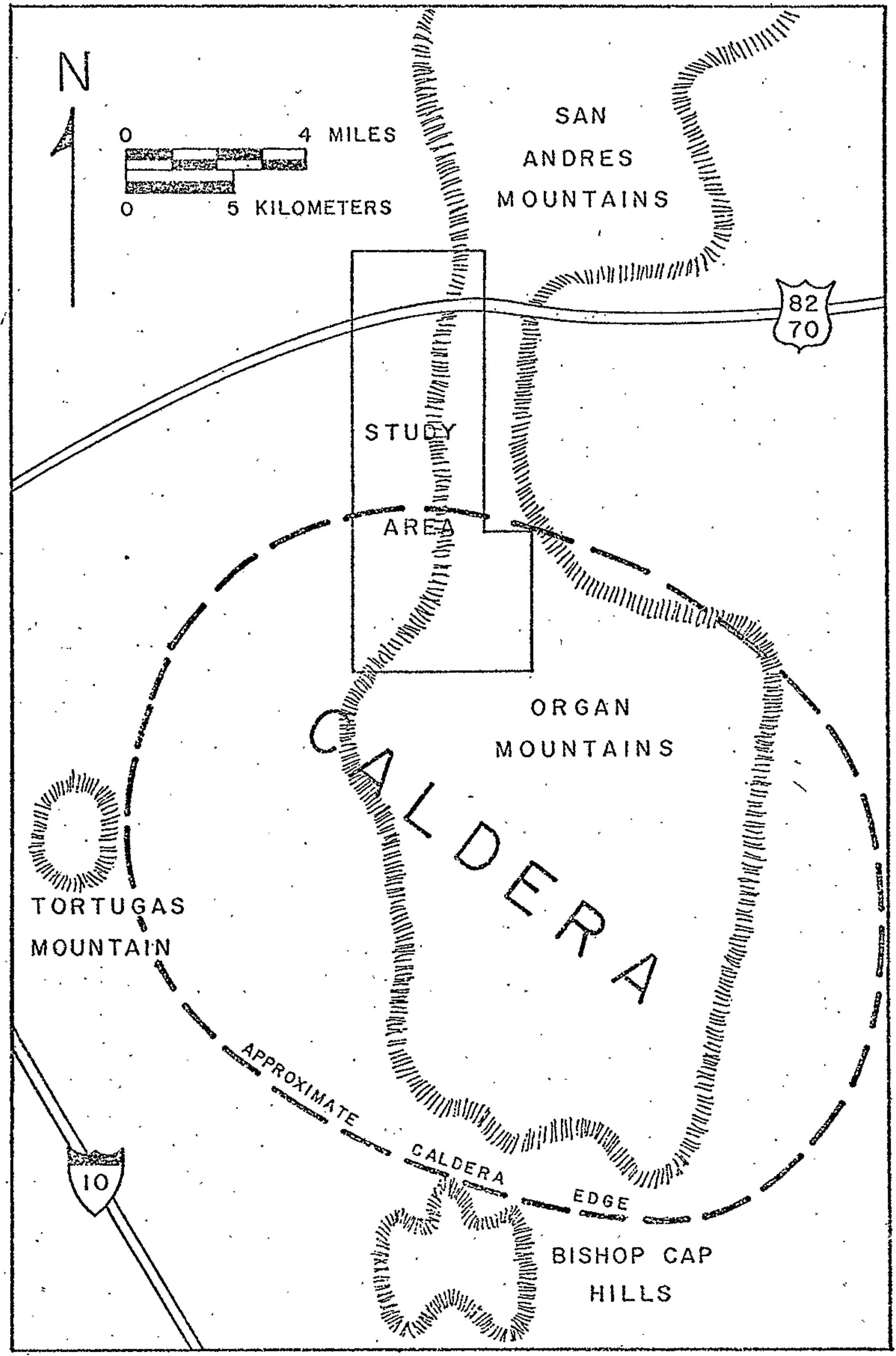


Figure 2: Location Map showing southern Organ Mountain caldera.

the Modoc fault appear to be related to formation of the southern Organ Mountain Caldera during late Oligocene time. All of them appear to be normal, strike N. 5° E. to N. 20° E., and dip steeply to the east.

The most prominent fault in the southern half of the study area is the Modoc fault, so named by the writer because of its good exposure and related mineralization at the Modoc mine. It strikes N. 10° E., dips approximately 80° E., and has a stratigraphic displacement of approximately 2,500 feet (762 m). The exposed strike length of the fault in the study area is nearly 3 miles (5 km) and it appears to continue southward beyond the study area. Brecciation and gouge are common locally and a large dike (Tds) is present along the fault in the eastern 1/2 of section 1, T. 23 S., R. 3 E.

Apparently the Modoc fault served as a channel for solutions which mineralized the adjacent Hueco Formation (Permian). Pyrometasomatic minerals in the wall rock on the footwall side of the fault (Hueco) include andradite, epidote, magnetite, calcite, quartz, specularite, sphalerite, chalcopyrite, pyrite, and galena.

Batholith Intrusion Related Faults

After collapse of the caldera, the Organ Mountain Batholith intruded into the area. Emplacement was probably gradual, since only minor faulting and brecciation occurred near the intrusive contact. Several faults in the area appear to have been caused by intrusion of the batholith or caldera related faults reactivated by intrusion of the batholith. Most of the faults have strikes that are normal to the intrusive contact, dividing the Paleozoic sedimentary rocks and Cenezoic volcanic rocks into a series of large blocks.

The faults strike N. 50° E. to east-west, but direction and amount of dip could not usually be determined. Stratigraphic displacement of the rocks ranges from 10 feet (3 m) to over 200 feet (61 m). Mineralization along faults, related to intrusion of the batholith, consists of minor garnet, epidote, and quartz.

A small thrust fault cuts the Hueco Formation in the eastern 1/2 of section 36, T. 22 S., R. 3 E. The fault dips approximately 10° east; the stratigraphic displacement of the rocks is not known. Drag folding is common along the fault.

Torpedo-Bennett Fault Zone

The most extensive faulting in the northwestern Organ Mountains occurs between the Torpedo and Stevenson-Bennett mines. Faulting occurred after emplacement of the batholith and may be related to Basin and Range tectonics (Miocene). The major fault appears to continue northward into the southern San Andres Mountains (Dunham, 1935); southward, the large faults split into numerous smaller faults. Faulting in the Ruby mine area may be the southern continuation of the zone.

The Torpedo-Bennett fault system is mappable along strike in the study area for 5 miles (8 km) and reaches a maximum width of over 2,000 feet (610 m). Faults in the zone strike from N. 20° W. to N. 20° E. and dip from 70° W. to 55° E. At least two stages of recurrent movement occurred within the zone, but stratigraphic displacement of the rocks could no be determined.

Normal faults in the Ruby mine area (Plate II) strike N. 20° E. and dip 50° to 75° E. Fluorspar, calcite, and quartz were deposited as void fillings in at least six major veins and dozens of fracture zones, all within the Hueco Formation (Permian) and andesite dike (Tertiary). Slickensides indicate oblique slip, however, stratigraphic displacement of the rocks could not be determined. Minor amounts of breccia occur in the larger veins.

The most extensive faulting in the Torpedo-Bennett zone is in the Stevenson-Bennett mine area (Fig. 6). Five major faults, trending N. 10° E. and dipping 80° W to 80° E., cut sedimentary rocks of Cambrian, Ordovician-Silurian, Devonian, Mississippian, and Permian age and the Organ Mountain Batholith. Numerous small faults and fracture zones are located between the major faults. All faults appear to be normal.

Distinctive zones of silicified and brecciated limestone (jasperoid) crop out along the westernmost and easternmost faults between the Torpedo and Stevenson-Bennett mines. Replacement deposits of galena, argentiferous galena, and sphalerite occur in the Ordovician-Silurian dolomites and are closely related to the fault and fracture zones.

In the vicinity of the Torpedo mine, two faults form a 100 foot (30 m) wide breccia zone between the Hueco Formation (Permian) and the Organ Mountain Batholith (Fig. 9). The faults strike N. 15° E. and dip 55° to 80° E. and are probably normal. The breccia is composed of quartz monzonite and minor amounts of limestone. Gouge along both faults ranges from 4 to 12 feet (1 to 4 m) in thickness. Copper mineralization in the breccia zone consists of replacements and veinlets of chalcopyrite.

HISTORICAL GEOLOGY

The probable sequence of geologic events in the study area appears to be as follows:

1. Marine sediments were deposited intermittently in the area from Cambrian through Permian time. A complete sedimentary record for each time period is not present in the study area. Deposition was not continuous, as hiatuses are known to exist between Mississippian and Devonian strata and probably during Ordovician and Silurian times.

2. Mesozoic strata may have been deposited in the Organ Mountain area, but, if so, subsequent erosion removed all evidence of such deposits.

3, Sedimentary strata were tilted and folded during late Cretaceous or early Tertiary time (Laramide Orogeny).

4. Erosion of Laramide structures resulted in the deposition of the Love Ranch Formation on an angular unconformity of approximately 20°. Deposition of the Love Ranch conglomerate was followed by minor erosion.

5. Intrusion of the andesite dike (Ta) occurred east of the Ruby mine.

6. A thick sequence of the Orejon Andesite was extruded and deposited in Eocene time in the southern Organ Mountains. Minor erosion of the sequence occurred after its deposition.

7. The Cueva Rhyolite and Soledad Rhyolite extruded and were deposited unconformably on the Orejon Andesite during Oligocene time. Location of the vents has not been determined.

8. Development of the southern Organ Mountain Caldera probably began in late Oligocene time. Collapse of the structure caused the formation of the Modoc fault.

9. Emplacement of the Organ Mountain Batholith occurred during late Oligocene time and caused faulting and tilting of the Paleozoic sedimentary rocks and Cenezoic volcanic rocks.

10. Emplacement of the batholith was accompanied by metamorphism and metasomatism in adjacent sedimentary rocks. Late in the metasomatic stage, high and intermediate temperature deposits of galena, sphalerite, chalcopyrite, and fluorite were formed in the Modoc and Memphis mine areas.

11. Fissures and shattering of the partly consolidated or congealed outer shell of the batholith permitted quartz latite magma from the still fluid interior to intrude adjacent formations as dikes and sills.

12. Granitic rock (Tg) intruded into the batholith east of the Stevenson-Bennett mine.

13. During late Oligocene or early Miocene time, the Torpedo-Bennett fault zone formed. The faulting is probably related to Basin and Range structures and formation of the Rio Grande Rift.

14. Silicification and recurrent movement along faults resulted in the formation of breccia and shear zones.

15. Hydrothermal fluids brought up copper, lead, zinc, silver, and fluorine and ore minerals of those elements were deposited in country rock along and adjacent to fault zones. Minor recurrent movement along some faults occurred after the ore mineralization.

16. Quaternary and late Tertiary age erosion cycles formed the existing topography.

ECONOMIC GEOLOGY

GENERAL STATEMENT

The northwestern Organ Mountain area has been an important producer of copper, silver, lead, zinc, and fluorspar in the past. The ore deposits are localized in Paleozoic sedimentary rocks and the Organ Mountain Batholith. Movement of the ore-bearing fluids probably was controlled by fault and fracture systems. The deposits are the result of both void filling and replacement in and adjacent to fault and shear zones.

There are no operating mines within the study area at present. Small reserves of ore are known to exist in the Torpedo, Memphis, and Stevenson-Bennett mine areas. Preliminary exploration for fluorspar has been done at the Ruby mine. Geologic relationships in the vicinity of the town of Organ are suggestive of porphyry copper mineralization and some exploratory drilling has been done by several companies. Extensive additional exploration will be required to evaluate the mineral potential of the Organ Mountain area.

HISTORY OF MINING AND EXPLORATION IN THE AREA

Most of the mines in the Organ Mountain area are located along the northwestern corner of the range in the Organ Mining District. Since the late 1840's, at least 207 unpatented and 35 patented mining claims have been filed in that area (Figures 3 and 4). The total value of reported mineral production from the area exceeds $2,500,000. The history of

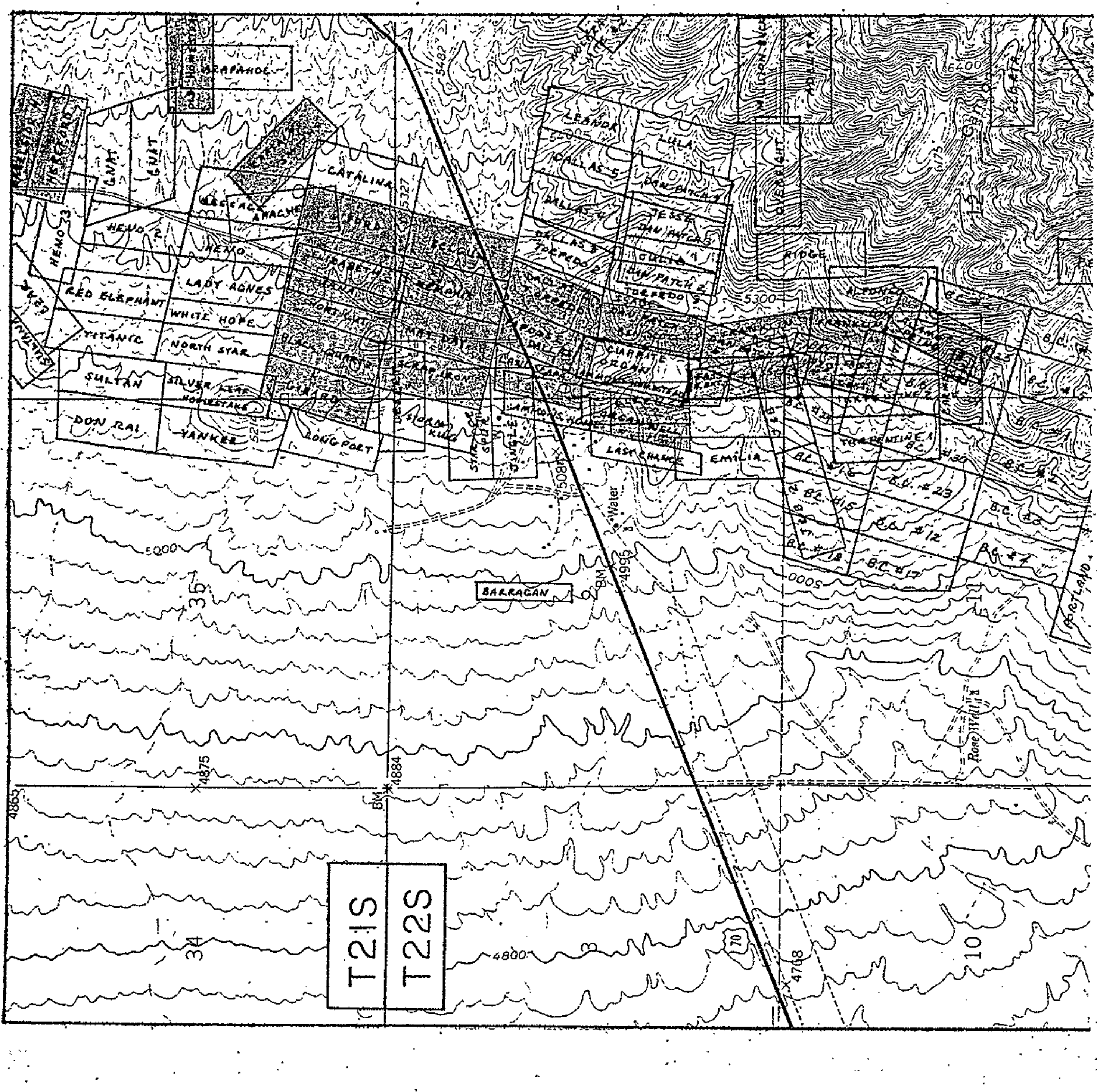
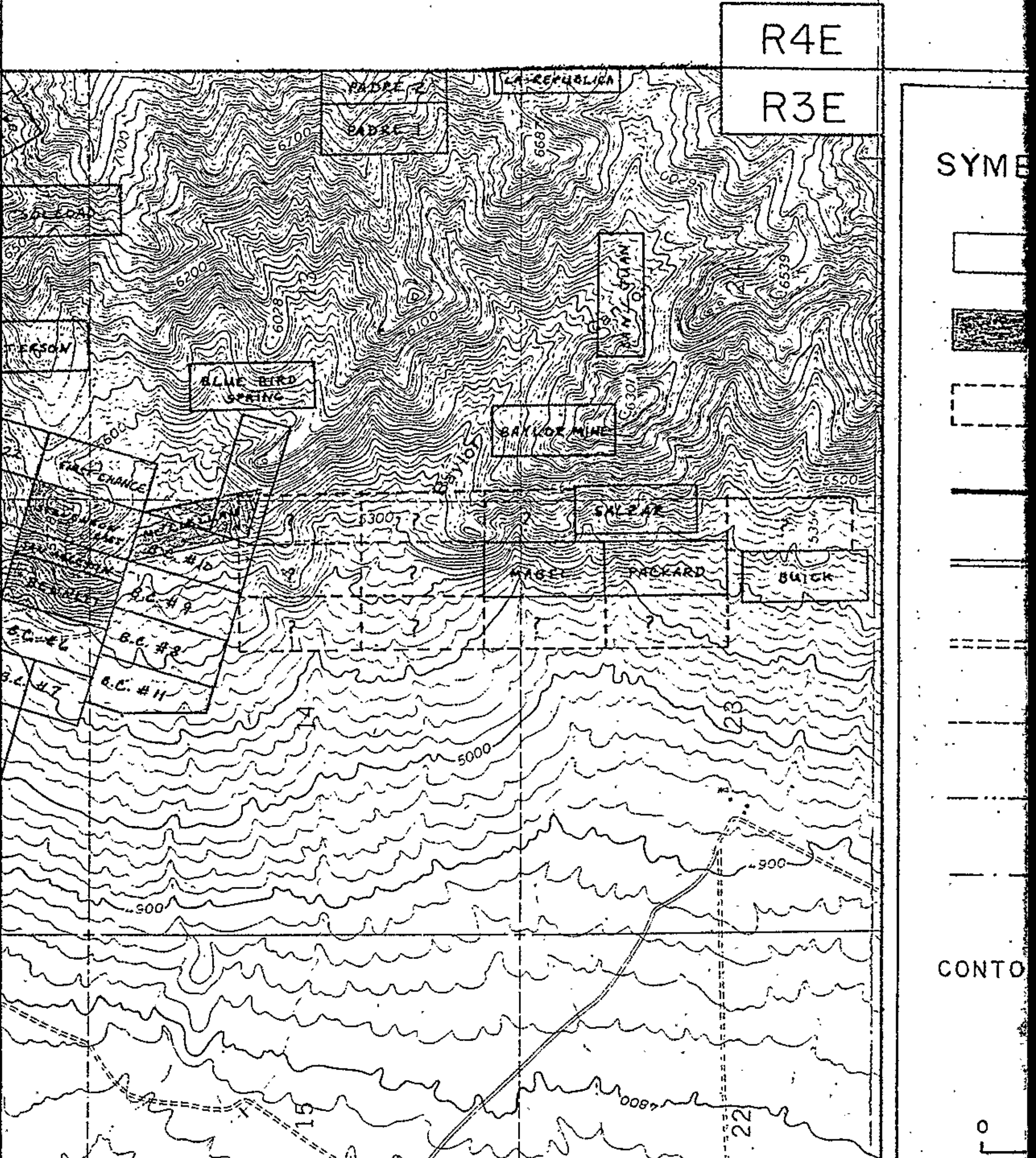


Figure 3: Claim map of the northern half of the study area.


R4E
R3E
PADRE 2
PADRE 1
LA REPUBLICA
SOLEDAD
TERSON
BLUE BIRD SPRING
SAN JUAN
BAYLOR MINE
FIRST CHANCE
B.C. #10
B.C. #9
B.C. #8
B.C. #11
B.C. #7
B.C. #6
SALZAR
MABEL
PACKARD
BUICK
7100
6700
6200
6028
6100
6689
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6539
6301
5600
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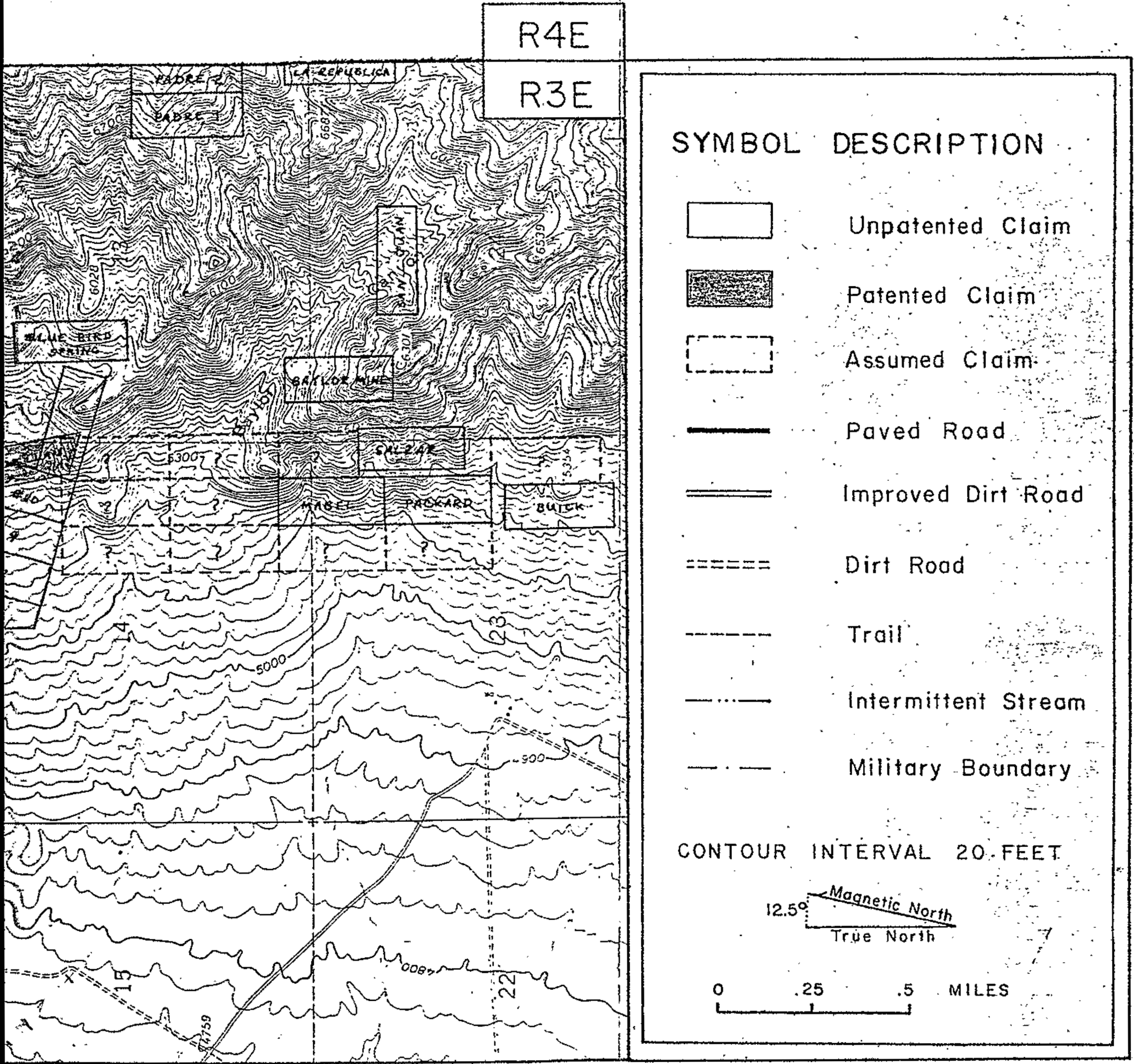
R4E
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PADRE 2
PADRE 1
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6700
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6028
6100
SAN JUAN
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BLUE BIRD SPRING
BAYLOR MINE
SALZAR
5300
5334
MABEL
PACKARD
BUICK
14
23
5000
4900
4800
15
22
4759
SYMBOL DESCRIPTION
Unpatented Claim
Patented Claim
Assumed Claim
Paved Road
Improved Dirt Road
Dirt Road
Trail
Intermittent Stream
Military Boundary
CONTOUR INTERVAL 20 FEET
12.5°
Magnetic North
True North
0
.25
.5
MILES

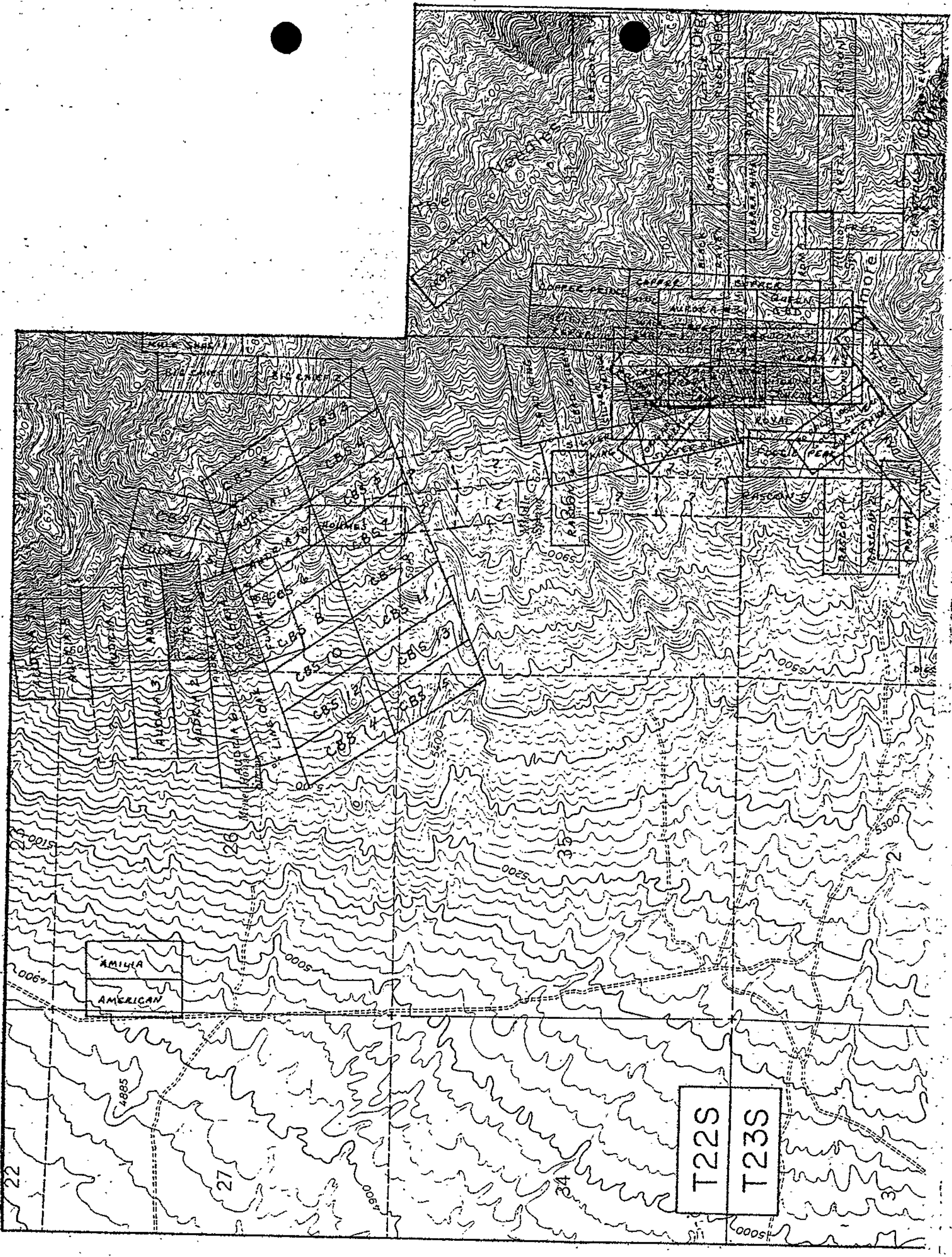
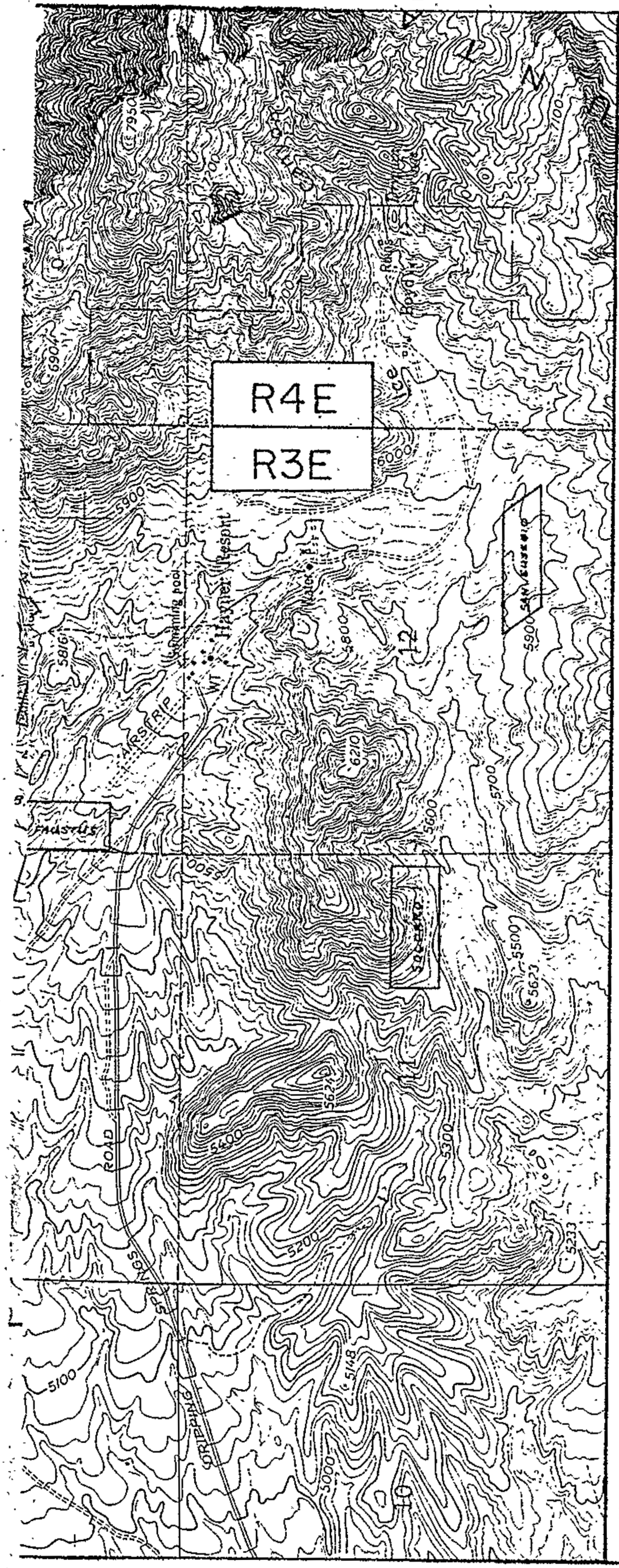
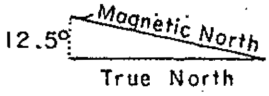


Fig 4: Claim Map of the southern half of the study area.



SYMBOL	DESCRIPTION
☐	Unpatented Claim
▨	Patented Claim
⬚	Assumed Claim
━━━	Paved Road
═══	Improved Dirt Road
=====	Dirt Road
------	Trail
—··—	Intermittent Stream
—·—	Military Boundary

CONTOUR INTERVAL 20 FEET



mining in Dona Ana County from the early 1880's until 1935 was summarized by Dunham (1935).

The Stevenson ore body (Stevenson-Bennett mine) was discovered by Mexicans in 1847 and Hugh Stevenson's development of the deposit started the first major mining in the Organ Mountains. Although argentiferous galena was the principal ore mineral, the lead was discarded and only silver was recovered for marketing. Mining and smelting methods were very crude, but an estimated $150,000 worth of silver was produced from the Stevenson deposit between 1849 and 1882. In 1854, the Modoc deposit was discovered by a man named Barilla and claims were located in 1879. An estimated $200,000 worth of lead was produced from the Modoc mine between 1854 and 1905 (Howard, 1967). High transportation costs and constant Indian trouble limited production in the Organ Mountain area until a railroad was built through the county in 1881.

Between the years 1882 and 1900, exploration, development and mining flourished and several metal mines were discovered during that time. The Memphis deposits were discovered prior to 1882 and were worked intermittently until 1929. A total copper-zinc-silver production of $200,000 was reported from the Memphis by Howard (1967). The Bennett ore body (Stevenson-Bennett mine) was discovered by a man named Carerra in 1884 and the mine soon became a major producer of lead as well as silver. Carerra produced approximately $250,000 worth of lead and silver before his lease was taken over by the Stevenson-Bennett Consolidated Mining Company in 1888; estimated production between 1890 and 1917 was $750,000 worth of lead and silver. The Torpedo mine claims were located in 1896, however, the major ore deposit was not discovered until 1899 by Henry Foy. The Torpedo mine operated almost continuously from 1899 to

1907, but subsequent production until 1949 was small and sporadic. Production from the mine until 1921 is estimated to have had a value of as much as $800,000.

There was no activity in the area between 1909 and 1914 except for minor production from the Homestake property ($25,000 worth of lead, silver, and gold). In 1914, the area became active again, mainly at the Stevenson-Bennett mine. The Ruby fluorspar deposit was discovered in 1926 by Frank Hayner and 400 tons of ore were produced in 1933. The Orejon and Philadelphia deposits were discovered and worked in the early 1900's. Most mining in the Organ Mountain area had ceased by 1934.

Ownership and leases of properties changed hands dozens of times. Major companies that worked in the area include: Phelps Dodge Copper Company, American Smelting and Refining Company, Stevenson-Bennett Consolidated Mining Company, Torpedo Mining Company, and the Organ Ore Company.

Several types of mills and smelters were built on the major properties. In the early operations, ore was hand mined and sorted (using no explosives), hauled out of the mine by Mexican laborers, shipped by burro to the Rio Grande River, and smelted in adobe furnaces. Milling processes were varied and depended to a large extent on the availability of water. The Modoc property had very little water and several types of dry concentrators were tried, without success. Water-jacketed smelters replaced the adobe furnaces, but eventually all of the major operations shipped their concentrates to large custom smelters.

Activity in the Organ Mountain district between 1947 and 1952 consisted of exploration through mine development, surface core drilling, and underground core drilling. Several small deposits were discovered and known ore reserves were extended on a few properties, but no production was reported.

Several companies have conducted limited exploratory drilling programs in the Organ Mountains since 1952. Texaco, Conoco, AMAX Exploration Company, Kerr McGee Corporation, Donegan and Donegan, Phelps Dodge Copper Company, and Bear Creek Exploration are a few of the major companies involved in the exploration. Most of the work has been concentrated in and adjacent to the Torpedo-Bennett fault zone and on pediments north of the town of Organ. Cougar Fluorspar Corporation has completed preliminary exploration work at the Ruby fluorspar property.

The only indicator of future activity in the northwestern Organ Mountains is the increasing number of new and updated claims.

ORIGIN, NATURE, AND MODES OF OCCURRENCE OF MINERALIZATION

Pyrometasomatic and late stage hydrothermal fluids associated with the Organ Mountain Batholith probably produced most of the mineralization in the Organ Mountains. Deposits of fluorspar and copper, lead, lead-silver, and zinc sulfides occur in fissure veins, breccia zones, skarn zones, and replacement bodies. Supergene ore deposits of copper, lead, and zinc minerals occur above many of the sulfide ore bodies and have contributed significantly to the production of the district. Hypogene and supergene ore minerals present in the area include:

galena - PbS
anglesite - $PbSO_4$
cerussite - $PbCO_3$
wulfenite - $PbMoO_4$
smithsonite - $ZnCO_3$
sphalerite - ZnS
fluorite - CaF_2
chalcocite - Cu_2S
cuprite - Cu_2O
native copper - Cu

argentiferous galena - $(Ag,Pb)S$
argentojarosite - $AgFe_3(SO_4)_2(OH)_6$
hemimorphite - $Zn_4(Si_2O_7)(OH)_2 \cdot H_2O$
chalcopyrite - $CuFeS_2$
azurite - $Cu_3(CO_3)_2(OH)_2$
malachite - $Cu_2CO_3(OH)_2$
chrysocolla - $CuSiO_3 \cdot 2H_2O$
brochantite - $Cu_4(OH)_6SO_4$
turquoise - $CuAl_6(PO_4)_4(OH)_8 \cdot 4H_2O$

Movement of the ore-bearing fluids was probably controlled by fault and fracture systems and igneous contacts. Localization of deposits appears to have been influenced and/or controlled by:

1. Wall rock composition.
2. Type and degree of previous metamorphism and metasomatism.
3. Breccia zones formed on large faults.
4. Intersection of faults with igneous structures.
5. Local changes in the dips and strikes of faults.
6. Open fractures on faults.

There were probably two separate stages of sulfide deposition in the Organ Mountain area. The earliest phase is directly related to intrusion of the Organ Mountain Batholith (pyrometasomatic) and the second phase is a result of late stage hydrothermal deposition and replacement. The deposits are distinguished on the basis of ore and gangue mineral associations.

Pyrometasomatic deposits occur at the Memphis, Modoc, and Orejon mines. They formed during or shorly after emplacement of the batholith and are usually close to the intrusive contact. The deposits are skarns which formed at high temperatures with the addition of solutions issuing from the intrusive. The principal gangue minerals include garnet, epidote, vesuvianite, diopside, tremolite, wollastonite, quartz, and calcite. Common sulfides are chalcopyrite, sphalerite, pyrite, and galena and magnetite and specularite are the most common oxides. Tetradymite (Bi_2Te_2S) is locally abundant in the Memphis mine area. The fluorspar and jasperoid mineralization south of the Orejon deposit may also be pyrometasomatic deposits, but their formation temperature was probably lower. Sulfide minerals usually formed after the calc-silicate minerals.

Late stage hydrothermal solutions under conditions of moderate temperatures and pressures (mesothermal) formed ore deposits at the Torpedo, Stevenson-Bennett, Ruby, Philadelphia, and Homestake mines. The batholith had already partly congealed and pockets of residual fluids formed. The fluids may have been released by late Tertiary or Miocene faults (Basin and Range) that cut the batholith. Both void filling and replacement ore bodies occur in the district. The principal gangue minerals include quartz, calcite, and iron oxides. The common sulfides are chalcopyrite, sphalerite, and galena. Jasperoid and fluorspar are locally abundant.

Precious Metals

Gold and silver are present in the copper and lead sulfides in the study area. No native gold or silver has been reported, but both were recovered from the mesothermal chalcopyrite ores in quartz monzonite breccias at the Torpedo mine.

Silver occurs in replacement deposits of argentiferous galena in Permian limestones and Ordovician-Silurian dolomites. Most of the argentiferous galena was produced from the Stevenson-Bennett and Orejon mines. Argentojarosite was produced from oxidized zones in the Homestake and Philadelphia mines.

Base Metals

Hypogene Mineralization

Copper, zinc, and lead sulfides occur in the study area in and adjacent to fault zones as both replacement and void filling deposits. The principal primary ore minerals, chalcopyrite, sphalerite, galena, and argentiferous galena, were deposited under pyrometasomatic and late stage hydrothermal conditions (mesothermal).

Chalcopyrite has not been a major source of copper in the Organ Mountains. Past production from the Torpedo mine (the major copper producer) was largely from the oxidized copper zone; below the 200 foot (61 m) level, chalcopyrite occurs as void fillings and replacements in quartz monzonite breccia. Gouge zones on both sides of the quartz monzonite breccia appear to have confined the primary sulfide deposition; no copper mineralization occurs outside the fault zone in the Torpedo area. Lesser amounts of chalcopyrite occur in the Stevenson-Bennett, Memphis, and Orejon deposits, where it is closely associated with galena-sphalerite replacement bodies in Paleozoic sedimentary rocks.

Sphalerite is fairly widespread, but has been mined only as a by-product of galena production. It occurs in close association with chalcopyrite and galena in the Memphis, Torpedo, Stevenson-Bennett, Modoc, and Orejon mines. The sphalerite is fine-grained to massive, yellowish-brown, and commonly contains exsolution blebs of chalcopyrite.

Galena and argentiferous galena were of major economic importance in the Organ Mountain area. They usually occur as fine-grained to massive replacement deposits in Paleozoic sedimentary rocks, but also as veinlets cutting other sulfides and altered rock material. Galena was important at the Philadelphia and Modoc mines, and argentiferous galena was economically important at the Stevenson-Bennett, Orejon, and Homestake mines. Lesser amounts of galena and argentiferous galena occur in the Memphis and Torpedo mines.

Supergene Mineralization

Most of the copper production and substantial amounts of the lead, zinc, and silver production came from oxidized zones. The depth of oxidation is 200 feet (61 m) in the Memphis mine, 300 feet (91 m) in the Torpedo mine, and 450 feet (137 m) in the Stevenson-Bennett mine. The oxidation level extends below the present day water table in several localities. Sulfide enrichment in the Memphis and Torpedo copper deposits consists of bluish-black chalcocite.

Oxidized copper minerals occurring in the district include: chrysocolla, turquoise, malachite, azurite, cuprite, and native copper. Chrysocolla was the most important source of copper at the Torpedo mine, where it appears to replace alteration products in quartz monzonite breccia.

Small amounts of chrysocolla were reported at the Memphis mine. Native copper, cuprite, brochantite, and turquoise are locally abundant on the Torpedo property and have contributed to past copper production. Significant amounts of malachite and azurite were present at the Memphis mine; smaller amounts were present in the Torpedo mine.

Oxidized lead minerals (anglesite, cerussite, and wulfenite) were important at the Stevenson-Bennett mine, where cerussite occurs as large masses in limestone; wulfenite occurs as clusters of crystals associated with red muds in the Bennett ore body. The cerussite and wulfenite appear to have been deposited at the same time (Dunham, 1935). Anglesite occurs as fine-grained, concentric layers on galena.

Hemimorphite and smithsonite, the major oxidation zone minerals derived from sphalerite, are abundant at the Memphis, Torpedo, and Stevenson-Bennett mines. Hemimorphite occurs as colorless to pale blue crystalline aggregates lining cavities in dolomite and limestone. Smithsonite is present in botryoidal masses. All of the minerals are closely associated with sphalerite, limonite, quartz, and oxidized lead minerals.

Argentojarosite is the only oxidized silver-bearing mineral in the study area. It was locally abundant in the Homestake, Philadelphia, and Memphis (?) mines. It is a yellow-brown sulfate which is closely associated with limonite. Some argentojarosite in the Homestake mine is reported to have assayed at 600 ounces of silver per ton (Dunham, 1935).

Fluorspar

Fluorspar in the northwestern Organ Mountains occurs in fissure eins and fracture zones, along intrusive contacts, in pods and veinlets ssociated with jasperoid, and as minor replacements of Hueco limestone. ost of the fluorspar was deposited by late stage hydrothermal fluids of he Organ Mountain Batholith, however, fluorite and jasperoid south of the rejon mine may be pyrometasomatic deposits. Hydrothermal fluoritization n the study area probably occurred during the last stages of the ineralization sequence. Factors that appear to have controlled deposition re ground preparation (the amount of open space available for deposition) nd character of the host rock.

The largest fluorspar deposit in the study area crops out at the uby mine. Fluorite, calcite, quartz, and minor barite were deposited in six veins and numerous fracture zones that cut the Hueco Formation and ndesite dike (Ta). Veins are lenticular or tabular and fracture zones ave irregular shapes. The sequence of events in vein formation appears o be as follows:

1. Emplacement of the Organ Mountain Batholith caused marbleization and minor garnetization of the Hueco Formation in the Ruby mine area.

2. Late Tertiary or early Miocene age faults (Basin and Range) cut the Hueco Formation and andesite dike and opened major fissures. Fracturing and brecciation occurred in and adjacent to the faults.

3. Mineralization began when late stage hydrothermal fluids from the Organ Mountain Batholith deposited fine-grained quartz along faults and fractures. Well formed radiating quartz crystal aggregates are present in the larger veins.

4. White and purple fluorite were deposited, accompanied by minor replacement of the breccia fragments.

5. Recurrent movement on the faults caused minor fracturing of fluorite and quartz vein material and deposition of fine-grained calcite in the fractures in the fluorite and quartz followed.

6. Large amounts of recurrent movement on the faults caused major brecciation and opening of fissures.

7. Alternate deposition of green fluorite and calcite occurred until the fissure was closed.

It is possible that some of the initial breccia fragments were produced by chemical brecciation and not by recurrent movement on the faults (Sawkins, 1969).

Other occurrences of fluorspar in the study area include the following:

1. Medium- to coarse-grained (1 to 50 mm) fluorite and calcite occur along faults and contacts in Ordovician-Silurian dolomites at the Stevenson-Bennett mine. Fluorspar has been reported only within 50 feet (15 m) of the surface.

2. Fine- to medium-grained (0.01 to 4 mm) fluorite, calcite, and jasperoid occur in the Hueco Formation adjacent to the Modoc fault. The fluorspar occurs in small veinlets and pods and is approximately 200 feet (61 m) south of the Orejon mine in the mouth of Fillmore Canyon.

3. Medium-grained (1 to 2 mm) fluorite, calcite, quartz, and barite occur along a single fracture in the Hueco Formation approximately 1,000 feet (305 m) west of the Modoc mine.

4. Fine- to coarse-grained (0.1 to 20 mm) fluorite and calcite occur in the Hueco Formation adjacent to and on both sides of the andesite dike (Ta) between the Ruby and Modoc mines. The fluorite and calcite occur along fractures ranging in thickness from 0.25 to 4 inches (6 to 102 mm).

Fluorite in the study area occurs as anhedral to euhedral, white, pale green, and purple crystals. Individual crystals range in size from less than 0.1 mm to greater than 50 mm. Calcite, quartz, and barite are commonly associated with the fluorite.

Paragenesis

A paragenetic sequence of mineral deposition was determined by the study of mineralized outcrops and thin sections. Dunham's (1935) work was helpful in determining the paragenetic sequence of a few minerals from the Memphis, Torpedo, and Stevenson-Bennett mines.

Early and late stage solutions from the Organ Mountain Batholith probably effected most of the mineralization of the rocks. Deposits that formed from the early stage solutions are classified as pyrometasomatic or contact metasomatic. The early fluids were at a medium to high temperature and deposition of minerals occurred at a moderate depth (hypothermal). The late stage solutions were at a medium to low temperature and deposition of minerals occurred at a moderate to shallow depth (mesothermal). Both types of hydrothermal solutions probably gained access to the host rocks through previously formed fault and fracture systems.

The genetic and mineralogical relationships between ore deposits in different mines are usually complex and difficult to determine. Spacial zoning of ore deposits in the Torpedo and Stevenson-Bennett mines fits the classic mesothermal copper-silver-lead-zinc-fluorspar pattern. Pyrometasomatic deposits at the Modoc, Orejon, and Memphis mines follow the lead-silver-zinc-chalcopyrite sequence away from the batholith. Ore deposition resulting from the two separate systems may have produced overlap of the different zones in some areas.

Contact metamorphism resulting from emplacement of the Organ Mountain Batholith during Oligocene time resulted in recrystallization of Hueco strata to hornfels, marble, and lime-silicate rocks. Marbleization extends into the Hueco Formation up to 1,000 feet (305 m) in some areas. The initial stage of mineralization (pyrometasomatic) occurred late in the batholith intrusive cycle with iron and silica rich hydrothermal solutions moved up through fault and fracture zones into Paleozoic sedimentary rocks. The fluids reacted with the limestones and formed large skarn replacement deposits of andradite, grossularite, epidote, diopside, wollastonite, vesuvianite, calcite, and quartz. During the metasomatism, large amounts of carbon dioxide, calcium oxide, and magnesium oxide were released from the limestones and solutions carrying these products sericitized and epidotized the intrusive igneous rocks. Skarn rock formation was very intense in the Memphis, Modoc, and Orejon mine areas and extends into the wall rock up to 100 feet (30 m).

Magnetite, specularite, calcite, and quartz were deposited after the skarn rocks. Minor brecciation occurred in many localities, however, chemical reactions involving hydrothermal fluids may have caused the brecciation instead of recurrent fault movement (Sawkins, 1969). The hypothermal sulfide phase started near the end or shortly after deposition of the oxides. Most of the sulfide minerals occur as replacements of limestone (marble) and calcite between calc-silicate grains. Areas of intense garnetization contain only minor amounts of sulfide mineralization. Pyrite was deposited first, followed by sphalerite, chalcopyrite, argentiferous galena, galena, and tetradymite (Bi_2Te_2S). Fluorspar and jasperoid south of the Orejon mine may represent the outermost zone of hypothermal mineralization. Hydrothermal activity appears to have ceased after the batholith congealed partly and it is possible that the quartz latite porphyry dikes and sills intruded into the area during this time.

Faulting in the Torpedo-Bennett zone (Basin and Range) cut and brecciated Cambrian, Ordovician-Silurian, Devonian, Mississippian, and Permian strata and the Organ Mountain Batholith, quartz latite - quartz feldspar porphyry dikes and sills, and the andesite dike. Pockets of residual fluids in the batholith were probably cut and the second stage of mineralization began. The most intense silicification stage in the study area started the mineralization sequence and produced fine-grained and radiating quartz that was deposited as both replacement and void fillings. Widespread silicified limestone breccia (jasperoid) in the Torpedo-Bennett fault zone may have formed during this time. Recurrent movement on faults produced additional brecciation and post-silicification fractures. Sericitization followed and, some time before the end of the sericitization cycle, the mesothermal sulfide stage began.

The first minerals deposited during the mesothermal sulfide stage were sphalerite and chalcopyrite. Polished section studies of ore from the Stevenson-Bennett mine (Dunham, 1935) revealed that the sphalerite was in solid solution with chalcopyrite. Galena and argentiferous galena were deposited afterward and can be seen as veinlets in the sphalerite ores. Minor gold in chalcopyrite possibly was deposited after the galena stage. Minor amounts of quartz were deposited at different times throughout the mesothermal sulfide deposition sequence.

Most of the fluorspar deposits in the study area were deposited near the end of the mesothermal sulfide stage. In the Ruby mine area, an initial quartz stage of deposition was followed by alternate depositions of fluorite and calcite. A complete paragenesis of the Ruby mine vein formation is given in the 'Fluorspar' section of this thesis.

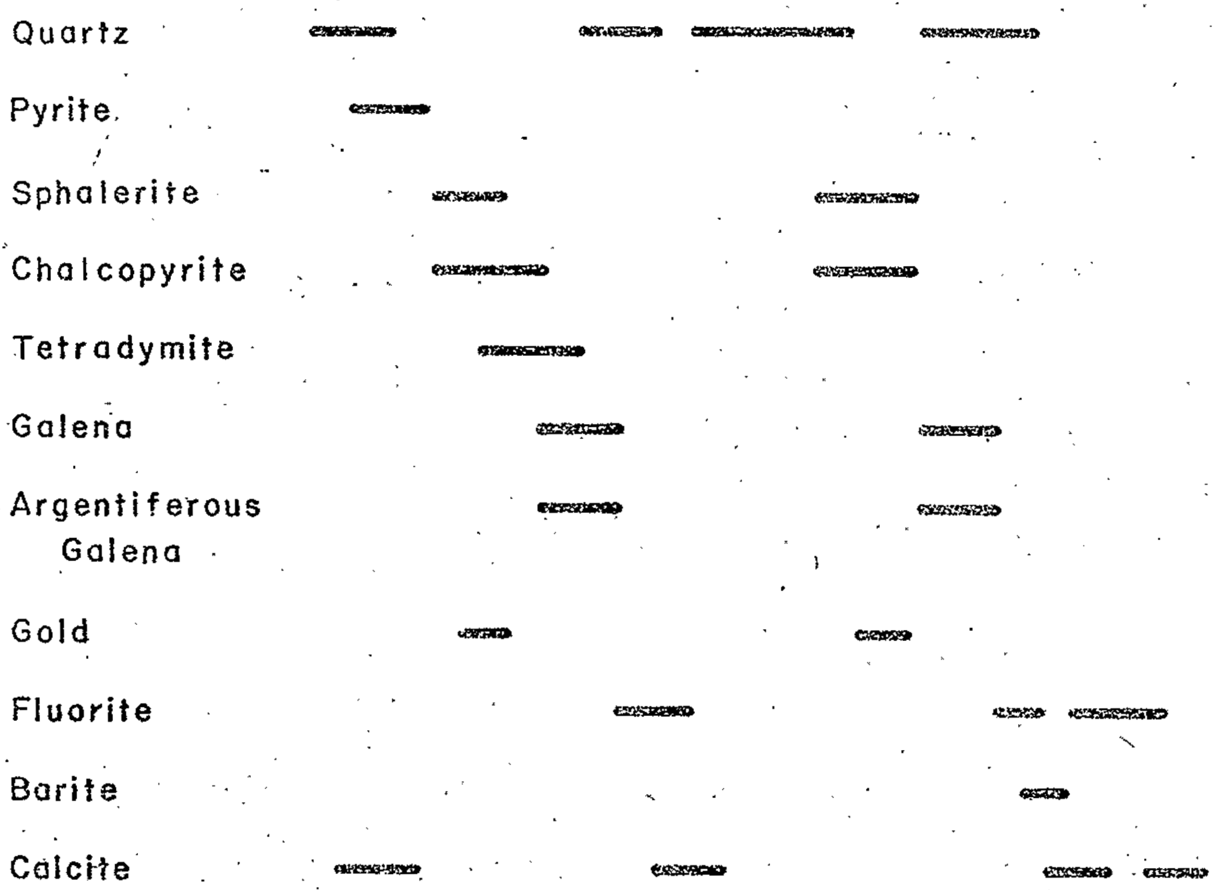


Figure 5: Paragenesis of mineralization in the Northwestern Organ Mountains.

DESCRIPTION OF MINES AND PROSPECTS

Most of the mines in the study area are in very poor condition nd were not entered during this study. Descriptions of individual mines ere published by Dunham (1935). Publications by Soule (1951) and othrock (1946) were helpful in describing the Torpedo and Ruby mines. laim data and other miscellaneous information were furnished by the ureau of Land Management, Las Cruces, New Mexico. The base and precious etal mines are discussed in the order of their past economic significance, tarting with the highest producer.

Base and Precious Metal Mines

Stevenson-Bennett Mine

The Stevenson-Bennett mine is located in the southeast 1/4 of ection 11, T. 22 S., R. 3 E., approximately 1.5 miles (2.4 km) south of he town of Organ and is at an elevation of 5,400 feet (1,646 m)(Plate VI). uring the years 1882 thru 1920, the mine produced an estimated $1,200,000 orth of lead and silver. The property consists of numerous unpatented ining claims and three patented claims: the Stevenson East, San Augustin ode, and Bennett Mine Lode. The patented claims are presently owned by . B. Cox, Las Cruces, New Mexico.

The geology in the Stevenson-Bennett mine area is very complex Fig. 6). High-angle normal faults have cut Cambrian, Ordovician-Silurian, evonian, Mississippian, and Permian strata, and intense brecciation and

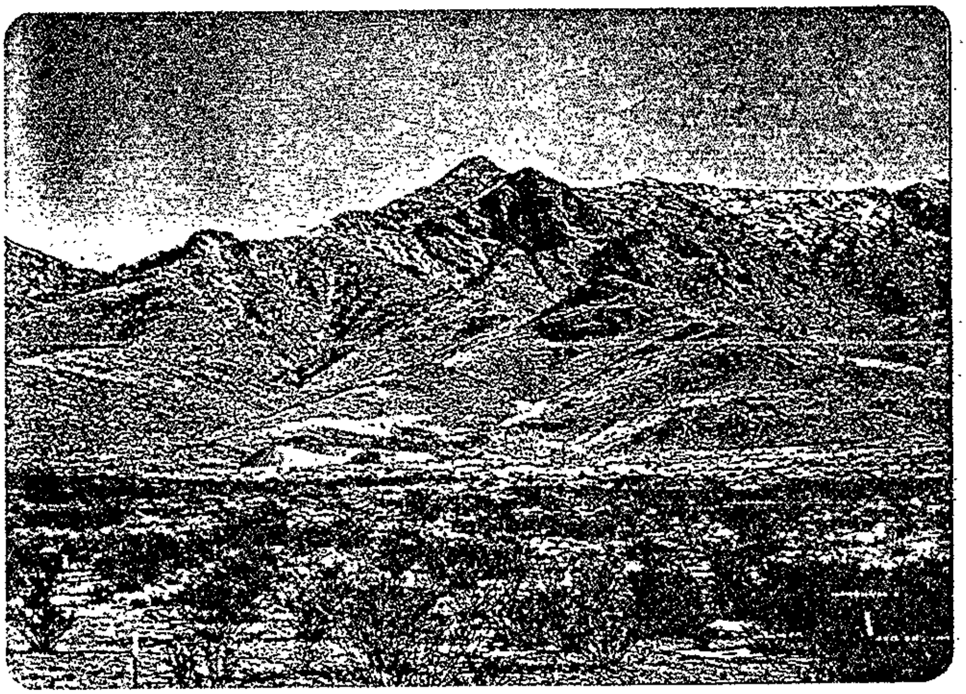


Plate VI: Stevenson-Bennett mine, view looking to the east.

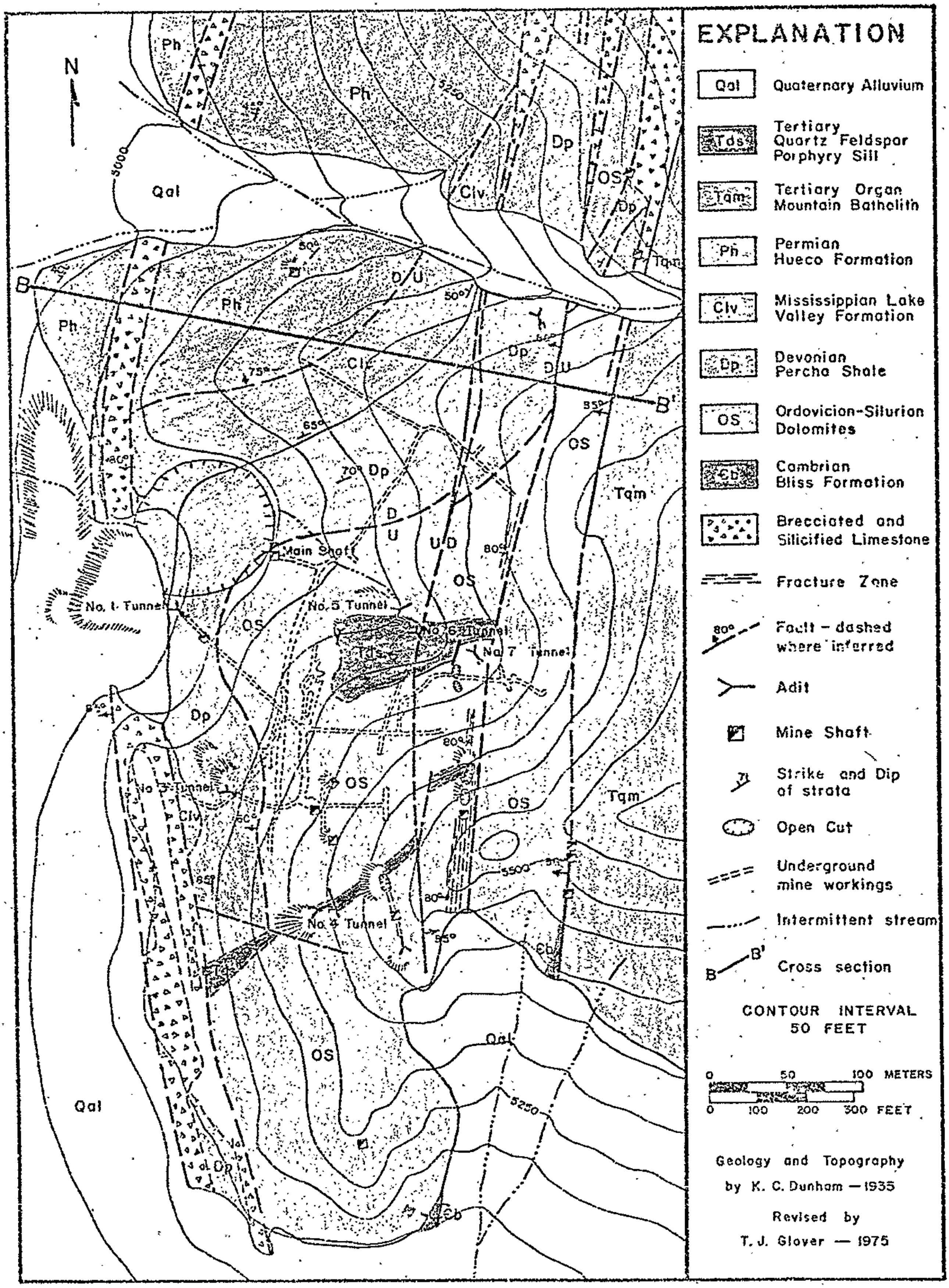


Figure 6: Geologic Map of the Stevenson–Bennett mine area.

silicification have formed jasperoid zones along a few of the faults. The areas of intense silicification may represent conduits through which the late stage silica-rich solutions moved. Ore deposits occur only in dolomites of Orodvician-Silurian age. The overlying shales of Devonian age may have blocked rising ore-bearing solutions and prevented deposition in Mississippian and Permian strata (Fig. 7).

The Stevenson ore body crops out on the surface in a fracture zone that parallels one of the major north-trending faults (Fig. 8). Approximatly 0 feet (15 m) below the surface, the ore follows the lower contact of a quartz feldspar porphyry sill. The ore body consists of quartz, fluorite, cerussite, smithsonite, and argentiferous galena. Oxidized material at the surface reportedly contained 120 ounces of silver per ton.

The Bennett ore body also follows a fracture zone but does not crop out (Fig. 8). The ore deposit is tabular, striking N. 10° E. and dipping 70° W., and reaches a maximum strike length of nearly 500 feet (152 m). The known vertical extent of the ore body is 600 feet (183 m) and thickness of the zone is reported to have been approximately 10 feet (3 m) on the 200-foot (61 m) level. Hypogene ore consisted of galena and sphalerite in a gangue of quartz, pyrite, and silicified dolomite. The Bennett ore body contained much less silver than the Stevenson ore body.

The Page ore deposit is a small replacement in the Ordovician-Silurian dolomites between the Stevenson and Bennett ore bodies (Fig. 8). The ore contained galena, cerussite, smithsonite, quartz, and silicified dolomite.

Ore assays, reported by Dunham (1935) and Antisell (1856), are as follows:

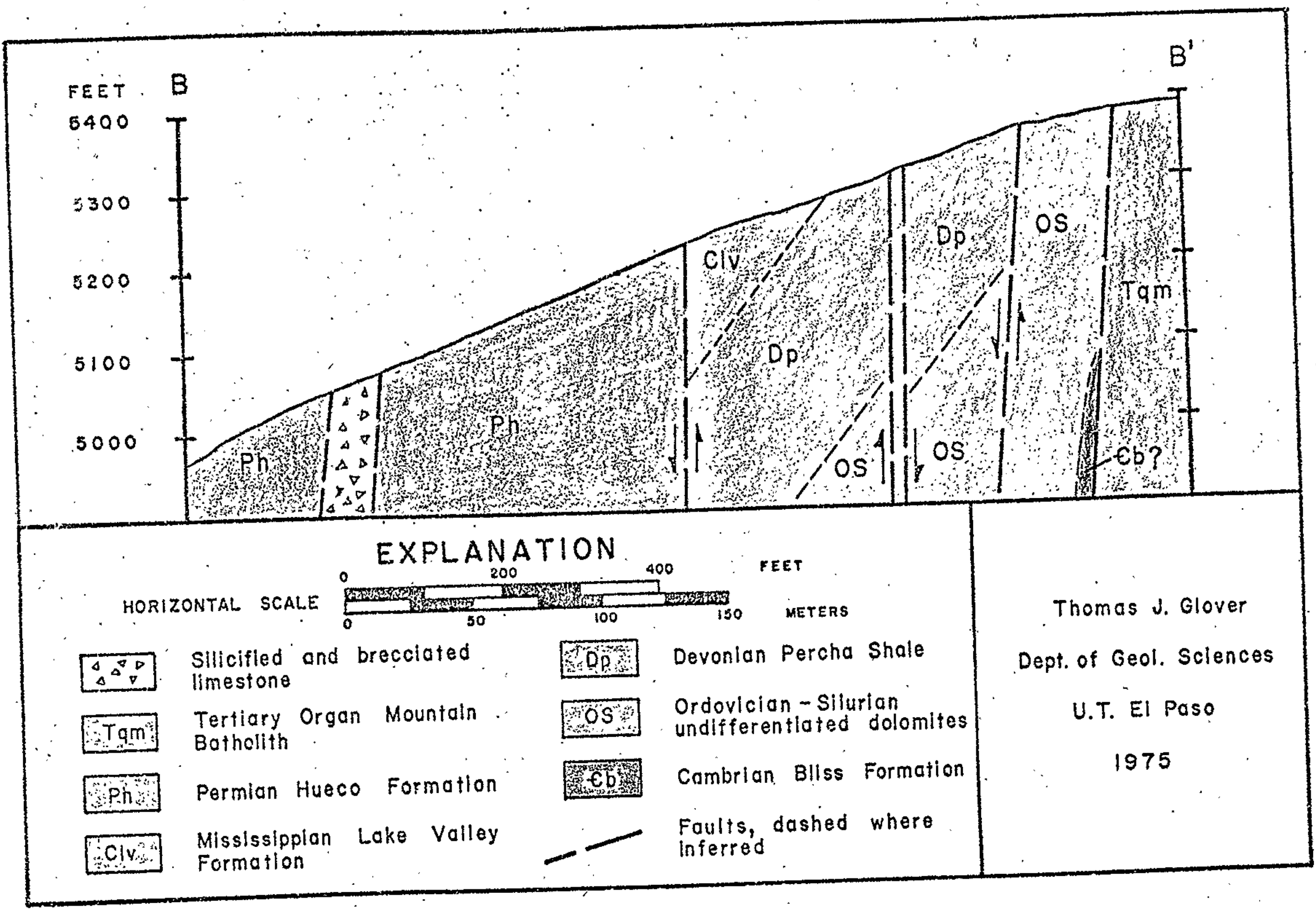


Figure 7: Geologic cross section of the Stevenson-Bennett mine area.

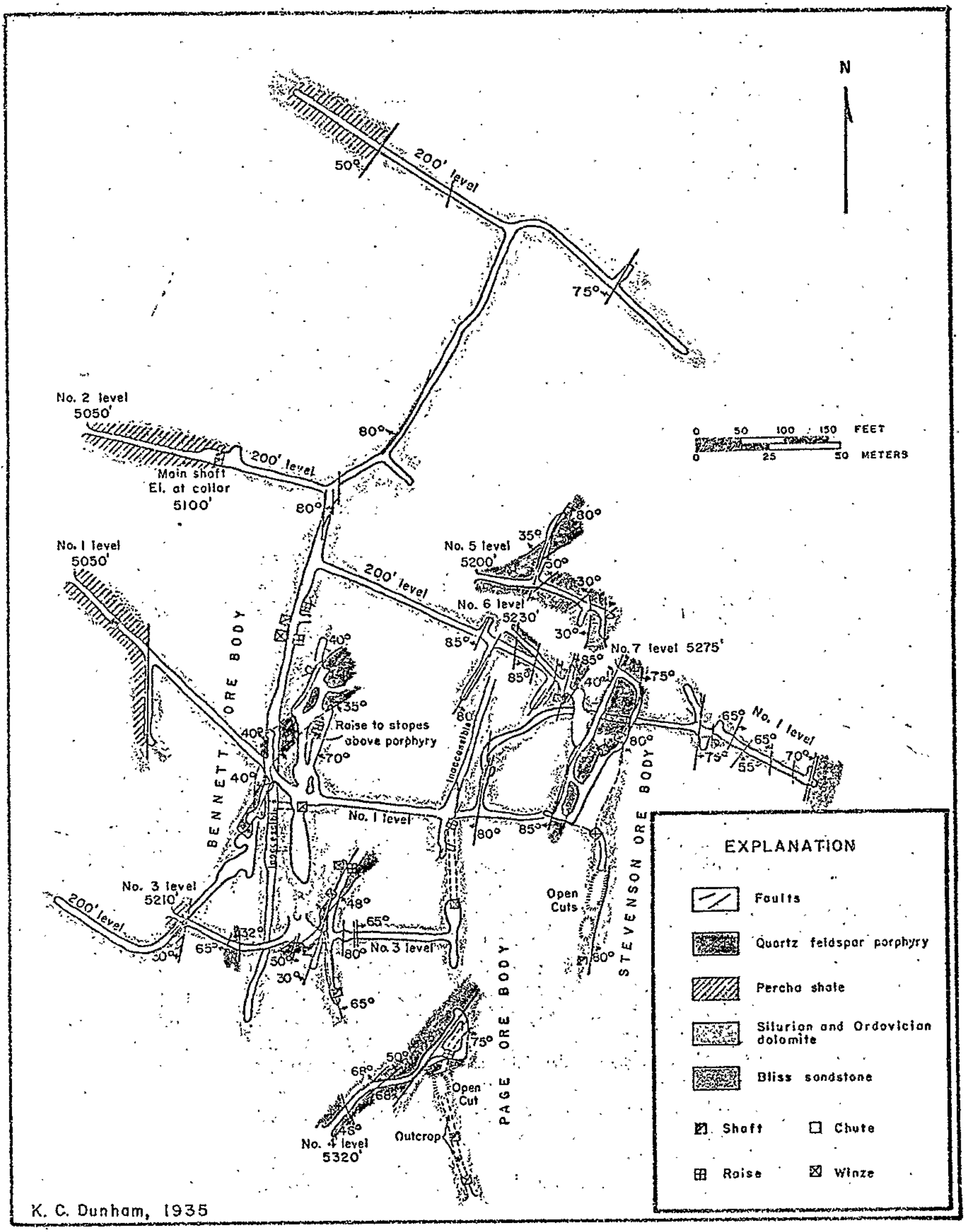


Figure 8: Composite level map of the Stevenson-Bennett Mine showing underground geology.

property, however, one private company report estimated 35,000 tons of 15 percent base metal sulfides in the Stevenson-Bennett mine.

Torpedo Mine

The Torpedo mine is approximately 1,000 feet (305 m) southeast of the town of Organ, in the northwest 1/4 of section 1, T. 22 S., R. 3 E., at an elevation of 5,240 feet (1,597 m). Total production from the property since its discovery has been approximately 3,500,000 pounds (1,587,000 kg) of copper and minor amounts of silver (Soule, 1951). The property consists of two patented claims, the Torpedo and Little Ben Scott, and several other patented and unpatented claims nearby. Most of the property is presently owned by Walter W. Isaacks, Las Cruces, New Mexico.

The copper deposit is a replacement in quartz monzonite breccia between two major faults of the Torpedo-Bennett fault zone. The faults strike N. 15° E. and dip 50° to 80° E. The Organ Mountain Batholith crops out east of the breccia zone and the Hueco Formation crops out west of the breccia zone (Fig. 9). Gouge zones, 4 to 12 feet (1 to 4 m) thick, occur along both major faults. Adjacent to the Torpedo-Bennett fault zone, the batholith has been moderately altered to kaolinite and the Hueco limestones have been garnetized, marbleized, and silicified. Both, however, are completely barren of copper mineralization. The maximum thickness of the breccia zone is approximately 200 feet (61 m) and it averages about 100 feet (30 m) in thickness. Past productive copper zones extended along a strike length of about 500 feet (152 m).

Stevenson ore: Pb-86.4%, S-13.34%, Ag-46 oz/ton

Bennett ore: 200-foot level: Pb-15.6%, Zn-15.2%, Ag-11.45 oz/ton

400-foot level: Pb-10.77%, Zn-12.96%, Ag-2.89 oz/ton

Dunham (1935) published the following description of the workings:

> The developments include, on the Stevenson ore body, open stopes where the ore follows the fault, three tunnels (Nos. 5, 6, and 7) and two underground stopes in which the ore in the dolomite below the porphyry has been mined. These were the earliest workings.
>
> The main entrance to the mine is No. 1 tunnel, which intersects the Bennett ore body 340 feet from its portal. There are large open stopes on this ore body, supported by pillars of low-grade ore and by a few stulls; apart from the pillars, the ore has been stoped out down to the level of the drainage tunnel, 240 feet below the collar of the main shaft. A crosscut on No. 1 level runs to the east, connecting with the Page stopes, and continues east, where a branch drift has cut the Stevenson fault, and has been continued to cut the fault which brings dolomite against Bliss sandstone. No. 3 tunnel cuts the Bennett ore body near its intersection with the porphyry sheet. It also continues to the east, joining with the Page workings. Between No. 1 and 3 levels there are stopes both above and below the porphyry sheet. No. 4 tunnel has explored the lower contact of the porphyry sheet to the south. A continuation of the Page ore body was found, and this has been stoped up to the surface. The deep levels are accessible from the main shaft, situated to the northwest of the Bennett ore body. This goes down through the shale into the dolomite, and reaches a depth of 450 feet, with levels at 200, 250, 350, and 450 feet. The water stands just below the 200-foot level at present. On the 200-foot level a long drive was carried north, without, however, finding any more ore. There are exploratory crosscuts to the east, but continuations of the Page and Stevenson ore bodies in depth have not been found. Only a small amount of stoping has been done below the 250-foot level. The drainage tunnel, 3,000 feet long, cuts the shaft at the 250-foot level. There has been some caving in this tunnel, and it is not functioning at present.

Very little information is published on the potential of the

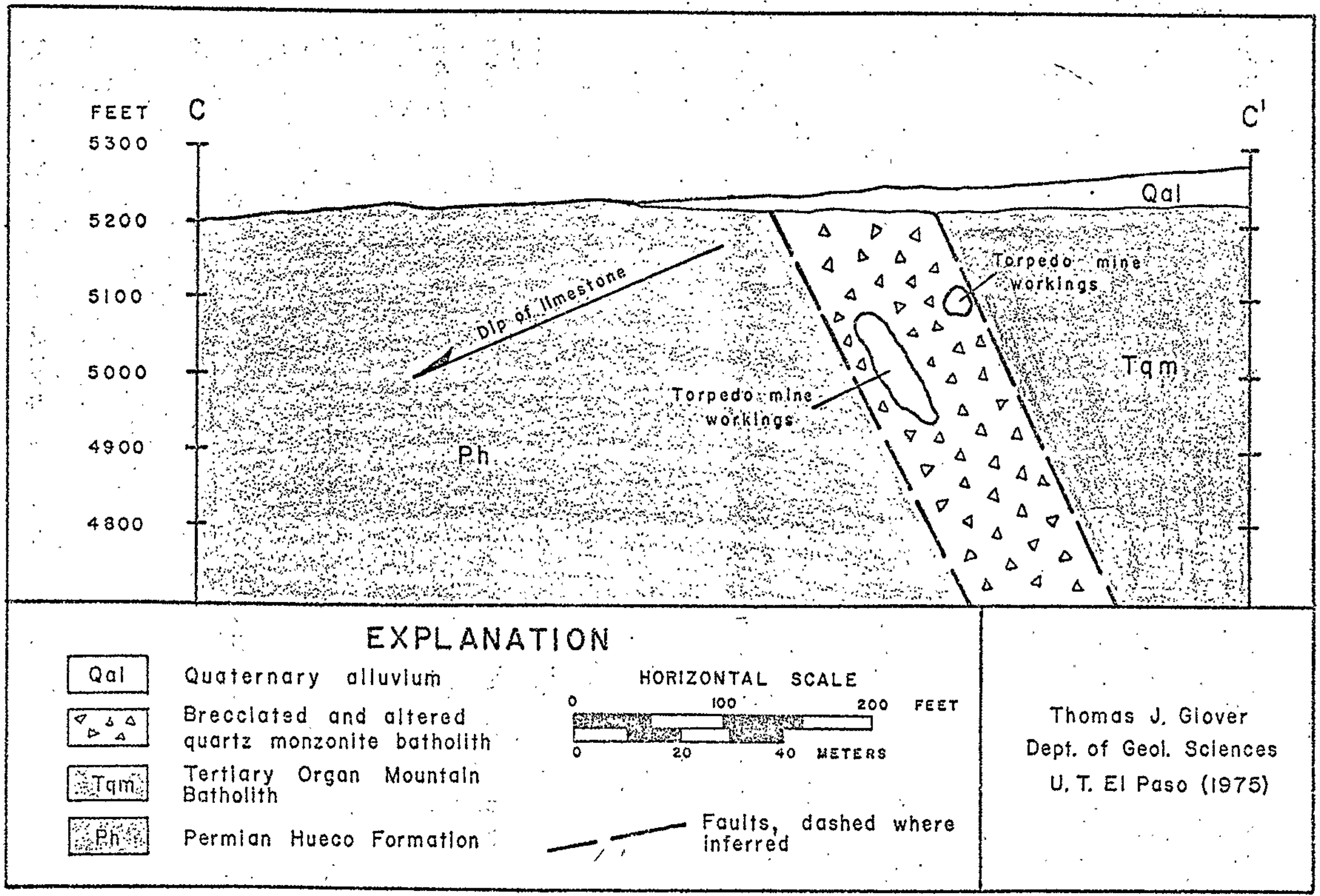


Figure 9: Geologic cross section of the Torpedo mine area.

Portions of the breccia zone have been silicified and highly altered; brecciated, and recemented with silica. The primary ore minerals are quartz, pyrite, and chalcopyrite. Copper production was mainly from the oxidized zone where chrysocolla occurs as replacements of the quartz monzonite breccia. The oxide zone extends to a depth of at least 300 feet (91 m). Native copper, cuprite, brochantite, turquoise, azurite, and malachite are abundant locally. Sulfide enrichment (chalcocite) has been reported at a depth of approximately 365 feet (111 m). The grade of ore mined between 1899 and 1901 ranges from 9 to 19.2 percent copper and 0.3 to 10.4 ounces of silver per ton. The average silver content was approximately 2 ounces of silver per ton.

The workings consist of four vertical shafts: No. 1 is 200 feet (61 m) deep, No. 2 is 250 feet (76 m) deep, No. 3 is 500 feet (152 m) deep, and No. 4 is 165 feet (50 m) deep. All of the shafts are interconnected by stopes and tunnels, and a tunnel also connects them with the Copper Bar south shaft on the Memphis property. Most of the mining was done between the 200-foot (61 m) and 300-foot (91 m) levels. The workings are presently inaccessible.

Memphis Mine

The Memphis mine is located in the northwest 1/4 of section 1, T. 22 S., R. 3 E., at an elevation of 5,180 feet (1,579 m). The property consists of one patented claim, the Memphis, which is approximately 750 feet (228 m) northeast of the town of Organ. The claim is presently owned by Walter W. Isaacks, Las Cruces, New Mexico.

Mineralization on the Memphis property is in the Hueco Formation (Permian). The sedimentary strata are overlain to the north by an intensely altered quartz feldspar porphyry sill, and are bounded on the east and west by high-angle faults of the Torpedo-Bennett fault zone. The southern end of the claim is covered by alluvium.

Certain beds of the limestone were totally replaced by andradite, diopside, and wollastonite during the pyrometasomatic stage of mineralization. The remaining limestone beds, between the calc-silicate units, were then replaced by quartz, specularite, and sulfides. No sulfide mineralization occurs in the Organ Mountain Batholith or quartz feldspar porphyry sill adjacent to the Hueco Formation. Sulfide and oxide ores were mined at the Memphis property. The oxide ores, extending to a depth of 200 feet (61 m), were the most important in terms of production.

Four principal ore deposits were discovered during the years 1882 to 1929. The largest and most productive ore deposit was developed at the South shaft. The principal ore minerals included malachite, azurite, chrysocolla, and complex sulfides. The workings consist of a 180 foot (55 m) vertical shaft and numerous large stopes. Average assays of the complex sulfide ores, taken during the years 1911 to 1915, are as follows:

Silver	10.8 ounces per ton
Copper	6.6 percent
Zinc	15.4 percent
Lead	7.1 percent

An ore body of chalcocite was discovered between the 30- and 50-foot (9 and 15-m) levels in the Roos shaft. The workings consist of a 200 foot (61 m) vertical shaft with working levels developed at 30, 50, 100, and 200 feet (9, 15, 30, 61 m). Malachite and chrysocolla were mined from open cuts south of the main shaft.

The Zinc shaft produced malachite, azurite, and calamine (hemimorphite) ores from a 4 foot (1 m) thick deposit. Ore was mined for 200 feet (61 m) down the dip. Massive sphalerite ore was reported in the bottom of the stope. The workings consist of a 200 foot (61 m) vertical shaft and numerous stopes.

Southwest of the Roos shaft, a fracture zone contains limonitic material with high silver content. The mine consists of a small shaft extending to a depth of only 20 feet (6 m). Tetradymite (Bi_2Te_2S) is abundant in a few deposits south of the Roos shaft.

Modoc Mine

The Modoc mine is approximately 5.5 miles (8.9 km) south of the town of Organ (Plate VII). The mine is at an elevation of 6,580 feet (2,006 m) and is in the southwest 1/4 of section 31, T. 22 S., R. 4 E. Four patented claims, the Michigan, Easy Pickins, Wall Street B-28 Lode, and Pacific Republic Lode, are presently owned by Daniel J. Ford, Las Cruces, New Mexico.

The deposit is an irregular replacement in the Hueco Formation (Permian) adjacent to the Modoc fault. Hueco limestone makes up the footwall of the Modoc fault and Orejon Andesite makes up the hanging wall (Fig. 10). The limestones have been intensely garnetized, marbleized, and silicified and the mineralized ground is extensive, but only a few small ore bodies have been discovered. The deposit is classified as pyrometasomatic.

Galena, the principal ore mineral, occurs as massive replacement

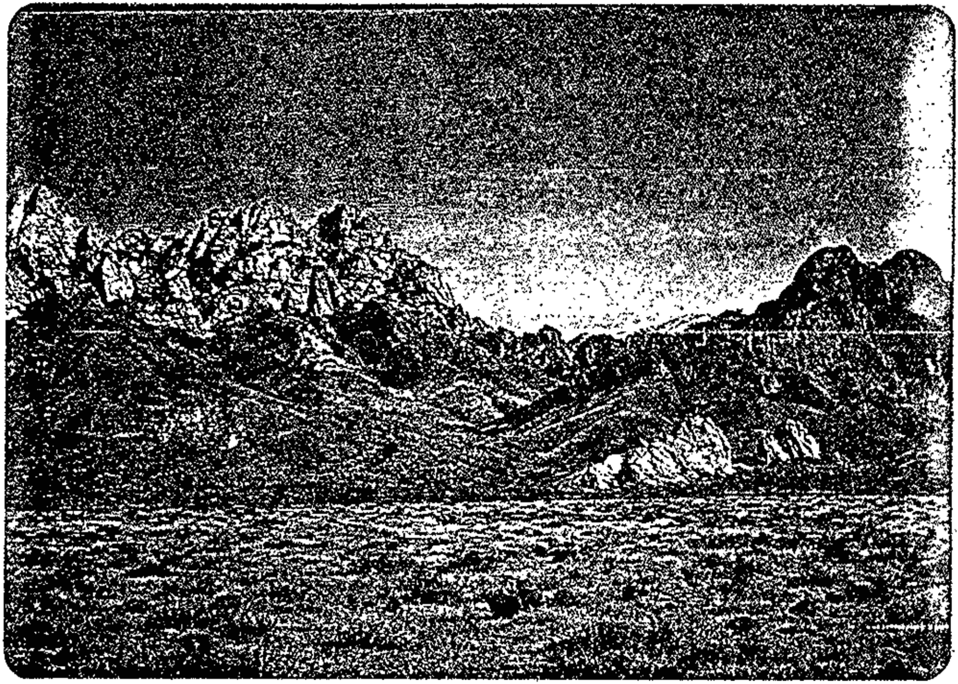


Plate VII: Modoc mine and vicinity, view looking to the east.

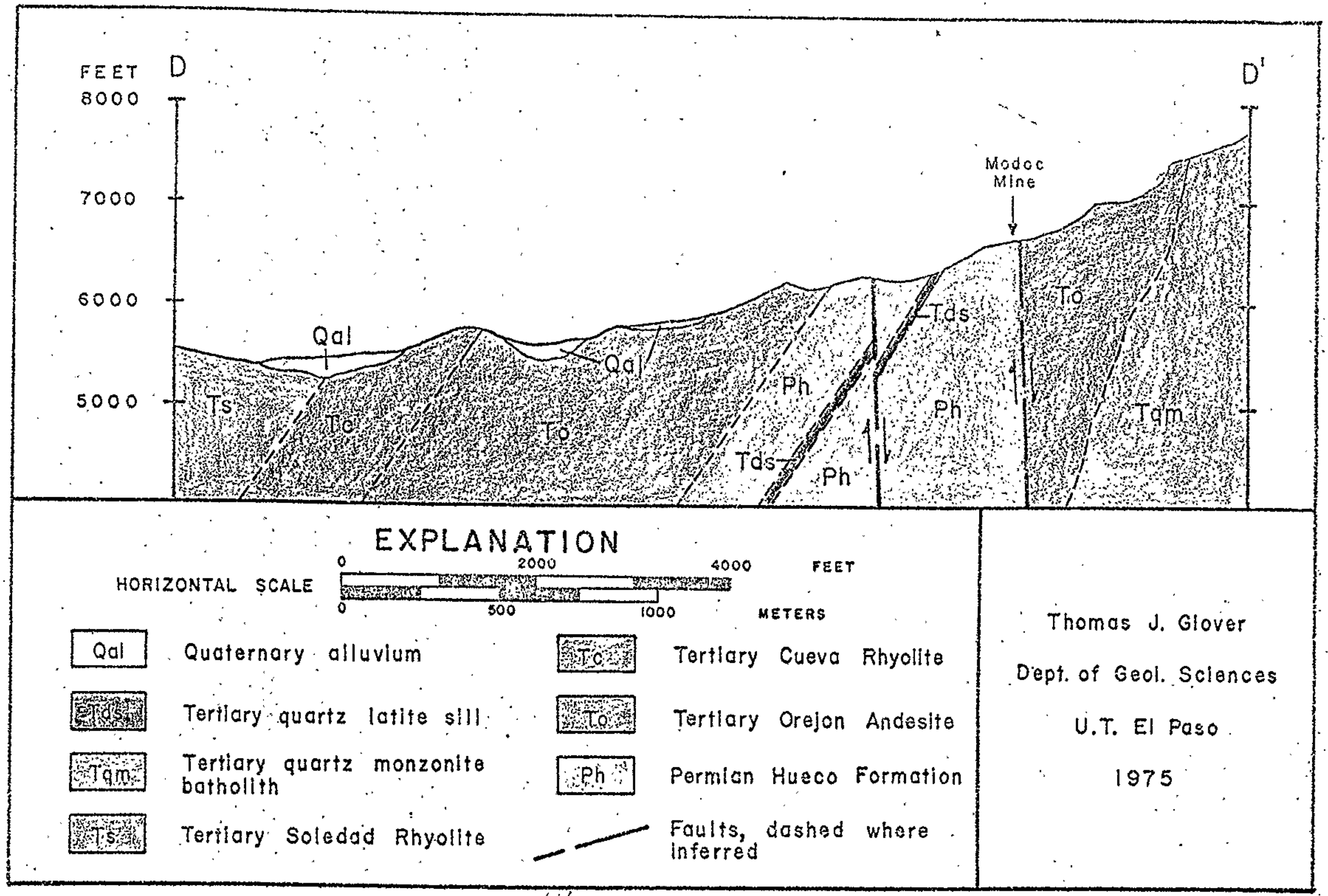


Figure 10: Geologic cross section of the Modoc mine area.

of limestone adjacent to garnetized limestone. Argentiferous galena and sphalerite are present in minor amounts. The silver content was reported to be 2 ounces per ton. Gangue minerals include andradite, grossularite, epidote, chlorite, quartz, calcite, and specularite.

The workings consist of an 185 foot (56 m) inclined shaft down the dip of the Modoc fault and an 85 foot (28 m) adit that intersects the shaft at the 95-foot (29-m) level. Most of the mining was done between the 95-foot (29-m) level and the 185-foot (56-m) level. There are numerous small shafts, pits, and trenches in the vicinity of the Modoc mine.

Homestake Mine

The Homestake mine is approximately 4,000 feet (1,219 m) northwest of the Memphis mine and is at an elevation of 5,140 feet (1,567 m). The property consists of several unpatented claims in the southwest 1/4 of section 36 and the southeast 1/4 of section 35, T. 21 S., R. 3 E. Present ownership of the property is unknown.

The ore occurs in replacement bodies in the Hueco Formation (Permian) adjacent to a highly altered quartz feldspar porphyry sill. The limestone-porphyry contact strikes N. 40° E. and dips 35° to 40° NW. and the ore bodies appear to parallel the contact. Argentiferous galena and cerussite were the principal ore minerals, however, small amounts of argentojarosite were mined from the oxide zone. Common gangue minerals include calcite, pyrite, quartz, and limonite. Dunham (1935) reported that an average assay of the ore mined from 1912 to 1914 was Au-0.08 ounces per ton, Ag-27.8 ounces per ton, and Pb-11.5 percent.

The workings consist of an incline shaft, an open stope, vertical shaft, and several small pits. The workings are presently in very poor condition.

Philadelphia Mines

The Philadelphia group consists of three patented claims, the Girard, Black Quartz, and Short Cut, approximately 1,500 feet (457 m) northwest of the Memphis mine. The mines are in the southwest 1/4 of section 36, T. 21 S., R. 3 E., at an elevation of 5,140 feet (1,567 m). Small amounts of lead and silver were produced from oxide ores prior to 1934. The present owner is Walter W. Isaacks, Las Cruces, New Mexico.

Dunham (1935) described the small deposit as follows:

> A quartz-galena deposit replacing a thin Magdalena limestone (now classified as Hueco Formation). The ore shoot occurs where a fissure zone striking N. 15° W. comes into contact with a quartz monzinite dike, striking N. 40° W. The limestone strikes NE. and dips 55°NW. Mineralization includes limonite, cerussite, argentojarosite, quartz and residual galena masses.

The workings, now inaccessible, consisted of three vertical shafts connected by underground stopes and an incline that paralleled the limestone bedding.

Orejon Mine

The Orejon mine is located approximately 800 feet (244 m) south of the Modoc property, at an elevation of 6,260 feet (1,908 m). The mine is in the northeast 1/4 of section 1, T. 23 S., R. 3 E., at the mouth of

Fillmore Canyon. The property consists of one patented claim, the Orejon, and numerous adjacent unpatented claims. The Orejon claim is presently owned by Daniel J. Ford, Las Cruces, New Mexico.

The deposit is a cylindrically-shaped replacement (pyrometasomatic) in Hueco limestone adjacent to the Modoc fault. The hanging wall of the fault is Orejon Andesite and the footwall is the Hueco Formation (Permian). Argentiferous galena was the main ore mineral and spalerite and chalcopyrite were locally abundant. Common gangue minerals include andradite, epidote, chlorite, quartz, and specularite. Dunham (1935) reported that assays made in 1910 indicated the following metal content of the ore:

Silver..................	28.5 percent
Lead.....................	21.2 percent
Copper..................	10.4 percent
Zinc.....................	9.0 percent
Gold......................	0.06 percent

The workings consist of an 125 foot (38 m) incline shaft connected to a 100 foot (30 m) tunnel. The mine was inaccessible during the time of the field study (summer, 1974).

Fluorspar Mines and Prospects

Ruby Mine

The Ruby mine, also known as the Hayner mine, has accounted for the only production of fluorspar in the northwestern Organ Mountains. The mine is approximately 4 miles (6 km) south of the town of Organ and is at an elevation of 5,720 feet (1,743 m). The property consists of two contiguous patented claims, the Ruby and Gloria, located in the northwest 1/4 of section 25, T. 22 S., R. 3 E. (Fig. 11). Numerous unpatented claims are also in the area. The present owner of the claims is Audria Hayner Palmer, Las Cruces, New Mexico. Cougar Fluorspar Corporation, Las Cruces, holds a lease on the property.

Fluorspar occurs in the andesite dike (Ta) and the Hueco Formation (Permian) in a series of subparallel fissure veins and fracture zones. The faults and fractures strike approximately N. 20° E. and dip 50° to 75° E. and may be a southern continuation of the Torpedo-Bennett fault zone. Six veins are exposed on the surface in the Ruby mine area (Plate II). Vein Nos. 2 through 6 cut the Hueco Formation and Vein No. 1 is a bedding plane vein that dips 45° to 60° W. There are eight additional mineralized fracture zones exposed in the underground workings that contain minor amounts of fluorite (Plate III). The Hueco limestones are moderately to intensely marbleized and the andesite dike is intensely chloritized and epidotized. Most of the Fluorspar occurs as void fillings, however, minor replacement of marbleized limestone breccia fragments is evident in the larger veins.

A summation of known surface vein lengths and thicknesses are as follows:

	Length	Thickness
Vein No. 1	246 feet (75 m)	1.5 feet (0.5 m)
Vein No. 2	415 feet (126 m)	1.5 feet (0.5 m)
Vein No. 3	570 feet (174 m)	3 feet (1 m)
Vein No. 4	369 feet (112 m)	1.5 feet (0.5 m)
Vein No. 5	401 feet (122 m)	1.5 feet (0.5 m)
Vein No. 6	615 feet (187 m)	2.5 feet (0.8 m)

Plate VIIIa: Ruby mine and vicinity, view looking to the east.

Plate VIIIb: Vein #5 in the Ruby mine area.

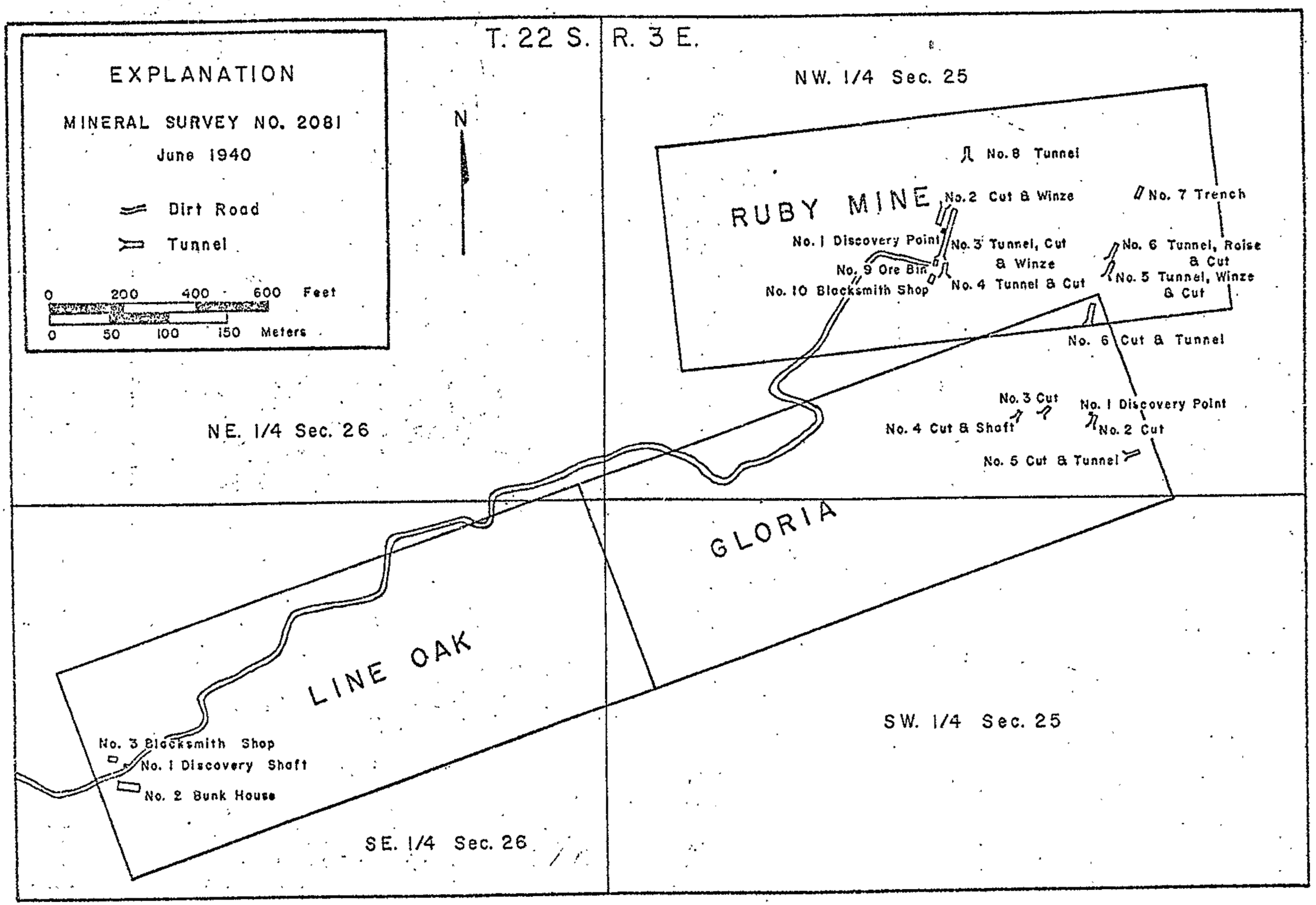
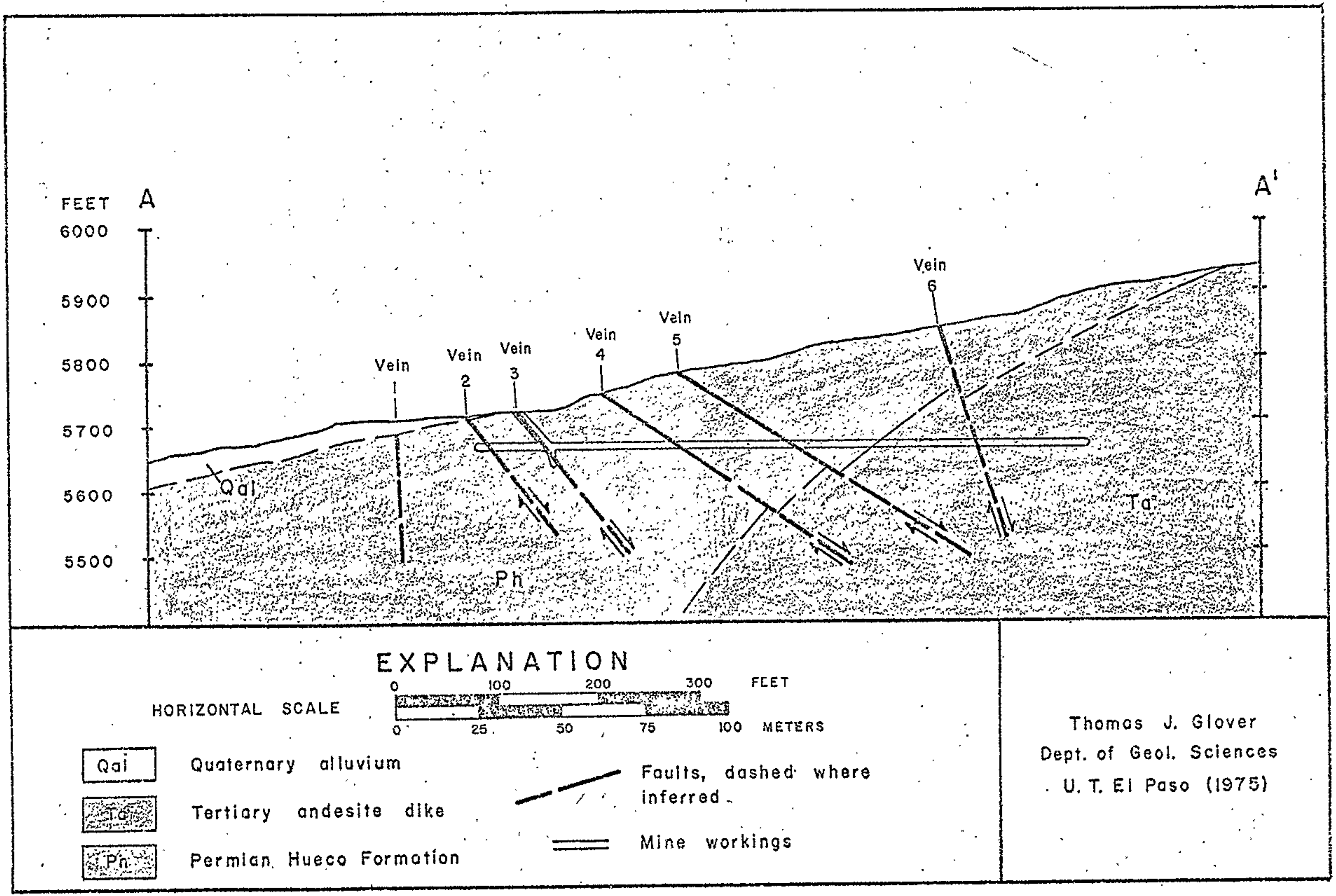


Figure 11: Claim Map of the Ruby Mine area.



Thomas J. Glover
Dept. of Geol. Sciences
U. T. El Paso (1975)

Figure 12: Geologic cross section of the Ruby mine area.

The fluorite in the area is white, pale green, and purple and occurs as fine- to coarse-grained vein material with alternating bands of calcite. Quartz occurs near the outer edges of each vein. Calcite-fluorite bands in the central portion of the vein are apparently free of quartz. Minor amounts of barite were reported by Rothrock (1946).

The principal workings consist of open stopes, trenches, and drifts on Vein No. 2, Vein No. 3, and Vein No. 6 (Plate II). Most of the work was carried out prior to 1943. Vein No. 2 has been trenched along the strike for 80 feet (24 m) and to a depth of approximately 20 feet (6 m). Vein No. 6 has been worked by 25-, 32-, and 55-foot (8, 10, 18 m) adits, all parallel to the strike. The principal workings of the Ruby mine are on Vein No. 3. It was worked by adits on two levels in the early stages of development, and later the bottom level was stoped to the surface. The workings on Vein No. 3 consist of an open stope 160 feet (49 m) along the strike of the vein and to a depth of approximately 50 feet (15 m). Exploratory work between 1973 and 1975 consisted of sinking a 95 foot (29 m) incline shaft on Vein No. 3 and drifting east 595 feet (181 m). This tunnel cuts all the veins except Vein No. 1.

The reported CaF_2 content ranges from 20 to 90 percent. Moderate fluorspar reserves may exist on the property, however, additional drilling and exploration would be necessary to prove minable reserves.

Fillmore Canyon Fluorspar Prospect

The Fillmore Canyon Fluorspar Prospect* is approximately 200 feet

*Named by writer

(61 m) south of the Orejon Mine. The prospect is in the northwest 1/4 of section 6, T. 23 S., R. 4 E. and at an elevation of 6,400 feet (1,951 m). The property consists of one patented claim, the Orejon, owned by Daniel J. Ford, Las Cruces, New Mexico. No production has been reported.

Fluorspar occurs in the Hueco Formation (Permian) in small pods and replacements associated with jasperoid. The deposit is in the footwall of the Modoc fault and much of the area is covered by alluvium.

The fluorspar is fine- to medium-grained (0.1 to 4 mm) and is intermixed with quartz. Common gangue minerals include andradite, calcite, epidote, specularite, and limonite.

ECONOMIC POTENTIAL OF THE AREA

The mineralized belt along the western front of the Organ Mountains contains silver, gold, lead, zinc, copper, fluorine, and minor amounts of tellurium, bismuth, antimony, and molybdenum. Limited exploration, primarily for fluorspar and porphyry copper, has been conducted in the Organ Mining District. There has been little or no exploration in the Modoc mine area. It will probably be necessary to use geophysical and geochemical methods, drilling, and detailed alteration mapping in exploration programs as deposits may be at depth or covered with pediment gravels and alluvium.

Mineral reserves (from private company reports) reported in the past few years include the following:

1. Stevenson-Bennett mine: 35,000 tons of ore with 15 percent base metal sulfide content.

2. Torpedo mine: 17,000 tons of 3 percent copper ore with about 2 ounces of silver per ton.

3. Torpedo and Memphis mine areas: 300,000 tons of 1 percent copper.

4. Ruby mine: Possible reserves of fluorspar.

Future exploration will undoubtedly add to the known mineral deposit list.

White, coarsely crystalline marble in the Ruby mine area may be a source for roof and yard gravels. The Dripping Springs area could provide an estimated 25,000,000 cubic yards of high quality unconsolidated coarse gravel, cobbles, and sand. The Bureau of Land Management is currently investigating possible geothermal energy sources in the area.

Environmental groups are requesting withdrawal of the Organ Mountains for recreational use, and that could happen in spite of the fact that preliminary environmental impact studies show that prospecting, exploration, and development in the area would not seriously affect the environment.

CONCLUSIONS

Paleozoic sedimentary rocks and Cenozoic igneous rocks make up most of the Organ Mountains. Most faults in the area are high angle and normal and are related to the Organ Mountain Caldera, intrusion of the Organ Mountain Batholith, or Basin and Range faulting in the Torpedo-Bennett zone. Several periods of movement are evident on some faults. Mineral deposits are located in and adjacent to faults that trend north to northeast.

Both pyrometasomatic and late stage hydrothermal (mesothermal) ore deposits occur in the study area and consist of galena, argentiferous galena, sphalerite, chalcopyrite, and fluorspar. Hypogene and supergene minerals have been economically important in past mining operations. Mineral deposits occur in fissure veins, breccia zones, skarn zones, and replacement bodies. Major factors influencing the localization of the deposits appears to have been host rock composition, type and degree of previous metamorphism and metasomatism, local changes in strike and dip of faults, and the amount of open space in faults, fractures, and breccias. Metamorphism, metasomatism, and alteration types include marbleization, epidotization, garnetization, sericitization, silicification, argillization, and kaolinitization.

Exploration in the Organ, Ruby mine, and Modoc mine areas may discover future commercial deposits of ore minerals. Present activity in the area consists of limited exploration, primarily for fluorspar and porphyry copper.

APPENDIX "A"

MICROSCOPIC DESCRIPTIONS OF IGNEOUS ROCKS

Slide No. 10a

Location: Center of section 31, T. 22 S., R. 4 E., batholith near the Modoc mine, 30 feet (9 m) from igneous contact; Organ Mountain Batholith (Tqm).

Name: Quartz monzonite

Texture: Holocrystalline, medium-grained (1 - 5 mm), equigranular.

Major Constituents:

K-feldspar: (45%)	Anhedral crystals; maximum size 5 mm, average size 2 mm; perthites common; moderate to intense alteration to calcite and kaolinite, K-feldspar alteration is generally more intense than plagioclase alteration.
Oligoclase?: An_{20} (22%)	Usually as anhedral perthites in the K-feldspar, occurs as cores, veins and irregular patches; average size of cores 1 mm, veins and patches 0.2mm; moderate alteration to kaolinite, sericite, and calcite.
Quartz: (22%)	Anhedral grains; occurs as blebs and small grains; maximum size 2 mm, average size 1 mm.

Minor Constituents:

Hornblende: (2%)	Euhedral crystals; average size 1 mm x 0.5 mm; weak alteration to magnetite, chlorite, and calcite.
Biotite?: (0.5%)	Anhedral fragments associated with magnetite; average size 0.5 mm; moderate alteration to magnetite and iron oxides.

Alteration Products:

Calcite: (5%)	From alteration of feldspars and some from alteration of mafic minerals.
Magnetite: (2%)	From alteration of mafic minerals, minor amount may be primary.

Kaolinite: (2%)	From alteration of feldspars.
Sericite: (2%)	From alteration of feldspars.
Chlorite: (Tr)	From alteration of mafic minerals.

Slide No. 120

Location: Southeast 1/4 of section 11, T. 22 S., R. 3 E., approximately 900 feet (274 m) east of the Stevenson-Bennett mine, 10 feet (3 m) from the granite (Tg) contact; Organ Mountain Batholith (Tqm).

Name: Quartz monzonite

Texture: Holocrystalline, medium- to coarse-grained (1 - 9 mm), inequigranular.

Major Constituents:

K-feldspar: (46%)	Anhedral to subhedral phenocrysts; maximum size 9 mm, average size 1.5 mm; perthites common; two distinct generations of K-feldspar are present; commonly intergrown with quartz; moderate alteration to kaolinite, sericite, and calcite.
Oligoclase: An_{19} (30%)	Anhedral phenocrysts and cores of larger grains; albite and carlsbad twins are common; some crystals are mantled by perthite; zoning present in some crystals; size ranges from 0.2 mm to 1.5 mm, average size 1 mm; moderate to intense alteration to kaolinite and sericite.
Quartz: (18%)	Anhedral grains, many are intergrown with feldspars; average size 0.3 mm.

Minor Constituents:

Sphene: (3%)	Anhedral, interstitial crystals associated with quartz; average size 0.2 mm.
Biotite: (1%)	Anhedral crystals; average size 0.2 mm; moderate alteration to chlorite and magnetite.
Apatite?: (Tr)	Anhedral grains; average size 0.1 mm.

Alteration Products:

Kaolinite: (1%)	From alteration of feldspars.
Sericite: (Tr)	From alteration of plagioclase.
Chlorite: (Tr)	From alteration of biotite.
Magnetite: (Tr)	From alteration of biotite.
Calcite: (Tr)	From alteration of feldspars.
Iron oxides: (Tr)	From alteration of magnetite and biotite.

Slide No. 130

Location: Southeast 1/4 of section 24, T. 22 S., R. 3 E., batholith in the Baylor Pass area; Organ Mountain Batholith (Tqm).

Name: Quartz monzonite

Texture: Holocrystalline, medium-grained (1 - 5 mm), equigranular.

Major Constituents:

K-feldspar: (38%)	Anhedral grains; maximum size 6 mm, average size 2 mm; perthites common; moderate alteration to kaolinite, K-feldspar more altered than plagioclase in general.
Andesine: An_{36} (23%)	Anhedral perthites in the K-feldspars, occurs as cores, veins and irregular patches; cores average size 1 mm, patches and veins average size 0.1 mm x 0.3 mm; moderate alteration to kaolinite, sericite, and calcite.
Quartz: (35%)	Anhedral grains, occur as blebs and small grains; maximum size 2 mm, average size 1 mm.

Minor Constituents:

Biotite: (0.5%)	Anhedral fragments, good cleavage; average size 0.5 mm; moderate alteration to magnetite and iron oxides.

Alteration Products:

Kaolinite: (3%)	From alteration of feldspars, K-feldspar most extensively.
Magnetite: (1%)	From alteration of biotite, some may be primary.
Sericite: (Tr)	From alteration of plagioclase.
Calcite: (Tr)	From alteration of feldspars.

Slide No. 10

Location: Southeast 1/4 of section 1, T. 22 S., R. 3 E., within Dunham's Phase 3 boundaries; Organ Mountain Batholith.

Name: Biotite quartz monzonite

Texture: Holocrystalline, medium-grained (1 - 5 mm), equigranular.

Major Constituents:

Andesine: An_{34} (38%)	Anhedral to subhedral laths, many are zoned; maximum length of 7 mm, average size 1 mm x 2.5 mm; albite and carlsbad twins are common; alteration varies from moderate to intense; plagioclase constitutes 66% of the total feldspar.
Quartz: (28%)	Anhedral grains; occurs as blebs and small crystals in the matrix; maximum size 2 mm x 1.5 mm, average size 1 mm x 1.5 mm.
K-feldspar: (18%)	Anhedral grains; size ranges from 1 mm to 2 mm, average size 1.5 mm; moderate alteration to kaolinite and calcite.

Minor Constituents:

Biotite: (8%)	Anhedral to subhedral crystals; average size 1 mm; relatively unaltered.
Amphibole: (2%)	Anhedral grains; maximum size 1.5 mm x 0.2 mm, average size 1 mm x 0.2 mm; intense alteration to magnetite, epidote, and iron oxides.

Alteration Products:

Sericite: (3%)	From alteration of feldspars.
Magnetite: (1%)	Anhedral to subhedral grains; average size 0.3 mm; mostly from alteration of amphibole.
Epidote: (1%)	From alteration of amphibole and feldspar.
Calcite: (Tr)	From alteration of feldspars and mafic minerals.
Chlorite: (Tr)	From alteration of mafic minerals.

Slide No. Pc

Location: Eastern 1/2 of section 11, T. 22 S., R. 3 E., approximately 900 feet (274 m) east of the Stevenson-Bennett mine; Granite (Tg).

Name: Biotite granite

Texture: Holocrystalline, medium-grained (1 - 2 mm), equigranular.

Major Constituents:

K-feldspar: (55%)	Anhedral crystals; size from 0.5 mm to 1.7 mm, average size 1 mm; carlsbad twinning in most crystals; perthitic intergrowths are common; moderate to intense alteration to kaolinite.
Quartz: (20%)	Anhedral grains; sizes range from 0.2 mm to 1 mm, average size 0.5 mm; numerous tourmaline needles in the quartz grains.
Biotite: (11%)	Anhedral to subhedral crystals; sizes range from 0.3 mm to 1 mm, average size 0.4 mm; intense alteration to magnetite and miscellaneous iron oxides, corrosion of edges is common.
Plagioclase: (10%)	Anhedral to subhedral laths, 0.6 mm to 1.2 mm, average size 1 mm; intensely altered to kaolinite and calcite, no composition determination is possible.

Alteration Products:

Kaolinite: (2%) From alteration of feldspars.

Magnetite: (1%) From alteration of biotite, some may be primary.

Calcite: (Tr) From alteration of plagioclase.

Iron oxides: (Tr) From alteration of biotite.

Slide No. 76

Location: Southeast 1/4 of section 26, T. 22 S., R. 3 E., approximately 1,200 feet (366 m) south of Mine House Spring; Orejon Andesite (To).

Name: Porphyritic hornblende andesite

Texture: Holocrystalline, porphyritic; flow structure in the groundmass.

Groundmass: Constitutes about 52% of the whole rock; average size is less than 0.05 mm; consists mostly of plagioclase with very minor amounts of K-feldspar and quartz; alteration of the matrix is moderate to very intense.

Major Constituents:

Andesine: An_{30} (71%) Subhedral to euhedral phenocrysts; sizes range from 0.8 mm to 2.1 mm, average size 0.4 mm x 1.2 mm; intense alteration to kaolinite, sericite, and calcite; normal and oscillatory zoning in many crystals along with carlsbad and albite twins; many of the crystals are broken, probably due to flowage; most of the groundmass is plagioclase with minor amounts of K-feldspar and quartz, large amounts of altered material are also in the groundmass.

Hornblende: (20%) Subhedral crystals both as phenocrysts and groundmass; sizes range from 0.1 mm to 1.5 mm, average size 0.8 mm; most crystals are completely altered to calcite, magnetite, and chlorite; some of this material may be highly altered biotite.

Minor Constituents:

K-feldspar: (2%) Subhedral crystals, both in the groundmass and as phenocrysts; sizes range from less than 0.1 mm to 1 mm, average size 0.3 mm; moderate to intense alteration to calcite, kaolinite, and sericite.

Sphene?: (1%) Subhedral crystals; average size 0.2 mm.

Quartz: (1%) Anhedral crystals usually in the groundmass; average size 0.3 mm.

Alteration Products:

Kaolinite: (2%) From alteration of feldspars.

Calcite: (2%) From alteration of feldspars and mafic minerals.

Sericite: (Tr) From alteration of feldspars.

Chlorite: (Tr) From alteration of mafic minerals.

Magnetite: (Tr) From alteration of mafic minerals.

Epidote: (Tr) From alteration of plagioclase.

Slide No. 88

Location: Eastern 1/2 of section 1, T. 23 S., R. 3 E., intruded along the Modoc fault approximately 2,500 feet (762 m) south of the Modoc mine; Quartz latite porphyry dike (Tds).

Name: Quartz latite porphyry

Texture: Holocrystalline, porphyritic.

Groundmass: Constitutes 50% of the whole rock; average grain size is less than 0.1 mm; consists mostly of plagioclase and K-feldspar with minor amounts of quartz and biotite; alteration in the matrix is moderate to intense.

Major Constituents:

Andesine: An_{40} (50%)	Subhedral to euhedral phenocrysts constitute 45% of the entire rock, sizes range from 1 mm to 4 mm, average size 2 mm, good carlsbad and albite twins in only a few crystals, faint relic zoning in larger crystals; anhedral crystals of plagioclase groundmass constitute 5% of the entire rock; moderate to intense alteration to kaolinite, sericite, and calcite.
K-feldspar: (29%)	Anhedral crystals, confined to the groundmass; average size 0.2 mm; intense alteration to kaolinite.
Quartz: (12%)	Anhedral crystals confined to the groundmass; average size 0.2 mm; slight corrosion of the crystal edges.

Minor Constituents:

Biotite: (3%)	Anhedral phenocrysts; average size 1.5 mm x 0.5 mm; moderate to intense alteration to magnetite, chlorite, and miscellaneous iron oxides.
Zircon: (0.5%)	Euhedral prismatic crystals; average size 0.3 mm.

Alteration Products:

Magnetite: (2%)	From alteration of biotite; finely disseminated crystals in the groundmass may be primary.
Kaolinite: (1%)	From alteration of feldspars.
Sericite: (Tr)	From alteration of plagioclase.
Calcite: (Tr)	From alteration of feldspars.
Chlorite: (Tr)	From alteration of biotite.

Slide No. 37

Location: Southeastern 1/4 of section 25, T. 22 S., R. 3 E., 15 foot thick dike that crosscuts Ta and Ph; Quartz latite porphyry dike (Tds).

Name: Quartz latite porphyry

Texture: Holocrystalline, porphyritic, equigranular phenocrysts.

Groundmass: Constitutes 50% of the whole rock; average grain size is less than 0.1 mm; consists mostly of K-feldspar and quartz with minor amounts of plagioclase, magnetite, and biotite?; moderate alteration of K-feldspar to kaolinite.

Major Constituents:

Plagioclase: (45%) Anhedral phenocrysts; maximum size 3 mm, average size 2 mm x 1 mm; very intensely altered to calcite, sericite, and kaolinite; no composition could be determined, minor zoning present; small percentage as groundmass crystals.

K-feldspar: (33%) Anhedral crystals, confined to the groundmass; moderate alteration to kaolinite.

Quartz: (15%) Anhedral crystals, confined to the groundmass; average size 0.2 mm; distinct lack of alteration.

Minor Constituents:

Biotite: (1%) Subhedral phenocrysts and as minor amounts in the groundmass; maximum size 2 mm, average size 1.5 mm; many crystals are intensely altered to magnetite, chlorite, and miscellaneous iron oxides; skeletons of magnetite are common.

Zircon: (0.5%) Euhedral prismatic crystals; average size 0.2 mm.

Alteration Products:

Magnetite: (2%) From alteration of biotite; minor amounts may be primary.

Kaolinite: (2%) From alteration of feldspars.

Sericite: (Tr) From alteration of plagioclase.

Calcite: (Tr) From alteration of feldspars.

Chlorite: (Tr) From alteration of biotite.

Iron oxide: (Tr) From alteration of biotite and magnetite.

Slide No. 53

Location: Southeastern 1/4 of section 36, T. 22 S., R. 3 E., two foot thick sill in the Hueco Formation west of the Modoc mine; Porphyritic quartz latite sill (Tds).

Name: Porphyritic quartz latite

Texture: Holocrystalline, porphyritic, equigranular phenocrysts.

Groundmass: Constitutes 62% of the whole rock; average grain size is 0.05 mm; consists of K-feldspar and plagioclase with minor amounts of quartz, magnetite, an unidentified mafic mineral, and miscellaneous iron oxides; weak alteration of feldspars to kaolinite.

Major Constituents:

Albite: An_6 (57%) Subhedral phenocrysts; sizes range from 0.5 mm to 2 mm, average size 1 mm x 0.5 mm; albite and carlsbad twinning are common; anhedral crystals constitute 55% of the groundmass; weak to moderate alteration to calcite, sericite, and kaolinite.

K-feldspar: (28%) Anhedral crystals, confined to the groundmass; average size 0.05 mm; crystals have a feathery appearance; moderate alteration to kaolinite and calcite.

Quartz: (10%) Anhedral, very corroded grains; average size 0.5 mm; minor amounts in groundmass.

Minor Constituents:

Mafic mineral: (2%) Extremely altered and corroded phenocrysts of a mafic mineral that is probably either amphibole or biotite; maximum size 1 mm, average size 0.1 mm x 0.3 mm; altered to magnetite, chlorite, calcite, and iron oxides.

Alteration Products:

Calcite: (1%) From alteration of feldspars and mafic mineral, very fine-grained.

Kaolinite: (Tr) From alteration of feldspars.

Sericite: (Tr) From alteration of plagioclase.

Chlorite: (Tr) From alteration of mafic mineral.

Magnetite: (Tr) From alteration of mafic mineral.

Iron oxides: (Tr) From alteration of magnetite and mafic mineral.

Slide No. 129

Location: Northeast 1/4 of section 36, T. 22 S., R. 3 E., approximately 500 feet (152 m) north of the Modoc fault; Andesite dike (Ta).

Name: Porphyritic andesite

Texture: Holocrystalline, porphyritic.

Groundmass: Constitutes about 75% of the whole rock; average grain size is less than 0.1 mm; consists mostly of plagioclase with minor portions of K-feldspar, quartz, and magnetite; alteration in the matrix is moderate to intense.

Major Constituents:

Andesine: An_{49} (80%) Anhedral to subhedral phenocrysts constitute 10% of the entire rock, size ranges from 0.1 mm to 1.5 mm, a few good albite and carlsbad twins, minor zoning in larger crystals; anhedral to subhedral crystals constitute most of the groundmass and are 70% of the entire rock, average size 0.1 mm, intermixed with K-feldspar; moderate alteration.

Minor Constituents:

K-feldspar: (8%) Subhedral crystals, confined to the groundmass; average size 0.1 mm; many are inclusions in crystals of plagioclase groundmass; moderate to intense alteration to calcite, kaolinite, and sericite, but less intense than plagioclase alteration.

Quartz: (3%) Anhedral grains and clusters of grains confined mostly to the groundmass; average size 0.1 mm.

Mafic mineral: (1%) Traces of completely altered mafic minerals, (probably biotite or hornblende), magnetite grains form skeleton outlines of original crystals; average size 0.5 mm, size ranges from

2 mm to 0.2 mm; chlorite, magnetite, iron oxides, and minor amounts of epidote are the common alteration products.

Alteration Products:

Magnetite: (3%)	From alteration of mafic minerals, a few grains are probably primary; average size 0.1 mm; forms good skeletal structure around original mafic crystals.
Chlorite: (1%)	From alteration of mafic minerals.
Iron oxides: (0.5%)	From alteration of magnetite and mafic minerals.
Calcite: (0.5%)	From alteration of feldspars and mafic minerals; very fine-grained.
Kaolinite: (Tr)	From alteration of feldspars.
Sericite: (Tr)	From alteration of feldspars.
Epidote: (Tr)	From alteration of plagioclase.

Slide No.	E
Location:	Northwest 1/4 of section 25, T. 22 S., R. 3 E., approximately 1,000 feet (305 m) east of the Ruby mine; Andesite dike (Ta), 30 feet (9 m) from igneous-sedimentary contact.
Name:	Hornblende andesite porphyry
Texture:	Holocrystalline, porphyritic.
Groundmass:	Constitutes 35% of the whole rock; average grain size is less than 0.1 mm; consists mostly of plagioclase with minor amounts of K-feldspar and quartz, and much smaller portions of hornblende and pyrite; alteration of the matrix is moderate to intense.

Major Constituents:

Andesine: An_{36} (75%)	Anhedral to subhedral phenocrysts constitute 38% of the entire rock, size ranges from 0.2 mm to 2 mm, average size 1 mm x 0.5 mm, weak zoning

in some phenocrysts, a few minor albite, carlsbad, and pericline twins; anhedral to subhedral crystals constitute approximately 95% of the groundmass and are 37% of the entire rock, average size less than 0.1 mm, intermixed with small amounts of K-feldspar and quartz; moderate alteration.

Hornblende: (10%)	Subhedral phenocrysts; sizes range from 0.5 mm to 2.5 mm, average 1 mm x 0.5 mm; intense alteration to chlorite and magnetite; magnetite forms a few skeletons on crystals.

Minor Constituents:

Quartz: (6%)	Anhedral to subhedral grains both as phenocrysts and groundmass; average size 0.3 mm.
K-feldspar: (1%)	Subhedral crystals, confined to the groundmass; average size 0.1 mm; many are inclusions in crystals of plagioclase groundmass; moderate alteration to calcite, kaolinite, and sericite.
Pyrite: (0.2%)	Subhedral crystals disseminated throughout the groundmass; average size 0.2 mm.

Alteration Products:

Epidote: (7%)	Subhedral to anhedral crystals from alteration of plagioclase mainly; good cores of epidote occur in the larger phenocrysts of plagioclase; average size 1 mm x 0.5 mm.
Chlorite: (1%)	From alteration of hornblende.
Magnetite: (0.5%)	From alteration of hornblende, some is primary.
Calcite: (Tr)	From alteration of feldspars and hornblende.
Sericite: (Tr)	From alteration of feldspars.
Kaolinite: (Tr)	From alteration of feldspars.
Iron oxide: (Tr)	From alteration of magnetite and hornblende.

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VITA

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This thesis was typed by Thomas J. and Georgia A. Glover

PLATE I

Geologic Map of the Northwestern Organ Mountains, Dona Ana County, New Mexico

EXPLANATION

CENOZOIC	Quaternary & Tertiary		Qal	Alluvium and coluvium
	Tertiary	Intrusive Igneous Rocks	Tir	Intrusive rhyolite
			Tg	Granite
			Tds	Quartz latite-quartz feldspar porphyry dikes and sills
			Tqm	Quartz monzonite batholith
			Ta	Andesite dike
		Extrusive Igneous Rocks	Ts	Soledad Rhyolite
			Tc	Cueva Rhyolite
			To	Orejon Andesite
	Tertiary ?		Tlr	Love Ranch Formation
PALEOZOIC	Permian		Ph	Hueco Formation
	Mississippian		Clv	Lake Valley Formation
	Devonian		Dp	Percha Shale
	Ordovician-Silurian		OS	Undifferentiated dolomites
	Cambrian		Cb	Bliss Formation

SYMBOLS

	Paved highway		Fault, U on up side, D on down side, dashed where inferred or covered, 60 amount and direction of dip
	Improved dirt road		Thrust fault
	Unimproved dirt road		Bedding contact, dashed where inferred
	Pack trail		Bedding contact, dashed where inferred
	Military boundary	10	Strike and dip
◪	Mine shaft		Plunging syncline
	Adit		Plunging anticline
X	Prospect pit	A—A'	Cross section
	Well		Intermittent stream
▨	Ranch		Spring

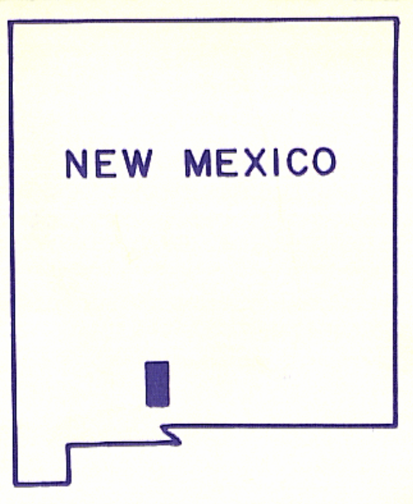
1:14400

Contour Interval: 100 feet

Miles 0 0.5 1

Feet 0 3000 6000

Kilometers 0 1 2



Map Location

12.5°

True North

Magnetic North

Approximate Mean Declination — 1955

Topographic Base Maps: U.S.G.S. Organ and Organ Peak Quadrangles, New Mexico

Geology by Thomas J. Glover

Cartography by Georgia A. Glover

Department of Geological Sciences U. T. El Paso

1975

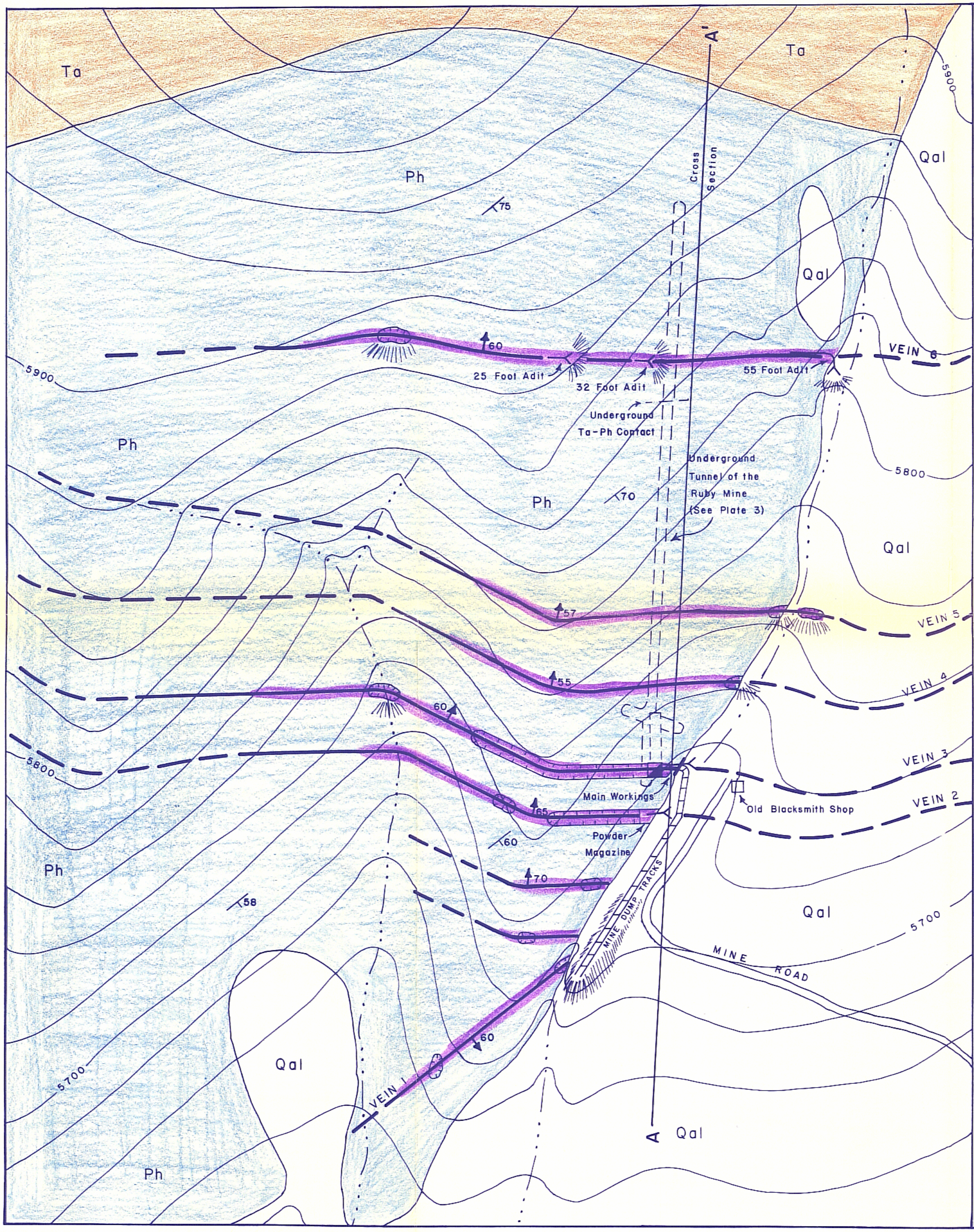


PLATE II

GEOLOGIC MAP OF THE RUBY MINE AREA, DONA ANA COUNTY, NEW MEXICO

EXPLANATION

QUATERNARY	Qal	ALLUVIUM
TERTIARY	Ta	ANDESITE DIKE
PERMIAN	Ph	HUECO FORMATION

SYMBOLS

60	Fault, showing down side and dip, dashed where inferred
10	Dip & strike of strata
	Intermittent stream
	Adit
	Shaft
	Pit, trench, or open cut
	Flourspar

MN
TN 12.5°
1955

20 FOOT CONTOUR INTERVAL

0 25 50 75 METERS

0 100 200 FEET

Geology by - Thomas Glover

Plane Table Work by - Thomas Glover
Georgia Glover
Gene Larson

Cartography by - Georgia Glover

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U T EL PASO — 1975

EXPLANATION AND SYMBOLS

- Ta Tertiary andesite dike
- Ph Permian Hueco Formation
- Marbleized limestone
- Fluorspar
- Calcite
- FeO Iron oxide
- Brecciated zone
- Inclined shaft, with chevrons pointing down
- Lagging along workings
- Fault, showing dip
- Fault, vertical
- Joint, showing dip
- Joint, vertical
- Contact, showing dip
- Stringers or veinlets

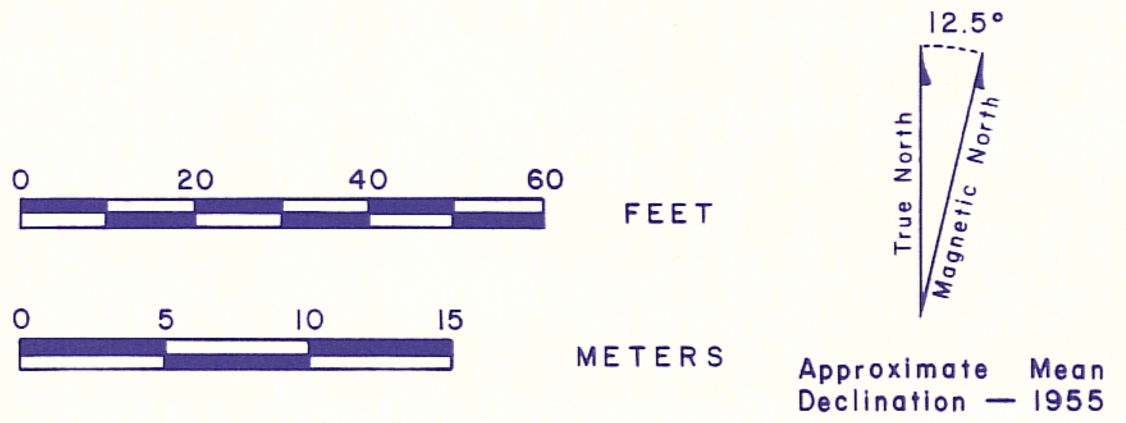

PLATE III

UNDERGROUND GEOLOGY OF THE RUBY MINE, DONA ANA COUNTY, NEW MEXICO

Thomas Glover and Gene Larson

Dept. of Geological Sciences, U. T. El Paso, 1975

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