CARBONATE PETROLOGY AND DEPOSITIONAL ENVIRONMENTS
OF THE QUEEN AND SEVEN RIVERS FORMATIONS
(UPPER PERMIAN), MYERS-LANGLIE-MATTIX UNIT,
SOUTHEAST NEW MEXICO

A Thesis
Presented in Partial Fulfillment of the
Requirements for the Degree Master of Science

by
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The Ohio State University
1982

Approved by

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El Capitan, at south end of the Guadalupe Mountains (from an engraving in Bartlett's Personal Narrative of Explorations in Texas etc., published in 1854).
Drill cores from the Upper Permian (Guadalupian) Upper Queen Formation and Lower Seven Rivers Formation of the Myers-Langlie-Mattix Unit of southeast New Mexico were examined in this study. The rocks consist of interfingering sandstone and dolomite/evaporites deposited on a shallow broad shelf. Cyclic patterns of clastic and carbonate deposits are found in the cores and probably record the depositional response on the shelf to a rising relative sea level punctuated by still sea level stands. During rising sea level carbonate deposition predominated on the shelf, represented by a wackestone/mudstone facies in quiet water environments, and calcisphere packstone and peloid packstone facies in more active water. Periods of exposure of shoals on the shelf are represented by a dismicrite facies with features of subaerial diagenesis. Anhydrite was also deposited subaqueously during the carbonate phase of deposition. During still stands of sea level, carbonate deposition caught up to sea level and dismicrite facies developed in some areas. At the same time, sands transported by wind and water prograded across the shelf.
ACKNOWLEDGEMENTS

I would like to sincerely thank the people of the Getty Oil Company Research Center and in particular Dr. Emily Stoudt and Mr. Mike Yusas for making this project possible. Dr. James Collinson was the source of many thought provoking conversations and guidance. Dr. Larry Krissel and Dr. Peter Webb critically reviewed the manuscript and provided many helpful suggestions.
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I. INTRODUCTION

The purpose of this project was to determine the depositional environment and diagenetic history of the Myers-Langlie-Mattix Unit rocks. In this study Upper Permian (Guadalupian) rocks from the Myers-Langlie-Mattix Unit of southeast New Mexico were examined. The rocks consist of shelf deposits of interfingering dolomite and sandstone. The Myers-Langlie-Mattix Unit is part of the Langlie Mattix Field in Lea County, New Mexico, approximately 50 miles east of Carlsbad, New Mexico (Fig. 1). The Myers-Langlie-Mattix-Unit is a subdivision of the Langlie Mattix Field developed in the last decade for purposes of enhanced oil recovery. This study is the first of its kind on the Myers-Langlie-Mattix Unit.

The seven drill cores recovered from the Myers-Langlie-Mattix Unit during 1981 were analysed in this study. Each core was slabbed and described (see Appendix B) to determine the lithologies present. The cores averaged about 46 m (150 feet) in length. A total of 324 m (1062 feet) of core was examined. Samples for thin sections were taken at lithologic changes and at other significant features. The average sample separation was about 0.6 m (2 feet). Petrographic study of the cores were used to determine depositional environments of and diagenetic changes in the rocks (see Appendix A).

This project originated as part of a reservoir study which was initiated prior to the planning of a secondary recovery water flood project. During the study, conducted by the author for Getty Oil Company in 1981, four drill cores were examined at Getty Oil's Exploration and Production Research Center (EPRC) in Houston, Texas.
Figure 1. Map of southeast New Mexico and west Texas showing structural features of Guadalupian time and their relation to present geographic features (after King, 1942). Star indicates location of Myers-Langlie-Mattix Unit.
Scanning electron microscope (SEM) and x-ray diffraction (XRD) studies of the authigenic clays in the sandstone were conducted at the EPRC. Three additional cores were studied at the laboratories of the Ohio State University. Supplemental analyses included examination of several thin sections under cathode luminescence to determine cementation sequences.

This study shows that the cored rocks of the Myers-Langlie-Mattix Unit consist of shelf deposits of interfingering sandstone and dolomite which probably record the cyclic response of sedimentation to eustatic sea level changes. Dolomite units contain four different facies that depict subenvironments on a broad carbonate shelf. Two sandstone facies are also present. The rocks have been altered by a variety of diagenetic events from dolomitization and anhydritization to emplacement of hydrocarbons.
II. Regional Setting

The regional structural setting of the Myers-Langlie-Mattix Unit and adjacent areas during the Permian is illustrated in Figure 1. The Queen and Seven Rivers formations of this study were deposited along the margin of the Delaware Basin and on the Central Basin Platform during the early Late Permian Guadalupian Age. During Medial Guadalupian time the Delaware Basin was bounded to the west, north, and east by shallow water areas of the Diablo Platform, the Northwestern Shelf Area, and the Central Basin Platform, respectively. The Midland Basin, located east of the Central Basin Platform, was the site of similar geologic processes during the Permian.

The Delaware Basin originated in the western part of the mid-Paleozoic Tobosa Basin. As a median ridge within the Tobosa Basin began to rise during the Early Pennsylvanian, the Delaware Basin began to take shape (Adams, 1965) (Fig. 2). Early Permian block faulting and uplift formed the Central Basin Platform and defined the eastern margin of the Delaware Basin. At this time, the rapidly subsiding Delaware Basin nearly foundered as it filled with clastic sediment (Adams, 1965). Broad shelves to the northwest, north and northeast were the sites of deposition of shallow water carbonates. Late Early Permian time saw the slowing of subsidence of the basin (Adams, 1965). Extensive carbonate build-ups developed around the margin of the basin and continued into early Late Permian (Guadalupian) time.

Cyclic sedimentation has been described as a common feature of the Permian Basin. These cycles consist of alternating predominantly
Figure 2. Map showing location of Tobosa Basin and development of Delaware Basin (after Adams, 1965).
"carbonate" and "clastic" sedimentation, corresponding to high and low stands of sea level respectively (Meissner, 1969; Silver and Todd, 1969; and others). Guadalupian strata differ from older Permian rocks in that the repetitious interbedding of clastic units with carbonate and/or evaporite strata is more frequent. Silver and Todd (1969) suggest that the greater frequency of the repetitious interbedding of clastics and carbonates is due to a greater frequency of relative sea level changes.
III. Stratigraphic Relationships

The rocks analysed in this study were drill cores from the upper part of the Queen Formation and the lower part of the Seven Rivers Formation. The boundary between these two formations marks the division between the Upper and Lower Artesia Group. Figure 3 summarizes the stratigraphy of the Delaware Basin.

The name "Queen Formation" was first coined by Crandall (1929) for exposures near the old Queen Post Office in the Guadalupe Mountains; however, no specific type section was designated. Deford and Lloyd (1940), Woods (1940) and others used the term Queen extensively in the subsurface of southeast New Mexico for a unit with numerous sandstone beds lying between the Seven Rivers Formation and the Grayburg Formation. A type section for the Queen was proposed by Moran (1954) at an outcrop two miles south of the old Queen Post Office where the unit is 421 feet thick. The Queen was described by Tait et al. (1962) as predominantly sandstone and anhydrite with minor interbedded dolomite and shale.

The term Seven Rivers was first applied to a gypsiferous member of the Chupadera Formation of New Mexico by Meinzer, Renick, and Bryan (1927). A type section was not designated. In the subsurface of New Mexico and west Texas, the Seven Rivers was assigned formation status by Dickey (1940), who described this unit as predominantly anhydrite and dolomite. Hayes and Koogle (1958) designated the Seven Rivers Formation type section in the Guadalupe Mountains, where the formation is about 565 feet thick. Tait et al. (1962) described the Seven Rivers Formation as consisting predominantly of anhydrite with thin interbeds
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<td>Bell</td>
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<td>Yates Formation</td>
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<td>Seven Rivers Formation</td>
<td>Limestone Formation</td>
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<td>Lower</td>
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<td>Queen Formation</td>
<td>Cherry Canyon Formation</td>
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<td>Grayburg Formation</td>
<td>Limestone Formation</td>
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Figure 3. Guadalupian stratigraphic nomenclature of the Delaware Basin.
of shale, dolomite, siltstone and sandstone. However, Ball et al. (1971) reported the Seven Rivers as composed of mainly anhydrite and carbonates.

Both the Queen and Seven Rivers formations were formed in a shelf environment. Figure 4 shows the lateral equivalents to the Queen and Seven Rivers and their relative position in the Delaware Basin. The Queen Formation is correlative with the "reefal" limestone of the Goat Seep limestone. The basinal equivalent of the Queen Formation is the Cherry Canyon Formation. The Capitan Limestone is the "reef" equivalent of the Seven Rivers Formation and in the Delaware Basin the Seven Rivers correlates with the Bell Canyon Formation.
Figure 4. East-west cross section of Delaware Basin margin showing lateral equivalents (after Silver and Todd, 1969).
IV. Previous Work

The Permian Basin carbonates are one of the best-exposed and best-documented carbonate complexes in the world. Lloyd (1929) is generally credited with recognizing exposures in the Guadalupe Mountains as a kind of fossil "reef" that rimmed the subsurface Delaware Basin. The general facies and structural relations of these carbonates have been known since the 1930's and are summarized by King (1942, 1948). The Delaware Basin was encircled by a carbonate rim which separated sand and silt deposition in the basin from the (shallow water) lagoonal carbonate and evaporite facies of the shelf. The Guadalupian shelf facies of this study were proposed as the Artesia Group (Tait, et al. , 1962) and included, in ascending order, the Grayburg, Queen, Seven Rivers, Yates, and Tansill formations.

Accretion of the carbonate rim along the margin of the Delaware Basin kept pace with subsidence throughout Permian time (Silver and Todd, 1969). As a result, the carbonate rim built basinward and produced a steep carbonate shelf margin (Kendall, 1969). The precise nature of the carbonate rim has been a point of controversy since its identification. Early investigators, including Crandall (1929), were generally agreed on the definition of the carbonate rim as a barrier reef (Dunham, 1972), whose role was to trap and bind allochthonous sediments. Lang (1937), however, developed the marginal mound hypothesis, where the role of the organisms on the rim was to actually produce, rather than bind sediment. Mapping by King (1948) led to his development of the "uninterrupted slope hypothesis" that indicated that the shelf descended to the basin without an interruption in slope.
Adams and Frenzel (1950) described the carbonate rim as a barrier reef composed almost entirely of the interlocking remains of encrusting algae and calcareous sponges. Newell et al. (1953), who were among the first workers to initiate interest in the paleoecology and depositional environments of the Permian Basin, also described the rim as a barrier reef. Achauer (1969) suggested that the Guadalupian rim, called the Capitan Reef, was an organic bank made up of baffle-producing organisms such as bryozoans, sponges and algae. Cys (1970) disputed the organic bank theory of Achauer (1969) with new evidence that the Capitan Reef was indeed a complex reef tract which acted as a shelf wave barrier. Further support for the organic bank theory was provided by Kendall (1969) and Babcock (1978). Kendall (1969) postulated that the Capitan Reef was similar to mounds presently found in Florida Bay, consisting of calcareous algae that bound fine-grained sediment. Further evidence for the organic bank origin of the Capitan reef was presented in Babcock's (1978) description of phylloid algae, which are well known sediment trappers, in the Capitan Limestone.

At low stands of sea level many parts of the carbonate rim were exposed. Dunham (1965 and 1969) and Thomas (1968) described the pisolites of the Capitan Reef and interpreted them as ancient vadose caliche soils. In a study of the Guadalupian carbonate and evaporite shelf sediments (Carlsbad Group) of the Guadalupe Mountains, Kendall (1969) suggested that most of the pisolites were marine in origin and did not form in place as concretionary soil structures. He argued that the structures observed by Dunham (1965) and Thomas (1968) were the result of modification of marine pisolites by subsequent cementation.
and diagenesis in the water table and capillary zone (Kendall, 1969).

Behind the carbonate rim of the Delaware Basin, carbonate and evaporite sediment dominated accumulation on a broad shelf. Jacka and Franco (1974) discussed the deposition and diagenesis of Permian evaporites and associated rocks on the shelf areas. The Queen Formation of this study was described in outcrop and its response to sea level fluctuation was proposed by Ball et al. (1971). Sarg (1981) reinterpreted the carbonate-evaporite facies transition of the Seven Rivers Formation in the Guadalupe Mountains as interfingering evaporite and carbonate lagoonal facies rather than the generally accepted sabkha facies. The sedimentation of the Guadalupian cyclic shelf deposits in the northern Guadalupe Mountains was discussed by Smith (1974).
V. Sedimentary Petrology

INTRODUCTION

The Queen and Seven Rivers formations, as they are represented in this study, consist of a complex intertonguing of clastic, carbonate and evaporite facies. In the surface outcrops of the Guadalupe Mountains, the Queen and Seven Rivers formations are easily differentiated. The Queen Formation is made up of predominantly quartz sandstone and evaporite, while the Seven Rivers Formation is mainly carbonate and evaporite (Ball, et al., 1971). The two units are separated in surface outcrops by the Shattuck Member of the Queen Formation (Silver and Todd, 1969; and others). The Shattuck Member is a relatively thick (125 feet) sandstone.

In the subsurface of the Myers-Langlie-Mattix Unit, several hundred miles to the east of the Guadalupe Mountain surface outcrops, the Queen and Seven Rivers formations are not easily distinguished. The locations of the seven cored wells in the Myers-Langlie-Mattix Unit are shown in Figure 5. These cores consist mostly of carbonate and clastic rocks in nearly equal proportions, with or without evaporites. Figure 6 illustrates the different lithologies present in the cores. The absences of the grouping of lithologies described by Ball et al. (1969) and of the Shattuck Member present obstacles to locating the cores within the traditional stratigraphy. Therefore, formation boundaries were positioned by using completion reports of the cored wells from the New Mexico Oil Conservation Commission. These formation boundaries are based on the subsurface stratigraphy established by the New Mexico Oil Conservation Commission. While not precise, these
Figure 5. Location of cored wells in Myers-Langlie-Mattix Unit.
Figure 6. Lithologies of Myers-Langlis-Matix cores. Standard lithologic symbols are used (see Appendix A). Depth in feet on left margin of core. Core number at top.
boundary positions are satisfactory in the context of this study.

The dolomite of this study has been classified according to depositional texture using a scheme originally developed by Dunham (1962) for use in studies of limestone. Dunham's classification is valid for this study because the very fine-grained nature of the dolomitization has preserved the original carbonate texture. Figure 7 summarizes Dunham's classification scheme. The term dismicrite used in this study was developed by Folk (1959) to describe patches of coarse spar in a microcrystalline matrix. Authigenic constituents of both dolomite and sandstone are described using the grain-size scale of Folk (1959). The size classification of Folk (1968) has been used for the description of clastic rocks. Constituent abundance was visually estimated using the comparison charts of Bacelle and Bosellini (1965).

DOLOMITE

The dolomite of the Myers-Langlie-Mattix Unit is the most complex of all the rock types present. The dolomite units can be divided into four facies on the basis of prominent features, with each facies named for its respective prominent feature. The facies present include mudstone/wackestone, peloid packstone, dismicrite, and calcisphere packstone. All facies are well represented in both the Queen and Seven Rivers formations in the cores. The dolomite in all four facies generally consists of aphanocrystalline to very finely crystalline, xenotopic dolomite. The fine texture of the dolomite crystals (10-30μm) preserves original structures. The best example of this preservation is seen in the relict microstructure of dolomitized bioclasts.
### DEPOSITIONAL TEXTURE

Original components not bound together during deposition

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<tr>
<th>Contains mud (particles of clay and fine silt size)</th>
<th>Lacks mud and is grain supported</th>
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<tr>
<td>Mud supported</td>
<td>Grain supported</td>
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<tr>
<td>Less than 10% grains</td>
<td>More than 10% grains</td>
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<tr>
<td>Mudstone</td>
<td>Wackestone</td>
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<td></td>
<td>Packstone</td>
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<td>Grainstone</td>
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Figure 7. Summary of Dunham's classification according to depositional texture as represented in this study (Dunham, 1962).
A generalized dolomite unit in both the Queen and Seven Rivers formations contains all four dolomite facies: mudstone/wackestone facies at or near the base; the peloid packstone and calcisphere packstone facies vertically adjacent to each other in the upper part of the unit, possibly overlain by more mudstone/wackestone facies; and the dismicrite facies at the top of the unit. The average total thickness of a dolomite unit is about 80 feet (24 m).

Wackestone/Mudstone Facies

The wackestone/mudstone facies is the most common carbonate facies in the Myers-Langlie-Mattix cores. These rocks are generally very light gray. Sedimentary structures range from moderately well developed planar laminae to poorly developed bedding. The allochems consist largely of skeletal grains and sparse peloids. Calcispheres are the most abundant skeletal grain (5%); endothyrid forams are next in abundance (3%). Rare algal fragments, intraclasts and encrusting forams are also present. Very fine-grained quartz sand and coarse silt may occur in these rocks in abundances varying from a trace to as much as 40%.

The laminated rocks of this facies are predominantly mudstone. The laminations reflect alternating layers of very finely crystalline dolomite of different grain size. These laminated mudstones commonly contain sparse calcispheres and endothyrids. Narrow (1-2 mm) layers of calcisphere and foram wackestone may occur parallel to bedding in mudstone that is otherwise devoid of fossil grains.

Pyrite is present in trace to locally abundant amounts in the wackestone/mudstone facies and also the peloid packstone and
calcisphere packstone facies. The two common modes of pyrite occurrence are large multicrystalline masses (Fig. 8) and scattered small crystals (Fig. 9). Both types occur in about equal abundance in the three facies.

Kerogen occurs rarely in the Myers-Langlie-Mattix cores; when present, it generally is found in the mudstone/wackestone facies. The kerogen is composed of insoluble organic material that is reddish brown in thin section. It is found as undulating filaments 0.1 to 1 mm long and typically 50µm thick, oriented parallel to bedding (Fig. 10). The filaments, dark reddish brown in transmitted light, may occur individually or in irregular bunches. The kerogen is nearly always associated with algal fragments.

Dolomite with a sugary texture is generally rare and occurs only in the mudstone/wackestone facies. It appears to be slightly more common in the easterly part of the unit. The sugary texture is characterized by fine to medium-crystalline (30-60µm) dolomite (pseudospar after Folk, 1965). The dolomite crystals have "dirty" appearance and are generally nearly equigranular (Fig. 11).

Peloid Packstone Facies

The peloid packstone facies has some of the characteristics of the dismicrite facies but differs in its skeletal grain content. The rocks which compose this facies are generally light gray to very light brownish gray in color. Structures include moderately well developed bedding and mottling.

The peloid packstone facies is typified by an abundance of peloids in generally grain-supported dolomite with a microcrystalline matrix
Figure 8. Photomicrograph of multicrystalline masses of pyrite in mudstone matrix. Long dimension of photo is 3.4 mm. #243,3610'. Reflected light.

Figure 9. Photomicrograph of scattered pyrite crystals in mudstone. Pyrite is present in center of photograph in band of opaque grains. #94,3788'B. Transmitted light.
Figure 10. Photomicrograph of kerogen filaments in algal mudstone/wackestone. Kerogen appears as reddish brown wisps. Long dimension of photograph is 3.4 mm. #243, 3619'. Transmitted light.

Figure 11. Photomicrograph of sugary dolomite in mudstone/wackestone facies. Long dimension of photograph is 0.83 mm. #243, 3610'. Transmitted light.
Figure 12. Photomicrograph of peloid packstone facies. Note intraclasts in peloids. Long dimension of photograph is 3.4 mm. #243, 3501'. Transmitted light.

Figure 13. Photomicrograph of peloids in peloid packstone facies. Long dimension of photograph is 3.4 mm. #243, 3515'. Transmitted light.
(Figs. 12, 13). Skeletal grains are common, including numerous calcispheres and rare encrusting forams and endothyrid forams. Ooids and aggregate grains are also found in this facies (Fig. 14, 15). Many of the aggregate grains are similar to those described as grapestone by Purdy (1962a) on the Bahama Bank. The matrix of many of the rocks in the peloid packstone facies contains very fine-grained quartz sand in amounts ranging from a trace up to 15%.

Similarities of the peloid packstone facies to the dismicrite facies include irregular patches of dolosparr, relative location of the facies within the dolomite unit, and associated rock types. Both the peloid packstone and the dismicrite facies commonly contain irregular patches of dolosparr and occur near the top of dolomite units. These facies which contain well developed patches of spar fabric are usually found to be overlain by a thin layer of greenish black shale. The association of spar fabric and shale also exists when the peloid packstone facies occurs in the middle parts of dolomite units.

Blocky anhydrite is commonly associated with those rocks of the peloid packstone facies that have a well developed dismicrite texture and that are located at the top of dolomite units. The anhydrite may be present in the peloid packstone facies or in an adjacent mudstone.

Calcisphere Packstone Facies

Unlike the other dolomite facies, the calcisphere packstone facies contains a relatively high abundance of bioclasts. The facies consists predominantly of highly fossiliferous grain-supported dolomite with a micrite matrix (Fig. 16), but also includes calcisphere and algal fragment-rich wackestones. Calcispheres and algal fragments are
Figure 14. Photomicrograph of sand aggregate grain in peloid packstone facies. Long dimension of photograph is 3.4 mm. #94,3640'. Transmitted light.

Figure 15. Photomicrograph of aggregate grain of peloids in sandy dolomericite matrix. Long dimension of photograph is 3.4 mm. #243,3593'. Transmitted light.
abundant to common in all of the rocks of this facies. Other skeletal components include common endothyrid forams (Fig. 17), algal fragments, fossil ghosts, and sparse mollusk fragments.

The rocks of the calcisphere packstone facies are generally medium light gray. Sedimentary structures of this facies include massive bioturbated dolomite and poorly bedded dolomite.

Cryptalgal laminates, described by Sarg (1981) from the Seven Rivers Formation of the Guadalupe Mountains, occur rarely in the Myers-Langlie-Mattix cores and are included here in the calcisphere packstone facies. The laminates are composed of layers of dense calcisphere and peloid-rich packstone alternating with calcisphere wackestone or mudstone (Fig. 18). The calcisphere wackestone laminae are lighter in color and generally more coarsely crystalline. The laminae are less than 1 mm to 4 mm thick and generally have a hummocky form. Figure 19 shows cryptalgal laminae cut by burrows.

As noted earlier, the matrix of the packstone facies is predominantly micrite, but irregular patches of medium crystalline dolospar also occur. Kaolinite occurs locally and very rarely in the centers of patches of medium crystalline dolospar. Medium crystalline dolospar also fills the intragranular pores.

Dismicrite Facies

The dismicrite facies is characterized by a dismicritic fabric consisting of small (0.1 to 0.8 mm) irregular patches of coarse to finely crystalline dolospar in a very finely crystalline mudstone or wackestone. The mudstone/wackestone is generally sparsely peloidal and may rarely contain calcispheres or forams. The large crystals of
Figure 16. Photomicrograph of calccisphere packstone facies. Long dimension of photograph is 3.4 mm. #94,3622. Transmitted light.

Figure 17. Photomicrograph of endothyrid forams in calccisphere packstone facies. Long dimension of photograph is 3.4 mm. #41,3663. Transmitted light.
Figure 18. Photomicrograph of cryptalgal laminate in calcisphere packstone facies. Long dimension of photograph is 3.4 mm. #82,3464.9'. Transmitted light.
Figure 19. Photograph of slab showing cryptalgal laminates cut by burrows. Width of slab is about 3 inches. #162,3603'.

dolospar tend to coarsen towards the center of the patches. These patches commonly cut across peloids. It is not uncommon for a crystal at or near the center of a patch to be composed of anhydrite. The patches of spar may constitute up to 40% of the rock. In polished slabs the dismicrite facies typically appears as a thin, 2 to 5 cm-thick zone of diffuse light pinkish gray to light brownish gray undulating laminations that parallel bedding. The laminations are nearly always overlain by a 2-4 cm-wide layer of greenish gray shale. The dismicrite facies generally is located at the top of a dolomite unit; it rarely occurs elsewhere. Characteristics of the dismicrite facies, in particular the irregular patches of dolospar, are rare in other facies. Associated features of the dismicrite facies include fractured dense mudstones, pebble packestones/wackestones, cylindrical fossil molds and clotted micrite.

The fractured dense mudstones are made up of micritic clasts and coated grains that are broken by fractures generally less than 2 mm in length. Dolospar fills the fractures. The micritic particles are generally in a very finely crystalline matrix with abundant patches of dolospar (Fig. 20).

The pebble packstones generally overlie the laminated zone of the dismicrite facies, and are composed of pinkish gray to light bluish gray, flattened to angular pebbles which are 1 to 10 cm long and commonly laminated. The laminated clasts often can be fitted together (Fig. 21). The clasts are in a very finely crystalline dolomite matrix.
Figure 20. Photomicrograph of fractured micrite clast in dismicrite facies. Long dimension of photo is 3.4 mm. #102,3539'. Transmitted light.
Spherical and cylindrical fossil molds are rare, but do occur in the dismicrite facies. These dolospar filled molds generally are oriented normal to bedding, and average 0.5 to 2 mm in length and penetrate a mudstone matrix (Fig. 22). The circular cross-section and size of these structures suggest that they may be worm burrows. Similar structures in calcareous crust profiles in Barbados (James, 1972) and the Florida Keys (Multer and Hoffmeister, 1968) have been interpreted as root tubules.

Clotted micrite occurs sparsely in the dismicrite facies, appearing as aggregates of poorly defined micritic round blobs approximately 0.1 mm in size separated from adjacent aggregates by slightly coarser microcrystalline dolomite (Fig. 23). The clotted texture resembles that described by James (1972) in Barbados.

ANHYDRITE

The occurrence of calcium sulfate minerals in the Myers-Langlie-Mattix cores, chiefly as anhydrite, can be divided into three groups based on texture. These groups are nodular anhydrite, crystallotopic anhydrite, and anhydrite cement. The nodular form, while making up the greatest volume of anhydrite, is present in only two of the cores (82 and 162). Crystallotopic anhydrite is also only found in cores 82 and 102. Anhydrite cement occurs in trace amounts in all cores.

Nodular Anhydrite

The nodular anhydrite displays a variety of textures. According to the classification of Maiklem et al. (1969), the masses of anhydrite range in texture from mosaic and nodular mosaic to nodular and
Figure 21. Slab photograph showing angular laminated clasts of dismicrite facies. Slab is three inches wide. #162,3480'.

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Figure 22. Photomicrograph of spherical and cylindrical fossil molds in dismicrite facies. Long dimension of photograph is 3.4 mm. #41,3654'. Transmitted light.

Figure 23. Photomicrograph of clotted micrite texture in dismicrite facies. Long dimension of photograph is 3.4 mm. #82,3463'. Transmitted light.
distorted nodular laminated (Figs. 24, 25). Gypsum commonly is present in the nodules, but comprises only about 20% of the sulfate present. The felted lath texture of the sulfates is characterized by approximately 1 mm long laths in a radiating or subparallel orientation. The blades are clear and lack inclusions (Fig. 26). A sheath of very finely crystalline dolomite, 0.1 to 0.3 mm wide, commonly surrounds the bladed masses (Fig. 27). Matrix, when present, is composed of sandstone or dolomite depending on the nature of the adjacent rock. The sandstone matrix generally consists of very fine-grained quartz sand and abundant clay cemented by anhydrite and traces of finely crystalline dolomite. The dolomite matrix generally has a uniform finely crystalline texture and may be fossiliferous. The fossil content ranges in abundance from only a trace of fossil ghosts to 10%.

Crystallotopic Anhydrite

The crystallotopic anhydrite consists of blocky, very coarsely crystalline anhydrite that is composed of generally subhedral unit crystals (Fig. 28). Grains display a poikilotopic fabric containing inclusions of very finely crystalline dolomite. Subhedral crystals range in size from 0.5 mm to 2 mm. Veinlets of similarly textured anhydrite are commonly associated with the blocky anhydrite. These veinlets appear to have occupied fractures and to have developed a poikilotopic texture at their margins. Commonly the blocky anhydrite also develops the poikilotopic texture at its margin and the center of the crystal is nearly free of inclusions (Fig. 29). In bioclastic sediment, the blocky anhydrite may include fossil grains with the
Figure 24. Photograph of slab with nodular mosaic anhydrite. Slab width is about 3 in. #82,3367'.
Figure 25. Photograph of slab showing distorted nodular laminated anhydrite. Slab width is about 3 in. #82,3363'.

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Figure 26. Microphotograph of bladed anhydrite. Long dimension of photograph is 3.4 mm. Transmitted light. #82,3340'.

Figure 27. Microphotograph of bladed anhydrite. Note micrite sheath and sandy matrix. Long dimension of photograph is 3.4 mm. Crossed nicols. #82,3340'.
Figure 20. Photograph of slab showing crystallographic anhydrite in laminated dolomite. Slab width is about 3 inches. 
#82,3365'. 
Figure 29. Photomicrograph of crystallotopic anhydrite. Note distribution of inclusions. Long dimension of photograph is 3.4 mm. #82'-3354'. Transmitted light.
original texture preserved. When present in laminated dolomite, the blocky crystals commonly trace laminae. This feature is particularly conspicuous in laminated dolomite that is slightly deformed.

Anhydrite Cement

Anhydrite occurs least commonly as a cement. It forms finely to medium crystalline xenotopic cement in sandstone and void filling medium crystalline spar in dolomite. Gypsum also occurs rarely as crystals among the anhydrite restricted to brownish gray sandstone. Anhydrite commonly has partially replaced quartz grains. In dolomite, xenotopic crystals of anhydrite or gypsum occur in the center of patches of dolospar that have filled voids created by dissolution.

SANDSTONE

Terrigenous rocks of the Myers-Langlie-Mattix cores can be divided into two facies. These facies can be distinguished by color, sedimentary structures and petrology. One facies is bluish gray sandstone and the other an olive gray sandstone.

The bluish gray sandstone facies varies from light gray to grayish black in color and is well indurated. Bedding is generally well defined and includes closely spaced (2-3 mm) horizontal planar bedding and abundant wispy bedding consisting of undulating black wisps of mica clay in an anastomosing pattern (Fig. 30). Planar bedding is commonly deformed by small (1-2 cm) scale slump features and burrowing (Figs. 31,32).

The bluish gray sandstone is a quartz arenite (classification of Folk, 1968) composed of well to very well-sorted fine-grained sand to coarse silt. Feldspar and rock fragment grains also occur in the
Figure 30. Slab photograph showing types of bedding present in bluish gray sandstone. Width of slab is about 3 inches.
Figure 31. Slab photograph showing overturned bedding (lower center) in blue gray sandstone. Width of slab is about 3 inches. #102, 3507'.

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Figure 32. Slab photograph of blue gray sandstone showing burrows in moderately bedded sandstone. Note banded anhydrite mass in burrow on left. Slab width is about 3 inches. #162,3496'.
sandstone in trace amounts. Comparison with the standard images of known roundness (Powers, 1953) indicates that the grains are subangular to subrounded.

The bluish gray sandstone is distinguished from the olive gray sandstone on the basis of detrital clay content and cement abundance (Fig. 33). The bluish gray sandstone commonly contains up to 20% detrital clay, predominantly mica plates that are 0.05 mm to 0.2 mm long. Dolomite cement makes up a greater proportion of the rock in the bluish gray sandstone than in the olive gray sandstone. The dolomite crystals range in size from very finely to finely crystalline (10-25 μm). Very small amounts of authigenic clay occur in the olive gray sandstone, with illite predominant over much smaller amounts of chlorite and kaolinite. Kaolinite is locally abundant (30%) as a cement in core 102.

Textures in the bluish gray sandstone exhibit a small degree of compaction. Detrital clay places are rarely slightly bent by adjacent quartz grains.

The olive gray sandstone facies is similar to the bluish gray sandstone facies in that both are quartz arenite in composition, are moderately to well sorted, have subangular to subrounded grains, and are composed of very fine sand and coarse silt-sized material. Ball et al. (1969) report that the provenance of the sandstone is the granitic terrain of the Pedernal Massif to the north of the Delaware Basin.

The olive gray sandstone facies varies from light olive gray to olive black and rarely light greenish gray. These rocks are
Figure 33. Photomicrograph of blue gray sandstone showing detrital clay. Width of photograph is 0.83 mm. #94,3654'. Transmitted light.
predominantly massive to poorly bedded. The olive gray sandstone is commonly mottled by oil which appears to mimic the poorly developed bedding (Fig. 34). Rarely, the olive gray sandstone displays wispy bedding and olive gray layers are interbedded with narrow (3 to 5 cm thick) bands of light greenish gray sandstone.

The olive gray sandstone is cemented by a variety of materials: anhydrite, clay, dolomite, and pyrite. The most common cement type is dolomite that occurs as very fine crystals (10-15μm). Trace amounts of finely crystalline ferroan dolomite are also present (Fig. 35). XRD and SEM work indicates that clay cement is next greatest in abundance and consists predominantly of illite with lesser amounts of chlorite and kaolinite.

Anhydrite and pyrite cements occur rarely, and only in trace amounts. Anhydrite is present as large irregular poikilotopic anhedral crystals (Fig. 36). These crystals partially replace some quartz grains. A similar texture is present in the pyrite cement where large irregular multicrystalline masses of pyrite have enclosed quartz grains and may have replaced some of the quartz (Fig. 37).

In rare cases the olive gray sandstone is poorly cemented. These rocks are friable with high porosities. Nearly all of the sandstone porosity in the Myers-Langlie-Mattix cores is found in the olive gray sandstone. The porosity typically occurs as intergranular or leached porosity. Figure 35 shows several quartz grains that have been corroded.

Fossils are rare in both sandstone facies. Fusulinid forams, which are not found in any of the dolomite units, occur in a sandstone
Figure 34. Slab photograph of olive gray sandstone showing mottling by oil. Width slab is about 3 inches. #102,3461'.
Figure 35. Photomicrograph of olive gray sandstone with ferroan dolomite stained blue. Several corroded quartz grains are located near center of photo. Width of photograph is 0.83 mm. #243,3589'. Transmitted light.
Figure 36. Photomicrograph of poikilotopic anhydrite cement in olive gray sandstone. Width of photograph is 0.83 mm. Crossed nicols.

Figure 37. Photomicrograph of opaque pyrite cement in olive gray sandstone. Width of photograph is 0.83 mm. Transmitted light.
in one of the cores (243). The fusulinids, probably *Parafusulina*, occur in a very fine quartz sand and coarse silt. The tests appear to be partly encased in an irregular sheath of micrite (Figs. 38,39), which may indicate that the fusulinids were reworked from partly eroded lithoclasts. Other carbonate grains include possible pisoids (Fig. 40) and small intraclasts (Fig. 41) that are relatively common. Pisoids are sand-sized pisolites described by Flügel (1982).

Table 1 and 2 summarize the characteristics of the various facies of the Myers-Langlie-Mattix cores.
Figures 38, 39. Photomicrographs of fusulinids in sandstone. Note micrite rims. Width of photograph is 3.4 mm. Transmitted light.
Figure 40. Photomicrograph of pisoliths in sandstone. Note micrite rims. Width of photograph is 0.83 mm. Transmitted light.

Figure 41. Photomicrograph of micrite intraclasts in sandstone. Width of photograph is 3.4 mm. Transmitted light.
<table>
<thead>
<tr>
<th></th>
<th>Wackestone/Mudstone</th>
<th>Peloid Packstone</th>
<th>Calcisphere Packstone</th>
<th>Dismicrite</th>
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<tr>
<td><strong>Lithology</strong></td>
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<td>Peloid packstones</td>
<td>Calcisphere packstones</td>
<td>Dismicritic, fractured dense</td>
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<td></td>
<td>mudstones</td>
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<td>cryptalgal laminates</td>
<td>clotted micrite</td>
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<td>Sparse; calcispheres, R-C</td>
<td>Abundant; calcispheres, C-A</td>
<td>Very sparse; calcispheres, VR</td>
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<td>endothyracean forams, VR</td>
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<td></td>
<td>mollusks, VR</td>
<td>encrusting forams, R</td>
<td>algal fragments, R-C</td>
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<td>ostracodes, VR</td>
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<td></td>
<td>dismicrite fabric</td>
<td>bedding and also</td>
<td>massive bioturbated</td>
<td>burrows/root tubules</td>
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<td>mottling</td>
<td>dolomite, cryptalgal</td>
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<td>Medium light gray</td>
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<td>very light brownish</td>
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VR - very rare (<1% grains)
R - rare (1-3%)
C - common (3-10%)
A - abundant (>10%)

Table 1. - Summary of carbonate lithofacies characteristics
<table>
<thead>
<tr>
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<th>Anhydrite</th>
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<th>Olive Gray Sandstone</th>
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<td>Very fine-grained sand and coarse silt, moderately sorted,</td>
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Table 2. - Summary of non-carbonate lithofacies characteristics
VI. Diagenesis

The rocks of the Myers-Langlie-Mattix cores have been extensively altered during diagenesis. The post-depositional modification of the rocks is discussed below by lithologic group.

DOLOMITE

The most complex diagenesis of the Myers-Langlie-Mattix cores has occurred in the dolomite units. Diagenetic features include dolomitization, cementation, neomorphism, development of dismicrite facies and related features, precipitation of ferroan dolomite cement, porosity development and hydrocarbon emplacement.

Of all the aspects of diagenesis in the cores the process of dolomitization has been the most extensive. Several features of the dolomite suggest that the process of dolomitization was either penecontemporaneous with deposition or very early diagenetic. The very fine crystalline nature of the dolomite compares favorably with the crystal size (<5μm) of modern penecontemporaneous dolomite described by Adams and Rhodes (1960). Other evidence for the early timing of dolomitization is the pervasiveness and uniformity of the dolomite (Sarg, 1981). Such thorough dolomitization of the rocks would require a porous and permeable sediment (Chilinger et al., 1979), a condition favored during or immediately following deposition. A secondary origin of much the dolomite is indicated by the replacement of aragonitic or calcitic fossils.

Model for Queen and Seven Rivers dolomitization

It appears evident that magnesium-rich waters interacted with the carbonate sediment of the Myers-Langlie-Mattix very early in their
history in order to form the dolomite observed today. The precise mechanism of the dolomitization of these rocks is not well understood. One model that has been suggested is that of seepage refluxion. Hypothesized by Newell et al. (1953) to explain the dolomitization of the Permian reef complex, this model requires that dense brines, enriched in Mg$^{++}$ and SO$_4^-$ and formed in broad hypersaline lagoons, percolate down through the sediment. The brines displace the connate water and dolomitization occurs. Adams and Rhodes (1960) also applied this model to dolomite of the Permian Basin shelf. In the work of Jacka and Franco (1974), the seepage refluxion concept of Newell et al. (1953) and Adams and Rhodes (1960) was rejected in favor of a hypothesis proposed by Deffeyes et al. (1965). Work on the recent and Pliocene-Pleistocene dolomites of Bonaire Island, Netherlands Antilles by Deffeyes et al. (1965) has shown that the dolomitization there is similar to that of the seepage refluxion model but that the origin of the brine is different. On Bonaire it is suggested that the fluids are formed in supratidal lakes or flats in contrast to the broad hypersaline lagoons discussed by Newell et al. (1953) and Adams and Rhodes (1960). The near absence of supratidal facies points to limited development of supratidal environments in the area of the Myers-Langlie-Mattix Unit. Therefore the author favors the seepage refluxion model as a probable explanation for the mechanism of dolomitization in the Seven Rivers and Queen formations.
Dolomitization by evaporative concentration

Other models for dolomitization call for an intimate association with a well developed supratidal environment or a shoreline. The concept of evaporative concentration of seawater has been theorized as a mechanism for dolomitization by Patterson and Kinsman (1981) and Hsü and Schneider (1973). The model of Kinsman and Patterson (1981) involves shallow bodies of seawater that are episodically driven by wind inland over the sabkha. A brine, formed by evaporative concentration of this seawater, then infiltrates the sediment and causes dolomitization. Hsü and Schneider (1973) have proposed a mechanism for the development of dolomite in the Abu Dhabi sabkha of the Persian Gulf in which ground water recharge from adjacent mountains is transported to the sabkha via a permeable conduit where the saline water rises to replace evaporative loss. As in the other models, evaporation concentrates the brine until conditions for dolomitization are attained. Both of the above models are reasonable in their own context but their association with a supratidal setting make them unsuitable as an explanation for dolomite development in the Myers-Langlie-Mattix Unit rocks.

Dolomitization by water mixing

Other proposed mechanisms for dolomitization result from the interaction of seawater and freshwater (Badiozamani, 1973; Folk and Land; 1975). Badiozamani (1973) developed the dorag model of dolomitization in which the mixing of freshwater and sea water occurs in the phreatic zone. Chemical conditions develop which favor the replacement of calcite by dolomite. The formation of dolomite by the
schizohaline flushing model proposed by Folk and Land (1975) also involves the flushing of marine saline waters with freshwater producing conditions appropriate for dolomitization. Both the dorag and the schizohaline flushing models develop in a phreatic environment. In the Myers-Langlie-Mattix Unit rocks however, very little evidence for a well developed phreatic zone exists. Therefore, these two mechanisms for dolomitization probably are not applicable to the rocks of this study.

The dolomitization of the Seven Rivers and Queen formation in this study was probably eogenetic and occurred in a subaqueous environment in a hypersaline lagoon. Seawater was concentrated through evaporation. Magnesium was supplied by the influx of seawater across the shelf. The precipitation of sulfates increased the Mg/Ca ratio, providing a driving force for dolomitization. The process of dolomitization probably occurred by the seepage of dense Mg-rich brines into the relatively permeable carbonate sediment. This seepage produced a chemically favorable environment for magnesium-calcium exchange and the removal of calcium (Adams and Rhodes, 1960).

Prominent cement is generally confined to the packstones where two types of cement occur: an isopachous rim cement and an equant cement. The isopachous cement occurs sparsely, but when it does occur, it generally occupies spaces between grains. The finely crystalline bladed cement resembles cement precipitated in water saturated pores (Longman, 1980), and is characteristic of early crusts found in modern intertidal environments (Folk, 1974). The equant cement, which is common in packstones, can be divided into cloudy and clear types. The
cloudy cement is finely crystalline and bladed to equant. The clear
cement is also finely crystalline and bladed to equant and is common in intraparticle cavities such as the centers of calcspheres or forams. Both cement types are generally xenotopic. Equant cements with the aforementioned characteristics have been found in environments ranging from the phreatic (Longman, 1980) to subsurface (Folk, 1974).

Study of thin sections of the dolomite under cathode illuminescence revealed as many as three rims along the margins of cement filled vugs. The distinction of the rims is due to different trace element concentrations recognizable under cathode illuminescence. These rims suggest up to three episodes of cement emplacement.

Some of the dolomite of the Myers-Langlie-Mattix cores has developed by interaction with iron-rich brines, resulting in the development of ferroan dolomite cement. The ferroan dolomite is very sparse in the dolomite units, but when present it occurs as finely to medium crystalline, xenotopic, near equant fracture-filling cement. The occurrence of ferroan dolomite is commonly associated with oil traces in the dolomite. Choquette (1971) reports that ferroan dolomite, consisting of relatively large crystals with undulatory extinction, was probably formed by fluids with a subsurface origin. This assertion by Choquette (1971) and the relationship of the ferroan dolomite and hydrocarbons suggests that the ferroan dolomite may have precipitated from brines associated with hydrocarbon migration.

**Exposure diagenesis**

The dismircite facies developed under diagenetic conditions of subaerial exposure or near shoaling of carbonate mud banks. The
patches of medium crystalline spar which characterize the facies
developed as a result of solution of the original carbonate and
precipitation of cement in the vugs. The equant cement, which coarsens
towards the center of the cavities, resembles cement that develops in
the freshwater phreatic zone (Longman, 1980). Kaolinite found in
association with some dolosparg patches and also as a sandstone cement
probably originated from the breakdown of feldspar grains during
subaerial diagenesis (Dunham, 1972). Kaolinite is common in parts of
the Capitan Reef that have undergone subaerial diagenesis (Dunham,
1972). Other features of the dismicrite facies are also the result of
subaerial exposure. The dense laminae of alternating light and dark
micrite associated with the dismicrite facies may have been formed by
the dissolution of metastable carbonate phases and precipitation of
laminated carbonate by the influx of meteoric waters and rising
capillary brines. Conditions such as these have been described by
Walls et al. (1975) in Upper Mississipian carbonates in northeast
Kentucky. These laminated carbonates, which are up to 1.5 m thick,
also are overlain by green claystone which was interpreted as ancient
soil horizons. The claystone horizons of the dismicrite facies are only
a few centimeters thick and commonly less than a centimeter. The
similarity of features of the dismicrite facies to the horizons in the
Upper Mississippian suggests development under similar conditions of
subaerial exposure. The disparity between the thickness of the
claystone layers in the two cases may be due to the more arid climate
of Guadalupian New Mexico (Sarg, 1981) which prevented the extensive
development of a soil horizon.
A zone of brecciated mudstone commonly underlies the laminated carbonate of the dismicrite facies. Brecciation of the mudstones varies from slight to intense, and may extend up into the laminated horizon. Because the brecciated clasts can commonly be fitted together, the disruption is interpreted to be a result of solution and weathering of the rocks. Folk (1973) has reported similar structures and interpretation in rocks of the Marathon Basin, Texas. The clotted texture noted in some of the rocks of the dismicrite facies develops from the diagenetic process of micritization (Kendall and Skipwith, 1967) common in the near surface environment. Many of the features of the dismicrite facies resemble characteristics of early phases of caliche development (Scholle and Kinsman, 1974).

The present porosity of the Myers-Langlie-Mattix carbonates was visually estimated at approximately 0 to 3%. This porosity occurs as intercrystal spaces where hydrocarbons have been found. Some of the carbonate units have developed a sparse and very local vuggy porosity. The vuggy porosity can be as great as 12 to 15% and probably resulted from dissolution by mesogenetic fluids. Associated hydrocarbons were also mesogenetically emplaced.

The Myers-Langlie-Mattix rocks have undergone very little alteration by burial diagenesis. Early cementation probably prevented compaction to any great extent. Only very slight compaction is evident in the sandstone, as indicated by the bending of some mica plates and the stylolitization of the dolomite. Styloïdes are abundant but generally have a displacement of no more than 2 cm. The occurrence of kerogen and petroleum in the rocks indicates that they have not been thermally altered.
The sugary dolomite of the mudstone/wackestone facies is a result of neomorphism of the pre-existing mudstone/wackestone rocks. James (1972) indicated that recrystallization of this sort is common in conditions of near shoaling or very brief subaerial exposure.

SANDSTONE

Sandstone diagennesis in the Myers-Langlie-Mattix cores includes cementation, precipitation of authigenic clays, compaction, and emplacement of hydrocarbons.

The earliest diagenetic event affecting the sandstone was cementation. The initial cement was probably calcite, which was subsequently dolomitized by similar processes as the carbonates. The sparse patches of anhydrite cement were also precipitated at this time. Conditions of pH and Eh appropriate for the precipitation of the calcite cement are also those under which silica goes into solution. Therefore, the corrosion of quartz grains probably occurred during early cementation. The seepage refluxion model would provide an avenue for the removal of silica from corroded quartz grains.

Mesogenetic alteration of the sandstone includes precipitation of authigenic clays and emplacement of hydrocarbons. The clays may have formed from basinal fluids associated with migrating oil.

ANHYDRITE

The occurrence of sulfates in the Myers-Langlie-Mattix cores in several phases represents several distinct diagenetic events.

The nodular anhydrite resulted from the dehydration of early diagenetic gypsum crystals. The original gypsum crystals were probably formed by interstitial precipitation from percolating brines as
discussed by Kinsman (1969). Evidence that the growth of the gypsum physically displaced surrounding sediment exists in the clarity of the laths and also the sheath of carbonate material that occurs between closely spaced nodules and between nodules and matrix. Upon burial the gypsum nodules undergo dehydration to develop the anhydrite that is found in the subsurface (Kerr and Thomson, 1963).

Many authors consider the presence of nodular or "chicken-wire" anhydrite as indicative of a sabkha environment (Hsü, 1972; Friedman, 1973; Hsü et al., 1973). This hypothesis is supported by numerous reports of modern nodular anhydrite in the sabkha of the Persian Gulf (Kinsman, 1966; Butler, 1969; Kendall and Skipwith, 1969). However, Kinsman (1969) cautioned against using the modern analogue of nodular anhydrite as indicative of the sabkha environment because of the lack of association with emergent facies of some ancient nodular anhydrite. Careful examination of the sulfates and related carbonate facies in this study would suggest a subaqueous origin for the anhydrite.

Several aspects of the nodular anhydrite and adjacent facies suggest development in a subaqueous environment. The sulfates contain no evidence for a sabkha origin. The thickness of the anhydrite beds (7-10 m) does not compare favorably with the thin layers (0.3-1 m) of modern evaporites. The interbedded and adjacent dolomite units contain no evidence of a subaerial-supratidal origin that would occur on a sabkha. A dismicrite fabric and solution breccia are absent and the units commonly contain a mesohaline biota. Sarg (1981) has shown that the mean \( \delta^{34}S \) value of the evaporites in the Seven Rivers Formation of the Guadalupe Mountains compares well with the mean value for
Permian seawater, which suggests a marine source for the brine precipitating the sulfates. The source brines for many models of sabkha mineralization are freshwater (Hsü and Schnerder, 1973; Badioramani, 1973; Folk and Land, 1975).

The blocky or crystallatopic anhydrite has a different origin than the nodular anhydrite. The poikilotopic texture and the zonation of the blocky grains and also the replacement of bioclastic grains indicates that the blocky crystals had a replacement origin (Murray, 1964). The process of replacement probably occurred by the simultaneous dissolution of the parent carbonate and precipitation of the anhydrite. This process is demonstrated by the preservation of in place inclusion-produced relict textures. The composition of the inclusions may show whether the development of the anhydrite predated or postdated dolomitization. The close association and textural similarity of the veinlets and the blocky crystals suggest that they are cogenetic.
VII. Depositional Environment

The cores of the Myers-Langlie-Mattix Unit record several cycles of possible change in relative sea level across the northeast shelf of the Delaware Basin. The cycles have been thoroughly discussed by previous authors (Meissner, 1969; Silver and Todd, 1969; Coogan, 1969; and others). Evidence for the different relative sealevel stands are preserved in different lithologies. Relative high sea level stands are represented by carbonate deposition and low stands by clastic deposition. The high sea level stand or relative rise in sea level reflected by carbonate sedimentation may actually be a still stand where carbonate material accumulated to sea level. The relative lowering of sea level of only a few meters would have a great effect on the broad shelf area of the Delaware Basin. During the relative low sea level clastic material prograded across the shelf.

Kendall (1981) has explained these relative sea level changes by a model which incorporates continual sea level rise punctuated by still sea level stands and varying rates of carbonate sediment production. As relative sea level rises, carbonate production may "catch up" to sea level, forming a shoaling upward sequence. When sedimentation exceeds sea level rise or during still stand, supratidal deposits form, or as is the case in the Myers-Langlier Mattix rocks, clastic sediments prograde across the shelf. In the complex setting of the Delaware Basin shelf, where rates of sediment production and relative sea level rise are constantly varying, Kendall's model could produce the intricate interfingering of facies found in the Myers-Langlie-Mattix cores.
Alternating sequences of clastic and carbonate sedimentation can be seen in Myers-Langlie-Mattix cores (Fig. 39). Individual depositional phases may not be of equal thickness in adjacent wells because of the influence of local topography. Typical cyclic sequences include horizons developed under subaerial or very shallow water conditions during the clastic stage (Jacka and Franco, 1974) and horizons subaqueously deposited during the carbonate stage.

**Clastic depositional phase**

Numerous interpretations exist for the sandstone units of the Queen and Seven Rivers formations outside the Myers-Langlie-Mattix Unit area. Jacka and Franco (1974), Kendall (1969) and others maintain that the clastics represent material deposited on the sabkha by eolian processes, based on the presence of adhesion ripples (Jacka and Franco, 1974) and traction current structures (Kendall, 1969). Boyd (1958) and others favor a lagoonal origin for the sandstone based on the occurrence of current ripples and crossbedding. The absence of well-defined bedding in cores, particularly any of the aforementioned structures, makes the interpretation of the sandstone of the Myers-Langlie-Mattix cores difficult.

Jacka and Franco (1974) deduce an eolian origin for the Queen and Seven Rivers sandstones by comparing structures found in these formations to adhesion ripples described by Glennie (1972). Glennie (1972), working in the Permian Rotliegendes Sandstone of northwest Europe, concluded that those sandstones developed by the deposition of wind-blown grains on a sabkha, where moisture drawn to the surface by capillary action caused the grains to adhere to the surface and form adhesion ripples. One of
the characteristics of adhesion ripples is the presence of microforeset bedding (Glennie, 1972). While this feature is not prominent in the sandstone of this study, adhesion ripples are common in the bluish gray sandstone.

Characteristics of the sandstone in the Myers-Langlie-Mattix cores that have been taken to indicate a subaqueous depositional environment are primarily features of soft sediment deformation and texture. While well developed horizontal bedding is not common, the bedding does display structures similar to micro-block slumping and overturning of laminae on a very small scale. The slumping occurs at such a low angle that its occurrence on a dune face is unlikely. The micro-block slumping may have occurred in response to the slight compaction of underlying sediment. The overturned laminae are on a scale of only a few centimeters and may be the result of waves acting on slightly consolidated sediment. The slightly convoluted bedding of interbedded dolomite and bluish gray sandstone laminae may also reflect wave action.

The presence of burrows provides further evidence for a lagoonal origin of the sandstone. In the bluish gray sandstone burrows can extend a few centimeters below bioturbated sediment into moderately well laminated sediment. The olive-gray sandstone is characterized by the poor bedding features which may be the result of bioturbation.

It is evident from the literature that the sand which accumulated on the shelf of the Delaware Basin during Guadalupian time was deposited in both eolian and marine environments. The sandstone of this study was probably laid down in a marginal marine lagoonal setting. The sediment may have been carried across the shelf by migrating delta lobes. The
deposition of the sand at distal parts of the sand body probably involved distinctive bedding which may not be obvious in the narrow outcrop represented in core. It is likely that some of the sand may have been blown in from land areas.

**Carbonate depositional phase**

The carbonate facies of the Myers-Langlie-Mattix cores represent several different subenvironments that existed on the shelf in Medial Guadalupian time. The dismircite facies represents shelf carbonate sediment which was exposed briefly to subaerial conditions. The typical fabric of patches of coarse spar indicate short periods of solution. The truncation of allochems in these cavities of spar shows a sequence of solution followed by cement infilling as opposed to simple cementation. The poorly developed emergent diagenetic features of this facies may be the result of the arid climate of the Guadalupian Delaware Basin (Ball et. al, 1969) preventing extensive subaerial diagenesis rather than only brief periods of exposure.

Micritization, coating of some grains, and solution brecciation are early features of caliche formation. The well developed caliche of other areas of the Permian Reef complex include features such as pisolites (Dunham, 1965; Thomas, 1968) which are not present to any extent in the rocks of this study. The absence of pisolites is probably due to the lack of coarse-grained material on which the pisolites could nucleate. The dismircite facies is unique in this study in that its features were superimposed on other facies which were pre-emergent.

The wackestone/mudstone facies is interpreted as representing a mud flat that, except for very brief periods of shoaling, was continuously
submergent. Calcispheres in this facies and others provide many clues to the environment of deposition. The non-ornamented calcispheres found in the Queen and Seven Rivers rocks bear a striking resemblance to the reproductive cysts of modern calcareous green dasycladacean algae belonging to the subfamily Acetabulariaceae (Rupp, 1967). Recent acetabulariacean algae are present in waters where salinity varies from brackish to supersaline. Modern calcispheres occur exclusively in areas characterized by shallow protected waters with restricted or semi-restricted circulation. These characteristics allow the acetabulariacean algae to proliferate in waters generally inhospitable to normal marine biota. Marzalek (1975) notes that the acetabulariacean algae are restricted to a maximum water depth of about 2.5 m. These attributes of calcispheres suggest that the rocks in which they are found were deposited in shallow, mesosaline to hypersaline waters in a relatively quiet setting.

Other features of the wackestone/mudstone facies support the environmental interpretation based on the occurrence of calcispheres. The laminated bedding of many of the mudstones and an abundance of micrite requires an environment with very little wave action. The very low diversity of the biota of the facies (predominately calcispheres and endothyrid forams) is probably the result of hypersaline conditions. Hypersalinity is also indicated by sporadic occurrences of masses of felted lath anhydrite. The very rare emergent features of the mudstone/wackestone facies indicate the uncommon shoaling events which occurred during deposition of these rocks.
The high micrite content of the mudstone/wackestone rocks may indicate a low energy depositional environment. An alternative and perhaps more plausible explanation would be that part of the mudstone/wackestone facies was deposited below an organic baffle such as an algal "sea grass" that would have dampened out the wave action near the seafloor permitting very fine grained sediment to accumulate in a moderately active environment. The "sea grass" would have provided a possible substrate for endothyrids and encrusting forams. The wisps of kerogen in the mudstone/wackestone facies could be the remains of "sea grass." Grass-covered mud banks, occasionally exposed to subaerial conditions, are a common feature in the Florida Bay.

The texture of the sediment deposited on the "sea grass" covered banks would be massive as a result of the bioturbation by roots. The laminated mudstone/wackestone would have accumulated in areas were the sediment was not churned by biologic activity.

The similar textures of peloid packstone facies and the calcisphere packstone facies may indicate that these two facies formed in somewhat similar environments. The relatively low micrite content and small scale current features of these facies suggest deposition in a relatively quiet to moderately active shallow lagoonal setting. Once again, the sparse biota may indicate a high salinity of the overlying waters. The bioturbation of these facies may be caused by infaunal feeders in the biota of calcspheres and endothyracean forams. The rare grainstone which occurs in the cores probably represents a channel deposit of slightly higher energy, thereby explaining the subsequent lack of micrite.
Differences in the depositional environments of the peloid packstone and the calcisphere packstone facies did exist, however, and caused the difference in their allochemical composition. While some of the peloids of the peloid packstone facies may be fecal in origin, many of them were probably formed by the micritization of bioclasts. Fecal pellets are generally spheroidal and fall into a particular size range. In contrast, micritized bioclasts are formed by re-crystallization or by the action of boring algae. Therefore, micritized bioclasts may have a great range in grain size. Micritization with the subsequent destruction of microstructure is a common shallow water phenomenon (Kendall and Skipwith, 1969). The grapestone grains found in the peloid packstone facies are cemented carbonate grain aggregates. The occurrence of the grapestone and also rare coated grains in the peloid packstone facies may indicate a slightly shallower depositional environment than that of calcisphere packstone facies. Grapestone described by Purdy (1962) on the Bahama Bank is characteristic of very shallow water conditions punctuated by occasional exposure to subaerial conditions. The sparse occurrence of a disomicritic texture in the peloid packstone facies also suggests brief periods of exposure or near shoaling. Some peloid packstone samples also display recrystallization to microspar, a characteristic common in the development of subaerial crusts (James, 1972). The grapestone grains also give an indication of the mechanical energy of the depositional environment. In order for the grains of the grapestone to be cemented together, bottom agitation must be limited. (Purdy, 1962). The requirement of little bottom agitation would seem to contradict the interpretation of sparse micrite as indicating a
moderately active environment, but the rocks in which the grapestone is found generally have a smaller component of micrite than the rest of the facies. Thus, the grapestone-bearing intervals of the peloid packstone facies may have been deposited during periods of relatively quiet water, while the grapestone-poor intervals were formed during times of more vigorous circulation. It is also possible that the grapestone is an allochthonous sedimentary component.

Based on the aforementioned interpretations of the peloid packstone facies, it appears that the calcisphere packstone facies was deposited in a comparatively less emergent environment. The abundance of the low diversity biota may demonstrate that the depositional environment of the calcisphere packstone facies was less saline than that of the peloid packstone facies.

The dismicrite facies of this study represents the lithofacies which developed under conditions of subaerial exposure described by many authors (Smith, 1974; Jacka and Franco, 1974; Ball, et al., 1971; and others) on the shelf of the Delaware Basin during Guadalupian time. The dismicrite facies developed at a point in the cyclic deposition when carbonate sedimentation had caught up with sea level and just prior to the influx of clastic material. The extensive development of pisolites noted by Dunham (1965) and Thomas (1965) for rocks of the Permian Reef complex are not present in the Myers-Langlie-Mattix rocks. The poor development of the pisolites may be due to the lack of coarse grained particles which act as nuclei during formation. The occurrence of features of the dismicrite facies in the middle of dolomite units may
represent brief periods of shoaling of mud banks similar to modern mud-body shoals (Harris, 1979).

It appears likely that at least a small degree of water circulation occurred on the Queen and Seven Rivers shelf. The sparse packstone facies may represent sediment deposited in channels that crossed the shelf. The modest currents in these channels could account for the packstone texture of the underlying sediment.

Generalizations can be made about the quality of lagoonal waters of the Queen and Seven Rivers formations represented in this study based on the occurrence of evaporites. Both the irregular masses of felted lath anhydrite (which occur in much of the dolomite) and the extensive nodular anhydrite masses only develop in environments of restricted circulation and subsequent high salinity waters as a result of evaporative concentration. Butler (1969) has shown that salinities are on the order of 145 0/00 are found in areas of the Trucial Coast in the Persian Gulf where sulfates are presently forming. Therefore, a hypersaline depositional environment is indicated for the anhydritic rocks of the Myers-Langlie-Mattix cores.

In the past, nodular anhydrite has been used as an indicator of deposition in a supratidal environment(Friedman, 1973; Hsü, 1972; and others). The most unequivocal evidence for the subaqueous origin of the Queen-Seven Rivers sulfates is the lack of associated exposure fabrics. While evidence for exposure is found in the dolomite, none of the facies adjacent to the nodular anhydrite units display any supratidal characteristics that would suggest a supratidal origin for the anhydrite.
Facies distribution

The complex interfingering of facies in the Myers-Langlie-Mattix cores suggests a more complicated arrangement of facies on the shelf than is commonly acknowledged. For example, Jacka and Franco (1974) indicate a facies distribution of broad bands parallel to the shoreline based on their work on shelf deposits of the Permian Basin. Studies of modern carbonate facies, on the other hand, illustrate both the patchy distribution of facies and the primary dependence on water circulation for facies development. Work by Pursar and Evans (1973) in the Persian Gulf and Purdy (1962) on the Bahama Bank are only two examples demonstrating that the distribution of modern carbonate facies in environments similar to the Guadalupian Delaware Basin shelf is very complex; no simple pattern describes the facies arrangement. Therefore, the distribution of the carbonate facies described in this study was controlled by distribution of the migrating patterns of water circulation on the shelf. These migrating depositional patterns then produced the complicated stratigraphic arrangement of facies described in this study.

Origin of clastic and carbonate phases

The distribution of facies within the carbonate units is the result of local phenomena, whereas the repetition of clastic and carbonate stages is influenced by processes of a much larger scale. The cyclic sedimentary patterns observed in the Myers-Langlie-Mattix cores (see Fig. 42) may have been caused by eustatic sea level changes (Meissner, 1969; Jacka, 1967; Silver and Todd, 1969). Similar patterns of cyclic sedimentation are found in the Permian of the Paradox Basin, Denver Basin and the Perm Basin of the Soviet Union and provide the most compelling
Figure 42. Clastic and carbonate phases of deposition in Myers-Langlie-Mattix Unit cores. Number at top of cores is core identification number. Figures on left margin of cores are depths below surface in feet. C = carbonate phase, S = clastic phase.
evidence for eustatic control of sea level. Cyclic deposition can also be caused by tectonism, but the relatively constant development of shelf lithofacies around the basin, the relatively homogeneous nature of the lithofacies and the good correlation of strata between the Delaware Basin and other basins are evidence that favor an eustatic sea level control (Silver and Todd, 1969). In addition, it seems unlikely that the tectonic gymnastics necessary to form the observed repetition of clastic and carbonate stages could have occurred over the short stratigraphic interval represented by the Seven Rivers and Queen formations.

**Glacial eustatic sea level control**

Meissner (1969) suggests that climate may have played a part in influencing the pattern of sedimentation, with changes in precipitation and temperature controlling the initiation and extinction of clastic sedimentation in a given depositional environment. Glacial cycles are one mechanism which may have caused the climatic changes in conjunction with eustatic sea level changes. Evidence that glaciations occurred in the Southern Hemisphere during late Paleozoic time (Hamilton and Krumbsley, 1967; Teichert 1941; and others) are summarized below.

In Tasmania, dropstones occur in marine beds from Early Permian to approximately Guadalupian in age (Banks, 1981) and are considered to be evidence of glacial influence. The Sydney Basin of Australia contains evidence of waning glaciation during the Guadalupian in marine sediments containing isolated ice-rafted megaclasts, erratics or dropstones (Herbert, 1980). Clast rafting has also been identified in the Verkoyansk region of Siberia during the Guadalupian (Crowell and Frakes, 1975). As a result of this evidence, many workers have assumed that sea
level changes in the Pennsylvanian (Wanless and Cannon, 1966) and Permian
(Meissner, 1967; Silver and Todd, 1969) in North America were
eustatically controlled.

**Hypothesis for Myers-Langlie-Mattix Unit**

The cycles of sedimentation of this study are represented by a
carbonate unit and an overlying clastic unit. The carbonate unit was
deposited during rising sea level. Cycles exist within the carbonate
unit of facies that appear to be shoaling upward. The carbonate unit is
commonly capped by dismicrite facies which represents the "catching up"
of carbonate sedimentation to sea level during a still sea level stand
(Kendall, 1981). During the still stand clastic material advanced across
the shelf and into the basin. The cycle of carbonate and clastic
deposition is regressive.

Despite the abundant evidence and popular acceptance of
glacially-induced eustatic sea level changes as the control of cyclic
sedimentation in the Delaware Basin, it appears that the primary factor
influencing information of the Myers-Langlie-Mattix Unit rocks is a
relative rise in sea level with varying carbonate sedimentation.
Evidence for continental glaciation that could potentially control
eustatic sea level during the Guadalupian is nonexistent. In summary,
the cyclic sedimentation patterns of the Myers-Langlie-Mattix Unit rocks
probably developed as a result of carbonate sediment production and
clastic deposition during relative sea level stands which varied from a
relative rise to still stand.
VIII. Conclusions

1. The Queen and Seven Rivers formations of the Myers-Langlie-Mattix Unit were deposited on a broad mesosaline to hypersaline shelf.

2. Alternating sequences of sandstone and dolomite/evaporite in the Myers-Langlie-Mattix cores represent the response of sedimentation to a relative rising sea level punctuated by still sea level stands.

3. Carbonate/evaporite sedimentation predominated during rising sea level. During still sea level stand, carbonate sedimentation built to sea level and sand prograded across the shelf transported by wind and water currents.

4. The carbonate facies include: mudstone/wackestone, calcisphere packstone, peloid packstone and disomicrite. The mudstone/wackestone facies was deposited in moderately quiet water, possibly bioturbated, and with a low diversity biota of sparse calcispheres, endothyrids and algal fragments. The calcisphere packstone and peloid packstone facies were deposited under moderately active conditions. Abundant calcispheres and endothyrids and sparse algal and mollusk fragments are present in the calcisphere packstone facies. Abundant peloids and sparse calcispheres, endothyrids and other fossils characterize the peloid packstone facies. The disomicrite facies developed by subaerial diagenetic modification of a pre-emergent facies.

5. Two sandstone facies are represented by a bluish gray sandstone and an olive gray sandstone. Both sandstones are moderately sorted, generally very fine grained quartz arenites cemented by fine
grained dolomite. The bluish gray sandstone is characterized by an abundance of terrigenous clay and wispy bedding which in some cores displays features of soft sediment deformation. The olive gray sandstone is characterized by a lack of clay, greater porosity than the bluish gray sandstone poorly developed bedding and oil occurrences.

6. Evaporites occur in the cores predominantly as "chicken-wire" anhydrite which was deposited subaqueously. This felted-lath texture anhydrite precipitated from interstitial fluids and physically displaced the surrounding sediment. Anhydrite is rarely present as blocky replacement crystal and also as a cement in both sandstone and dolomite.

7. The carbonates of the Myers-Langlie-mattix Unit have been extensively dolomitized, probably by the mechanism of seepage refluxion. Other diagenetic modifications of the rocks include cementation, anhydritization, subaerial dissolution and reprecipitation, and mesogenetic emplacement of hydrocarbons.
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APPENDIX A

Thin section descriptions of thin section samples used in this study.
<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3585</td>
<td>Dolomitic quartz arenite, very fine sand, moderately sorted, subangular, trace bladed anhydrite trace peloids, trace feldspar and rock fragments, microcrystalline dolomite matrix.</td>
</tr>
<tr>
<td>3586</td>
<td>Quartz arenite, v.f. sand, mod. sorted, subangular, trace anhydrite and feldspar, micro. dolomite cement.</td>
</tr>
<tr>
<td>3588</td>
<td>Quartz arenite, v.f. sand, mod. sorted, subangular, trace feldspar, anhydrite and clay, micro. dolomite cement.</td>
</tr>
<tr>
<td>3590A</td>
<td>Quartz arenite, v.f. sand. mod. sorted, subangular, trace anhydrite cement, trace of oil, micro, dolomite cement.</td>
</tr>
<tr>
<td>3592</td>
<td>Sandy microcrystalline dolomite mudstone, trace intraclasts and peloids.</td>
</tr>
<tr>
<td>3593</td>
<td>Silty microcrystalline dolomite mudstone.</td>
</tr>
<tr>
<td>3594</td>
<td>Silty microcrystalline dolomite mudstone.</td>
</tr>
<tr>
<td>3595</td>
<td>Quartz arenite, coarse silt, mod. sorted, subangular, trace of feldspar, clay and pyrite, dolomite cement.</td>
</tr>
<tr>
<td>3597</td>
<td>Quartz arenite, v.f. sand, well sorted, subangular, trace anhydrite and gypsum, porosity 3-5%, dolomite cement.</td>
</tr>
<tr>
<td>3598</td>
<td>Quartz arenite, v.f. sand, mod. sorted, subangular, trace feldspar, limonite staining and anhydrite, dolomite cement.</td>
</tr>
</tbody>
</table>
3599  Silty dolomite mudstone, trace of calcispheres and endothyracean forams.
3600  Very silty dolomite mudstone.
3601  Silty dolomite mudstone, trace of calcispheres and endothyracean forams.
3602  Silty dolomite mudstone.
3603  Silty dolomite mudstone.
3604  Silty dolomite mudstone, rare to trace of calcispheres, trace endothyr inforams.
3605  Dolomite mudstone/wackestone, rare to common calcispheres, microstylolitic.
3606  Dolomite mudstone, rare calcispheres and endothyr forams occur in rare layers, sparse patches of coarsely crystalline dolospar.
3607  Quartz arenite, v.f. sand, poorly sorted, subangular, common pervasive pyrite, trace feldspar dolomite cement.
3608  Dolomite mudstone, trace endothyracean forams.
3609A Intracrystalline dolomite packstone, common calcispheres, endothyracean forams, rare algae, sparse patches of coarsely crystalline dolospar, vuggy porosity up to 5%.
3609B Algal dolomite dismicrite, common algal fragments, trace calcispheres and endothyr forams, common patches of medium crystalline dolospar.
3610  Sandy dolomite mudstone, laminae of sand and clay in micrite matrix.
3611A  Dolomite mudstone, trace algal fragments and silt.
3611B  Dolomite mudstone, trace calcispheres and peloids, rare patches of coarsely crystalline spar.
3613A  Dolomite mudstone, trace of calcispheres and endothyrid forams occurring in fine layers.
3613B  Quartz arenite, v.f. sand, mod. sorted, subangular, trace feldspar, rock fragments abundant clay, dolomite cement.
3614  Quartz arenite, coarse silt to v.f. sand, mod. sorted, subangular, trace clay, common oil, dolomite cement.
3615  Quartz arenite, v.f. sand, mod. sorted, subang., common oil, 2-3% porosity in areas lacking oil, dolomite cement.
3616  Quartz acenite, v.f. sand, mod. sorted, subang., trace of calcispheres, dolomite cement.
3617  Dolomite wackestone, common to abundant calcispheres, common algal fragments and peloids, sparse fine layers of sand.
3618  Quartz arenite, v.f. sand, mod. sorted, subang., traces of feldspar, ferroan dolomite, traces of patches of mudstone with calcispheres, dolomite cement.
3619  Same as 3618.
3620  Quartz arenite, coarse silt, mod. sorted, subang., trace feldspar and rock fragments, dolomite cement replaces same quartz grains.
3622  Dolomite mudstone, slightly sandy, race intraclasts with calcispheres, sparse replacement of sand by dolomite.
Calcisphere wackestone, abundant calcispheres and common endothyrid forams, trace mollusc fragments, interparticle porosity filled with coarse dolospar, trace ferroan dolomite.

Dolomite mudstone, trace calcispheres.

Quartz arenite, coarse silt to v.f. sand, mod. sorted, subang., laminated by clay and silt.

Quartz arenite, coarse silt, mod. sorted, subang., trace clay, common oil in intergranular porosity.

Similar to 3626.

Quartz arenite, v.f. sand, mod. sorted, subang., trace clay, and feldspar, common ferroan dolomite cement, rare patches of pyrite cement porosity up to 5%.

Quartz arenite, v.f. sand to coarse silt, mod. sorted, subang., laminated by grain size and traces of clay, traces of oil, dolomite cement, traces of ferroan, dolomite in corroded quartz grains.

Dolomitic quartz arenite, v.f. sand., mod. sorted, subang., dolomite matrix, sparse micrite intraclasts.

Dolomite wackestone, common possible encrusting forams, some with neomorphased substrate, trace sand.

Dolomite wackestone, common calcispheres and forams, trace of pyrite, trace of patches of coarse dolospar.

Dolomitic quartz arenite, coarse silt, poorly sorted, angular, dolomite matrix, traces of clay and pyrite.

Quartz arenite, v.f. sand, mod. sorted, subang., sparse patches of micrite, some with fossils, trace of oil in intergranular porosity, trace of ferroan dolomite cement, and feldspar, dolomite cement.

Quartz arenite, v.f. sand, mod. sorted, subrounded, common micrite granule size clasts with forams, rare oil in intergranular porosity, traces of ferroan dolomite cement, and feldspar dolomite cement.

Dolomite wackestone, common calcispheres, enoothyrid forams, rare algal fragments, rare patches of medium dolospar.

Dolomite wackestone, similar to 3639, trace pyrite.

Dolomitic quartz arenite, coarse silt and very fine sand, mod. sorted, subang., dolomite matrix, traces of clay.

Quartz arenite, v.f. sand, mod. sorted, subang., common oil in intergranular pores, cement predominately ferroan dolomite in vicinity of oil show, traces of clay, and feldspar, trace rock fragments, dolomite cement.

Quartz arenite, coarse silt, mod. sorted, subang., rare clay, common pyrite occurs as band of sparse cement across sample.

Quartz arenite, v.f. sand to coarse silt, mod. sorted, subang., trace feldspar, numerous clay wisps, dolomite cement.
3649A  Dolomite wackestone, common fossil ghosts, rare blebs of clayey sand, trace pyrite.

3649B  Dolomite mudstone, rare calcispheres and endothyrid forams, trace fossil ghosts, rare oil show in intergranular porosity.

3649C  Dolomite mudstone, trace endothyrid forams, sparse patches of dolospar.

3652  Dolomite wackestone, rare to common calcispheres and endothyrid forams, rare patches of medium dolospar.

3654  Dolomite mudstone, possible burrows filled with medium dolospar, traces of algal fragments.

3656  Dolomite mudstone, trace of oil in intergranular porosity, rare patches of dolospar.

3659  Quartz arenite, v.f. sand, mod. sorted, subang., trace feldspar and rock fragments, dolomite cement, rare replacement of quartz by dolomite, rare patches of matrix support sand.

3660  Dolomite mudstone, fractures filled with dolospar, rare bladed anhydrite.

3661  Dolomite mudstone, rare patches of very fine dolospar.

3662  Dolomite mudstone, microstylolitic, very rare calcispheres, rare patches of coarse dolospar.

3663  Dolomite packstone, common calcispheres, and endothyrid forams.

3664  Dolomite mudstone, trace of fossil ghosts, trace kerogen.

3666  Dolomite packstone, common granule size interclasts with dolomite pseudomorphs of gypsum, abundant peloids and fossil ghosts.
Dolomite mudstone, rare peloids.

Dolomite wackestone/packstone, common peloids, trace calcispheres and endothyrid forams, trace gypsum.

Dolomite wackestone, common intraclasts containing calcispheres, fracture and filled with dolospar.

Dolomite packstone/wackestone, common calcispheres and endothyrid forams, rare patches of dolospar, layers of sugary dolomite.

Dolomite mudstone, slightly sandy.

Dolomite wackestone, common fractured micrite intraclasts, rare calcispheres, slightly sandy.

Dolomite mudstone, fractured, traces of gypsum, pyrite, rare patches of medium dolospar.

Quartz arenite, coarse silt to v.f. sand, mod. sorted, subang., trace feldspar, rare micrite intraclasts containing calcispheres and endothyrid forams, rare replacement of quartz by dolomite.

Same as 3676.

Dolomite packestone/wackestone, abundant peloids, common calcispheres, rare patches of dolospar some containing gypsum crystals.

Dolomite mudstone, slightly sandy.

Dolomite packstone, abundant calcispheres, rare endothyrid forams and algal fragments, common patches of medium dolospar, some crosscut allochem, rare gypsum.

Similar to 3683.

95
Dolomite packstone, abundant calcispheres and peloids, rare endothyrid forams and algae, rare patches of dolospar trace pyrite.

Dolomite mudstone, rare calcispheres and endothyrids, rare patches of medium dolospar some crosscut allochems.

Dolomite packstone/wackestone, abundant peloids and fossil ghosts, rare patches of fine dolospar.

Dolomite packstone/wackestone, abundant algal fragments, common calcispheres, rare peloids and endothyrids, slightly sandy.

Quartz arenite, v.f. sand to medium silt, poorly sorted, subang., bioturbated with patches of micrite, trace of pyrite and feldspar, dolomite cement.

Dolomite packstone/wackestone, common calcispheres and algal fragments, sparse patches of medium dolospar some with trace of anhydrite.

Quartz arenite, v.f. sand, mod. sorted, subang., trace feldspar and rock fragments, in part patches of micrite with peloids, sparse evidence for compaction, trace pyrite in globular masses, dolomite cement.

Quartz arenite, v.f. sand, mod. sorted, subang., trace of replacement of quartz grains by dolomite, trace clay, trace feldspar and pyrite, dolomite cement.

Quartz arenite, similar to 3703, laminated by micrite matrix content.
<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3340</td>
<td>Felted lath anhydrite, rare matrix of dolomitic sand with sparse anhydrite cement, 0.1-0.3 mm sheath of dolomicrite around anhydrite.</td>
</tr>
<tr>
<td>3341</td>
<td>Same as 3340</td>
</tr>
<tr>
<td>3342</td>
<td>Dolomite mudstone with felted lath anhydrite, sheath of carbonate around anhydrite, rare vein filling anhydrite and blocky anhydrite.</td>
</tr>
<tr>
<td>3343.5</td>
<td>Dolomite packstone, abundant peloids with sugary texture, rare crystallotopic anhydrite with inclusions of carbonate, sandy.</td>
</tr>
<tr>
<td>3346</td>
<td>Dolomite mudstone, slightly sandy, rare crystallotopic anhydrite with inclusions.</td>
</tr>
<tr>
<td>3341.1</td>
<td>Felted lath anhydrite with dolomitic clayey v.f. sand matrix.</td>
</tr>
<tr>
<td>3348.5</td>
<td>Sandy dolomite mudstone, sugary texture, rare oil show, traces blocky anhydrite.</td>
</tr>
<tr>
<td>3349.5</td>
<td>Dolomite wackestone laminate, common calcispheres, and peloids, rare endothyrids and algal fragments, fractured with anhydrite filling, trace blocky anhydrite with inclusion, margins of fracture filling anhydrite also contain inclusions.</td>
</tr>
<tr>
<td>3350</td>
<td>Quartz arenite, v.f. sand, mod. sorted, subang., trace feldspar, terrigenous clay 15-20%, common anhydrite cement also dolomite cement.</td>
</tr>
</tbody>
</table>
3350.3 Sandy dolomite mudstone, rare micrite intraclasts, common anhydritic sand and silt.

3350.7 Dolomite wackestone, laminated by rare fossil ghosts and v.f. sand, rare calcispheres, endotoyroids and algae.

3352.5 Dolomite mudstone, laminated by sand content, rare bladed anhydrite crystals.

3354 Dolomite mudstone/wackestone, rare encrusting forams and algal fragments, rare anhydrite filled fractures.

3356 Dolomite wackestone, rare algal fragments, rare blocky anhydrite, rare patches of dolospar and blocky anhydrite.

3358 Felted lath anhydrite.

3363.8 Felted lath anhydrite, rare dolomite matrix.

3365.5 Dolomite mudstone, common blocky anhydrite crystals with concentric layers of inclusions, trace calcispheres, sugary matrix texture.

3366.5 Sandy dolomite wackestone, common micrite clasts in sandy dolomite matrix, rare felted lath anhydrite.

3367.5 Felted lath anhydrite, matrix of endothyrid wackestone with sugary texture.

3370.3 Dolomite packstone, common peloids, rare calcispheres and endothyrids, common blocky anhydrite.

3371.8 Dolomite mudstone, rare felted lath anhydrite, finely crystalline texture.

3378 Felted lath anhydrite, matrix of dolomitic v.f. quartz sand.

3381 Quartz arenite, v.f. sand, mod. sorted, subang., abundant anhydrite cement, clay 20%, rare dolomite cement.
3383 Dolomite wackestone/packstone, abundant calcispheres, rare endothyrids and possible algal fragments, common blocky anhydrite/gypsum.

3384.4 Sandy dolomite mudstone, common blocky anhydrite.

3387 Quartz arenite, coarse silt, mod. sorted, subang., clay 20%, trace feldspar and rock fragments, dolomite cement.

3388 Dolomite wackestone/packstone, abundant possibl encrusting forams or algae, common calcispheres and endothyrid forams, rare patches of coarse dolospar, replacement anhydrite of fossils and blocky anhydrite common.

3390 Quartz arenite, coarse silt, mod. sorted, subang., clay 15%, trace feldspar,

3390 Quartz arenite, v.f. sand and coarse silt, mod. sorted, subang., trace feldspar and rock fragments, dolomite and anhydrite cement, porosity 5-10%.

3395 Dolomite mudstone, sugary texture, fine to medium crystalline.

3397.5 Dolomite wackestone/mudstone, laminated by fossil content, rare calcispheres and endothyrids.

3401.3 Quartz arenite, v.f. sand, mod. sorted, subang., abundant terrigenous clay, trace feldspar and rock fragments, dolomite cement.

3403.9 Dolomite packstone, laminated by fossil-rich dolomicrite and fossil poor fine dolospar layers, abundant algal fragments, forams and peloids, rare patches of coarse dolospar.

3407.5 Dolomite mudstone, sugary texture.
3413.1 Dolomite packstone, common calcispheres and peloids, rare patches of medium dolospar, trace of anhydrite and gypsum.

3414.8 Dolomite packstone, recrystallized, common peloidal ghosts.

3415.1 Dolomite mudstone, slightly silty.

3415.3 Dolomite mudstone, sugary texture.

3418.2 Dolomite wackestone/packstone, laminated by abundant fossil laminae and dolospar, abundant calcispheres, common kerogen.

3420 Dolomite mudstone, rare calcispheres, peloids, slightly sugary texture.

3421.8 Dolomite wackestone/packstone, possible bioturbated laminae of fossil rich/fossil poor layers, abundant calcispheres and algal fragments, common coarse dolospar patches, rare endothyrids and kerogen.

3422.2 Dolomite wackestone, common algal fragments and small intraclasts, rare possible algal bails.

3423 Dolomite laminated wackestone and mudstone, common algal fragments, rare endothyrids and calcispheres, rare patches of dolospar.

3424 Similar to 3423, rare kerogen wisps.

3425.2 Quartz arenite, v.f. sand, mod. sorted, subang., abundant authigenic clay, rare patches of poikilotopic dolomite cement, trace feldspar, dolomite cement, porosity 15%.

3427.7 Quartz arenite, v.f. sand and coarse silt, poorly sorted, subang., laminae of clay, silt and dolomicrite clasts in dolomicrite matrix, trace rock fragments and feldspar.
3428.1  Dolomite mudstone, rare calcispheres, rare dolospar patches.

3430   Dolomitic quartz arenite, v.f. sand, mod. sorted, subang., dolomite matrix.

3433.3 Quartz arenite, v.f. sand, mod. sorted, subang., abundant authigenic clay and kerogen, trace feldspar.

3435.2 Dolomite mudstone, common wisps of kerogen orientated horizontal to bedding, rare patches of coarse dolospar, trace fossil ghosts, finely crystalline dolomite.

3437.1 Quartz arenite, v.f. sand and coarse silt, poorly sorted, subang., laminated by grain size, abundant terrigenous clay, patchy low porosity, trace feldspar.

3439   Quartz arenite, v.f. sand. mod. sorted, subang., patchy dolomicrite matrix, trace feldspar and rock fragments.

3443   Quartz arenite, v.f. sand and coarse silt, poorly sorted, common terrigenous clay, trace-feldspar, dolomite cement.

3445.1 Dolomite mudstone, slightly sandy, abundant fine grained disseminated pyrite.

3449.5 Quartz arenite, v.f. sand, mod. sorted, subang., clay 10%, trace feldspar and rock fragments, intergranular oil up to 15%, rare blocky dolomite cement.

3451.5 Dolomite mudstone, slightly sandy, rare partial replacement by dolomite, sugary texture.

3454.5 Dolomite mudstone, trace intercrystalline oil shows, sugary texture.
3455.9 Dolomite wackestone, common peloids, common dolospar patches, rare spar filled fossil molds.

3457.9 Quartz arenite, v.f. sand, mod. sorted, subang., dolomite cement, trace feldspar.

3462.3 Quartz arenite, v.f. sand, mod. sorted, ssubang., clay 15%, rare intergranular oil, trace feldspar and rock fragments, dolomite cement.

3463 Dolomite wackestone, common calcispheres and endothyrids, rare algae, rare dolospar patches.

3464 Dolomite wackestone, common fossil ghosts, v.f. to finely crystalline dolomite.

3465.4 Quartz arenite, v.f. sand, poorly sorted, subang., dolomite cement.

3464.9 Dolomite laminated wackestone/packstone, fossil-rich and fossil-poor laminae, abundant peloids, algal fragments, rare endothyrids, rare patches of dolospar.

3468 Quartz arenite, v.f. sand, mod. sorted, subang., clay 5%, rare intergranular oil, trace feldspar, dolomite cement.

3471.9 Quartz arenite, v.f. sand, mod. sorted, subang., dolomite cement, porosity 2-3%, trace feldspar and rock fragments.

3472.9 Dolomite grainstone, abundant calcispheres, endothyrid forams, peloids, common algal fragments, grains generally partially micritized.
3473.9 Dolomite crystalgal laminate, laminae of fossil-rich and fossil-poor, abundant endothyrids and peloids, common dolospar patches.

3475 Dolomite grainstone, abundant endothyrids, common calcispheres, rare phylloid algae and mollusc fragments, trace ostracode molds, rare coated grains, abundant dolospar patches some with trace of gypsum.

3476.4 Dolomite packstone/wackestone, abundant aggregate grains, common endothyrid forams and peloids, common dolospar patches, rare fossil molds.

3481 Dolomite mudstone, rare large coated grains and dolospar patches, traces of anhydrite in dolospar, fractured.

3482 Quartz arenite, mod. sorted, subang., v.f. sand, trace feldspar, dolomite and authigenic clay matrix, rare intergranular oil, porosity 5%.

3484.2 Dolomite packstone, abundant endothyrids and peloids, rare blocky anhydrite with inclusions.

3485.5 Dolomite wackestone/packstone, abundant patches of coarse dolospar, surgery matrix texture, common peloids, aggregate grains.

3487 Dolomite mudstone, rare dolospar patches, sugary texture.

3491 Dolomite mudstone, trace possible algal fragments, sugary texture.

3493 Quartz arenite, v.f. sand, mod. sorted, subang., clay 10%, trace feldspar and rock fragments, dolomite cement.
3493.5  Quartz arenite, v.f. sand, mod. sorted, subang., surgery
dolomite matrix, rare micrite intraclasts, rare sand filled
fractures, trace feldspar.

3495.2  Dolomitic quartz arenite, v.f. sand, mod. sorted, subang.,
common angular clasts of sandy cryptalgal laminate, dolomite
cement.

3497.5  Quartz arenite, v.f. sand, mod. sorted, subang., trace feldspar
and rock fragments, dolomite cement, trace intergranular oil.

3498.8  Dolomite grainstone, abundant peloids and coated grains,
slightly sandy, common patches of dolospar with trace of
gypsum.

3502   Dolomite mudstone, sugary texture, fractured, filled with
medium crystalline dolospar.

3502.5  Dolomite wackestone, common peloids and endothyrids, common
dolospar patches with trace of gypsum/anhydrite, trace
anthigenic clay.

3503   Dolomite wackestone, common filled ovoid molds, rare
endothyrids, common dolospar patches.

3505   Shaley quartz arenite, v.f. sand and silt, poorly sorted, trace
feldspar, subang., abundant terrigenous clay.

3506.9  Laminated siltstone and wackestone, common peloids endothyrids,
traces of opague organic material.

3509.5  Dolomite wackestone, rare peloid with sugary texture, rare
dolospar patches.
3511  Dolomitic quartz arenite, v.f. sand, subang., clasts of sandy wackestone of peloids in a shaley sand matrix, dolomite cement.

3515.5  Dolomitic quartz arenite, v.f. sand, poorly sorted, subang., trace feldspar, clay 15%, dolomite matrix.

3517.5  Same as 3515.5

3518.8  Dolomite wackestone/packstone, common to abundant peloids, slightly sandy.

3520  Quartz arenite, v.f. sand, mod. sorted, subang., trace feldspar and rock fragments, dolomite cement.

3521.5  Quartz arenite, v.f. sand, mod. sorted, subang., common flat intractasts of micrite, trace feldspar, dolomite cement.
<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3530</td>
<td>Dolomite mudstone/wackestone, common algal fragments, slightly sand, finely crystalline dolomite matrix.</td>
</tr>
<tr>
<td>3531</td>
<td>Quartz arenite, v.f. sand to coarse silt, subang., variegated by grain size, clay rare to common, trace feldspar, dolomite cement.</td>
</tr>
<tr>
<td>3534</td>
<td>Quartz arenite, coarse silt, mod. sorted, subang., sparse patches of micrite, trace feldspar and rock fragments, dolomite cement.</td>
</tr>
<tr>
<td>3535</td>
<td>Dolomite wackestone, common peloids, rare possible encrusting forams, slightly silty.</td>
</tr>
<tr>
<td>3539</td>
<td>Quartz arenite, v.f. sand, mod. sorted, subang., common micrite intraclasts, trace feldspar, trace of clay and oil, dolomite cement.</td>
</tr>
<tr>
<td>3540</td>
<td>Quartz arenite, v.f. sand to coarse silt, mod. sorted, subang., trace feldspar, common intraclasts of mudstone with calcispheres, traces ferroan dolomite, dolomite cement.</td>
</tr>
<tr>
<td>3544</td>
<td>Dolomite wackestone, common intraclasts and calcispheres, rare endothyrids, rare patches of dolospars, trace oil in patches of dolospars in intercrystal porosity.</td>
</tr>
<tr>
<td>3546</td>
<td>Quartz arenite, v.f. sand, mod. sorted, subang., rare granule size clasts of mudstone, trace of oil, rare ferroan dolomite, trace feldspar and rock fragments, dolomite cement.</td>
</tr>
</tbody>
</table>
3547B Dolomite disomicrite, sandy, common fossil ghosts, common patches of medium dolospar rare calcispheres.

3552 Similar to 3547B, common mudstone intraclasts with calcispheres and peloids.

3554 Quartz arenite, coarse silt, mod. sorted, subang., common clay, trace feldspar, numerous micro-stylolites.

3555 Quartz arenite, v.f. sand, mod. sorted, subang., rare to common intergranular oil, trace feldspar and rock fragments, rare patches of micrite matrix, dolomite cement.

3557 Dolomite wackestone, laminae of mudstone and wackestone of calcispheres, peloids and endothyrids, rare laminae of coarse silt.

3562 Dolomite mudstone/wackestone, common algal ghosts, slightly sandy.

3590 Dolomite mudstone, trace fossil ghosts, sparse oil filled fractures, trace quartz, very finely crystalline dolomite.

3491 Same as 3490.

3492 Dolomite mudstone, laminae of v.f. sand. and fossil ghosts with rare patches of medium dolospar, microstylolitic.

3594 Quartz arenite, medium silt, mod. sorted, subang., dolomite matrix, common clay, disseminated pyrite, trace feldspar.

3598 Dolomite packstone, abundant peloids and algal fragments, rare calcispheres, trace of patches of medium dolospar, rare cement filled fractures.
Dolomite grainstone, abundant calcispheres, common endothyrid forams and mollusc fragments, finely crystalline dolomite matrix.

Sandy dolomite mudstone, trace of quartz grains replaced by dolomite, trace pyrite.

Dolomite mudstone, finely crystalline dolomite trace quartz silt.

Dolomite mudstone, trace gypsum, trace coarse quartz silt.

Dolomite mudstone, trace calcispheres, rare bladed anhydrite and gypum masses, trace arcuate cement filled molds.

Dolomite mudstone, laminated micrite and black organic matter, rare patches of dolospars, trace calcispheres.

Dolomite mudstone, rare ripped up algae.

Dolomite mudstone, trace calcispheres and ostracodes, rare kerogen occurring in anastamosing layers with associated pyrite.

Dolomite packstone, common peloids, trace endothyrids, rare bladed anhydrite masses.

Dolomite packstone/wackestone, abundant calcispheres, common peloids, fossil ghosts, in part laminated with v.f. sand., sparse patches of very finely crystalline dolospars.

Dolomite mudstone, trace algal fragments.

Dolomite mudstone, trace fossil ghosts, common masses of bladed anhydrite.

Dolomite mudstone, trace calcispheres, rare laminae of kerogen, trace sand.
Quartz arenite, v.f. sand, mod. sorted, subang., trace opaque organic material, trace feldspar and rock fragments, dolomite cement, trace patches of medium dolospar.

Same as 3630.

Dolomite mudstone, trace calcispheres.

Dolomite packstone, abundant peloids with micrite rims, trace grapestone, rare quartz sand, common patches of medium dolospar.

Dolomite packstone, abundant peloids, trace intraclasts of sandy mudstone, trace algae.

Dolomite wackestone, common peplets, grapestone, trace calcispheres and micrite ghosts, rare patches of dolospar with intercrystal oil, rare quartz sand.

Quartz arenite, v.f. sand, mod. sorted, subang., trace of patches of micrite, rare to common blebs of opaque organic matter dolomite cement.

Same as 3642.

Quartz arenite, coarse silt, mod. sorted, subang., rare patches of medium dolospar, trace feldspar, rare pyrite and organic matter, trace clay dolomite cement.

Quartz arenite, coarse silt, mod. sorted, subang., in part rare pyrite cement replaces some grains, rare organic matter, clay 5-7%, dolomite cement.

Quartz arenite, v.f. sand, mod. sorted, subang., trace feldspar and rock fragments, rare clay wispies, trace opaque organic matter.
Quartz arenite, coarse silt, mod. to poorly sorted, subang., trace glauconite, clay 2-7%, trace pyrite, trace feldspar, in part dolomite matrix supported.

Dolomite packstone, common calcispheres and endothyrids, slightly sandy, rare patches of medium dolospar, moderately pustular laminated.

Dolomite packstone, common peloids, rare patches of medium dolospar, sandy, some dolomite replacement of quartz.

Quartz arenite, v.f. sand, mod. sorted, subang., traces of ferroan dolomite, clay 10%, dolomite cement.

Dolomite wackestone, cryptalgal laminae of algal ball wackestone/packstone and mudstone, trace cement filled fractures, trace quartz sand.

Quartz arenite, v.f. sand, mod. sorted, subang., authigenic clay 5-7%, common ferroan dolomite, dolomite cement.

Quartz arenite, v.f. sand, mod. sorted, subang., trace of possible pisoids, rare patches of dolospar, trace algal fragments, common dolomite replacement of quartz, clay 3%.

Quartz arenite, coarse silt, mod. sorted, subang., laminae of sand and musstone, trace algae and endothyrids, common patches of medium dolospar, trace pyrite.

Quartz arenite, v.f. sand, mod. sorted, subang., patches of micrite supported sand, trace oil in sandy patches, trace feldspar, clay up to 7%, dolomite replacement of quartz common.

Dolomite mudstone, traces of patches of dolospar, trace quartz sand, trace pyrite.
Dolomite wackestone, in part cryptalgal laminael ferroan
dolomite filled fractures rare, trace of bladed gypsum, rare
patches of dolospar, common endothyrids.
<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3462</td>
<td>Quartz arenite, v.f. sand, mod. sorted, subang., rare oil in intergranular porosity, trace pyrite, clay 5%, rare dolomite replacing quartz grains, trace feldspar and rock fragments, dolomite cement.</td>
</tr>
<tr>
<td>3463</td>
<td>Dolomite packstone/wackestone, cryptalgal laminal of rare calcispheres and common fossil ghosts and mudstone, slightly sandy, stylolitic.</td>
</tr>
<tr>
<td>3467</td>
<td>Dolomite packstone, calcisphere packstone laminated with peloid calcisphere wackestone, vuggy in part, porosity to 20%, rare patches of dolospar.</td>
</tr>
<tr>
<td>3470</td>
<td>Dolomite packstone/wackestone, common peloids and calcispheres, patches of dolospar common, associated with oil show, trace vuggy porosity.</td>
</tr>
<tr>
<td>3475</td>
<td>Dolomite packstone, abundant calcispheres, peloids, common fossil ghosts, rare endothyrids, very rare univerial forams and ostracodes.</td>
</tr>
<tr>
<td>3476</td>
<td>Quartz arenite, coarse silt, mod. sorted, subang., trace feldspar, terreginous clay 15%, common blebs of kerogen/bitumen.</td>
</tr>
</tbody>
</table>
3481 Dolomite wackestone, common calcispheres and endothyroid forams, rare peloids, trace oil in intercrystal pores, trace quartz silt.

3485 Dolomite wackestone, cryptagal laminae of common calcispheres and algae rare endothyroid forams and possible encrusting forams, trace quartz silt.

3492 Dolomite mudstone/wackestone, common peloids and aigal fragments, rare calcispheres and endothyroids.

3498 Quartz arenite, v.f. sand, mod. to poorly sorted, subang., authigenic clay 5%, oil show in greatest amount in areas lacking clay, trace feldspar.

3504 Sandy dolomite mudstone, trace of peloids and endothyroids, trace clay.

3511 Sandy dolomite mudstone, trace peloids and fossil ghosts, rare oil, trace clay, trace pyrite.

3514 Laminated quartz arenite and peloid packstone/wackestone, fine sand to coarse silt, clay 5%, rare calcispheres.

3520 Dolomite wackestone, rare grapestone and oëids, finely crystalline dolomite matrix.

3522 Quartz arenite, v.f. sand, mod. to poorly sorted, subang., trace feldspar and rock fragments, trace of oil porosity 3-5%, clay to 5%.

3528 Quartz arenite, coarse silt, mod. to poorly sorted subang., trace of quartz overgrowths, trace feldspar, clay 5-7%, trace pyrite, dolomite cement.
Quartz arenite, v.f. sand, mod. to poorly sorted, subang., trace quartz overgrowths, trace feldspar and rock fragments, trace porosity, dolomite cement.

Dolomite packstone, abundant algal fragments, common peloids, trace calcispheres, rare zyusum blades, trace kerogen associated with algae, sparse finely crystalline patches of ferroan dolospar, trace quartz and clay.

Dolomite grainstone/packstone, abundant algal fragments and peloids, rare patches of dolospar with traces of anhydrite, rare calcispheres and endothyrids, porosity 15%.

Quartz arenite, coarse silt, mod., sorted, subang., clay 5%, small degree compaction, trace feldspar, traces ferrdon dolomite, dolomite cement.

Dolomite mudstone, trace calcispheres.

Dolomite mudstone, trace calcispheres and pellets, rare patches of dolospar, rare intercrystal oil show.

Quartz arenite, v.f. sand, mod. sorted, subang., porosity interparticle 5-10%, rare possible barite cement crystals, dolomite cement.

Quartz arenite, v.f. sand., mod. to well sorted, subang. common intraclasts of sandy dolomicrite, stylolitic, sparse patches of dolospar, traces of possible barite/celestite, dolomite cement.

Dolomite packstone, abundant calcispheres and peloids, rare endothyrid forams, trace vuggy porosity with oil lining some vugs, traces of bladed possible barite/celestite.
3555 Dolomite mudstone, traces of calcispheres, peloids and endothyrids, rare patches of coarse dolospar, allochems occur in bands trace vuggy porosity.

3556 Quartz arenite, v.f. sand, mod. to poorly sorted, subangular, trace pyrite, slight compaction, dolomite cement.

3566 Quartz arenite, v.f. sand, mod. sorted, subang., traces of dolomite replacement of quartz, trace feldspar and rock fragments, dolomite cement.

3569 Dolomite wackestone, common micrite intraclasts and algal fragments, traces of bladed barite/celestite, trace quartz.

3571 Quartz arenite, v.f. sand., mod., sorted, subang., sparse small patches of sand in micrite matrix, clay 1-2%, trace feldspar, dolomite cement.

3573 Similar to 3571, rare opaque organic grains.
<table>
<thead>
<tr>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>3480(144,289),(318,312)</td>
</tr>
<tr>
<td>Description</td>
</tr>
<tr>
<td>Dolomite wackestone, common angular clasts of wackestone with calcospheres and peloids, matrix of slightly sand micrite, trace clay.</td>
</tr>
<tr>
<td>Dolomite mudstone, rare calcispheres, peloids and quartz silt, trace clay.</td>
</tr>
<tr>
<td>Dolomite wackestone/packstone, cryptagal laminate, common calcispheres and algal fragments, very rare algal plates, rare patches of dolospar.</td>
</tr>
<tr>
<td>Sandy dolomite mudstone, laminated v.f. quartz sand and nucriti.</td>
</tr>
<tr>
<td>Quartz arenite, v.f. sand, mod, sorted, subang., rare dolomite replacement of quartz grains, trace feldspar and rock fragments, trace pyrite, trace authigenic clay dolomite cement.</td>
</tr>
<tr>
<td>Quartz arenite, v.f. sand, mod, sorted, subang., trace chlorite, trace feldspar, dolomite cement, clay 3%.</td>
</tr>
<tr>
<td>Quartz arenite, coarse silts, mod to poorly sorted, subang, dolomite cement, clay 20-30%.</td>
</tr>
<tr>
<td>Dolomite mudstone, trace peloids, trace anhydrite, rare patches of dolospar.</td>
</tr>
<tr>
<td>Quartz arenite, v.f. sand, mod. sorted, subang., trace feldspar, dolomite matrix, clay 15%.</td>
</tr>
<tr>
<td>Dolomite packstone, common peloids with dark micrite rims, trace calcispheres and endothyrids, common quartz silt.</td>
</tr>
</tbody>
</table>
Quartz arenite, v.f. sand, mod. sorted, subang., clay 5% up to 15%, rare patches of dolospar, trace feldspar.

Quartz arenite, v.f. sand, mod. sorted, subang., laminae of sand and micrite, clay 10%, trace feldspar and rock fragments, rare authigenic clay, dolomite cement.

Similar to 3499.

Quartz arenite, coarse silt to v.f. sand, poorly sorted, subang., common wisps of clay, clay to 20%, trace feldspar, dolomite cement.

Quartz arenite, v.f. sand, mod. sorted, subang., dolomite cement, trace feldspar and rock fragments.

Quartz arenite, v.f. sand, mod. sorted, subang., dolomite matrix, rare replacement of quartz by dolomite, rare clay wisps.

Dolomite mudstone, trace fossil ghosts, rare patches of dolospar, trace quartz.

Dolomite mudstone, generally v.f. crystalline, rare patches of f. crystalline dolospar, rare quartz sand.

Dolomite packstone, abundant pellets, trace calcspheres, common fossil ghosts, trace quartz silt.

Quartz arenite, v.f. sand, mod. sorted, subang., dolomite matrix, common leached grains replaced by dolomite, trace clay.

Quartz arenite, v.f. sand, mod. sorted, subang., authigenic clay to 5%, trace feldspar and rock fragments, intergranular porosity 5%, dolomite cement.
3519A Dolomite dismicrite, abundant coarse dolospar with micrite rims, common peloids and fossil ghosts, rare pyrite, micrite rims commonly have "marching men" relics, trace anhydrite.

3519B Dolomite mudstone, f. crystalline dolospar, trace quartz and fossil ghosts.

3521 Dolomite packstone/wackestone, common peloids, f. crystalline dolomite.

3523 Quartz arenite, v.f. sand, mod. sorted, subrounded, rare clay, some bent indicating slight compaction, trace feldspar, dolomite cement.

3526 Quartz arenite, v.f. sand, poorly sorted, subang., laminated by quartz concentration, dolomite matrix and cement, clay 2-3%.

3529 Dolomite packstone/wackestone, common peloids, trace calcispheres, common patches of dolospar, rare clotted micrite.

3530 Dolomite mudstone, common bladed masses of gysum/anhydrite, rare patches of dolospar and clotted micrite.

3533 Dolomite mudstone, finely crystalline, trace quartz sand.

3534 Dolomite mudstone rare quartz silt.

3535 Quartz arenite, v.f. sand, mod. sorted, subang., clay 2-3%, trace feldspar and rock fragments, dolomite cement.

3536 Dolomite wackestone, common peloids, rare possible oöoids, rare patches of dolospar, rare sugary dolomite obliterates some allochems.

3540A Quartz arenite, v.f. sand, mod. sorted, subang., traces oil in intergranular porosity, trace grain replaced in part by authigenic clay, dolomite cement.
3540B  Dolomite grainstone, abundant pellets, ooids, rare coated grapestone grains, rare patches of dolospar, trace anhydrite gypsum.

3541  Dolomite wackestone, common coated grapestone grains, trace patches of dolospar.

3543  Dolomite mudstone, trace fossil ghosts, trace quartz silt.

3545  Dolomite wackestone, common algal fragments and peloids, trace grapestone, trace quartz silt.

3546  Quartz arenite, coarse silt, mod. sorted, subang., dolomite matrix, clay 1-2%.

3548A  Dolomite mudstone, rare patches of dolospar, clay 1-2%.

3548B  Dolomite mudstone, very slightly siltly, trace clay.

3550  Quartz arenite, v.f. sand, mod. sorted, subang., clay 5-20%, laminated with clay, dolomite cement.

3555  Quartz arenite, v.f. sand, mod. sorted, subang., trace quartz overgrowths, trace authigenic clay, trace feldspar and rock fragments, trace patches of pikiotopic dolomite cement, dolomite cement.

3556  Dolomite mudstone, laminated with coarse silt.

3558  Dolomite mudstone, laminated with clayeg coarse silt.

2560  Dolomite mudstone, rare patches of medium dolospar, rare silt and clay, trace clotted micrite.

3562  Quartz arenite, v.f. sand, poorly sorted, subang., trace feldspar, trace replacement by dolomite trace clay.
Quartz arenite, v.f. sand, mod. sorted, subang., trace authigenic clay, trace piokilotopic dolomite cement, dolomite cement.

Dolomite mudstone, rare algal laminae, rare patches of medium dolospar.

Dolomite mudstone, trace fossil ghosts, rare quartz silt.

Dolomite mudstone/wackestone, common peloids and fossil ghosts, v.f. to f. crystalline matrix.

Quartz arenite, v.f. sand, poorly sorted, subang., trace rock fragments and feldspar, in part clay rich to 15%, rare layers of dolomicrite, dolomite cement.

Quartz arenite, v.f. sand, mod. sorted, subang., trace porosity, rare authigenic clay.

Dolomite packstone/grainstone, abundant peloids, trace fossil ghosts, rare patches of dolospar.

Quartz arenite, v.f. sand, mod. sorted, subang., clay to 20%, rare replacement by dolomite, trace feldspar, rare authigenic clay, dolomite cement.

Dolomite packstone, abundant peloids, possible oncolites, rare patches of dolospar slightly sandy/silty.

Quartz arenite, v.f. sand, mod. sorted, subang., trace enhedral quartz overgrowths, dolomite cement.

Quartz arenite, v.f. sand, mod. sorted, subang., trace chlorite, and feldspar, clay 1-2%, dolomite cement.
Quartz arenite, v.f. sand, mod. sorted, subang., in part
dolomicrite matrix, trace of peloids and clasts of patches of
dolospars and micrite mud 1-2%.

Quartz arenite, v.f. sand, mod. sorted, subrounded, common algal
balls, trace quartz overgrowths, trace ferroan dolomite, trace
pyrite, trace authigenic clay, trace feldspar and rock
fragments, dolomite cement.

Dolomite wackestone, rare calcispheres and fossil ghosts, rare
patches of medium dolospars, slightly sandy.

Dolomite wackestone, rare peloids, grapestone and possible
oncolites, common patches of medium dolospars, trace quartz
sand.

Dolomite dismicritic common patches of dolospars with trace of
anhydrite, common fossil ghosts, trace calcispheres and
possible ooliths.

Dolomite packstone/wackestone common peloids, common large
patches of medium dolospars, rare fossil ghosts, slightly silty.

Dolomite packstone, common peloids, trace patches of dolospars,
trace quartz silt.

Dolomite mudstone, sugary texture, sandy, rare enehedral
overgrowths.

Quartz arenite, v.f. sand, poorly sorted, subang., trace
feldspar and rock fragments, dolomite matrix, common patches of
medium dolospars, trace endothyrids.

Dolomite wackestone, rare algal balls, peloids and intraclasts,
slightly sandy.
Dolomite wackestone, common peloids, rare mollusc fragments, slightly silty, rare patches of medium dolospar some with ferroan dolomite trace of bladed anhydrite.

Quartz arenite, v.f. sand, mod. to poorly sorted, subang., trace feldspar, trace authigenic clay, depositional clay 10-15%, trace ferroan dolomite cement, dolomite cement.

Quartz arenite, v.f. sand, poorly to mod. sorted, subang., trace feldspar, dolomite matrix, laminated by sand concentration, trace peloids, trace clay.

Quartz arenite, v.f. sand, mod. sorted, subang., dolomite matrix, trace feldspar, trace clay, rare patches of dolospar with trace pyrite.

Dolomite wackestone/packstone, common peloids, mud flakes, rare endothyrids, algal fragments, rare patches of dolospar with trace gypsum.

Dolomite mudstone, sugary, trace endothyrids, rare patches of medium dolospar.

Dolomite mudstone, laminated by dolomite grain size.
<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3478.5</td>
<td>Quartz arenite, v.f. sand, mod. sorted, subang., anhydrite cement partially replaces some grains, trace feldspar and rock fragments.</td>
</tr>
<tr>
<td>3480</td>
<td>Dolomite mudstone, rare blocky anhydrite crystals, trace silt, sugary texture.</td>
</tr>
<tr>
<td>3483</td>
<td>Quartz arenite, v.f. sand, mod., sorted, subang., common intergranular oil, trace anhydrite cement, trace feldspar trace authigenic clay dolomite cement.</td>
</tr>
<tr>
<td>3485.5</td>
<td>Dolomite mudstone, common blocky anhydrite, rare quartz silt, rare fossil ghosts sugary texture.</td>
</tr>
<tr>
<td>3487.5</td>
<td>Dolomite mudstone, abundant replacement anhydrite, common replacement of mollusc fragments and other fossils, sparse fossil ghosts.</td>
</tr>
<tr>
<td>3489.9</td>
<td>Quartz arenite with anhydrite module, v.f. sand, mod. sorted, subang., common anhydrite cement and authigenic clay, trace feldspar.</td>
</tr>
<tr>
<td>3491</td>
<td>Anhydritic sandy mudstone, abundant replacement anhydrite, common v.f. sand.</td>
</tr>
<tr>
<td>3492</td>
<td>Dolomite wackestone/packstone, common calcispheres, and peloids, common blocky anhydrite, sugary texture.</td>
</tr>
</tbody>
</table>
3494  Dolomite mudstone/wackestone, common calcispheres, some crushed, common fossil ghosts, rare peloids, trace patches of medium dolospar.

3496  Dolomite wackestone, common encrusting algae, rare blocky anhydrite, trace patches of dolospar.

3504.9 Dolomite wackestone and laminted nodular anhydrite, common algal fragments and endothyrids, rare blocky anhydrite.

3508  Laminated dolomite mudstone/wackestone, common blocky anhydrite, common fossil ghosts and peloids laminated with mudstone with sugary texture and kerogen wisps.

3524.5 Quartz arenite, v.f. sand, mod. sorted, subang., rare clay, rare anhydrite cement, trace feldspar and rock fragments, dolomite cement, rare dolomite matrix.

3517  Laminated quartz arenite and peloid packstone, common blocky anhydrite, v.f. sand, mod. sorted, subang., rare clay; abundant peloids, rare calcispheres.

3529  Dolomite mudstone, rare blocky anhydrite, rare silt and clay in layers.

3533.9 Quartz arenite, v.f. sand, mod. sorted, subang., rare clay, trace feldspar and rock fragments, dolomite cement.

3535.5 Dolomite mudstone/wackestone, common encrusting forams or possible algae, rare endothyrids.

3536.5 Dolomite wackestone/mudstone, rare large patches of gypsum/anhydrite, common small patches of dolospar, common calcispheres, peloids, rare endothyrids and algae.

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3541  Dolomite mudstone, abundant spherical patches of sugary dolomite, trace silt.

3544  Dolomite wackestone/mudstone, common endothyrids, calcispheres, peloids and algae fragments trace silt.

3548  Quartz arenite, v.f. sand, mod. sorted, subang., trace feldspar, common terrigenous clay, rare authigenic clay, dolomite cement.

3551.9 Dolomite mudstone/wackestone, laminated surgery mudstone and wackestone with common endothyrids, peloids and algae, trace blocky anhydrite.

3552.5 Dolomite mudstone, abundant avoid patches of sugary texture, common berothen wisps.

3555  Dolomite mudstone, trace silt, trace blocky anhydrite, rare small patches of dolospár.

3556  Dolomite mudstone/wackestone, rare peloids and silt.

3558  Dolomite mudstone, rare silt, trace ghosts.

3563  Dolomite wackestone/packstone, common endothyrids calcispheres, algal fragments, peloids, rare patches of dolospár, rare microstylolites.

3566  Same as 3563.

3568.5 Dolomite mudstone, common angular masses of blocky anhydrite, stylolitic.

3571  Dolomite mudstone, trace silt, algal fragments.

3575  Dolomite mudstone, common blocky anhydrite, rare encrusting forams or possible algae
Dolomite packstone, abundant coated grains, peloids, possible pisoids, rare patches dolospar, microstylolitic.

Dolomite mudstone, abundant blocky anhydrite, sugary texture.

Dolomite packstone, common peloids, calcispheres, abundant kerogen laminated with allochems trace silt and replacement anhydrite.

Dolomite wackestone/packstone, common calcispheres, peloids, and endothyrids, rare possible algal fragments, trace phylloid alge.

Dolomite mudstone, rare calcispheres, peloids, algae.

Dolomite packstone, common to abundant peloids, rare sand, rare patches dolospar, rare beroegen wisps.

Quartz arenite, v.f. sand, mod. sorted, subang., trace feldspar and rock fragments, common authigenic and terrigenous clay, dolomite cement.

Laminated quartz arenite and sandy mudstone, v.f. sand, mod. sorted, subang., dolomite cement.

Dolomite mudstone, sugary texture, rare silt.

Sandy dolomite packstone/wackestone abundant sand and silt, abundant peloids with concentric laminae, not pisoids, common peloids, are aggregate grains.

Dolomite wackestone, common algal wispies.

Quartz arenite, v.f. sand, mod. to well sorted, subang., trace feldspar, common authigenic clay, rare dolomite cement, porosity 1-2%.
Quartz arenite, v.f. sand, mod. sorted, subang., porosity low to 20% in part, dolomite cement, rare corrosion or replacement of some grains.

Dismicritic wackestone, abundant patches of dolospar with micrite rims, common coated grains, micritization.

Dolomite mudstone, abundant patches of dolospar, common elongate and circular molds, possible burrows/root tubules, rare fossil ghosts.

Dolomite mudstone, trace silt, rare fossil ghosts, peloids, sugary texture.

Same as 3637.9.

Dolomite mudstone, silty, trace clay trace patches of dolospar.

Dolomite mudstone, rare fossil ghosts, possible algae.

Quartz arenite in dolomite matrix, v.f. sand and coarse silt, mod. to poorly sorted, subang., common terrigenous clay, trace feldspar, laminated by grain size.
# Thin Section Description for

**Myers-Langlie-Mattix Core No. 243**

<table>
<thead>
<tr>
<th>Depth</th>
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</tr>
</thead>
<tbody>
<tr>
<td>3476</td>
<td>Quartz arenite, v.f. sand, mod. sorted, subang., trace feldspar, trace of enahedral quartz overgrowth, porosity 20%, dolomite cement.</td>
</tr>
<tr>
<td>3477</td>
<td>Dolomite packstone, common peloids, rare calcispheres and mollusc fragments, common patches of medium dolospar, slightly sandy, trace clay.</td>
</tr>
<tr>
<td>3478</td>
<td>Dolomite mudstone, rare fossil ghosts, trace calcispheres, slightly silty, trace clay, numerous stylolites.</td>
</tr>
<tr>
<td>3482</td>
<td>Dolomite wackestone, rare calcispheres, endothyrids, and pellets, rare patches of medium dolospar with traces of gyspum, traces intercrystalline oil, trace quartz silt.</td>
</tr>
<tr>
<td>3485</td>
<td>Dolomite packstone, common peloids and calcispheres, trace gyspum, trace pyrite.</td>
</tr>
<tr>
<td>3486</td>
<td>Dolomite mudstone, trace of calcispheres, ostracodes, mollusc fragments, very slightly sandy, trace pyrite.</td>
</tr>
<tr>
<td>3489</td>
<td>Dolomite wackestone, common peloids, rare algae, very slightly sandy.</td>
</tr>
<tr>
<td>3492</td>
<td>Dolomite wackestone/mudstone, common pellets and algal fragments, trace grapestone grains, trace quartz sand.</td>
</tr>
</tbody>
</table>
Quartz arenite, coarse silt to very fine sand, poorly sorted, subang., laminae of silty mudstone and sandstone, trace feldspar and rock fragments, clay 5-20% up to 15%, rare pyrite.

Dolomite wackestone, common algal fragments, rare to trace calcispheres, rare patches of medium dolospars, sandy, clay 3-5%, rare pyrite blades.

Dolomite wackestone/mudstone, rare calcispheres, algal fragments, encrusting forams, trace quartz sand, trace large algal fragments.

Dolomite packstone, common peloids and calcispheres, trace endothyrids, rare patches of medium dolospars with trace gypsum, relict finely bladed crust in leached grain.

Dolomite wackestone, common calcispheres, rare algal fragments and endothyrids, traces of fibrous crust and possible oncolites, trace quartz silt.

Quartz arenite, v.f. sand, poorly sorted, subang., trace feldspar, clay wispies 15-20%, laminated by clay content, dolomite cement.

Quartz arenite, v.f. sand, mod. sorted, subang., trace of oil in intergranular porosity, rare poikilotopic dolomite cement, trace feldspar and rock fragments, traces ferroan dolomite, dolomite cement.

Quartz arenite, v.f. sand, mod. sorted, subang., rare oil shows, clay 5%, trace feldspar and rock fragments.
Dolomite packstone, common pellets and calcispheres, rare encrusting forams, trace endothyrids, rare patches of coarse dolospar and ferroan dolospar and pyrite, trace quartz silt.

Dolomite wackestone/mudstone, slightly sandy common to rare intraclasts of mudstone, rare patches of dolospar.

Dolomite mudstone, rare calcispheres, trace endothyrids and algae, rare patches of dolospar.

Dolomite packstone/wackestone, common to rare algal fragments, rare calcispheres, rare patches of coarse dolospar crosscutting some allochems, trace gypsum and pyrite.

Quartz arenite, coarse silt, mod. sorted, subang., shaley irregular laminae, trace feldspar.

Quartz arenite, v.f. sand, modl. sorted, subang., clay 5-7%, bands of micrite, rare ferroan dolomite, trace opaque organic matter, trace feldspar and rock fragments.

Dolomite mudstone, rare algal fragments, trace calcispheres and endothyrids, trace quartz silt.

Quartz arenite, v.f. sand, mod. sorted, subang., trace feldspar and rock fragments, trace anhydrite cement, clay 5-20%, dolomite cement.

Dolomite packstone, common peloids and algal fragments, rare patches of fine dolospar with micrite rims.
3538A Dolomite wackestone/packstone, laminated by micrite content, common calcispheres, micrite ghosts, rare ostracodes endothyrids and encrusting forams, rare patches of fine dolospar.

3538B Quartz arenite, v.f. sand, mod. sorted, subang., clay 20%, trace pyrite, trace feldspar and rock fragments.

3542 Dolomite mudstone, rare endothyrids and algal fragments, trace patches of very coarse dolospar with gypsum, trace quartz silt.

3545 Dolomite packstone, algal mat laminae of common calcispheres, endothyrids and other forams, abundant algal fragments, common patches of medium dolospar, trace gypsum and quartz silt.

3551 Dolomite mudstone, trace calcispheres, microst?olitic.

3553 Quartz arenite, v.f. sand, mod. sorted, subang., rare sericitized feldspar grains, common ferroan dolomite, rare corroded quartz grains, rare pyrite and organic matter clay 10-15%, trace feldspar and rock fragments, dolomite cement.

3557 Sandy dolomite mudstone, clay 5-10%, trace pellets.

3559 Dolomite packstone/wackestone, common algal fragments and peloids, trace calcispheres, rare patches of coarse dolospar, slightly sandy.

3566 Quartz arenite, v.f. to fine sand, poorly sorted, subang., rare leached grains with ferroan dolomite, clay 10-15%, trace feldspar and rock fragments, dolomite cement.
Quartz arenite, v.f. sand to coarse silt, poorly sorted, subang., clay 15-30%, trace feldspar, dolomite cement.

Quartz arenite, coarse silt, poorly sorted, subang., trace sericitized feldspar grains, in part micrite matrix supported, clay 10-15%, trace feldspar and rock fragments, dolomite cement.

Quartz arenite, coarse silt, mod. sorted, subang., clay 20%, trace ferroan dolomite, dolomite cement.

Quartz arenite, coarse silt, mod. to poorly sorted, subang., clay 15-20% abundant authigenic clay, dolomite cement.

Quartz arenite, coarse silt to v.f. sand, mod. to poorly sorted, subang., traces oil, common ferroan dolomite, traces ferroan dolomite, dolomite cement.

Quartz arenite, v.f. sand, poorly sorted, subang., common fusulinids and peloids, trace feldspar and rock fragments.

Sandy dolomite wackestone, common peloids, algal fragments, fusulinids, rare encrusting forams, trace endothyrids, and grapestone grains and mollusc fragments, clay 5%.

Quartz arenite, v.f. sand, mod. sorted, subang., trace oil, clay 5-10%, trace feldspar and rock fragments, dolomite cement.

Dolomite wackestone, rare peloids and algal fragments, sandy, clay 5%, common patches of coarse ferroan dolospar.

Dolomite packstone, common peloids, agal fragments, trace endothyrids and ostracodes.

Dolomite mudstone, rare organic matter, sparse pyrite.
Quartz arenite and shale interfingered, v.f. sand, mod. sorted, subang., trace feldspar, dolomite cement.

Quartz arenite, v.f. sand, mod. sorted, subang., trace oil and ferroan dolomite, trace leached sericitized grains, clay 15%, trace feldspar and rock fragments, trace authigenic clay.

Dolomite wackestone, rare algal fragments, trace calcisphere, rare berojen, trace quartz silt.

Dolomite mudstone, sandy, rare fossil ghosts, sand and clay rich burrows.

Quartz arenite, v.f. sand, mod. sorted, subang., rare patches of mudstone, abundant clay (30%), trace feldspar and rock fragments.

Dolomite mudstone/wackestone, rare algal fragments, sandy, stylolitic.

Dolomite mudstone, sandy, clay 5%, sparse replacement of quartz sand by dolomite.

Dolomite mudstone, slightly sandy, trace oil and ferroan dolomite and anhydrite, trace pyrite.
APPENDIX B

Description of cores used in the study. Explanation of standard symbols used follows. Core descriptions are in back pocket. Core descriptions were drafted in part by Getty Oil Co. and in part by the author. All descriptive work was conducted by the author.
Lithic Types

- Shaie mudstone
- Sandstone
- Dolomite
- Anhydrite or gypsum

Lithic Modifiers

- Fractured
- Dolomitic
- Sandy or silty
- Anhydritic or gypsiferous
- Shaley
- Argillaceous
- Stylolitic

Sedimentary Structure Symbols

- Horizontal laminations
- Inclined laminations
- Flaser and wavy bedding
- Whispy partings
- Convolute bedding
- Burrow
- Structureless
- Nodules (mineralogy to accompany in description
- Breccia

135
\[\text{Authigenic minerals}\]
\[\text{Algal mat}\]
\[\text{Lenticular layers}\]

<table>
<thead>
<tr>
<th>Cement</th>
<th>Samples</th>
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<td>Dolomite</td>
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<td>A</td>
<td>Anhydrite</td>
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**Fossil Symbols**

- \(\hat{\text{H}}\): Undifferentiated algae (calcspheres)
- \(\hat{\text{F}}\): Foraminifera (endothyrid)
- \(\otimes\): Fusulinid
- \(\otimes\): Fossil molds
- \(\text{•}\): Peloid
- \(\text{•}\): Aggregate grain
- \(\otimes\): Ostracode
- \(\otimes\): Mollusk

**Grain Type Symbols**

- \(\otimes\): Ovalites
- \(\otimes\): Pisolites
- \(\otimes\): Oncolites
- \(\text{•}\): Intraclasts
- \(\text{•}\): Pyrite

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Myers-Langlie-Mattix Unit No. 41
Getty Oil Co.  
Langlie Mattix Field  
Lea County  
New Mexico  
3585'-3705' cored interval

<table>
<thead>
<tr>
<th>DEPTH</th>
<th>GRG. ANH</th>
<th>OIL DIPES</th>
<th>% ON EXIT</th>
<th>LITHOLOGY</th>
<th>CORE</th>
<th>QUILF</th>
<th>SEDIMENTARY STRUCTURE</th>
<th>CRYSTAL SIZE</th>
<th>GRAIN SIZE</th>
<th>SORTING</th>
<th>MAJORITY</th>
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**DESCRIPTION OF SAMPLES**

- **3585-3592**: Medium greenish gray to light olive gray to dark yellowish brown, silty to very fine grained dolomitic quartz arenite. Bioturbated with anhydrite/dolomite cement, varying in color from gray to black, giving a mottled appearance as shown. Organic wacks as shown in lower part.

- **3592-3485**: Pale yellowish brown mudstone with numerous clay-rich stylolites and partings.

- **3594.5-3601**: Olive gray to greenish black, very fine grained quartz arenite, patches of gypsum cement as shown, and traces of oolites.

- **3601-3606**: Light brownish to dark yellowish brown, dolomitic mudstone with numerous mud-filled stylolites and partings, some oolites, a trace of miliolids, pellets and some ooliths as shown.
| Depth | Porosity | Lithology | Fossils | Grain Size | Cement | Maturity | Description of
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<td>3605</td>
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<td>3606-14 - Light brownish gray to light olive gray dolomitic pellet wackestone/mudstone, with calcispheres, miliolids and minor intraclasts, as shown.</td>
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<td>3610</td>
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<td>3612 - Nodding due to laminae of pellet ghosts and carbonate mud.</td>
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<td>3615</td>
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<td>3614-21.5 - Variegated dark greenish gray to moderate yellowish brown to black dolomitic quartz arenite. Variegation due to presence of petroleum. Some calcispheres.</td>
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<td>3620</td>
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<td>3621.5-25 - Light brownish gray to light olive gray, generally massive, dolomitized pellet calcispheres packstone, numerous miliolids, trace of bivalve fragments, as shown.</td>
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<td>3625</td>
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<td>3625-33 (Identical to 3614-21.5).</td>
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<td>3630</td>
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<td>3635-35 - Light brownish gray to light medium bluish gray mudstone/wackestone, abundant encrusting forams, some calcispheres.</td>
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<td>3665</td>
<td>Minor dolomite pseudomorphs after gypsum intraclasts.</td>
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<td>3670</td>
<td>Packstone with possible algal rip-up with dissolution fabric.</td>
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<td>3675</td>
<td>Calcite replacing gypsum.</td>
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<tr>
<td>3675-81</td>
<td>Light-medium gray dolomitic quartz arenite with medium sand sized clasts of dolomitized lime mud.</td>
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<td>3680</td>
<td>Light gray to medium gray dolomitized packstone and wackestone with calcispheres and mollusks, as shown.</td>
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<td>3681-95</td>
<td>Solution fabric within packstone, minor occurrence of gypsum.</td>
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<tr>
<td>3685</td>
<td>Algal laminae and pellets.</td>
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<td>3690</td>
<td>Wackestone.</td>
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<td>3695</td>
<td>Algal laminae in sandy wackestone.</td>
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### Myers-Langlie-Mattix Unit No. 82

**Lea County**

**New Mexico**

**Langlie Mattix Field**

**3340'-3525' cored interval**

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<th>DEPTH</th>
<th>OIL SHOWS</th>
<th>POROSITY</th>
<th>LITHOLOGY</th>
<th>COLOR</th>
<th>FOSSILS</th>
<th>GRAIN TYPES</th>
<th>CRYSTAL SIZE</th>
<th>SEDIMENTARY STRUCTURE</th>
<th>GRANULARITY</th>
<th>CEMENTING AGENT</th>
<th>CEMENT MATURE</th>
<th>ROUGHNESS</th>
<th>SAMPLES</th>
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**DESCRIPTION OF SAMPLES**

- **T3340-3342:** Moderate in dusky blue, nodular mosaic anhydrite in matrix of predominantly medium gray and grayish brown dolomitic sand. Bedded nodular at base. Sharp underlying contact.

- **T3342-3344:** Graphitic pale yellowish brown dolomite with partial reddish brown of blocky anhydrite. Massive dolomite. Numerous septarie and nodules in stringers as shown. Capped by thin layer of moderately laminated pale yellowish gray dolomite and grayish brown to light olive gray mudstone to poorly laminated sand with small thin ripple at bottom as shown. Blocky anhydrite at base associated with ventifacts of anhydrite. Generally mudstone.

- **T3345:** Peloid packstone.

- **T3346-3349.5:** Graphitic orange pink and medium bluish gray laminated dolomite. Small 1.5 cm of blocky crystals of anhydrite occur along laminae. Variegated olive green and light brown sand at top, wavy bedding. Blocky anhydrite and ventifacts at base.

- **T3349.5:** Wackestone/laminite.

- **T3350-3352:** Laminated dolomite. Bladed and dolomite, cut and banded as shown.

- **T3352.5:** Siltstone and dolomite, at top banded as shown.

- **T3355:** Sandy mudstone.

- **T3355:** Mudstone.

- **T3355.5:** Laminated anhydrite.

- **T3356-3357:** Light olive gray and dark medium brown gray massive to laminated dolomite, as shown.

- **T3357:** Diagnostic settling of dolomite, small anhydrite crystals with reaction rims.

- **T3358:** Large anhydrite crystals (1-2 cm) associated with vertical vesicles.

- **T3359:** Light olive gray dolomite, slightly laminated, sparse blocky anhydrite and ventifacts.

- **T3358-3359:** Mudstone/mudstone.
<table>
<thead>
<tr>
<th>Depth</th>
<th>Data</th>
<th>Rock Type</th>
<th>Porosity</th>
<th>Lithology</th>
<th>Fossils</th>
<th>Grain Types</th>
<th>Sedimentary Structure</th>
<th>Crystal Size</th>
<th>Sorting</th>
<th>Cement</th>
<th>Maturity</th>
<th>Roundness</th>
<th>Samples</th>
<th>Description of</th>
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<td>3425</td>
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<td>3425-24 Huttons/Adelolome</td>
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<td>Gradational underlying contact.</td>
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<tr>
<td>2785-2795</td>
<td>Medium yellowish-brown and medium gray limestone, moderately bedded. Some soft sediment deformation as shown. Signs of gray sand in olive gray sand.</td>
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<td>3440.5-3440</td>
<td>Dark gray, generally well bedded siltstone, sparse bit sediment deformation features, distortion as shown.</td>
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<tr>
<td>3420-3430.5</td>
<td>Medium light gray to medium gray, generally well bedded sandy siltstone, slightly bioturbated as shown. Sparse clay matrix.</td>
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<tr>
<td>3430</td>
<td></td>
<td>Dark yellowish-brown bioturbated sand.</td>
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<tr>
<td>3430-343.5</td>
<td>Medium gray to light olive-gray, massive except for sparse black mottling as shown. Stylop 3430.5 with granular crystals. Some shale parting. Sharp underlying contact.</td>
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<tr>
<td>3430-343.5</td>
<td>Predominantly medium gray to light gray siltstone and siltstone. Sparse light olive-gray and medium olive-gray sandstone. No bioturbation as shown.</td>
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<td>3440-3445</td>
<td>Medium gray to light gray dolomite, poorly laminated, stylolitic and with sparse black mottling.</td>
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<td>3445.5-3450</td>
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</tbody>
</table>
3509.5-36 Presumably medium bluish gray and medium gray sandstone and siltstone.

3503-3511 Gray sand interbeds with brown and dark gray clay shales.

3510.5-3518 Light olive gray sandstone with numerous slabs of blue gray shale with sparse volcanic inclusions.

3503.5 Medium olive gray friable sandstone.
### Myers-Langlie-Mattix Unit No. 94
#### Getty Oil Co.
Langlie Mattix Field
3530'-3686' cored interval

<table>
<thead>
<tr>
<th>Depth</th>
<th>Porosity</th>
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<th>Fossils</th>
<th>Grain Types</th>
<th>Sedimentary Structure</th>
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<td>3530-30.5 - Pinkish light brownish gray dolomitic mudstone with algal laminae.</td>
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<td>3530.5-35 - Light olive gray to greenish gray dolomitic quartz arenite.</td>
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<td>3535-36 - Pinkish, brownish gray wackestone. Some encrusting forams.</td>
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<td>3539-41 - Greenish gray to brownish black dolomitic quartz arenite with intracrystalline dolomitic and slump features as shown.</td>
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<td>3541-45 - Light brownish gray to light gray mudstone/wackestone.</td>
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<td>3545-46 - Light medium bluish gray dolomitic quartz arenite.</td>
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<td>3546-51 - Light brown to grayish orange pink dolomitic wackestone.</td>
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<td>3557-62</td>
<td>3557-62</td>
<td>Light brownish gray to olive gray dolomitic wackestone.</td>
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</table>

150
3590-3642 - Generally pinkish to brownish gray dolomitic mudstone/mackstone, packstone locally.

3596 - Local vuggy porosity, up to 12%.

3598-3600 - Algal and pelletal packstone.

3608 - Minor occurrence of gypsum.
0 3612 - Common granule/pebble size nodules of anhydrite, with minor gypsum in mudstone.

0 3614 - Ripped up algal mat.

0 3618 - Minor occurrence of plant material in algal wackestone.

0 3619 - Minor occurrence of displaceive sand sized anhydrite nodules in pellet packstone.

0 3622 - Calisphere pellet packstone with plant material.

0 3626 - Occurrence of displaceive anhydrite and gypsum nodules.

0 3630 - Minor occurrence of pellet packstone, trace of red algal.
<table>
<thead>
<tr>
<th>DEPTH</th>
<th>POROSITY</th>
<th>LITHOLOGY</th>
<th>GRAIN SIZE</th>
<th>SEDIMENTARY STRUCTURE</th>
<th>CRYSTAL SIZE</th>
<th>ORIGIN</th>
<th>CEMENT</th>
<th>MATURITY</th>
<th>ROUNDING</th>
<th>DESCRIPTION OF SAMPLES</th>
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<td>3674-77 - Light brownish grey dolomitic wackestone with crystal-lgal laminae, numerous calcispheres as shown.</td>
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<td>3679 - Trace of phosphatic material.</td>
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<td>3684 - Laminas of sand and carbonate mud, trace of phosphatic material.</td>
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<td>3689-86 - Light brownish gray dolomitic wackestone with forams and crystal-lgal structures.</td>
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</table>

154
3495-3500 - Greenish gray to light olive gray variegated quartz arenite. Nodules due to presence of oil associated with bioturbation.

3500-12 - Pinkish light-brownish gray to light gray dolomitic mudstone, locally slightly sandy, also slightly laminated and showing soft sediment deformation, weathering in part due to oil staining.
<table>
<thead>
<tr>
<th>Depth</th>
<th>Engel DATA</th>
<th>OIL SHALES</th>
<th>Porosity</th>
<th>LITMOURY</th>
<th>COLES</th>
<th>FOSSILS</th>
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<td>3512-35 - Medium bluish gray and medium olive gray quartz arenite, with soft sediment deformation and slump features, local small layers of silty dolomite.</td>
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<td>3520 - Sandy ooid-grapestone wackestone.</td>
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<td>3535-47 - Pale dark yellowish brown to yellowish light olive grey dolomitic mudstone/wackestone, with local packstone. Calci spheroids and miliolids as shown. Algal mat fragments and kerogen at 3536'.</td>
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<td>3539 - Algal pellet packstone with minor occurrence of gyspum.</td>
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<td>Grain Size</td>
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<td>8 3542 - Disturbed dolomitic sandy mudstone.</td>
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<td>5547-77 - Light olive gray to light medium bluish gray dolomitic quartz arenite, generally bioturbated; interbedded with pinkish light-brownish gray dolomitic wackestone/mudstone; in sand oil staining minor sedimentary structures, trace of coarse authigenic kaolinite, as shown.</td>
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<td>8 3552 - Intracalcs of sandy dolomericite in quartz arenite. 8 3553 - Calcispheres pellet packstone.</td>
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<td>8 3555 - Allochems in packstone interbedded with mudstone.</td>
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<td>8 3560 - Intraclastic wackestone.</td>
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<tr>
<td>3481-3482</td>
<td>Light gray and pinkish gray to light bluish gray dolomite.</td>
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<tr>
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<td>Number of carbonates in upper part with</td>
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<tr>
<td>3484-3485</td>
<td>Numeral carbonate calcite (0.2-2 cm)</td>
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<td>Light gray and bluish gray dolomite.</td>
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<tr>
<td>3488</td>
<td>Well laminated, with minor to medium sericite and</td>
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<tr>
<td>3489</td>
<td>Detritus of authigenic calcite.</td>
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<tr>
<td>3490-3491</td>
<td>Variegated dark brown and medium gray very fine quartzose</td>
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<td>3492-3493</td>
<td>Sandstone, with and less than a few percent of</td>
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<td>Variegated dark brown and medium gray very fine quartzose</td>
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<td>Variegated dark brown and medium gray very fine quartzose</td>
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<td>Variegated dark brown and medium gray very fine quartzose</td>
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<td>3500</td>
<td>Variegated dark brown and medium gray very fine quartzose</td>
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160
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<thead>
<tr>
<th>Depth</th>
<th>Description of Samples</th>
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<tbody>
<tr>
<td>3565</td>
<td>Light olive gray to light bluish gray argillaceous silt. Slightly inclined bedding.</td>
</tr>
<tr>
<td>70</td>
<td>Algal laminated wackestone. Trace of mottled porosity. Gradational underlying contact.</td>
</tr>
<tr>
<td>3575</td>
<td>Light gray to light olive gray argillaceous silt. Moderately bedded, in part mottled by oil as shown. Abundant dolomite cement. Sharp underlying contact.</td>
</tr>
<tr>
<td>80</td>
<td>Light olive gray to light gray argillaceous silt. Variegated in part by oil, wavy bedding. Moderate striation.</td>
</tr>
<tr>
<td>3585</td>
<td>Medium light gray and medium bluish gray sandy to silty argillaceous silt. Very well mottled. Interbedded algal skeletal packstone. Very fine grained argillaceous siltstone.</td>
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<tr>
<td>Depth</td>
<td>Description of Samples</td>
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<tr>
<td>3590-3590.5</td>
<td>Very light gray to light bluish gray, moderately laminated dolomite. Slightly sandy in part.</td>
</tr>
<tr>
<td>3590.5-3600.5</td>
<td>Medium light gray to olive gray (and some black) dolomitic quartz sandstone. Generally near massive, with some traces of horizontal bedding.</td>
</tr>
<tr>
<td>3590</td>
<td>Band of sandy dolomite with numerous mud-filled stylolites. Mottled in part as shown, by oil, displays contorted bedding.</td>
</tr>
<tr>
<td>3595</td>
<td>Small irregular blocks of dolomite in moderately bedded sand.</td>
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<tr>
<td>3600</td>
<td>Numerous interbeds in same matrix.</td>
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<tr>
<td>3600-3609.5</td>
<td>Very light gray to yellowish gray, generally massive, dolomite with numerous clay-filled stylolites and partings as shown.</td>
</tr>
<tr>
<td>3601-3605</td>
<td>Generally wackestones with dolomite fabric.</td>
</tr>
<tr>
<td>3605</td>
<td>Numerous coarse sand-sized blocks of anhydrite/gypsum.</td>
</tr>
<tr>
<td>3607</td>
<td>Pelvic packstone with traces of dolomitic fabric.</td>
</tr>
<tr>
<td>3609</td>
<td>Sandy mudstone. Gradual underlying contact.</td>
</tr>
<tr>
<td>3609-3610.5</td>
<td>Light gray to medium light gray, slightly sandy dolomite with numerous clay-filled partings, traces of horizontal bedding as shown. Generally algal peloidal packstone with dolomitic fabric in part.</td>
</tr>
<tr>
<td>3611</td>
<td>Narrow zone of very porous.</td>
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<tr>
<td>3614</td>
<td>Gravel size intragrit.</td>
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<tr>
<td>3614-3618.5</td>
<td>Brownish gray to light bluish gray, to olive black quartz sandstone, mottled in part by oil. Generally massive, traces of horizontal bedding.</td>
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<tr>
<td>3618-3622.5</td>
<td>Medium light gray to medium bluish gray dolomitic quartz sandstone, moderate to well-developed horizontal bedding, common clay stringers. Sharp underlying contact.</td>
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<td>DEPTH</td>
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3625-3627 Medium bluish gray to pinkish gray dolomite cut by numerous clay-rich partings with microstylolites. 3625 Lagenid dolomite wackestone with sparic diamictite fabric. 3627 Laminated mudstone.
# Myers-Langlie-Mattix Unit No. 166

**Getty Oil Co.**

Langlie Mattix Field

**Lea County**

New Mexico

**3478-3657 cored interval**

<table>
<thead>
<tr>
<th>DEPTH</th>
<th>EAVG. DATA OIL SHOWS</th>
<th>POROSITY</th>
<th>% OIL EXT.</th>
<th>LITHOLOGY</th>
<th>FOSSILS</th>
<th>GRAIN TYPES</th>
<th>SEDIMENTARY STRUCTURE</th>
<th>CRYSTAL SIZE</th>
<th>GRAIN SIZE</th>
<th>SORTING</th>
<th>CEMENT</th>
<th>MATURENESS</th>
<th>ROUNDERNESS</th>
<th>SAMPLES</th>
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</table>

- 3478-3479.5: Dark bluish gray sandstone, generally massive, sparse large nodules or cherts of chert, sharp underlying contact.
- 3479.5-3480.2: Massive dolostone with numerous nodules of chert, sharp underlying contact.
- 3480.2-3480.5: Dark bluish brown to greenish gray, and olive brown, moderately bedded sandstone and siltstone, wispy bedding, gradational underlying contact. 3480 mudstone.
- 3480-3485: Light gray to medium gray sandstone with abundant blocky dolomite, numerous horizontal fractures. Large dolomite nodules near base, gradational underlying contact. Generally mudstones.
- 3485-3490: Dark grayish olive green sandstone, generally well bedded, dolomite nodules as shown.
- 3491-3492: Light grayish to medium gray dolomite, generally massive. Abundant blocky dolomite, sparse dolomite nodules. 3492 dolomite mudstones.
<table>
<thead>
<tr>
<th>DEPTH</th>
<th>OIL SHOWS</th>
<th>POROSITY</th>
<th>LITHOLOGY</th>
<th>FOSILS</th>
<th>GRAIN TYPES</th>
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</table>

- 3560 Intracrustal authigenic/packstone.
- 3566-3570 Mudstone.
- 3568-3569 Irony authritic manto, 3570 Packstone with abundant carbon grains.
- 3570-3580 Light blue nodular to massive and massive anhydrite with calcite matrix.
- 3580-3581 Pink gray and mottled light gray dolomite. Abundant nodular anhydrite is shown. Sharp contact. Mudstone.


3596-3599 Light brownish gray to medium light gray dolomitic. Numerous clay cements in silty/sandy. Anhydrite bands as shown (blocky). Laminated biotactic-rich siltstone with burrows at base. Sharp underlying contact.

3599-3610.5 Very light gray to medium dark gray sandstone and siltstone. Generally moderately bedded. Silt clay. Sharp underlying contact.

3610.5-3615 Light gray and very light bluish gray dolomitic with numerous clay filled partings. Fractures as shown. Generally massive section as shown. At top convoluted laminae. Muscovite.
### Description of Samples

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>3620</td>
<td>Light gray and very light brownish gray sandstone and very sandy dolomite. Generally moderately bedded. Dark gray at base.</td>
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<tr>
<td>3630</td>
<td>Very light gray and medium bluish gray silted dolomite, moderately bedded. Blackstone.</td>
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<tr>
<td>3640</td>
<td>Light gray to light gray and medium greenish gray sandstone. Generally moderately bedded, well bedded as shown. Some slightly inclined bedding as shown. At base, dark greenish gray with wispy bedding.</td>
</tr>
<tr>
<td>3660</td>
<td>Light gray wackestone, lenticular grains common.</td>
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<tr>
<td>3670</td>
<td>Light gray mudstone, possible cement filled cavities/root voids.</td>
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<tr>
<td>3680</td>
<td>Frequently medium greenish gray to bluish gray moderately bedded sandstone.</td>
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<tr>
<td>3690</td>
<td>Sparse lenses of olive sandstone interfingered with bluish gray sandstone.</td>
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</tbody>
</table>
Myers-Langlie-Mattix Unit No. 243
 Getty Oil Co.                              Lea County
 Langlie Mattix Field                      New Mexico

3475'-3637' cored interval

<table>
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<tr>
<th>Depth</th>
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<th>Porosity</th>
<th>Lithology</th>
<th>Fossils</th>
<th>Grain Types</th>
<th>Sedimentary Structure</th>
<th>Crystal Size</th>
<th>Sorting</th>
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<td>3476-77 - Light olive gray quartz arenite.</td>
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<td>3477-93 - Pinkish light-brownish gray to medium light gray fine grained dolomitized mudstone/wackestone with local packstone, Abundant pellets and calcispheres, minor ostracodes, as shown.</td>
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<td>3477 - Sandy pellet packstone. 3481 - Minor occurrence of gypsum.</td>
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<td>3493-95 - Dark grey argillaceous quartz sandstone interstratified with thin layers of dolomite.</td>
</tr>
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<td>LITHOLOGY</td>
<td>COLOR</td>
<td>FOSSILS</td>
<td>GRAIN TYPES</td>
<td>SEDIMENTARY STRUCTURE</td>
<td>CRYSTAL SIZE</td>
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<td>LITHOLOGY</td>
<td>FOSSILS</td>
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<tr>
<td>3525.5-25 - Dark gray to dark greenish gray well laminated shaly quartz sand and dolomicrospar with some bioturbation.</td>
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</table>
3525-51.5 - Light brownish gray to pinkish light-brownish gray fine-grained dolomitic predominantly mudstone/wackestone, some packstone as shown; laminated in part with algal mats; interfingered with small layers of argillaceous, dark gray to brownish gray quartz arenite, sill as shown.

* 3529 - Minor occurrence of gypsum also traces of oncolites.

* 3530 - Algal pellet packstone.

* 3535 - Packstone/wackestone laminated with algal mat material.

* 3542 - Mudstone with minor gypsum.

* 3545 - Algal mat packstone, trace gypsum, abundant calcispheres encrusting forams and minor oysters.

3551.5-56.5 - Medium gray and moderate yellowish brown argillaceous quartz arenite with blebs of pyrite and organic wisps as shown.
<table>
<thead>
<tr>
<th>DEPTH</th>
<th>SHALE A</th>
<th>SHALE B</th>
<th>LIMESTONE</th>
<th>CLAY</th>
<th>Fossils</th>
<th>GRAIN TYPES</th>
<th>SEDIMENTARY STRUCTURE</th>
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<td>3556.3-74 - Pinkish light-brownish gray to medium gray poorly to moderately laminated dolomitized wackestone/packstone with local minor occurrences of anhydrite/gypsum in granule sized beds, as shown.</td>
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<td>3557-92 - Medium gray to brownish gray generally well laminated quartz arenite.</td>
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<td>0 3567, 84, 89 - Soft sediment deformation.</td>
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</table>
3592-3602.5 - Light gray, pinkish light brownish gray, mottled moderate yellowish brown to gray, quartz arenite grading into thin, more dolomitic units (dolomitized wackestone), fossils as shown.

3598 - Quartz filled vug.

3602.5-13 - Light brownish gray to medium brownish gray, fine grained, generally massive, dolomitized mudstone and pellet packstone.

3613-17 - Light olive gray to grayish black interbedded shale and dolomitic quartz arenite.
<table>
<thead>
<tr>
<th>DEPTH</th>
<th>ENH. DATA</th>
<th>PHOT.</th>
<th>% ON EST</th>
<th>FOSSILS</th>
<th>GRAIN</th>
<th>SEDIMENTARY</th>
<th>CRYSTAL</th>
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<td>0 3615 alump and soft sediment deformation features.</td>
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<td>3617-32.5 - Pinkish light-brownish light gray, to light olive gray generally massive, fine grained dolomitized algal mudstone/wackestone. In part slightly to very sandy and organic as shown.</td>
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<td>0 3619 - Algal mat with kerogen.</td>
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<td>0 3624 - Dolomite in clay rich quartz sand.</td>
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<td>0 3631 - Minor occurrence of gypsum and anhydrite.</td>
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</table>

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