INVESTIGATION AND EVALUATION OF THE ROYAL FLUSH AND MEX-TEX MINES, AND ADJACENT AREA, HANSONBURG MINING DISTRICT, SOCORRO COUNTY, NEW MEXICO

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by
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ABSTRACT

The Hansonburg mining district is in the northern part of the complexly faulted block of the Oscura range and the adjacent trough of the Jornada del Muerto in central New Mexico. Bedrock in the study area is mostly limestone and sandstone of upper Pennsylvanian age. These units have been broken by approximately north-south trending faults and fractures.

The ore deposits are relatively flat-lying bodies of barite, fluorite, and galena that have been formed by fissure and cavity filling accompanied by wall rock alteration of certain Pennsylvanian limestones. The ore deposits are closely associated with minor faults which have small vertical displacements and are related to major faults that served as master conduits for ore solutions. Fluid inclusions suggest the ore solutions were moderately to strongly saline brines and isotopic data identify the lead components as J-type, similar to Mississippi Valley type deposits.

Ore reserves (proven and probable) in the study area are estimated to be 4,750 tons; geologic evidence indicates potential concealed mineralization which may develop an additional 94,000 tons. Present value of the ore reserves combined with potential geologic tonnages is estimated to be $1,179,000.

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INTRODUCTION

The purpose of this study is to examine and evaluate ore deposits in and around the Royal Flush mine and the Mex-Tex mine, both of which are located in the Hansonburg mining district, Socorro County, New Mexico. The district has long been known as a source of barite, fluorite, and lead in New Mexico.

Field work consisted of the preparation of a reconnaissance geologic map encompassing about 1 1/2 square miles surrounding the Royal Flush and the Mex-Tex mines. Stope areas of the mines were also mapped at waist level at a scale of 1:600, using a Brunton compass and tape. The field work was carried out during the fall of 1971. Laboratory work consisted largely of microscopic examination of thin sections and polished sections prepared from samples collected in the area.

GEOGRAPHY

Location and Accessibility

The Royal Flush and the Mex-Tex mines are in the northern end of the Oscura Mountains in eastern Socorro County. The area may be reached by car by traveling 30.8 miles east from San Antonio on U.S. Highway 380 to the Bingham Post Office, turning south on a gravel road, and traveling 5.2 miles south, bearing left at each road fork. The area lies in sections 25 and 26 of township five south, range five east, and sections 30 and 31 of township five south, range six east (Figure 1).

Topography

The Hansonburg mining district is in the easternmost part of the Basin and Range province (Roedder, et al., 1968, p. 337). The district lies along the western face of the northern part of the Oscura Mountains. The Oscura range is a broken, eastward-tilted fault block. East of the Oscura Mountains the topography is lower and is dissected by numerous valleys cut into the Abo Formation. These valleys are bordered on the east by Chupadera Mesa. West of the Oscura Mountains is a broad north-south trending plain, the Jornada del Muerto or "Journey of the Dead," named by the Spaniards because of its inhospitable nature (Lasky, 1932, p. 14). It is a desert valley, described by Kottlowski (1953, p. 1) as an intermontane alluvial plain, which occupies a large part of eastern Socorro County. The Jornada del Muerto has an average altitude of approximately 5,200 feet. Oscura Peak rises to an altitude of 8,732 feet near the south end of the

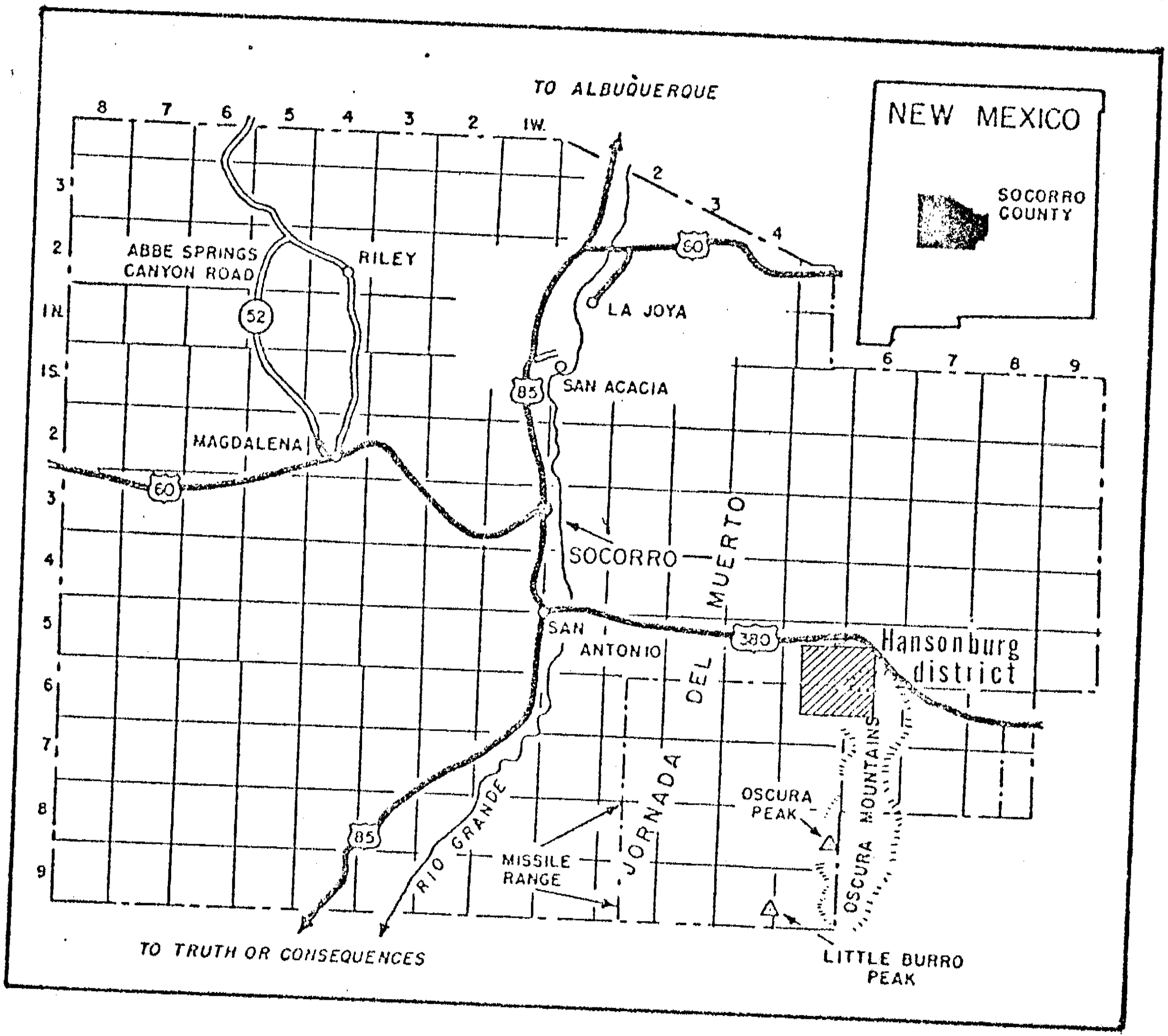


Figure 1: Index map of Socorro County. Shaded portion represents area of study.

range (Figure 1).

Julian Arroyo dissects the north end of the range, passing through the northern part of the study area, and drains westward onto the Jornada del Muerto. Gullies are abundant on hillside slopes. Julian Arroyo and the gullies are normally dry except during infrequent summer thunder showers.

Climate and Vegetation

The climate of the district is warm except during a few months in the winter. The climate is rather dry throughout the year as is typical of the arid southwest. Precipitation averages about 11 inches a year, with the period of greatest precipitation occurring between July and October; mean annual temperature is about 56°F.

Rocky Mountain juniper or "cedar," alligator juniper, and mountain mahogany dominate the vegetation at higher altitudes. At lower altitudes, such as the Jornada del Muerto, sagebrush and cactus are prominent.

HISTORY AND PREVIOUS INVESTIGATIONS

Mineralization in the Hansonburg mining district was first discovered by Higgins in 1872 and the district received its name from a prospector named Hanson (Jones, 1904, p. 103). Several prospect pits and mines were developed in the past. Mines that are present in the study area are described below and the locations of the mines are indicated on the geologic map, Plate 1. Production figures for each mine are not available, but it is estimated that more than 33,000 tons of ore have been mined from the study area.

The Royal Flush mine. The mine was first developed as an open cut at approximately the middle of a north-south trending ore body. The cut is 100 feet long by 30 feet wide, and bears east into the hillside. From the east end of the open cut, an open stope about 400 feet long, 30 to 40 feet wide, and up to 20 feet high, was driven into the northern portion of the ore body. Several large pillars of ore were left in this stope for roof support. On the south side of the east face of the open cut, an adit, 14 feet wide by 12 feet high by 240 feet long was driven, bearing S.3°W along the southern portion of the ore body.

A minor fault having a vertical displacement of about 40 feet bounds the west side of the stope and the adit, and the ore body is on the up-thrown side of the fault (Plate 3).

Kottlowski (1953, p. 6) reported that ore from the Royal Flush mine contained from 30 to 55 percent barite, from 12 to 23 percent fluorite, and about 5 percent galena in a gangue of quartz and limestone.

The Mex-Tex mine. The mine is known as the "upper Mex-Tex

Plate 3: North stope of the Royal Flush mine, looking north. Dashed line indicates fault plane.

workings." Most of the northwest portion of the ore was mined by open cut. An open stope, 50 feet wide, 18 feet high and 350 feet long, was opened southeastward along the ore body. Almost all the ore at the mine was removed, except for pillars, and small amounts of ore along the southeast stope wall.

A minor fault marks the northeast side of the stope, and displacement on the fault is approximately 60 feet (Plate 4). The ore here is also on the up-thrown side of the fault.

Samples from the Mex-Tex mine were analysed by F. E. Williams (1964, p. 43); the ore consisted of 58.8 percent barite, 11.8 percent fluorite, 19.3 percent SiO_2, and 9.1 percent $CaCO_3$.

The Mountain Canyon Mine. An open stope was driven along a fault zone, that strikes approximately S.5°W. Entrance to the stope is through a short opening, 15 feet high by 20 feet wide, that extends westward from an open cut at the foot of a hillside. Analyses of ore from the mine are not available.

The Ora mine. The Ora mine was opened through a 12-by 12-foot adit, 45 feet long and bearing N.45°E. The mineralization occurs along fractures and bedding planes. No ore has been produced from the mine and no assays of the mineralized materials have been made.

The Hickey No. 1 mine. The mine was developed as a 200 foot long open cut along the west slope of the Oscura Mountains. The floor of the open cut exposes a 10-foot wide zone of barite stringers in limestone paralleling the long axis of the open cut. No significant amount of ore has been produced, and assays of the mineralized materials are not available.

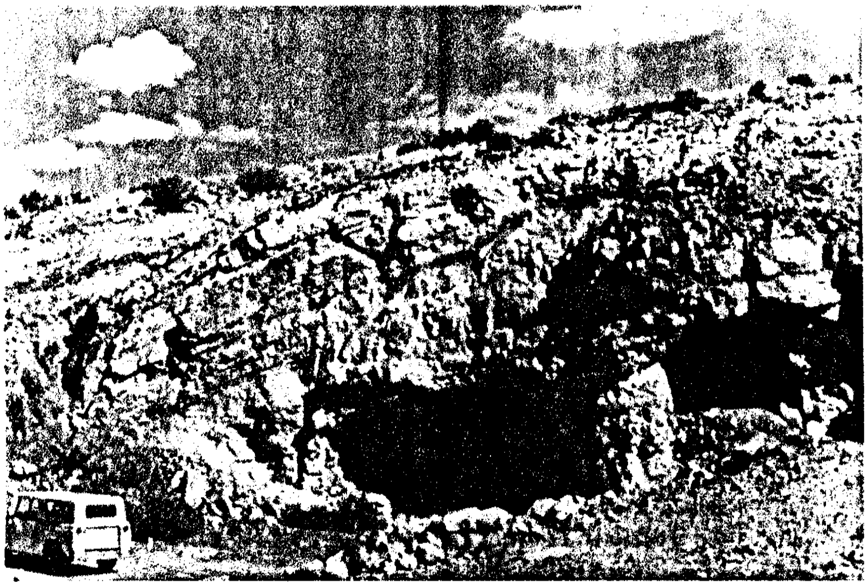


Plate 4: Northern working of the Mex-Tex mine, looking east. Dashed line indicates fault plane.

Most of the mines in the district have been abandoned for several years. The most recent mining activity was in 1966. Recently, Basic Earth Science System, Inc. of Colorado has conducted exploration and drilling work in the district and expects to resume mining operations in the near future.

Previous investigations of the Hansonburg mining district are summarized as follows:

Lindgren, Graton, and Gordon (1910, p. 203) briefly mentioned lead and copper deposits in the western front of the Oscura Mountains.

Johnston (1928) investigated the Hansonburg lead mine and reported that the ores occurred as fissure-fillings in the Magdalena limestone which rested directly upon Precambrian granite. He also examined the mine workings and milling operations in the area.

Lasky (1932, p. 63-73) examined the Hansonburg mining district, and reported that the mineralization was chiefly open-space filling and replacement of limestone host rock by silica along fault zones. He also reported the presence of dolomite as a replacement gangue mineral.

Rothrock, et al. (1946, p. 175-176) investigated the McCarthy lead mine which was owned by F. L. Blanchard of Roswell, New Mexico. He reported that deposits of quartz, fluorite, barite, calcite, and galena occurred along faults.

Clippinger (1949, p. 17) examined fluorite deposits at the Mex-Tex and Royal Flush mines, and reported the fluorite was deposited in the interstices of silicified fault breccia.

Kottlowski (1953) studied the Mex-Tex property, and reported the ore bodies were open-space fillings in fissures, fault breccia, and small caves. He also pointed out the banded structure, a characteristic of much of the ore.

Austin and Slawson (1961) studied lead isotopes obtained from the Blanchard mine to determine the geologic environment of the ore deposits.

Kopicki (1962) studied the paragenesis of hypogene and supergene minerals in the northern part of the Hansonburg district.

Williams (1964, 1966) described barite and fluorspar deposits and associated mine workings in the Hansonburg mining district.

Roedder, et al. (1968) published their work on fluid inclusions obtained from the Mex-Tex mine, and reported that the ores were open-space fillings in fissures and solution channels in limestone adjacent to faults.

GEOLOGY

Stratigraphy

The area mapped during this investigation contains sedimentary rocks assigned to the upper Pennsylvanian system. These rock units are principally marine limestones and calcareous shales with a few interbedded sandstone layers. Limestone layers are more resistant than shale or sandstone beds, and where exposed in valley walls, the limestones form prominent, near-horizontal ledges and near-vertical cliffs. Shales and sandstones, however, are generally mantled by less-steep accumulations of slope wash and talus. Neither igneous nor metamorphic rocks are exposed in the area, but small, irregularly-shaped intrusive masses of monzonitic composition are exposed to the north and northwest of the area. Granite, schist, quartzite, rhyolite, and granitized metasediments of Precambrian age crop out to the south of the area. Sandstones, shales, and limestones of Permian age are exposed to the north and northeast (Wilpolt and Wanek, 1951, map sheet 1).

Pennsylvanian Strata

Rock units in the area studied were mapped using Thompson's terminology (1942, p. 55-83). The mapped units, in proper stratigraphic sequence are shown in Figure 2, and their distribution is shown on the geologic map (Plate 1).

Since only the upper part of the Bolander Group is exposed in the mapped area, no attempt has been made to differentiate it from the overlying Coane Formation on the geologic map.

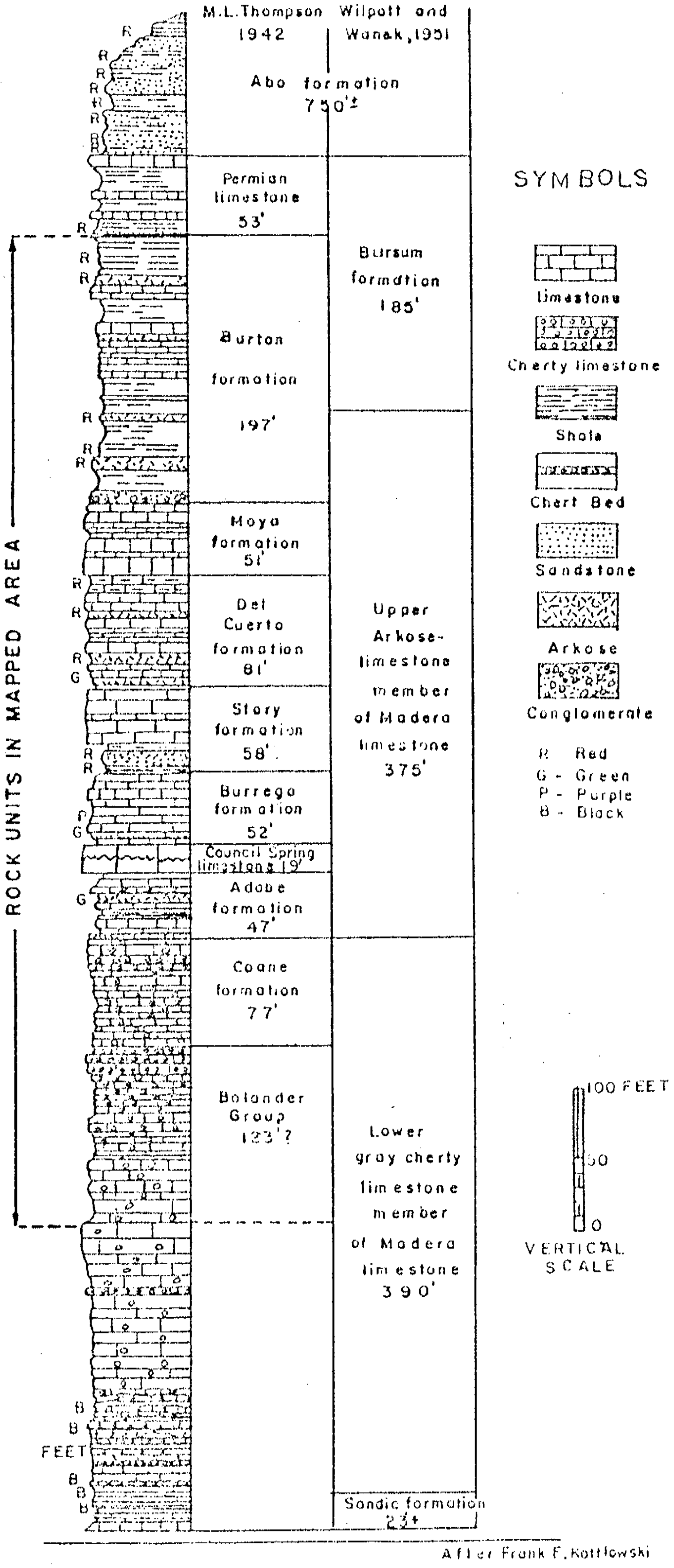


Figure 2: Stratigraphic section of rock units in mapped area. After Kottlowski, 1953.

Bolander Group and Coane Formation.

The upper part of the Bolander Group of the upper Des Moines Series and the Coane Formation of the Missouri Series represent the oldest rocks mapped. Approximately the lower two-thirds of the Bolander Group is covered by alluvium throughout the area. The top of the Coane Formation is a bluish-gray nodular limestone approximately 10 feet thick (Figure 2). The combined thickness of the exposed portions of the Bolander Group and the Coane Formation is about 90 feet. Owing to the prevailing near-horizontal attitudes of these units, their more resistant beds form prominent ledges and cliffs where exposed in valley walls.

Most of the Bolander-Coane stratigraphic interval consists of thick- to medium-bedded, gray limestones. The limestones are fine-grained, dense and hard, and their weathered surfaces develop a pitted texture. Chert nodules are scattered throughout the limestones, but they are most numerous in the limestones of the upper part of the Bolander Group (Hambleton, 1954, p. 5). The nodules weather to dark brown, are roughly lenticular in shape, and rarely exceed three inches in maximum dimension.

Fusulinids assigned to the genera Triticites and Waeringella were reported in the limestone beds of these two units (Thompson, 1942, p. 61).

Adobe Formation

The Adobe Formation of the Missouri Series is approximately 47 feet thick and rests conformably on the Coane Formation. The base of the Adobe Formation is a greenish, arkosic sandstone approximately five feet thick. The uppermost bed in this formation is a thin, greenish-gray shale approximately four feet thick.

The Adobe Formation consists of interbedded limestones, shales, and sandstones. The limestones are thin-bedded and are gray on both fresh and weathered surfaces. Chert is exposed as irregular masses on weathered surfaces of the limestone beds in the upper part of the formation. Brachiopod and fusulinid remains are scattered through all of the limestone beds in the section.

The shales are calcareous and exhibit a prominent fissility. Exposures of shales in the area weather a light-brown color but are gray to black on fresh surfaces.

The sandstones are greenish on fresh surfaces and weather to brownish tones. They are medium to fine-grained and are arkosic in composition, containing pink angular feldspar grains, rounded quartz grains and small flakes of mica.

Council Spring Limestone

The Council Spring Limestone of the Missouri Series is approximately 19 feet thick and rests conformably on the Adobe Formation. This formation is a single unit of limestone and it forms prominent ledges and cliffs along valley walls throughout most of the study area. Joints, oriented nearly perpendicular to the upper and lower surfaces of this unit, are widespread and they are particularly evident at outcrops where they have been subjected to more rapid weathering than the surrounding limestone. The resulting columnar-like appearance of this unit makes it the most distinctive formation in the area.

The limestone is light-gray to white on fresh surfaces and brownish-gray on weathered surfaces. It is medium- to fine-grained, dense and hard, and it contains scattered, translucent rhombic crystals of recrystallized calcite. These calcite crystals are approximately 1-2 mm in greatest dimension. Fossils reported in the limestone consist of fusulinids of genus Triticites (Thompson, 1942, p. 62).

Much of the mineralization in the area occurs in fractured zones of the Council Spring limestone.

Burrego Formation

The Burrego Formation of the Missouri Series is approximately 52 feet thick and rests conformably on the Council Spring Limestone. The basal unit of the Burrego Formation is a nodular, fossiliferous limestone approximately five feet thick. The uppermost bed in this formation is a thin, gray nodular limestone approximately two feet thick (Figure 2).

The Burrego Formation consists almost entirely of limestones that range from massive to thin-bedded. Thin nodular limestone interbeds occur throughout the section and a thin shale bed also is present.

The massive to thin-bedded limestones are mostly gray to light gray on both fresh and weathered surfaces; however a few of the thinner limestone beds are relatively brilliant in color, ranging through hues of purple to orange. The limestones are medium to fine-grained, dense, and hard. Chert nodules were identified in the limestone beds near the middle of the formation. A thin, bluish-gray limestone bed near the base of the formation is characterized by a rough, sand-like texture that has developed on weathered surfaces.

The nodular limestones are gray to bluish gray on fresh surfaces and they weather to light brown. They are medium to fine-grained, dense and hard, and highly fossiliferous. Exposures of the nodular limestones are intensely weathered and ovoid or lenticular shapes with their longer dimensions approximately parallel to the bedding have developed.

The thin shale unit is gray, calcareous, fissile, and it locally exhibits reddish-brown spots on weathered surfaces.

Mineralization also is found in fractured zones in the lower part of the Burrego Formation.

Story Formation

The Story Formation of the Missouri Series is approximately 58 feet thick and it rests conformably on the Burrego Formation. The base of the Story Formation is a thin-bedded, reddish-brown, micaceous shale approximately five feet thick. The top of the formation is a thick light-gray limestone approximately 15 feet in thickness (Figure 2).

The Story Formation consists of two distinct stratigraphic intervals of contrasting lithology; (1) a lower 20 feet consisting of two thin-bedded shales separated by a thick sandstone bed and (2) an upper 38 feet comprised of two thick limestone beds.

The sandstone is reddish-brown on both fresh and weathered surfaces and it is prominently cross-bedded. It is medium to fine-grained and fresh exposures are dense and hard. The sandstone is arkosic in composition, containing rounded quartz grains, angular feldspar grains, and small flakes of mica. The Story sandstone is well exposed south of the Royal Flush mine, along Arroyo Julian where it forms the east bank of the arroyo.

The shales are gray to light brown on fresh surfaces and weather to reddish-brown. They are thin-bedded with a prominent fissility. Abundant mica flakes less than 0.5 mm in diameter occur in the shale.

The limestones are light-gray and coarse- to medium-grained. They are dense and hard, and develop a pitted texture on weathered surfaces. The limestones contain scattered fusulinids referred to the genera Triticites, Dunbarinella (?), and Pseudostaffella (?) (Thompson, 1942, p. 66).

Del Cuerto Formation

The Del Cuerto Formation of the Virgil Series is a series of limestone layers interbedded with arkosic sandstones and shales. This formation is approximately 81 feet thick and it rests conformably on the Story Formation. The base of the Del Cuerto Formation is a thin, reddish-brown shale approximately four feet thick, and the uppermost bed is a fossiliferous limestone approximately 10 feet thick (Figure 2).

The limestones are gray to bluish-gray on fresh surfaces and they weather yellowish-red to orange. They are thin-bedded, medium to fine-grained, dense and hard. Brachiopod, gastropod, coral, and fusulinid remains are abundant.

The sandstones are reddish-brown on both fresh and weathered surface. They are coarse- to medium-grained, and arkosic, containing rounded quartz grains, angular feldspar grains, and calcareous cement.

The shales weather to reddish-brown tones and they exhibit a prominent fissility.

Moya Formation

The Moya Formation of the Virgil Series is approximately 51 feet thick and it rests conformably on the Del Cuerto Formation. The base of the formation is a fossiliferous limestone approximately 20 feet thick, and the uppermost bed is a light-gray limestone bed approximately 7 feet thick (Figure 2).

The entire Moya Formation consists of thick to medium-bedded limestones. The limestones are gray to light-gray on both fresh and weathered surfaces. They are medium to fine-grained as well as dense and hard. Abundant fossil faunas of pelecypods, gastropods, and fusulinids are present.

Bruton Formation

Only the lower 75 feet of the Bruton Formation of the Virgil Series is exposed in the mapped area. The base of this unit is at the lower contact of a gray shale, approximately 10 feet thick. The uppermost exposed bed is a thin gray limestone.

The exposed interval consists of interbedded shales, sandstones, and limestones. The shales weather to purplish and greenish gray and are calcareous. They commonly exhibit a prominent fissility.

The sandstones are reddish-brown on fresh exposures, and they weather to dark-brown tones. They are coarse-grained, and arkosic, containing rounded to angular quartz grains and reddish-brown, angular feldspar grains. The cement is calcareous.

The limestones are light gray on both fresh and weathered surfaces. They are medium to fine-grained, dense, and hard. No fossils were found in these limestone beds.

Quaternary Alluvium

Most of the western portion of the area is covered with alluvium, consisting primarily of reddish sands and silts which were derived from the younger Abo Formation. Valley floors in other parts of the area, particularly along Arroyo Julian, are covered with gray to light brown silt, clay, sand, and gravel which are derived mostly from the Pennsylvanian rocks.

Structure

Faults

The major structural features in the study area and the surrounding region are the complexly faulted block of the Oscura range and the adjacent trough of the Jornada del Muerto (Figure 1). Major faults in the region trend approximately north-south, and a steep, west-facing fault-line escarpment has developed on the Oscura block. The beds in the upthrown (Oscura) block have gentle dips to the east; the down dropped (Jornada) block on the west underlies a broad alluvium-covered valley.

Faults within the area may be grouped into two classifications; (1) major faults which have large vertical displacement, and can be traced for several miles; (2) minor faults with small vertical displacement, usually less than 100 feet, which can be traced only for relatively short distances.

Three major faults were identified within the area (Figure 3). The Oscura fault (Fault 1, Figure 3) is west of the study area, strikes roughly N.15°E, and is mostly concealed by alluvium. The throw of the fault decreases from south to north and dies out a few miles north of the study area. The exact vertical displacement along the fault is unknown but may be several hundred feet.

The second major fault (Fault 2, Figure 3) is located about a mile east of the Oscura fault. The fault trends approximately north-south

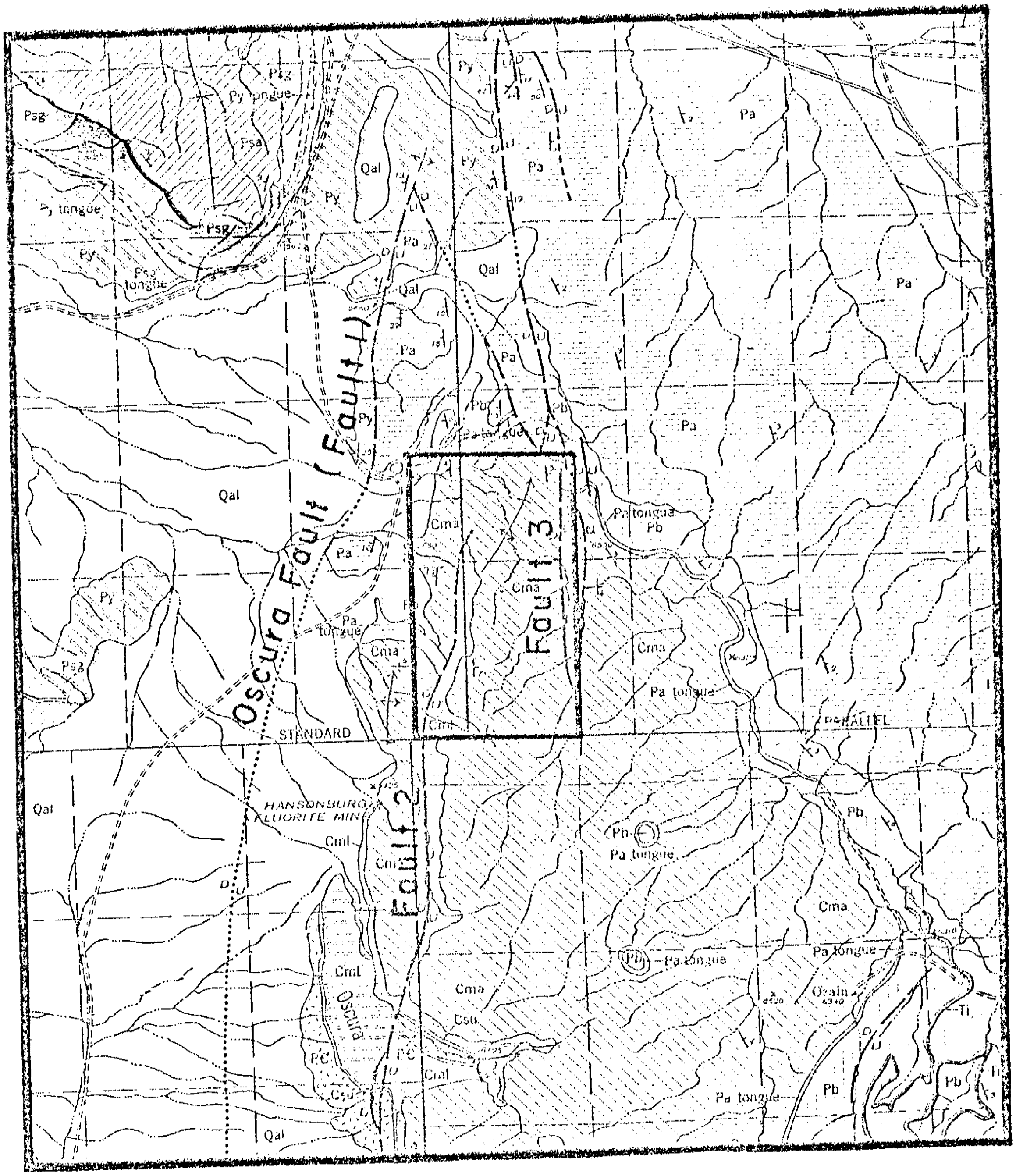


Figure 3: Geologic map showing the major faults associated with the investigated area (shown by the central rectangular outline), and their relation to the structure of the surrounding region. After Wilpolt and Wanek (1951).

where it enters the study area at the southwest corner. The west side is downthrown about 550 feet (Kottlowski, 1953, p. 6), and the fault curves to the east before dying out in the southwest corner of section 30.

The third major fault (Fault 3, Figure 3) is located about one mile east of Fault 2. Fault 3 trends approximately north-south, entering the area from the north at the northeast corner. Fault 3 splits into two roughly parallel faults before dying out at the southeast corner of the mapped area.

The minor faults in the area are the result of movement along the major faults, and their trends are parallel or subparallel to those of the major faults. Vertical displacements are small, ranging from a few feet to about 100 feet. The mineralized fault at the Royal Flush mine has a vertical displacement of about 40 feet, and vertical displacement on the mineralized fault at the Mex-Tex mine is about 60 feet. Most of the minor faults in the area are normal faults whose displacements die out rapidly along the strike.

Joints and Fractures

Joints and fractures are abundant in bedrock occupying the northern part of the area. All of the joints are less than 1 inch wide. The best exposures of these features can be observed on bedding surfaces of the Del Cuerto Formation, in the northwest part of the study area (Plate 1). The joints occur in two intersecting sets with one set striking from north to N.42°E, and another set striking from north to N.15°W. Field evidence regarding age relationships of these two sets is contradictory, hence the joint sets may be contemporaneous (Plate 5).

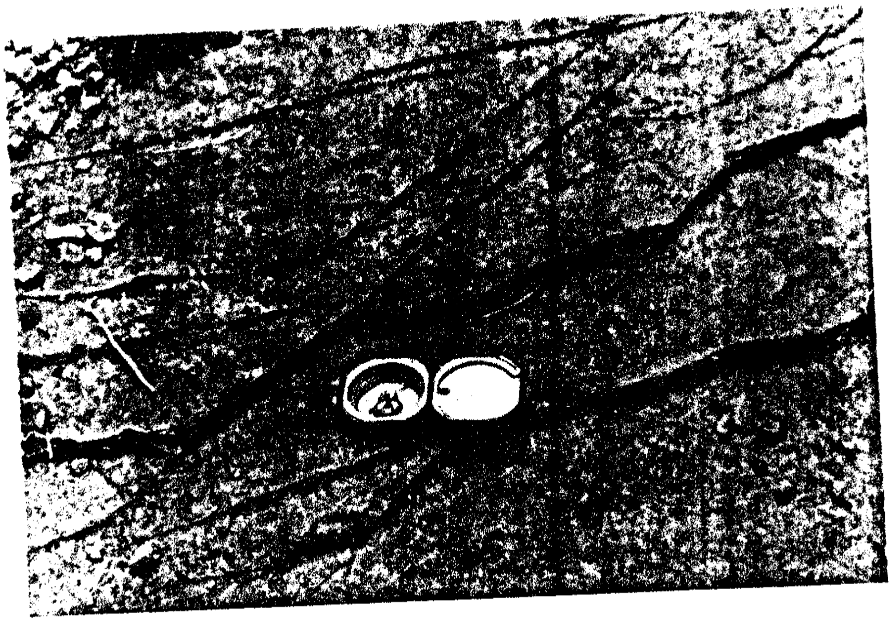


Plate 5: Intersecting sets of joints in the Del Cuerto Formation. Looking southeast.

ORE DEPOSITS

General Features of the Ore Deposits

The Royal Flush Mine, the Mex-Tex Mine, and three other small mines are in the study area (Plate 1). Most of the mineralization at these mines occurs in the Council Spring Limestone and the lower part of the Burrego Formation (Plate 6). Small mineralized zones occur locally in the Del Cuerto Formation, the Story Formation] the Burrego Formation, the Council Spring Limestone, and the Coane Formation (Appendix I, drill holes 1, 4, 5, 7, and 8).]

The ore deposits are open-space fillings (Kottlowski, 1953, p. 8). The ore minerals were deposited in irregular- or tabular-shaped vugs and cavities which had been formed by dissolution of brecciated limestone. The size of these openings where recognized, ranged from fractions of an inch up to 10 feet in the greatest dimension.

The mineral deposits occur along, or adjacent to minor faults. They are wedge- or crescentic-shaped in cross-section and have an elongate tabular to oval shape in plan (Plate 6). The longest axes of the deposits parallel the faults, and the deposits are roughly conformable with the bedding. The deposits vary greatly in size. Small, irregular mineralized zones occur in brecciated zones along minor faults in several of the formations. The larger deposits, which have been of economic importance, range from 25 to 85 feet in width, 4 to 15 feet in height and from 100 to 450 feet in length (Plate 6). These larger bodies have occurred mostly in the Council Spring Limestone and the lower part of the Burrego Formation.

The primary minerals of the deposits are barite, fluorite, quartz, galena, calcite, gypsum, chalcopyrite, sphalerite, and pyrite. Many of these minerals occur as large, euhedral crystals, however the crystals are commonly fractured. Silicification is prominent within and adjacent to the ore bodies, and silicified zones are found locally along the minor faults and fractures.

Minerals of the Deposits

Barite has been the principal ore mineral mined in the past. Fluorite also has been produced, but it apparently occurs in considerably lesser quantities than barite. The only sulfide mineral recovered in the area was galena, a lead ore. Where present, galena composed about five percent of the ore. The galena also contains silver, a small amount of which was once obtained from the Hansonburg area (Lasky, 1932, p. 68).

The minerals described below, arranged according to indicated abundance, are primary minerals which are found in the area. Many secondary minerals, products of alteration or supergene enrichment, have been identified but they have little significance regarding the origin of the ores, and are not considered further.

Barite ($BaSO_4$). Barite is the most abundant ore mineral in the area, comprising from 30 to 55 percent of the ore at the Royal Flush mine (Kottlowski, 1952, p. 7), and an average of 58.8 percent at the Mex-Tex mine (Williams, 1968, p. 41). Barite occurs mostly in the central part of the filled vugs and cavities where it forms both as bladed and tabular crystals. Individual crystals having a greatest dimension of as much as six inches are common. Barite occurs in three colors, white, brown, and tan. The white barite has a high strontium content (Kopicki, 1962, p. 45) while the brown and tan shades are partly the result of discoloration by iron oxides. Under the microscope, the barite crystals exhibit irregular tabular grain boundaries. The boundary irregularity could be the result of interference with late stage replacement by fluorite, quartz and calcite crystals.

Fluorite (CaF_2). Fluorite is the second most abundant mineral in the area, comprising from 12 to 23 percent of the ore at the Royal Flush mine (Kottlowski, 1953, p. 7), and 11.8 percent of the Mex-Tex mine ore (Williams, 1964, p. 41). Two modes of fluorite occurence have been noted; (1) in silicified limestone surrounding filled vugs and cavities; (2) as open space fillings of vugs and cavities. In the silicified limestone, fluorite occurs as scattered small irregular or cubic crystals surrounded by cryptocrystalline quartz; this phenomenon can be best observed under the microscope. In the vug and cavity fillings, fluorite occurs as cubic and octahedral crystals as much as two inches across. According to Roedder, et al., (1968, p. 338), single crystals of fluorite grew in five distinct stages. The earliest stage (I) occurs as nearly round, pale green crystals coated with parallel, multiple-stepped cube facets. These appear externally corroded, and have an internal zonal pattern that superficially appears to be the result of repetitive leaching and deposition. This early stage fluorite was covered by well-formed cubes of the same pale green color, forming the second stage (fluorite II). An overgrowth of cloudy, very slightly greenish-white fluorite represents the third stage (fluorite III) and is followed by limpid blue and blue-green fluorite of stage four (fluorite IV). Finally a very sparse lavender to purple fluorite, with blue bands, designated as stage five forms mainly as a thin film over the earlier crystals (fluorite V).

Quartz (SiO_2). Quartz has been identified in the deposits in three modes of occurrence; (1) as silicification of limestone host rock, (2) as larger crystals filling cavities and (3) as late stage drusy crystals coating the earlier-formed minerals.

In the first mode of occurrence, quartz occurs as cryptocrystalline prisms disseminated in the limestone. Under the microscope, the quartz crystals are approximately 0.1-0.2 mm across. Most of these quartz crystals contain minute grains of unaltered calcite, commonly near the center of the crystals. Plate 7 is a photomicrograph showing quartz crystals in material from a silicified limestone at the Royal Flush mine. This type of quartz is quite similar to "jasperoid" quartz crystals found in the Tri-State district and other Mississippi Valley type districts.

In the second mode of occurrence, quartz occurs as larger crystals with their greatest dimensions up to two inches across. This mode is found throughout the filled vugs and cavities, and is commonly arranged in comb structure as shown in Plate 8.

In the third mode of occurrence, quartz occurs as minute crystals coating the surfaces of barite and fluorite masses. This quartz belongs to a late stage of deposition.

Galena (PbS). Galena is visible in most of the deposits in variable quantities, comprising as much as five percent of the ore at the Royal Flush mine (Kottlowski, 1953, p. 7) and lesser amounts in the other

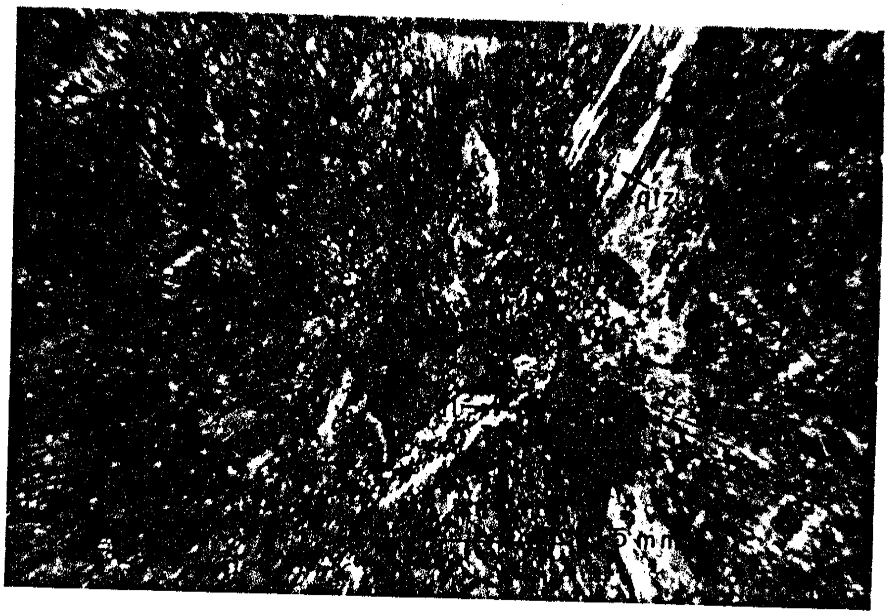


Plate 7: Photomicrograph showing the relationship of calcite and quartz in a silicified limestone at the Royal Flush mine; qtz = quartz, cal = calcite.

Plate 8: Photomicrograph showing comb quartz deposited in filled vugs.

eralized occurrences. It occurs chiefly with fluorite, to a lesser ent with barite and rarely with both. Galena occurs in two modes of osition: first, in minor amounts as small (1-2 mm) cubic crystals, rounded by cryptocrystalline quartz in silicified limestone; second, ccarsely crystalline individual cubes as much as two inches across owing as fillings in vugs and cavities.

Most of the galena crystals show surface oxidation to anglesite, russite, and covellite to depths of less than 1 mm. Plate 9 shows a lished surface of irregular layers of anglesite with covellite laths tween them. Lasky (1932, p. 68) reported microscopic crystals of what y be argentite (Ag_2S) in galena.

Calcite ($CaCO_3$). Calcite is the principal mineral of the host cks of the deposits and also occurs as crystals in the open-space lling deposits. The crystals exhibit a variety of habits and range size from 1 mm up to 5 cm in greatest dimension. Translucent rystals and various shades of cloudy white to light brown aggregates re common. Under the microscope, small (1-2 mm) irregular crystals f calcite commonly fill the interstices between older quartz, fluorite, nd barite (Plate 10). Some of this calcite may represent post mineralzation solution and deposition of limestone host rock.

Gypsum ($CaSO_4 \cdot 2H_2O$). Gypsum is present in the silicified host rocks nd the mineral bodies in trace amounts only. It is identified in silicified limestone as small irregular grains ranging from 0.05 to 0.1 mm in reatest dimension. Gypsum is always associated with cryptocrystalline quartz, a relationship which makes it difficult to identify, even under the microscope. Gypsum has not been found in the vugs and cavities.

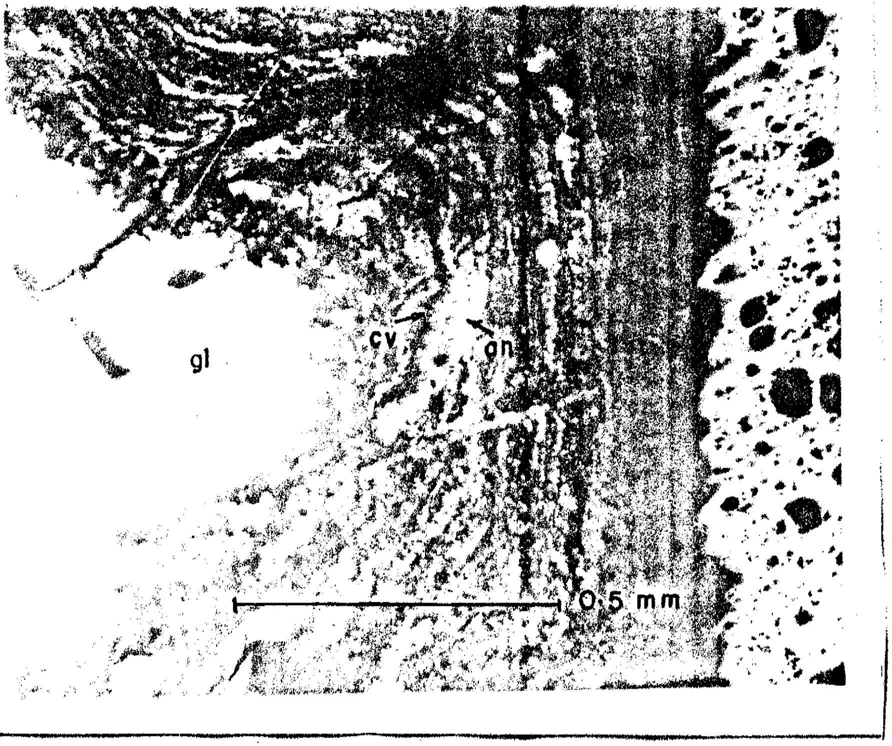


Plate 9: Photomicrograph of a polished surface showing typical relationship between galena and its oxidized products, anglesite and covellite; gl = galena, an = anglesite, cv = covellite.

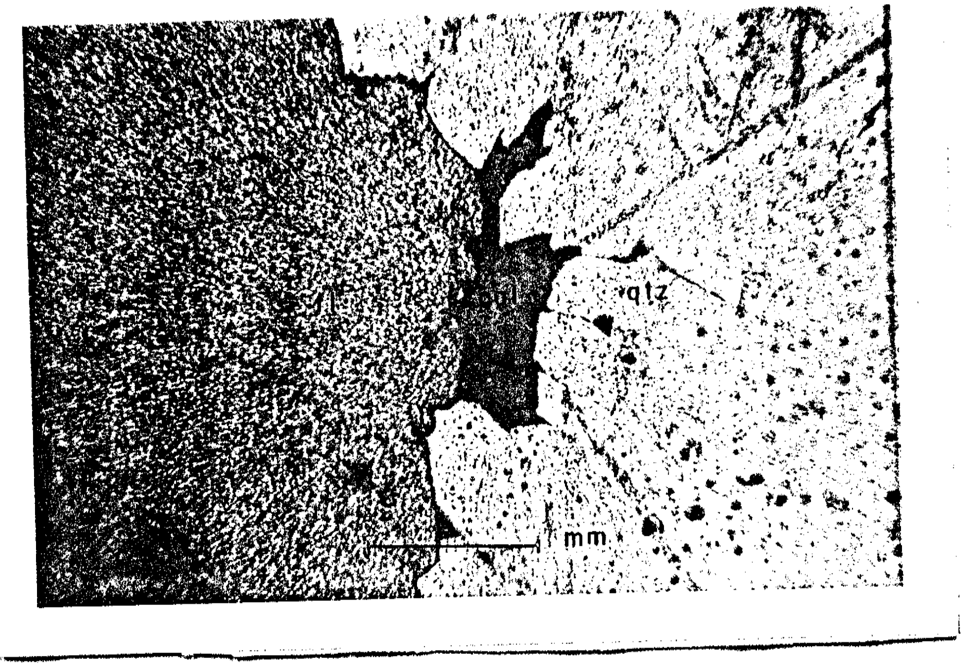


Plate 10: Photomicrograph showing calcite filled interstitially between quartz and fluorite grains in a vug; fl = fluorite, qtz = quartz, cal = calcite.

Chalcopyrite ($CuFeS_2$). Trace amounts of chalcopyrite were recognized in the ore at the Mex-Tex mine. The grains rarely exceed 1.0 mm in their greatest dimension and are commonly associated with cryptocrystalline quartz. Chalcopyrite has been altered to goethite ($Fe_2O_3 \cdot H_2O$) along the periphery and in the fractures of larger grains, while alteration of smaller grains is usually complete. Plate 11 shows a typical relationship between these two minerals.

Sphalerite (ZnS). Sphalerite is present in the ores in trace amounts, occurring usually as minute crystals less than 0.5 mm across. Sphalerite crystals are commonly surrounded by cryptocrystalline quartz.

Pyrite (FeS_2). Pyrite is present in the ores in trace amounts. Under the microscope, it occurs as rounded to oval grains with the greater dimension ranging from 0.01-0.02 mm; it is commonly surrounded by cryptocrystalline quartz.

Roedder, et al., (1968, p. 338) reported the presence of tetrahedrite, siderite, and ankerite as hypogene minerals but provided no paragenesis or descriptions. During the present investigation these minerals were not recognized.

Texture of the Ore Deposits

The predominant megascopic feature of the ore deposits is a layered pattern. It is characterized by a texture which, in cross section, appears to consist of alternating layers of galena, fluorite, and barite crystals and gray silicified limestone. The thickness of these layers ranges from one to four inches. In three dimensions this texture consists of plate-like masses of galena, fluorite, and barite in

Plate 11: Photomicrograph showing chalcopyrite altered to goethite; cp = chalcopyrite, go = goethite.

alternate, parallel arrangement with silicified limestone. The layering gives a markedly banded appearance to exposed surfaces as shown in Plate 12. This banded texture was suggested by Roedder, et al., (1968, p. 336) to be similar to the banded texture of fluorite deposits, locally termed "coontail," in the Cave-in-Rock district, Illinois.

A noteworthy feature of the fluorite and galena layers is their prevalent crustification or comb structure. Where crystal growth has been incomplete the layers are marked by irregular vugs and cavities (see Plate 12). The layered structure is enhanced by the contrast in grain size between the very fine grained, dense silicified limestone and the more coarsely crystalline galena and fluorite zones.

A study of several thin sections reveals a distinctive microscopic serrate texture. It is characterized by irregular contacts between mineral grains. Most barite crystals show irregular grain boundaries, especially when in contact with fluorite. Some fluorite and gypsum crystals also show this serrate texture.

Genetic Sequence

The primary mineralization sequence in the area studied is shown in Figure 4 and Figure 5. Figure 4 shows the sequence of mineral deposition reported by Roedder, et al., (1968, p. 338) from a study of the mineral relations at the Mex-Tex mine. Paragenetic study by the author of minerals from the Royal Flush and Mex-Tex mines has not revealed any difference in the paragenetic sequence reported by Roedder, et al. The late-stage filling by calcite and the widespread association of gypsum with the silicified limestones suggest the positions shown in Figure 5. Calcite filling interstices between ore minerals is clearly

Plate 12: Banded ore at the Royal Flush mine.

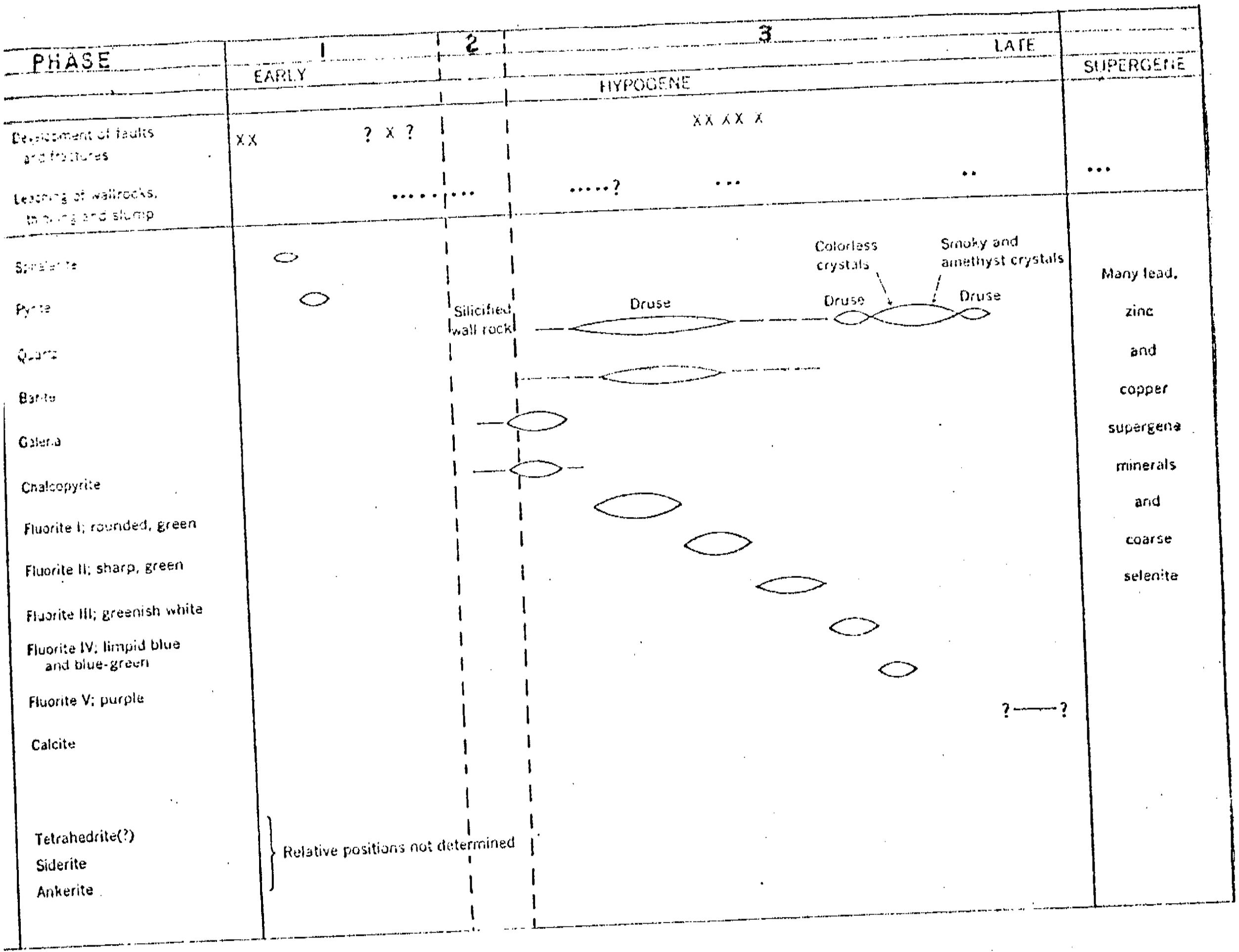


Figure 4: Paragenetic sequence of minerals in the Hansonburg district, Socorro County, New Mexico. After Roedder, et al. (1968, Figure 1).

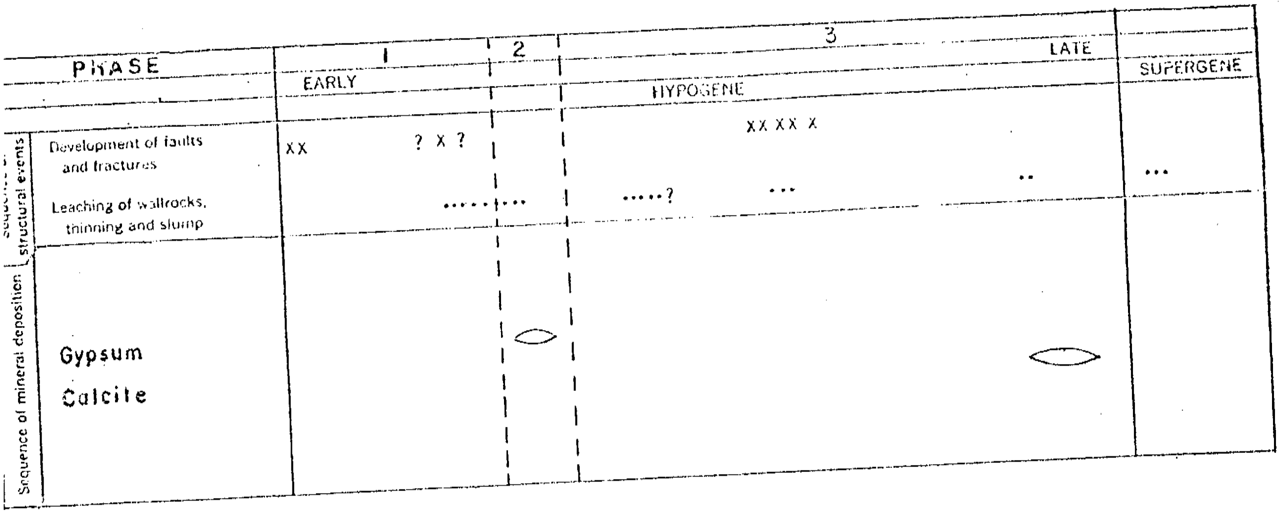


Figure 5: Additional genetic relationship derived from the present investigation by the author.

later than much of the mineralizing activity. Accordingly, it is placed last in the sequence in Figure 5 in agreement with the position suggested by Roedder, et al. (Figure 4).

The mineralization sequence apparently was continuous but it is divided into three phases for convenience in reference and description.

The first phase was marked by development of faults and fractures in the limestone host rock followed by the introduction of small amounts of sphalerite and pyrite. This was followed by dissolution of the limestone host rock adjacent to joints and fractures to form vugs and cavities. Minor fracturing also took place at the end of this phase. In the second phase, silicification of the wall rocks occurred with the addition of cryptocrystalline quartz, accompanied by small amounts of galena and gypsum. The third phase is marked by the replacement of locally undissolved parts of the limestone by fluorite, and the deposition of fluorite, galena, barite, quartz, and calcite in the vugs and cavities. Large amounts of fluorite and galena, and trace amounts of barite and quartz were deposited as coatings on the walls of the openings. Further deposition of barite, quartz, late fluorite and calcite followed, with successive layers forming progressively toward the center of the vugs and cavities. Calcite was the last hypogene mineral deposited in the sequence. Minor fracturing took place during the third phase.

Silicification

Metallic and nonmetallic ore minerals are often found where silica (SiO_2) has replaced the original substance comprising the rock--a process called silicification. Silicification is a common form of

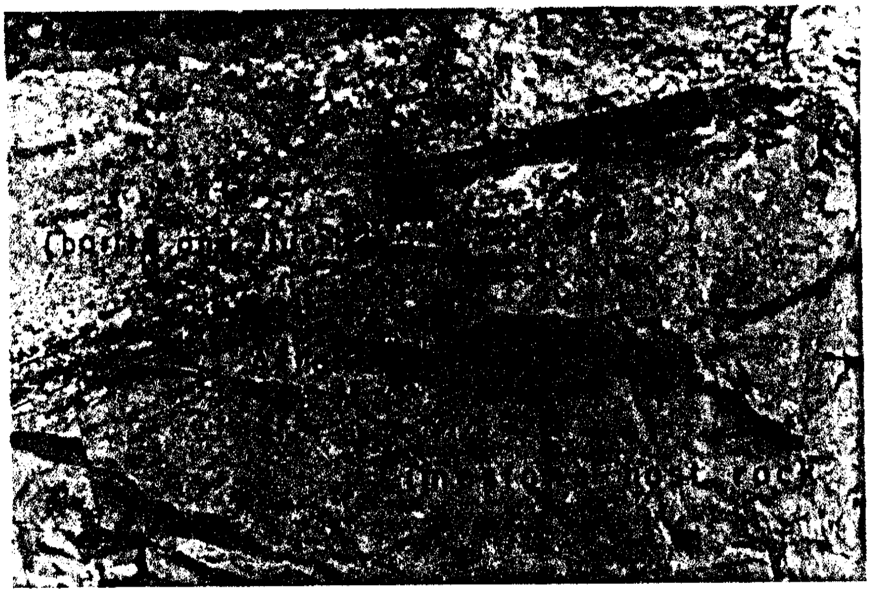


Plate 13: Wall rock alteration at the Royal Flush Mine.

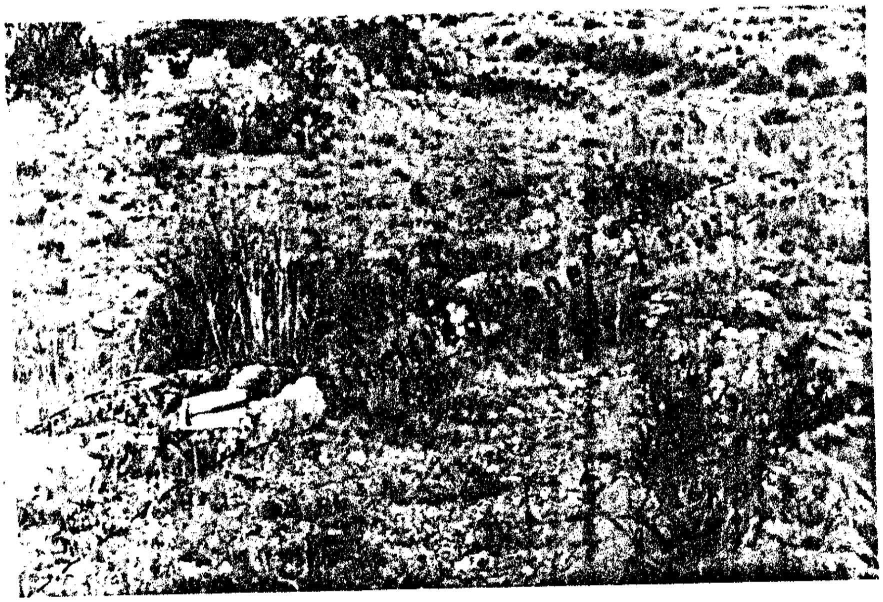


Plate 14: Silicified zone exposed on the ground surface, north of the Mountain Canyon mine.

where concentrations of 15 to 20 weight-percent or more salts, and an average of 18 percent was reported (Roedder, 1967, p. 552). The lower salinities of ore fluids in the Hansonburg district, however, are still higher than those of ore fluids of magmatic hydrothermal deposits which show concentrations of well under 10 weight-percent dissolved salts and average less than 5 percent (Roedder, 1967, p. 552).

Roedder, et al. (1968, p. 347) indicated that the solutions were increasing in salinity during ore deposition; they suggested that this phenomena was due either to the flushing out of earlier fluids by new, more saline fluids introduced from below, or by progressive dewatering resulting from compaction of shales in a sedimentary basin.

The temperatures of formation of the various ore minerals found in the study area, as determined by Roedder, et al. (1968, p. 336) fall within a narrow range from 185° to 205°C. The temperatures show a slight uniform decrease during much of the depositional sequence; however during crystallization of barite a sharp drop in temperature of formation is indicated.

The temperatures of formation determined from studies of Hansonburg ores are considerably higher than those given for minerals from deposits of the Mississippi Valley type. Temperatures of formation of Mississippi Valley type deposits have been reported to range from 52°C to 185°C with most being less than 145°C (Roedder, 1967, p. 553). Figure 6 compares temperatures of formation of the Hansonburg deposits to some other well-known Mississippi Valley type occurrences. Temperatures of formation for ore deposits in the Hansonburg district are considerably higher, and thus many geologists are reluctant to classify them as

Locality of Deposit	Temperature Range (°C) and Source of Data
Pine Point, Canada	50-100 (Roedder, 1968)
Central Kentucky	72-132 (Roedder, 1969)
Upper Mississippi Valley (Wis., Ill., and Ia.)	46.2-121 (Erickson, 1965)
Tri State district (Mo., Kans., and Okla.)	115-135 (Newhouse, 1932)
Cave-in-Rock district, Ill.	94-142 (Freas, 1961)
Hansonburg district, N. M.	186-205 (Roedder, et al., 1968)

Figure 6: Table of Temperatures of Formation of Mississippi Valley Type Lead-Zinc Deposits from Fluid Inclusion Studies

Mississippi Valley type deposits. However, other characteristics, such as mineralogy, textures and structures of the ores, composition of the ore solutions, and lead isotope relationships are similar.

Lead Isotopes

Work by Austin and Slawson (1961, p. 1132-1140) on isotopic analyses of single galena crystals from the Blanchard mine, a deposit about one-half mile south of the area studied, indicated that the lead ore is characterized by J-type lead. J-type lead is enriched in radiogenic isotopes relative to non-radiogenic Pb^{204} and is a common characteristic of Mississippi Valley type deposits. Austin and Slawson (1961, p. 1135) measured a lower content of radiogenic lead in the rims as compared to the centers of single galena crystals; they interpreted this to mean that the mineralizing solutions apparently contained less radiogenic lead as the end of deposition was approached. They suggest two possible theories to explain changes in the isotopic composition of lead ores with continuing deposition. The first theory is that radiogenic lead probably was collected as a contaminant by ore fluids as they passed through whatever country rock intervened between the source of the fluids and the site of ore deposition. Thus the early fluids that traveled through a permeable zone should extract relatively large quantities of radiogenic lead from that zone. Later fluids passing through the same volume should encounter a decreasing amount of extractable radiogenic material and thus should show corresponding decreases in their radiogenic content as time progresses.

The second theory is based upon the assumption of an isotopically nonhomogeneous source for the mineralizing solutions. When the ore solutions leave the source area, the readily mobilized radiogenic lead components leave the source in the early solutions, and the radiogenic content of the ore solutions should again decrease with increasing time. (Radiogenic lead, occurs in spaces between rock mineral grains and not in rock mineral structures, hence it is more mobile than that lead tied into the molecular structures of the rocks comprising the fluid source area and/or the wall rocks of the fluid conduits).

OK?

Associated Igneous Rocks

Roedder, et al., (1968, p. 337), in the paper on the environment of ore deposition at the Mex-Tex mine, state: "The Hansonburg Mining District lies along the margin of the central craton in which the alkalic suite of igneous rocks is most abundant." Alkalic hypabyssal intrusions of Tertiary age crop out as stocks and dikes 30 miles east of the district in the Carrizo Mountains of southwestern Lincoln County (Griswold, 1959, p. 13; Perhac and Heinrich, 1964, p. 226; Roedder, et al., 1968, p. 337), and alkalic trachytes of late Cretaceous or early Tertiary age crop out in the Gallinas Hills, 36 miles northeast of the district (Perhac and Heinrich, 1964, p. 227; Roedder, et al., 1968, p. 337).

Near the study area, a sill of hornblende-sodaclase diorite crops out on a low knoll east of the dirt road to the Royal Flush and Mex-Tex mines, about one-quarter mile south of Highway 380 (Kottlowski, 1953, p. 6). Another igneous intrusive has been identified about one mile northwest of the area studied, west of the dirt road and about two miles south of the highway. This intrusive crops out as a dike (?) intruding Pennsylvanian limestone, and was identified as hornblende monzonite.

A monzonite dike crops out in the Jones Camp area, about 30 miles north of the Hansonburg District. An age date of 27.2 ± 1.1 million years (mid-Tertiary) has been determined for this monzonite dike by the New Mexico State Bureau of Mines and Mineral Resources (R. E. Beane, 1973, personal communication). The monzonite dike at Jones Camp has a composition similar to the hornblende monzonite that crops out near the study area. Thus, the two intrusives may be of similar ages.

ORE GENESIS AND MINERALIZATION CONTROLS

Stratigraphic and Lithologic Controls

A thin shale bed in the lower part of the Burrego Formation is commonly found overlying the ore bodies. This shale bed may have been a barrier that prevented the ore solutions from moving upward, and forced the solutions to spread laterally into the brecciated zones of the limestone host rock. Although the shale is dominantly illite (Kopicki, 1962, p. 74; Williams, 1964, p. 35) it may not have been sufficiently impermeable to block the solution flow; however as a result of faulting, the shale could have been pulverized to form gouge which could have created an effective impermeable zone .

The principal ore-bearing rocks, the Council Spring Limestone and the lower part of the Burrego Formation, are massive, fine grained, dense limestones with well-developed vertical fractures. These units are apparently more susceptible to shattering than other limestones in the area because their exposures show more abundant joints and fractures. According to Rove (1947, p. 190), a dense, fine-grained rock commonly develops open fractures and is favorable for ore deposition. He also indicated that the most favorable ore-bearing rock will not be the strongest or the weakest rock, but a rock of intermediate strength whose deformation pattern has been caused by its proximity to a stronger, more competent rock, or a weaker, more easily deformed rock.

Kottlowski (1953, p. 8) suggested that massive beds of non-cherty limestone are the most favorable host rocks for ore deposition as they are intensely broken and shattered along faults, whereas less-massive beds break cleanly or are folded.

Primary permeabilities of the host rocks are not favorable for the migration of ore solutions. These permeabilities are so low as to minimize the probability of any long-distance or large-volume intergranular migration of ore-bearing solutions. The permeability that has allowed the ore solutions to penetrate these formations is a secondary permeability resulting from cracks and fractures in the rock.

Structural Controls

The ore bodies in the area are tabular, elongate masses, tending to lenticular shapes, and generally lying with their long axes parallel to approximately north-south trending minor faults. Mineralized faults in the study area are normal faults with a component of rotational movement along the fault plane about a hinge point where displacement ceases. Ore bodies are found near the point of least displacement, or pivot, of the faults as illustrated in Figure 7. At such a position, the rotational component of movement is greater relative to the translational component than at other places along the fault. This relationship causes the rock to shatter more intensely near the pivot and form favorable zones for subsequent mineralization.

The minor faults at the Royal Flush and the Mex-Tex mines are high angle faults. Both dip from 70° to 90°, within the range characteristic of faults in Mississippi Valley type deposits. The footwall blocks of these mineralized faults are more stable and less deformed than the hanging wall blocks. During faulting, the hanging wall (unstable side) moves relatively downward, creating shattered zones on

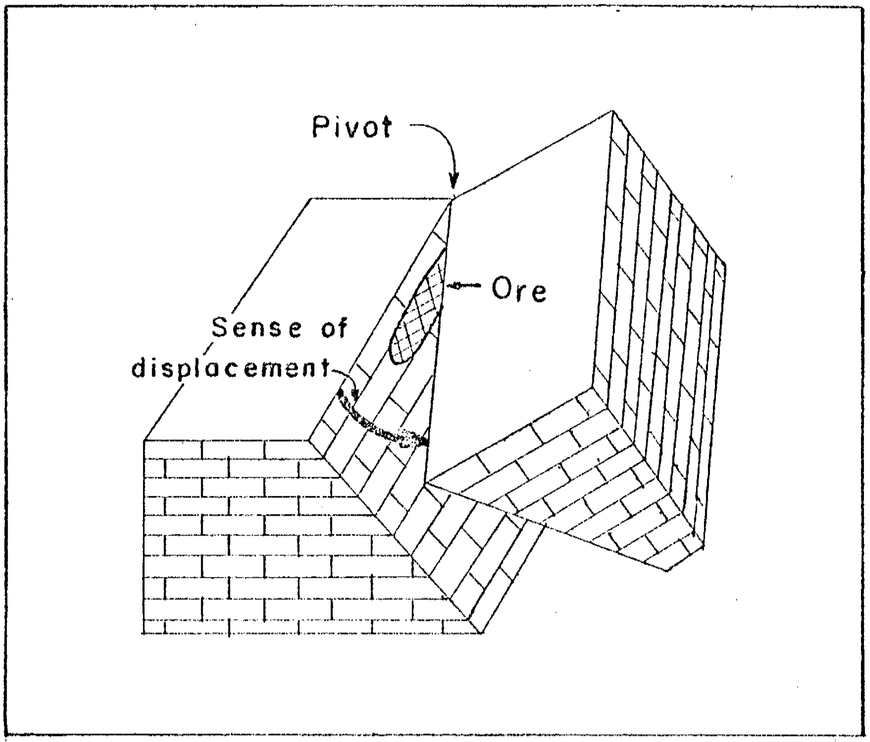


Figure 7: Diagram illustrating a normal fault with a rotational component of movement. Shaded area indicates typical location of ore deposit.

both sides of the faults due to friction along the fault plane. The ore body at the Royal Flush mine parallels a minor fault on the west flank of a stable and slightly deformed block of Pennsylvanian strata (Plate 1). A similar relationship can be observed at the Mex-Tex mine.

However, if both blocks (hanging wall and footwall) are moving during faulting because of a lack of a stable block on either side, shattering due to the release of strain energy will be less severe and the end result will be small ore bodies limited to the fault zones. Closely spaced joints and fractures or even minor faults may be developed on both blocks, as strain energy is released. Mineralization at the Mountain Canyon mine is typical of this condition where both blocks along the mineralized fault have apparently moved (Plate 1).

Rove (1947, p. 166-179) has described fractures developed in limestone. He indicated that there are two main types of fractures; (1) shear fractures which are inclined to the direction of compressive forces at about 45° and (2) tension fractures which occur parallel to the direction of the compression. The surface of the shear fractures usually shows granulation and commonly is slickensided, while surfaces of tension fractures generally show no evidence of granulation or slickensides. The mineralized faults in the area are of the tension type.

Many ore deposits similar to those in the study area commonly occur along or close to faults with small displacement. In many mining districts faults which have several hundreds of feet of displacement are unfavorable zones for ore deposition. The large displacement Oscura fault, which is believed to be the principal conduit for ascending ore solutions, may have been sealed at a considerable depth below the present surface with gouge developed from shale beds of Permian age on the down-thrown (west) side of the fault. From this lower level, the ore solutions must have been transported via the minor fault systems to the limestones of the upthrown block.

Chemical Controls of Ore Deposition

The ore solutions underwent considerable change in chemical properties after reaching the sites of ore deposition. These changes were due to the new environment as well as probable mixing with ground water. To understand these chemical changes, it is important to review solubilities and chemical behavior of the minerals that are observed in the ore deposits in the study area.

Mineral Solubilities

Equilibrium constants for dissolution of the major minerals found at the Royal Flush and the Mex-Tex mines are shown in Figure 10 as a function of temperature. These curves were plotted from equilibrium constants tabulated by Helgeson (1969, p. 775-780).

Barite. The solubility of barite increases with increasing temperature at low temperatures (0° to $100^{\circ}C$). Figure 8 shows that maximum solubility of barite occurs at about $100^{\circ}C$ with an equilibrium ion activity product of -9.22 for the following reaction:

$$BaSO_4 = Ba^{++} + SO_4^{=}$$

The solubility decreases with further temperature increase above $100^{\circ}C$.

Work by Uchameyshvili, et al. (1966, p. 461) on barite solubility in concentrated chloride solutions and liquid inclusions in minerals

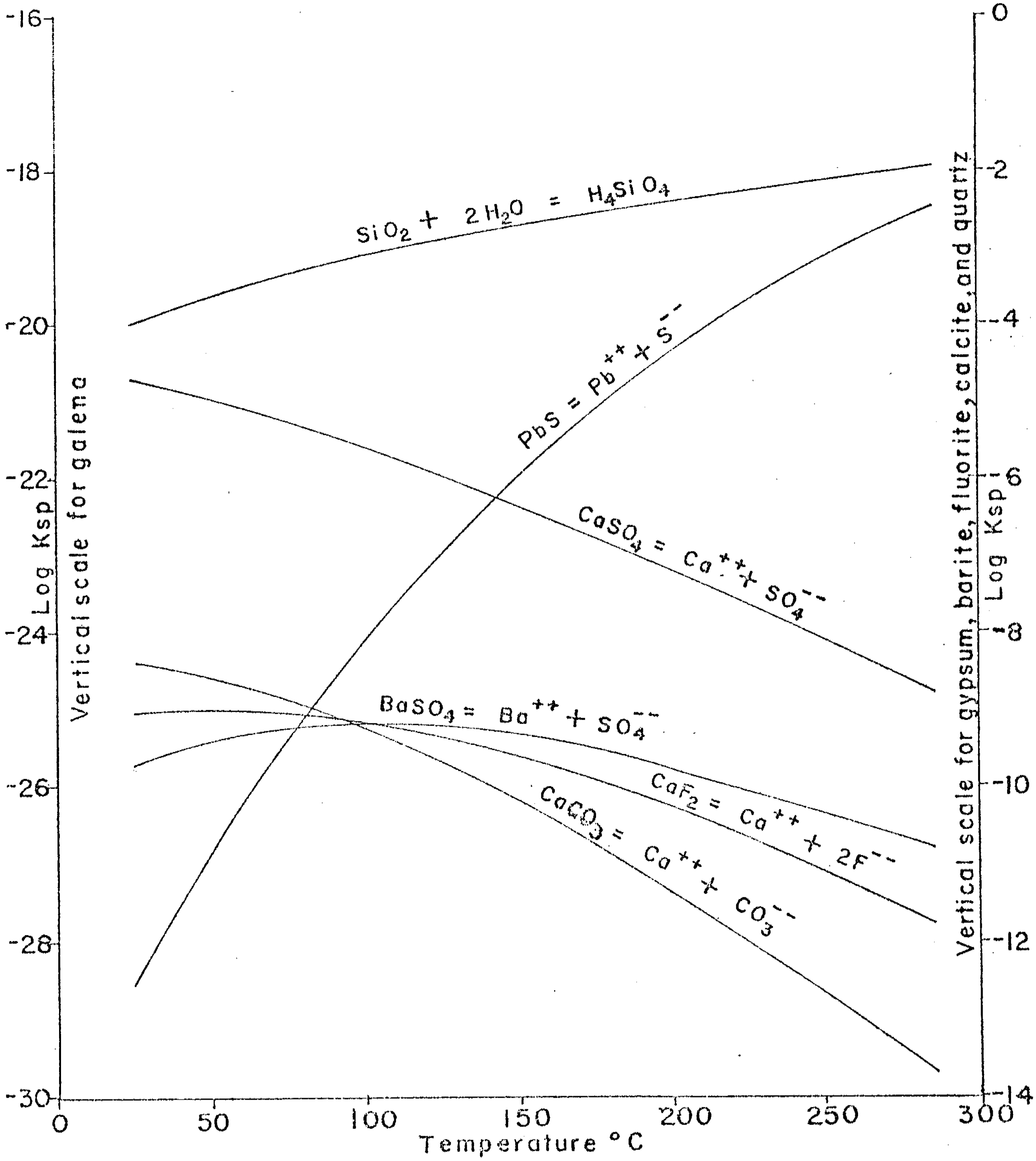


Figure 8: Graph of activity products (K_{sp}) for the major minerals found in the Royal Flush and the Mex-Tex mines. Data obtained from Helgeson (1969, p. 775-780).

of a series of barite deposits, indicates that temperatures above 200°C are unfavorable for the deposition of barite. However, barite probably would be deposited below 200°C because of an increase in the $SO_4^=$ concentration in the solutions, resulting from oxidation of sulfides.

Calcite. According to Garrels and Dreyer (1952, p. 339) calcium carbonate solubility in natural solutions changes with five important variables; (1) solubility decreases with increase of temperature with other factors constant; (2) solubility increases with increase in pressure; (3) solubility increases with decreasing pH; (4) solubility increases with addition of salts to the solution, and (5) solubility increases with an increase in the total amount of CO_2 in the solution. From the above facts, it would appear that calcite can be dissolved by simple cooling and favorable chemical properties of the solution.

Gypsum. The solubility of gypsum, like that of carbonate minerals, decreases rapidly with increasing temperature. Calcium sulphate probably was originally deposited as anhydrite at temperatures above 57°C (Holland, 1967, p. 419) as the result of increasing Ca^{++} in the solutions provided by solution of calcite. The anhydrite was later hydrated to gypsum.

Fluorite. The solubility of fluorite decreases with increasing temperature (Figure 8). Holland (1967, p. 394) indicated that the solubility also responds to the presence of other salts. The quantity of fluorite dissolved or precipitated is a function of the ratio of the concentration of calcium ions to that of fluoride ions in solution. White (1968, p. 311) stated that "fluorite might precipitate from fluorite-saturated brines that became supersaturated with cooling or dilution by other waters."

Galena. Lead was probably transported in the form of chloride complexes of lead ($PbCl_4^{=}$ or $PbCl^{+}$) in acid and high chloride concentration solutions (Helgeson, 1964, p. 66). As shown in Figure 8, solubility of galena increases with increasing temperature. Barnes and Czamanske (1967, p. 360) pointed out that decreasing temperatures and probable increasing pH may cause galena to precipitate from solution. Precipitation of galena from solution may also be caused by dilution which would destroy the complexes.

Quartz. The solubility of quartz increases with increasing temperature. Quartz deposition depends only on decreasing temperature and is independent of the effects of other dissolved species in solution (Holland, 1967, p. 391).

Possible Source of the Ore Solutions and Mechanism of Deposition

Ore emplacement, clearly epigenetic, involved extensive open space filling as well as replacement resulting from solution of the host rock by ore-solutions. Metal bearing solutions are thought to have been derived from Paleozoic sediments of nearby sedimentary basins. Noble (1963, p. 1153) proposed that water expelled from sediments during compaction may have been the ore-forming fluids of the Mississippi Valley type deposits. Such water might contain sufficient dissolved metals to form ore deposits prior to burial. Expulsion of connate formation fluids from saturated sediments is certain to occur during compaction. Large quantities of fluids must be expelled through permeable zones, and compaction of sediments probably begins as soon as deposition takes place.

Discharge of water during early stages of compaction probably is predominantly upward (Emery, and Rittenberg, 1952, p. 758). A significant part of the fluids, which may be drained water of compaction from adjacent fine-grained units, probably moves laterally through more permeable formations as shown in Figure 9, and can be expected to flow from the interior of a basin toward its periphery. This mechanism was suggested to be similar to the mechanism that forms red-bed sandstone-type copper, uranium, and vanadium deposits.

The Rio Grande structural belt probably originated in late Miocene time (Kelley, 1952, p. 101), and resulted in parallel fault blocks of north-south trend in the Hansonburg mining district. These faults, including the Oscura fault, might have cut through transmissive layers of Paleozoic sediments. The metal-bearing solutions from these transmissive layers may then have moved upward along the faults to places where they were clogged with gouge, produced by extensive (several hundreds of feet) displacement. From there the ore fluid was probably forced out into the rocks via the system of minor faults and fractures which in turn conducted it further outward and upward, and ultimately brought the solution into contact with sites favorable for ore deposition.

Present day "normal" temperature gradients in New Mexico range from 0.4 to 2.6°F (0.2 to 1.4°C) or average 1.0°F (0.6°C) per 100 feet of depth (Summers, 1965, p. 3). Depths of cover during ore deposition in the study area are considered to have been between 4,000 and 6,000 feet. Thus, inclusion temperatures of the ore deposits (186-205°C) are anomalously high for the present "normal" thermal gradients. The

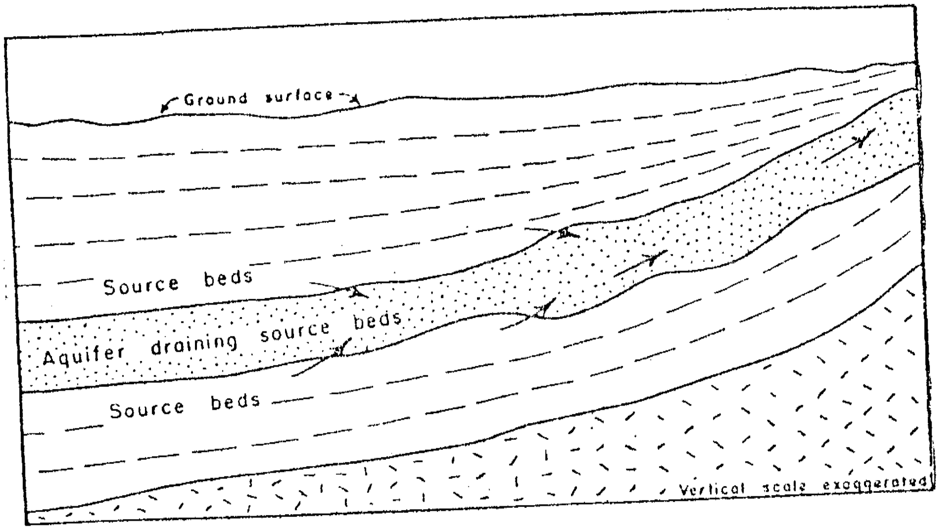


Figure 9: Idealized section showing permeable bed transmitting water of compaction from source beds. After Noble, 1963, p. 1148.

monzonite dikes which probably were emplaced during the same time as the development of the Rio Grande structural belt (late Miocene), may have provided local sources of heat. Such local heat sources may have stimulated a deep convective circulation of connate water while supplying little or no magmatic water or dissolved constituents to the mineralizing solutions.

Deposition of the minerals from connate water containing concentrations of Na-Ca-Cl has been suggested to involve several factors which are as follows:

1) Decreasing Temperature. Simple cooling of the ore fluids may precipitate quartz, galena, and pyrite in openings and in silicified limestone.

2) Oxidation-Reduction Reactions and Increasing pH. Oxidation-reduction reactions and increasing pH can cause deposition of many metals, contained in solution (Helgeson, 1970, p. 180-184). The sites of ore deposition may contain oxidized species such as hematite, magnetite, $SO_4^=$, CO_2, NO_3^- or O_2. When ore solutions containing metals came in contact with these oxidized species, the following reactions may have occurred as temperature increased:

$$SO_4^= + 2H^+ = H_2S + 2O_2$$

$$SO_4^= + H^+ = HS^- + 2O_2$$

If the amount of oxygen in the system was constant, the ratio of $SO_4^=$ to $S^=$ would have decreased with increasing temperature as shown in Figure 10.

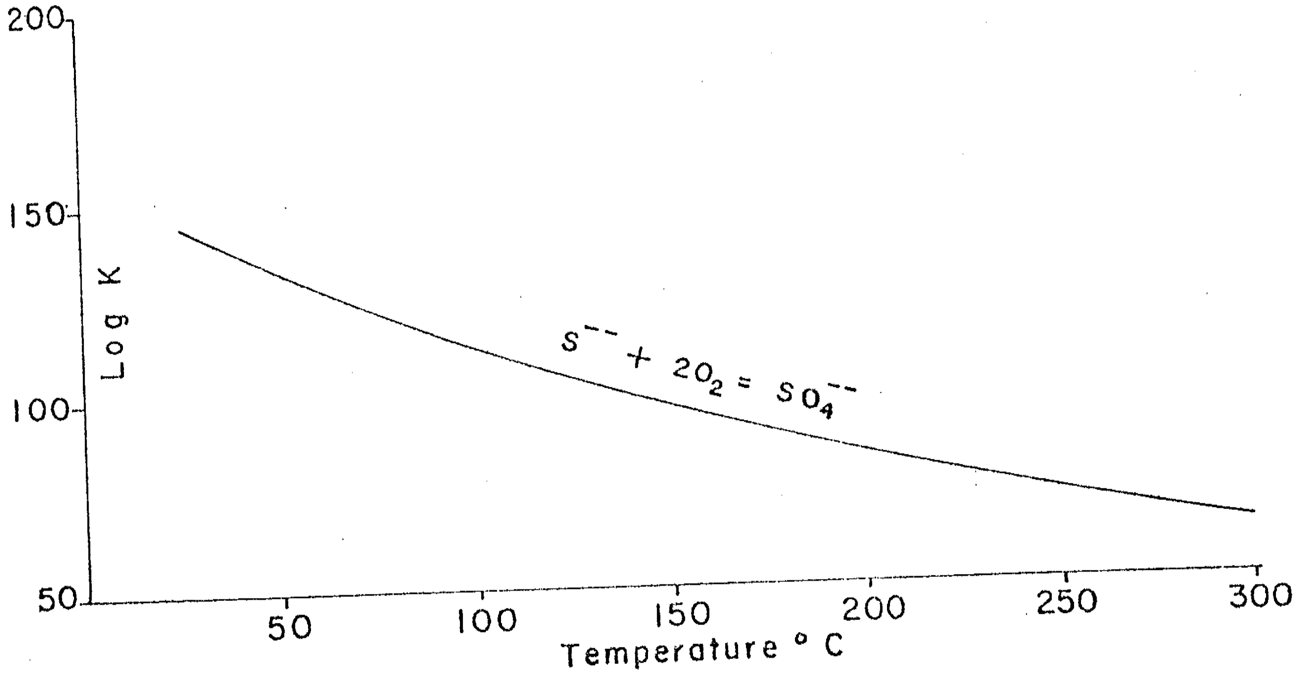


Figure 10: Graph of equilibrium constants for a hydrothermal oxidation reaction involving oxygen and sulfur. Data from Helgeson (1969, p. 775).

Barton (1967, p. 371) suggested that oxidation-reduction of organic matter may cause precipitation of metal sulfides. Metal-rich brines entering the shattered host rock would encounter organic matter already in the sites of mineral deposition. The sulfides could have precipitated when sulfate existing in the solutions was reduced non-biogenetically to sulfide by organic matter according to the following reaction:

$$CH_4 + 2H^+ + SO_4^= = CO_2 + H_2S + 2H_2O \ .$$

3) Increase in Ca^{++} and pH. An increase in Ca^{++} and pH would result from the dissolution of the limestone host rock. The increase in Ca^{++} to the ore solutions may cause fluorite to precipitate as the following reaction proceeds:

$$CaCO_3 + 2F^- + 2H^+ = CaF_2 + H_2CO_3 .$$

The increase in pH may also cause calcite to equilibrate with the solutions.

4) Dilution by Meteoric Ground Water. Metal-bearing solutions may be diluted by meteoric ground water either during migration or at the site of deposition. White (1968, p. 311) suggested that barite may precipitate from mixing of metal-bearing solutions with other waters (including meteoric ground water) high in $SO_4^=$.

In the area studied, the following mechanism of ore deposition is believed to have occurred. The metal bearing solutions, which may have been moderately to strongly saline brines, came into the sites of ore deposition moderately to highly acidic in character. The solution must have been at least moderately acidic, in order for the limited solution and replacement observed at the deposits to have occurred. Neutrality pH is on the order of 5.7 in the temperature range of 150^{o}-200^{o}C (Barnes and Ellis, 1969, p. 638). The solutions are believed to have dissolved little or no limestone adjacent to the through-going faults serving as channelways because the walls may have been protected by gouge or a thin film of precipitated quartz. But when the solutions reached the sites of ore deposition, the shattered condition of the limestone provided more surface area for the solutions to react with and caused a rapid decrease in velocity of the migrating fluid (Helgeson, 1970, p. 303).

Meteoric ground water passing through Permian rocks such as the Yeso Formation, the San Andres Formation, etc. which contain abundant gypsum ($CaSO_4 \cdot 2H_2O$), may have dissolved this gypsum and transported sulfate ($SO_4^{=}$) downward along through-going faults or percolated down through permeable beds where mixing with the metal-bearing solutions occurred. Deposition of barite and gypsum, increased salinity of the ore solutions, and a rapid decrease in temperature during barite formation, as suggested by Roedder, et al. (1968, p. 336), may have resulted.

Mixing of meteoric ground water with the metal-bearing solutions may have reduced the sulfate that was in the meteoric ground water to sulfide due to increasing temperature (Figure 10) as discussed earlier. This process and oxidation of organic matter that was in the sites of ore deposition may have been the mechanisms that provided sulfide for the ore deposition. The combination of oxidation-reduction processes, mixing of the metal bearing solutions with ground water, increasing pH, and decreasing temperature may have caused sphalerite and pyrite to precipitate.

As the deposition proceeded, the solutions continued to dissolve the limestone as a result of increasing pH from oxidation-reduction processes, thus enlarging open spaces for further ore deposition according to the reaction:

$$\mathrm{CaCO_3 + 2H^+ = Ca^{++} + H_2CO_3} \quad \text{(pH less than 7.1 at } 200^\circ\text{C)}$$

This reaction increases the calcium concentration of the solutions and may have caused fluorite to precipitate.

Quartz and galena, observed in the alteration wall rock, may have been precipitated by simple cooling. They may have precipitated and filled open spaces where the limestone wall rock had been dissolved.

An experiment studied by Garrels and Dreyer (1952, p. 325-379) indicated that limestone replacement at low temperatures and pressures is caused by diffusion of mineralizing solutions. The process is volume-for-volume replacement and pH is noted to be the major control of the replacement which requires acid solutions. The replacement of limestone by fluorite in the altered wall rock may be the result of this mechanism.

The alteration of the limestone is terminated when the ore solutions are either in equilibrium with the host rock or further replacement is inhibited by precipitated silica.

Quartz, galena, and fluorite continued to precipitate in the openings (vugs and cavities). Deposition of large amounts of barite may be due to continued mixing of the metal bearing solutions with meteoric ground water.

At the latest stage, calcite was deposited and filled interstitial openings between earlier-formed minerals. The calcite deposition may have been caused by decreasing temperature and/or changing pH of the ore solution.

SUGGESTIONS FOR FURTHER EXPLORATION AND MINING METHODS

This study has indicated that ore deposition was controlled by geologic structure and lithology. Any attempt at further exploration should be guided by both features. Ore deposits should be sought particularly on the up-thrown side of minor faults in areas where the favorable bedrock units are present in the section. The most favorable bedrock units for ore deposition are the Council Spring Limestone and the lower part of the Burrego Formation. Less favorable bedrock units are the Del Cuerto Formation, the Story Formation, the upper part of the Burrego Formation, and the Coane Formation. However, stratigraphically lower units in the lower Madera Limestone or still lower Pennsylvanian rocks may be favorable host rocks (Kottlowski, 1953, p. 8).

Prospect pits, trenches, shallow shafts, and adits have been favored methods of exploration due to their relatively low cost. Exploration for new deposits at greater depths should be carried on by drilling, as the other methods mentioned above are economical only where the expected deposits lie at very shallow depths. Core drilling is unquestionably the most satisfactory drilling procedure, as the stratigraphy and many of the structural features of the penetrated beds can best be determined by this method.

In limiting the target areas for drilling, the geologic features which appear to have controlled the deposits must be taken into account. These factors are as follows:

1) The favorable bedrock units should underlie the drilling area.

2) The drilling area should be close to minor faults. The faults should be normal faults with a rotational component of movement. Fault

displacements measured at known sites of ore deposition have not exceeded 60 feet. Ore bodies are commonly found near the point of least displacement or pivot. The up-thrown side of the fault is the more favorable area. The fault should be at the margin of a broad and relatively undisturbed area of Pennsylvanian strata.

3) The favorable bed should be overlain by a shale bed which may have acted as an impermeable layer to block the upward movement of the ore solutions.

4) Silicified zones appearing along the faults and fractures may be an indication of an ore deposit below. At least, these features indicate past migration of mineralized solutions. The drilling area should include such silicified zones.

Other areas, in which faulting is not evident on the surface, should not be ignored. Geophysical methods might be applied to locate concealed faults which may be associated with undiscovered deposits.

Underground mining of ore deposits of this type is usually done by random room and pillar, and retreating methods. Where deposits are exposed along a hillside, they are entered through horizontal adits, from which drifts, crosscuts, and irregular rooms are developed. Generally these openings follow the mineral bodies, avoiding lean or barren material so far as possible, and leaving pillars for support as needed. After a mine has been worked out, the mining operation retreats to the portal, removing such pillars as contain ore. The procedure is similar to the room and pillar method utilized in coal mining.

Where the ore body is not exposed at the surface, vertical shafts may be sunk, from which drifts and rooms are developed. In these workings a retreating method also is generally used. Economic factors commonly force the operator to develop a larger area in shaft mining than in adit mining before the pillars are removed, hence larger ore deposits should be sought at depth.

Very little timbering has been required in underground operations as practiced in this area. But in the future, if timber is needed for shaft sinking or deeper mining, it is available within a few miles (Kottlowski, 1953, p. 1). The amount of underground water anticipated is also very small and should present no particular difficulty.

Hand-sorting of ore in the mines is an economic way to increase the values as long as the operation remains small. Such sorting decreases the haulage costs and upgrades the heads for the mill. Ore reserves in the study area are calculated on the basis of three product recovery and sale. A metallurgical flow sheet combining gravity and flotation separations and concentrations needs to be developed before final decisions regarding valuation and development are reached.

EVALUATION

Ore Reserves

An exact figure for the total ore reserves in the district cannot be determined because of the lack of extensive development work, the apparent random nature of the deposits, and insufficient drilling data. However, the structural features, genetic relationships, and stratigraphic controls of the deposits are sufficiently well understood to allow an estimate of ore reserves based on measurable factors combined with reasonable assumptions.

Ore reserves in the area studied have been calculated for two categories: (1) proven ore and (2) probable ore. Proven ore is that which is exposed on three or more sides so that reserves can be calculated with a high degree of certainty. More simply stated, proven ore refers to ore blocks whose overall dimensions can be measured. Proven ore in the district is confined to pillars which were left in the mines for roof support.

The area of the ore pillars in the Royal Flush mine totals 850 square feet, with an average thickness of nearly 5.9 feet (Plate 6). The volume of the ore pillars is approximately 5000 cubic feet. Using a tonnage factor for this ore based on published values (Kottlowski, 1953, p. 6) of 10.25 cubic feet per ton, the proven ore can be calculated to be slightly less than 500 tons.

Proven ore at the Max-Tex mine was calculated in the same manner. Total pillar area is 1375 square feet, average height is 8.5 feet, and the total volume is approximately 11,700 cubic feet. A tonnage factor or ore at the Mex-Tex mine based on published values (Williams, 1964, , 43) of 9.75 cubic feet per ton gives a total of 1200 tons of proven ore.

Probable ore is defined as ore which can be measured on one or two sides. Tonnages of probable ore are estimated by projecting existing exposures of ore for reasonable distances based on geologic evidence.

Probable ore at the Royal Flush mine is exposed along the east side of the stope wall. Geologic evidence indicates a decreasing ore thickness away from the fault (Plate 6) and suggests that the ore may extend 10 feet into the rib. The average thickness of this ore is about 4 feet. These estimates indicate a volume of 13,357 cubic feet, hence probable ore at the Royal Flush mine, based on a tonnage factor of 10.25 cubic feet per ton, is approximately 1 300 tons.

At the Mountain Canyon mine, ore is exposed in the north and south faces of the stope. Surface mineralization and silicification suggest 15 additional feet north and south as a reasonable extension of this mineralization. A stope height of eight feet and a calculated area of mineralization of 1562 square feet (Plate 6) give a probable volume of 12,500 cubic feet. Using an average tonnage factor of 10.00 cubic feet per ton for ores in the study area, the probable ore is estimated to be slightly more than 1250 tons.

10 ft³/ton

Probable ore at the Mex-Tex mine is exposed along the southwest and northeast sides of the stope. The ore is estimated to extend about ten feet into the ribs and geologic evidence indicates a decreasing ore thickness away from the fault (Plate 6). Using an average thickness of 5.3 feet; the computed volume is about 5 000 cubic feet. Probable ore at the Mex-Tex mine is about 500 tons, based on a tonnage factor of 9.75

cubic feet per ton.

Total proven ore and probable ore in the study area is estimated to be 1700 tons and 1050 tons, respectively.

Estimated Potential Geologic Tonnage from Geologically Favorable Areas

Potential geologic tonnage is defined as blocks of possible mineralization based on geologic inferences which require additional exploration by drilling or other methods to assure their estimations. Figure 11 shows areas of potential geologic tonnage which have been identified as such from geologic evidence, similarities to known ore deposits in the area, and available drilling data.

Area 1. Area 1 is located approximately 1000 feet north of the Royal Flush mine (Figure 11). The Del Cuerto and Story formations are partially mineralized in this area (Drill holes 4, 5, and 7) as well as the Burrego and Story formations (Drill hole 8). Area 1 lies as a pivot of a fault which trends approximately N30°E, and the site is on the flank of stable, undisturbed Pennsylvanian strata (Plate 1). These features indicate that Area 1 may be a favorable locus for potential geologic tonnage in the underlying Burreto and Council Spring Limestone formations.

The mineralization at Area 1 is assumed to have dimensions similar to the Mountain Canyon mine (the smallest known ore deposit in the study area), with the tonnage factor equal to the average for ores in the study area (10.00 cubic feet per ton). The potential geologic tonnage at Area 1 is estimated to be 3600 tons.

Areas 2, 3, and 4. Areas 2, 3, and 4 are located about 500 feet southwest of the Mountain Canyon mine (Figure 11). Barite and galena

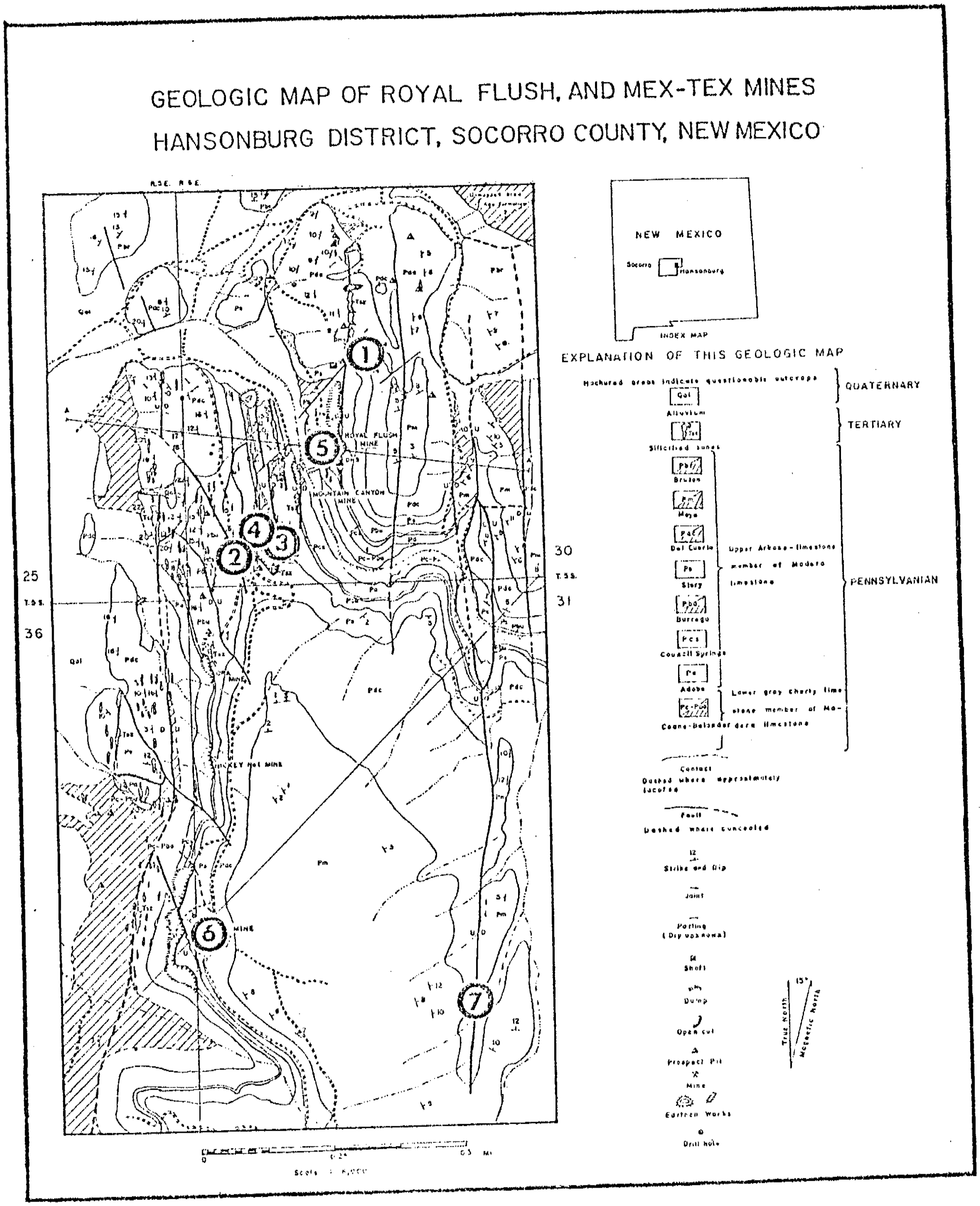


Figure 11: Locations of potential geologic tonnage blocks of ore in the study area.

mineralization is exposed at the surface where it occupies fault zones similar to those of the Mountain Canyon mine. The mineralized faults are closely spaced minor faults with abundant silicification. The faults die out into stable and undisturbed Pennsylvanian strata to the south and thus are favorable loci for potential geologic tonnage in the underlying Burrego and Council Spring Limestone formations.

Each of the fault zones is assumed to have dimensions similar to the Mountain Canyon mine (Plate 6), and a tonnage factor of 10.00 cubic feet per ton. On this basis Areas 2, 3, and 4 may contain a total of 10,800 tons of potential geologic tonnage.

Area 5. Area 5 is on the downthrown side of a fault a few feet west of the workings of the Royal Flush mine (Figure 11). The potential geologic tonnage is based on the probability that mineralization may occur in the same bedrock unit on both sides of a mineralized fault. The tonnage factor and volume of the mineralized zone are assumed to be similar to the ore mined at the Royal Flush mine. Thus, the potential geologic tonnage for Area 5 is estimated to be 9 200 tons (94,300 cubic feet at 10.25 cubic feet per ton).

Area 6. Area 6 (Figure 11) is located on the down-thrown side of a fault at the Mex-Tex mine. The estimate is based on geologic characteristics similar to Area 5. In addition, Williams (1964, p. 35) reported the lower part of a 140-foot drill hole (drill log not available) cut 12 feet of ore in the downthrown side of the fault. The mineralized body at Area 6, based on the throw of the fault, is estimated to be 150 feet below the ground surface. The potential geologic tonnage of Area 6 is assigned the same tonnage factor and volume as the ore mined from the Mex-Tex mine. Potential geologic tonnage in Area 6 is calculated to be 23,800 tons. (233,000 cubic feet at 9.75 cubic feet per ton).

Area 7. Area 7 is located about half a mile east of the Mex-Tex mine (Figure 11). The area is interpreted as a geologically favorable area because: (1) the fault in Area 7 is a normal fault with the throw decreasing from north to south, (2) the fault is on the east flank of a stable and undisturbed block of Pennsylvanian strata and (3) the favorable formations (the Council Spring Limestone and the lower part of the Burrego Formation) are below the surface of the area. Although silicified zones have not been identified along the surface of the fault, they may occur at depth. Thin shale beds may have prevented the ore solutions from ascending to the stratigraphic interval exposed.

Mineralization is possible on both sides of the fault. On the up-thrown west side it is estimated to be about 290 feet below the surface, while on the east side it is estimated to be about 350 feet below the surface. Each potential geologic tonnage block at Area 7 is assumed to be similar to the ore mined at the Mex-Tex mine, since the assumed mineralization in Area 7 is on the opposite side of the same stable and undisturbed Pennsylvanian block, and is at approximately the same elevation. The tonnage factor used is taken as the average for ores in the study area (10.00 cubic feet per ton). The potential geologic tonnage in Area 7 is estimated to be 46,600 tons.

The total potential geologic tonnage in the study area is estimated to be 94,000 tons.

Estimated Present Value of the Ore Reserves and Potential Geologic Tonnages

Considering the characteristics of open-space filling deposits, mining operations using random room and pillar, and retreating methods should recover approximately 80% of the ore reserves and potential geologic tonnages. Recovery of these coarse-grained ores during milling should also be at least 80%. Based on these recovery figures, the present values of the ore reserves and potential geologic tonnages can be estimated (details of the estimations are shown in Appendix II). The following present values are arranged in order of decreasing degree of assurance from the proven ore tonnages to the potential geologic tonnage of area 7, which would require extensive exploration to acquire any degree of certainty.

Present value of the proven ore (1700 tons) is estimated to be	$ 41,600
Present value of the proven ore and probable ore (total 4750 tons) is estimated to be	122,160
Present value of the proven ore, probable ore, and potential geologic tonnage at Area 1 (total 8350 tons) is estimated to be	171,888
Present value of the proven ore, probable ore, potential geologic tonnage at Area 1, and Areas 2, 3, and 4 (total 19,150 tons) is estimated to be	394,320
Present value of the proven ore, probable ore, potential geologic tonnage at Area 1, Areas 2, 3, and 4, and Areas 5 and 6 (total 52,150 tons)is estimated to be	773,450
Present value of the proven ore, probable ore, potential geologic tonnage at Area 1, Areas 2, 3, and 4, Areas 5 and 6, and Area 7 (total 98,750 tons) is estimated to be	1,179,000

The relationship of these estimated present values and estimated tonnage figures is shown in Figure 12.

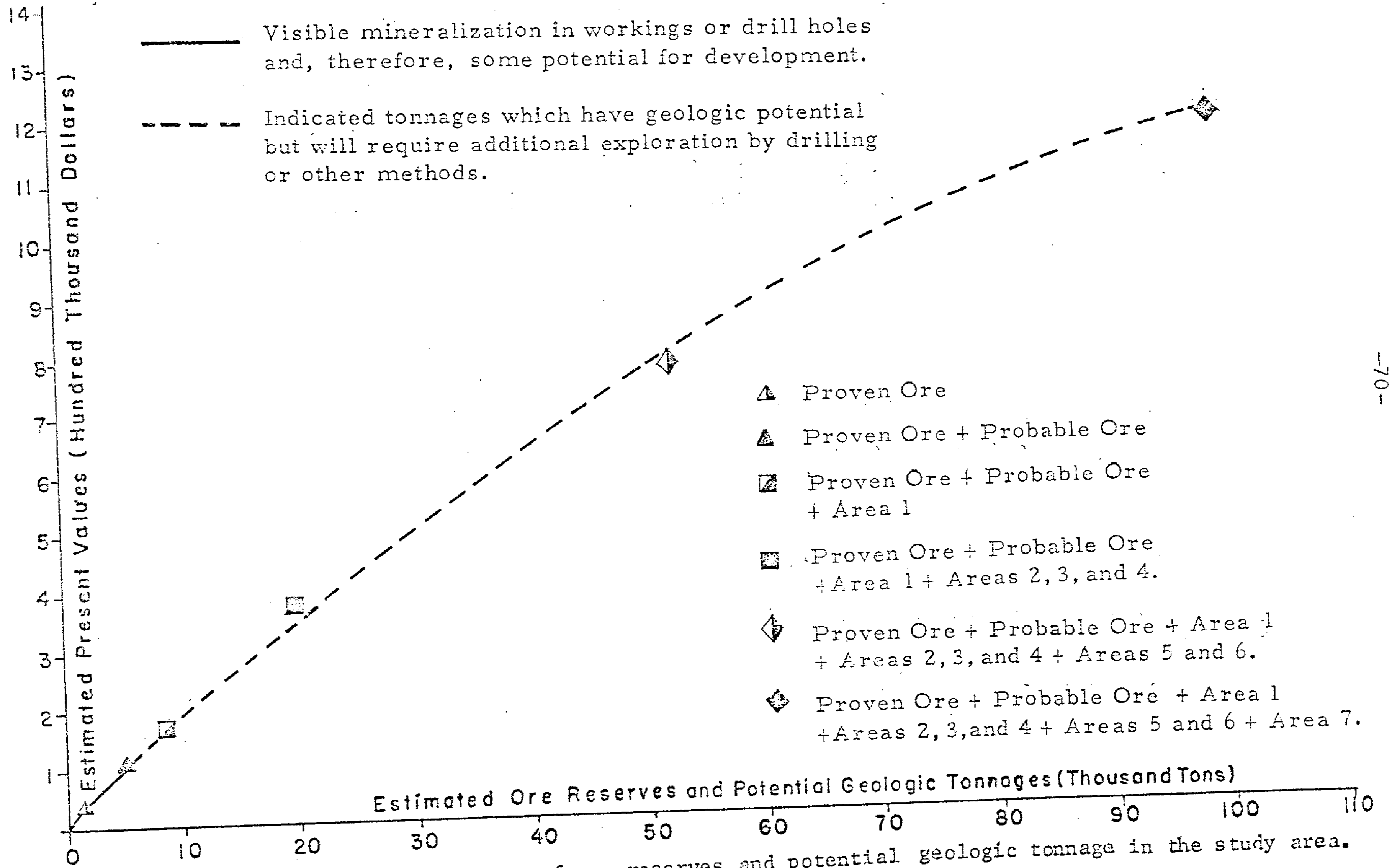


Figure 12: Estimated present values of ore reserves and potential geologic tonnage in the study area.

CONCLUSION

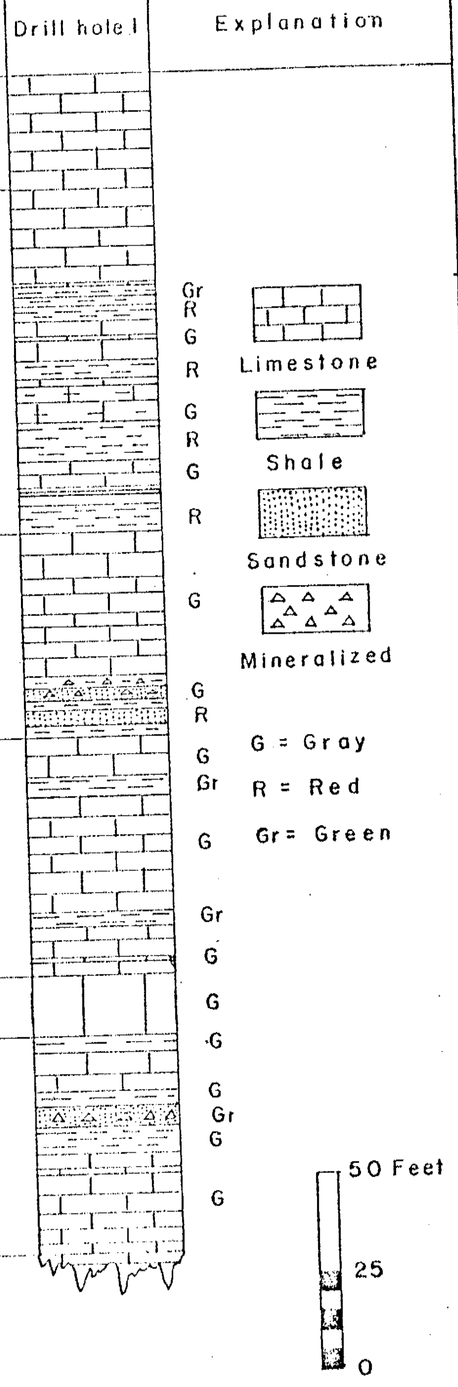
A geologic study of the Royal Flush and the Mex-Tex mines, and adjacent area has been made. Structural, stratigraphic and other geologic evidences in the area have indicated a potential for large tonnages of concealed mineralization. More drilling is needed to verify and delineate the limits of such blocks.

The ultimate value of this study lies in the possible encouragement of further exploration in the area. If the estimates of the ore reserves and potential geologic tonnage in this thesis are correct, a small mining operation would make a very attractive investment.

APPENDIX I

Drill Logs-- Holes 1 through 8 (Plate 1). Formation breaks and interpretation by C. Lewchalermvong, lithologic descriptions from Basic Earth Science Systems, Inc., Denver.

Formation	Depth in feet
Moya Formation(?)	0 - 30
Del Cuerto Formation	30 - 129
Story Formation	129 - 182
Burrego Formation	182 - 245.5
Council Spring Limestone	245.5 - 265
Adobe Formation	265 - 320



DRILL HOLE 1 - Hansonburg

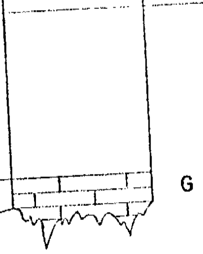
Total Depth 320', Cored 60-320

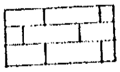
0-60	Chips of white, dark reddish gray, dark gray ls, white and clear secondary calcite and quartz, some white to buff clay.
60-61.5	Limestone, lt gray, dense, some sugary places, several horiz. stringers of white & brown calcite; 1/4" white calcite filled fractures (vertical).
61.5-64.5	Shale, green, red, lt blue, vertical fractures in green shale at top coated with alteration micas, weathered feldspars and very small flecks of native copper.
64.5-67	Calcareous shale, argillaceous limestone, dk gray.
67-71	Shale, hematite red, chocolate red, a few limy streaks.
71-75.5	Limestone, greenish gray, reddish gray, red to chocolate red clay clods at top because clay streaks near bottom. Clay gives red & green coloration. Dense.
75.5-76.6	Limestone, gray, dense. Occasional pieces and thin stringers of calcite. Mega and micro fossils become abundant near bottom. Last foot has several thin vertical fractures healed with light brown material (limonite?). Bottom two inches has clay stringers with feldspar grains, limestone becomes crystalline.
82-86.5	Shale, dk red, blue-gray, thin-bedded, some sand grains. Limonite stains at many of the horizontal partings. Upper three inches and bottom 2.5 feet are dark red. Remainder is blue-gray.
86.5-88	Limestone, gray, fairly dense, some recrystallization, occasional red clay partical, a few fossils. Vertical thin fractures filled w/limonite stained calcite. Free calcite including 1" x 2" vug w/dog-tooth crystals.
88-89	Limestone, shale, dr gray, brown, greey, maroon, reddish brown, conglomerate appearance of limestone and shale. Much calcite in limestone pieces.
89-98.5	Limestone, gray, dense, occasional dark gray, greenish gray or reddish gray due to included shaly particals. Shale pieces at top foot become shale partings. Shale is black, green, red. The 94'-95' interval is mostly hard, brittle dk gray to black shale w/thin limestone stringers. At 97' is a 2" streak of soft maroon shale. Bottom 6" is transitional to the underlying shale. Thin, vertical limonite-filled fractures throughout limestone. Macro and micro fossils, mostly replaced by calcite.
98.5-110	Shale, maroon, dk gray, dr red, soft w/occasional limy streaks. Maroon color for upper seven ft. At 105.5' to 106.0' is a dark gray limestone with much calcite. At 106' to 108' shale is dk gray, the remaining 2' is red with mottled gray areas.
110-116.5	Limestone, dk gray, lt gray, upper and lower foot dk gray; remainder mottled dk & lt gray. Vertical and near vertical fractures up to nearly 1/4" thick filled w/siderite (?). Occasional calcite pieces up to 1" diameter. Fossiliferous.

116.5-117	Limestone & shale, gray, red, green, mottled mixture of limestone & shale. Fossiliferous.
117-117.5	Limestone, dk green, maroon, crystalline, quite granular.
117.5-121	Limestone, red and green, brown, gray, limestone and clay mixture grading into granular limestone, then becoming a dense fossiliferous limestone. Color changes with the lithologic changes from mottled red and green to brown to gray. Near-vertical fractures as wide as 1/4" filled with calcite and siderite (?).
121-129	Shale, red, green, black, dk gray, interval telescoped into 4.5'. Thin-bedded, flakey shale; dark red at the top, changing with depth to dark green, then black, and finally dark gray. The black and gray intervals appear to contain organic material.
129-144	Limestone, medium and dk gray, large inclusions of yellowish to olive-green shale in upper foot. Medium to dark gray limestone, mostly mottled rather than in distinct intervals. Yellow-brown to dark brown calcite (and siderite?) fill the many near-vertical fractures; white to blackish brown calcite replace fossils up to one inch in diameter. Many of the near-vertical fractures (which get as wide as 1/4") are offset by near-horizontal fractures. The limestone is quite dense wherever the many forams have not been replaced by crystalline calcite.
144-149	Limestone, gray-brown. Gray-brown granular, crystalline limestone with abundant micro fossils, clay particles and calcite.
149-166.5	Limestone, medium and dk gray, dense medium and dark gray limestone, often a mottled appearance. Most abundant micro and macro fossils of any limestone to this depth. A few very thin vertical fractures filled with siderite (?)
166.5-169.5	Shale, black, dk and medium gray, black micaceous thin-bedded shale changing to dark, then medium gray, becoming less thin-bedded and softer. Upper part has micro fossils. Pyrite (?) and marcasite throughout. Analysis of 167'- Marcasite and Sphalerite - Au = .03 ppm; Ag = <.2 ppm; Cu = .001%; Pb = .16%; As = 1000 ppm; Zn = 2000 ppm.
169.5-172.5	Sandstone, green, fine grained very argillaceous calcareous sandstone. Abundant muscovite (?), chlorite, and feldspar throughout. Green color with red, black, and white grains. Two 2" seams of arenaceous, micaceous shale, the upper dark gray; the lower maroon. Pyrite in upper foot. Analysis of 170' - Disseminated chalcopyrite and pyrite - Au = .02 ppm; Ag = <.2 ppm; Cu = .030%; Pb = .002%.
172.5-175	Shale, maroon, micaceous, arenaceous maroon shale.
175-179	Sandstone, maroon and green, fine grained micaceous, argillaceous sandstone. Variegated maroon and green. Limonite in fractures and partings.
179-182	Shale, maroon and dk bluish-gray, variegated maroon and dark bluish-gray crumbly shale.
182-192	Limestone, dk gray, gray, green, dense, slightly fossiliferous limestone. Clay particles at top and bottom. Color changes with depth from dark gray to medium gray, and to

(Con't) 182-192	a green color at the lower foot which has shale partings as well as the included particles of clay.
192-198	Shale, green and maroon. Variegated green and maroon thin-bedded shale with a few encased megafossils; very little mica.
198-217	Limestone, dk gray. Dense dark gray fossiliferous limestone with occasional shale partings, especially near the top and the bottom.
217-222	Limestone, green and maroon. Green and maroon very granular, very fossiliferous, limestone. Argillaceous, arenaceous, clay partings, much calcite, some shlorite. Mega fossils include crinoid stems.
222-227	Limestone, dk gray. Very dark gray dense limestone with dark gray to black shale partings. Upper part very fossiliferous, especially in the shale.
227-230.5	Shale, green and maroon. Variegated green and maroon shale. Upper 1.5 feet are flakey; bottom two feet are limy and somewhat massive with a very few flakes of mica.
230.5-240	Limestone, gray. Gray limestone with greenish gray shale partings near top which become thinner and more widely separated towards the bottom. Interval from 233'-239' is silicified and contains chert. Very fossiliferous in bottom two feet.
240-241	Limestone, brownish gray. Very hard brownish gray limestone. Granular, very argillaceous and fossiliferous. Brown calcite.
241-245.5	Limestone, dk brownish gray. Very hard dark brownish gray recrystallized dense limestone. Possibly argillaceous; very few fossils. Thin black shale partings. A very few healed thin vertical fractures.
245.5-265	Limestone, gray. Dense gray limestone with thin vertical fractures filled by siderite(?). Some fossils and large pieces of calcite. Interval from 259' to 262' is mottled dark gray and brownish gray. Black shale partings in the bottom 1.5 feet.
265-268.5	Shale, black, dk greenish gray. Upper foot is black shale with pyrite. Changes to dark greenish gray limy shale without pyrite. Steadily becomes more calcareous and fossiliferous.
268.5-280	Limestone, dk grayish green, dk grayish brown. Dark grayish green and dark grayish brown fossiliferous limestone with shale partings and particles. Contains more shale with depth. At 273 feet large quantities of very small grained mica appear in the shale partings.
280-283	Shale, dk greenish gray. Dark greenish gray micaceous shale. Calcareous and arenaceous, becoming sandier with depth. Grains of quartz and feldspar appear at 281'; chlorite in bottom two inches.
283-288	Sandstone, grayish green. Grayish green sandstone with grains of quartz, feldspar, mica, shale, and limestone. Shale partings. Mostly very fine grained but with medium grained quartz and feldspars in near-horizontal bands. Chalcopyrite, pyrite

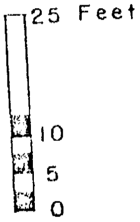
(Con't) 283-238	and galena at 285'. Analysis of 285' - Disseminated pyrite and chalcopyrite; Galena (?) Au = <.02 ppm; Ag = <.2ppm; Cu = .003% Pb = .002%.
288-295	Shale, black & dk greenish gray. Black and dark greenish gray micaceous shale with occasional hard streak. Evenly and thinly bedded.
295-298	Limestone, dk brownish gray. Dark brownish gray dense limestone with shale partings. Becomes almost black in bottom half.
298-299	Shale, very dk gray. Very dark gray shale with slight brownish tinge.
299-318	Limestone, dk brownish gray. Dark brownish gray dense, very hard limestone. Very few fossils in upper 9 feet. Below 9 feet are fairly abundant fossils and shale partings.
318-320	

Formation	Depth in feet		Drill hole 2	Explanation
Burrego Formation	0 - 21			
	21 - 23			



Limestone

G = Gray

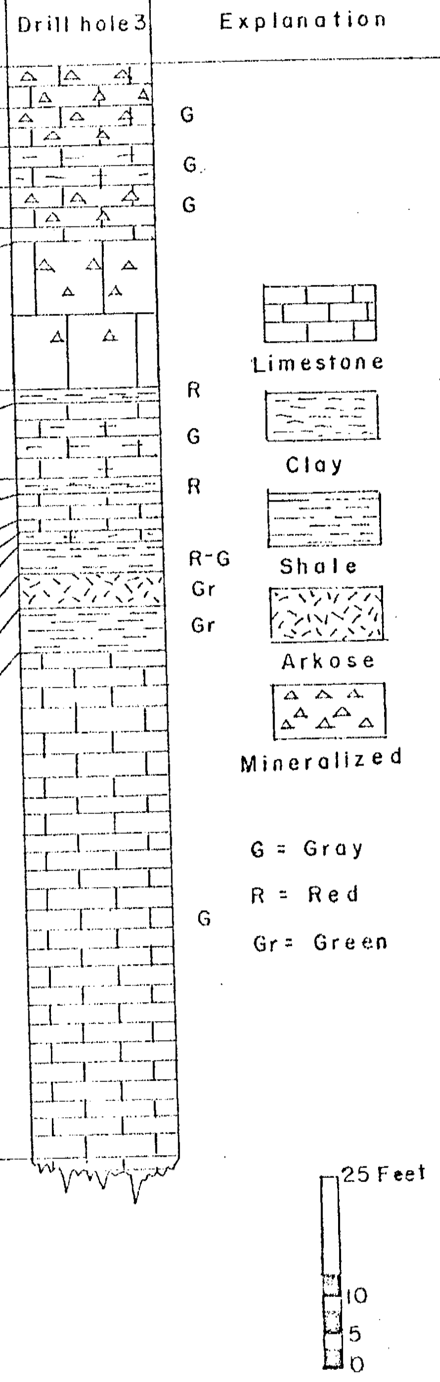


DRILL HOLE 2 - Hansonburg

Total Depth 23' - Cored 21-23

0-21	
21-23	Dense gray crystalline ls, w/fractures filled with limonitic calcite. Near horizontal separations of fine grained poorly cemented white to yellow non-crystalline calcite.

Formation	Depth in feet
Burrego Formation	0 - 5
	5 - 10
	10 - 15
	15 - 20
	20 - 22
Council Spring Limestone	22 - 41
Adobe Formation	41 - 42
	42 - 52
	52 - 54
	54 - 57
	57 - 58·5
	58·5 - 60
	60 - 63·5
	63·5 - 68
	68 - 74
Coane Formation	74 - 140

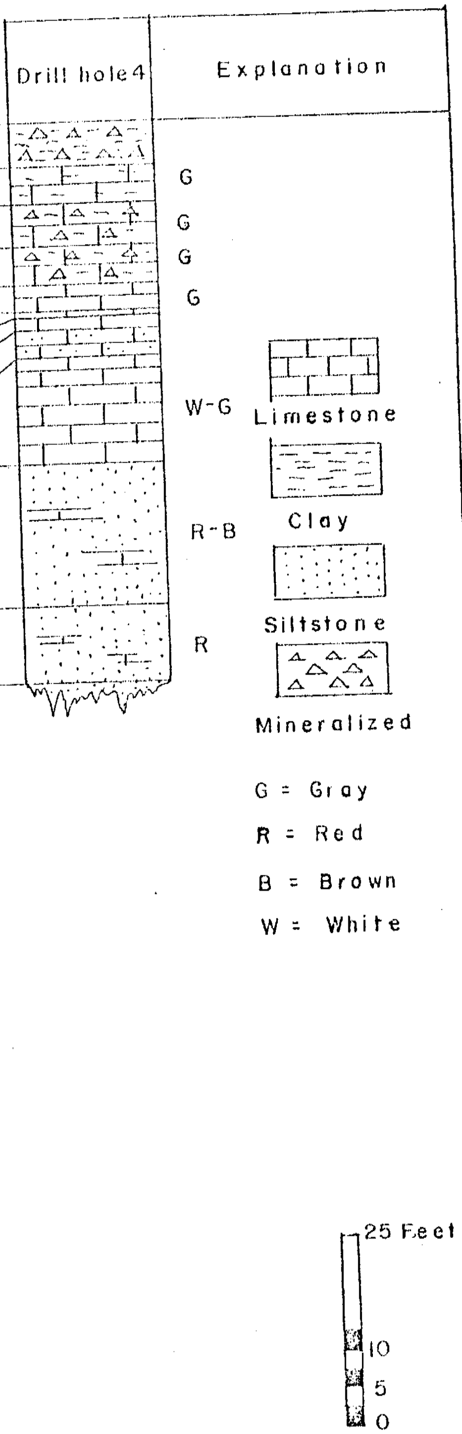


DRILL HOLE 3 - Hansonburg

Total Depth 140' - Cored 20-140

0-5	Chips of white to dark gray ls- quartz xtals, light greenish white clay, fine clastics, calcite, barite, fluorite.
5-10	Same as above.
10-15	Gray ls, quartz, some white to buff clay.
15-20	Gray ls, quartz, galena, calcite, fluorite.
20-22	Greenish to grayish brown crystalline limestone, fossiliferous, occasional dense streaks, shaley streaks, vertical fractures filled with limonite.
22-41	Brownish gray dense limestone with fossils and calcite. Many vertical and near vertical fine to 1/4" fractures filled with brown and limonitic calcite. A few fluorite & galena crystals. Some of larger fractures still have voids, some limonite stains, manganese spots & dendritic patterns.
24.5-25.0	Start brown calcite filled fractures.
25.0-27.5	Start galena & fluorite filling (small, scattered, thin xtals.)
27.5-33.0	End fractures.
41-42	Grayish olive brown & chocolate red shale.
42-52	Grayish olive brown limestone with thin red shale partings and pieces, vertical fractures. Limestone becomes predominantly mottled with gray near bottom.
52-54	Mottled maroon, yellow and green shale.
54-57	Mottled gray & olive green dense limestone w/vertical fractures filled w/limonitic calcite. Lower half has wide vertical fracture filled with red clay.
57-58.5	Grayish brown dense limestone w/brown calcite.
58.5-60	Same with larger and larger amounts of olive clay.
60-63.5	Hard micaceous dark reddish brown and green layers of shale.
63.5-68	Arkosic micaceous quartz, green clay sand with much limonite, especially in vertical fractures. Generally green but limonite colors to some extent, including yellow-brown horizontal streaks. Becomes quite shaley at bottom.
68-74	Olive, black, micaceous hard layered shale. Lower foot is quite limonitic, olive green color.
74-140	Mottled dense gray brown and gray fossiliferous limestone. Calcite some limonite filled fractures. At 88' becomes poker chip appearance due to horizontal fractures which separate pieces when coring. Some intervals become quite shaley.

Formation	Depth in feet
Del Cuerto Formation	0 - 5
	5 - 10
	10 - 15
	15 - 20
	20 - 23
	23 - 24
	24 - 25
	25 - 28
	28 - 42
	42 - 60
	60 - 70

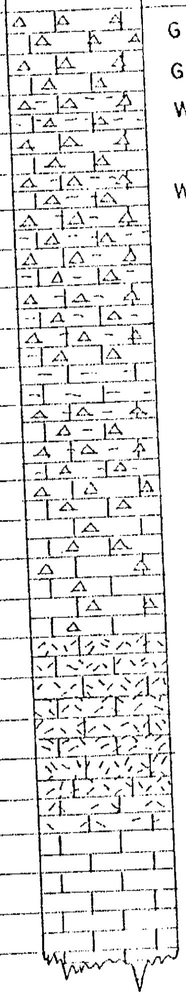


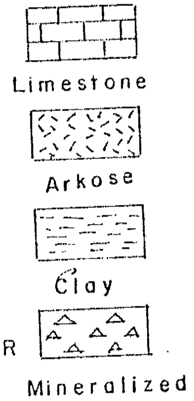
DRILL HOLE 4 - Hansonburg

Total Depth 70' - Cored 20-70

0-5	Calcite, red clay, barite.
5-10	Gray ls with calcite, red clay, some red calcite
10-15	Light gray ls, with reddish and yellow calcite, barite, quartz.
15-20	Gray ls, calcite, white & red clay, fluorite, quartz.
20-23	Dense gray crystalline ls mottled with red-brown mudstone.
23-24	Dense gray crystalline ls w/fracture containing chocolate brown dull siderite?, clear to orange dog-tooth spar and small coatings of native copper?
24-25	Dense milk-white to lt gray crystalline ls with siderite in tight fractures.
25-28	Gray crystalline ls interbedded and mottled with red-brown soft silty ls and red brown siltstone.
28-42	Dense milk-white to light gray crystalline ls mottled with dark red-brown poorly crystalline fine grained ls, few fractures with yellow-brown dog-tooth spar.
42-60	Red-brown, limy siltstones.
60-70	Dark red mottled white limy siltstone.
	Bottom

Formation	Depth in feet		Drill hole 5	Explanation
Del Cuerto Formation	0 - 5			G
	5 - 10			G
	10 - 15			W,G,R
	15 - 20			
	20-25			W,G,R
	25-30			
	30-35			
	35 - 40			
	40-45			
	45-50			
	50-55			
	55-60			
Story Formation	60-65			
	65-70			
	70-75			W,G,R
	75-80			
	80-85			
	85-90			
	90-95			R
	95 - 100			
Burrego Formation	100-105			
	105-110			
	110-115			
	115-120			

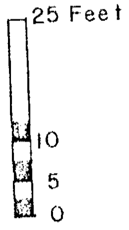




G = Gray

R = Red

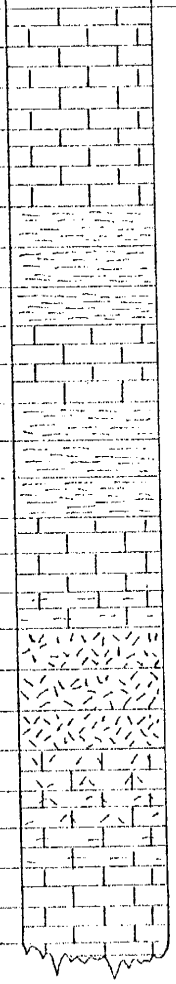
W = White

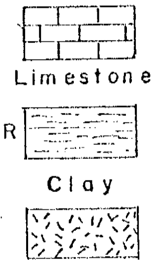


DRILL HOLE 5 - Hansonburg

Total Depth 130' - No core

0-5	Chips of light to dark gray ls, yellowish orange to dark brown ls, red ls with red clay, white to red calcite xtals, red clay. White to red calcite is vuggy and has some qtz xtals, abundant barite, crystalline, some fluorite.
5-10	Same.
10-15	White, gray, red ls, white to buff clay, abundant barite, minor fluorite.
15-20	White, gray, red massive ls; abundant barite, fluorspar, and quartz xtals.
20-25	White, gray, red dense ls; some calcite, abundant barite, fluorite, and qtz xtals, some white to greenish buff clay.
25-30	White, gray, yellow, red dense ls, white and red clay, some calcite, sparse qtz, abundant barite.
30-35	White, gray, red dense ls, white, buff, lt green clay, calcite, barite, fluorspar, qtz.
35-40	Same.
40-45	White, gray, red dense ls, white and red clay, calcite, barite, fluorspar, and qtz.
45-50	Gray and red dense ls, some white clay, calcite.
50-55	Gray and red dense ls, some white clay, calcite, some barite, galena and qtz.
55-60	Gray and red dense ls, some white and red clay, calcite, some barite and qtz.
60-65	Same.
65-70	White, gray, and red ls, calcite, sparse barite.
70-75	Same.
75-80	Same.
80-85	White, gray ls, calcite, arkosic, micaceous ss.
85-90	Arkosic, mica ss, white, gray, red ls.
90-95	Same.
95-100	Arkosic, mica ss, white, gray, red ls, calcite, sparse barite?
100-105	White, gray ls, calcite, sparse ss.
105-110	Same.
110-115	White, gray, red ls.
115-120	Same.

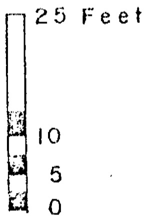
Formation	Depth in feet		Drill hole 6	Explanation
Del Cuerto Formation	0 - 5			W, G, R
	5 - 10			
	10 - 15			
	15-20			
	20-25			
	25-30			R
	30 - 35			R
	35-40			R
	40-45			W, G, R
	45- 50			
	50 - 55			
	55-60			R
	60-65			
Story Formation	65-70			W, G
	70 - 75			
	75 - 80			W
	80 - 85			
	85 - 90			R
	90-95			
	95 - 100			
Burrego Formation	100-105			G
	105-110			
	110 - 115			G
	115 - 120			



G = Gray

R = Red

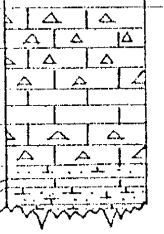
W = White

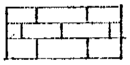


DRILL HOLE 6 - Hansonburg

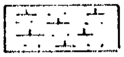
Total Depth 120' - No core

0-5	White, gray, red ls, calcite.
5-10	Same.
10-15	Same.
15-20	Same.
20-25	Same.
25-30	Red clay.
30-35	Red clay.
35-40	Red clay.
40-45	White, gray, red ls.
45-50	Same.
50-55	Red clay.
55-60	Same.
60-65	Same.
65-70	White, lt gray ls.
70-75	Same.
75-80	Gray, red clay, white ls.
80-85	Arkosic, mica ss, lt gray ls, gray and red clay.
85-90	Arkosic, mica ss.
90-95	Arkosic, mica ss, gray and red clay.
95-100	Gray and red clay, gray ls, arkosic mica ss, calcite.
100-105	Gray ls, micaceous, arkosic ss.
105-110	Gray ls, red clay.
110-115	Gray ls.
115-120	Same.

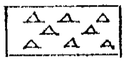
Formation	Depth in feet		Drill hole 7	Explanation
Del Cuerto Formation	0 - 5			G
	5 - 10			
	10 - 15			G
	15 - 20			
	20 - 22			R
	22 - 23			
	23 - 25			



Limestone



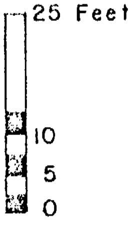
Calcitic rock mixed with silt



Mineralized

G = Gray

R = Red

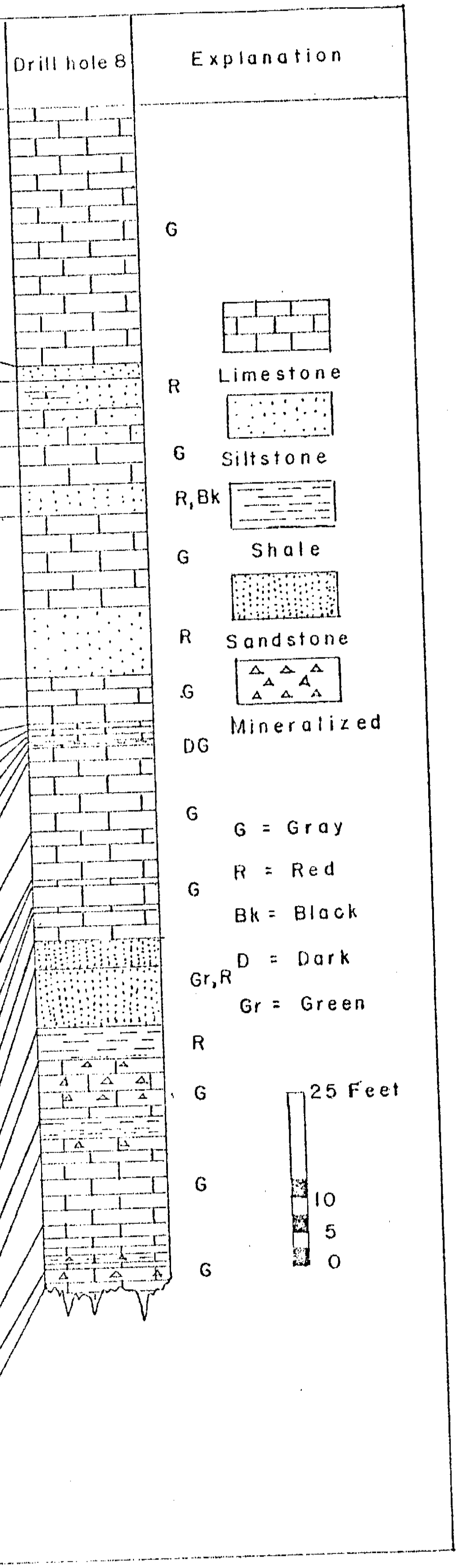


DRILL HOLE 7 - Hansonburg

Total Depth 25' - Cored 20-25

0-5	Gray ls, white and pink clay, barite, calcite.
5-10	Gray ls, clear qtz xtals, calcite, barite.
10-15	Gray ls, calcite, qtz.
15-20	Gray ls, quartz, calcite, fluorspar.
20-22	Dark red w/white mottled calcitic rock mixed with red silt.
22-23	Gray massive ls with dark red silt.
23-25	Red mixture of calcitic rock with silt.

Formation	Depth in feet
Del Cuerto Formation	0 - 37
	37 - 39
	39 - 43
	43 - 48
	48 - 54
	54 - 58
	58 - 71
	71 - 91
Story Formation	91 - 95
	95 - 97
	97 - 97.5
	97.5 - 98
	98 - 99
	99 - 100
	100 - 102
	102 - 112
	112 - 119
	119 - 120
	120 - 123
	123 - 123.5
	123.5 - 128
	128 - 132.5
	132.5 - 140
	140 - 145
Burrego Formation	145 - 152
	152 - 160
	160 - 171
	171 - 180
	180 - 183



DRILL HOLE 8 - Hansonburg

Total Depth 183' - Cored 20-183

0-37		Dense lt gray crystalline ls mottled with yellow and red-brown finer grained ls, fractures filled with clear calcite xtals and brown calcite xtals. Fractures are brown iron stained. Some siderite.
37-39		Dark red limy siltstone.
39-43		Dark red, brown, green, sometimes black-red limy siltstone.
43-48		Mottled mixture of red siltstone and med gray massive ls.
48-54		Dense lt gray crystalline ls with tight siderite & calcite fractures.
54-58		Dark red to black siltstone.
58-71		Dense lt gray ls with siderite filled fractures, partings of red, green, black lime siltstone.
71-91		Dark red to black siltstone.
91-95	* * *	Gray to clear ls mottled with yellow-brown finer grained ls, many vugs and fractures partially filled or filled with calcite xtals, siderite, and silica. Dog-tooth spar. Brown siderite in many partings gives the rock an overall brown appearance megascopically. Some yellow-brown clay partings. Also red-purple fine grained calcite (mud?) partings. Some clear calcite xtals with rotten brown centers. Some qtz xtals in voids.
95-97		Massive crystalline ls, lt gray to lt purple, with yellow, green, reddish clay partings and mottling. Clear dog-tooth spar in voids.
97-97.5	*	Massive crystalline ls, lt gray to clear with voids, dog-tooth spar, qtz xtals, yellow to brown clay partings, abundant siderite.
97.5-98		Milky massive and crystalline ls mixed with deep maroon limy clay.
98-99	*	Massive lt gray crystalline ls, clear dog-tooth spar and siderite in voids, also scattered qtz xtals.
99-100		Black clay, stained yellow, brown, red.
100-102		Dense massive mottled dk gray-med gray ls.
102-112		Red, green, black clay with thin layers of med gray massive ls.
112-119	*	Med gray, dense, xtalline ls, minor white clay with bright orange soft (H3) euhedral xtals which are not affected by HCL. Orange mineral with clay only and visible under microscope (30X) only. Scarce thin fractures with siderite filling. Orange xtals 111-115 only.
119-120		Med gray dense xtalline ls, with parting of white to buff clay.
120-123		Dense lt gray xtalline ls, fractures partially filled with dark brown calcite.
123-123.5		Same as above with white to buff and yellow to green clay partings.

123.5-128		Dense med gray ls with fractures filled with dark brown siderite or calcite.
128-132.5	* *	Lt brown ss?, yellowish green groundmass with occasional books of mica, 10%? bright orange soft precipitate, and 30% clear qtz, and 30% mica. Fracture filled with soft metallic? mineral (wad?) and barite?, some silicification, much iron staining.
132.5-140		Green arkosic sandstone w/mud muscovite, some quartz. Fine-grained green material appears to be shale. At 135' vertical fractures with qtz xtals with yellow-green lead stains & manganese dentrites color becomes pinkish-gray due to little clay and becoming mostly quartz layers of muscovite & limonite show good bedding planes. At 136' quartz drops to much lower % and sandstone becomes dark green and dark red due to some clay & feldspars. Maroon clay partings become abundant. Lower 1 foot very heavily fractured, filled with quartz xtals and limonite.
140-145		Maroon, dark green, and finally brick-red sand- micaceous shale.
145-152	*	Dark grayish brown limestone. Some fossils. Galena in quartz crystal pocket at 145.5. Limestone is dense & crystalline, gray to olive irregular clay percentages. At 146.5 are green copper stains, becoming quite heavy with thick, vertical fracture filling of quartz crystals, galena, fluorite, malachite, azurite, linerite, cryscolla, and possibly Barite for 1.5 lead.
152-154		Med to dark gray dense crystalline ls, some partings of white clay.
154-157		Red, blue, black mottled shale, some parts sandy.
157-158		Dark gray dense ls.
158-158.2	*	Same as above with barite, fluorite, galena, and quartz xtals in numerous voids.
158.2-160		Dark gray dense ls.
160-171	*	Dark gray dense ls with barite, fluorspar, galena, and quartz in voids.
171-174		Dark gray dense ls.
174-175		Gray, red, green shale.
175-176		Black shale.
176-178		White to buff ls with galena, fluorite, quartz, malachite, in voids and in the ls.
178-180		Clayey white to gray ls with calcite quartz and siderite in filled fractures. Realgar? at 179.
180-		Galena with quartz and siderite in ls.
180-183		Dense gray ls with calcite filling small fractures.

APPENDIX II

Estimated Present Values of the Ore Reserves and Potential Geologic Tonnage

The present values of the ore reserves and potential geologic tonnage at the Royal Flush and Mex-Tex mines are based on published assay values; Kottlowski (1953, p. 6) reports from 30 to 55 (average 42.5) percent barite, from 12 to 23 (average 17.5) percent fluorite, and about five percent galena in a gangue of quartz at the Royal Flush mine. Williams (1964, p. 43) gives 58.8 percent barite, 11.8 percent fluorite, 19.3 percent SiO_2, and 9.1 percent $CaCO_3$ for production from the Mex-Tex mine.

Selling prices of barite, fluorspar, and lead obtained from the Engineering and Mining Journal are as follows:

Barite The price of dry ground drilling mud grade barite, with 83-93% $BaSO_4$, 3-12% Fe, and specific gravity 4.20-4.30 is averaged (1971-1972) to be $40.00 per short ton.

Fluorspar The f.o.b. price of dry, acid-grade (97% CaF_2) fluorspar is averaged (1971-1972) to be $80.00 per short ton.

Lead The average price (1971-1972) of lead at the New York market price is 14.500 cents per pound and the predicted price for 1974 by using the least squares method is 16.600 cents per pound.

Present value factors which are used to estimate the present value of the ore reserves and potential geologic tonnage are obtained from Baxter and Parks (1957), Table 8, page 413.

The details of the estimated present values are as follows:

Proven Ore

The proven ore at the Royal Flush mine (42.5% $BaSO_4$, 17.5% CaF_2, and 5.0% PbS)	500 tons
Mining loss 20%, obtained ore	400 tons
Milling loss 20%, recovered ore	320 tons
Contained in recovered ore	
Barite	136 tons
Fluorite	56 tons
Galena	16 tons
or Lead (PbS = 86.8% Pb)	13 tons

The proven ore at the Mex-Tex mine (58.8% $BaSO_4$, 11.8% CaF_2, 19.3% SiO_2, and 9.1% $CaCO_3$)	1,200 tons
Mining loss 20%, obtained ore	960 tons
Milling loss 20%, recovered ore	768 tons
Contained in recovered ore	
Barite	452 tons
Fluorite	90 tons

Total Mineral Concentrates from Proven Ore	
Barite Concentrate (88% $BaSO_4$)	665 tons*
Fluorite Concentrate (97% CaF_2)	149 tons
Lead Concentrate (60% Pb)	22 tons

Estimated Value of Total Proven Ore	
Barite ($40.00 per ton)	$26,600
Fluorite ($80.00 per ton)	11,920
Lead ($140.00 per ton)	3,080
Total	$41,600

This 1,700 tons of proven ore could be mined in a few months, therefore, the estimated present value is	$41,600

Probable Ore

The probable ore at the Royal Flush mine (42.5% $BaSO_4$, 17.5% CaF_2, and 5.0% PbS)	1,300 tons
Mining loss 20%, obtained ore	1,040 tons
Milling loss 20%, recovered ore	832 tons
Contained in recovered ore	
Barite	354 tons
Fluorite	146 tons
Galena (PbS = 86.8% Pb)	42 tons
or Lead	36 tons

The probable ore at the Mountain Canyon mine (An average assay - 50.7% $BaSO_4$, 14.7% CaF_2, 2.5% PbS 27.2% SiO_2, and 4.6% $CaCO_3$)	1,250 tons

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* The 588 tons of barite derived from assay values would yield 665 tons of 88% barite concentrate.

Mining loss 20%, obtained ore	1,000 tons
Milling loss 20%, recovered ore	800 tons
Contained in recovered ore	
Barite	406 tons
Fluorite	118 tons
Galena	20 tons
or Lead (PbS = 86.8% Pb)	18 tons

The probable ore at the Mex-Tex mine (58.8% $BaSO_4$, 11.8% CaF_2, 19.3% SiO_2, and 9.1% $CaCO_3$)	500 tons
Mining loss 20%, obtained ore	400 tons
Milling loss 20%, recovered ore	320 tons
Contained in recovered ore	
Barite	188 tons
Fluorite	38 tons

Total Mineral Concentrates from Probable Ore	
Barite Concentrates (88% $BaSO_4$)	1,077 tons
Fluorite Concentrates (97% CaF_2)	311 tons
Lead Concentrate (60% Pb)	90 tons

Estimated Value of Total Probable Ore	
Barite ($40.00 per ton)	$43,080
Fluorite ($80.00 per ton)	24,880
Lead ($140.00 per ton)	12,600
Total Value	$80,560

Total value of proven ore and probable ore is estimated to be	$122,160
These 4,750 tons of proven ore and probable ore could be mined in a few months, therefore, the estimated present value is	$122,160

Proven Ore + Probable Ore + Area 1

Area 1

The potential geologic tonnage at Area 1 (50.7% $BaSO_4$, 14.7% CaF_2, 2.5% PbS, 27.2% SiO_2, and 4.6% $CaCO_3$)	3,600 tons
Mining loss 20%, obtained ore	2,880 tons
Milling loss 20%, recovered ore	2,304 tons
Contained in recovered ore	
Barite	1,168 tons
Fluorite	340 tons
Galena	58 tons
or Lead (PbS = 86.8% Pb)	50 tons

Total mineral concentrates from Area 1	
Barite concentrate (88% $BaSO_4$)	1,327 tons
Fluorite concentrate (97% CaF_2)	350 tons
Lead concentrate (60% Pb)	83 tons

Estimated Value of Total Potential Geologic Tonnage at Area 1	
Barite (\$40.00 per ton)	\$53,080
Fluorite (\$80.00 per ton)	28,000
Lead (\$140.00 per ton)	11,620
Total estimated value	\$92,700
The estimated value of total proven ore, probable ore, and Area 1 (total 8,350 tons) is	\$214,860
This 8,350 tons could be mined within one year (100 tons per day); at 25% interest and 5% redemption the present value factor is 0.80000. The estimated present value is	\$171,888

Proven Ore + Probable Ore + Area 1 + Areas 2, 3, and 4

Areas 2,3, and 4

The potential geologic tonnage at Areas 2, 3, and 4 (50.7% $BaSO_4$, 14.7% CaF_2, 2.5% PbS, 27.2% SiO_2, and 4.6% $CaCO_3$)	10,800 tons
Mining loss 20%, obtained ore	8,640 tons
Milling loss 20%, recovered ore	6,912 tons
Contained in recovered ore	
Barite	3,504 tons
Fluorite	1,016 tons
Galena	173 tons
or Lead (PbS = 86.8% Pb)	150 tons

Total mineral concentrates from Areas 2, 3, and 4	
Barite concentrate (88% $BaSO_4$)	3,982 tons
Fluorite concentrate (97% CaF_2)	1,047 tons
Lead concentrate (60% Pb)	250 tons

Estimated value of total potential geologic tonnage at Areas 2, 3, and 4	
Barite (\$40.00 per ton)	\$159,280
Fluorite (\$80.00 per ton)	83,760
Lead (\$140.00 per ton)	35,000
Total	\$278,040
The estimated value of the proven ore, probable ore, Areal, Areas 2, 3, and 4 (total 19,150 tons) is	\$492,900
This 19,150 tons could be mined within one year (100 tons per day); at 25% interest and 5% redemption, the present value factor is 0.80000. The estimated present value is	\$394,320

Proven Ore + Probable Ore + Area 1 + Areas 2, 3, and 4 + Areas 5 and 6

Areas 5 and 6

The potential geologic tonnage at Area 5 (42.5% $BaSO_4$, 17.5% CaF_2, and 5.0% PbS)	9,200 tons
Mining loss 20%, obtained ore	7,360 tons
Milling loss 20%, recovered ore	5,888 tons
Contained in recovered ore	
Barite	2,502 tons
Fluorite	1,030 tons
Galena	294 tons
or Lead (PbS = 86.8% Pb)	255 tons

The potential geologic tonnage at Area 6 (58.8% $BaSO_4$, 11.8% CaF_2, 19.3% SiO_2, and 9.1% $CaCO_3$)	23,800 tons
Mining loss 20%, obtained ore	19,040 tons
Milling loss 20%, recovered ore	15,232 tons
Contained in recovered ore	
Barite	8,956 tons
Fluorite	1,797 tons

Total mineral concentrates from Areas 5 and 6	
Barite concentrate (88% $BaSO_4$)	13,020 tons
Fluorite concentrate (97% CaF_2)	2,914 tons
Lead concentrate	425 tons

Estimated value of potential geologic tonnage at Areas 5 and 6	
Barite ($40.00 per ton)	$520,800
Fluorite ($80.00 per ton)	233,120
Lead ($163.08 per ton*)	69,309
Total estimated value	$823,229

Estimated value of total proven ore, probable ore, Area 1, Areas 2, 3, and 4, and Areas 5 and 6 (52,150 tons)	$1,316,129
This 52,150 tons can be mined in three years, (100 tons per day); at 25% interest and 5% redemption the present value factor is 0.58767. The estimated present value is	$773,450

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* The potential geologic tonnage will not be mined for at least 3 to 5 years in the future. Therefore, the expected price is increased by an amount derived from a least square analysis of lead prices over 1962 to 1972. The projected trend line indicates an approximate two cents per pound increase in average lead prices.

Proven Ore + Probable Ore + Area 1 + Areas 2, 3, and 4 + Areas 5 and 6 + Area 7

Area 7

The potential geologic tonnage at Area 7 (50.7% $BaSO_4$, 14.7% CaF_2, 2.5% PbS, 27.2% SiO_2, and 4.6% $CaCO_3$)	46,600 tons
Mining loss 20%, obtained ore	37,280 tons
Milling loss 20%, recovered ore	29,824 tons
Contained in recovered ore	
Barite	15,120 tons
Fluorite	4,384 tons
Galena	745 tons
or Lead (PbS = 86.8% Pb)	647 tons

Total mineral concentrates from Area 7	
Barite concentrate (88% $BaSO_4$)	17,180 tons
Fluorite concentrate (97% CaF_2)	4,520 tons
Lead concentrate (60% Pb)	1,078 tons

Estimated value of potential geologic tonnage at Area 7	
Barite ($40.00 per ton)	$687,200
Fluorite ($80.00 per ton)	361,600
Lead ($163.08 per ton)	175,900
Total estimated value	$1,224,700

Estimated value of total proven ore, probable ore, Area 1, Areas 2, 3, and 4, Areas 5 and 6, and Area 7 (total 98,750 tons of ore) is	$2,540,829

This 98,750 tons could be mined in five years (100 tons per day); at 25% interest and 5% redemption; the present value factor is 0.46406. The present value for all ore reserves and potential geologic tonnage is estimated to be	$1,179,000

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