GEOLOGY OF THE RANCHO DE LÓPEZ AREA
EAST OF SOCORRO, NEW MEXICO

by

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Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science in Geology

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ABSTRACT

The Rancho de Lopez area is located nine miles east-northeast of Socorro, New Mexico (Socorro County). The majority of the field is located on the Lomas de las Cañas Quadrangle. This field area forms the eastern flank of the Rio Grande Rift.

The rocks exposed in the area range from Pennsylvanian (Missourian) to Permian (Leonardian). An incomplete Pennsylvanian section is present due to normal faulting.

The landmass responsible for the majority of clastics was probably the Pedernal Landmass to the northeast. Clastic content increases toward the east.

Pennsylvanian strata in this field area are represented by limestones, shales, arkose and fine-grained sandstones. Pennsylvanian rocks are not conformable with the overlying Permian strata.

Permian rocks are variable in lithology. Marine and continental sedimentary structures are preserved in the strata. Permian strata in the Rancho de Lopez area, consist of mudstone, limestone, sandstones, siltstones, and gypsum.

The structural style of the area is dominated by extensional tectonics (normal faulting). A subordinate amount of gentle folding is present. Stratigraphic throw ranges from a few meters to 36.4 meters. Major faults trend roughly north-south.
Stratigraphic nomenclature used herein is essentially that of Thompson (1942). The only deviation is use of Bursum Formation (Wilpolt and Wanek, 1946) instead of Bruton Formation.
INTRODUCTION

Location, Size, and Accessibility

The study area is located along the east flank of the Rio Grande Rift, nine miles east-northeast of Socorro, New Mexico (Figure 1). The majority of this area is located on the Lomas de las Cañas Quadrangle. Remaining field area is contained on the following quadrangle maps: Bustos Well, Mesa del Yeso, and Sierra de la Cruz. Coordinates involved are: 106° 45' 6" E and 106° 42' 37" E longitude; 34° 7' 32" N and 34° 4' 25" N latitude.

Study area encompasses approximately ten square miles. Sections included are: 19, 20, 21, 22, 27, 28, 29, 32, and 33 in T. 2 S., R. 2 E.; 3, 4, 5, and 6 in T. 3 S., R. 2 E.

Gravel roads along west and east borders provide access to the area studied. These roads are maintained by the Bureau of Land Management.

Purpose

The purpose of this project is three-fold. One is to generate a detailed, lithostratigraphic map. A second is to construct geologic cross-sections which delineate tectonic-produced structural features. Third, to postulate possible, depositional environments which might have been active in the Rancho de Lopez area.
Methods of Investigation

Before detailed mapping began, a reconnaissance of the study area was completed. Aerial photographs (1:31,500) were used for field reference. Data obtained from field mapping is plotted on topographic maps enlarged to final map scale (1:12,000).

The thickness of rock units comprising the stratigraphic section was determined using a pocket transit and Jacob staff. When possible, a steel tape was used to measure thickness. Bedding classification of McKee and Weir (1953) is used throughout this thesis.

Rock samples were primarily collected at the site of the measured section. These samples were taken at important changes in lithology. The "average" lithotype is represented by these samples. Other samples were collected throughout the field area if unusual sedimentary structures or paleontological horizons were discovered. Grain size scale of Wentworth (in Pettijohn et al., page 72, 1972) is used throughout this paper.

Thin sections were made from most hand samples and stained with Alizarin red S (stains calcite, but not dolomite). Two sections of Pennsylvanian strata were measured in T. 2 S., R. 2 E. The west section location is: W/2, W/2, W/2, section 29 (Plate 1). Approximately 2.6 kilometers northeast of this section is the location of the
east measured section. Its location is: SE/4, NW/4, section 21.

Rock descriptions included in this report will follow the classification scheme of Pettijohn et al. (1972) for carbonates and Dunham (1962) for clastics. The term "carbonate mudstone" will replace Dunham's mudstone to avoid confusion with clastic mudstones.

Previous Work

A detailed geological map of this study area has never been produced. Wilpolt and Wanek (1951) drafted a preliminary reconnaissance map (1:62,500), but good detail is lacking. Angel Rejas (1965) mapped twelve square miles west of this study area. John Bauch is mapping ten square miles south of this study (see figure 1). William Siemers (1978) completed an interpretation of depositional environments for upper Paleozoic strata around Socorro, New Mexico. Siemers did not compile a lithostratigraphic map. Published work by Thompson (1942) and Kottlowski (1960) describes strata encompassed by this field study.

Topography, Relief, and Drainage

Topography is dominated by long (up to 4.8 km.) fault scarps produced by normal faulting (Figure 2). Topographic relief increases from west to east. Elevation ranges from 1581 meters (5200 feet) to a maximum of 1886.6 meters (6206 feet) above sea level.
Figure 2  Long fault scarp produced by normal faulting between Pennsylvanian and Permian strata. Section 5, T. 2 S., R. 2 E.
Subsequent streams predominate in the drainage patterns. Small tributaries appear to be controlled by faulting. Several large tributaries, trending east-west, feed the Rio Grande River.

Vegetation

Vegetation is sparse, due to the semi-arid climate. The dominant plants include: mesquite, ocotillo, creosote bush, numerous cacti, wild flowers, and varieties of gramma grass. Few trees are able to survive. Junipers are the exception. Vegetation does not seem to prefer any particular lithology. Enough grass is available to run two to three head of cattle per section of land.

Wildlife

Mammals and reptiles are quite abundant in this desert environment. Numerous deer, rabbits, and ground squirrels are observed throughout the field season.

Reptiles are represented by lizards, and rattlesnakes. Western Diamond-back and prairie rattlesnakes are the main species in this area.

Climate

A semi-arid environment prevails in the study area most of the year. July and August are the wet months of the year. Fifty percent of the yearly rainfall usually occurs during this sixty day interval. The average yearly rainfall in Socorro is less than nine inches (22.9 cm.). This
precipitation is probably close to the amount received by this field area.

In the summer, temperatures climb as high as 110° F. January average, maximum temperature is 52° F. January average, minimum temperature is 23° F. In the winter, a few, light snowfalls will occur.

GEOLOGY

Rocks in the study area range in age from Pennsylvanian (Late Missourian) to Permian (Middle Leonardian). Emphasis of this study is on the Pennsylvanian System. Most of the area is covered by a veneer of Quaternary alluvium. Outcrops of igneous rocks (pre-Cambrian) can be found two miles west of this study area.

STRATIGRAPHY

Stratigraphic units described by Thompson (1942) were used for this study (Figure 3). These same stratigraphic units were used by Rejas in 1965 in an adjacent field area. A much more simplified stratigraphic column was used by Wilpolt and Wanek in 1951. Greater stratigraphic detail was recognized and needed, than could be provided by Wilpolt and Wanek.

Thompson (1942) named the unit located between the Abo Formation (Permian) and Moya Formation (Pennsylvanian), the Bruton Formation. The Bruton was described from exposures in the Oscura Mountains. Bruton type section was not observed
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*not present in Rancho de Las Cruces*
by this writer.

Wilpolt and others (1946) named the unit between the Moya and Abo Formations the Bursum Formation. The type section is west of the Bursum triangulation point in the SE/4, Section 1, T. 6 S., R. 2 E., Socorro County, New Mexico. Since this type section is closer to the Rancho de Lopez Area than the Bruton type section, this writer favors use of Bursum Formation for red arkosic sands, conglomerate and interbedded, nodular limestones between the Moya and Abo Formations.

Reasonably good lithologic correlation, with stratigraphic units recognized by Rejas, is achieved herein. The major difference seems to be increasing clastics eastward (this report). The Del Cuerto Formation is not differentiated into lower, middle, and upper members in this report due to poor exposure.

The Moya and Story Formations provide easily recognizable marker beds throughout the field area. Lower Moya Formation is usually found capping cuestas when the Moya is present. The Story Formation comprises the lower prominent ledge of a "double ledge" display (Figure 4).

The Joyita, Cañas, and Torres Members of the Yeso Formation are mapped together as Torres Member, but differentiated in measured sections.
Figure 4A Prominent double ledge found in the upper Pennsylvanian strata in New Mexico. Looking northward; section 32, T. 2 S., R. 2 E.

Figure 4B Same double ledge observed from measured section 2. Looking eastward; section 21, T. 2 S., R. 2 E.
DESCRIPTIVE SEDIMENTOLOGY

Pennsylvanian Rocks

Hansonburg Group

Burrego Formation

The term Burrego was proposed by Thompson in 1942 for a group of massive to massively bedded and nodular limestones directly above the Council Springs Limestone. The type section is found north of Burrego Spring on the northeast side of the Oscura Mountains. This is also coincident with the type locality for the complete Hansonburg Group.

At the type locality (Figure 5), the Burrego Formation is 16 meters thick (Thompson, 1942). South and northwest of the type section, the Burrego is much thicker due to increased clastic material.

Burrego Formation measured for this study is thicker than Thompson (1942) or Rejas (1965) recorded. Burrego in both measured sections is not complete due to faulting. In the west, 81.1 meters is recorded. Northeast of this section, 102.4 meters of Burrego is present. Rejas measured a Burrego section 2.4 km. west of this writer’s section 1. Rejas recorded 11.3 meters. Burrego Formation appears to conformably underlie the Story Formation.

Section 1 (west) is predominantly light olive-brown, fissile shales and carbonate mudstones (Figure 6). Shales and mudstones are silty and micaceous (see complete
Figure 5  Type section for Burrego, Story, Del Cuerto, and Moya Formations in the Oscuras. Looking northward; section 31, T. 5 S., R. 6 E.

Figure 6  Burrego Formation carbonate mudstone and shale (App. A, unit 1).
descriptions in Appendix A and B). Only seven percent of the exposed section is sandstone. The sandstone is fine- to medium-grained sand; subrounded, moderately sorted. The sand body is lenticular (Figure 7) and exhibits planar cross bedding. Localized occurrences of limestone cobble conglomerate are located at the base of this sand unit (Figure 8). Limonite-stained concretions are present within some shale intervals. Pelmatozoan stems are abundant in several carbonate intervals. Productid brachiopods are also observed. All fossil material is highly abraded. In thin sections, Triticites spp. similar to those from the lower half of the Pine Shadow Member of the Wild Cow Formation (Early Virgillian) is recognized. The Wild Cow Formation is located in the southern part of the Manzano Mountains. The lithology described above, corresponds with the western measured section of Rejas (1965). Major difference between the two is thickness of strata.

Burrego Formation in section 2 is dominated by clastics (33%). Again, a complete section of Burrego is lacking due to faulting. Clastics are primarily arkosic sandstones (Figure 9A). Color of arkose ranges from yellowish-brown to olive gray. Coarse silt to fine sand dominates clastic grain size. Several arkosic sandstones contain as much as 5% micaceous material. Small-scale planar crossbedding dominates sedimentary structures (Figure 9B). Distorted bedding was also observed at the top of two fine grained sandstone units(Figure 10). An imprint of plant material
Figure 7  Lenticular, channel sand (App. A, unit 8) within the upper Burrego. Looking eastward.

Figure 8  Channel lag gravels and cobbles in Burrego.
Figure 9A  Burrego, arkosic sandstone from measured section 2. Scale is 30.5 cm. in length.

Figure 9B  Small-scale, planar crossbedding within a Burrego arkosic sandstone (App. A, unit 26). Scale is same as above.
Figure 10A

Figure 10B

Figure 10 A and B  Distorted bedding displayed in a Burrego sandstone (App. A, unit 12).
was found on one of the thin, arkosic sandstones. The plant fragment is identified as Calamites sp. Most of the arkosic intervals are interbedded with laminated carbonate mudstones and shales (Figure 11A).

Calcareous siltstones and shales are light to dark gray (Figure 11B). These rock types are most abundant in the lower half of measured section 2. Clastic units display very thin to thick tabular bedding.

Limestones within this interval are wackestones, with an occasional packstone. Fossils include pelecypods, fenestrate bryozoans, and pelmatozoan fragments. Most skeletal grains are abraded. Thin section analysis reveals ostracods throughout most of the Burrego Formation. There is also evidence of bioturbation in two carbonate mudstone thin sections.

Story Formation

The term Story Formation was proposed for the upper 17.7 meters of the Hansonburg Group (Thompson, 1942). Thompson described a lower unit (6 meters) of reddish-brown shale, arkosic and micaceous sandstone and gray shale, and an upper unit (11.5 meters) composed of light gray, massive to massively bedded and highly fossiliferous limestone (Figure 5). This formation has been recognized throughout most of central New Mexico (Thompson, 1942). The Story Formation appears to conformably overlie
Figure 11A  Carbonate mudstone and gray, fissile shale (App. B, unit 6) found within the Burrego Formation. Scale is 30.5 cm. in length.

Figure 11B  Burrego siltstones and shales (App. B, unit 8) from measured section 2.
the Burrengo Formation, and conformably underlie the Del Cuerto Formation.

**lower clastic unit**

In section 1 this unit is represented by 9.5 meters of grayish-red, micaceous, thin bedded, arkosic siltstone (Figure 12). Section 2 unit is similar, but thicker (13.2 meters). This unit is best described as an arkosic sandstone (fine sand-size quartz). It too is micaceous, and thin bedded.

**upper limestone unit**

Section 1 contains about 6.8 meters of fossiliferous, carbonate mudstone (Figure 13). Both contacts are sharp. From outcrop observation, pelmatozoan stems (up to 19 cm. long), solitary rugose corals, phylloid algae, and fenestrate bryozoans are common. Thin section analysis yields pelecypod valves, forams, calcispheres (algal reproductive structures), and ostracods. Bedding is very poor to massive. The light brownish-gray limestone is one of two prominent and easily traceable ledge-formers.

Section 2 (east) contains 6.4 meters of light yellowish-brown carbonate mudstone (Figure 14). The mudstone is massively bedded. Similar fossils to those in section 1 were noted. Here too, the upper Story Formation forms a prominent ledge. Lithology is constant between the two sections.
Figure 12  Arkosic siltstone characteristic of the lower unit of the Story Formation (App. B, unit 27). Scale is 30.5 cm. in length.

Figure 13  Upper limestone unit of Story Formation from measured section 1. Looking northeastward; section 29, T. 2 S., R. 2 E.
Figure 14  Upper limestone unit of Story Formation from measured section 2. Looking eastward; section 21, T. 2 S., R. 2 E.
KELLER GROUP

Del Cuerto Formation

As a result of extensive work throughout New Mexico, Thompson (1942) states that "... the Virgillian Series lithology in New Mexico varies more markedly geographically than the lithology of any other Pennsylvanian Series. Lithology varies from marine limestone to deltaic to brackish water silts and silty limestones to sandstones."

The terms Keller and Del Cuerto were first used by Thompson in 1942. Type locality is at the north end of the Oscura Mountains. The predominant lithology at the type section is limestone. Twenty-five meters of Del Cuerto Formation was recognized by Thompson. Although dominant lithology is limestone, interbedded arkosic sandstones, red to gray shales, and limestone conglomerate are present.

Rejas (1965) divided the Del Cuerto Formation into three members. Due to poor outcrop exposure in both measured sections of this study, the Del Cuerto Formation is described as a single unit. Rejas measured 17.3 meters of Del Cuerto.

In section 1 (west), Del Cuerto attains a thickness of 11.8 meters. Lithology is characterized by light gray carbonate mudstones, sandy packstones, and cherty, carbonate mudstones (near its contact with overlying Moya Formation). The fossiliferous packstones contain abraded pelmatozoan
debris. This unit weathers back beneath the Moya Formation.

Section 2 contains about fifty percent less section (6.2 meters). Outcrop exposure is poor. Lithology here is characterized by light gray, fossiliferous wackestone. Upper contact is gradational with overlying Moya Formation. It appears upper and lower contacts are conformable. At the outcrop, brachiopods and pelmatozoan debris is common. Bedding is wavy. The top one meter is a thin bedded, pelecypod packstone.

Moya Formation

Thompson (1942) proposed the term Moya Formation for the massive to massively bedded and irregularly bedded to nodular limestone between the top of the Del Cuerto Formation below and the base of the Bruton Formation above. Thompson recognized the Moya throughout central New Mexico. The type locality is found on the northeast side of the Oscura Mountains. When the upper limestone unit of the Moya Formation is present, it forms the caprock on cuesta ridges. Most east dip-slopes throughout the Oscura Mountains are Moya Formation.

At the type locality, the Moya Formation is 15.5 meters thick (Figure 5). Thompson (1942) did note an increasing thickness toward the north and south. Total Moya thickness in this study (measured section 1) is 26.8 meters. At measured section 2, the upper Moya is not present due to
erosion on the dip slope. Thickness for the lower limestone is 10.6 meters. Rejas (1965) measured 23.3 meters of Moya. His section is located approximately 4.8 km. west of this writer's measured section 1. In the Rancho de Lopez area, it was possible to divide the Moya into an upper and lower limestone unit.

**lower limestone unit**

Measured section 1 contains 15.9 meters of light gray carbonate mudstone (Figure 15). The lower one meter contains large nodules of chert (Figure 16). Location of this chert within the member is fairly constant throughout the study area. Medium to thick bedding predominates in this poorly bedded unit (Figure 17). Pelmatozoan stems and brachiopods (disarticulated) are also abundant. Phylloid algae are abundant.

Petrographic analysis yields further faunal information. In addition to fauna mentioned above, ostracods, encrusting bryozoans, and encrusting, red algae are observed. Mineralogy is mostly calcite.

**upper limestone unit**

Total thickness of the upper unit from measured section 1 is 10.9 meters. Lithology is quite similar to the lower unit. Wackestone comprises most of this unit, but packstones are observed. Wackestone is medium to thick bedded, light gray, and poorly bedded. Disarticulated
Figure 15  Lower limestone unit of Moya Formation near measured section 1. Looking northward.

Figure 16  Chert nodules in the basal one meter of lower Moya Formation. Scale is 30.5 cm. in length.
Figure 17  Closeup of bedding characteristic of the lower Moya Formation. Scale is 15 cm. long; section 29, T. 2 S., R. 2 E.
pelmatozoan stems are common at outcrops. Phylloid algae are common (Figure 18).

Petrographic analysis yielded further fauna present. Foraminifera and fusulinids, bryozoa, ostracods, molluscs, punctate brachiopods, and encrusting, red algae can be identified. One thin section shows evidence of burrowing. Mineralogy is predominantly calcite. This limestone is dense.

At most localities throughout this study area, the transition between upper and lower Moya Formation is subtle. In some locations, a thin bedded, brown, arkosic sandstone separates the two units (Figure 19). This sandy interval is usually covered. Where the sandstone is covered, a slight break in slope is arbitrarily used as the contact between the two limestone units of the Moya.

Permian Strata

Bursum Formation

The type section of the Bursum Formation, named by Wilpolt and others (1946), is west of the Bursum triangulation point in the SE 1/4, section 1, T. 6 S., R. 4 E., Socorro County, New Mexico. At the type locality, the Bursum Formation consists of thick beds of dark purplish-red and green shale separated by thinner beds of arkose, arkosic conglomerate, and gray limestone. A thin, rubbly, nodular, purplish-gray limestone consisting of material possibly
Figure 18A  Phylloid algae found in the Moya Formation (App. A, unit 27).

Figure 18B  Remains of phylloid algae now filled with sparry calcite in the Moya Formation.
Figure 19A

Figure 19B

Figure 19 A and B Thin bedded, fine grained, arkosic sandstone unit between the upper and lower Moya limestone units. Looking eastward. Scale is 15 cm. in length.
derived from the underlying Moya Formation occurs locally at the base (Wilpolt and Wanek, 1951). They considered the Bursum Formation to be Wolfcampian in age, as determined by fusulinid identification. This age is supported by fusulinid data obtained from the current study area. *Triticites creekensis* is the most abundant fusulinid identified in this area. *Bradyina* sp. is also noted, but may be detrital (Myers, personal communication, 1981). *T. creekensis* was described by Thompson (1964) from material in the Camp Creek Shale of north-central Texas, where it is associated with *Schwagerina campensis*. Thompson (1964) also described specimens *T. creekensis* from the Bursum Formation in the Oscura Mountains, and from the southern part of the Los Piños Mountains, in New Mexico. Maximum thickness at the type locality is 75.6 meters.

Rejas (1965) measured 60.6 meters of Bursum Formation in the Cerros de Amado area. In the Rancho de Lopez area, 76.7 meters of Bursum is present. Rock type is dominated by conglomerates (see Appendix C). At most outcrops viewed in this study area, a basal, limestone, pebble conglomerate is located above the Moya Formation (Figure 20). This conglomerate is very poorly bedded (wavy) and weathers into talus piles of limestone pebbles. The other type of conglomerate observed is a quartz and pink feldspar pebble conglomerate (Figure 21). Quartz pebbles and feldspar grains are in a calcareous, sandy matrix. Hematite staining of grains and matrix is abundant.
Figure 20A Basal, nodular, limestone conglomerate (App. C, unit 1) in the Bursum Formation. Upper unit is one meter thick. Upper unit is quartz-feldspar pebble conglomerate.

Figure 20B Closeup of Bursum basal conglomerate. Section 5, T. 2 S., R. 2 E.
Figure 21 Quartz-feldspar conglomerate in the Bursum Formation (App. C, unit 2). Unit length of grasshopper = 2.54 cm.
Two intervals of quartz and limestone pebble conglomerate exhibit a fining-upward sequence. Poorly developed crossbedding (planar) can also be recognized. Limestone clasts range in size from coarse sand to pebbles. Quartz clasts fall in the same size range. Most clasts are poorly sorted and subrounded. Thin beds of very light gray mudstone are interbedded with the conglomerates. Bursum Formation upper contact is gradational (conformable) with the overlying Abo Formation.

Abo Formation

W. T. Lee named the Abo Sandstone in 1909. The type section is located in Abo Canyon, Torrance County, New Mexico. There, the total thickness is 242 meters and consists of sixty percent red shales and forty percent sandstone, arkose, and conglomerate (Needham and Bates, 1943). Rejas (1965) measured 139.4 meters of reddish-brown, slightly massive, calcareous shale and carbonate mudstone interbedded with quartz siltstones and sandstones. He also noted occasional beds of pebbly conglomerate up to 3/10 meter thick. Pebbles are subrounded limestone clasts in the Rancho de Lopez area.

In this study area, the Abo Formation is 187 meters thick. It is approximately 67 percent sandstones and siltstones, and 33 percent mudstones and shales. Lithology remains fairly constant throughout the field area. Dark reddish-brown siltstones dominate the clastic intervals
(Figure 22). Near the top of the Abo, there is a thick (20.3 m.) light brown sandstone containing very fine to fine quartz sand. The sand is moderately sorted; subrounded; and exhibits small-scale planar crossbedding. Mudstones are also dark, reddish-brown. Most are silty and similar to the siltstones mentioned above. Some mudstone and siltstone intervals contain white spots on weathered surfaces. Many of these spots are circular. Rejas (1965) and others have referred to these patches as "reduction spots". These spots are not uniformly distributed and a wide variety of sizes is present (Figure 23).

The Abo Formation does not contain limestones or marine fossils, but burrows are present (Figure 24). Leaf casts were found in collections made for this study (Figure 25). Besides plant remains, numerous mud cracks (Figure 26), ripple marks (both wave and current), and low angle planar crossbedding are observed. At the Chupadera Mine (4 km. west), tracks of reptiles have been recovered (Rejas, 1965). These tracks are found in association with plant remains preserved as casts. Numerous fluvial channels (Figure 27) can be observed in the Rancho de Lopez area. A brecciated unit was also observed (Figure 28).

In the Rancho de Lopez area, the lower contact with the Bursum Formation is gradational, but at other localities, around the state, this lower contact suggests an unconformity. Abo rests on beds spanning a broad range of
Figure 22  Dark, red siltstones characteristic of the Abo Formation. Vertical relief is 30 meters. Looking northward; section 32, T. 2 S., R. 2 E.
Figure 23A  "Reduction spots" in the Abo Formation. Spot on right side of photo is 4 cm. in diameter. Section 30, T. 2 S., R 2 E.

Figure 23B  Similar Abo "reduction spots" showing circular nature of many spots. Largest spot on photo is 2.5 cm. in diameter. Section 30, T. 2 S., R. 2 E.
Figure 24  Burrows noted on Abo bedding surface. Section 4, T. 2 S., R. 2 E. Photo by D. B. Johnson
Figure 25A Conifer(?) casts found on Abo bedding surface. Section 30, T. 2 S., R. 2 E.

Figure 25B Abo conifer imprints. Same location as above.
Figure 26A  Mud cracks preserved on Abo bedding surfaces. Section 4, T. 2 S., R. 2 E. Keys are 5 cm. in length.

Figure 26B  Abo mud cracks. Section 30, T. 2 S., R. 2 E. Same scale as above.
Figure 27A  Lenticular, Abo channel. Channel height is 3.6 meters. Looking westward; section 32, T. 2 S., R. 2 E.

Figure 27B  Closeup of Abo channel showing lenticular shape. Vertical scale and location same as above.
Figure 28  Abo Formation breccia. Section 5, T. 2 S., R. 2 E. Clasts are actual size.
geologic time throughout New Mexico.

The Abo-Yeso contact is also gradational (Rancho de Lopez). The transition from reddish-brown Abo siltstones and mudstones to buff-colored siltstones and sandstones is taken as the upper contact. At some localities, Abo-Yeso contact is placed at the first siltstone below a thin bedded mudstone (containing halite casts). In strata studied herein, the mudstone (Figure 29) with halite casts is found much higher in the section. A thin basal limestone separates the Yeso and Abo Formations at the Yeso type locality (16 km. northeast of Socorro, N. M.).

Alternating beds of shales and siltstones produce a topographic expression similar to valley and ridge topography. Vegetative cover on the Abo Formation is sparse; consequently, the distinct red color can be observed for long distances.

Yeso Formation

Rocks designated as Yeso Formation were introduced by Lee in 1909. The name was derived from Mesa del Yeso located 19.2 km. north of Socorro, New Mexico; however, exposures at the mesa are poor. Needham and Bates (1943) remeasured and described the Yeso section 3.2 km. southeast of the mesa. The Yeso Formation can be divided into four members in the Rancho de Lopez area. These members in ascending order are: Meseta Blanca, Torres, Cañas, and
Figure 29  Halite casts found in upper Meseza Blanca mudstone. Section 4, T. 2 S., R. 2 E.
Joyita.

Meseta Blanca Member

The Meseta Blanca Member was named by Wood and Northrop in 1946. This member is composed entirely of buff, reddish-brown, brown, and red siltstones and sandstones. The Meseta Blanca, at the type locality, is characterized by pink, orange, and white sandstones. Erosion usually produces mesas supported by Meseta Blanca Member (Figure 30). These mesas are capped by the lowest limestone unit of the Torres Member.

Quartz grains ranging in size from coarse silt to fine sand are subangular to subrounded and moderately sorted. Several units cemented by calcium carbonate are friable. The majority of the Meseta Blanca is cemented with silica, with subordinate amounts of carbonate cement. Bedding ranges from thin to medium. Sandstones are well-bedded. Planar crossbedding (small-scale) is common. A small channel (1.5 m. long by .6 m. deep) is noted at the top of the member. Total thickness in this field area is 71.1 meters.

The lower contact with the Abo Formation is gradational. Upper contact throughout the field area is sharp. The upper contact in this field area, is mapped between the lowest limestone unit of the Torres Member and the upper sandstone interval of the Meseta Blanca Member.
Figure 30  Mesa supported by flat-lying Meseta Blanca Member of the Yeso Formation. Caprock is the lowest limestone in Torres Member (Yeso Formation). Looking eastward; section 5, T. 2 S., R. 2 E.
Rejas (1965) estimated Meseta Blanca thickness in his area to be 97 meters.

Torres Member

Wilpolt and others (1946) named the Torres Member from a type section found 11.2 km. south of Black Butte, Socorro County. The member is 181.8 meters thick and composed of interbedded orange-red and buff sandstone and siltstone, gray limestone, and gypsum. Rejas reconstructed a thickness of 66.7 meters based on structural cross sections.

In the Rancho de Lopez area, the Torres Member is incomplete due to faulting. An incomplete thickness in section four (east side) is 52.1 meters. On the west side of section four, gypsum is present above the lowest limestone ledge. A fault appears to coincide with this gypsum unit. One stratigraphic section bounded by faults, contains at least four limestone beds interbedded with orange-red sandstones. If this section is not repeated by faulting, the multiple limestone beds seem to indicate cyclic sedimentation.

Cañas Member

Needham and Bates (1943) named the middle evaporites of the Yeso Formation. The Cañas Member is 29.1 meters thick at its type section, but is quite variable in thickness elsewhere; ranging from 34.8 meters in the south part of New Mexico, to 24.2 meters in the northern part.
Twenty-nine kilometers north of Socorro, the Cañás Member is not present in a fully exposed Yeso Formation section.

In the Rancho de Lopez area, 29.3 meters of gypsum is measured. This gypsum is light gray on weathered and fresh surfaces. Bedding is massive. Several very thin bedded, brown siltstones are found interbedded with Cañás gypsum. Rejas (1965) estimated 12.1 meters of Cañás gypsum from his cross sections.

Joyita Member

La Joyita Hills contain 48.5 meters of pink, orange, and yellow thin bedded sandstone (Needham and Bates, 1943). In the Rancho de Lopez area, Joyita Member is approximately 18 meters thick. At most exposures, the Joyita is missing due to faulting. The lower 12.1 meters is a gypsiferous, pale red, siltstone. Pale red to red sandstone comprises the upper unit. This sandstone is poorly indurated, poorly sorted, and subrounded quartz grains are dominant. In this study area, the upper contact with the Glorieta Sandstone is distinct.

Glorieta Sandstone

Keyes (1915) was the first geologist to use the name Glorieta (Needham and Bates, 1943). From 1944 to the late 1950's, the sandstone was considered to be the lower member of the San Andres Formation by the United States Geological Survey. The United States Geological Survey adopted
Glorieta Sandstone as a formation in 1957 (Borton, 1972). Keyes did not designate a type section. Needham and Bates designated the type section at Glorieta Mesa (1.6 km. west of Rowe, New Mexico, San Miguel County). In this study area, the Glorieta Sandstone attains a thickness of 41.2 meters (Figure 31). West of Rancho de Lopez area, Rejas (1965) measured an incomplete thickness of 33.3 meters. Essentially, the same lithology is described by Rejas.

In this study area, the Glorieta is pale red, yellowish-brown, or white quartz sandstone. The quartz is subrounded, and poorly to well-sorted. Thin to medium bedding prevails. In the Rancho de Lopez area, the Glorieta weathers into alternating rounded and vertical-faced ledges. Sandstones producing rounded ledges are not as well-indurated and seem to contain more calcareous cement. Several units exhibit small-scale, planar crossbedding. Five intervals can be classified quartz arenites. Quartz grains are fine sand-size, well-rounded, well-sorted, well-indurated, and are bonded together with siliceous cement. It is these quartz arenites that produce the prominent, vertical-faced ledges.

The lower contact with the Yeso Formation (Rancho de Lopez area) is sharp (Figure 32). This lower contact is mapped at the first buff-colored sandstone. This buff-colored sandstone is better indurated and more mature than the underlying Joyita Member. The upper Joyita is
Figure 31  Westward view of Torres, Cañas, Joyita Members of Yeso Formation and Glorieta Sandstone and San Andres Formation. Section 3 and 4, T. 2 S., R. 2 E. Vertical height is 100 meters.

Figure 32  Westward view of contact between Permian Yeso Formation, Glorieta Sandstone, and San Andres Formation. Section 4, T. 2 S., R. 2 E. Vertical height of outcrop is 67 meters.
friable and pale red. The upper contact with San Andres Formation in this study area, is sharp. The upper contact is placed at the base of the first San Andres limestone ledge. Glorieta Sandstone is placed in the Leonardian Series by Dunbar (1960).

San Andres Formation

Lee named the San Andres Limestone in 1909. This name was derived from the San Andres Mountains in southern Socorro County (Needham and Bates, 1943). Total thickness of the San Andres Formation at the type locality is 179.8 meters. In the northern part of the state, the San Andres is thin and outcrops are discontinuous. Moving south and east, San Andres thickens and crops out over 5,000 square miles.

On paleontological grounds, the San Andres Formation is correlated with the Bone Springs Limestone in the Delaware Basin (Lang, 1937). San Andres is considered to be Upper Leonardian in age (Adams, 1939 and Dunbar, 1960). The San Andres Limestone, in the Rancho de Lopez area is incomplete due to erosion. Partial thickness measured is 21.7 meters.

The main lithotypes are calcareous mudstones, wackestones, and packstones. One sandstone unit (6.2 m.) is interbedded with limestone. This sandstone is a buff-colored quartz arenite. Quartz grains are fine sand-sized, well-sorted and rounded. Silica cement is
dominant. A striking similarity is recognized between this sandstone and highly resistant sandstone within the Glorista Sandstone.

Quaternary System

Rocks younger than San Andres Formation are not present in the Rancho de Lopez area due to erosion or nondeposition. The only strata younger than Leonardian Age are represented by recent alluvial deposits. This alluvium is composed of unconsolidated gravels, pebbles, cobbles, and sand derived from Pennsylvanian and Permian strata in the area. Several of the largest accumulations are shown on the geologic map (Plate 1). Thin veneers of alluvium blanket many flat, low-lying areas. These are not all shown on the geologic map.

STRUCTURAL GEOLOGY

Folding

Folded strata due to compressional forces, are not abundant in the Rancho de Lopez area. Gentle folding, probably predates faulting, as shown by the faulted, west side of the syncline in the center of Section 32, T. 2 S., R. 2 E. No evidence of drag folding along the faulted west side of the syncline was found. Dip measured on flanks of these and other folds is less than twenty-five degrees.

Rejas (1965) mapped an intensely folded area with fold axes trending NW-SE in the center of SE/4, section 6, T. 2 S., R. 2 E. Some his folds are overturned with axial
planes dipping 45 to 70 degrees to the west. This type of tight folding can also be observed in the area to the south and west mapped by Bauch. Tightly folded strata are not present in the Rancho de Lopez area.

Conclusions on Field Area Folding

On the basis of stratigraphic evidence available within this area of study, the deformation can be dated only as post-Permian. The major faults in this field area, may have been localized in the weakened limbs of the folds.

Faulting

The Rancho de Lopez study area is dissected by numerous faults. Stratigraphic throw ranges from less than 3.0 meters to 36.4 meters. Two longer north-trending faults can be traced for several kilometers. These major faults generally trend parallel to the direction of the Rio Grande Rift in this area.

A majority of the faults are normal faults with the downthrown side on the west. Dipping beds produced by fault "drag" are common (Figure 33).

Numerous smaller faults intersect major faults at random orientations. A relationship between the large and small fault trends is not recognized. In one area (center of NE/4, section 29, T. 2 S., R. 2 E.) of closely spaced, short "faults", there is a distinct possibility that movement of these small blocks resulted from slumping. An
Figure 33A  Fault produced bed "drag" between the Pennsylvanian Moya Formation and Permian Abo Formation. Looking eastward; section 34, T. 2 S., R. 2 E.

Figure 33B  Similar "drag" produced by normal faulting. Looking northward; section 29, T. 2 S., R. 2 E.
Faulting is initiated during the Late Miocene-Early Pliocene. It is possible that much of the major tectonic stress was vertical, and the least principal stress was north-south; and the least principal stress would have been orthogonal east-west. Intermediate shear strain has produced extensional faulting, which were produced by extensional tectonics, a result of the collision of the North American and ?

These faults, which are normal, faulting trending north-south.

A number of faults trended north-south, and normal rocks probably correspond to his fault system. The major faults between Pennsylvania and adjacent field area. The major faults in this field area are defined by the fault systems in his regions (1965). We constructed on faulting based on field data to the site of negligible offset.

S. R. 2 E. (can be traced from the area of maximum throw, fault (near junction of sections 20, 21, 28, and 29, T. 2
fault and Pennsylvania strata (upthrown side) A "knife" side (and Pennsylvania strata (upthrown side). The differences between Pennsylvania rocks (usually on downthrown klippen) were made possible by the striking lithologic position to faults. Tracing many of the faults for several kilometers, we observed that many of the faults in this field area, have their most if not all offsets in this field area, owe their

(Tores Member)

Contact with a thick unit of gypsum in the Tores formation is described as a gravity fault, this structural discontinuity is a shape, may have been a result of low angle reverse faulting. S. R. 2 E. (which seem to curve around in an arcuate intersection fault of "Faults" (N/2) NE 1/4, section 4, T. 2
technique (Conley, 1972) on an interfered, grating, to determine if organic material is present. Thin sections and spectrometry, the presence of aliphatic (straight-chain) and aromatic (Conley, 1972) compounds were tested to appear to contain interferential blurs. Using a multi-

Two samples from the Burke 2 Formation were tested to

this time (1981).

strata. These prospects contain subeconomic deposits at
associated with Permain (Bursum) and Pennsylvanian (Moya)
fluid with the interior of mining red bed copper deposits
border of this study area. Apparently, these claims were
several small prospects are located along the eastern

ECONOMIC GEOLOGY

from east to west.

this area. Clastic material in measured sections decreases
probably contributed most of the clastic material found in
measured in the Rancro de Lopez area, the Pedernal had mass
Middle Permian time. Judging from east-west sections
these uplifts probably remained as a positive area until
the Pedernal uplift was initiated in Pennsylvanian time.
(Armstrong and others, 1979). Most geologists agree that
from the overlap of that surface by Pennsylvanian rocks
down to the south and general northward thinning resulted
depositional surface in early Pennsylvanian time was tilted
Pennsylvanian (Armstrong and others, 1979). The regional
pre-Pennsylvanian time (Figure 34) were modified during the
positive and negative elements active in

Structural Blues during Pennsylvanian Time

55
direction of Burro Gap cherts comes from contemporaneous muds and the greenish cherts. Evidence for the transport (Pedernal?) to the east was providing abundant silt-laden during Burro Gap deposition, an uplifted source area.

DEPOSITIONAL HISTORY

...sustainless this...

(subsurface). Further geochemical testing is needed to strata located in the southern part of New Mexico conditions may have been similar for the Pennsylvanian Ranchito de Lopez area. Environmental and diagenetic rocks composition and hydrcarbons (a source bituminous material) is residually hydrcarbons (a source present. It is difficult to determine whether this from this study area suggests that organic material was bituminous material in Upper Pennsylvanian wackestones.

By R A D.

Both samples. Plutonite is the dominant mineralogy detected. powder was made, X-ray diffraction was then performed on passed through a 200-mesh sieve. A smear mount of this the samples tested above. The residue was powdered, and A substantial amount of insoluble residue remained from aromatic (ring-structure) hydrocarbons was confirmed in one.
Illyry: Soft sediment deformation produced by loading does not occur in the graded sediments below, tectonic deformation is not due to lack of distortion of the contact with similar turbidite.

Turbidite, loading, or a thin (20 cm.) fine-grained (Figure 10). This structure could be a product of severalstratigraphic units exhibit disturbed bedding carbonate mudstone and siltstone. Material from plants is present in the lower burrowed mud. Debris is common in this lower facies. Carbonaceous plant debris influenced the structure of sediment from suspension, explained by continuous fall-out of sediment from suspension, base of the delta front, Punta de Llano. Facies of marlstone could be siltstone were probably deposited out of suspension at the shelf, uniform sequences of shale, mudstone, and suggests a possible eolian environment. Obtained from a field area limited to ten square miles. Part of a fluvial-dominated delta front sequence. The data and bodies. It is quite possible that the arentes were determined, with reasonable accuracy, the geometry of these, due to lack of community of outcrops, it is difficult to classify these, are predominantly eolian barchan dunes. Further supports this origin, fine-grained, marginal marine origin, discovery and identification of a marine fossils associated with this mud (now shale) suggests kilometers west of the Rancho de Lopes area. Punta of
If these carbonate mudstones and wackestones mentioned above were deposited below wave base, abraded fossils are below marine-wave base; and behind a shelf margin.

Where wave action is subdued, carbonate mudstones and wackestones accumulate.

Periods of more turbulent sea water movement.

Clastic intervals, most fossils are abraded indicating interrupted, a marine transgression proceeded over the various times, with the clastic supply temporarily fossiliferous. In the Burro Gap clastic sediments decreased at bearing marine carbonate mudstones and wackestones (bearing marine 1978).

8 Similar depositional sequences are described by reading can be observed at the base of this sandstone unit (figure cannel of a delta lobe. Channel lag (pebbles and gravels) from measured section I probably represents the distributary

The medium grained, tenacious sandstone unit noted of a turbidity current.

Evidence suggests that distorted bedding may be the product deformed and undeformed intervals. Therefore, the educated interval size is equivalent between grain size of two different size distributions (means and time not seem reasonable. This is usually observed between
accumulate without generation of much wave or tidal energy. The shallow nature of this sea would allow open marine muds to probably relatively fast and covered by a shallow sea. The carbonate mudstone seems to indicate deposition occurred behind the shelf margin. This depositional surface was widespread occurrence and uniform thickness of this phytoplankton algae suggest deposition within the photic zone. Story formation was produced. Localized occurrences of (Thompson, 1942), the thick carbonate mudstone unit of the a result of this proposed, northward transgression transgression again proceeded over the clastic interval. A marlstone deposited, clastic input was interrupted. A marlstone After the lower unit of the story formation was

shale of the lower story formation, burrowed time produced the gravitationel argillaceous and silty
renewed uplift and subsequent erosion at the end of

of this study area is needed to test this hypothesis.
Further work east
indicate increasing distance from clastic sources to the
thinning of clastic units from east to west may

burulation.

the lagoon area. Lack of bedding here could be caused by
storm waves may have washed the abraded fossils back into
vertical succession. Deposition above wave base is favored.
base. Grain supported rocks are not observed in the
gratstones. If these mud supported rocks formed below wave
the vertical succession should yield packstones and
due to methods of sampling. This carbonate precipitation may be greater than in the lower Moya Formation. This may be due to the higher porosity of fauna in the upper Moya appear to be similar to lower Moya. Biofacies indicate marine conditions. Upper Moya lithology indicates marine conditions. Upper Moya have prevailed for the calcareous mud to accumulate.

the range of the photic zone, quieter water conditions must be associated with sedimentation in a quiet sea water. In occurrence of physical algae, muddy shallow sea water, common abundance suggests normal marine conditions. The lower unit of the Moya Formation was once again favored. The result is the accumulation of calcareous was reduced carbonate when a source of clastics was reduced carbonate.

mature enough to have a near-shore, beach or dune origin. Terrigenous clastics, sand grains do not appear to be carbonate mudstone unit suggesting a brief influx of amount of sand (fine sand) was introduced into a middle conditions could account for this paucity of fauna. A major paucity, lack of preservation or restriction of marine water of fauna provides little insight into marine conditions. Paucity to medium bedding present in the Del Quere. Paucity of fauna provides little insight into marine conditions. Carbonate deposition continued to be the dominant mass matrix of bedding suggests constant, uniform carbonate mud deposition.
Numerous lines of evidence point to fluviatil deposition.

Formation sedimentation. The formation lasted until the end of Abo dominance. This dominance lasted until the beginning of fluviatil deposition, probably the beginning of fluviatil deposition. The upper arkosic beds do not contain carbonate. Pennsylvanian clastics (silt and fine sand-sized quartz) were present, the majority of the source area being adjacent to the area providing the majority of the source. Large igneous or metamorphic source was probably different. Feldspar pebbles composing the bulk of the Bursum Formation, and of larger, or metamorphic source provided the quartz and underforming Moya Formation. Renewed or more intense uplift these pebbles appear to be lithologically equivalent to the base of the Bursum Formation. Throughout this study, the underlying Moya Formation and the Bursum is found at the period of time, evidence for a depositional hiatus between short intervals. Indicating an interruption of clastics for a short limestone is present, a thin bedded carbonate mudstone processes. This is suggested by subordinated amounts of deposition of Bursum Formation was dominated by fluviatil accumulation until the Permian Terno Formation was deposited.
possible, that the mudstone unit below each gypsum intercalation and carbonate mudstone. It is intermittent, not necessarily present, in this area. Cyclic deposition of strata suggests a depositional environment conducive to accumulation and preservation.

Environmental conditions during formation member necessary for halite crystal growth. Shallowness of the sea, provided the elevated salinity, barrier beach, these barrier beaches or possibly the angle cross-stratified, quartz, martz, sandstone suggests a low water. Some type of barrier must have been present to restrict circulation of sea water. Some type suggests the sea was shallow. Salt casts and mud cracks in shelly mudstone intervals

The presence of wave ripples marks, salt casts, low northwesterly clastic source area, supplemented, increasing thickness further north suggests a continuous clastic influx of long duration must have been judged from the thickness of the (2m) meters, a temperature to semi-arid environment.

Alvialina can, the presence of concretors (Figure 26) indicates
The marine transgression was probably occurring during times of classic supply interruption that thinned limestone units. The only known marine fauna were large formational deposits. It was only during times of classic supply interruption that thinned limestone units could accumulate. Brachiopods are the only known marine fauna throughout San Andres formation deposition. It was only during times of classic supply interruption that thinned limestone units could accumulate. Brachiopods are the only known marine fauna to occur in the New Mexico Bureau of Mines and Mineral Resources is recommended (Miller, 1978).

This sandstone implies a beach sandstone. The mature nature of angle cross-stratified quartz sand, well sorted, low interbeds are composed of well rounded, well sorted, low mudstone is similar to the dolomite sandstone. These sandstone interbeds are composed of well rounded, well sorted, low mudstone. Limestone units could accumulate throughout San Andres formation deposition. It was only during times of classic supply interruption that thinned limestone units could accumulate. Brachiopods are the only known marine fauna to occur in the New Mexico Bureau of Mines and Mineral Resources is recommended (Miller, 1978).

The marine transgression was probably occurring during times of classic supply interruption that thinned limestone units. The only known marine fauna were large formational deposits. It was only during times of classic supply interruption that thinned limestone units could accumulate. Brachiopods are the only known marine fauna to occur in the New Mexico Bureau of Mines and Mineral Resources is recommended (Miller, 1978).
Rocks are located farther north and south.
not present in this study area. These younger Permian strata younger than the San Andres Formation is
REFERENCES


Cox, New York: Disbrey, 57p.


APENDIX A through APENDIX D

EXPLANATION:

(m) — color of rock on a weathered surface

(f) — color of rock on a fresh surface

Grain size scale from Wentworth (Pettijohn et al., page 72, 1972)

Colors used to describe strata are from the Munsell Color Chart.

Pelmatozoans are sessile echinoderms (blastoids, crinoids, cystooids).
<table>
<thead>
<tr>
<th>METERS</th>
<th>DESCRIPTION</th>
<th>THICKNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.2</td>
<td>Covered</td>
<td>11.6</td>
</tr>
<tr>
<td>16.0</td>
<td>Top of Burgeo Formation</td>
<td></td>
</tr>
<tr>
<td>17.1</td>
<td>Top of lower unit</td>
<td></td>
</tr>
<tr>
<td>18.9</td>
<td>Top of upper unit -- Story Formation</td>
<td></td>
</tr>
<tr>
<td>19.9</td>
<td>Moved, weathered back under overlying</td>
<td>9.1</td>
</tr>
<tr>
<td>20.5</td>
<td>Covered</td>
<td>4.5</td>
</tr>
<tr>
<td>21.2</td>
<td>Trace of chalk; medium bed</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>Dark gray carbonate; light yellow</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dissolution of petromatronics: all</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lime carbonate; dark gray</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Possess less than one cm; recrystallized</td>
<td></td>
</tr>
<tr>
<td>9.6</td>
<td>Silstone--grayish-red (m) and thin</td>
<td>6.8</td>
</tr>
<tr>
<td></td>
<td>Limestone--mudstone; light brownish-gray (m)</td>
<td>18.0</td>
</tr>
<tr>
<td></td>
<td>Limestone--mudstone; thin</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Phyllloid algae</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Common</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Anhydrite abundant</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cretaceous ortho-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dark gray; medium bed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pale gray; top of unit cover</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limestone--mudstone; light gray</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limestone--mudstone; pale yellow</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(m)</td>
<td></td>
</tr>
</tbody>
</table>
and (f)

SHALET--fissile; moderate yellow-gray (m)

former

graptolites rare; ridge
bergs; limestone cobbles; conglomerate- Rounded; uncertain sand bodies?
 Quartz; moderately sorted; sub-
crossbedding; medium sand-sized;
Gray (f) well interbedded; planar
particles
SANDSTONE--moderate brown (w); light

8. 3.6

gravel on (w) and (f); silt near top;
Wavy laminae; contains more

SHALET--interbedded with laminae; calcareous mudstone; shale is

Tight gray (f) silt; thin bedded.
LIMESTONE--mudstone; olive brown (w)

10. 4.5

Silt at the top.
Wavy laminae; contains more

LIMESTONE--grayish-brown (w)

11. 1.8

bedded. Distorted bedded; some shale inter-
Fine sand; medium to thick bedded;
Gray (f) wavy; micaceous; silt to very
sandy
SANDSTONE--dark grayish-brown (w); light

12. 1.8

ded. Some laminaed siltstones interbed-
SHALET--fissile; olive brown (w) and (f)

13. 2.5

ridge former.
Crossbedding (small-scale); silt
bedding; upper contact covered; planar
Distorted bedding; medium to thick
brown (w) Tight gray (f) silt;
Siltstone--terragenous; dark grayish-

14. 0.73

METERS

UNITS DESCRIPTION

71
<table>
<thead>
<tr>
<th>Unit Thickness (meters)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Thin bedded.</td>
</tr>
<tr>
<td>2.0</td>
<td>Light gray (f); micaceous; stripy.</td>
</tr>
<tr>
<td>3.0</td>
<td>Limey--muds tone; olive brown (w)</td>
</tr>
<tr>
<td>4.4</td>
<td>Limey--muds tone; moderate yellowish.</td>
</tr>
<tr>
<td>5.0</td>
<td>Shaly--muds tone; very fine sand-size particles.</td>
</tr>
<tr>
<td>6.0</td>
<td>Shaly--muds tone; light yellow.</td>
</tr>
</tbody>
</table>
DESCRIPTION

UNIT

THICKNESS

METERS
Way bedded planes.

Peabody are grey and montane strata

 quartz and feldspar up to 5 cm. long;

to montane pebble conglomerate:

crossbedded (plane); lower one meter

AHKOSB--to--light-grey (m) ! light grey

11. 2.0

In lower two meters

sandstone (m) ! light grey

SHALES--light-grey (m) ! light grey

12. 5.5

red, surrounded.

dark: the sand--gravel, well sorted.

some bioturbation: interbedded: sandstone;

SANDSTONE--light-grey (m) ! and J

13. 2.4

Ray near the top.

Lower two meters: shale becomes dark

SHALES & SANDSTONES--interbedded in

14. 12.5

SANDSTONE: medium--yellow

15. 1.8

DIMENSION--packstone: moderate yellow.

16. 11.9

Shales: are fissile;

SILTS & SHALES--light-grey (m) !

17. 2.4

SANDSTONE--light-brownish-grey (m) !

DESCRIPTIION

UNIT THICKNESS

KETERS
<table>
<thead>
<tr>
<th>SHADE</th>
<th>LIGHT</th>
<th>ORANGE</th>
<th>GREEN</th>
<th>DARK</th>
<th>RED</th>
<th>MEDIUM</th>
<th>LIGHT</th>
<th>MEDIUM</th>
<th>DARK</th>
<th>RED</th>
<th>MEDIUM</th>
<th>LIGHT</th>
<th>MEDIUM</th>
<th>DARK</th>
<th>ORANGE</th>
<th>RED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.4</td>
<td>1.7</td>
<td>1.2</td>
<td>0.9</td>
<td>1.0</td>
<td>1.1</td>
<td>0.8</td>
<td>1.0</td>
<td>1.2</td>
<td>1.4</td>
<td>1.7</td>
<td>1.2</td>
<td>0.9</td>
<td>1.0</td>
<td>1.1</td>
<td>0.8</td>
</tr>
</tbody>
</table>

*Note: The table represents different shades and lightness levels.*
<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>SANDSTONE--tower</td>
</tr>
<tr>
<td>1.2</td>
<td>SANDSTONE--brown (w); tight brown (f)</td>
</tr>
<tr>
<td>1.3</td>
<td>SANDSTONE--same as above except than bedded.</td>
</tr>
<tr>
<td>1.4</td>
<td>SANDSTONE--calcareous cement; medium dark brown; lower contact; basal silt; plane.</td>
</tr>
<tr>
<td>2.0</td>
<td>SANDSTONE--pale red mud-brown (w) and (f).</td>
</tr>
<tr>
<td>2.3</td>
<td>SANDSTONE--tight brown (w); white; top of member.</td>
</tr>
<tr>
<td>2.5</td>
<td>SANDSTONE--dark red mud-brown (w) and (f).</td>
</tr>
<tr>
<td>2.7</td>
<td>SANDSTONE--pale red mud-brown (w) and (f).</td>
</tr>
<tr>
<td>3.0</td>
<td>SANDSTONE--dark mud-brown (w); very thin to medium beddings; plane.</td>
</tr>
<tr>
<td>3.1</td>
<td>SANDSTONE--dark red mud-brown (w) and (f).</td>
</tr>
<tr>
<td>3.2</td>
<td>SANDSTONE--same as above except thin bedded.</td>
</tr>
<tr>
<td>3.3</td>
<td>SANDSTONE--same as above except thin bedded.</td>
</tr>
<tr>
<td>3.4</td>
<td>SANDSTONE--same as above except thin bedded.</td>
</tr>
<tr>
<td>3.5</td>
<td>SANDSTONE--dark red mud-brown (w) and (f).</td>
</tr>
<tr>
<td>3.6</td>
<td>SANDSTONE--pale red mud-brown (w) and (f).</td>
</tr>
<tr>
<td>3.7</td>
<td>SANDSTONE--dark red mud-brown (w) and (f).</td>
</tr>
<tr>
<td>3.8</td>
<td>SANDSTONE--pale red mud-brown (w) and (f).</td>
</tr>
</tbody>
</table>

Top of measure plane. Base formation.
Pennsylvania Mover Formation

1. Unit 4 above.
TIMESTONE PEABBLE CONGLOMERATE--same as unit
2.5 above.
QUARZITE PEABBLE CONGLOMERATE--same as unit

2. Pebbles are poorly rounded and sorted.
LIGHT GREY (m) Medium Grey (f)
with carbonate cement; pebbles are
fine sand-size quartzite; well indurated
GRAYISH-RED MATRIX; matrix contains
TIMESTONE AND QUARZITE PEABBLE CONGLOMERATE--

3. Lower contact covered.
Very poor, very bedded; thin bedded;
Into plates of TIMESTONE pebbles;
GREY (m) Medium Grey (f)
TIMESTONE CONGLOMERATE--very tight
TIMESTONE PEABBLE CONGLOMERATE--

4. Layer to subrounded and poorly sorted.
Planar crossbedded; quartz-sandstone
4 cm. in diameter; poorly cemented
TED BIPEDAL; some pebbles up to
THROUGHOUT normal;
RED BIPEDAL; medium banded
CARBONATE cement; cryptocrystalline
QUARTZITE; some pebbles up to
GRAYISH-RED MATRIX--GRAYISH-
QUARZITE PEABBLE CONGLOMERATE--GRAYISH--

5. Rounded pink orthoclaste.
Tough crossbedding; abundant sub-
thin bedded; top of unit exhibits
from very coarse sand to cm.
TIMESTONE CONGLOMERATE--

6. (continued) pebbles fine upward; thin quartzite

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>THICKNESS</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIMESTONE PEABBLE CONGLOMERATE</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>UNIT</td>
<td>THICKNESS (METERS)</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>Top of San Andres Formation</td>
<td>33.8</td>
<td>Incomplete</td>
</tr>
<tr>
<td>32.</td>
<td>6.2</td>
<td>SANDSTONE—buff to light brown (w); white (f); orthoquartzite; fine sand; well sorted and rounded; thin to medium bedded; similar to lower contact of Glorieta Sandstone.</td>
</tr>
<tr>
<td>31.</td>
<td>5.2</td>
<td>LIMESTONE—packstone; sandy; fine sand; light tan to olive gray (w); medium dark gray (f); light coarse granules; medium bedded; moderately sorted; lower contact of Glorieta Sandstone.</td>
</tr>
<tr>
<td>30.</td>
<td>4.1</td>
<td>LIMESTONE—packstone; medium dark gray (w); many loose crumbled shell fragments; dark gray (f); medium bedded; lower contact of Glorieta Sandstone.</td>
</tr>
<tr>
<td>29.</td>
<td>1.3</td>
<td>Covered</td>
</tr>
<tr>
<td>Top of Glorieta Sandstone</td>
<td>7.3</td>
<td>SANDSTONE—alternating pale red and light yellow (w) and f; quartzite; some beds not well indurated; majority beds well indurated; less clay matrix; low angle, planar, cross-bedding.</td>
</tr>
</tbody>
</table>
21.4
SANDSTONE - same as unit 2Z above, except poorly bedded.
22.9
SANDSTONE - yellow, yellowish-brown (w)!

22.1
sandstone with poorly sorted, subrounded, fine sand! medium to thick bedding!
24.9
SANDSTONE - buff (w)!

24.1
small-scale, planar crossbedding; fine sand. upper contact coarser; lower contact finer.
26.5
SANDSTONE - grayish-pink (w)!

27.6
weathered back. poorly sorted, well rounded; top and well sorted, well rounded; top and
28.0 (continued)
bedded (small-scale) sand; fine sand, moderately sorted, medium to thick bedding!

UNIT THICKNESS DESCRIPTION

82
PERFORATION ON (J) THIN BEDDED;

TIMBERLINE- MUDSTONE! THICK TO VERY-THICK

TOP OF TORKEL MEMBER

29.7

GRANITE- LIGHT GREY (W and J)

TOP OF CARNE MEMBER

12.1

STILLSONE- RED (W and J)

14.

PORTLAND- LIGHT RED TO RED (W and J)

5.9

SANDSTONE- RED TO RED (W and J)

16.

LATE CREATURO- YELLOW-BROWN (W)

17.

LATE CREATURO- YELLOW-BROWN (W)

18.

SANDSTONE- YELLOW-BROWN (W and J)

19.

SANDSTONE- MODERATE YELLOW-BROWN (W)

20.

( ) METERS

DESCRIPTION

THICKNESS
<table>
<thead>
<tr>
<th>UNIT</th>
<th>THICKNESS (METERS)</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>.25</td>
<td>LIMESTONE—medium dark gray (w); dark gray (f); packstone; abundant, plecoped shells, many articulate, shells exhibit a bimodal size distribution; medium bedding; upper contact gradational; good marker bed.</td>
</tr>
<tr>
<td>10</td>
<td>1.2</td>
<td>LIMESTONE—mudstone; light gray (w); medium gray (f); light gray (w) lower contact covered.</td>
</tr>
<tr>
<td>9</td>
<td>3.4</td>
<td>SANDSTONE—light yellowish-brown (w); white, well sorted, fine sand; poorly sorted, thin bedded.</td>
</tr>
<tr>
<td>8</td>
<td>10.3</td>
<td>GEPHYSUM—buff to light gray (w and f); medium bedding; both contacts covered; fine grained, planar.</td>
</tr>
<tr>
<td>7</td>
<td>.53</td>
<td>LIMESTONE—mudstone; light gray (w); medium gray (f); thin bedding; both contacts are sharp.</td>
</tr>
<tr>
<td>6</td>
<td>7.7</td>
<td>GEPHYSUM—yellowish-brown (w); light yellowish-gray (f); mudstone; thin bedding; both contacts covered; slight ridge form.</td>
</tr>
<tr>
<td>5</td>
<td>3.2</td>
<td>LIMESTONE—mudstone; light gray (w); medium gray (f); thin bedding; both contacts covered; slight ridge form.</td>
</tr>
<tr>
<td>4</td>
<td>5.9</td>
<td>SANDSTONE—light yellowish-brown (w); fine sand-size, quartz, subrounded, moderately sorted; thin bedding; small-scale, planar cross-bedding.</td>
</tr>
<tr>
<td>3</td>
<td>.91</td>
<td>LIMESTONE—light yellowish-brown (w); mudstone; thin bedding; slightly wavy bedding; top is covered.</td>
</tr>
<tr>
<td>UNIT</td>
<td>DESCRIPTION</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>10.4</td>
<td></td>
</tr>
</tbody>
</table>

**DESCRIPTION**

- **LIMESTONE-mudstone**: silty; yellowish-brown, pale red, and buff alternating; poorly bedded; thin bedded.
- **LIMESTONE-mudstone**: light olive-gray at top; subangular; moderately sorted quartz grains.
- **LIMESTONE-mudstone**: light gray; sandy (very fine sand) becomes more clayey (muddy) through the interval; poorly bedded; thin bedded.

Incomplete Yeso Formation section due to faulting.
EXPLANATION

RANCHO DEL LOPEZ AREA

Permian Measured Section One

Socorro County

PLATE 5
EXPLANATION

Permian Measured Section Two

SAN ANDRES

Socorro County

Rancho del Lopez Area

PLATE 6
Permian Measured Section One

RANCHO DEL LOPEZ AREA

Socorro County

PLATE 5
VERTICAL and HORIZONTAL SCALE: 1 INCH = 1,000 FEET
VERTICAL and HORIZONTAL SCALE: 1 INCH = 1,000 FEET
1981

Burrolo Formation

Story Formation

Del Cuerno Formation

Moisco Formation (lower member)

Moisco Formation (upper member)

Burroso Formation

Abi Formation

Yeso Formation (Meseta Blanca Member)

Yeso Formation (Torres Member)

Griete Sandstone

San Andres Formation

Quaternary Alluvium

KEY