UPPER PALEOZOIC DEPOSITIONAL AND DIAGENETIC FACIES IN A MATURE PETROLEUM PROVINCE (A FIELD GUIDE TO THE GUADALUPE AND SACRAMENTO MOUNTAINS)

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PART I

THE PERMIAN REEF COMPLEX OF THE GUADALUPE MOUNTAINS

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Introduction

Setting

The Permian Basin region (fig. 1) provides an excellent opportunity to study the interrelationships of depositional facies, diagenetic alteration patterns, oil generation and migration, and ultimately, petroleum potential and production. The entire depositional spectrum from far-back-reef to deep basin can be observed in the Guadalupe and Delaware Mountains with little or no structural deformation and very slight vegetation or soil cover. The reef complex of this region is also dissected by a series of deep canyons cut at right angles to the regional facies strike. These canyons provide cross-sectional views of the lateral and vertical relations of environments through time. Finally, the region is rather exceptional in that, at the end of Guadalupian time, the entire suite of facies was essentially preserved (pickled) by extremely rapid deposition of evaporites (anhydrite, halite, sylvite, and more exotic salts). These evaporites filled the Delaware Basin and even covered adjacent shelf areas. Thus, original facies relations were preserved from extensive erosional modification, and late Tertiary uplift, coupled with dissolution of the very soluble evaporites, has led to resurrection of original (Permian) topography (Plate 1, in pocket), greatly facilitating facies reconstruction.

In addition to the advantages provided by these outcrops, the Permian Basin has a wealth of subsurface data. More than 30,000 exploration wells and 150,000 development wells have been drilled in the Permian Basin region. All the outcrop facies of the Guadalupe, Delaware, and Glass Mountains are encountered in the subsurface Delaware Basin, Northwest Shelf, and Central Basin Platform as well as in the Midland Basin, and to a lesser degree, the Marfa Basin (fig. 1). Thus, the associations of oil and gas with specific depositional and diagenetic facies can be rather clearly established in this region.

Previous studies

A number of classic studies have been completed on the "Permian reef complex" of Texas and New Mexico which have established an excellent stratigraphic and sedimentologic framework for the region. Three early studies (King, 1948; Adams and Frenzel, 1950; Newell, and others, 1953), in particular, presented the overall outlines of our modern concept of reef-related depositional environments. Subsequent studies, including those of Babcock (1977), Dunham (1972), Esteban and Pray (1977), Harms (1974), Hayes (1964), Mazzullo and Cys (1977), Meissner (1969), Schmidt (1977), Tyrell (1969) and others, have fleshed in the details of many of the depositional environments and have contributed to our understanding of the diagenetic history of the region. In spite of this, however, few areas have more unresolved geological controversies than the Permian reef complex. Not a single one of the facies represented in the spectrum of basinal to far-back-reef settings has not evoked a variety of opinions as to its origin or significance. Thus, although the overall environmental framework of facies is generally agreed upon, much work remains to be done on specific interpretations.

Depositional and stratigraphic setting

The Permian reef complex is characterized by three sections of time equivalent but lithologically very dissimilar rocks. The first facies consists of thick masses of finely laminated siltstones and sandstones with thinner, interbedded black-gray limestone bodies. The second facies contains massive, light-gray limestones overlying steeply bedded, partially dolomitized, blocky limestone rubble. The third zone contains tan, fine-grained, medium-bedded dolomites with interbedded evaporites and red to brown sandstone and siltstone units.

As early as the late 1920's, it was recognized that this represented a basin-reef-back reef sequence of environments (Lloyd, 1929; Crandall, 1929; Blanchard and Davis, 1929). These conclusions were drawn largely on lithologic criteria. Subsequent work (eg. King, 1948; Newell and others, 1953; Babcock, 1977) on faunal, floral, sedimentologic, and stratigraphic aspects of these units has confirmed the initial conclusions. Never-the-less, considerable controversy exists over whether the Capitan Formation, the second facies mentioned above, represents a "true" or "ecologic" reef. The controversy is well summarized in Cys and others, 1977. Various workers have considered the Capitan to represent an unconsolidated shelf margin skeletal bank, or mound (Lang, 1937; Achauer, 1969), a true barrier reef (Newell and others, 1953), or an uninterupted slope facies (King, 1948). Others have felt that the abundance of inorganic, early submarine cement indicated that the wave-resistant nature of the Capitan "reef" was a result of primarily inorganic rather than organic processes making this a "cement reef" rather than an "organic or ecologic reef" (Schmid and Klement, 1971). Basically, the problem boils down to the recognition of in-situ, frame-building organisms in the Capitan Formation. If these can be recognized (in quantity), and we believe they can be, then the complex can reasonably be called a reef. The biological diversity of this environment (see table 1); the abundance of framework calcareous sponges, bryozoans, and hydrocorallines; the ubiquitous presence of encrusting organisms (*Tubiphytes, Archaeolithoporella, Girvanella,* and other groups); the remarkably high productivity of organisms (generating vast masses of reef and fore-reef skeletal debris); the presence of major volumes of inorganic, radial-fibrous, originally aragonitic cements; and the large-scale fragmentation and disruption of fabrics by wave and current activity are all features of the Permian reef complex which are highly analogous to modern reefs. Indeed, much of the semantic confusion over the reef nature of the Capitan Formation is largely a product of the "fair-weather" examination of modern reefs. On a clear, calm day when most geologists venture forth, the modern reef is a truly wave-resistant structure consisting of abundant, in-situ framework organisms. The day after a hurricane, however, much of this "wave-resistant framework" has been smashed into rubble which accumulates within the reef or is transported into deeper water settings. Indeed, quarries in Pleistocene or older reefs show only a small percentage of in-place framework organisms coupled with extensive encrustation and submarine cementation of reef debris.

Each of the major depositional facies of the Permian Basin will be examined during this field excursion and so the other, non-reef facies will not be extensively described here. The generalized facies patterns are shown in figure 2 and Table 1. The back reef area consists of skeletal sand banks, islands, lagoons, and sabkhas. From the farthest back-reef area to the reef these sediments include: nodular gypsum and anhydrite beds interlayered with red siltstones; tan, aphanocrystalline dolomitic mudstone beds with evaporite crystal casts; interbedded thin, laminated sandstone-siltstone units; pure, locally stromatolitic or calcisphere-rich, dolomitized carbonate mudstones; dolomitized pelletal mudstones; dolomitized pisolitic grainstones; partially dolomitized green algal-foraminiferal grainstones; and a very narrow zone of reef-derived, back-reef rubble.

The basinal areas contain turbidites and slumps of reef- and back-reef-derived carbonate material. Some of it accumulated as thin sheets of fine-grained debris which spread over much of the basin. The bulk of the carbonate debris accumulated near its sources along the margins of the basin (in a few cases reworked into submarine mounds or "lithoherms" by contour currents). The main volume of basinal sediment is finely laminated sandstone and siltstone also transported from the shelf to the basin by gravity-driven currents.

It must be kept in mind that, although the three rock packages mentioned above are lateral time-equivalents of each other and have approximately the same overall thickness, this equivalence does not necessarily extend to smaller scale units. Thus, laminated sandstones which are tens to hundreds of meters thick in the basin facies may have essentially no equivalents in the reef or back-reef sections. Likewise, reef and back-reef limestone and dolomite sequences which, again, may be tens to hundreds of meters thick, will commonly thin to less than a meter toward the basin center. So although large-scale overall age equivalence is present, we must also think in terms of non-synchronous or "reciprocal" sedimentation on smaller scales (Wilson, 1967; Meissner, 1972). This reciprocal sedimentation may be related to tectonic movements or eustatic fluctuations in sea level which shift the locus of active sedimentation or change the balance of influx of clastic terrigenous versus carbonate sediment.

The abrupt lateral facies changes in these Permian sediments are reflected in the complex stratigraphic terminology which has been applied to these units.

The detailed stratigraphic nomenclature of the Permian Basin will not be discussed here as the terminology of King (1948) and Newell and others (1953) will be followed with only minor modification. Stratigraphic nomenclature, correlations, and age designations for shelf, shelf edge, and basin units are shown in Table 2 and figure 3.

The Permian Basin region was subdivided during Guadalupian and earlier Permian time into a series of smaller basins and platforms (fig. 1). The orientation of these features was largely controlled by pre-Permian northwest-southeast oriented faulting of the Ancestral Rockies trend. These early lineaments, still visible in the Sierra Diablo Mountains, were modified by gentle, late Pennsylvanian and early Permian flexures. An even greater modification was produced by differential sedimentation. Original structural relief was significantly accentuated by higher rates of sedimentation of shallow water carbonate deposits on structural "highs" compared with lower rates on structural "lows". Thus, basins which were only a few tens of feet deep at the start of Permian time eventually had water depths in excess of 1,500 ft by the close of Guadalupian time.

The three major facies packages mentioned earlier--basin, reef, and back-reef--are strictly controlled by these structural sedimentologic features. Basinal facies cover the entire region of Delaware and Midland Basins. Reef facies are discontinuously distributed both in space and time but generally are confined to a very narrow belt bounding the platform areas. The back-reef province, in its broad sense, covers much of the platform areas.

The interrelationships between these facies are governed by a number of factors. Eustatic sealevel stands and(or) relative rates of subsidence versus sedimentation, as mentioned earlier, can lead to "reciprocal" sedimentation patterns. Ecological conditions, such as water temperature, salinity, turbidity, or other factors, can affect reef formation and, thus, overall facies patterns. Indeed, just within the Permian facies of the Guadalupe Mountains region, one can see remarkable variations in microfacies patterns. Bank margins of non-reefal bioclastic calcarenite are present in some intervals (Victorio Peak and Getaway units). Reefs which prograde largely horizontally out over reef talus are dominant at other times (upper Capitan unit). Yet other reefs which build up almost vertically in the section form the bank margin in the Goat Seep unit. Finally, terrigenous sand sheets cover the entire region from back-reef to basin at other times. So the discussion of facies patterns in the Permian Basin region must take into account these major variations in modifying factors. This excursion will focus primarily on the upper Capitan interval as this is the best exposed and most intensely studied part of the section. It must be kept in mind, however, that this is just one of a number of facies patterns which can be observed in the region.

The climatic setting of the Permian reef complex also had a major influence on both depositional and diagenetic processes. The region lay at the western margin of a broad alluvial plain to the east of the Appalachian area. The basin was presumably connected to a major western and southern ocean by narrow channels (fig. 1). The entire region lay within 10 degrees of the Permian equator and, as evidenced by the extensive back-reef evaporite deposits, clearly had a hot and very arid climate.

During Guadalupian and earlier Permian time water circulation in the Delaware Basin was apparently adequate to maintain normal marine salinity of the surface water along the bank margins. Waters penetrating deeper onto the banks were evaporatively concentrated to high salinities. Generation of heavy brines on the banks, which periodically flowed into the basin, may have contributed to euxinic, stratified water masses in the deeper parts of the Delaware and Midland Basins. Progressive restriction of the passageways between the Delaware Basin and the "open oceanic" areas to the south and west led to apparent salinity increases and extinction of reef growth in the region at the close of the Guadalupian. Continued aridity, coupled with restricted influx of marine waters led to the deposition of more than 2,000 ft of evaporite sediments in the Delaware Basin, completely filling the topographic depression left after Guadalupian time.

The extreme aridity of the region also had other influences. Transportation of clastic terrigenous debris was dominated by eolian processes. Equilibrium eolian deflation surfaces (sabkhas) are present in back-reef areas and dune migration may have been responsible for transport of a significant volume of sand to the shelf edge from where it could be moved into the basin, especially during low stands of sea level. Aridity also presumably prevented the formation of extensive karstification during sea level drops, allowed the development of widespread "coastal caliche", and led to the formation of hypersaline brines which may have contributed to the extensive dolomitization of back-reef carbonate sediments.

The question of relative sealevel changes, mentioned previously as part of the model of "reciprocal sedimentation", should also be examined further. Regional subsidence, local tectonic effects, eustatic sealevel stands, and epirogenic movements all can play a role in relative sealevel stands. Other factors, such as variations in sedimentation rate, also can yield apparent changes due to progradation or retrogression of shorelines. Numerous authors have pointed out that cyclic sedimentation of one sort or another is widespread in the Permian Basin in Pennsylvanian as well as Permian strata (eg. Meissner, 1969; Silver and Todd, 1969). Cyclic sedimentation operated at a number of scales involving fractions of an inch to hundreds of feet of sediment and were superimposed on an apparently long-term drop in sea level throughout the Late Permian. Known Late Pennsylvanian to Early Permian glaciation may have contributed to some of the cycles by creating periodic eustatic sea level changes. Although dating of these southern hemisphere glacial events is far from exact due to the provinciality and endemism of the floras and faunas present, glaciation is not considered to extend into the Late Permian and thus may not explain Guadalupian cycles and the global regression at the close of Guadalupian time. Epeirogenic events, late orogenic deformation in Appalachian and Hercynian regions, and variations in seafloor spreading may account for Late Permian cycles. Moreover, regional basin subsidence patterns may have been episodic and could also have contributed to the cyclicity of sedimentation.

Diagenetic Patterns

Generalized patterns of diagenesis in the Guadalupian section are outlined in figure 2 and table 1. The back reef area is characterized by the highest average porosities. These areas, which were the topographically highest facies in the complex, were frequently subjected to subaerial exposure and freshwater diagenesis. Evaporitic conditions in restricted lagoons and sabkhas led to the formation of evaporite minerals (gypsum and anhydrite). the withdrawal of these calcium sulphate minerals from the shelfal waters led to elevated Mg/Ca ratios and perhaps also to the formation of dolomitizing brines as in the modern Persian Gulf. Alternatively, but less probably, freshwater input and mixing with marine pore fluids may have led to dolomitization through "brine mixing" ("Dorag" dolomite). Thus, the back reef areas of the Permian reef complex are typified by calcareous grainstones and mudstones with a mixture of preserved primary porosity and secondary porosity related to such factors as early freshwater cementation and leaching, early dolomitization, or late (mesogenetic) dissolution of evaporite minerals.

The reef facies has very low average porosities. Small-scale permeability is very low but large-scale permeability is quite high as a result of fracturing. Porosity in this facies was completely obliterated by submarine cements probably within a few tens to hundreds of years after the time of reef deposition. These relatively coarse, radial, fibrous crusts of orginally aragonitic(?) cement formed within open pores in these Permian reefs just as in many modern reefs. Futher porosity destruction was accomplished by the infiltration of muddy, pelletal, internal sediment into remnant pores.

This type of cementation affected not just the reef-crest sediments but extended for several hundred feet down the fore-reef slope (a feature also seen in modern reefs). Thus, the upper fore-reef slope also has very low porosities. The lower half of the fore-reef talus facies has more complex diagenetic relations. Lesser amounts of submarine cementation are seen here. However, medium-crystalline, relatively late, very strongly fabric-selective dolomitization is present within this environment and has resulted in the replacement of about 1/2 of the original carbonate material in this facies. The source of dolomitizing fluids may be either from the overlying back-reef facies or from the hypersaline basin waters of Castile and Salado time. Such dolomitization has not led to significant secondary porosity in this facies, however.

The toe of the fore-reef slope is characterized by compaction and silicification. Calcitic fossil fragments, especially brachiopods, bryozoans, and echinoderms, were selectively and delicately silicified by chert, chalcedony, and megaquartz. In some cases, silicification extended to aragonitic fossils or formed non-selective chert nodules which cross-cut primary fabric elements. The source of silica most likely is from siliceous sponges and radiolarians which lived in lower slope and (or) basinal settings.

The basin facies is typified by calcite and very subordinate quartz cementation of sandstones as well as compaction of sandstone, siltstone, shale, and carbonate beds. Porosity in finer-grained basinal sandstones can be quite high (as high as 27 percent; Williamson, 1977, p. 414) with corresponding permeabilities in the tens to hundreds of millidarcies.

Recent Models

The Permian depositional and diagenetic patterns described here (and summarized in figs. 2 and 3 and in table 1) can be matched quite closely in some modern settings. The basinal relations can be modeled in the Mediterranean, the Black Sea, and to some degree, in the Bahamas-Florida area. The restricted circulation and partially euxinic conditions can be found, to some degree, in the Red Sea, Mediterranean, and Black Sea during the Tertiary or Quaternary; but the deep, relatively elongate, structurally controlled basins surrounded by steep, reefal escarpments bordering isolated platform areas are best modeled in the Bahamas. The suite of facies from fore-reef debris, reef, back-reef rubble, near-back-reef skeletal sands and muds, islands, restricted lagoons, and finally supra-tidal facies seen in the Permian is remarkably similar to the general facies spectrum found in the Florida Keys-Florida Bay area. Yet climatically and paleogeographically, the Permian of west Texas and New Mexico was much more like the arid, continent-interior southwestern margin of the Persian Gulf than the high-rainfall, ocean-margin region of south Florida. Thus, the lagoons and sabkhas of the Trucial Coast of the Persian Gulf provide an excellent analog for the far-back-reef areas of the Permian.

It is clear, then, that no single area today provides a complete or exact analog for the Permian Basin. Yet if we combine the climatic factors of the Persian Gulf with the tectonic-sedimentologic patterns of the Florida-Bahamas region and the hydrographic factors of the Mediterranian-Black-Sea-Red Sea area we can very closely approximate the patterns seen in the Permian.

Oil and Gas Production

The Permian Basin has had hydrocarbon production for nearly 60 years and is one of the most prolific petroleum provinces in North America. To date, "approximately 91.6 billion barrels of oil-in-place and about 106.2 trillion cu ft of dissolved/associated and non-associated gas-in-place have been discovered in the Permian Basin" (Dolton and others, 1979. p. 1). Production from the Permian Basin extends from the Cambrian (Wilberns Fm.) to the Cretaceous (thin carbonate units) although production from units younger than Permian is negligible. Paleozoic reservoirs produce oil from depths of less than 500 to greater than 14,000 ft and also produce gas from depths of less than 500 ft to greater than 21,000 ft (Dolton and others, 1979). The Permian section is mainly oil productive with greater than 65 billion barrels of oil-in-place (71 percent of the total discovered in the Permian Basin) having been discovered to date (in 2,188 pools). Non-associated gas production, on the other hand, comes predominantly from pre-Mississippian strata. Permian units contain only about 6.3 trillion cu ft of non-associated gas-in-place (about 13 percent of the total for the Permian Basin). However, Permian units contain 32.7 trillion cu ft of associated/dissolved gas-in-place (54 percent of the Permian Basin total) (Dolton and others, 1979).

The predominance of oil production from Permian units is clearly related to their relatively shallow burial in this region where virtually all Permian strata are found at present-day burial depths of less than 15,000 ft. Furthermore, virtually all production from Permian rocks comes from units at less than 10,000 ft burial depths; most of it from less than 5,000 ft depths (Dolton and others, 1979).

"The four provincial series of the Permian do not contain hydrocarbons in equal amounts. The largely evaporitic Ochoan rocks have accounted for only about 6 million bbls of discovered oil in-place, less than 0.01 percent of the Permian's 65 billion bbls" (Dolton, and others, 1979, p. 24).

"By contrast, the Guadalupian has accounted for 67 percent of all Permian oil found and 62 percent of all Permian gas. The Leonardian follows with 28 percent of the oil and 32 percent of the gas. The Wolfcampian contains 5 percent of the oil and 10 percent of the total Permian gas. These amounts are directly related to the progressive development of reefs and back-reef lagoons beginning in the Wolfcampian, increasing in the Leonardian, and culminating in the development of the Capitan reef complex in the Guadalupian.

Hydrocarbon traps in Permian rocks are largely a combination of stratigraphic and structural types, although each type does occur alone. the intricate stratigraphic interfingering of lithologies responsible for trapping much of the Permian oil has resulted largely from the constantly shifting... sedimentary environments. Primary sealing mechanisms are porosity and permeability barriers of carbonate, evaporite or shale.

About 40 percent of the [Permian] reservoirs are limestone, 29 percent are dolomite and 29 percent are sandstone. Porosities range from 1.5 to 25 percent and reservoir permeabilities from 0.02 to 200 millidarcies.

Recovery factors range from a low of 7.6 percent to a high of 47.5 percent. The fractured siltstone Spraberry reservoir of the Midland Basin has a very low recovery factor, although the volume of oil in-place is the largest of any single Permian pool. The average recovery factor for the Permian System is 25 percent." (Dolton and others, 1979, p. 24).

Detailed production (not reserve) figures for oil and gas fields developed in selected Leonardian, Guadalupian, and Ochoan units are shown in Table 3 (listed by county). Production totals for each producing stratigraphic unit are given in Table 4 along with a grand total for all these strata in the Permian Basin region. Only units which will be seen on this field trip have been included in these tables. Extensive production from age-equivalent but differently named units from the Central Basin Platform, Midland Basin, and Eastern Shelf have not been listed. Data for these tables was supplied by the Petroleum Data System, University of Oklahoma, Norman, Oklahoma.

Even a cursory examination of these tables will show that there is no production from the Capitan, Victorio Peak, or Goat Seep reef or fore-reef facies which were tightly cemented at the seafloor shortly after deposition. The vast bulk of production (greater than 90 percent) is from primary or early diagenetic secondary porosity in back reef dolomites and sandstones of the Tansill, Yates, Seven Rivers, Queen, and Grayburg Formations or the open shelf facies of the San Andres Limestone. A second, much smaller, peak of production comes from channel sandstones of the Delaware Mountain Group (particularly in the Bell Canyon Fm.) and basinal limestones of the Bell Canyon Fm. or Bone Spring Limestone. More significant oil reserves in basinal sandstones are found in the Midland Basin. There, the Spraberry Fm. has more than 8 billion barrels of oil-in-place. However, recovery factors of less than 10 percent indicate ultimately recoverable reserves of about 534,000,000 barrels of oil.

Individual channels in the "Ramsey Interval" near the top of the Bell Canyon Fm. are up to 100 ft thick, 1/4 to 4 miles wide, and 50 miles in length (Williamson, 1977). These channels have a very pronounced regional trend (NE-SW for the "Ramsey") which strongly controls the shape and distribution of basinal oil fields.

In this setting, then, back-reef environments account for greater than 90 percent of all hydrocarbon production with basinal sediments accounting for the rest. Reef and fore-reef facies are totally non-productive. Clearly, penecontemoraneous and early burial diagenesis played a major role in controlling the distribution of reservoirs. Evaporite formation and dissolution, synsedimentary dolomitization, early vadose and phreatic leaching and cementation, coupled with probable early oil migration from rapidly deposited and buried, overpressured source rocks in the basins, led to outstanding reservoir characteristics on the shelf. Early submarine cementation obliterated reservoirs on the shelf edge and slope long before oil migration. Finally, some basinal reservoirs may have been preserved from compactional porosity loss by overpressuring beneath 2,000 or more feet of rapidly deposited evaporites.

The source for most of this Permian oil is presumably from the euxinic, relatively organic carbon-rich, basinal sediments such as the Bone Spring Limestone and some intervals within the Delaware Mountain Group. Although these units generally have organic carbon contents of less than 1 percent (King, 1948; Palacas, oral commun., 1978), their carbonate composition, great thickness, and intervening sandy, permeable zones may mean that they can act as very efficient source rocks. Oil reservoired in the basinal facies, then, has probably migrated only a short distace from source to reservoir. Much of the oil in the back-reef sections, however, presumably moved upsection or laterally through fractured reef sediments to get from source to reservoir. The fracturing of the reef was essentially contemporaneous with deposition (because of compaction of the thick, underlying reef talus) and thus, even syndepositional reef cementation probably did not significantly retard fluid movement. Indeed, even today, the tightly cemented reef zone has the highest permeability of any of the Guadlaupian bank-to-basin facies (Motts, 1968).

Current estimates of the volume of undiscovered hydrocarbons in-place for Permian rocks of the Permian Basin are that "at the 95 and 5 percent probabilities, 1.0 to 6.0 billion bbls of oil in-place (1.5 to 9.2 percent of the discovered Permian crude oil) remain undiscovered, while 0.7 to 4.1 trillion cu ft of dissolved/associated gas in-place (2.2 to 12.4 percent of the discovered dissolved/associated gas) remain undiscovered. Finally, 0.2 to 0.6 trillion cu ft of non-associated gas in-place (3 to 21 percent of the discovered non-associated gas) remain undiscovered. Most of these undiscovered in-place hydrocarbons occur above 10,000 ft" (Dolton and others, 1979, p. 47).

"These undiscovered amounts will probably occur in circumstances similar to known fields and pools with respect to reservoir characteristics, seals, source beds, and nature of the hydrocarbons. Traps will probably be predominantly stratigraphic. The undiscovered deposits are likely to be distributed in undrilled areas surrounded by or flanking known production. Such flanking areas are in the western part of the Northwestern Shelf, the western areas of the Delaware Basin, and the southern and western parts of the Val Verde Basin." (Dolton and others, 1979, p. 47).

Studies have shown that "undiscovered pool sizes are small; only at the 5 percent probability is there a chance of occurrence of an oil pool of 16 million bbls or larger, or a non-associated gas pool of 24 billion cu ft or larger." (Dolton and others, 1979, p. 47).

Concluding Notes

For further general discussions of Permian Basin depositional and diagenetic facies patterns the papers by King (1948), Newell and others (1953), Hayes (1964), and Cys and others (1977), are recommended. Other, more specific papers, can be found in the extensive bibliography on the Permian Basin region given at the end of this section of the guidebook.

Further discussions of the specific details of facies patterns and diagensis are also presented in the roadlog section of this guidebook. The log is based, in large part, on preexisting guidebooks (Nelson and Haigh, 1958; West Texas Geological Society, 1960 and 1969; Hobbs, Roswell, and West Texas Geological Societies, 1962; Roswell Geological Society, 1964; Dunham, 1972; Pray, 1975; and Pray and Esteban, 1977). However, this guidebook has extensive additional commentary on many localities and is organized differently from previous guides. All roadlogs are based on continuous routes with side trips being presented as separate, supplementary logs. Thus, the trip from El Paso to Carlsbad is logged as a continuous route with the excursions to McKittrick Canyon, Walnut Canyon, and Dark Canyon-Rocky Arroyo being listed as separately logged routes. This adds complexity to a bus tour but makes the logs much easier to use on car trips. Furthermore, for ease of use, all figures are in a single section after the roadlogs. Roadlog routes are shown in fig. 4. A generalized geologic map of the Guadalupe Mountains area is presented in Plate 2 (in pocket).

EL PASO TO CARLSBAD ROADLOG

Mileage	Cumul. Mileage From El Paso	Mileage From Carlsbad	Description
0.0	0.0	159.4	Leave Caballero Motel; turn right (heading east) on U.S. Highway 62 and 180 (Montana Avenue).
0.6	0.6	158.8	Intersection with Airway Road (airport about 1/2 mi to left); continue straight ahead.
6.5	7.1	152.3	Stabilized (vegetated) dunes of clastic terrigenous debris blown from the floor of the Hueco Bolson, the flat, intermontane basin we have been and are continuing to cross. The Hueco Bolson is one of the southernmost grabens of the Basin and Range Province and is bounded on the west by the Franklin Mountains and on the east by the Hueco and Sacramento ranges. To the north, near the Texas-New Mexico border, the the Hueco Bolson is separated from the Tularosa Basin (which has completely internal drainage) by a low ridge. The Hueco Bolson has external drainage along its southeastern side through the Rio Grande River valley. The average elevation of the Hueco Bolson is approximately 4,000 ft, and the basin averages 25 mi in width and 80 mi in length. "A recent (1967) USGS seismic and gravity profile across the Hueco Bolson from the base of the Franklin Mountains to the base of the Hueco Mountains indicates a deep structural trough bounded on the west by a large normal fault. The maximum thickness of the Hueco Bolson fill in the center of this trough is calculated to be about 9,000 feet." (McGlasson and Seewald, 1969). The bolson fill ranges in age from Miocene to Holocene; the Pleistocene deposits are particularly thick, with local accumulations of as much as 5,000 ft of Pleistocene alluvial and lacustrine sediment (Strain, 1969).
1.5	8.6	150.8	El Paso city limit.
3.1	11.7	147.7	Junction with Texas FM Road 659 to Ysleta (on right) and start of two-lane section of U.S. Highway 62 and 180; continue straight ahead. The intensely block-faulted, low-relief (ca. 1,000-1,500 ft) Hueco Mountains can be seen directly ahead. Precambrian to Tertiary igneous, metamorphic and sedimentary rocks are exposed in this range (see fig. 5). Cerro Alto, the highest peak, is a Tertiary syenite porphyry intrusive. The Permian (Wolfcampian to early Leonardian) section of the Hueco Mountains contains nearly 2,000 ft of limestone and very subordinate shale. The pre-Permian sedimentary section consists of a lower interval of Cambrian to Mississippian strata (mainly limestones and dolomites) and an upper interval of Pennsylvanian limestones, shales,

and subordinate sandstones. The upper and lower intervals each contain up to 2,000-4,000 ft of section. The lower interval shows disconformable contacts typical of stable shelf sections, whereas the upper interval contains angular unconformities indicative of the increased tectonic activity and bank-to-basin differentiation of that time period.

Throughout this trip, the bank-to-basin facies sequences we see will be related in one way or another to the initial, structurally controlled topographic variations generated during this Pennsylvanian and Permian deformation. The folding and faulting of this period, part of the Ancestral Rockies movements, generally trends northwest-southeast. The Diablo Platform, Orogrande Basin, Pedernal High, Northwest Shelf, and Delaware Basin (fig. 1) were among the many major physiographic features formed during this time interval. This primary structural relief was, in most cases, strongly modified by subsequent differential sedimentation.

4.4	16.1	143.3	Loose (unvegetated) dunes deposited by winds from the northwest which lose velocity and drop sand near the base of the Hueco Mountains. The hills on the right (largely covered by dunes) are made of Wolfcampian limestones of the Hueco Group.
2.5	18.6	140.8	Quarry in Hueco Group limestone on the right. The limestone here is about 97 percent pure $CaCO_3$ and the quarry exposes a single, thin, fusulinid-rich bed about 3/4 of the distance up the rock face.
0.4	19.0	140.4	Lower part of Hueco Group is exposed in hill on right. The unconformable contact between the Hueco limestone and the underlying lower part of the Pennsylvanian Magdalena Limestone is exposed in the low knob at the base of the eastern slope of the hill. This unconformity is an indication of pre-Permian uplift and erosion on the Powwow anticline.
0.8	19.8	139.6	Exposures of the Mississippian Helms and Pennsylvanian Magdalena Formations in hills on left.
0.6	20.4	139.0	Quarry at 2:00 o'clock in Magdalena Limestone The very pure (99.8 percent $CaCO_3$) limestones in this quarry, as well as those from the quarry at mile 18.6, were formerly transported to El Paso where they were calcined to CaO (quick lime).
0.3	20.7	138.7	Junction with Texas SF Road 2775 to Hueco Tanks State Park; continue straight ahead.
0.3	21.0	138.4	Hills on left capped by Magdalena Limestone. The southeast dips visible here are on the flank of the Powwow anticline. The Jones No. 1 Sorley well, drilled a few miles west on the crest of the Powwow anticline, encountered Precambrian granites at 2,172 ft depth. Helms Peak (elevation 5,409 ft) at 2:00 o'clock is capped by limestones of the Hueco Canyon Formation unconformably overlying middle

			Magdalena Limestone.
0.7	21.7	137.7	Entering Powwow Canyon.
1.9	23.6	135.8	Road cut in middle Magdalena Limestone.
0.5	24.1	135.3	Road cut in middle Magdalena Limestone.
0.8	24.9	134.5	Roadside park on left. The unconformity at the base of the Permian is clearly visible directly ahead. On the western side of the Hueco Mountains this unconformity cuts down to the Ordovician El Paso Limestone. In the outcrop directly ahead, the unconformity is between the Magdalena Limestone and the basal Hueco Group.
0.4	25.3	134.1	Road cut in upper 130 ft of Magdalena Limestone.
0.3	25.6	133.8	Road cut in the basal part of the Permian Hueco Group (including the poorly exposed Powwow Conglomerate and the overlying upper member of the Hueco Canyon Formation). The Powwow Conglomerate varies locally in thickness but is about 30 ft thick in this area. It contains red shales, siltstones, and chert- and limestone-pebble conglomerates. Another redbed interval (the Deer Mountain Shale) occurs near the top of the Hueco Group. These redbeds are considered to be the southern tongues of the thick, predominantly redbed Abo Formation of the Sacramento Mountains.
0.2	25.8	133.6	Road cut in Hueco Canyon Formation, mainly shelfal limestones.
1.2	27.0	132.4	Hueco Inn on left. Continued Hueco Group outcrops for next twelve miles.
8.7	35.7	123.7	Forty Mile Hill (elevation 5,427 ft). Leaving Hueco Mountains; emerging onto Diablo Plateau.
3.1	38.8	120.6	Roadside rest area on left with view of numerous extrusive and intrusive igneous features to the north and northeast in the Cornudas Mountains. The central, high volcanic cone is San Antonio Peak (7,020 ft).
13.3	52.1	107.3	Limestones of Hueco Group in road cut.
4.7	56.8	102.6	Road on Lower Cretaceous Campagrande Formation.
0.5	57.3	102.1	Junction with Texas Ranch Road 2317; continue straight ahead. Molesworth Mesa, which lies to the south, is composed of Cretaceous Trinity and Fredricksburg sediments.
1.9	59.2	100.2	Mountains at 9:00 o'clock are the Sierra Tinaja Pinta, a breached laccolith. The anticlinal structure in the center is composed of Bone Spring Limestone and is flanked by sediments of the Yeso Formation.
5.0	64.2	95.2	Junction with Texas Ranch Road 1111; continue straight ahead.
6.1	70.3	89.1	The Antelope Hills, containing basal Cretaceous sandstones cut by a Tertiary sill, are visible at 3:00 o'clock.
2.7	73.0	86.4	Road is on Bone Spring Limestone.
1.5	74.5	84.9	Junction with Texas Farm Road 1437 to Dell City on left; continue straight ahead. Dell City is a farming community in the Salt Flat Bolson which has grown up as a consequence of the development of wells

drawing Pleistocene(?) ground water from the bolson-fill. Rapid depletion of the water supply (use exceeds recharge) and increasing soil salinites indicate a short or very expensive continued existence for agriculture in this region.

0.1	74.6	84.8	Road crosses basal Cretaceous sandstones and passes into Bone Spring Limestone.
6.5	81.1	78.3	Los Alamos Hills can be seen to the south of the highway, in foreground. Leonardian to basal Guadalupian rocks are exposed here.
1.0	82.1	77.3	Junction with Texas FM Road 1576 to Dell City. Turn left for view stop.
0.25	82.35	77.05	STOP I-1. This location provides an excellent view of the Guadalupe and Delaware Mountains and the Salt Flat Bolson (in which we are now standing). We can see a magnificent panorama including the Upper Permian section of the Guadalupe Mountains, about 20 miles to the northeast. This 5,000 ft escarpment is formed by a major north-south trending normal fault system which marks the eastern boundary of the Salt Flat Bolson. To the northwest and west we can see the Cornudas Mountains, Cerro Diablo, and Sierra Tinaja Pinta, a series of Tertiary igneous plugs and lava flows. To the south lies the Sierra Diablo range which is terminated by the Babb flexure zone, a monocline, at its northern end. Upper Permian (Guadalupian) limestones and sandstones of the Cherry Canyon Formation compose the two mesas to the north of the Babb flexure. Also visible beyond these mesas is Sierra Prieta, another Tertiary intrusive. Finally, to the southeast, Upper Permian strata, primarily Brushy Canyon Formation basinal sandstones, are visible in the face of the long Delaware Mountain escarpment.

Because the Guadalupe Mountains are the major focus of this portion of the field trip, let us take a closer look at that range (fig. 6). Although the topography of the eastern side of the Guadalupe Mountains is controlled almost entirely by the undeformed primary facies distribution of the Guadalupian sediments, the western face is completely controlled by Tertiary normal faults. Thus, on the on the western side, strata with a northeast-southwest facies strike are obliquely transsected by a north-south trending fault zone. Furthermore, we are viewing the exposure obliquely which makes accurate geologic observation even more difficult.

For reference purposes let us name the major peaks on the Guadalupe Mountain skyline. From south to north these include the massif of El Capitan (elevation 8,078 ft), Guadalupe Peak (the highest point in Texas at 8,751 ft), Shumard Peak (8,626 ft), an unnamed spur off Shumard Peak (about 8,350 ft), Bartlett Peak (8,513 ft), and Bush Mountain (8,676 ft).

The massive, light colored rocks, which compose the upper parts of El Capitan, Guadalupe, and Shumard Peaks, are Upper Permian (Guadalupian) Capitan limestones and dolomites (see fig. 6 and table 2). Most of this mass is thick-bedded, fore-reef talus (largely of Rader age) which dips steeply (up to 35 degrees) to the southeast, into the basinal sediments of the Delaware Basin. The top of Guadalupe and nearby peaks, however, have true Capitan reef facies and even back-reef sediments. The Capitan reef and fore-reef strata undoubtedly originally extended several miles further south in this region but have been trimmed back by subsequent erosion.

To the north, Bartlett Peak is capped by the oldest exposed Capitan reef limestones which overlie rubble of an older (Goat Seep) reef. The area to the north of Bush Mountain contains the main reef-massif of the Goat Seep as well as age equivalent back-reef calcarenites and terrigenous sandstones (Queen and Grayburg) which stand out clearly as vegetated zones on the mountain slope. "At Guadalupe Peak the smooth slopes below the Capitan are Cherry Canyon and Brushy Canyon sandstones. North of Shumard Peak the upper part of the Cherry Canyon grades into Goat Seep reef. A tongue of Cherry Canyon sandstone continues northward under the Goat Seep reef and grades into small reefs and reefy lime banks in the southern Brokeoff Mountains, and into bedded back-reef rocks in the central Brokeoff Mountains. There Boyd has measured approximately 600 feet of beds which he calls the San Andres formation, and Frenzel, considers to be lower San Andres . . .

The rugged cliffs outcropping below the Delaware sand slopes are cut from the dark-bedded Bone Spring limestone of Leonard age. Between El Capitan and Shumard Peak the top of the Bone Spring limestone rises over 1000 feet and this is the Bone Spring flexure described by King. Below Shumard Peak the upper part of the Bone Spring has changed to the gray Victorio Peak . . . , a reefy lime-bank facies. The Brushy Canyon sandstone onlaps the Bone Spring flexure and is absent in the slope below Bartlett Peak" (West Texas Geological Society, 1960, p. 50).

The bulk of the strata just described represent just two major phases of basinal progradational filling (Pray, 1975). The Victorio Peak Dolomite and the underlying Bone Spring Limestone form the older (Leonardian) phase. This sequence represents at least two to three miles of basinal infilling and progradation of shelf facies during the accumulation of about 1,000 ft of section (McDaniel and Pray, 1967). "The Leonardian bank margin was eroded in latest Leonardian and/or in early Guadalupian time, and a major transgression of basin facies dark carbonates (Cutoff shaly member of King) brought basinal environments far to the north, overlapping Leonardian basin, basin margin, and shelf deposits alike" (Pray, 1975, p. 5). Presumably this transgression was a consequence either of major regional subsidence or of eustatic sea level rise, perhaps associated with the latest stages of Permian glaciation.

This transgression was followed by the second major cycle of progradation, represented by Goat Seep and Capitan reef complexes. These units built the Guadalupian shelf edge outward several miles by filling in a basin of 1,000 to 1,800 ft depth with steeply dipping, reef-derived debris beds which are clearly visible at the southern end of the Guadalupe escarpment. It is the upper part of this progradational sequence which will occupy much of our attention on this trip.

Turn around and return to U.S. Highway 62 and 180.

0.25 82.6 76.8 Turn left on U.S. Highway 62 and 180.

0.8 83.4 76.0 Crossing northern extension of East Diablo fault with the Salt Flat basin down-thrown on the eastern side.

2.7 86.1 73.3 Historical marker near site of former spring-fed oasis (Crow Springs) and a relay station of the Butterfield Overland Stage. The Butterfield route (see cover illustration) was established in 1858 and passed through the area of Guadalupe Pass (Pine Springs). This route lasted only about one year, however, before the entire line was shifted south to the approximate course of the present Interstate 10 through the Davis Mountains.

1.5 87.6 71.8 OPTIONAL STOP. Center of playa area of Salt Flat. This major graben, the easternmost of the Basin and Range province, formed in middle to late Tertiary time. The basin is about 60 mi long and 10 mi wide and has been the site of continuous alluvial, fluvial, and lacustrine sedimentation since the middle Tertiary. The thickness of sediments in the basin probably is many thousands of feet. Basin margin sediments include coarse gravels and sands alternating with clays derived from the weathering of the adjacent mountains (especially the Guadalupe and Sierra Diablo ranges). Because there is no natural outlet for the basin, all drainage is internal and sediments become finer-grained toward the basin center. Several important aquifers are present within the basin fill and these are currently being exploited for irrigation in areas such as Dell City to the northwest.

Modern saline playas occur in the Salt Flat area of Texas and the Crow Flat area of New Mexico and Texas, in the topographically lowest parts of the basin (elevations about 3,630 ft). These playas form in a region of low rainfall (about 9 or 10 in/yr average) and high evaporation (about 80 in/yr)

(Dunham, 1972). Thus, groundwater, which stands at a level near the playa surface, is drawn upward and is evaporated, leading to gradually increasing salinities. These high salinities greatly restrict vegetation and allow eolian deflation of the rather fine-grained playa preciptates.

Pits excavated in the playa sediments reveal firm but not hard, fine-grained, laminated, non-fossiliferous lacustrine materials. Modern gypsum and minor halite are the dominant evaporite minerals but calcite, aragonite, and dolomite have also been found in the playa sediments either as primary or secondary minerals (see Friedman, 1966; and Dunham, 1972, for further details). C^{14} age dating and geological mapping of basinal units indicates that much of the sediment found at the surface today may be relict from a larger Pleistocene pluvial lake (King, 1948; Dunham, 1972). Eolian deflation has piled up some of of these primary and secondary minerals as dunes along the margins of the playa area.

Halite has been mined from the surface of the playa in areas to the south of the road although halite is not preserved to any extensive degree in buried sediments. This salt was a most highly valued commodity in the 1880's and was used for food preservation, final curing of hides, and other purposes. It was such a valuable substance that it was hauled by mule- and ox-drawn vehicles for many hundreds of miles over the southwest trail to Fort Quitman, then to San Elizaro, Franklin (now El Paso), Paso del Norte (now Juarez), and on to Chihuahua City. Disputes between Mexican and American mining interests in the area led to the El Paso Salt War of 1877. The conflict culminated in the battle of San Elizaro (then the county seat of El Paso County). Improved(?) food preservation techniques and more economical sources of salt have eliminated the relatively small-scale mining in this area.

On the south side of the road the Paso Tex oil pipeline can be seen sitting on trestles; on the north side of the road the El Paso Natural Gas pipeline to the Pacific Coast is buried beneath playa sediments.

0.8	88.4	71.0	Gypsum-bearing dunes are derived from deflation of the nearby playa surface.
2.2	90.6	68.8	Eastern edge of the Salt Flat Basin.
0.8	91.4	68.0	Folded and downfaulted blocks of Upper Permian on the left.
1.2	92.6	66.8	Beacon Hill on the left is composed of Capitan Limestone with Rader Limestone at the base of the hill. This is the southern end of the Patterson Hills which consist of complexly faulted and folded Upper Permian limestones. Farther north are the Brokeoff Mountains.

0.5	93.1	66.3	El Paso Natural Gas Co. Guadalupe Compressor station on the left.
0.3	93.4	66.0	Road cut in Bell Canyon Formation.
0.4	93.8	65.6	Road cut in Bell Canyon Formation.
0.3	94.1	65.	Road cut in Cherry Canyon Formation; note greenish bentonite beds.
1.0	95.1	64.3	Road cut in downfaulted Bell Canyon Formation.
0.8	95.9	63.5	Road cut in Cherry Canyon Formation. The Patterson Hills to the left are capped by Capitan-age limestone.
0.6	96.5	62.9	Road cut in Cherry Canyon Formation exposing contact with Brushy Canyon Formation at east end of outcrop.
0.5	97.0	62.4	Junction with Texas Highway 54 to Van Horn on right. Keep left for Carlsbad.
0.3	97.3	62.1	OPTIONAL STOP. An excellent view of the south end of the Guadalupe Mountains here shows the clear relations between reef, fore-reef, and basinal facies (fig. 7). Ahead and to the right, is the escarpment of the Delaware Mountains composed of Brushy Canyon and Cherry Canyon basinal sediments mainly sandstones and siltstones). The Delaware Mountain ridge is capped by the resistant Getaway Limestone which is exposed near the radar station visible at the top of the cliff. The Getaway Limestone Member occurs at a level about 100-200 ft above the base of the Cherry Canyon Formation and, in this area, is a very fossiliferous, gray to black limestone. Note the abundance of lenticular, channelized bedding in the Brushy Canyon and basal Cherry Canyon sections exposed in the Delaware Mountains escarpment. This entire sequence was apparently deposited in water depths of at least several hundred feet by a combination of density currents, mass flows, localized slumps, and perhaps even contour currents. Much of the darker material visible in the cliff face represents relatively fine-grained overbank or non-channelized flows. The lighter-colored, lenticular sediments are coarser-grained, massive, channel-fill sandstones. Finally, at the very base of the escarpment, a dark ledge of the basinal Bone Spring Limestone is exposed. To the left we can see the great mass of Capitan Limestone which forms the upper part of El Capitan. The Capitan Limestone in this face represents a fore-reef rubble facies which is the time equivalent of the Hegler, Pinery, and Rader Members of the Bell Canyon Formation. Below the massive (1,000-1,500 ft thick) limestone, gently sloping deposits of the Cherry Canyon Formation are evident. "The three distinctly visible ledges represent in ascending order the three basinal limestone tongues of this formation named Getaway, South Wells, and Manzanita" (K. W. Klement, in West Texas Geological Society, 1969, p. 18). The rest of the lower slopes of El

Capitan are composed of Brushy Canyon Formation.

The lateral flattening of dips from El Capitan to the Delaware Mountains is not a result of deformation, but rather represents a primary facies transition from reef to basin. The thick, steeply dipping, rubbly limestones of the fore-reef facies thin rapidly toward the basin so that 100 or more feet of reef limestone may have a time equivalent 1-5 ft thick limestone in the center of the Delaware Basin. The color change from the light colored, largely oxidized beds of the reef and fore-reef to the dark colored, organic carbon-rich, anoxic basinal facies can also be seen in these exposures.

It should be pointed out that the great thicknesses of basinal sandstones (about 3,500 ft of Delaware Mountain Group), although derived from the shelf, have only thin equivalents in the back-reef facies and are virtually absent in the reef itself. In part, this may reflect the fact that much of the basinal sandstone was apparently transported from the north and north-east, across the Central Basin Platform and the then-filled Midland Basin from sources in the Pedernal Massif and the Arbuckle and Wichita uplifts (Watson, 1979; Bozanich, 1979). Thus, much of the sand influx may have been funneled through gaps in the reef in areas not currently exposed in outcrop. There is evidence, however, from submarine channel orientation, other current direction indicators, stratigraphic relations of basinal sandstones and fore-reef carbonate rocks, and the presence of numerous, if thin, back-reef sandstone beds, that some sand moved across the northwestern part of the basin margin along which we are now standing.

Thus, in all probability, another explanation must be sought for the inverse relationship of thick carbonate and thin sandstone units on the shelf and thin carbonate and thick sandstone units in the basin. Silver and Todd (1969) and Meissner (1972) proposed similar concepts of reciprocal sedimentation to explain these observations. This model suggests that the carbonate sediments were deposited during high eustatic sea level stands. During these times of strong surface-water circulation, reefs flourished and climates were arid. The shelf areas had massive carbonate buildups which maintained the shelf edge at or near sea level. During this time, terrigenous sands were largely trapped in back-reef lagoons or in continental basins. The evaporitic conditions led to the formation of saline bottom-waters and a density-stratified basinal water column. This, in turn, led to largely euxinic, sediment starved conditions on the floor of the basin.

During lowered sea level stands, on the other hand, eolian and fluvial(?) transport of large volumes of well-sorted arkosic sand to the shelf edge provided a massive supply of unconsolidated material on the upper slope. From there the sands were reworked into the basin by a variety of gravitationally driven current mechanisms. Subsequent transgression in the next cycle removed virtually all traces of sand from the tightly cemented shelf-edge limestones.

Thus, in the reciprocal sedimentation concept, although there is overall time-equivalence of the shelf and basin sediments, they are not exact time-equivalents when looked at in detail. The thick, basinal sandstones are equivalent, in most cases, to hiatuses in reef deposition and to thin sandstone beds in back-reef areas. Thick reef and back-reef limestones are equivalent to very thin, black limestones in the basin.

1.4	98.7	60.7	STOP II-2. This outcrop, faulted at its northern end, exposes Bone Spring Limestone in its basinal facies. This Leonardian limestone, the oldest unit exposed in the Guadalupe and Delaware Mountains, reaches at least 1,700 ft thickness in this area (King, 1948). A thickness of 3,123 ft has been measured for the combined Hueco Limestone-Bone Spring Limestone interval in the Updike well near El Capitan. This combined section thickens to greater than 4,500 ft in the Delaware Mountains to the south (King, 1948, p. 13). At this locality we can see typical, dark gray to black, cherty, interbedded limestones and calcareous shales which are the dominant lithology of the basinal part of the Bone Spring Limestone. Fossils, especially small ammonites, can be found at this locality, but are generally restricted to isolated, granular or calcarentic beds. Bedding surfaces in the basinal Bone Spring Limestone are typically wavy. Both the limestone and the shale units contain considerable amounts of organic matter and may have acted as source rocks within this basin. Indeed, trapped oil can be found even on outcrop in small cavities in the Bone Spring Limestone.
0.4	99.1	60.3	Road cut in Brushy Canyon sandstone.
0.5	99.6	59.8	Well exposed, lenticular, sandstone channel deposits of the Brushy Canyon Formation are visible in the distance on both the left and right sides (fig. 8).
1.6	101.2	58.2	STOP II-3. An exposure of basinal Brushy Canyon Formation, the lowest unit in the Delaware Mountain Group. The feature of special interest at this locality is the exposed margin of a submarine channel (fig. 9). Such channels are common in this formation and, at least in this area, generally trend northwest-southeast, that is, perpendicular to the shelf margin.

At this locality, we can see dark-colored, graded, relatively fine-grained sandstones, siltstones, and shales in thin beds with some soft-sediment deformation features. These àre abruptly cut by a uniform, thick-bedded, sandstone-filled channel. Both types of sediments were clearly soft, even fluid, at the time of deposition, as shown by the fact that the channel margins are extensively deformed by sand injection.

Hayes (1964), Jacka and others (1968), Payne (1979), Berg (1979) and other authors have interpreted these or similar deposits as submarine fans. The graded, finer-grained sediments are considered to be interchannel or overbank turbidity-current deposits. The cut and fill, massive sandstones are interpreted as part of an anastomosing system of fan channels, eventually abandoned or filled by sand transport. Harms (1974), on the other hand, proposed that the finer-grained sediments were deposited by density overflows which dropped suspended sediments as they moved out over density interfaces within the water column rather than at the sediment-water interface. The channels were cut, according to Harms, by saline and cold density currents (rather than turbidity currents) which formed on the shelf. The sand fillings of the channels were also laid down by density currents.

In either case, these large (commonly more than 1/2 mile wide and 50-100 ft thick) channelized sandstones, surrounded by lower permeability siltstones and shales, represent significant potential stratigraphic traps. This is especially true because of the close spatial association of these sandstones and the potential basinal source rocks. Indeed, exploration efforts to date have located more than 100 oil and gas fields which produce from channel-sandstone reservoirs of the Delaware Mountain Group, primarily (but not exclusively) from the Bell Canyon Formation (see table 3).

0.5 101.7 57.7 Roadside rest areas on left and right. Excellent views of El Capitan (fig. 10) and the Delaware Mountains escarpment. Again, the bank-to-basin transitions of the Capitan Limestone and its equivalents are well shown.

0.7 102.4 57.0 Road cuts in sandstones and siltstones of the Brushy Canyon Formation.

0.4 102.8 56.6 OPTIONAL STOP. View along the Delaware Mountains escarpment on the right. Outcrops on the left consist of upper Brushy Canyon Formation sandstones with oriented fusulinid Foraminifera (fig. 11) which were reworked into the Delaware Basin from the adjacent Northwest Shelf. In thin section one sees compaction of the sandstones, some quartz overgrowth cement (minor), clacite cementation (very

			extensive), numerous fine-grained carbonate clasts mixed with well-rounded and well-sorted quartz and feldspar grains. The detraital carbonate grains show intense pressure solution, especially where they are in direct contact with the less soluble quartz or feldspar grains.
0.3	103.1	56.3	An enigmatic Brushy Canyon-Cherry Canyon contact is exposed in this outcrop. The contact strikes N 30^{o} E and dips at about 17 degrees to the southeast. This relationship has been variously explained as a fault contact, an erosion surface, or a large and coherent slide mass. Note the abundant high-angle faults in the outcrops in this area. They generally have only minor offsets (although a few have 100 ft or greater throw) and are part of the Tertiary block fault system which marks the western boundary of the Guadalupe and Delaware Mountains.
0.3	103.4	56.0	OPTIONAL STOP. Shales, siltstones, and sandstones of the Cherry Canyon Formation are seen here. They show a number of interesting sedimentary features including a large channel, graded beds, flame structures, ripple marks, slump folds, and abundant horizontal lamination. Again, as for the Brushy Canyon section, evidence is present for the involvement of both traction and suspension processes in the deposition of these units. The Cherry Canyon Formation is about 1,000 ft thick in this area and thickens to about 1,300 ft in the subsurface sections measured to the east. Organic carbon-rich shales and limestones within the Cherry Canyon Formation may have acted as source rocks for a significant part of the oil in the Permian strata of the Delaware Basin.
0.4	103.8	55.6	Road cut in Tertiary-Quaternary alluvium.
0.4	104.2	55.2	Thin-bedded Cherry Canyon Formation exposed on right.
1.0	105.2	54.2	Rest area on left.
0.4	105.6	53.8	Fault zone. Graded carbonate beds are present in the Cherry Canyon Formation at this locality.
0.7	106.3	53.1	Crest of Guadalupe Pass (elevation 5,695 ft). Pine Springs Canyon is visible to the left; the Pine Springs Camp and gas station are just ahead. The cliffs to the left (10:00 o'clock) are composed of Guadalupian basinal facies from the base to the middle of the slope; that is overlain by a thick zone of fore-reef rubble which, in turn, is capped by a thin zone of preserved reef limestone. The Getaway Limestone is visible in hills on the right and overlying sediments of the Cherry Canyon Formation are present in the slopes ahead and to the left. The greenish outcrops in these slopes (for example on Nipple Hill, directly ahead) are intercalated bentonite beds (volcanic ash) and shales in the Manzanita Limestone Member of the Cherry Canyon

			Formation. U.S. Highway 62-180 is still cut through the extensively faulted zone on the western side of the Guadalupe and Delaware Mountains. Numerous small faults are present here, as they have been in most of the outcrops we have passed in the last 10 to 15 miles. The ruins of a way-station of short-lived Butterfield Overland Stage route are located behind the Texas Highway Department garage on the left. As with other parts of this route, the station was abandoned in 1859.
1.3	107.6	51.8	Guadalupe Mountains National Park headquarters (Frijole Station) on the left. This park is one of the newest in the National Park system, having opened in 1972. In 1978 approximately 60 percent of the park was designated as wilderness area, precluding any large-scale development. The establishment of the park resulted, in large part, from the concern and generosity of Wallace Pratt, one of the first geologists of the original Humble Oil and Refining Co., who lived for many years in the McKittrick Canyon area. Pratt's gift to the government of more than 5,000 acres was the first concrete step toward the formation of this park.
1.3	108.9	50.5	Exposures of Cherry Canyon Formation sandstone; this section is just below the South Wells Limestone Member.
0.8	109.7	49.7	Quaternary fanglomerates in road cuts.
0.5	110.2	49.2	Road cuts in Cherry Canyon Formation. The South Wells Limestone Member is present at the top of this exposure and consists of thin-bedded sandstone and thin, lenticular, brachiopod-bearing limestones. The limestone beds range in thickness from a few inches to a few feet and are generally micritic. The intercalation of thin limestones and sandstones tends to lower the erosional resistance of this unit and therefore it does not form a prominent scarp. This is not true of the other limestone members of the Cherry Canyon Formation, however.
1.0	111.2	48.2	We are descending off the Rader Ridge. The ridge is capped by the Rader Limestone Member of the Bell Canyon Formation (the third named member up from the base of the formation). We are now, once again, passing through the upper part of the Cherry Canyon Formation.
0.2	111.4	48.0	Nickle Creek Exxon Station on the left. The greenish, bentonitic beds of the Manzanita Limestone Member are visible at 11:00 o'clock, about half way up the hill.
0.8	112.2	47.2	Road cut in Manzanita Limestone. The Manzanita is between 100 and 150 ft thick in this area.
0.3	112.5	46.9	STOP II-4. This section shows a major submarine slide deposit at the base of the Rader Member of the Bell Canyon Formation. The southwestern end of the outcrop consists of laminated sandstones and siltstones

of an unnamed member of the Bell Canyon Formation. At the top of this sandstone is a conglomerate zone with limestone blocks set in a sandstone matrix. The limestone clasts are very poorly sorted and range from pea-sized pebbles to car-sized boulders (fig. 12). The clasts are non-dolomitic, generally light-colored limestones derived from the Capitan reef and upper fore-reef environments. Above this zone of bouldery rubble is a thick, graded bed of similar, but finer grained, carbonate clasts with carbonate matrix and cement. This, in turn, is capped by a series of thin-bedded, fine-grained, dark-colored limestones which are typical of the basinal limestone members of the Bell Canyon Formation.

This slide deposit is one of several which have found in the Delaware Basin. Three superimposed slides within the Rader Member make up the hummocky Rader Ridge in this area. Other slides are locally present in the Manzanita Member of the Cherry Canyon Formation and at the top of the Lamar Member of the Bell Canyon Formation (Newell and others, 1953, p. 69-77). These are, however, exceptional and localized events which move reef- and slope-derived material far beyond the range of the normal fore-reef rubble fans. For example, the outcrop we are at represents a slender, perhaps channelized, tongue of rubble which extends off a broader slide. This tongue of transported debris extends nearly five miles into the basin from the reef crest. This deposit has been shown to thin rapidly from reef to basin (Newell and others, 1953). It is nearly 100 ft thick at the base of the steep fore-reef slope but has thinned to less than 10 ft at this locality.

The mechanism of transport of the limestone clasts probably is largely as a submarine slide or debris flow. The volume of material involved is comparable to that of large, documented, subaerial landslides (Newell and others, 1953, p. 77). As with subaerial landslides, there is remarkably little disturbance of underlying soft sediment substrates. The incorporation of sandstone matrix with limestone boulders, and the channelized or abruptly terminated margins of the slides indicates that there was some erosion and inclusion of the underlying Bell Canyon sandstone in the slide. There may also have been some subsidence or foundering of the large, heavy, limestone blocks into the underlying sands.

The event which triggered the slide also, apparently, led to the generation of a turbidity current which deposited the thick graded bed which overlies the slide. This association appears to be a common one and has even been observed in modern submarine slides.

The Rader Limestone Member has a total thickness

			of about 15 ft in this area, and about 10 ft is exposed at this outcrop. The unit thickens to a maximum of about 120 ft within about 3 miles as one approaches the basin margin (to the northwest).
0.1	112.6	46.8	Road cuts in Rader Limestone.
0.5	113.1	46.3	STOP II-5. Well-sorted, subarkosic sandstones of the Bell Canyon Formation showing remarkable uniformity of bedding and horizontal lamination. The Bell Canyon Formation is about 700 ft thick at its type locality, but has been reported to be as thick as 860 ft in subsurface sections (Hayes, 1964, p. 14). As with the other basinal sandstone units of the Delaware Mountain Group, the depositional mechanisms of the Bell Canyon sandstones have been extensively debated. The abundance of horizontal lamination and the apparently euxinic conditions in the basin center lend credence to the idea of density overflows and suspension deposition of much of the sand and silt. On the other hand, the presence of numerous subparallel erosional channels, most of them oriented from northeast to southwest, indicates that seafloor erosion, transportation, and deposition by long-lived density underflows, turbidity currents, or grain flows were also important. More than 100 oil and gas fields have been discovered in the Bell Canyon Formation as of 1979 (table 3). These "are stratigraphic-hydrodynamic traps which occur where sandstone-filled channels are incised into less permeable interchannel sandstone" (Williamson, 1979, p. 39). These channels are as much as 5 miles wide, 100 ft deep, and 50 miles long and the shape and orientation of these channels clearly controls the size, trend, and productivity of oil and gas fields.
0.7	113.8	45.6	Entrance to McKittrick Canyon day-use area of the Guadalupe Mountains National Park on the left. See McKittrick Canyon supplementary roadlog.
0.1	113.9	45.5	The escarpment ahead is formed by the Lamar Limestone Member of the Bell Canyon Formation.
1.0	114.9	44.5	STOP II-6. This section exposes basinal, black, laminated limestones and shales of the Lamar Limestone Member (fig. 13). Some features indicative of turbidite deposition of platform-derived, fine-grained carbonate sediment can also be seen. The Lamar is largely unfossiliferous at this locality. It becomes darker and more organic carbon-rich toward the basin center; indeed, all benthic organisms are absent from these basin-center sediments. Conversely, the unit becomes lighter colored and more fossiliferous toward the basin margin. It seems, therefore, that euxinic conditions were largely restricted to the deepest parts of the Delaware Basin (Babcock, L. C., 1977). In this area, relatively near the basin margin, a

moderately diverse fauna which includes burrowing pelecypods, siliceous sponges, holothurians, and conodonts, is evidence that conditions here were not uniformly anaerobic (Babcock, L. C., 1977). Yet the evaporite crystal casts found on many bedding surfaces, the organic carbon-rich sediment, and the widespread preservation of very fine-scale lamination all indicate that largely, euxinic, evaporitic bottom waters occupied this region during much of Lamar time. Presumably, the dominantly anocix conditions were periodically relieved by input of turbidity currents bringing sediment-laden, oxygenated waters downslope into the basin. These events were probably accompanied by short-lived but widespread colonization of the basin floor by benthic organisms.

The lateral thickness variations of the Lamar follow a similar pattern of basin-margin to basin-center change. The Lamar thins from 300 ft along the Capitan slope, to approximately 20-30 ft in this area, to as little as 6 ft in outcrops about 17 miles from the basin edge, and eventually to only a few feet of silty shale in subsurface sections near the basin center (Tyrrell, 1969; Babcock, L. C., 1977).

The Lamar is the youngest limestone unit in the Guadalupian part of the Delaware Basin. As such, it is a lateral facies equivalent of the uppermost part of the Capitan Limestone on the shelf edge, and the Tansill Formation in back-reef, shelf-interior areas.

1.2	116.1	43.0	Roadside rest area on right. Excellent exposures of reef and fore-reef deposits can be seen to the southwest. The exposed part of the reef becomes progressively older toward the south. The crest of the reef at the southern end of its outcrop (near Guadalupe Peak) is approximately 1,000 ft lower stratigraphically than the reef exposed at Walnut Canyon, about 25 miles to the north of this location. This implies that the face of the reef has been eroded back by at least 1/2 mile in the southern Guadalupe Mountains region.
7.9	124.0	35.4	Straight ahead lies the solution escarpment of the Castile evaporites. We are driving on a surface of Quaternary gravels which lie on the basal limestone and shale unit of the Castile and on the Lamar Limestone.
1.4	125.4	34.0	Junction with Texas Ranch Road 652 on the right. Continue straight ahead.
0.1	125.5	33.9	Texas-New Mexico state line. Welcome to New Mexico.
1.6	127.1	32.3	Notice the difference in vegetation on the gravel surface on which we are now driving versus that on the hills of Castile gypsum and anhydrite directly ahead.
0.5	127.6	31.8	STOP II-7. Excellent exposures of the Castile Formation in deep roadcuts. This unit is the oldest post-Guadalupian sediment in the region and conformably

overlies the Guadalupian Bell Canyon Formation. The Castile is entirely confined to the Delaware Basin and does not extend onto the adjacent shelf areas. It has a thin, basal limestone and shale zone which may be a lateral facies equivalent of the very youngest part of the Capitan and Tansill Formations. The bulk of the Castile, however, consists of a thick section of laminated anhydrite with intervals of laminated halite. The Castile Formation has been reported to reach a maximum thickness of 1,550 to 2,000 ft in subsurface sections in the northeastern part of the Delaware Basin (King, 1948, p. 89).

The Castile grades conformably upward into the Ochoan Salado Formation; the Salado contains laminated halite, anhydrite, sylvite, polyhalite, and even more soluble evaporite minerals. The extreme solubility of its components means that the Salado does not generally appear in outcrop. Indeed in this area, much (or all) of the Salado may have been removed by erosion. The Salado does, however, form a wedge of sediment which thickens toward the the northeast to a maximum of greater than 2,000 ft (Anderson and others, 1972, p. 82). In the northeastern part of the Delaware Basin, the Salado is extensively mined for potash minerals. Unlike the Castile, the Salado Formation extends beyond the borders of the Delaware Basin onto the surrounding shelf areas where it generally lies directly on Guadalupian carbonate rocks. The Salado, in turn, is unconformably overlain by the dolomitic Upper Permian Rustler Formation, the Dewey Lake Redbeds, and younger units. The pre-Rustler unconformity shows extensive Permian tilting and erosion for, in places (particularly the southwestern part of the region), it has completely removed the Salado, allowing the Rustler to lie directly on the Castile Formation or Guadalupian carbonate rocks.

The onset of Castile evaporite deposition coincided closely with the termination of reef growth around the Delaware Basin margin. It is not entirely clear whether this is a causal or coincidental relationship. Eustatic sea level drop, tectonic movements, reef growth, or other factors could have increased the restriction of influx of normal marine water into this already partially barred basin. This, coupled with the extreme aridity and high evaporation rates in the area, may have led to drastic increases in the salinity of basin water, with the associated killing of the salinity-sensitive reef organisms and the eventual start of evaporite deposition. It must be emphasized, however, that although the changes in depositional patterns at the Guadalupian-Ochoan transition were dramatic, the causes of these changes may have been considerably more subtle.

Strongly evaporitic conditions existed throughout Guadalupian time as, apparently did hypersaline stagnant bottom waters in the basin. Marine influx from the south was certainly present during Guadalupian time to maintain normal marine conditions in the surface waters of the Delaware Basin. This influx must have continued through much of Ochoan time, if in a somewhat more restricted form, to supply the salts of the Castile and Salado Formations. Thus, it appears most likely that it was a gradual change in marine water supply versus evaporative water removal which led to the abrupt shift from carbonate to evaporite sedimentation, presumably when a critical salinity level was reached. This gradual (but not perfectly continuous) salinity transition apparently continued through Ochoan time, leading to deposition of anhydrite, then halite and sylvite, and eventually the true bittern salts found in the northeastern Delaware Basin.

The Castile Formation, then, represents an evaporite filling of the approximately 1,800 ft deep basin left at the end of Guadalupian time. Although there may have been some drop in basinal water levels, the Castile clearly was deposited in deep water as indicated by the complete absence of shallow-water sedimentary structures and the presence of fine-scale lamination. The laminae consist of regular (although variable thickness) alternations of white anhydrite laminae and darker laminae containing a mixture of organic matter and calcite (fig. 14). The anhydrite-calcite couplets average 1-2 mm in thickness throughout the Castile Formation (Anderson and others, 1972 p. 73). On outcrop, the anhydrite may have been altered to gypsum (this locality has both gypsum and anhydrite exposed according to S. D. Kerr in Dunham, 1972). The laminations have remarkable lateral continuity, as one might expect for deeper-water evaporites, and individual laminae have been traced for more than 70 miles (Anderson and others, 1972). Contortion and deformation structures (fig. 15) are post-depositional and presumably represent volume changes due to hydration and/or dehydration reactions.

The laminations of the Castile Formation (as well as those in the uppermost Bell Canyon and Salado Formations) have been interpreted as annual varves (Udden, 1924; Anderson and others, 1972). The calcite and organic-matter layers represent periodic (annual?) freshening of the water and the development of plankton blooms. The anhydrite layers represent restricted, more evaporitic conditions. Approximately 260,000 such cycles have been counted in the uppermost Bell Canyon-Castile-Salado sequence. This implies extremely rapid deposition of thousands of feet of evaporites in the Delaware Basin, a common situation with major evaporite deposits.

The evaporite filling of thè Delaware Basin is largely responsible for the spectacular exposures of the Guadalupian facies which we are seeing on this trip. The complete plugging of the "hole" left at the close of Capitan reef growth and the subsequent, Tertiary, removal of that plug has left us with resurrected Guadalupian topography and facies relations in this area.

The Castile and Salado evaporites may also have had a major impact on the oil and gas distribution in the Permian Basin. The rapid burial of basinal source rocks to depths sufficient for oil and (or) gas generation is one probable effect. It is quite possible that compactional geopressuring of the basinal sediments resulted from the rapid deposition. This may have eventually aided the early migration of hydrocarbons from the basin, before deep burial and destruction of porosity in potential shelf reservoirs. Overpressuring and early oil migration may have been significant factors in the excellent hydrocarbon productivity of the Permian Basin region. The early oil movement may also explain why primary porosity and early diagenetic porosity modifications, rather than later diagenetic porosity types, are so important in many Permian Basin reservoirs. Finally, the extensive blanketing of both shelf and basin by an impermeable cover of evaporites clearyly provided an outstanding seal for the entire region.

1.9	129.5	29.9	Note hummocky, solution-generated topography on top of the Castile evaporite. These are the Yeso Hills.
1.1	130.6	28.8	White's City visible directly ahead in the distance. The valley to the left is developed on the uppermost Bell Canyon strata (Lamar and post-Lamar beds). The Capitan reef escarpment can be seen plunging to the north beneath Ochoan and younger sediments as a consequence of structural tilting. To the south, the reef rises higher and higher on the skyline to the point where it has been removed by erosion. The buildings at the entrance to Carlsbad Caverns can be seen on the ridge top at about 11:00 o'clock.
1.2	131.8	27.6	Zone of Quaternary rubble probably dervied from dissolution of upper Castile or Salado evaporites. Several thin, weathered, basaltic igneous dikes cut the evaporite section in this area.
1.4	133.2	26.2	Roadside rest area on left.
1.2	134.4	25.0	At a point approximately 300 ft east of the highway, loose boulders of Lower Cretaceous (Commanchean) limestone have been described by W. B. Lang who interpreted them as fragments of widespread Cretaceous cover down-dropped and preserved in solution pipes cut into the Ochoan evaporites.
1.5	135.9	23.5	Entrance road to Slaughter and Rattlesnake Canyons and

			New Cave on left. Both Rattlesnake and Slaughter Canyon have excellent exposures of the late Guadalupian fore-reef, reef, and back-reef facies (see Pray and Esteban, 1977). Continue straight ahead.
0.3	136.2	23.2	Highway is still on Castile Formation. The mouth of Slaughter Canyon is visible at about 8:00 o'clock; the mouth of Rattlesnake Canyon can be seen at about 9:00 o'clock. The northwest-southeast trending Huapache Monocline crosses the Capitan reef front between these two canyons.
1.8	138.0	21.4	Quaternary gravel in road cut.
3.3	141.3	18.1	Beautiful downtown White's City. Junction with New Mexico Highway 7 to Walnut Canyon and Carlsbad Caverns on left. See separate "Walnut Canyon" supplementary road log. Continue on U.S. Highway 62-180 to Carlsbad, New Mexico.
5.0	146.3	13.1	Bridge over Jurnigan Draw. Rustler Formation red beds can be seen in middle distance on right.
0.2	146.5	12.9	Junction with New Mexico Highway 396 on right. The Black River oil field is located to the right; the field produces 42° API gravity oil from sandstones and siltstones just beneath the Lamar Limestone member of the Bell Canyon Formation at about 1,950 ft depth. The hills to the left are composed of Capitan reef limestone.
1.5	148.0	11.4	Road cut in Rustler Formation.
0.7	148.7	10.7	Road cut in Rustler Formation.
2.6	151.3	8.1	Junction with Dark Canyon Road on left near old Frontier Trading Post and Museum. The hills to the west are composed of Tansill Formation near-back-reef limestones and dolomites. The one well Dark Canyon oil field lies about 1/2 mile to the west. Completed in 1952, the field produced from an 11 ft pay zone in Delaware Mountain sandstone at 1,876 ft. The well continued to produce for many years at 10 to 12 BOPD. Continue straight ahead for Carlsbad. See supplementary "Dark Canyon-Sitting Bull Falls-Rocky Arroyo" roadlog for route to left.
1.0	152.3	7.1	In the foreground to the left are the Frontier Hills composed of Ochoan Rustler Formation sediments which dip southeastward into the Delaware Basin. The Rustler Formation in this area consists of dolomite, red beds, fine-grained sandstones, and minor gypsum. The Rustler overlies the Salado Formation in the Delaware Basin but lies directly on the Capitan Limestone in the ridge west of the Frontier Hills.
1.8	154.1	5.3	Carlsbad city limit.
1.3	155.4	4.0	Quaternary caliche exposed in pits on right.
0.4	155.8	3.6	Caverns City Air Terminal (Carlsbad municipal airport) entrance on left. The Hackberry Hills to the west are composed mainly of Tansill dolomites and upper Yates dolomites and sandstone---both back-reef facies equivalents of the uppper part of the Capitan reef.

			The reef itself is completely buried beneath younger sediments in this area. The back-reef equivalents are exposed only because of the gentle (approximately 5 degree) eastward dip of the Guadalupian strata in this area.
2.5	158.3	1.1	Rodeway Inn on right.
0.1	158.4	1.0	Holiday Inn on right.
0.3	158.7	0.7	Ocotillo Hills located to the northeast.
0.7	159.4	0.0	Junction with U.S. Highway 285 to Pecos, Texas on the right. Road log ends here.

MCKITTRICK CANYON ROADLOG

Mileage	Cum. Mileage	
0.0	0.0	Junction of U.S. Highway 62-180 with paved road to McKittrick Canyon day-use area (mileage 113.8 on El Paso-Carlsbad road log). Take McKittrick Canyon road. Most of this new road is cut in the McCombs to Rader interval of the Bell Canyon Fm. The cliffs on the right (north) are capped by the Lamar Limestone Member.
0.4	0.4	The view ahead is directly into the steeply dipping Capitan fore-reef talus deposits.
1.6	2.0	The view to the northwest shows the exhumed Delaware Basin margin, largely stripped of its evaporite filling. The reef-massif is characterized by an apparent lack of bedding and a strongly developed vertical joint pattern which trends parallel to the reef front. These were penecontemporaneous growth faults probably produced by compaction of the 1,500-2,000 ft of largely unconsolidated reef talus over which the reef was prograding. The penecontemporaneous formation (and filling) of the joints is shown by the fact that locally one finds specialized Permian faunas lining fracture walls. The joints are also filled with submarine calcite cement crusts, Permian siltstones, soil crusts, and other materials. Steeply dipping fore-reef deposits are visible down-slope from the reef and these form a smooth transition to the nearly flat-lying toe-of-slope and basinal deposits seen at the base of the escarpment.
2.0	4.0	Outcrops of massive, fine-grained, toe-of-slope deposits of the Lamar Limestone on the left. Large-scale lenticular bedding is clearly visible. Although largely composed of micritic limestone, these deposits contain a significant reefal fauna. Thus, they were originally interpreted as bioherms formed in deep water (depths probably in excess of 1,600 ft). However, recent studies of the Florida Straits and similar areas have shown that such deposits can be produced by a combination of down-slope reworking of reefal debris, along-slope transport and deposition by contour currents, and submarine cementation. Thus, these lenticular deposits may be analogous to the "lithoherms" of the Florida-Bahamas region.
0.3	4.3	McKittrick Canyon parking area. STOP II-1. We will walk up the stream bed for a short distance (about 1/2 mi) and then climb up the spur on the south side of McKittrick Canyon, an approximately 1,000 ft climb. Please wear sturdy hiking boots as we will be crossing sharp rock- and cactus-covered terraine. Also remember that we are now in the Guadalupe Mountains National Park and rock hammering or collecting is not allowed without a permit. Finally, the difficulty of the terraine, the size of the group, and the lack of a clearly marked trail make it imperative that we all stay together as a group. PLEASE, DO NOT WANDER OFF ON YOUR OWN OR IN SMALL SUBGROUPS. We

will keep the pace slow enough so that we can all remain together.

The purpose of this stop is to examine the toe-of-slope and fore-reef facies transitions of the Capitan Limestone and its equivalents. Although it would be pleasanter if this facies change could be seen without resorting to a strenuous climb, this is not possible. It must be remembered that the facies transition is one which took place on a 30 degree slope over a vertical distance of more than 1,000 ft; thus, the vertical component is an important one. Also, these facies are exposed only in areas south of White's City and are easily accessible only in Rattlesnake, Slaughter, and McKittrick Canyons. All three areas require extensive climbing and McKittrick provides the best visual continuity of lateral facies.

Our upward climb will take us across a number of different Bell Canyon units (fig. 16). We start at the level of the Rader Limestone, and cross several unnamed sandstone units, and the McCombs Limestone before reaching the Lamar Limestone. We will then descend along the Lamar dip-slope and view the lateral changes within a single unit.

Because there is no well-marked path, it is not possible to provide a detailed description of this tour. However, it is possible to provide a general picture of the salient features of the route. We start in the thin-bedded, dark-colored, micritic limestones of the Rader. Bryozoans and brachiopods are the most commonly seen megafossils. Chert nodules and silicified (originally calcitic) organisms abound (fig. 17) with the silica having been derived from siliceous sponges (fig. 18) and radiolarians which lived or accumulated in the down-slope area. The only other macroscopic diagenetic feature visible is compactional deformation around fossils, concretions, nodules, or all ochtonous blocks of reefal debris (fig. 19). Channels filled with cross-bedded reef- and slope-derived debris and large blocks of reef limestone also can be seen locally in these beds.

As we move upslope, we will see thick packages of fine-grained, well-sorted sandstone and siltstone interbedded with the limestone members. The sandstones are compositionally identical to the thin back-reef sandstone and siltstone units we will see at other localities. The up-slope interfingering of discrete, basinward-dipping sandstone and carbonate units indicates that both were derived from the shelf. The sandstones also show extensive evidence of down-slope current transport including cross-bedding, channels, ripple marks, and other features. The farther upslope we move the more dominant the carbonate units become; at the same time, the sandstones become thinner and eventually pinch out entirely. The carbonate units become progressively more massive and coarser-grained in an up-slope direction (fig. 20); the carbonate grains also tend to be more clearly recognizable as reef- and slope-derived skeletal fragments. The fact that this is primarily reef rubble is clear from the abundance of original framework producing organisms, such as calcareous sponges and bryozoans, as well as the organic encrustation and submarine cementation of many of the clasts. In local areas, massive, sorted, and channelized grain flow and turbidity current deposits of carbonate material are visible. In most areas, however, these units have little obvious internal structure.

The diagenesis of these units is complex. Many of the clasts of calcareous debris underwent submarine cementation in their original environment of formation. Subsequent alteration in the down-slope depositional environment included (at least locally) partial, late-diagenetic dolomitization (fig. 21), leaching of aragonitic grains, and medium-crystalline calcite cementation. Compaction is not extensive in these units, but grain fracturing is common (fig. 22), and porosity is generally quite low.

As we approach the crest of the hill, apparently *in situ* and extensively encrusted material becomes dominant. Some of this may represent blocks of debris too large to recognize, but most of it presumably indicates *in situ* lithification and encrustation of material at the base of the active reef-forming area by organic and inorganic agencies. Reef growth, algal encrustation and inorganic (submarine) cementation extends into water depths of several hundred feet in many modern tropical reef areas. Similar patterns are to be expected in the Permian. Thus, although the zone of major faunal growth and diversity lay upslope from the highest point we will ascend to, some *in situ* growth of reef organisms, algal encrustations, and submarine cementation presumably extended downslope into the areas we are crossing.

The view from the small peak we have climbed is one of the finest in the Guadalupe Mountains from a geological perspective. This vantage point allows us to look directly at the north wall of McKittrick Canyon (fig. 16) and largely eliminates the problem of apparent dips which complicated our earlier panoramas. The vast bulk of the sediments which make up the lower 3/4th of the north wall of McKittrick consist of Capitan fore-reef debris (fig. 16). In many areas, particularly near the mouth of the canyon, the steep, dip (nearly 30 degrees) of these rubble beds is apparent. The gradual flattening of those dips to the near-horizontality of the basinal Bell Canyon sediments is equally apparent in that area. Indeed, the uppermost basinal limestone (the Lamar) can be traced as a virtually continuous bed from basin to shelf (fig. 16) as it rises more than 1,700 ft. The same transition can be viewed in the shelf-edge escarpment visible to the north and northeast.

Above the bedded Capitan talus lies a massive, nearly completely unbedded zone of the Capitan reef-massif (fig. 16). The massive character is a consequence of both the original skeletal framework with its encrusted (boundstone) fabric, and the massive, penecontemporaneous cementation which completely pervaded the reef and obliterated virtually all porosity. Although particularly well developed at its eastern end, the reef massif can be traced continuously toward the west. In this direction, the reef passes lower and lower in the section but continues to overlie thick, reef-talus deposits. Thus, from this vantage point we can see that the Capitan reef built upward nearly 1,000 ft during the time in which it prograded out over its own debris; the debris, furthermore, filled in a basin of between 1,000 and 2,000 ft water depth.

The ratio of reef rubble to *in situ* reef is extremely high, a fact noted by many workers. As pointed out by Dunham (1972), however, this is not a surprising situation. In modern reef-forming areas, the zone of significant reef growth is narrow, both laterally and vertically. The active growth zone is but a thin veneer on the upper and frontal edge of the reef platform. Much of this *in situ* material is eventually broken up by storms and reworked reworked down the fore-reef slope. New organisms grow in the reef crest area only to be reduced to rubble as well. Vast quantities of material are formed within the reef zone but only a small fraction of this volume remains in that environment. Most is swept away into fore-reef or back-reef settings. Thus, the vast amounts of rubble visible in the Capitan complex are not a valid piece of evidence to deny the existence of a true reef in this area. Rather, the rubble serves as evidence that the shelf edge was occupied by a faunally diverse assemblage of organisms with remarkably high rates of sediment production.

Above and to the west of the Capitan reef-massif, a wedge of flat lying, well bedded, back-reef sediments (Tansill and Yates Fms.) can be seen (fig. 16). The wedge thickens to the west where older sediments are exposed. The sediments (mainly green algal-fusulinid grainstones) of the near-back-reef Tansill can be seen to pass into and over the Capitan reef-massif and perhaps even to spill over onto the slope in front of the reef. This may be an indication that reef growth ceased before the end of carbonate sedimentation in the area. In that case, the final phase of shelf-edge deposition would have been marked by unconsolidated skeletal sand shoals rather than a barrier reef.

The spectacular view of facies relations on the north wall of McKittrick Canyon is matched by the vista to the north and northeast. It shows present-day topography which virtually exactly matches that of late Guadalupian time. Back-reef sediments mark the upland surface of the Northwest Shelf; Capitan reef sediments, characterized by their vertical, strike-parallel jointing, delineate the upper margin or rim of the Delaware Basin; steeply dipping slope deposits compose the flanks of the escarpment; and flat-lying basinal deposits of the upper Bell Canyon Fm. compose the floor of the present basin to the east-northeast (the

Delaware Basin). The exhumation of this Permian topography is entirely a consequence of the thick, (Castile) evaporite filling of the remnant Delaware Basin in Ochoan time, and its subsequent dissolution during the Tertiary.

To the east and southeast, a series of cuesta scarps of the various limestone members of the Delaware Mountain Group are visible. These culminate in the major escarpment of the Delaware Mountains, capped by the Getaway Ls.

On our descent down the dip slope of the Lamar, on which we are now standing, we will see a progressive change in the character of the rock. We will see greater amounts of finer-grained, darker-colored, less encrusted, and less obviously detrital sediment as we move downslope. Silicification will increase we approach the base of the slope.

We will eat lunch in the parking lot at the mouth of McKittrick Canyon and will then retrace our route back to U.S. Highway 62 and 180.

4.3 8.6 Junction with U.S. Highway 62 and 180. Turn right for El Paso or left for Carlsbad at mileage 113.8 on the El Paso-Carlsbad roadlog.

WALNUT CANYON ROADLOG

Mileage	Cum. Mileage	
0.0	0.0	Junction with U.S. Highway 62-180 and New Mexico Highway 7 in White's City, New Mexico at mileage 141.3 (reverse mileage 18.1) on El Paso-Carlsbad roadlog. Take NM Highway 7 toward Carlsbad Caverns.
0.5	0.5	STOP I-2. Carlsbad Caverns National Park entrance sign. Park along road or in dirt lot on south side of road. This locality, at the entrance to Walnut Canyon, provides excellent exposures of the reef and near-back-reef facies of the upper Capitan Limestone and Tansill and Yates Formations. In this area, the fore-reef facies and part of the reef have been buried beneath the thick Ochoan (and some thin Tertiary-Quaternary) filling of the Delaware Basin. The Castile Fm., although completely or partially removed in areas to the southwest, has been preserved in this area because of the northeastward tilting of this region. Thus, only a small exposure of the reef-crest and its transition to the near-back-reef are exposed. Because an outstanding guidebook is available for the entire Walnut Canyon route (Pray and Esteban, 1977), only rather brief descriptions will be given for these localities (this site corresponds to Locality guide I, stops I and II of Pray and Esteban, 1977).

We will examine the rock spur between Walnut Canyon, and Bat Cave Canyon (fig. 23). We will pay particular attention to several fresh outcrops in Bat Cave Canyon for these expose the reef fabric in an unweathered and more readily visible state. Please note, however, that much of this exposure is within the National Park boundaries and thus collecting permits are required for sampling.

Babcock (1974) noted a distinct zonation of the reef. He recognized an *Archaeolithoporella*-nodular boundstone, a phylloid algal boundstone, and a *Tubiphytes*-sponge boundstone/packstone (fig. 23) as well as some transitional zones. In all these facies there are four salient elements: 1) an *in situ* framework of oriented organisms; 2) encrusting and binding organisms which added stability to the framework; 3) internal sediment of skeletal fragments, pellets, or other grains which lodged in open pores in the framework; and 4) submarine cement crusts filling virtually all remnant porosity.

The dominant framework organism in this complex is the calcareous sponge (fig. 24). Many different types existed here, including members of the genera *Guadalupia, Amblysiphonella, Cystaulete,* and *Cystothalamia.* Other organisms such as *Tubiphytes* (of probematic affinities), stromatolitic blue-green algae, phylloid algae, and bryozoans also form significant framework elements, at least locally.

Encrustation and stabilization of this skeletal framework was accomplished by *Archaeolithoporella* (a possible alga), *Tubiphytes* (found as both framework and encrusting forms), *Solenopora* (a probable red alga), and other, less common organisms (fig. 25). Such encrustation, seen also in modern reefs, probably contributed greatly to the strengthening of the reef framework.

Internal sediment, although not a significant factor in the lithification of the reef, did play an imporant role in infilling and occluding the primary reef porosity. Internal sediments generally are found as laminated, geopetal fabrics, sometimes with interlayered submarine cements (fig. 26). The internal sediments contain a specialized fauna including foraminifers, ostracods, echinoids, pelecypods and other organisms which presumably lived within interstices in the reef framework.

Submarine cements form a very important component of the Permian reef. Coarse fans of radial-fibrous crystals fill much of the primary porosity in the reef and make up more than half the total volume of rock in many locations. The cement fans, probably originally aragonite, are commonly interlayered with *Archaeolithoporella* or other encrusting organisms (fig. 25). The submarine cements are restricted to a relatively narrow zone which extends from several hundred feet down the fore-reef slope to perhaps one half mile shelfward of the reef crest. Very similar relations have been seen in modern reefs such as in Belize, Florida, the Bahamas, and Jamaica. In these areas, as in the Permian, submarine cementation, largely in the form of aragonitic and high-Mg calcite fans and crusts, are restricted to the reef face, upper fore-reef, and near-back-reef zones.

After seeing these major fabric elements where they are unweathered and well exposed in Bat Cave Canyon we will cross the spur to Walnut Canyon. Examine the sediments on this traverse and try to recognize the same fabrics where they are more intensely weathered. Also examine the fracture fillings along Walnut Canyon.

We will now walk up Walnut Canyon examining the transition from reef to near-back-reef areas, eventually crossing from the south to the north side of Walnut Canyon.

On this traverse, be sure to note changes in bedding character as well as sediment composition. Also note the remarkably rapidity of the lateral lithologic changes. The most obvious change is from a boundstone fabric to one of grainstones and packstones containing ooids and skeletal grains. Cephalopods, foraminifers, pelecypods, gastropods, and most importantly, dasycladacean green algae, particularly *Mizzia* and *Macroporella*, rapidly supplant sponges and bryozoans as the major skeletal components. Bedding in these well-sorted grainstones is massive and indistinct (fig. 27) but still is far better defined than in the reef facies. Grain size ranges from coarse silt to coarse sand; sorthing moderately good to excellent. Coated grains and ooids form a significant percentage of the total sediment (figs. 27, 28 and 29).

Sediments further up-canyon (farther back-reef) show increasing amounts of dolomite, fenestral fabrics, coated (pisolitic) grains, algal(?) lamination, carbonate breccias, "tepee structures", and thin, clastic terrigenous sandstone-siltstone units.

The abrupt facies transition from reef to back-reef is similar to that seen in many modern settings. In the Florida Keys on the western side of Andros Island in the Bahamas, for examples, the change from reefal boundstones to skeletal, back-reef grainstones takes place over distances of just a few tens to hundreds of feet. The near-back-reef areas in Florida and the Bahamas generally consists of complex, small-scale mircofacies of green-algal (*Halimeda*) grainstones, grapestones (coated and coalesced grains), ooids, skeletal fragments, and other lithologies. In areas such as the Joulter's Cay region of the Bahamas, one can see these grainstone types closely intermingled as a series of submarine sand waves, islands, tidal channels, and beaches. Associated with these grainstones are mudstone-wackestone microfacies in sheltered areas of tidal flats and back-barrier coves. The extremely varied lithologies in the Permian near-back-reef setting presumably reflects similarly complex microfacies patterns. This is also evident in the intimate mixture of diagenetic patterns in the Permian near-back-reef sediments. Submarine as well as vadose phreatic nonmarine cements are all present in local zones in this area probably as a result of local (island facies) input of nonmarine fluids.

Return to vehicle(s) and proceed up-canyon.

0.2	0.7	Near-back-reef *Mizzia*-dominated grainstones on right which we have examined in our previous traverse.
0.2	0.9	Cross Walnut Canyon.
0.2	1.1	Pisolite-bearing dolomites and faulted upper Yates sandstones in roadcut.
0.1	1.2	Upper Yates and lower Tansill sediments in canyon walls. This locality exposes mainly pisolitic dolomites and sandstones and is an excellent area for examining tepee structures.
1.0	2.2	Exhibit area on right.
0.3	2.5	Road cuts on right expose Yates Fm. dolomite and sandstone.
1.0	3.5	Parking area on left with exposures of pisolitic dolomites, tepee structures, and sandstones of Yates Fm.
0.5	4.0	Exhibit area (showing botanical diversity of the area) on the left. Canyon wall on left has exposures of Yates Fm., including the large, sand-filled cavern described by Dunham (1972, Stop II-5).
1.25	5.25	Sharp bend in road; primitive road on right can be used as parking area to view exposures of Yates Fm. just ahead.
0.05	5.3	STOP III-7. Outstanding exposures of pisolitic dolomites of the upper Yates Fm. (see Pray and Esteban, 1977; Dunham, 1972). This locality illustrates numerous cycles of pisolitic sediments (termed "Walnutite cycles" by Pray and Esteban, 1977). Tepee structures (fig. 30) can be seen both in this outcrop and in the distant canyon wall to the north. The main small-scale features to be seen at this outcrop are

the abundant pisoliths which range from B-B-size to golf ball-size. They have concentric laminations of thin carbonate coatings around nuclei of fractured pisoliths (fig, 31) or, rarely, marine fossils. The pisoliths, which have been completely replaced by aphanocrystalline dolomite, occur in cyclic beds, commonly with reverse grading (fig. 31). In some (but not most) cases, pisoliths have intergrown or interlocking textures. There is considerable evidence to show that these pisoliths had original aragonite composition, now replaced by dolomite. They are associated with sheet cracks (broad bands of displacive, fibrous carbonate, presumably also originally aragonite but now dolomite or calcite; fig. 32). These displacive crusts are related to the origin of the tepee structures of this area for the tepees are expansion polygons formed by a volume increase of the associated sediments. This was most likely accomplished by *in situ*, near surface, displacive growth of aragonite and (or) evaporite minerals.

The origin of pisoliths and tepee structures in these sediments has been the subject of numerous studies and considerable controversy. Extensive discussions of these problems have been presented recently by Dunham (1972), Esteban and Pray (1977), and Pray and Esteban (1977) and so will be only briefly outlined here.

Basically there are two hypotheses: 1) the "all wet" model which proposes that the pisoliths were formed by organic (algal) or inorganic coating of grains in a shallow-water shelf setting with each grain acting as a free, clastic particle; and 2) the "caliche" hypothesis which suggests that pisoliths formed *in situ* as part of cyclic, reverse graded, caliche profiles which formed by alteration of carbonate sediment brought into the area by storms or other episodic processes. Advocates of either model can point to modern analogs (mainly from the Persian Gulf and Red Sea areas) with scattered, small-scale accumulations of aragonitic pisoliths in marginal marine, hypersaline settings. Yet nowhere have we discovered an analog which comes close to modeling the breadth and abundance of pisoliths that one sees in the Permian.

The differences of interpretation of these deposits, although important from the point of view of fully understanding the sediments, are not of great significance to the explorationist. There can be little argument that this facies must have stood as a paleotopographic high-point in Guadalupian time. The persistence of this facies in space and time (it is present in Seven Rivers, Yates, and Tansill rocks), its consistent geometry (an elongate facies, parallel to the reef trend), and its equally consistent juxtaposition between open marine (grainstones with a high faunal diversity) and restricted (hypersaline mudstones and evaporites) environments indicate that the pisolite facies must have been a major hydrographic barrier. Nowhere in the world today are evaporitic mudstones and open marine, faunally diverse sediments in close proximity without having an intervening barrier. It seems likely that to act as such a barrier, the region would have had to be subaerially exposed (except for tidal channels) and this would favor the caliche interpretation. It is possible, however, that broad, low relief, tidal flats could also act as partial hydrographic barriers. Finally, it is possible that a combination of processes could have acted. A number of different pisoliths can be seen in the Permian strata. These range from the small, irregularly coated grains seen at Stops III-2 and I-2 (and which almost certainly formed in a marine setting) to the larger, smoother, and more extensively encrusted grains present at this locality. Thus, a number of different origins can be envisioned for the different pisolith types.

The tepee structures and sheet cracks found in association with pisolitic sediments can also be interpreted as either marine or nonmarine. Displacive aragonite crusts and tepees have been noted in submarine cemented areas within the Persian Gulf itself as well as in coastal caliches and sabkha surfaces of the surrounding, subaerial-exposed coastlines.

0.3 5.6 Exhibit area on left; the thin sandstone-siltstone unit which marks the Tansill-Yates contact is exposed on the left. The road ascends into Tansill Fm. dolomites.

1.9 7.5 Cave entrance parking lot. Stop I-3. We will do the complete walking tour of Carlsbad Caverns - the Roswell Geological Society 1964 field trip guidebook provides a trail log of the caverns (Sanchez, 1964). The cave is cut primarily in the Capitan Limestone but the entrance and all of the upper level are in the back-reef dolomites of the Tansill and Yates Fms. The lowest parts of the cave are cut in steeply-dipping fore-reef talus of the Capitan, down to a level approximately 850 ft below the entrance. This level is presumably related to the regional groundwater discharge surface in the Pecos valley to the northeast. The history of development of the cave is extensively described by Jagnow (1979). The location and orientation of the Capitan reef and its early fracture system have controlled, to a large degree, the geometry of the local cave systems. Pliocene and Pleistocene uplift allowed percolation of phreatic groundwater through the joint system and eventual excavation of the caverns. The subsequent vadose history of the cave led to introduction (and later partial removal) of clay, silt, sand, and gypsum fills as well as calcitic speleothems. The cave is largely inactive today except for some areas in the lowest cave levels.

The outcrops at the southwest end of the parking lot provide exposures of tepee structures, sheet cracks, and pisolitic sediments of the Tansill Fm. We will probably not have time to visit these outcrops, but similar features are seen at Stop III-7.

Return down Walnut Canyon.

7.5 15.0 Junction with U.S. Highway 62-180 in White's City. End of supplementary roadlog. Turn left for El Paso or right for Carlsbad and rejoin main roadlog at mileage 141.2 (reverse mileage 18.1).

DARK CANYON - SITTING BULL FALLS-ROCKY ARROYO ROADLOG

Mileage	Cum. Mileage Clock-wise loop	Cum. Mileage Counter-clockwise loop	
0.0	0.0	80.1	Head west on paved road to Dark Canyon at mileage 151.3 (reverse mileage 8.1) on El Paso-Carlsbad roadlog.
0.4	0.4	79.7	The Hanson and Yates, King No. 1 well on the right is the entire Dark Canyon oil field. Numerous offset wells were dry holes.
0.8	1.2	78.9	Rustler Formation dolomite, sandstone, and gypsum make up the low Frontier Hills ahead.
1.5	2.7	77.4	Rustler Formation outcrops in hills on both sides of road.
1.2	3.9	76.2	Mouth of Dark Canyon. We have left the Delaware Basin and are now on the Northwest Shelf in the northeastern part of the Guadalupe Mountains. Bedded Capitan Limestone outcrops are present on both sides of the canyon.
0.15	4.05	76.05	Road intersection; take sharp right.
0.20	4.25	75.85	STOP III-1. We will examine the reef to near-back-reef transition in the uppermost part of the Capitan and lower Tansill Formations. These sediments have been mapped as reefal Capitan limestones by Motts (1962) and as back-reef limestones of the Tansill Formation by Kelley (1971). Tyrrell (1969) and Toomey and Cys (1977) presented extensive evidence to show that this locality provides an exposure of the transition beds between the Capitan and Tansill carbonates. Clearly, the major part of the reef front is buried beneath basinal sediments in this area but shelfward facies are well exposed. Thus, we can examine the near-back-reef skeletal grainstones containing ooids and algally coated grains, dasycladacean green algae (particularly *Mizzia* and *Macroporella*), crinoids, *belerophontid* gastropods, fusulinid Foraminifera, *Tubiphytes-Archaeolithoporella* colonies, and sponges (fig. 33). These rocks are similar in many ways to the sediments seen at the up-canyon end of the first stop in Walnut Canyon (Stop I-2) which would indicate that we are probably at, or only a short distance shelfward, of the main reef facies. Note the consistent change in bedding character as we walk in a shelfward direction. The abruptness of the facies transition seen here and in Walnut Canyon in the near-back reef setting is very similar to modern facies transitions in areas such as Florida or the Bahamas. There, as here, reefal debris tends to move primarily into fore-reef talus; back-reef sands

are dominated by grains of green algal origin (*Halimeda* in modern sediments; *Mizzia* in the Permian) ooids or coated grains, and other particles of shelf origin. Submarine shoals, channels, islands, and patch reefs have local distribtuion and complex, virtually unpredictable, patterns. Such modern setting appear to be excellent analogs for these older environments.

We will not be able to stay within the Tansill Formation in our entire traverse through the Capitan-equivalent shelf strata because erosion has removed much of the far-back-reef Tansill. We will see facies equivalents in older (but still Capitan-equivalent) strata of the Yates and Seven Rivers Formations. Evidence from remaining outcrops and subsurface data indicate that similar shelfward facies transitions occurred in all three back-reef units (fig. 34). The general sequence of facies from the shelf-edge landward tends to be reef; massive, skeletal (mainly green algal) grainstones; bedded and cross-bedded oolitic grainstones; dolomitized, fenestral grainstones and pisolitic mudstones; coarse, pisolitic, dolomitized grainstones with tepee structures; stromatolitic or pelloidal dolomitized mudstones; pure, calcisphere-bearing, dolomitic mudstones; with evaporite crystal casts and (or) collapse breccias; nodular gypsum or anhydrite units; and finally red siltstones.

Throughout this facies suite, thin but laterally persistent, fine-grained sandstone and siltstone beds are found. These sandstone-siltstone units, especially common in the Yates Formation, generally pinch out before reaching the reef facies; in several areas these sandstones approach within a few hundred yard of the reef. In the Yates (and the older Queen) strata, these terrigenous beds make up at least 1/3 of the formation thickness, are excellent regional correlation markers, and can act as reservoir units.

Because there was extensive (2-3 mile) basinward progradation of facies during Capitan deposition, the facies previously described as being lateral equivalents can also be seen to some degree in vertical sequence, a fact which has significant influence on the early diagenetic history of much of the sediment package. Figure 34 shows the progressive basinward shift of the evaporite-carbonate transition zones in successively younger, Capitan-equivalent back-reef units. Thus, the progradation of shallow-water, subaerial, or restricted environments over more normal marine sections may have allowed very early input of freshwater or hypersaline brines into unconsolidated and geochemically unstable sediments. Indeed, sediments from the shelfward edge of this outcrop to the platform interior show extensive signs of vadose as well as phreatic leaching and cementation combined with virtually complete, very finely crystalline dolomite replacement. The approximate thickness of back reef units of the Artesia Group in this region are (in ascending order): Grayburg Fm., 400-500 ft; Queen Fm., 200-400 ft; Seven Rivers Fm., 450-600 ft; Yates Fm., 300-400 ft; and Tansill Fm., 100-325 ft (all data from Kelley, 1971). The transitions from carbonate to evaporite facies generally occur within 5 to 15 miles shelfward of the bank margin or reef throughout the history of the Artesia Group (fig. 34). Turn around and return to main road.

0.20 4.45 75.65 Intersection with main Dark Canyon road; turn right.

0.55 5.0 75.1 STOP III-2 at junction with small dirt road on left. Park and walk down road to cliff outcrop on south side of canyon. This locality (equivalent to part of Dunham's (1972) Stop I-1) exposes dolomites and calcitic dolomites of the near-back-reef Tansill Formation. A wide variety of sediment types are present here, typical of the complex, small-scale microfacies patterns in this paleogeographic zone. We can see pisolitic mudstones, birdseye dolomites, cross-bedded green-algal grainstones, and other lithologies intimately intermingled at this site. Fusulinid Foraminifera, belerophontid gastropods, pelecypods, green algae, and probable blue-green algae are particularly abundant in these sediments.

These beds apparently represent a series of islands or banks (cross-bedded grainstones; fig. 35), subaerial and intertidal flats (birdseye fabrics; fig. 36), restricted or sheltered mud accumulation sites (pisolitic mudstones), and intervening tidal channels (fossiliferous packstones and grainstones). These facies patterns are quite similar to ones found in the Bahamas in regions such as Joulter's Cay, or in Trucial Coast barrier-lagoon complexes of the Persian Gulf.

Diagenetically, these Permian microfacies are equally complex. Within this outcrop one can find microscopic examples of submarine cement as well as vadose and phreatic freshwater cements (figs. 37 to 39). Porosities in this zone are variable but include some of the highest values found anywhere in the Guadalupian facies spectrum.

0.3	5.3	74.8	STOP III-3. Cross stream wash and examine two outcrops on north side of valley. The Tansill-Yates contact is exposed in the western part of the outcrop, marked by a thin sandstone-siltstone unit. We can see algally laminated dolomites, fusulinid grainstones, pisolitic beds, probable Permian breccia pipes, as well as infiltrated, red, lateritic soils in solution enlarged fractures and voids. The pisolitic microfacies was postulated by Dunham (1972) to be one of the highest paleotopographic zones in the Capitan complex. Pisolitic "caliche" zones and solution features would thus be a probable result of even minor relative sea level drops during deposition. The red void-fillings consist of kaolinite, hematite, quartz, goethite, illite, and amorphous iron oxide, a reasonable composition for a solution residue in this area. More extensive discussion of this facies will be given at Walnut Canyon (STOP III-7). The thin sandstone-siltstone bed at the Yates-Tansill contact is typical of such terrigenous units in this area. They are generally 1-8 ft thick, well-sorted, very fine sandstone or coarse siltstone, and have subarkosic or arkosic composition. Dunham (1972) showed that a progressive decrease in feldspar content of these units from shelf interior to the Capitan shelf margin is directly matched by a progressive increase in kaolinite content. Thus, these clastic terrigenous beds were probably uniformly arkosic but the near-reef sections underwent more intense post-depositional alteration. In spite of their relative thinness, these sandstone-siltstone beds have great lateral extent, particularly parallel to the reef trend, and serve as excellent stratigraphic marker beds (DeFord and Riggs, 1941). Some low-angle channel structures and ripples can be seen, locally, in these units, but generally these sediments are horizontally laminated or structureless. They presumably represent largely wind-transported material; the horizontal lamination may have resulted from dune migration over an equlilibrium deflation surface (sabkha) or from depostion in extremely shallow, lagoonal waters.
0.4	5.7	74.4	Optional Stop. Pisolitic dolomites with "tepee" structures well exposed on south side of

			valley. Note laminated sandstone-siltstone unit interrupting and truncating some "tepees". The sandstone-siltstone is the uppermost part of the Yates Fm.; overlying dolomites are in the Tansill Fm.
1.1	6.8	73.3	Yates outcrop on left contains pisolitic dolomite and sandstone.
0.3	7.1	73.0	Yates Fm.(?) pisolitic dolomite with evaporite crystal casts on right.
0.6	7.7	72.4	Yates Fm.(?) outcrop of thick-bedded, dolomitic mudstones with sparse evaporite crystal casts.
0.5	8.2	71.9	Dolomitic mudstones, peloidal grainstones, and pisolitic beds of Yates Fm.(?) on right.
0.4	8.6	71.5	Yates Fm.(?) dolomitized peloidal grainstones on left.
1.2	9.8	70.3	Road junction; continue straight ahead to Sitting Bull Falls.
0.2	10.0	70.1	STOP III-4. Walk down stream to outcrops on north side of valley. Exposure of thin-bedded, aphanocrystalline to very finely crystalline dolomitic mudstone with extensive evaporite crystal casts, pyrite nodules, and contorted, probably stromatolitic zones. These penecontemporaneously dolomitized mudstones contain pellets, some peloids, scarce encrusting foraminifers, and numerous calcispheres. These sediments, with their sparse assemblage of salinity tolerant organisms and evaporite minerals, apparently represent a shallow, hypersaline lagoon similar to those found today in many areas of the Persian Gulf.
0.5	10.5	69.6	Road junction; bear right.
2.1	12.6	67.5	Start gravel road; continue straight ahead.
0.9	13.5	66.6	W.G. Smith ranch road on right; continue straight ahead. Road is on Seven Rivers Fm.
0.3	13.8	66.3	Road intersection on right; continue straight ahead on main road.
0.5	14.3	65.8	STOP III-5. Interbedded thin-bedded, dolomitized mudstones and red, far-back-reef siltstones of the Seven Rivers Fm. on left. The Seven Rivers is the oldest Capitan-equivalent unit in the Artesia Group. These outcrops have been mapped as basal Yates Fm. by Motts (1962) but have been considered to belong to the Seven Rivers by most other workers. Note the uniformity of the aphanocrystalline to very-finely-crystalline replacement dolomite. The environment presumably represents a shallow lagoonal or lower sabkha environment.
0.3	14.6	65.5	Medium-scale contortions visible in Seven Rivers Fm. These were probably caused by near-surface dissolution of interbedded gypsum and anhydrive, although the Seven Rivers consists mainly of dolomites and siltstones in this area.

0.4	15.0	65.1	Road intersection on left; continue straight ahead.
0.9	15.9	64.2	Road intersection on left; bear right on main road.
1.2	17.1	63.0	Varicolored sediments on right are interbedded massive gypsum, dolomite, and red beds of Seven Rivers Fm.
0.2	17.3	62.8	Ranch road on left; continue straight ahead.
1.7	19.0	61.1	STOP III-6. Borrow pit in gypsum of Seven Rivers Formation. Surface weathering makes viewing of gypsum outcrops a frustrating exercise; most are altered to a very great degree with a solution residue covering most fabric elements. This borrow pit exposes the freshest samples easily accessible to a field trip group. Gray-white gypsum with a nodular, enterolithic texture can be seen in isolated blocks scattered around the pit (fig. 40). This "chicken-wire" fabric may be related to a sabkha origin of the evaporite, but may also be a consequence of dehydration-rehydration reactions during burial and uplift. (although the unit is gypsum on outcrop, it is generally anhydrite in the subsurface). The "chicken-wire" texture, with thin clay films between gypsum nodules, also been interpreted as the product of displacive growth of subaqueous gypsum in silty-clayey sediments in a shallow-water lagoon (Sarg, in Pray and Esteban, 1977). On the left one can see a reentrant of the Seven Rivers Embayment, an extensive planar feature developed by dissolution of the evaporites of the Seven Rivers Fm.
0.3	19.3	60.8	Road junction to right; continue straight ahead.
1.2	20.5	59.6	Road on left; continue straight ahead on main road.
0.8	21.3	58.8	Ranch house on right. Well drilled to left (Humble's Bandanna Point Unit No. 1 gas well) was completed as a gas producer from Morrowan (Pennsylvanian) sandstone. It encountered the following units: San Andres Fm. (top at 750 ft depth); Bone Spring Ls. (2,815 ft); Wolfcamp limestone (7,150 ft), Pennsylvanian (7,550 ft); Mississippian (Chester) (10,234 ft). Woodford Shale (10,868 ft); Devonian (10,932 ft); Montoya Group (11,622 ft); Simpson Group (11,995 ft); and Ellenburger Group (12,050 ft) (data from Hobbs, Roswell and West Texas Geological Societies, 1962 Field Trip Committee, 1962, p. 18).
1.2	22.5	57.6	Azotea Mesa on right is composed of Seven Rivers Fm. gypsum capped by a prominent dolomitic ledge. The ridge ahead in the distance consists of Queen and Grayburg beds downwarped

			along the Huapache Monocline. We are now entering the main part of the Seven Rivers Embayment with the road on thin alluvium over Queen Fm.
1.0	23.5	56.6	Intersection with New Mexico Highway 137 (a paved road from El Paso Gap to Carlsbad). Turn left toward El Paso Gap. Guadalupe Mountains ahead in distance; road traverses the Seven Rivers Embayment atop the Queen Fm.
2.6	26.1	54.0	Junction with road to Sitting Bull Falls on right; turn right.
3.2	29.3	50.8	Queen Fm.(?) redbeds, dolomites, and evaporites on right.
1.0	30.3	49.8	Road crosses approximate Queen-Grayburg contact and passes onto Grayburg Fm.
0.2	30.5	49.6	Entering Lincoln National Forest.
0.2	30.7	49.4	Road crosses first wash and traverses Huapache monocline ahead.
0.6	31.3	48.4	Road crosses onto San Andres Limestone.
0.3	31.6	48.5	Lenticular, partly silicified, skeletal grainstones of the San Andres, probably filling channels, on right at base of slope near stream crossing. Brown, thin-bedded Cherry Canyon sandstone beds can be seen in cliffs on right. This tongue of the generally basinal Cherry Canyon Fm. extends many miles into the shelf environment in this area. The Cherry Canyon sandstone tongue is 164 ft thick near the mouth of Sitting Bull Canyon.
0.7	32.3	47.8	A massive upper San Andres bioherm, overlain by Grayburg Fm. is visible ahead on right. Note lenticular bedding to the left of the bioherm.
0.6	329	47.2	Junction of Sitting Bull Canyon and Last Chance Canyon (along which have been travelling). Road turns into Sitting Bull Canyon. Cliff on north side of Last Chance Canyon (on right) has exposures of lower San Andres Ls. (at very base) overlain by the thick sandstone tongue of the Cherry Canyon Fm.; the upper San Andres, bioherm-bearing limestone and Grayburg Fm. sandstones and carbonates form the top of the section. A major angular discordance is visible between the Cherry Canyon sandstone tongue and the upper San Andres Ls. A more subtle angular discordance is also present between the upper San Andres and the Grayburg Fm. Excellent exposures of the lower San Andres, here extensively dolomitized, can be examined by walking up Last Chance Canyon for a few hundred feet.
0.2	33.1	47.0	The Cherry Canyon-San Andres unconformity is well exposed on both sides of the road.
0.3	33.4	46.7	Cherry Canyon sandstone outcrops with well

			developed cross-bedding are visible on right.
0.5	33.9	46.2	Parking area for Sitting Bull Falls. Lunch stop at picnic benches. The entire cliff on the northwest side of the picnic area is formed of modern travertine which can be examined in numerous fallen blocks. A short walk to the active waterfall area shows travertine in the process of formation. Calcium bicarbonate and carbon dioxide saturated waters emerge from springs in the Grayburg and San Andres units a short distance (about 1 mile) upstream from the falls. Warming of the waters, combined with release of CO_2 from waters plunging over the falls, induces precipitation of calcium carbonate. The withdrawal of CO_2 from the water by the numerous algae and higher plants which abound at the falls also contributes to the calcite precipitation. These plants are then incorporated within the calcite, later to rot away. This accounts for the unusual fabric seen in the travertine blocks. If you climb up or under the waterfalls, please take great care as the rocks here are very slippery. The other walls of the canyon in this area expose the Cherry Canyon sandstone tongue in their lower part, the upper San Andres Limestone in the middle part, and Grayburg Fm. in the upper part. Note the biohermal or bank structures in the San Andres; they were probably deposited as fusulinid grainstone banks rather than as true reefs. Return down-canyon to the El Paso Gap-Carlsbad road.
7.7	41.6	38.5	Junction with New Mexico Highway 137 (El Paso Gap-Carlsbad road). Note West Hess Hills at 2:00 to 3:00 o'clock and Azotea Mesa at 10:00 to 11:00 o'clock---both are composed of gypsum, red siltstones, and dolomites of the Seven Rivers Fm. Turn left toward Carlsbad.
2.6	44.2	35.9	Unpaved Dark Canyon road on right; continue straight ahead. Road is on Queen Fm.
3.2	47.4	32.7	Road now crossing the approximate contact between the Queen and Seven Rivers Fms. The road is located almost directly on this contact for the next few miles, with Queen sediments on the left and Seven Rivers on the right.
1.2	48.6	31.5	Hills ahead and to the right are composed of Seven Rivers evaporites and red siltstones. The strongly developed vertical gullying is characteristic of the evaporite facies of the Guadalupian far-back-reef units and contrasts sharply with the horizontal bedding which dominates in areas of carbonate facies within

			these same units (fig. 41). Most of these hills are capped by the resistant "Azotea Tongue" (usage of Sarg, 1976), a dolomite unit in the Seven Rivers Fm.
4.4	53.0	27.1	Road passes from Seven Rivers Embayment into Rocky Arroyo.
0.6	53.6	26.5	Road is at the level of the contact of the Queen Fm. (Shattuck Sandstone unit of Sarg, 1976) and Seven Rivers Fm. We are nearly 1 mile shelfward (northwest) of the carbonate-evaporite transition of the Seven Rivers Fm. (Sarg, 1976). This transition is remarkably abrupt (within about 500 ft) and remains in approximately the same location for nearly 200 ft of section (Bates, 1942; Pray and Esteban, 1977). This Seven Rivers facies transition has been shown by Sarg (1976) to be related to a depositional ridge in the underlying Shattuck Sandstone of the Queen Fm. The gullied hillside on the southeast side of the road has good exposures of the Seven Rivers evaporite facies (see Pray and Esteban, 1977, Stop VII). The section is dominated by bedded, nodular, mosaic gypsum with thin, pelletal or grapestone-bearing dolomites and red, gypsum-cemented, sandy siltstones. Note invigorating, heady aroma of hydrocarbons in the air; it emanates from the Indian Basin gas field about 0.3 miles ahead.
0.1	53.7	26.4	Low road cuts on right are Queen Fm. (Shattuck Sandstone). Conical hill visible to the north of the road is "The Tepee" and is capped by the resistant "Azotea Tongue" a massive dolomite of the Seven Rivers Fm. Underlying Seven Rivers evaporites, the Shattuck Sandstone and dolomites of the Queen Fm. are also exposed.
2.3	56.0	24.1	Intersection with road on left leading to Marathon Oil Co. Indian Basin gas field and plant. Production here is from Upper Pennsylvanian and Lower Permian reservoirs. Continue on main road.
0.1	56.1	24.0	Optional stop. Excellent view of the carbonate-evaporite facies transition in the Seven Rivers Fm. (see description of Stop VI in Pray and Esteban, 1977) on north wall of Rocky Arroyo. This extremely rapid transition can be seen in a narrow, nearly vertical, band in the upper half to two-thirds of the far wall of the valley. The transition is visible because of the radically different weathering patterns of the evaporite (vertical gullying) and carbonate (horizontal bedding) facies. The transition was was first described by Bates (1942) and has been recently examined by Sarg (1976).

			Also exposed in the lower part of the cliff is the upper dolomite and the overlying Shattuck Sandstone unit of the Queen Fm. The Shattuck, generally about 90 ft thick in this region, thickens to about 140 ft beneath the carbonate-evaporite transition and may have been partly reponsible for the generation of restricted, evaporitic conditions shelfward of this point during Seven Rivers deposition (Sarg, in Pray and Esteban, 1977).
0.7	56.8	23.3	Optional stop. Excellent exposures of Shattuck Sandstone (Queen Fm.) on the right (see Dunham, 1972, Stop I-5; Pray and Esteban, 1977, southwest end of Stop VIII). The sandstone has broad, channel-like structures with northwest-southeast axes.
0.1	56.9	23.2	Continuation of previous outcrop. These medium- to thin-bedded dolomites, about 12 mi shelfward of the Capitan scarp, are generally placed in the Seven Rivers Fm.; Sarg (1976), however, included them in the Queen Fm. Some interesting collapse breccias occur in these strata, which were included by Dunham (1972) in his "calcisphere dolomite wackestone" facies. The largest breccia occurs as an isolated pocket in a thick, light-tan dolomite bed. The breccia has large, angular clasts of dolomite with corroded and altered borders (fig 42). The clasts are held in a partial matrix of microcrystalline calcite, internal sediment (green illite-kaolinite clay and quartz silt), and coarsely crystalline, blocky, late, sparry calcite cement. Considerable remnant porosity also is present in the breccia zones. Pray and Esteban (1977) argued for a modern karstic origin for these features; Dunham (1972) postulated a Permian origin, presumably related to weathering and dissolution of evaporite minerals. Note the abundant evidence of associated evaporite (mainly gypsum) crystal casts in these dolomites.
0.3	57.2	22.9	Cyclic deposits of dolomite and red, silty shales. Generally grouped in the Seven Rivers Fm., these sediments were included in the uppermost part of the Shattuck Sandstone (Queen Fm.) by Sarg (1976) and Esteban and Pray (1977; see description for Stop VIII). These strata have been interpreted as "dolocalcrete cycles" with evidence of repeated deposition, exposure, weathering, and calichification (Pray and Esteban, 1977). Note also the abundant crystal- and nodule-casts of former gypsum (some voids now partly filled with calcite; see fig. 43).
0.8	58.0	22.1	A thick section of Seven Rivers dolomitic pack-

			stones and mudstones of probable lagoonal origin exposed on left. Note absence of evaporites and red beds.
0.3	58.3	21.8	Strata exposed behind Shafer Ranch are fossiliferous, dolomitic, pelletal packstones.
0.2	58.5	21.6	Dry wash across Rocky Arroyo with massive travertine deposits exposed on left.
0.5	59.0	21.1	Small cemetery on right. Cliffs to southeast expose Seven Rivers Fm. fossiliferous, dolomitic, pelletal packstones containing ostracodes, calcispheres, and some small foraminifers. Queen Fm. (Shattuck Sandstone) is exposed at the cliff base.
0.3	59.3	20.8	On the south side of the arroyo are cliffs exposing thin-bedded dolomite of the Seven Rivers Fm. dominated by pelletal wackestone and mudstone. Stromatolitic(?) units have been described from this locality (Sarg, 1976). Other, similar outcrops are along road on left.
0.5	59.8	20.3	Road cuts to left are Seven Rivers dolomite (Dunham's (1972) Stop I-6). This section, 11.7 miles shelfward of the Capitan escarpment, consists of thin-bedded, stromatolitic(?), dolomitic wackestone with pellets, ostracodes, and calcispheres. In and along the stream valley, travertine is abundant along with travertine-cemented gravels. The dolomite in these sediments, as in most of the back-reef areas, is very finely crystalline to aphanocrystalline and appears to be of very early diagenetic origin. Formation of early dolomite is probably related to restricted circulation in these back-reef lagoonal areas, precipitation of $CaSO_4$ minerals, and consequent increase in Mg/Ca ratios of lagoonal and interstitial fluids. Contact of Mg-rich surface and interstitial waters with unstable aragonitic muds has led to partial dolomitization of modern carbonate muds in the Persian Gulf and this most likely took place in the Permian back-reef areas as well. The exact mechanisms of this dolomitization (reflux brine movement, evaporative pumping, and other models) are debated even in modern setting and are even more disputed for the Permian examples.
0.9	60.7	19.4	Leaving Rocky Arroyo. Outcrops to the south are upper Seven Rivers Fm. Yates Fm. is present on the crest and eastern side of the hills to the south.
4.4	65.1	15.0	Junction with U.S. Highway 285; turn right toward Carlsbad. The road here is on Quaternary alluvium overlying Yates Fm. The Seven Rivers Hills, to the northwest, are the type section of the Seven Rivers Fm. (Meinzer and others, 1926).

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0.8	65.9	14.2	Bridge crossing over Rocky Arroyo.
0.9	66.8	13.3	Interbedded dolomites and red-brown sandstone of the Yates Fm. on both left and right.
0.6	67.5	12.7	Yates Fm. exposed in road cut.
0.3	67.8	12.4	Yates Fm. exposed in road cut.
1.5	69.2	10.9	Intersection of US Highway 285 with US 285 (Truck Route) on right. Continue left on main US Highway 285.
0.3	69.5	10.6	Basal Tansill Fm. is exposed in low cuts on both sides of road. Thin-bedded to laminated dolomitic mudstones with evaporite (anhydrite?) crystal casts can be found just below road level to the west. All back-reef units dip gently basinward in this area.
0.4	69.9	10.2	The Ocotillo Hills at 1:00 o'clock and Avalon Hills at 11:00 to 12:00 o'clock are composed of back-reef Tansill and Yates evaporitic dolomites. The hills are the topographic expression of an anticlinal structure over the buried Capitan reef, one of many such structures in the shelf area to the north and west of Carlsbad.
1.9	71.8	8.3	Thin-bedded Tansill dolomites with evaporite crystal casts present in roadcut. The type locality of the Tansill Fm., as described by DeFord and Riggs (1941), is located nearby in the Ocotillo Hills.
0.4	72.2	7.9	Gently dipping Tansill and Yates sediments in canyon to right are on eastern flank of the Tracy Dome.
1.1	73.3	6.8	Tansill dolomite overlying Yates sandstone is exposed in canyon on right.
0.7	74.0	6.1	Pecos River on left. Tansill Fm. in road cuts on right.
0.8	74.8	5.3	Living Desert State Park turn-off on right.
3.1	77.9	2.2	Carlsbad city center (junction of US Highways 62-180 (from north) and 285); La Caverna Hotel). Continue straight ahead.
2.2	80.1	0.0	Intersection of US Highways 62-180 (from south) and 285 (from southeast). Roadlog ends.

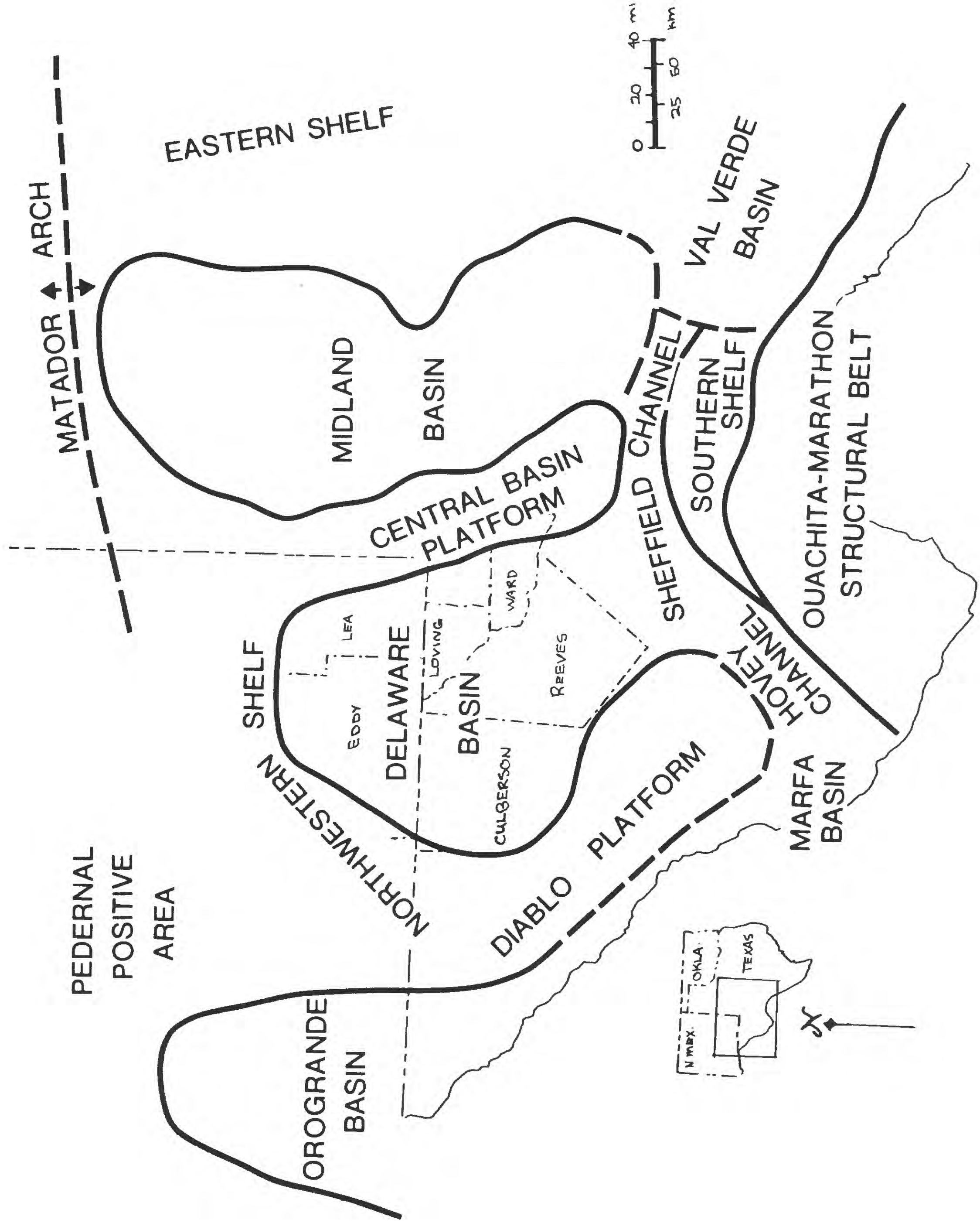


Figure 1.--Pennsylvanian and Permian physiographic features in the Permian Basin region. Modified from King (1948), McKee, Oriel and others (1967), and Williamson (1979).

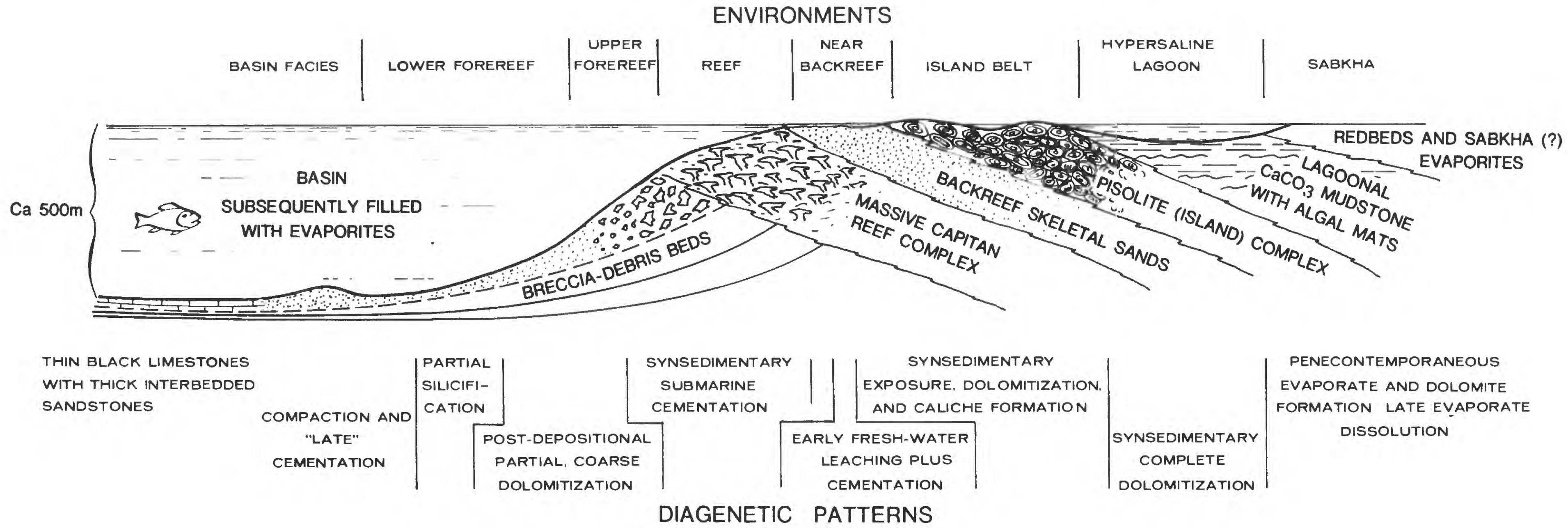
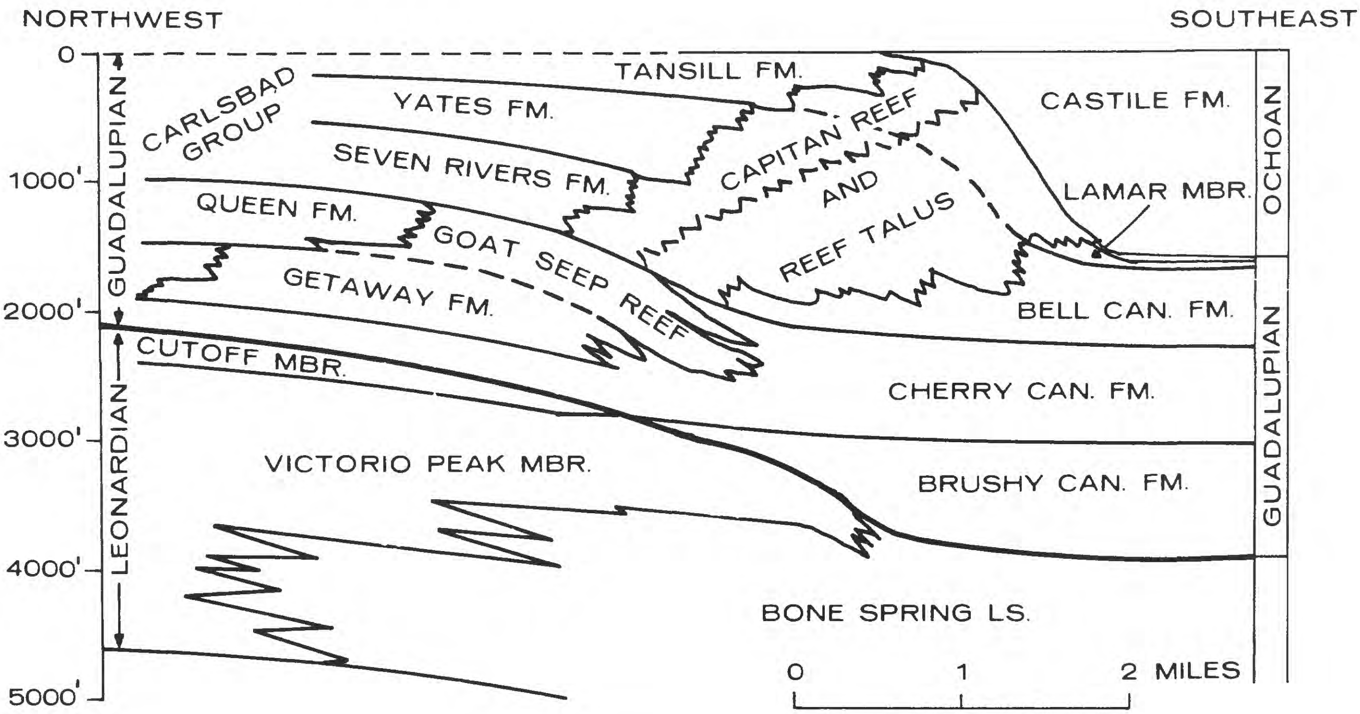


Figure 2.--Generalized cross-section of the Capitan reef complex showing inferred depositional environments and subsequent diagenetic alteration patterns.



AFTER KING 1948, NEWELL, ET. AL. 1953, HAYES 1957, AND TYRRELL 1964

Figure 3.--Stratigraphic nomenclature and inferred facies relationships for Leonardian, Guadalupian, and Ochoan units of the Northwest Shelf and Delaware Basin.

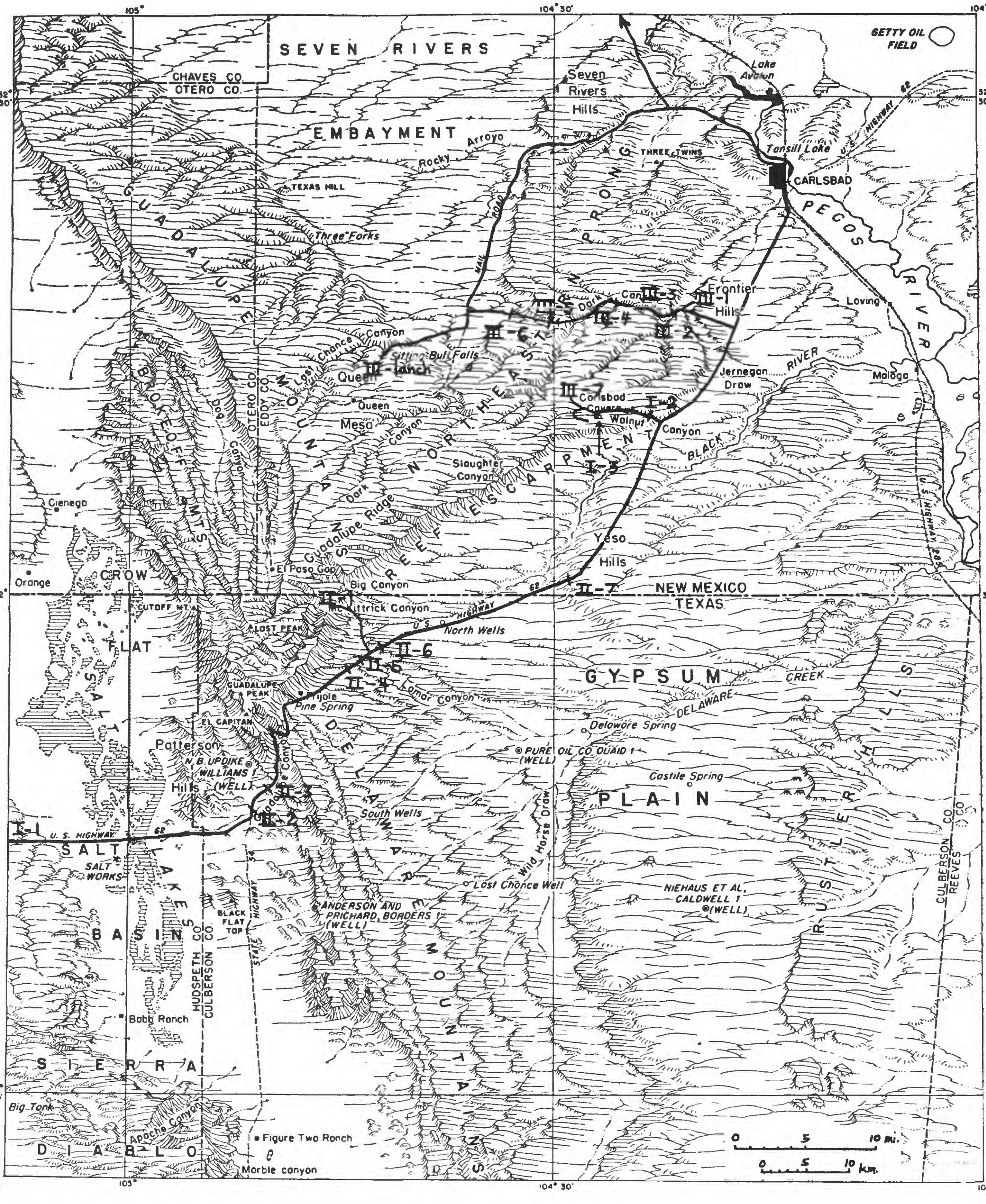


Figure 4.--Physiographic diagram of the Guadalupe-Delaware Mountains area showing the routes covered on this field trip and stop locations keyed to the roadlog. Adapted from King, 1948.

SYSTEM	SERIES	GROUP	FORMATION	MEMBER
POST-PERMIAN STRATA				
PERMIAN	WOLFCAMPIAN	HUECO GP.	ALACRAN MOUNTAIN FM.	DEER MOUNTAIN RED SHALE MBR. LOWER UNNAMED MBR.
			CERRO ALTO LIMESTONE	
			HUECO CANYON FM.	UPPER MBR. POWWOW CONGLOMERATE MBR.
PENNSYLVANIAN			MAGDALENA FM. 1/	UPPER UNIT MIDDLE UNIT LOWER UNIT
MISSISSIPPIAN			HELMS FM.	
DEVONIAN			CHERT, SHALE, AND LIMESTONE	
SILURIAN			FUSSELMAN DOLOMITE	
ORDOVICIAN	UPPER MIDDLE		MONTOYA LIMESTONE	
	LOWER		EL PASO LIMESTONE	
CAMBRIAN – ORDOVICIAN			BLISS SANDSTONE	
PRECAMBRIAN			RED GRANITE	

Figure 5.--Generalized pre-Mesozoic stratigraphy of the Hueco Mountains, Texas. Modified from King and others (1945) and Barnes (1968). Terminology does not conform to U.S.G.S. usage in many cases but follows that of the Texas Bureau of Economic Geology.

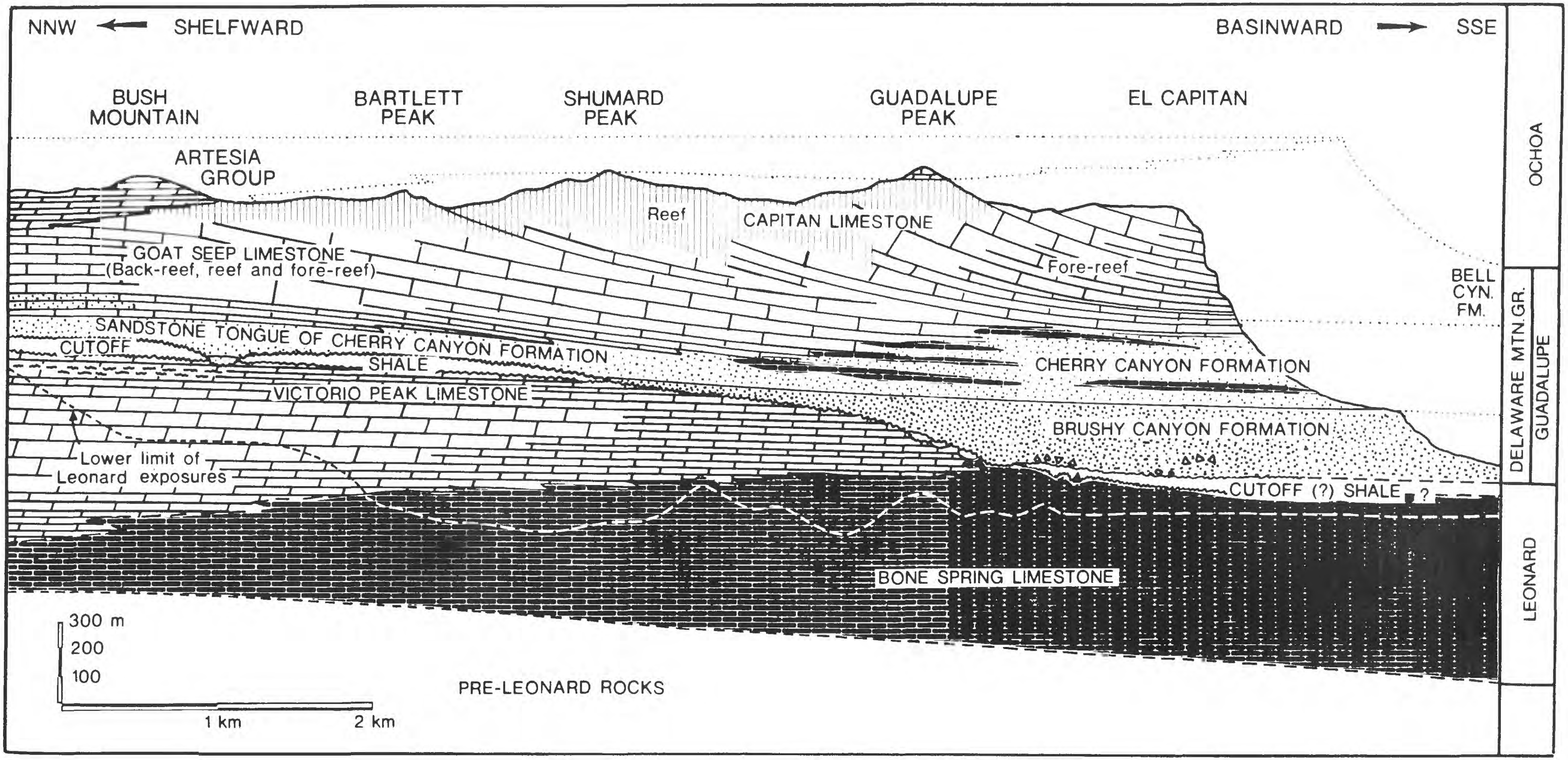


Figure 6.--Diagramatic section of the southwestern end of the Guadalupe Mountains, Texas. This approximates the view east-northeast from Stop I-1 on this trip. After King (1948 and 1967).

Figure 7.--Oblique aerial view of the southern end of the Guadalupe Mountains (El Capitan and Guadalupe Peak). Note transition from massive, steeply-dipping, Capitan reef-talus limestones at top-center to flat-lying sandstones, siltstones and limestones of the Delaware Mountain Group in right-center and center-bottom area. Photo from King (1948, plate 1). Major escarpments in center-middle and center-bottom of photo are composed of Brushy Canyon Formation.

Figure 8.--View of the southern end of the Guadalupe Mountains. Note massive Capitan limestones of El Capitan (top center), underlying basinal sandstones, siltstones, and shales of the Cherry Canyon and Brushy Canyon Formations and the lenticular, sandstone-filled channel in the Brushy Canyon in the foreground.

Figure 9.--Margin of sandstone-filled submarine channel in the Brushy Canyon Formation. This exposure (Stop II-3) illustrates overbank siltstones and shales (on right) cut and filled by a massive, fine-grained sandstone. Note injection structures at sandstone-shale contact.

Figure 10.--View of El Capitan from roadside rest area (mileage 101.7 on El Paso-Carlsbad roadlog). Hill in left foreground consists of lenticular sandstones interbedded with siltstones and shales (Brushy Canyon Formation). The Cherry Canyon Formation forms the recessive slope between the top of the foreground cliff and the massive, steeply-dipping Capitan limestones of El Capitan. Note the bank-to-basin transition in the right half of the photo (dips flattening to the east into the Delaware Basin).

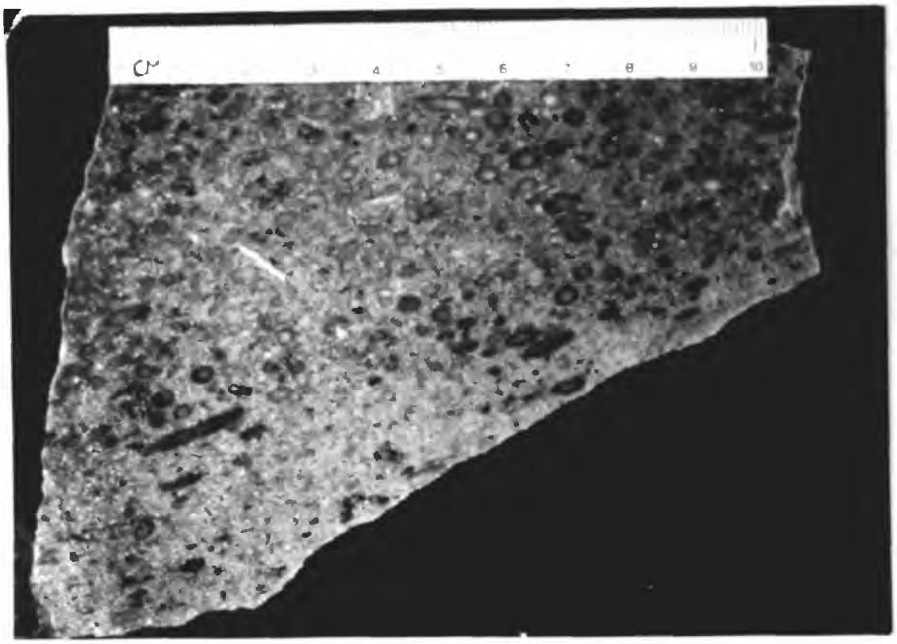


Figure 11.--Oriented fusulinid Foraminifera in basinal sandstone of the upper Brushy Canyon Formation. Fusulinids were reworked from the shelf and oriented by submarine currents. Locality is on U.S. Highway 62-180 at mileage 102.8 on El Paso-Carlsbad roadlog.

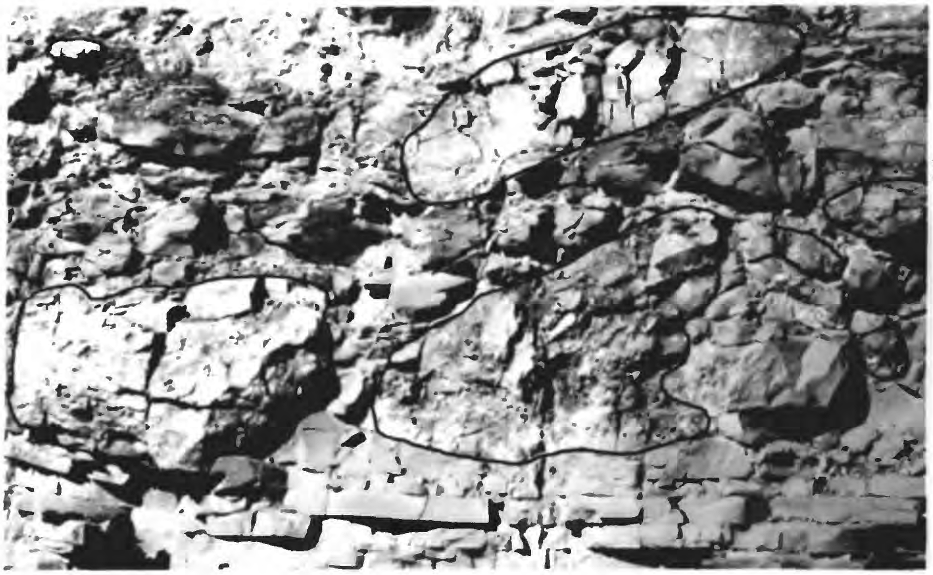


Figure 12.--Large, rounded, reef-derived limestone clasts of the Rader slide which have foundered into a matrix of Bell Canyon sandstone. This location (Stop II-4) exposes part of a thin, channelized submarine debris flow or slide which has carried reef material at least five miles into the basin.

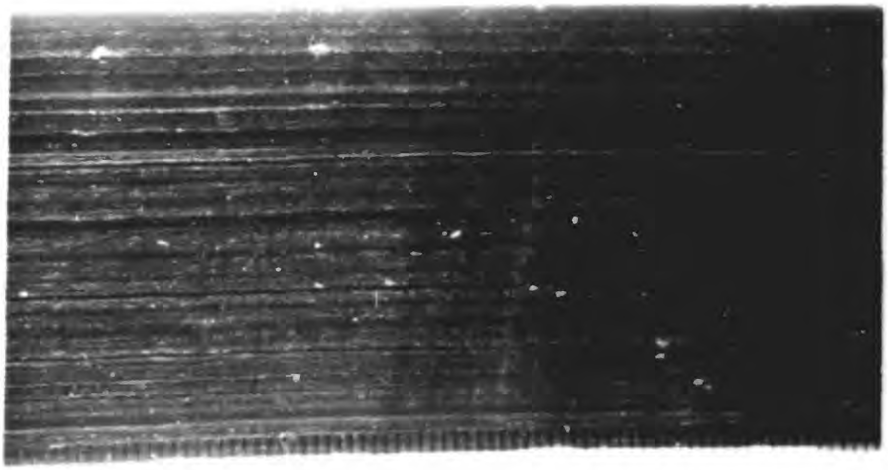


Figure 13.--Close-up photograph of a polished sample of the basinal Lamar Limestone Member of the Bell Canyon Formation (locality at Stop II-6). Note very small-scale, uniform lamination (small divisions at bottom of photo are millimeters) and dark color of sediment.

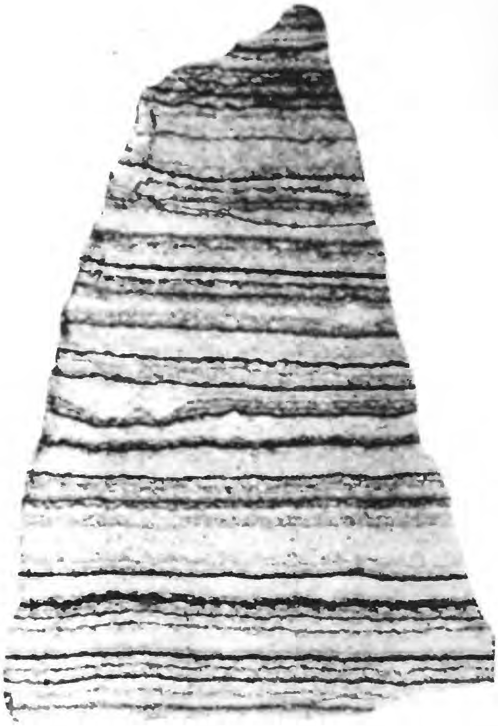


Figure 14.--Photograph of a thin-section of laminated anhydrite from the Castile Formation (2x magnification). The sample was collected from surface outcrops about 20 miles east of El Capitan. Photo from King (1948, plate 10-B). Note the regular, thin laminations which consist of alternations of anhydrite and (or) gypsum (light layers) and an organic matter-calcite mixture (dark layers). Although some small-scale discontinuities can be seen in this photo in some laminae, packages of these laminae have been traced laterally for greater than 70 miles.

Figure 15.--Small-scale contortions in laminated gypsum from Castile Formation. These structures are probably produced as a consequence of rehydration of anhydrite to gypsum during uplift and weathering. Sample from Stop II-7; vertical axis of photograph represents approximately 3 feet on outcrop.

Figure 16.--Panoramic view of north wall of McKittrick Canyon showing shelf edge facies transitions. Facies and formation boundaries are shown on the photograph.

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Figure 17.--View of bedding plane in toe-of-slope facies of the Lamar Limestone Member of the Bell Canyon Formation. Brachiopods are extremely abundant but bryozoans, echinoderms, and siliceous sponges are also commonly found. The originally calcitic fauna has been largely silicified in this area. Sample from mouth of McKittrick Canyon.

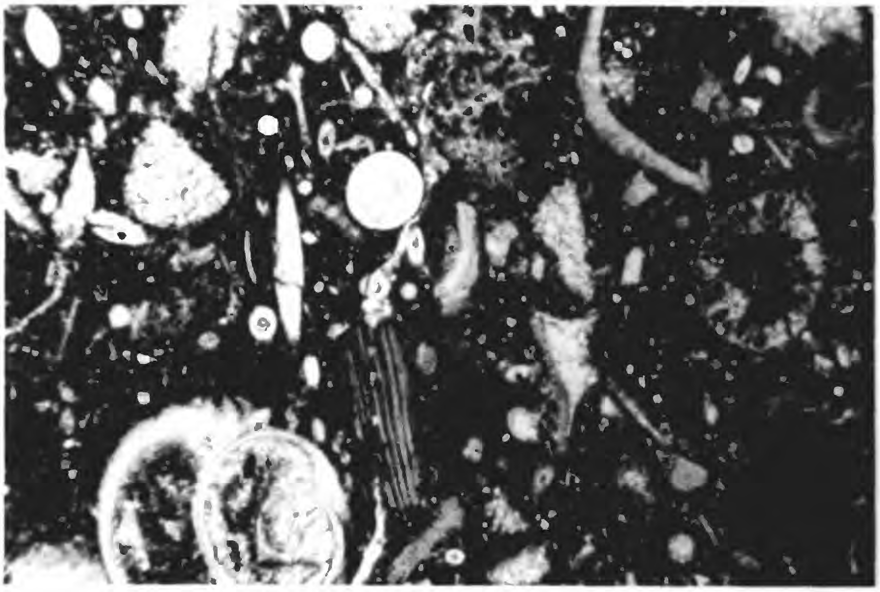


Figure 18.--Photomicrograph of toe-of-slope limestone from McKittrick Canyon. Note mixture of reef and slope fauna including abundant siliceous sponge spicules set in micritic matrix. Long axis of photo equals approximately 2.5 mm.

Figure 19.--Compactional drape in toe-of-slope limestones surrounding a large block of reef-derived limestone. Rader Member of Bell Canyon Formation at mouth of McKittrick Canyon.

Figure 20.--Angular, reef-derived rubble in the Capitan talus facies, McKittrick Canyon. Although some in-situ brecciation has taken place, much of this material consists of reef limestone, fragmented and redeposited in this fore-reef setting. Knife is approximately 3 inches long.

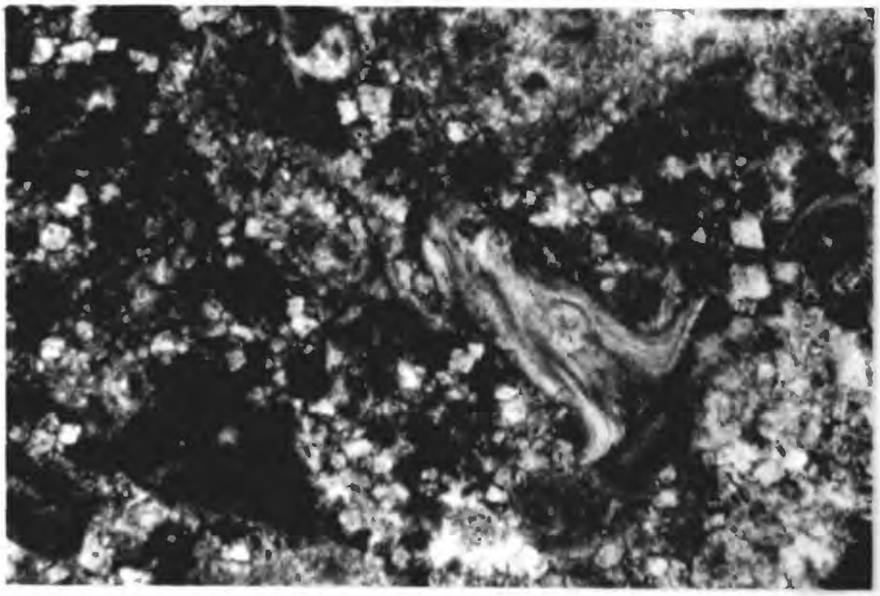
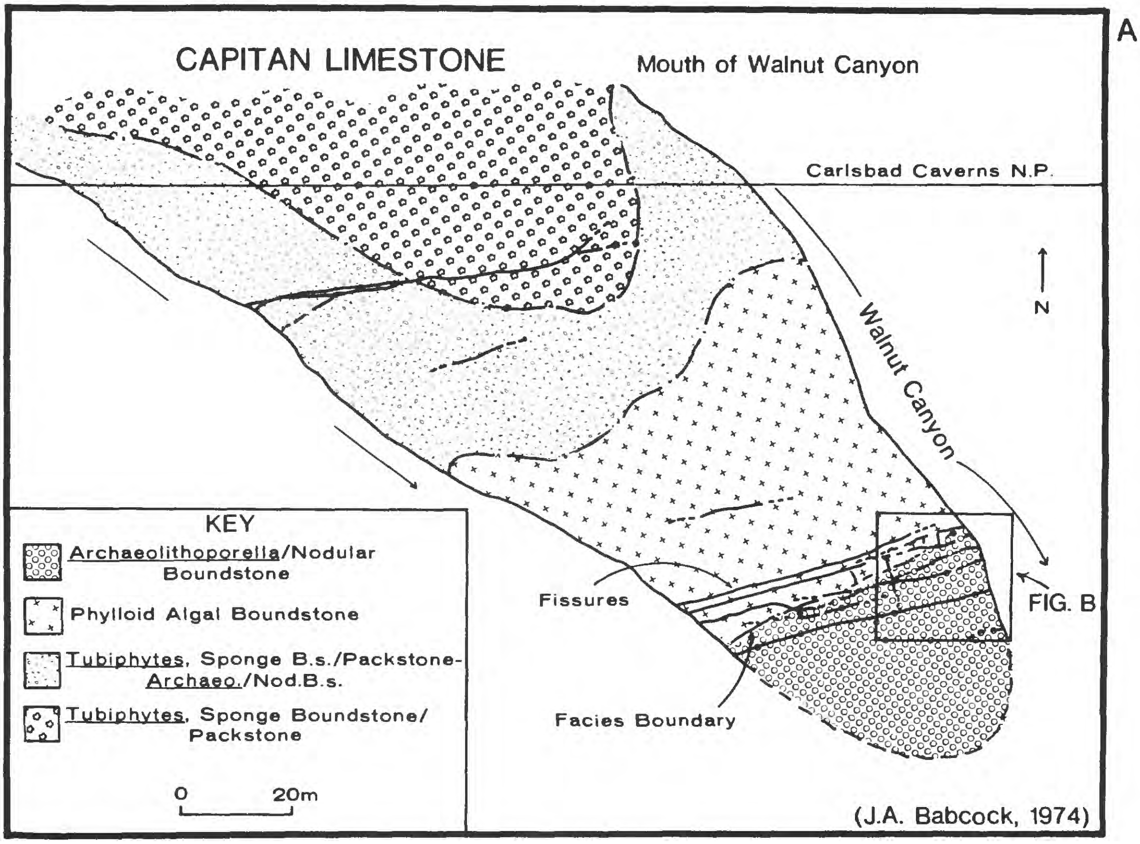


Figure 21.--Photomicrograph of typical Capitan talus facies. Note pellets, bryozoan fragments, and extensive but incomplete dolomitization of matrix but not framework grains. Long axis of photo equals approximately 2.5 mm.

Figure 22.--Photomicrograph of Capitan talus facies in McKittrick Canyon. Note in-situ fracturing of shelf-derived fusulinid foraminifer and extensive dolomitization of micritic matrix. Long axis of photo equals approximately 2.5 mm.



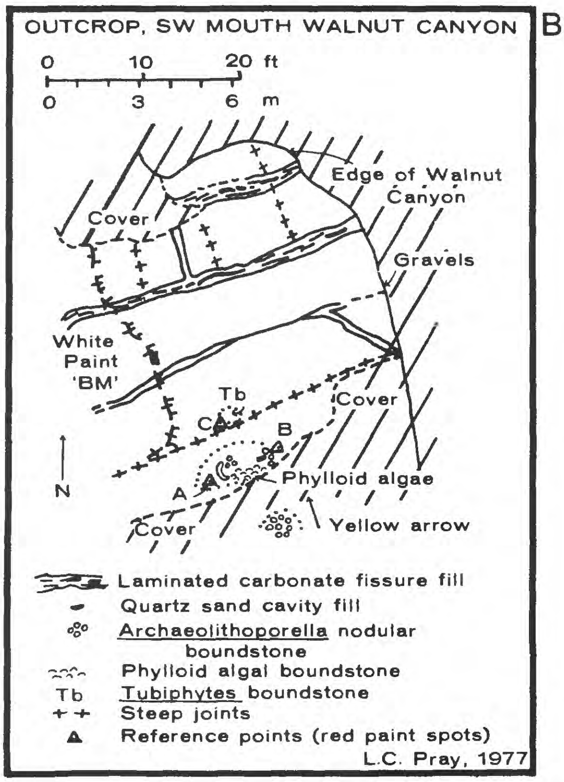


Figure 23.--Microfacies exposed at the mouth of Walnut Canyon (Stop I-2). After Babcock, J.A. (1977).

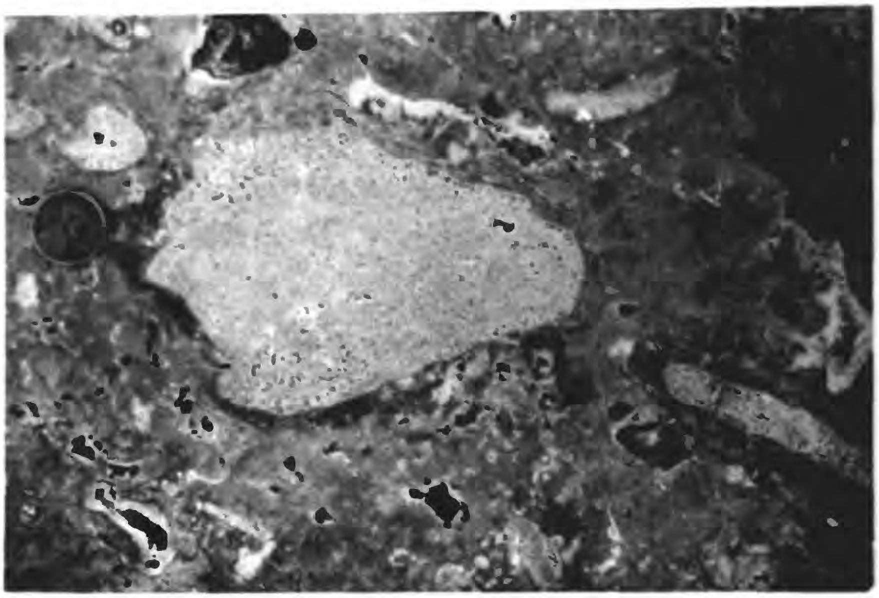


Figure 24.--Closeup of reef fabric near the mouth of Walnut Canyon (along north side of Bat Cave Canyon). Note oriented, in-place sponges surrounded by darker algal encrustations; porosity largely filled with fibrous, submarine cements.

Figure 25.--Photomicrograph of Capitan reef facies. Lower part of photo shows a largely neomorphosed calcareous sponge; this is overlain by numerous Archaeolithoporella encrustations (dark colored) interlayered with submarine cements (light colored). Long axis of photograph equals approximately 2.5 mm.

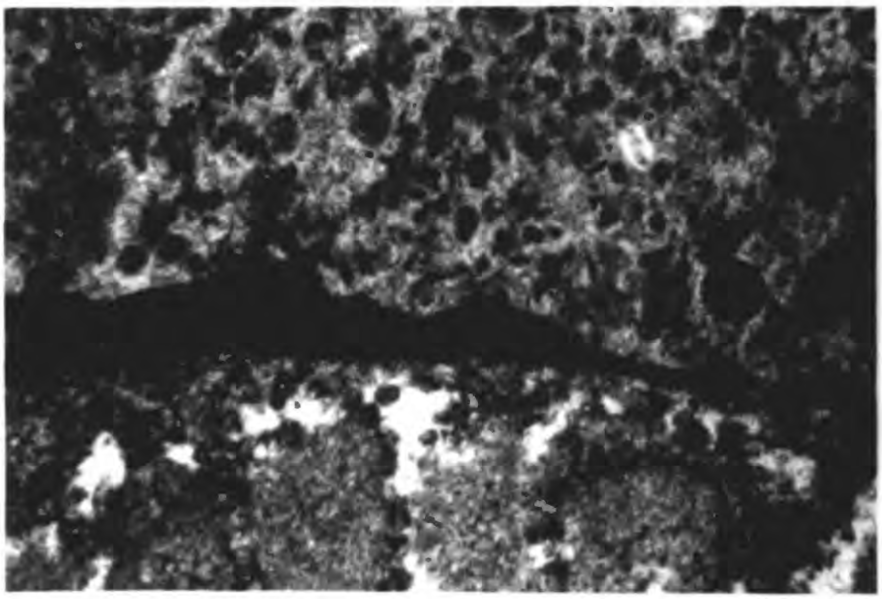


Figure 26.--Photomicrograph of Capitan reef facies. Lower half of photo shows a largely neomorphosed calcareous sponge; this is overlain by irregular, dark, algal encrustations. Remnant porosity filled by pelletal, penecontemporaneous, internal sediment. Same scale as previous photo.

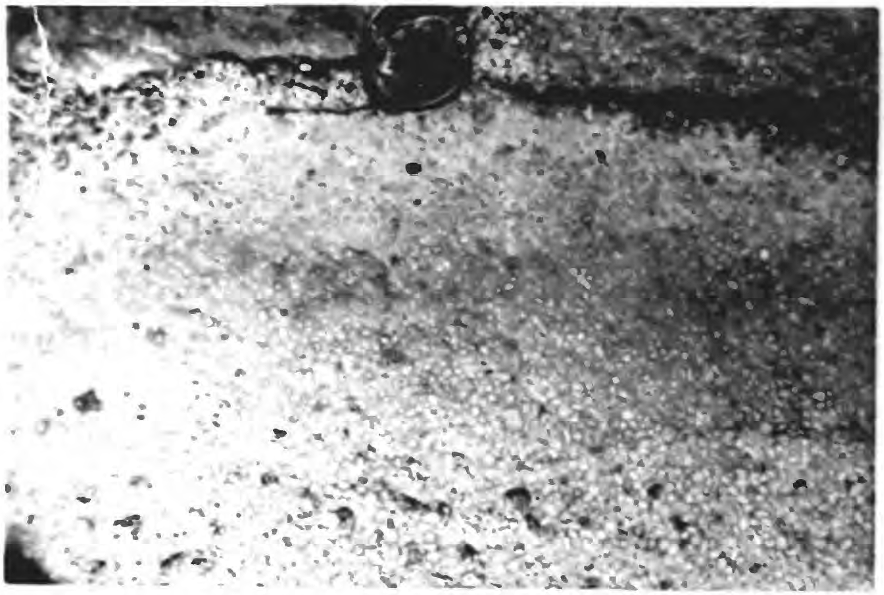


Figure 27.--Closeup of oolitic grainstone in Walnut Canyon. Grain nuclei are mainly green algae. Note excellent sorting and rounding of grains and general lack of internal sedimentary structures.

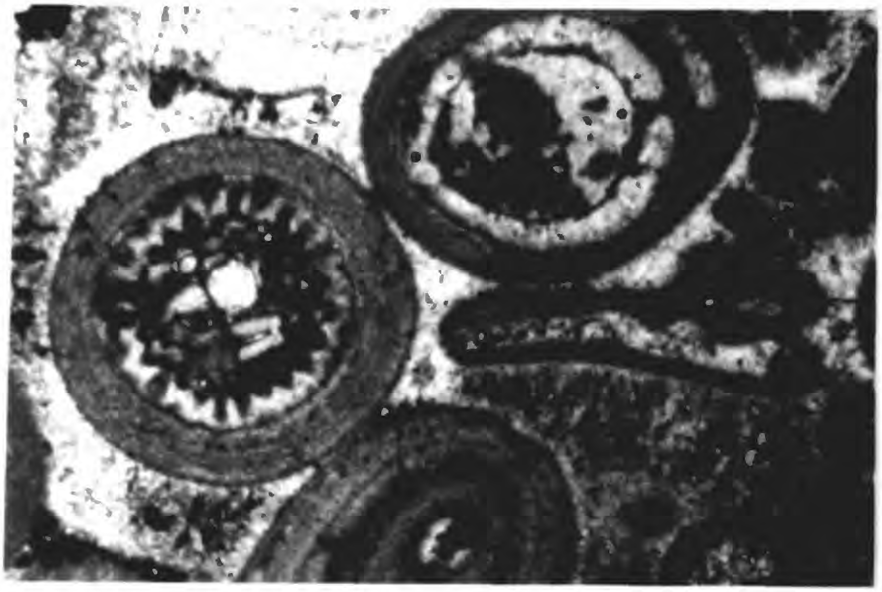


Figure 28.--Photomicrograph of grainstone shown in figure 27. Note nuclei of <u>Mizzia</u> green algae; these are oolitically coated and then surrounded by submarine cements. Long axis of photo equals approximately 2.0 mm.

Figure 29.--Photomicrograph of grainstone from Walnut Canyon. Virtually all grains are altered green algae; note extensive encrustation and binding of grains into "grapestones". Same scale as previous photo.

Figure 30.--Tepee structure in Walnut Canyon (Stop III-7). Sediments are pisolitic dolomites of the Yates Formation.

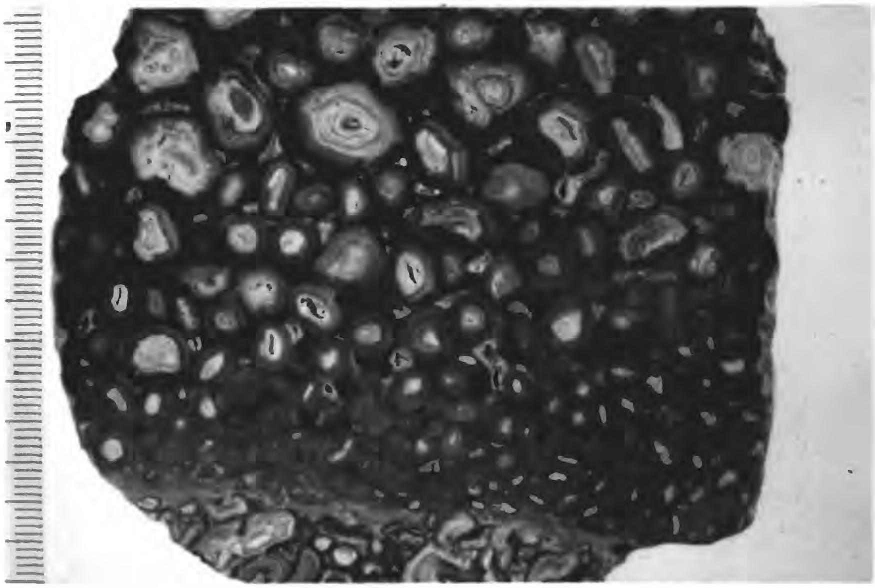


Figure 31.--Closeup of a polished slab of pisolitic dolomite from Walnut Canyon. Note well developed reverse grading, abundant nuclei of fractured pisolites, and excellent preservation of small-scale concentric laminations by replacement dolomite. Small scale divisions at left are millimeters.

Figure 32.--Pisolitic sediments of Yates Formation cut by a large, horizontal, sheet crack of calcite spar. Sheet crack is about 6 inches high.

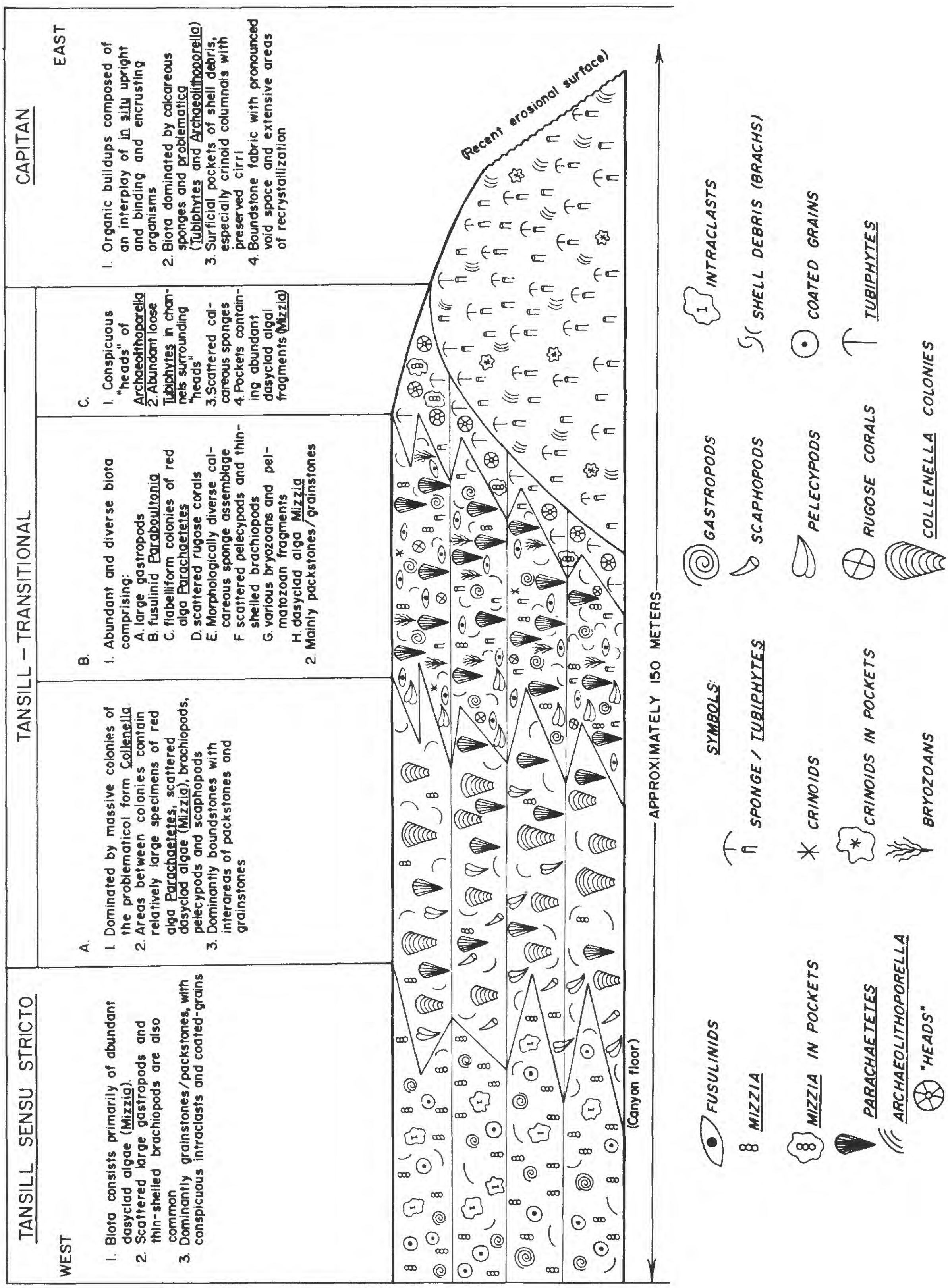


Figure 33.--Microfacies exposed at the mouth of Dark Canyon (Stop III-1). From Toomey and Cys (1977).

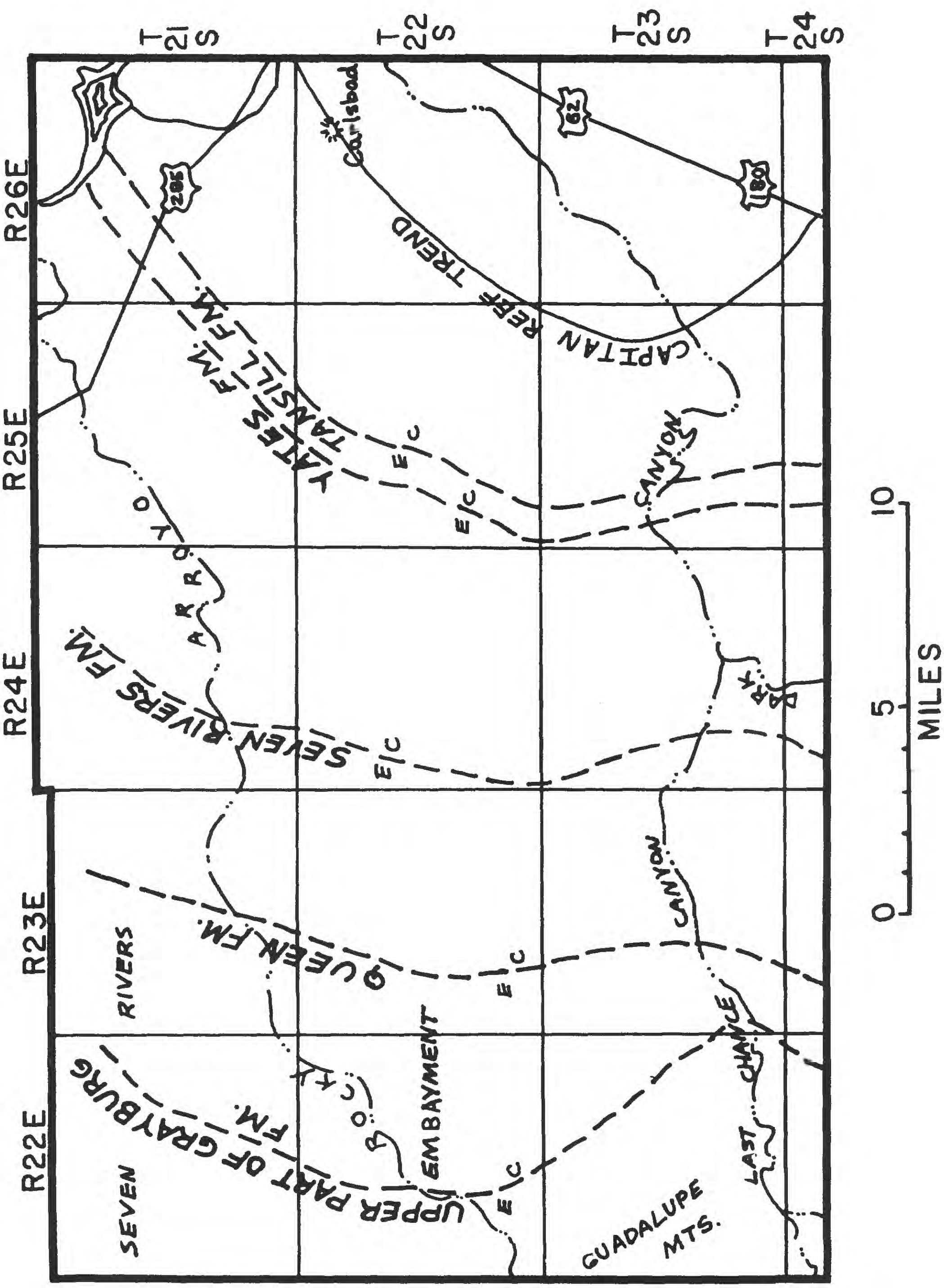


Figure 34.--Geographic location of the evaporite-carbonate transition in formations of the Artesia Group relative to the position of the uppermost Capitan reef facies. Adapted from Bjorklund and Motts (1959) and Motts (1968).

Figure 35.--Seaward-dipping low angle, cross-bedded grainstones in Tansill Formation at stop III-2 (Dark Canyon). These grainstones probably represent windward beaches on small islands. Cactus in center is approximately 2 feet high.

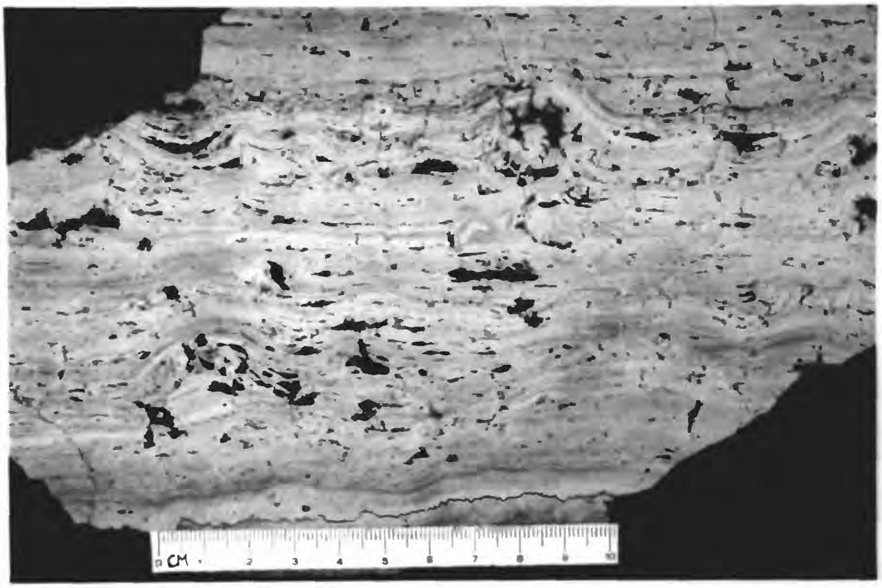


Figure 36.--Polished rock slab showing birdseye structures, fenestral porosity, and probable blue-green algal lamination of dolomitic mudstone in the Tansill Formation.

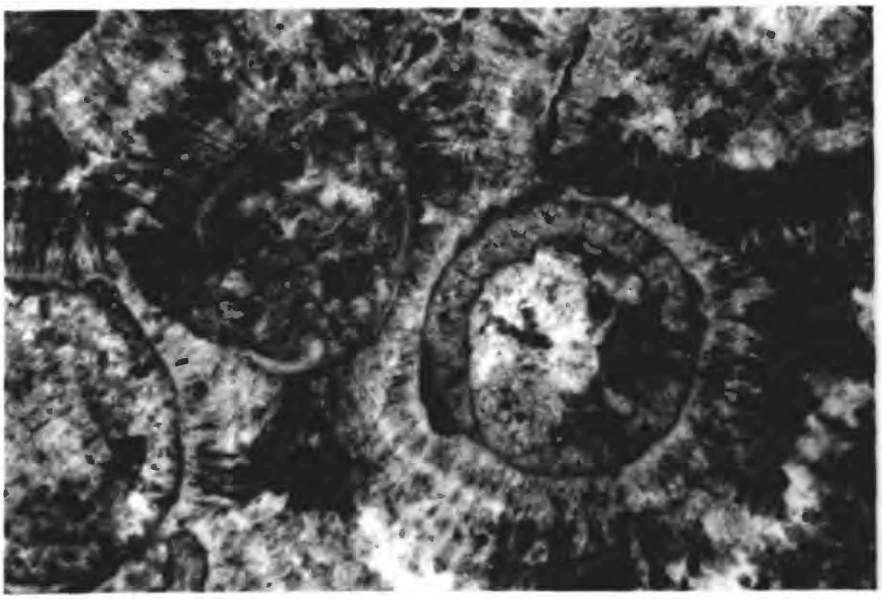


Figure 37.--Photomicrograph of green-algal grainstone showing coarse, radial, cloudy, fibrous, sub-marine cements (originally probably aragonite, now calcite). Long axis of photo equals 2.0 mm.

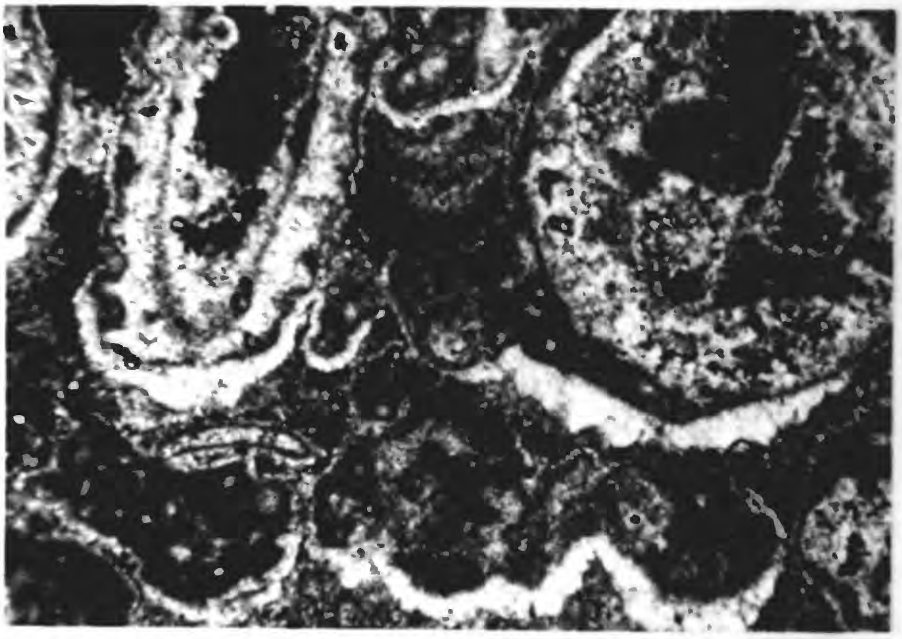


Figure 38.--Photomicrograph of green-algal grainstone showing microstalactitic or pendant calcite cement morphology indicative of cementation in a vadose (fresh water) environment. Long axis of photo equals 2.0 mm.

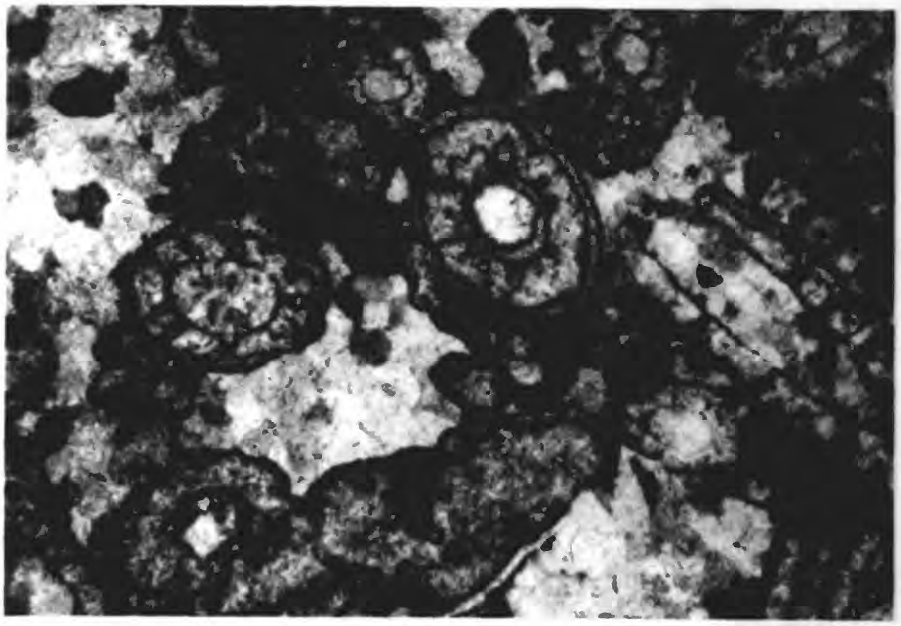


Figure 39.--Photomicrograph of green-algal grainstone showing blocky calcite cement fabric indicative of cementation in a phreatic (fresh water) environment. Long axis of photo equals 2.5 mm.

Figure 40.--Polished rock slab showing altered nodular or enterolithic fabric in back-reef bedded gypsum.

Figure 41.--Margin of the Seven Rivers Embayment along New Mexico Highway 137. Cliffs are capped by the resistant "Azotea Dolomite"; deeply gullied slopes are underlain by interbedded gypsum and red siltstone.

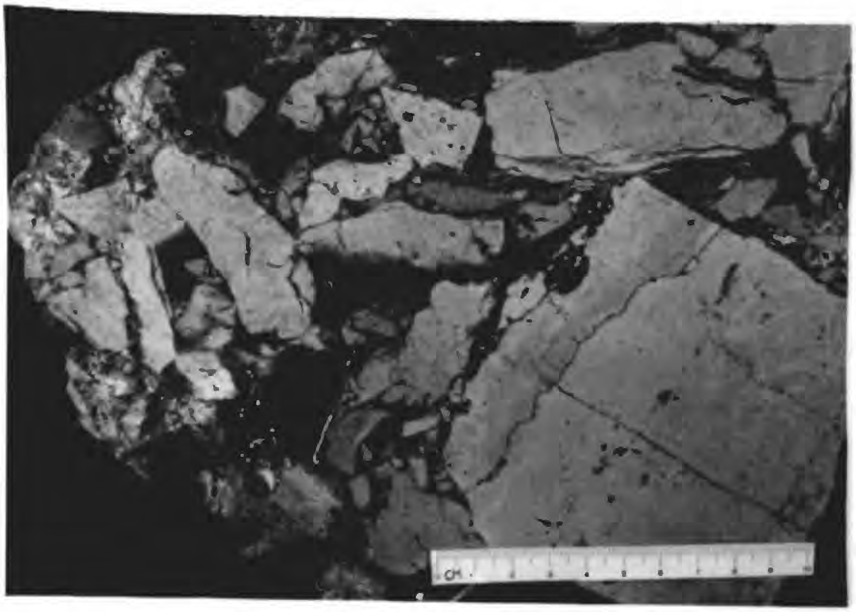


Figure 42.--Polished rock slab showing evaporite solution breccia from Rocky Arroyo. Note angular dolomite clasts and sparry calcite pore-lining cement.

Figure 43.--Crystal casts produced by the selective removal of evaporite minerals from Seven Rivers dolomite beds.

Table 1.--Correlations between faunal and sedimentary features and depositional environment (Data partially adapted from Newell and others (1953) and Schmidt (1977)) [C= common; P= present; R= rare; * indicates feature is generally or always detrital or allochthonous. Absence of any symbol indicates feature is absent or extremely rare]

Feature	Relative abundance in stratigraphic unit and/or environment						
	Artesia Group			Capitan Ls.			Bell Canyon Fm.
	Sabkha-lagoon	Pisolite facies	Near back-reef	Reef crest	Forereef Up.	Forereef Lo.	Basin
Fauna:							
Ostracodes	P	R	P	R	R	R	R
Calcispheres	C	P	P				P
Stromatolites	P	P	R	P	P		
Dasyclad algae		R	C	R	R*	R*	
Fusulinids		P	C	R	R*	R*	P
Other Foraminifera	P	R	P	P	R	R	R
Gastropods		R	C	P	R		
Pelecypods		R	C	P			
Red algae			P	C	P		
Echinoderms		R	P	P	P	P	R
Brachiopods			P	P	P	C	R
Calcareous sponges				C	C	P*	
Hydrozoans				C	C		
Tubiphytes				C	C		
Bryozoans				C	C	P	
Ammonoids			R	R	R	R	R
Siliceous sponge spicules						C	P
Conodonts						R	P
Radiolarians							P
Fish							R
Carbonate rock types:							
Boundstone	P		R	C	C	P*	
Grainstone		C	C	P	P	P	
Packstone							
Wackestone	R	P	P	P	C	C	P
Mudstone	C	P	P	R	R	P	C
Non-carbonate rock types:							
Shale							C
Siltstone	C	P	R			P	C
Sandstone	C	P	R			P	C

Table 1.--Continued.

Feature	Artesia Group			Capitan Ls.			Bell Canyon Fm.
	Sabkha-lagoon	Pisolite facies	Near back-reef	Reef crest	Forereef Up.	Forereef Lo.	Basin
Organic carbon-rich units	R					P	C
Grain types:							
Skeletal	R	P	C	C	C	P	P
Pelletal	C	R	P	P	P	R	
Pisolitic/oolitic	R	C	P				
Intraclastic	R	P	P	C	C	P	R
Sedimentary structures:							
Lamination	C	R	R			P	C
Bedding	C	C	P		R	P	C
Synsedimentary fractures			P	C	C		
Channels			P	?	C	P	C
Cross-bedding		R	P		R	P	P
Graded bedding			R		R	P	P
Breccias	C				C	P	R
Tepee structures		C					
Diagenetic features:							
Dolomitization	C	C	P		P	P	
Chertification					P	C	C
Evaporite nodules	C	R					
Freshwater cements	R	C	P				
Marine cements			P	C	C	P	
Primary porosity	P	R	P				C
Secondary porosity	C	R	C	R			

West Texas provincial series	International series[1]	Russian stages	WEST TEXAS AND SOUTHEASTERN NEW MEXICO: Glass Mountains Brewster County (1)	Guadalupe Mountains (back reef facies) (2)	Guadalupe Mountains (reef facies) (3)	Delaware basin (fore-reef facies) (4)	Franklin and Hueco Mountains and Sierra Diablo (5)	Central Basin platform (6)	Midland basin (7)	Eastern shelf (8)	Central and middle southern New Mexico (11)
Ochoa	Upper Permian	Tatarian	Tessey Limestone	Dewey Lake Redbeds Rustler Formation Salado Formation	Dewey Lake Redbeds Rustler Formation Salado Formation	Dewey Lake Redbeds Rustler Formation Salado Formation Castile Formation		Dewey Lake Redbeds Rustler Formation Salado Formation	Dewey Lake Redbeds Rustler Formation Salado Formation		
Guadalupe	Upper Permian	Kamian: Kazanian Ufimian	Altuda Fm Capitan Limestone Gilliam Ls Vidrio Limestone Member Word Formation	Artesia Group: Tansill Formation Yates Formation Seven Rivers Formation Queen Formation Grayburg Formation San Andres Limestone Cutoff Shale	Artesia Group: Tansill Formation Capitan Limestone Shattuck Tongue Goat Seep Limestone Sandstone tongue of Cherry Canyon Fm Brushy Canyon Fm	Delaware Mountain Group: Bell Canyon Formation (Lamar Ls Mbr, McCombs Ls Mbr, Rader Ls Mbr, Pinery Ls Mbr, Hegler Ls Mbr) Cherry Canyon Formation (Manzanita Ls Mbr, South Wells Ls Mbr, Getaway Ls Mbr) Brushy Canyon Formation Pipeline Shale Mbr	Delaware Mountain Group: Goat Seep Limestone Cherry Canyon Formation	Artesia Group: Tansill Formation Yates Formation Seven Rivers Formation Queen Formation Grayburg Formation San Andres Limestone: Upper member Lower cherty member	Artesia Group: Tansill Formation Yates Formation Seven Rivers Formation Queen Formation Grayburg Formation San Andres Limestone Sandstone and mudstone	Whitehorse Group	
Leonard	Lower Permian	Kungurian Artinskian	Leonard Formation: Shale, sandstone, and limestone Hess Limestone Member	Victorio Peak Limestone Bone Spring Limestone	Victorio Peak Limestone Bone Spring Limestone	Victorio Peak Ls Bone Spring Limestone	Cutoff Shale Victorio Peak Limestone Bone Spring Limestone Deer Mountain Red Shale Member	"Glorieta Sandstone" (Clear Fork Group) (upper part) Fullerton or Tubb Sand Clear Fork, Group (lower part) "Abo Formation" "Wichita Group"	"Glorieta Sandstone" Clear Fork Group Spraberry Sandstone Mudstone	Pease River Group: "Blaine of Texas" San Angelo Sandstone Clear Fork Group: Choza Formation Vale Formation Arroyo Formation Wichita Group: Lueders Formation Clyde Formation Belle Plains Formation Admiral Formation	San Andres Limestone Glorieta Sandstone Yeso Formation
Wolfcamp	Lower Permian	Sakmarian	Wolfcamp Formation Gaptank Formation (part)	Third Bone Spring sand Limestone and gray mudstone and dark gray to black mudstone with thin limestone	Third Bone Spring sand Limestone and gray mudstone and dark-gray to black mudstone with thin limestone	Third Bone Spring sand Limestone and gray mudstone and dark-gray to black mudstone with thin limestone	Hueco Limestone Powwow Conglomerate Member	Hueco Limestone Limestone	Wichita Group: Dean Sandstone Mudstone, limestone, and sandstone	Wichita Group: Putnam Formation: Santa Anna Shale Member Moran Formation Pueblo Formation	Abo Formation Bursum Formation Hueco Limestone Laborcito Formation

Table 2.--Correlation of Permian units from selected sections in west Texas and southeastern New Mexico. Adapted from McKee, Oriel and others (1967).

Table 3.--Oil and gas production, by county, for selected Leonardian (Lower Permian) and Guadalupian and Ochoan (Upper Permian) units in the Permian Basin of Texas and New Mexico. 1/

Field or pool name	Producing formation	Discovery Year	Prod. Depth (ft)	Prod. in-terval (ft)	Cumulative oil prod. (bbls)	Year re-ported	Cumulative gas prod. (cu ft)
			Andrews County, Texas				
FULLERTON, WEST	GRAYBURG	1960	04055	436			0000017973
TRIPLE-N	GRAYBURG	1964	04338	001			
EMBAR	GRAYBURG	1956	04010	064	0000006419	1977	
FUHRMAN-MASCHO	GRAYBURG	1956	04204	029		1977	
MCFARLAND	GRAYBURG	1955	05024	011	0000011878	1977	
PARKER, WEST	GRAYBURG	1962	04546	016	0000066107	1977	
FUHRMAN-MASCHO	GRAYBURG	1930	04700	029			
PHIL-BAR	GRAYBURG	1956	04020	015			0000896433
BLOCK 2	GRAYBURG	1957	04736	018	0001955190	1977	
EMMA	GRAYBURG	1939	04300	090	0016552009	1977	
FUHRMAN-MASCHO	GRAYBURG	1930	04700	060	0078866081	1977	
MEANS	GRAYBURG	1934	04400	090	0119214407	1977	
MIDLAND FARMS	GRAYBURG	1945	04800	080	0108777842	1977	
MIDLAND FARMS, NORTH	GRAYBURG	1953	04943	035	0012590377	1977	
TRIPLE-N	GRAYBURG	1964	04338	001	0004051895	1977	
SERIO	GRAYBURG	1970	04806	008	0000654352	1977	
MABEE	GRAYBURG	1943	04704		0052682331	1977	
PARKER	GRAYBURG SAN ANDRES	1935	04800	037	0001458371	1977	
MIDLAND FARMS, EAST	GRAYBURG, UPPER	1969	04780	011	0000064028	1977	
MCFARLAND, SOUTH	QUEEN	1956	04820	010	0000047523	1977	
MAGUTEX	QUEEN	1958	04862	016	0003666758	1977	
MCFARLAND, EAST	QUEEN	1955	04789	045	0001937991	1977	
MCFARLAND, EAST	QUEEN	1966	04730	010	0000190163	1977	
MCFARLAND, NORTH	QUEEN	1963	04745	010	0000120969	1977	
MCFARLAND	QUEEN	1955	04790	016	0033533593	1977	
MCFARLAND, SOUTHEAST	QUEEN	1967	04875	041	0000020804	1977	
MEANS, EAST	QUEEN SAND	1955	04710	048	0000019318	1977	
NOLLEY	QUEEN SAND	1955	04495	027	0000705203	1977	
MEANS	QUEEN SAND	1954	04024	042	0032988811	1977	
GOLDSMITH, NORTH	SAN ANDRES	1968		030			
NIX, NORTH	SAN ANDRES	1956	04466	037			0001100845

SMITH	SAN ANDRES	1952	04298				
BLOCK A-28	SAN ANDRES	1964	04370	051	0000059520	1977	
BLOCK A-34, NORTH	SAN ANDRES	1967	04653	041	0000036573	1977	
BLOCK 9	SAN ANDRES	1953	04300	071	0001006354	1977	
BLOCK 10	SAN ANDRES	1952	04620	060	0000020196	1977	
FULLERTON, EAST	SAN ANDRES	1966	04624	011	0000024228	1977	
M. H. B.	SAN ANDRES	1955	04678	052	0000001974	1977	
MARTIN, SOUTHWEST	SAN ANDRES	1956	04338	042	0000003860	1977	
NIX	SAN ANDRES	1956	04413	110	0000103985	1977	
SHAFTER LAKE, SOUTH	SAN ANDRES	1959	04635	046	0000001432	1977	
THREE BAR	SAN ANDRES	1960	04384	030	0000001097	1977	
MASCHO	SAN ANDRES	1942	04615		0000543549	1977	
WALLEN	SAN ANDRES	1969	04617	227	0000002559	1977	
FULLERTON	SAN ANDRES	1959	04410	070			0000505622
FULLERTON	SAN ANDRES	1945	04785	205	0007513238	1977	
FULLERTON, SOUTHEAST	SAN ANDRES	1957	04451	102	0000469247	1977	
JANE L.	SAN ANDRES	1956	04585	012	0000125967	1977	
LITTMAN	SAN ANDRES	1951	04313	020	0001088190	1977	
MARTIN	SAN ANDRES	1945	04300	040	0002876392	1977	
OPCO	SAN ANDRES	1968	04391	034	0000013302	1977	
SHAFTER LAKE, NORTH	SAN ANDRES	1952	04559	028	0001040864	1977	
SHAFTER LAKE	SAN ANDRES	1953	04482	053	0031719396	1977	
TRIPLE-N	SAN ANDRES	1966	04297	002	0000031693	1977	
FULLERTON	SAN ANDRES, SOUTH	1955	04400	050	0000028806	1977	
BLOCK A-34	SEVEN RIVERS	1968	03046	009	0000017263	1977	
MEANS	YATES	1934	02950				
EMBAR	YATES	1962	02815	040			0000259864
EMMA	YATES	1956	02724	161			0001125307
SHAFTER LAKE	YATES	1952	03054				
SHAFTER LAKE	YATES	1952	03054	057	0001601345	1977	
MEANS	YATES	1974	03066		0000020557	1977	
BLOCK 12	YATES SAND	1946	02750				

Cochran County, Texas

BLEDSOE, EAST	SAN ANDRES	1957	04918	014	0000005330	1977
COCHRAN	SAN ANDRES	1954	05008	046	0000003441	1977
RHODES	SAN ANDRES	1940	05100	020	0000055547	1977
WINTHROP	SAN ANDRES	1959	05124	040	0000038185	1977
BUCKSHOT	SAN ANDRES	1956	05010	030	0000013848	1975
LEVELLAND	SAN ANDRES	1945	04927	180		
BLOWING SAND	SAN ANDRES	1974	05072		0000001315	1977

BLEDSOE	SAN ANDRES	1951	04193		0000108990	1977	
BUCKSHOT	SAN ANDRES	1956	05010	030	0009042956	1977	
LEVELLAND	SAN ANDRES	1945	04927	180	0275469761	1977	
SLAUGHTER	SAN ANDRES	1937	05000	100	0725592762	1977	
TWO STATES	SAN ANDRES	1953	04920	020	0000010064	1977	

Crane County, Texas

CRANE COWDEN	GRAYBURG	1932	02550	060			
CONCHO BLUFF	GRAYBURG	1956	04386	008	0000000399	1977	
CRANE, SOUTH	GRAYBURG	1955	02400	018	0000002059	1977	
MCCLINTIC	GRAYBURG	1928	03200		0000739188	1977	
WADDELL	GRAYBURG	1928	03003	150			
BLOCK 31	GRAYBURG	1956	03200	020	0003041225	1977	
DUNE	GRAYBURG	1938	03270	170	0133237579	1977	
GIB	GRAYBURG	1947	02700	040	0000211960	1977	
MCELROY	GRAYBURG	1941	02900	150	0348067240	1977	
WADDELL	GRAYBURG	1927	03500	150	0086588362	1977	
GULF-MCELROY	GRAYBURG - SAN ANDRES	1926	03960		0004829939	1977	
BLOCK 31	GRAYBURG, UPPER	1958	02926	018			0000050119
SAND HILLS	MC KNIGHT ZONE OF SAN AN	1944	03420	080	0100224720	1977	
DUNE	PERMIAN SAN ANDRES	1938	03270	170	0000006036	1975	
UNIVERSITY WADDELL	QUEEN	1958	03004	120			
SAGE CANYON	QUEEN	1959	04064	016	0000008030	1977	
ATAPCO	QUEEN	1959	02140	032	0000881787	1977	
CONCHO BLUFF	QUEEN	1956	04131	020	0006766028	1977	
ABELL, NORTHEAST	SAN ANDRES	1963	02650	008	0000034794	1977	
CRANE, SOUTH	SAN ANDRES	1948	02705	080	0000002365	1977	
EPPENAUER	SAN ANDRES	1950	02463	020	0000017858	1977	
MCELROY, EAST	SAN ANDRES	1955	03384	114	0000230749	1977	
MCELROY, WEST	SAN ANDRES	1955	02882	132	0000002609	1977	
DUNE	SAN ANDRES	1954	03415		0001205822	1977	
BAYVIEW, SOUTH	SAN ANDRES	1969	02084	024	0000000933	1977	
MUNN-WYNNE	SAN ANDRES	1972	02144	058		1977	
SAND HILLS	SAN ANDRES	1960	03000		0000235214	1975	
WER	SAN ANDRES	1970	02132				
ABELL, NORTHWEST	SAN ANDRES	1955	02350	043	0000071910	1977	
BAYVIEW, EAST	SAN ANDRES	1967	02150	040	0000055270	1977	
BAYVIEW	SAN ANDRES	1961	02064	022	0000255831	1977	
C-BAR	SAN ANDRES	1949	03520	029	0014204696	1977	

NOELKE	QUEEN	1960	02065	013	0000000711	1977	
NOELKE, NORTHEAST	QUEEN	1943	02250	018			
NOELKE	QUEEN	1945	01400	200			0000239512
OLSON	QUEEN	1943	01790				0000001797
MILLARD, NORTH	QUEEN	1971	01280	020			
ELKHORN	QUEEN	1962	01190				0000025242
COX	QUEEN	1948	00883	016	0000044053	1977	
HOOVER	QUEEN	1941	01470	015	0000110938	1977	
NOELKE, SOUTHEAST	QUEEN	1958	01928	016	0000092221	1977	
PURE-BEAN	QUEEN	1952	01360	006	0001538002	1977	
MILLARD, NORTH	QUEEN	1959	01350	031	0000076149	1977	
VAUGHN	QUEEN	1971	01098	005	0000077421	1977	
NOELKE, SOUTHEAST	QUEEN, LOWER	1959	01851	016	0000182199	1977	
FITTING	SAN ANDRES	1955	01113	040			
SHANNON	SAN ANDRES	1944	01956	010			
TODD	SAN ANDRES	1951	01800	020			
BAIR	SAN ANDRES	1962	01565	016	0000002244	1977	
BLOCK 51	SAN ANDRES	1958	02389	040	0000002298	1977	
HOOVER	SAN ANDRES	1957	01850	010	0000005157	1977	
LANCASTER HILL	SAN ANDRES	1962	01400	095	0000011325	1977	
MIDWAY LANE, NORTHEAST	SAN ANDRES	1967	01539	011	0000004639	1977	
TIPPETT	SAN ANDRES	1956	02854	012	0000000924	1977	
TODD, NORTHEAST	SAN ANDRES	1964	01782	019	0000007662	1977	
TODD	SAN ANDRES	1951	01559	003	0000000547	1977	
TODD, SOUTHWEST	SAN ANDRES	1966	01647	007		1977	
HOOVER, SOUTHEAST	SAN ANDRES	1969	02060	058	0000001315	1977	
HOLT RANCH	SAN ANDRES	1954	01402	015			
TODD, NORTHWEST	SAN ANDRES	1954	01700	005			
HOWARD DRAW, NORTHEAST	SAN ANDRES	1967	01165				0002719614
AMIGO	SAN ANDRES	1955	02160	048	0001101567	1977	
BLOCK 44	SAN ANDRES	1951	01740	024	0000300878	1977	
FARMER	SAN ANDRES	1953	02240	264	0006683745	1977	
HOWARD DRAW	SAN ANDRES	1950	01286	015	0000043935	1977	
MIDWAY LANE	SAN ANDRES	1953	01300	006	0001601337	1977	
PURE-BEAN, SOUTH	SAN ANDRES	1964	01372	004	0000094297	1977	
SHANNON	SAN ANDRES	1943	02406	473	0009127919	1977	
TODD, NORTH	SAN ANDRES	1953	01828	004	0000278900	1977	
TODD	SAN ANDRES	1951	01440	020	0001531063	1977	
TODD, WEST	SAN ANDRES	1966	02142	030	0000015523	1977	
WEGER, NORTH	SAN ANDRES	1955	02318	084	0000322911	1977	
WEGER	SAN ANDRES	1955	02268	034	0001719732	1977	
WYATT	SAN ANDRES	1940	01224	020	0000509749	1977	

DELL	SAN ANDRES	1963	02953	060	0000170370	1977	
JORDAN	SAN ANDRES	1937	03700	150	0069990316	1977	
LEA	SAN ANDRES	1955	03075	079	0003578349	1977	
SAND HILLS, WEST	SAN ANDRES	1960	03342	020	0000134703	1977	
T. E. BAR	SAN ANDRES	1956	02570	005	0000114880	1977	
DUNE, SOUTHEAST	SAN ANDRES	1954	03520	273	0000764700	1977	
W. E. R.	SAN ANDRES	1970	02142	010	0000421552	1977	
CROSSETT	SAN ANDRES	1971	02519		0000006383	1977	
WYNNE	SAN ANDRES	1972	02144	058	0000418261	1977	
J.M.H.	SAN ANDRES	1973	02061		0000005641	1977	
BAYVIEW	SAN ANDRES, MIDDLE	1962	02348	010	0000024466	1977	
T. E. BAR	SEVEN RIVERS	1956	01621	016	0000000314	1977	
PENWELL	YATES	1952	03135				

Crockett County, Texas

BETTY	GRAYBURG	1951	01460	005	0000029000	1977	
BLOCK 46, EAST	GRAYBURG	1961	01280	042	0000009644	1977	
BLOCK 46	GRAYBURG	1959	02363	317	0000001135	1977	
DRY CREEK	GRAYBURG	1953	01150	012	0000000395	1977	
SHANNON	GRAYBURG	1940	01984	020	0000018992	1977	
DONHAM	GRAYBURG	1955	01190	016			0000317267
HOWARD DRAW	GRAYBURG	1955	01139				
SUSITA	GRAYBURG	1967	01616	525			0001373988
DONHAM	GRAYBURG	1962	01133				0000857096
DOUBLE R	GRAYBURG	1974	01949		0000000296	1977	
B & H	GRAYBURG	1958	01748	016	0000019478	1977	
CROCKETT	GRAYBURG	1938	01571	092	0003622639	1977	
HANSON	GRAYBURG	1961	01168	006	0000019349	1977	
MAGGIE NEAL	GRAYBURG	1955	02225	105	0000040475	1977	
OLSON	GRAYBURG	1940	01828	018	0011728872	1977	
TODD	GRAYBURG	1954	01580	100	0000125207	1977	
TODD, NORTHWEST	GRAYBURG	1957	01440	040	0000018277	1977	
VAUGHN	GRAYBURG	1947	01445	001	0010936290	1977	
WEGER, WEST	GRAYBURG	1956	02372	138	0000208665	1977	
WORLD	GRAYBURG LIME	1925	02600	003	0038548463	1977	
FERGUS	GRAYBURG UPPER	1968	02392				0001634031
FERGUS	GRAYBURG, LOWER	1968	02392				
LANCASTER HILL	LOWER GRAYBURG	1947	01718	018	0000037021	1977	
NOELKE	QUEEN	1973	01830	013			

SUSITA	SAN ANDRES	1967	01611	011	0000010614	1977	
FARMER	SAN ANDRES LIME	1953	02240	124	0000000997	1975	
TODD, SOUTHWEST	SAN ANDRES, LO.	1965	02210	024	0000024699	1977	
TODD, SOUTHWEST	SAN ANDRES, UP.	1965	02139	014	0000017527	1977	
OLSON, WEST	SEVEN RIVERS	1967	01279	009			0000039278
NOELKE, SOUTH	SEVEN RIVERS	1962	01632	014	0000000074	1977	
CROCKETT	SEVEN RIVERS	1945	01205	005			
OLSON	SEVEN RIVERS	1961	01358	006			0000456653
NOELKE	SEVEN RIVERS	1940	01133	025	0005464201	1977	
SIMPSON	SEVEN RIVERS	1938	01985	136	0000146998	1977	
HALFF	YATES	1952	01400	021	0000002870	1977	
CLARA COUCH	YATES	1942	01060				
NOELKE, WEST	YATES	1945	00880				0000850172
MIDWAY LANE	YATES	1964	01055	010	0000124000	1977	
VAUGHN	YATES	1962	01052	102	0000026020	1977	

Crosby County, Texas

FORBES	SAN ANDRES	1959	03002	059	0000024020	1977

Culberson County, Texas

SCREWBEAN, SOUTH	CASTILE	1964	01060	005		
PREWIT	CASTILE	1958	00900	010	0000007211	1977
SCREWBEAN	CASTILE	1958	01024	004	0000111431	1977
FORD, WEST	CHERRY CANYON	1963	04143	001	0000188269	1977
GERALDINE	CHERRY CANYON	1962	03953	001	0000037846	1977
GERALDINE, WEST	DELAWARE	1970	02440			
POKORNY	DELAWARE	1958	01693	003	0000000452	1977
RIDGWAY	DELAWARE	1958	02011	010	0000000500	1977
EITHERWAY	DELAWARE	1959	02436	028	0000035570	1977
SCREWBEAN	DELAWARE	1958	02548	013	0000638493	1977
GERALDINE, WEST	DELAWARE	1967	02437	012	0000225404	1977
ED POKORNY	DELAWARE	1969	01338	114	0000003878	1977
WAR-AM	DELAWARE	1970	02378	004	0000004424	1977
MARSH	DELAWARE SAND	1953	02670	020	0000002604	1977
GERALDINE	DELAWARE SAND	1957	02557	004		
RUSTLER HILLS	RUSTLER	1948	00456	010	0000004434	1977

Dawson County, Texas

ARVANNA	SAN ANDRES	1953	03875	004	0000018275	1977	
JO-MILL, SOUTH	SAN ANDRES	1964	03779		0000003146	1977	
WELCH, SOUTHEAST	SAN ANDRES	1964	04901		0000006107	1977	
CEDAR LAKE, EAST	SAN ANDRES	1966	05015		0000047396	1977	
CEDAR LAKE, SOUTHEAST	SAN ANDRES	1953	04940	055	0001224881	1977	
WELCH	SAN ANDRES	1941	05000	040	0101358337	1977	
WELCH, SOUTH	SAN ANDRES	1956	04880	053	0000022133	1977	

Ector County, Texas

PENWELL	GRAYBURG	1926	03800	100			
DONNELLY	GRAYBURG	1950	04020		0000001950	1977	
FASKEN, SOUTH	GRAYBURG	1958	04777	010	0000009136	1977	
HENCE	GRAYBURG	1962	04473	004	0000133988	1977	
VEM	GRAYBURG	1955	04180	198	0000051253	1977	
COWDEN, WEST	GRAYBURG	1955	04075	075	0000032241	1977	
DONNELLY, NORTH	GRAYBURG	1956	04060	105	0000004074	1975	
GOLDSMITH, EAST	GRAYBURG	1958	04100	012			0069640231
GOLDSMITH	GRAYBURG	1950	03660	090			
DONNELLY, NORTH	GRAYBURG	1956	04060	105	0000624333	1977	
DOUBLE H	GRAYBURG	1955	04456	032	0002892126	1977	
FOSTER	GRAYBURG	1948	04300	110	0192250982	1977	
GOLDSMITH	GRAYBURG	1966	03928	020	0000057620	1977	
MOSS	GRAYBURG	1955	03543	064	0001266362	1977	
MOSSWELL	GRAYBURG SAN ANDRES	1964	03972	232	0000067032	1977	
GOLDSMITH, EAST	GRAYBURG, NORTH	1970	04062	009	0000035224	1977	
CONCHO BLUFF, NORTH	QUEEN	1956	04490	035	0006002014	1977	
MOOSE	QUEEN	1958	04512	015	0003237262	1977	
GOLDSMITH	SAN ANDRES	1935	04300	050			
ADDIS	SAN ANDRES	1953	04260	076	0000904381	1977	
DOUBLE H, WEST	SAN ANDRES	1961	04062	047	0000007797	1977	
EDWARDS, NORTH	SAN ANDRES	1955	04284	036	0000083693	1977	
EMMA, SOUTHWEST	SAN ANDRES	1960	04286	062	0000002476	1977	
NOTREES, NORTH	SAN ANDRES	1956	04266	074	0000032245	1977	
TXL, NORTHWEST	SAN ANDRES	1956	04525	037	0000016027	1977	
GOLDSMITH, NORTH	SAN ANDRES	1964	04500		0000819877	1975	
GOLDSMITH, WEST	SAN ANDRES	1956	04280	016	0000004427	1975	
TXL	SAN ANDRES	1952	04380	050	0000042070	1975	
SLATOR	SAN ANDRES	1957	04387	018	0000000940	1975	

BOURLAND	SAN ANDRES	1952	04352	026	0000809121	1977	
COWDEN, NORTH	SAN ANDRES	1964	05276	033	0000389366	1977	
COWDEN, SOUTH	SAN ANDRES	1932	05050	225	0114105516	1977	
DONNELLY	SAN ANDRES	1950	04305	060	0007161549	1977	
EDWARDS	SAN ANDRES	1935	03400	040	0007224988	1977	
GOLDSMITH	SAN ANDRES	1935	04300	120	0301182320	1977	
GOLDSMITH, EAST	SAN ANDRES	1962	04224	014	0006754144	1977	
GOLDSMITH, NORTH	SAN ANDRES	1950	04500	050	0001515521	1977	
GOLDSMITH, NORTH	SAN ANDRES	1964	04500		0010346474	1977	
GOLDSMITH, WEST	SAN ANDRES	1956	04280	100	0005291922	1977	
LAWSON	SAN ANDRES	1950	04320	020	0012679822	1977	
FENWELL	SAN ANDRES	1926	03800	100	0062932746	1977	
SLATOR	SAN ANDRES	1957	04172	018	0002121679	1977	
TXL	SAN ANDRES	1952	04380	050	0008528694	1977	
ANDECTOR	YATES	1952	02720	110			

Gaines County, Texas

HOBBS, EAST	QUEEN	1950	03750	010	0000002184	1977	
HOBBS, EAST	QUEEN	1951	03700				0000792811
NORMAN, SOUTH	QUEEN	1972	04426		0000006761	1977	
NORMAN, SOUTH	QUEEN	1974	04426		0000006383	1977	
FLYING N	QUEEN	1956	04540	015	0000112463	1977	
HARRIS	QUEEN	1957	04148	017	0001210846	1977	
MEANS, NORTH	QUEEN SAND	1955	04341	010	0006344146	1977	
SEMINOLE, WEST	SAN ANDRES	1957	05042	160			
DEMPSEY CREEK	SAN ANDRES	1955	04320	016	0000002400	1977	
FLOREY	SAN ANDRES	1953	05150	052	0000000314	1977	
HOBBS, SOUTHEAST	SAN ANDRES	1964	04494	030	0000001096	1977	
MEDLIN	SAN ANDRES	1956	04992	032	0000001762	1977	
WESCOTT	SAN ANDRES	1964	05434	052	0000001860	1977	
TEX-MEX	SAN ANDRES	1951	04305	019			
ROBERTSON, WEST	SAN ANDRES	1967	04750		0000005492	1977	
SEMINOLE, NORTH	SAN ANDRES	1961	05470		0000153358	1977	
ADAIR	SAN ANDRES	1947	04874	060	0037588098	1977	
BALE	SAN ANDRES	1962	05508		0000317171	1977	
CARTER-NEW MEXICO	SAN ANDRES	1956	05204	073	0000175762	1977	
CEDAR LAKE	SAN ANDRES	1939	04800	160	0059287691	1977	
G-M-K	SAN ANDRES	1957	05598	025	0008510657	1977	
G-M-K, SOUTH	SAN ANDRES	1963	05450		0000488184	1977	
GEORGE ALLEN	SAN ANDRES	1956	04934	032	0000697425	1977	

HOBBS, EAST	SAN ANDRES	1951	04418	041	0000349335	1977	
JENKINS	SAN ANDRES	1950	04543	277	0000631080	1977	
O D C	SAN ANDRES	1957	05450	040	0001622269	1977	
ROBERTSON	SAN ANDRES	1952	04700	014	0000670057	1977	
RUSSELL	SAN ANDRES	1955	04898	028	0000287254	1977	
RUSSELL, SOUTH	SAN ANDRES	1964	04859	116	0001478090	1977	
RUSSELL, SOUTHWEST	SAN ANDRES	1966	05675		0000158773	1977	
SEAGRAVES	SAN ANDRES	1967	05696		0000113946	1977	
SEAGRAVES, SOUTH	SAN ANDRES	1961	05680		0000157258	1977	
SEMINOLE, EAST	SAN ANDRES	1959	05450	016	0003500718	1977	
SEMINOLE	SAN ANDRES	1936	05032	175	0250279422	1977	
SEMINOLE, SOUTHEAST	SAN ANDRES	1964	05310	010	0000865577	1977	
SEMINOLE, WEST	SAN ANDRES	1948	05042	160	0025217093	1977	
TEX-MEX	SAN ANDRES	1951	04305	013	0000401310	1977	
TEX-MEX, SOUTHEAST	SAN ANDRES	1963	04283	008	0000015988	1977	
WASSON	SAN ANDRES	1937	04900	250	1042773383	1977	
TEDBIT	SAN ANDRES	1971	05040	017	0000113403	1977	
BRUMLEY	SEVEN RIVERS	1970	03416		0000240293	1977	
HARRIS	YATES	1961	03010	061			
MAXEY	YATES	1964	03506	037			0000266604
TEX-PAC	YATES	1961	03060	038			0000016305
CEDAR LAKE	YATES	1946	02909	026			
FELMAC	YATES	1958	03216	070			0014657200
G-M-K	YATES	1957	03480	085			0015817396
HOMANN	YATES	1944	03416				
LOOP, NORTHEAST	YATES	1966	03313	071			0008349476
SEMINOLE	YATES	1939	03140				
BALE	YATES	1963	03422				0001640673
LOOP	YATES	1963	03345				0011534652

Garza County, Texas

JUSTICEBURG	SAN ANDRES	1957	02012	050	0000004508	1977
SIMS, SOUTHWEST	SAN ANDRES	1959	03232	020	0000000502	1977
POST, NORTHWEST	SAN ANDRES	1970	02809		0000001411	1977
ARLENE	SAN ANDRES	1958	02980	006	0000722532	1977
DORWARD	SAN ANDRES	1956	01875	009	0001183018	1977
DORWARD, WEST	SAN ANDRES	1961	02020	099	0000021924	1977
GARZA	SAN ANDRES	1966	03189		0001127257	1977
GARZA	SAN ANDRES	1966	03255		0001306193	1977
GARZA	SAN ANDRES	1965	03344		0001271172	1977
GARZA	SAN ANDRES	1966	03465		0000267319	1977
HUNTLEY, EAST	SAN ANDRES	1956	03138	100	0003400926	1977

HUNTLEY	SAN ANDRES	1954	03387	022	0006085839	1977
JUSTICEBURG, NORTHWEST	SAN ANDRES	1949	02044	018	0000267398	1977
P. H. D.	SAN ANDRES	1944	03565	060	0005035240	1977
P. H. D.	SAN ANDRES	1955	03762	020	0000209247	1977
ROCKER A, NORTHWEST	SAN ANDRES	1959	02772	197	0000567652	1977
ROCKER A, NORTHWEST	SAN ANDRES	1967	02953		0000077829	1977
ROCKER A, SOUTH	SAN ANDRES	1952	02510	040	0000165121	1977
STORIE	SAN ANDRES	1958	03598	005	0000111682	1977
THREE WAY	SAN ANDRES	1958	03493	021	0001110565	1977
P. H. D.	SAN ANDRES, LO.	1954	03704	101	0000006667	1977
JUSTICEBURG, NORTHWEST	SAN ANDRES, LO.	1959	02466	007	0000114144	1977
CURT-ROY	SAN ANDRES, LOWER	1955	02390	015	0000077065	1977
HACKBERRY	SAN ANDRES, LOWER	1957	04007	146	0000413782	1977
HACKBERRY	SAN ANDRES, UPPER	1957	03614	010	0000067259	1977

Glasscock County, Texas

FOOLS CREEK	GRAYBURG	1964	01678	002	0000010361	1977
W. Z. B.	GRAYBURG	1974	03653		0000033926	1977
CARTER	QUEEN	1959	01900	200	0000001752	1977
CLYDE REYNOLDS	QUEEN	1959	01883	008	0000112463	1977
FOOLS CREEK	QUEEN	1962	01723	001	0000208046	1977
ROBERTA	QUEEN	1968	01616	004	0000150985	1977
ROSEMARY	SAN ANDRES	1955	02485	015	0000013829	1977
FOOLS CREEK	SAN ANDRES	1963	02144	124	0000017733	1977
MCDOWELL	SAN ANDRES	1964	02341	002	0001387051	1977
ZANT	SAN ANDRES	1906	03788	063	0000226353	1977
MCDOWELL	SAN ANDRES, LO.	1964	02401	005	0000086824	1977
MCDOWELL	SAN ANDRES, MIDDLE	1964	02397	004	0000576727	1977

Hockley County, Texas

CLAUENE	SAN ANDRES	1953	05093	053	0000025219	1977
MARINELL	SAN ANDRES	1959	04711	016	0000022881	1977
PETTIT	SAN ANDRES	1958	03655	019	0000000639	1977
SLAUGHTER	SAN ANDRES	1937	05000	100		
YELLOWHOUSE	SAN ANDRES	1944	04463	067	0008432305	1977
YELLOWHOUSE, SOUTH	SAN ANDRES	1957	04705	012	0000460603	1977
D-L-S	SAN ANDRES	1971	05161	025	0002578992	1977

Howard County, Texas

MOORE	GRAYBURG	1937	03200	040	0008375368	1977
FAIRVIEW	SAN ANDRES	1945	03151	051	0000000363	1977
SNYDER	SAN ANDRES	1967	02085	044	0000012983	1977
VAREL	SAN ANDRES	1955	03080	012	0005011653	1977
HOWARD GLASSCOCK	YATES	1925	03200	019	0314288787	1977

Irion County, Texas

BINGHAM	GRAYBURG	1955	01772	074	0000000200	1977
SUGG, NORTH	SAN ANDRES	1956	01890	010	0000033684	1977
THOMAND	SAN ANDRES	1953	00432	020	0000000342	1977
PETERSON	SAN ANDRES	1955	01875	051	0000050365	1977
TANKERSLEY	SAN ANDRES	1968	01184	006	0000027239	1977
HOWDA	SAN ANDRES	1968	01994	173	0000285207	1977

Kent County, Texas

ELAM, SOUTH	SAN ANDRES	1964	01418	018	0000001264	1977
COGDELL	SAN ANDRES	1951	01475	095	0000680043	1977
FULLERVILLE, NORTHEAST	SAN ANDRES	1964	02395	009	0000013232	1977

Loving County, Texas

TWOFREDS, NORTHEAST	BELL CANYON	1959	04929	001	0000037289	1977
WHEAT	CASTILE	1951	02490		0000000566	1977
PONDITO	CHERRY CANYON	1963	05589	001	0000014716	1977
JEANITA	CHERRY CANYON	1963	04562	002	0000068089	1977
TUNSTILL, EAST	DELAWARE	1959	03652	030		
PINAL DOME	DELAWARE	1955	05032	006	0000048716	1977
PINAL DOME, WEST	DELAWARE	1966	04968	010	0000000310	1977
RED BLUFF	DELAWARE	1953	03106	012	0000009324	1977
TWOFREDS, EAST	DELAWARE	1967	04940	014	0000000401	1977
TWOFREDS, NORTHWEST	DELAWARE	1966	04807	005	0000002447	1977
VER-JO	DELAWARE	1958	04136	008	0000069734	1977
GRICE	DELAWARE	1956	04510	010	0000008792	1975

BATTLEAXE	DELAWARE	1963	04187	004	0000121402	1977
DIMMITT	DELAWARE	1957	04608	013	0000111033	1977
EL MAR	DELAWARE	1959	04532	006	0015410444	1977
GRICE	DELAWARE	1956	04510	010	0007265753	1977
MERIDIAN	DELAWARE	1961	04993	007	0000723814	1977
TUNSTILL, EAST	DELAWARE	1959	03652	016	0002076054	1977
TWOFREDS	DELAWARE	1957	04895	016	0009102191	1977
WHEAT	DELAWARE	1925	04300	020	0020002356	1977
MASON	DELAWARE	1937	03900	045	0002858541	1977
MASON, NORTH	DELAWARE SAND	1952	04055	020	0005896372	1977
TWOFREDS	DELAWARE, LOWER	1963	04895	011	0000048954	1977

Lynn County, Texas

BLOCK L	SAN ANDRES	1961	04248		0000002573	1977
GUINN	SAN ANDRES	1961	04031	003	0000592112	1977
SUNILAND	SAN ANDRES	1955	03803	007	0002687524	1977
Y. W. O.	SAN ANDRES	1959	04043	006	0000091152	1977
SUNILAND	SAN ANDRES, LOWER	1956	04000	110	0002267165	1977
BLOCK L	SAN ANDRES, MIDDLE	1969	04131		0000162135	1977

Martin County, Texas

GLASS	GRAYBURG	1952	04260	070	0000000184	1977
PHOENIX	GRAYBURG	1972	03930	042	0001672131	1977

Midland County, Texas

MIDLAND FARMS, SOUTHEAST	GRAYBURG	1953	04600	040	0000004560	1977
TEX-HARVEY	GRAYBURG	1955	03684	016	0000005901	1977
AZALEA	GRAYBURG	1967	04088	018	0000694122	1977
GERMANIA	GRAYBURG	1952	03940	020	0002559977	1977
GERMANIA	SAN ANDRES	1968	04163	007	0000005019	1977
DRIVER	SAN ANDRES	1955	03800	020	0000191489	1977
SWEETIE PECK	SAN ANDRES	1956	05760	010	0000191907	1977
WAR-SAN	SAN ANDRES	1972	06130	010	0000255774	1977
PEGASUS	SAN ANDRES	1954	05584		0007309065	1977

Mitchell County, Texas

TURNER-GREGORY	SAN ANDRES	1959	01876	101	0000062556	1977	
IATAN	SAN ANDRES	1957	02364	039	0001635388	1977	
ELLWOOD, NORTH	YATES	1971	00611				
ALBAUGH	YATES SD.	1956	01195	012	0000007321	1977	

Pecos County, Texas

COYANOSA, WEST	BELL CANYON	1962	05386	024	0000147911	1977	
ATHEY	BONE SPRING	1966	09138	069	0000154323	1977	
COYANOSA, NORTH	BONE SPRING	1963	08740	080	0000007520	1977	
HERSHEY	CASTILE	1963	05069	001	0000038139	1977	
COYANOSA, SOUTH	CHERRY CANYON	1965	05988	018	0000008878	1977	
COYANOSA	CHERRY CANYON	1965	05860	005	0000001592	1975	
COYANOSA	CHERRY CANYON	1965	05860	010	0000078940	1977	
CHANCELLOR	DELAWARE	1942	05300	030	0000135931	1977	
WAHA, SOUTH	DELAWARE	1963	03457	004	0000006016	1977	
COYANOSA, NORTHEAST	DELAWARE	1967	05228	010			0001361167
COYANOSA, NORTH	DELAWARE	1966	04809	034	0000448911	1977	
ROJO CABALLOS	DELAWARE	1962	05253	102	0000097676	1977	
COYANOSA	DELAWARE SAND	1959	04793	020			
CHANCELLOR	DELAWARE SAND	1954	05092	016	0000176567	1977	
WAHA	DELAWARE SAND	1960	04800	040	0000845264	1977	
COYANOSA	DELAWARE SD.	1959	04793	034	0000822269	1977	
ABELL, EAST	GRAYBURG	1958	02082	083			0001378799
GRAYBURG T. C. O.	GRAYBURG						
HOKIT	GRAYBURG	1960	02721	025			0000634284
BARBASAL	GRAYBURG	1958	02407	003	0000003752	1977	
SHEARER	GRAYBURG	1949	01696	005	0000056418	1977	
WENTZ, SOUTH	GRAYBURG	1964	01623	060	0000002421	1977	
WENTZ, WEST	GRAYBURG	1965	01710	020	0000002112	1977	
TCI	GRAYBURG	1950	02080	001			0006385246
WHITE & BAKER	GRAYBURG	1940	01714	040			
ONLAW	GRAYBURG	1973	01185				
ABELL, SOUTH	GRAYBURG	1960	02238	027	0000758970	1977	
T. C. I.	GRAYBURG	1950	02186	001	0000019284	1977	
YATES	GRAYBURG	1926	01500	220	0683477509	1977	
COYANOSA	LAMAR	1959	04782	018	0000080456	1977	
PUTNAM	OIL QUEEN	1956	01360	026	0000000717	1977	

BURKE	QUEEN	1967	02737	052			0000149794
NUZ	QUEEN	1960	02396	026			
HOKIT	QUEEN	1959	02567	023	0000000189	1977	
IRAAN, SOUTHEAST	QUEEN	1961	01120	008		1977	
PECOS-SHEARER, WEST	QUEEN	1955	01848	045	0000021249	1977	
ROCKY MESA	QUEEN	1961	02352	004	0000025062	1977	
JENLAW	QUEEN	1971	01822	009	0000000234	1977	
ROCKY MESA, NORTHWEST	QUEEN	1972	02578	004	0000000053	1977	
HOKIT	QUEEN	1959	02598	045			0004552138
FORT STOCKTON, SOUTH	QUEEN	1965	02686	038			0005479693
GIRVINTEX	QUEEN	1957	01379				0001226106
WILBROS	QUEEN	1971	01320	009			
MARLAW	QUEEN	1972	01516	002			0000005345
PENLAW	QUEEN	1973	01304				0000012451
FORT STOCTON, SOUTHEAST	QUEEN	1974	02698				
FROMME	QUEEN	1939	01400	050	0000444351	1977	
HINYARD	QUEEN	1962	02422	005	0000181938	1977	
LEHN-APCO, NORTH	QUEEN	1946	01945		0002933465	1977	
MASTERSON	QUEEN	1929	01500	040	0002578286	1977	
MILLARD	QUEEN	1957	01700	025	0000548957	1977	
PRIEST & BEAVERS	QUEEN	1957	02180	040	0001869894	1977	
U S M	QUEEN	1964	03368	033	0000108107	1977	
PECOS VALLEY-YOUNG	QUEEN	1970	01849	066	0000024306	1977	
BEVERLY	QUEEN	1974	02024		0000004423	1977	
MALICKY	QUEEN SAND	1949	01964	028	0003072802	1977	
MISHELLY	QUEEN SAND	1960	01530	030	0000016142	1977	
PECOS-SHEARER	QUEEN SAND	1955	01840	056	0000621011	1977	
WALKER	QUEEN SAND	1940	02016	030	0008607365	1977	
WHITE & BAKER	QUEEN SAND	1934	01100	040	0004901854	1977	
LEHN-APCO	QUEEN SD.	1956	01549	016	0000559808	1977	
FROMME	QUEEN-GRAYBURG	1939	01394	050			
CARDINAL	QUEEN, WEST	1968	01578	035			0001489788
ROXIE	RUSTLER	1970	01926	004	0000000400	1977	
OATES	RUSTLER	1947	00790	055	0000917533	1977	
DAMERON	SAN ANDRES	1961	02345	008	0000008754	1977	
LOWERY & WILSON	SAN ANDRES	1951	02003	012	0000001295	1977	
ABELL	SAN ANDRES	1949	03800	050			
ABELL	SAN ANDRES	1963	22601	024			0000330663
ABELL, NORTH	SAN ANDRES	1950	02386	015	0000415997	1977	
ABELL, SOUTH	SAN ANDRES	1950	02418		0000069193	1977	
ABELL	SAN ANDRES	1949	03800	050	0000742079	1977	
T. C. I.	SAN ANDRES	1949	02200	080	0000305662	1977	
ABELL	SAN ANDRES, LOWER	1950	03140	030			

FORT STOCKTON	SEVEN RIVERS	1970	02901	103			0000014459
T. C. I.	SEVEN RIVERS	1960	01450	038	0000025177	1977	
ABELL, NORTH	SEVEN RIVERS	1971	01660	024	0000000299	1977	
FORT STOCKTON	SEVEN RIVERS	1957	02970	093			
FORT STOCKTON	SEVEN RIVERS	1944	02892	055	0024448513	1977	
FORT STOCKTON	SEVEN RIVERS	1957	02970	093	0000294822	1977	
LEHN-APCO	SEVEN RIVERS	1939	01700	050	0002606074	1977	
SHEARER	SEVEN RIVERS	1938	01400	030	0004350629	1977	
ONLAW	SEVEN RIVERS	1974	01060	054	0000001063	1977	
LEON VALLEY	TANSILL	1962	02304	018			0000060535
PUTNAM	TANSILL	1967	00882	033			0000015779
FORT STOCKTON	TANSILL	1948	02470	040	0000166366	1977	
OWEGO	TANSILL	1959	00675	112			0000196017
THEDA GRIMM	TANSILL	1963	02810	011			0000006921
SANTA ROSA	TANSILL	1972	01456				0000000778
CHICKLYNN	TANSILL	1968	00838	005	0000015402	1977	
MCCANDLESS	TANSILL LIME	1958	00725	063			0000051147
PECOS VALLEY	YATES	1928	01800	060			
TAYLOR-LINK	YATES	1929	00912	075			
TRAGETY	YATES	1956	00752	007			0000596282
WESTERMAN	YATES	1961	04110				
WILLIAMS	YATES	1955	02780	020			0000315448
YATES	YATES		01463				
ABELL	YATES	1968	01600	259			0000173847
CRANDELL	YATES	1950	01077	036	0000018205	1977	
HEINER, WEST	YATES	1961	01323	019	0000001085	1977	
PRIEST & BEAVERS, WEST	YATES	1960	01650	086	0000003543	1977	
WILLIAMS	YATES	1951	02814	020	0000015168	1977	
MAC-DER	YATES	1954	01187				0000247141
PECOS VALLEY	YATES		01500				
PUTNAM, NORTH	YATES	1960	00840	017			0000274902
BELDING	YATES	1957	02616	054	0000049116	1975	0011835922
MPF	YATES	1968	02952	106			0002767639
T. C. I.	YATES	1971	01630	260			
BELDING, EAST	YATES	1965	02584	008	0000026604	1977	
BELDING	YATES	1964	02672	076	0000025356	1977	
FORT STOCKTON	YATES	1963	03244	081	0000031382	1977	
LEON VALLEY	YATES	1956	02498	025	0000426962	1977	
NETTERVILLE	YATES	1934	02400	030	0002910317	1977	

ORIENT	YATES	1948	01785	045	0000244035	1977
PECOS VALLEY	YATES	1928	01800	060	0016767484	1977
PECOS VALLEY	YATES	1928	01600	025	0006056877	1977
PECOS VALLEY, SOUTHEAST	YATES	1967	01625	003	0000038700	1977
ROXIE	YATES	1969	03121	003	0000168090	1977
MPF	YATES	1970	03023	025	0000251564	1977
T. C. I.	YATES	1970	01390	260	0000029651	1977
FORT STOCKTON	YATES-SEVEN RIVERS	1944	02892	055		
FORT STOCKTON	YATES, LOWER	1943	03072	006	0000058843	1977

Reagan County, Texas

BARNHART, NORTHEAST	GRAYBURG	1955	01912	043	0000000629	1977
BIG LAKE, SOUTH	GRAYBURG	1954	02403	012	0000000924	1977
WOLTERS	GRAYBURG	1953	02250	100	0000007220	1977
JOHN SCOTT	GRAYBURG	1953	02534	163	0002354972	1977
PRICE	GRAYBURG	1953	02410	070	0001826725	1977
PRISCILLA	GRAYBURG	1964	02450	062	0000088920	1977
SANTA RITA, SOUTH	GRAYBURG	1961	03134	004	0000095968	1977
TEXON, SOUTH	GRAYBURG	1968	03266	004	0000527874	1977
PRICE, NORTHEAST	GRAYBURG	1954	02644	111	0000835098	1977
BIG LAKE	QUEEN	1923	03000	008	0124475372	1977
BIG LAKE	SAN ANDRES	1957	02985	007	0000011891	1977
JOHN SCOTT, NORTH	SAN ANDRES	1957	02306	164	0000002525	1977
LONG-RODGERS	SAN ANDRES	1964	02560	008	0000009238	1977
ROCKER B	SAN ANDRES	1957	01774	073	0000002952	1977
ROCKER B, SOUTH	SAN ANDRES	1957	01858	118	0000002031	1977
BLOCK 49	SAN ANDRES	1955	02456	036	0000772266	1977
GRAYSON	SAN ANDRES	1928	03185	019	0001166409	1977
V-BAR	SAN ANDRES	1955	02294	020	0000102228	1977

HOBAN	BONE SPRING	1968	09038	321	0000035738	1977	
SCREWBEAN, EAST	CASTILE	1959	01005	007	0000000801	1977	
WORSHAM	CASTILE	1960	02800	010	0000016364	1977	
CAMPBELL	CASTILE LIME	1951	01923	042	0000001221	1977	
SUNNI	CHERRY CANYON	1964	05988	010			0000004767
WAHA, WEST	CHERRY CANYON	1966	06213	014	0000107560	1975	0004637818
WAHA, WEST	CHERRY CANYON	1972	06019	024	0000010042	1975	
FORD	CHERRY CANYON	1962	03968	106	0000008103	1977	
KATHY-SUE	CHERRY CANYON	1964	05765	001	0000004472	1977	
WAHA, WEST	CHERRY CANYON	1962	06450	024	0000730305	1977	
WAHA, WEST	CHERRY CANYON	1962	05750	183	0000072876	1975	
WAHA, WEST	CHERRY CANYON	1972	05514	030	0000002647	1975	
WORSHAM	CHERRY CANYON	1967	06258		0000007046	1975	
RACUE	CHERRY CANYON	1964	03798	005	0000117543	1977	
WAHA, WEST	CHERRY CANYON	1963	05508	030	0000188618	1977	
WAHA, WEST	CHERRY CANYON	1962	05750	008	0000372617	1977	
WORSHAM	CHERRY CANYON	1967	06288	343	0000010658	1977	
SULLIVAN	DELAWARE	1957	02665	019			
WAHA, WEST	DELAWARE	1968	05856	036	0000064739	1975	0001425024
KENNEDY-FAULKNER, SOUTH	DELAWARE	1969	02576	012	0000002479	1975	
BARSTOW	DELAWARE	1972	04928				0000014474
BIG FLAT	DELAWARE	1962	02908	006	0000045512	1977	
E. C. F.	DELAWARE	1964	03192	004	0000023643	1977	
ORLA, SOUTHEAST	DELAWARE	1959	03643	002	0000005543	1977	
PECOS, NORTH	DELAWARE	1958	04331		0000008185	1977	
RACUE	DELAWARE	1965	02685	004	0000005111	1977	
REAVES	DELAWARE	1958	03169	005	0000002594	1977	
TOYAH LAKE, WEST	DELAWARE	1962	05907	028	0000006759	1977	
WAHA, WEST	DELAWARE	1963	05833	014	0000187399	1977	
WEINACHT	DELAWARE	1966	04654	018		1977	
J. E. H.	DELAWARE	1963	02814	002	0000005624	1977	
REEVES-BLOCK 4	DELAWARE	1966	04465	020	0000000710	1977	
REAVES, NORTH	DELAWARE	1964	03200	011			
TORO	DELAWARE	1961	05158	012	0000026210	1975	
TUNSTILL	DELAWARE	1947	03270				
WAHA	DELAWARE	1960	04800	040			0097289740
WAHA, WEST	DELAWARE	1961	05034	002	0000000295	1975	
WORSHAM	DELAWARE	1957	05081	050			0084284093

ORLA, SOUTHEAST	DELAWARE	1959	03620	002			
AYLESWORTH	DELAWARE	1953	03940	008	0000090768	1977	
CHAPMAN, SOUTH	DELAWARE	1965	02931	004	0000170546	1977	
CRUSHER	DELAWARE	1964	05179	010	0000030701	1977	
HAYS	DELAWARE	1957	03002	012	0000056430	1977	
KEN REGAN	DELAWARE	1954	03350	010	0002215165	1977	
KENNEDY-FAULKNER	DELAWARE	1968	02643	008	0000035967	1977	
OLDS	DELAWARE	1958	03029	007	0001023932	1977	
ROJO CABALLOS, WEST	DELAWARE	1966	05262	012	0000020626	1977	
SABRE	DELAWARE	1958	02968	014	0004024864	1977	
SAND LAKE	DELAWARE	1958	04161	008	0000086612	1977	
SCREWBEAN, NORTHEAST	DELAWARE	1961	02519	001	0000942641	1977	
SULLIVAN	DELAWARE	1957	02665	019	0001530321	1977	
TUNSTILL	DELAWARE	1947	03270	015	0009898688	1977	
WORSHAW, SOUTHWEST	DELAWARE	1963	01535	003	0000213403	1977	
CHAPMAN	DELAWARE	1948	02900	006	0001226507	1977	
KENNEDY-FAULKNER, SOUTH	DELAWARE	1970	02614	007	0000010017	1977	
AMBLER	DELAWARE SAND	1964	04335	011			0000666115
ALLAR-MARKS	DELAWARE SAND	1954	03471	005	0000072626	1977	
ARNO	DELAWARE SAND	1956	04114	007	0000010609	1977	
TORO, SOUTH	DELAWARE SAND	1961	05322	005	0000001083	1977	
WAHA, NORTH	DELAWARE SAND	1960	04917	012	0000015082	1975	
HAMON	DELAWARE SAND	1966	05271	002			0000058362
FORD, EAST	DELAWARE SAND	1963	02730	015	0002665220	1977	
ORLA, SOUTH	DELAWARE SAND	1953	03562	040	0000850945	1977	
WAHA, NORTH	DELAWARE SAND	1960	04917	012	0004530723	1977	
WAHA, WEST	DELAWARE SAND	1961	05034	024	0001856241	1977	
WORSHAM	DELAWARE SAND	1960	04932	007	0000855766	1977	
WORSHAM, SOUTH	DELAWARE SAND	1961	05050	004	0000305403	1977	
TORO	DELAWARE SAND	1961	05158	009	0000724964	1977	
FORD	DELAWARE SD.	1956	02642	013	0004139470	1977	
WORSHAM, SOUTH	DELAWARE, LOWER	1962	06536	003	0000001017	1977	
PAMELA	RUSTLER	1958	00150	093	0000000265	1977	

Schleicher County, Texas

MOZELLE	QUEEN SD.	1956	02190	015	0000107632	1977

Scurry County, Texas

B. S. & N.	SAN ANDRES	1956	02170	025		1977	
ROUGH CREEK	SAN ANDRES	1956	02022	062	0000000200	1977	
CORAZON	SAN ANDRES	1953	02139	051	0003469592	1977	
DIAMOND M	SAN ANDRES	1950	02380	027	0001703608	1977	
SHARON RIDGE	SAN ANDRES	1923	01759	025	0034138142	1977	
TONTO	SAN ANDRES	1962	01751		0000011891	1977	
VAREL, NORTH	SAN ANDRES	1971	02328	082	0000025848	1977	

Sterling County, Texas

HERRELL	GRAYBURG	1962	01691	003	0000204709	1977	
PAROCHIAL-BADE, WEST	QUEEN	1965	01321	001	0000253297	1977	
HERRELL, EAST	QUEEN SAND	1953	01454	011	0002123321	1977	
PAROCHIAL-BADE	QUEEN SAND	1951	01103	016	0000976839	1977	
PAROCHIAL-BADE	QUEEN SAND, LO.	1954	01336	061	0000367413	1977	
DURHAM, WEST	SAN ANDRES	1953	01452	004	0000000089	1977	
DURHAM	SAN ANDRES	1966	01461	007	0000003557	1977	
KINKEL	SAN ANDRES	1959	01315	004	0000000397	1977	
CLARK	SAN ANDRES	1949	00890	008	0000853424	1977	
DURHAM	SAN ANDRES	1950	01404	016	0000362774	1977	
PAROCHIAL-BADE	SAN ANDRES	1954	01737	010	0000018533	1977	
PAROCHIAL-BADE, EAST	SEVEN RIVERS	1965	00984	003	0000014140	1977	
PAROCHIAL-BADE, WEST	SEVEN RIVERS	1965	01136	036	0000058982	1977	
DURHAM	YATES SAND	1957	00673	010	0000009558	1977	

Terry County, Texas

COVINGTON	SAN ANDRES	1956	05020	050	0000291004	1977	
WELLMAN, SOUTHWEST	SAN ANDRES	1966	05509		0000106048	1977	
WELLMAN, WEST	SAN ANDRES	1966	05583		0000801026	1977	
TOKIO	YATES	1962	03378	034			0000000900
WELLMAN, SOUTHWEST	YATES	1966	03430	088			
WELLMAN, WEST	YATES	1962	03440	075			0016708774

Tom Green County, Texas

HALL	SAN ANDRES	1951	01295	024	0000052073	1976
KNICKERBOCKER	SAN ANDRES	1952	00360	016	0000007099	1977
PULLIAM	SAN ANDRES	1953	00700	008		1977
FUNK	SAN ANDRES	1952	00739	002	0000202615	1977
WATER VALLEY	SAN ANDRES	1948	01035	010	0002971624	1977

Upton County, Texas

HURDLE	GRAYBURG	1966	02100	040		
M & S	GRAYBURG	1963	01976	011	0000008642	1977
MCCAMEY, EAST	GRAYBURG	1955	02757	030	0000007378	1977
CHURCH	GRAYBURG	1926	03300		0013008502	1977
CANLAW	GRAYBURG	1972	01806	007	0000011683	1977
CANLAW	GRAYBURG	1972	01797			
HURDLE	GRAYBURG	1936	02100	040	0000622501	1977
MCCAMEY	GRAYBURG	1925	02100	080	0126456150	1977
RODMAN-NOEL	GRAYBURG	1953	01745	073	0001053782	1977
SHIRK	GRAYBURG	1956	02850	070	0000672605	1977
WEBB RAY	GRAYBURG	1935	02100	013	0000122510	1977
MIETHER	GRAYBURG	1956	03241	174	0000795936	1977
SUGARLOAF	GRAYBURG	1970	02287	004	0000065693	1977
C-M-R	GRAYBURG	1969	02069	010	0000179294	1977
MCELROY	GRAYBURG - SAN ANDRES	1926				
HURDLE	QUEEN	1956	01634	008	0000010296	1977
AMACKER-TIPPETT, SOUTH	SAN ANDRES	1963	04913	016		
CASTLE GAP	SAN ANDRES	1966	02869	009	0000035907	1977
HERRINGTON	SAN ANDRES	1937	02890		0000072485	1977
WEBB RAY, SOUTHEAST	SAN ANDRES	1953	02180	062	0000000322	1977
WEBB RAY	SAN ANDRES	1965	02365	008	0000000113	1977
HELUMA	SAN ANDRES	1956	03005	072	0000002727	1977
RODMAN-NOEL	SAN ANDRES	1956	01834	010	0000034311	1977

Ward County, Texas

QUITO, EAST	BELL CANYON	1964	05293	017	0000004512	1977	
POQUITO	BELL CANYON	1961	05032	013			0017711917
MAGNOLIA SEALY, WEST	BRUSHY CANYON	1959	06190	010	0000068394	1977	
DELSTRAT	BRUSHY CANYON	1958	07675	006	0000129581	1977	
WAR-WINK	CHERRY CANYON	1964	06080	004	0000000250	1975	
LOVELADY	CHERRY CANYON	1964	06393	023	0000016727	1977	
MAGNOLIA SEALY, WEST	CHERRY CANYON	1959	05214	010	0000000892	1977	
PYOTE, SOUTH	CHERRY CANYON	1961	06216	012	0000061546	1977	
WAR-WINK	CHERRY CANYON	1965	06037	002	0000019127	1977	
QUITO, WEST	CHERRY CANYON	1974	06192	067			0000007742
LOVELADY	CHERRY CANYON	1965	06230	008	0000066252	1977	
PITZER, NORTH	CHERRY CANYON	1964	06400	015	0000028878	1977	
PYOTE, SOUTH	CHERRY CANYON	1961	06457	008	0000022371	1977	
BLOCK 16	CHERRY CANYON	1969	05981	013	0000305657	1977	
SCOTT	DELAWARE	1946	04239				
SCOTT	DELAWARE	1957	04835				0000029367
TWOFREDS	DELAWARE	1957	04895	040			
BLOCK 18	DELAWARE	1955	04982	022	0000004880	1977	
HAZIDA	DELAWARE	1957	04765	013	0000029330	1977	
MONROE	DELAWARE	1931	04600	010	0003045692	1977	
PRUITT, EAST	DELAWARE	1966	05278	007	0000002436	1977	
REGAN-EDWARDS	DELAWARE	1955	04801	005	0000006940	1977	
LION	DELAWARE	1945	04993	020			0000068300
MI VIDA	DELAWARE	1970	05002	010			0000154543
BLOCK 17	DELAWARE	1955	04977	023	0000103268	1977	
BLOCK 17, SOUTHEAST	DELAWARE	1956	05003	003	0000808394	1977	
LION	DELAWARE	1944	04965	015	0000135702	1977	
PITZER, SOUTH	DELAWARE	1964	06390	011	0000135202	1977	
QUITO, EAST	DELAWARE	1954	05124	010	0000135382	1977	
QUITO, WEST	DELAWARE	1955	04732	011	0002832338	1977	
WIL-JOHN, NORTHWEST	DELAWARE SAND	1961	05067	001	0000003424	1977	
BLOCK 17, SOUTHEAST	DELAWARE SAND	1956	05003	024	0000124639	1975	
PITZER	DELAWARE SAND	1957	06085	025			0004255394
QUITO	DELAWARE SAND	1953	04934	010	0002388514	1977	
WIL-JOHN	DELAWARE SAND	1953	05020	010	0000074394	1977	
SCOTT	DELAWARE SAND	1946	04239	020	0000849421	1977	
REGAN-EDWARDS	DELAWARE, UPPER	1957	04757	004	0000231049	1977	
BLOCK 17	LAMAR LIME	1963	05014	020	0000150969	1977	

QUITO, SOUTH	OLDS DELAWARE	1967	04850	010	0000029474	1977	
MONAHANS, WEST	QUEEN	1966	03097	097	0000369862	1977	
C & M	QUEEN	1962	03036	010	0000179287	1977	
H. S. A.	QUEEN	1966	03060	010	0000207520	1977	
MONAHANS, SOUTH	QUEEN	1961	03108	061	0005912100	1977	
MONAHANS, SOUTHWEST	QUEEN	1970	03084	004	0000059027	1977	
WRISTEN	QUEEN	1973	02766		0000007474	1977	
SHIPLEY, NORTH	QUEEN SAND	1961	02650	003	0000011047	1977	
WARD, SOUTH	QUEEN SAND	1952	06350		0000005342	1977	
DORR	QUEEN SAND	1955	02291	004	0000405493	1977	
MONAHANS	QUEEN SAND	1960	03269	025	0003982286	1977	
SHIPLEY	QUEEN SAND	1928	03075	080	0027338325	1977	
BLOCK 16	RUSTLER DOLOMITE	1970	01736	008	0000097053	1977	
CRAWAR	SAN ANDRES	1955	03510	014	0000013095	1977	
WARD, SOUTH	SAN ANDRES	1966	04274	027	0000003286	1977	
MAGNOLIA SEALY, SOUTH	SEVEN RIVERS	1940	02847	050			
PYOTE	SEVEN RIVERS	1942	02827	020	0000338486	1977	
WARD, SOUTH	SEVEN RIVERS	1953	02627		0000005713	1977	
WARD-ESTES, NORTH	SEVEN RIVERS	1929	03000	085			
MAGNOLIA SEALY	SEVEN RIVERS	1939	03000	070	0004390812	1977	
MAGNOLIA SEALY, SOUTH	SEVEN RIVERS	1940	02847	050	0003122608	1977	
SPENCER	SEVEN RIVERS	1941	02900	040	0002423874	1977	
WARD, SOUTH	SEVEN RIVERS	1938	02700	175	0096533385	1977	
WARD-ESTES, NORTH	SEVEN RIVERS	1929	03000	085	0323702128	1977	
H. S. A.	YATES	1954	02520	085			
WARD, SOUTH	YATES	1965	02462	016			0000010297
SEALY, SOUTH	YATES	1946	02700	010	0000916238	1977	
DORVENE	YATES	1970	02951	004	0000049180	1977	
SHIPLEY	YATES	1933	02065				
WARD, SOUTH	YATES	1931	02265	175			
MAGNOLIA SEALY, WEST	YATES	1958	03205	006	0000131401	1977	
PAYTON	YATES	1938	02000	040	0012550205	1977	
WICKETT, SOUTH	YATES	1952	02640	044	0001526982	1977	
MAGNOLIA SEALY, NORTHWES	YATES	1971	03356	006	0000205685	1977	
HOWE	YATES	1973	02590		0000178239	1977	
MAGNOLIA SEALY, SOUTH	YATES, LOWER	1968	03250	005			0000032969

Winkler County, Texas

WINK, SOUTH	BONE SPRING	1973	09630		0000016579	1977	
LECK, WEST	BONE SPRING	1959	08095	031	0000119880	1977	
LITTLE JOE, EAST	DELAWARE	1966	05049	002			0000126316
LITTLE JOE	DELAWARE	1965	05034	006	0000146965	1975	
LITTLE JOE, SOUTH	DELAWARE	1968	05004	002			0001484334
WAR-WINK, NORTH	DELAWARE	1965	05002	014			0000400119
WAR-WINK	DELAWARE	1966	05091	004	0000002289	1975	
WAR-WINK	DELAWARE	1959	05063	049			0001472649
LITTLE JOE	DELAWARE	1965	05034	006	0001035440	1977	
LITTLE JOE, EAST	DELAWARE	1966	05022	003	0000058911	1977	
LITTLE JOE	DELAWARE	1966	05002	012	0000206911	1977	
WAR-WINK	DELAWARE	1966	05091	004	0000064888	1977	
BLOCK 20	DELAWARE SAND	1953	05096	006	0000034180	1977	
UNIVERSITY BLK 21	DELAWARE SAND	1954	07235	043	0000197522	1977	
KERMIT	GRAYBURG	1957	03249	037	0000009706	1975	
SCARBOROUGH, NORTH	GRAYBURG	1947	03286	050	0003281823	1977	
KEYSTONE	GRAYBURG	1937	02918				0003325519
KERMIT	GRAYBURG	1957	03249	037	0000352241	1977	
KERMIT	QUEEN	1954	03285	032			
KEYSTONE	QUEEN	1939	03300	170			
DARMER	QUEEN	1967	03239	042	0000079870	1977	
KERMIT, SOUTHEAST	QUEEN	1973	03285		0000117006	1977	
HALLEY, SOUTH	QUEEN SAND	1960	03113	051			
PAT BISHOP	QUEEN SD.	1962	03238	011	0000105080	1977	
KEYSTONE	SAN ANDRES	1960	04465	006	0001039111	1977	
KERMIT	SAN ANDRES-YATES, UPPER						
EAVES	SEVEN RIVERS	1936	03200	030	0004412688	1977	
HALLEY	SEVEN RIVERS	1943	03150		0000004824	1977	
LECK	SEVEN RIVERS	1928	03100	150	0004914944	1977	
HALLEY	SEVEN RIVERS	1968	03106	007			0000650668
EMPEROR	SEVEN RIVERS	1935	02900	050	0022798528	1977	
EMPEROR	SEVEN RIVERS	1935	03000	050	0008939989	1977	
HALLEY	SEVEN RIVERS	1939	03150	100	0014900242	1977	
HENDRICK	SEVEN RIVERS	1926	03100	300	0254016915	1977	
LECK, WEST	TANSILL YATES	1959	03153	084	0000005055	1977	
HENDERSON	YATES	1963	05076	062			
PAT BISHOP	YATES	1963	02580	026			

HALLEY	YATES	1939	03150	100		
EMPEROR	YATES	1937	02450			
EMPEROR DEEP	YATES	1937	02360	050		
KERMIT	YATES	1928	02485			
KEYSTONE	YATES	1956	02492			
SCARBOROUGH	YATES	1927	03180	102	0000000118	1975
SCARBOROUGH	YATES	1952	02537			
SCARBOROUGH	YATES	1927	03200	075	0026638929	1977
HENDERSON	YATES	1936	03030		0014550161	1977
HALLEY	YATES OBRIEN	1935	02597	100		
WEINER	YATES, UPPER	1937	02401			

Yoakem County, Texas

BRONCO	SAN ANDRES	1952	11692	098	0000000333	1975
BRAHANEY, WEST	SAN ANDRES	1954	05268	076	0000238383	1977
BRONCO	SAN ANDRES	1954	05182	098	0000007123	1977
CHAMBLISS	SAN ANDRES	1955	05248	064	0000313275	1977
CONRAD	SAN ANDRES	1958	05292	022	0000002270	1977
FITZGERALD, EAST	SAN ANDRES	1960	05398	012	0000003455	1977
PLATANG	SAN ANDRES	1955	05137	029	0000012872	1977
PRENTICE, NORTH	SAN ANDRES	1956	05095	016	0000034082	1977
PRENTICE	SAN ANDRES	1965	05294	056	0000019311	1977
TAMARA	SAN ANDRES	1957	05308	020	0000005399	1977
WAPLES PLATTER	SAN ANDRES	1929	05300	113	0001134419	1977
WEST	SAN ANDRES	1973	05219		0000001601	1977
BAY	SAN ANDRES	1968	05350		0000072268	1977
HARTLEY	SAN ANDRES	1959	05365	016	0000047219	1977
HENARD	SAN ANDRES	1950	05205	135	0000204756	1977
JANICE	SAN ANDRES	1955	05263	017	0000190402	1977
LANDON	SAN ANDRES	1945	05100	040	0005350810	1977
OWNBY	SAN ANDRES	1941	05350	060	0007626377	1977
OWNBY, WEST	SAN ANDRES	1953	05307	161	0000781586	1977
·REEVES	SAN ANDRES	1957	05544	030	0018684618	1977
SABLE	SAN ANDRES	1957	05258	038	0004675397	1977
SPIVEY	SAN ANDRES	1958	05340	020	0000167096	1977
WEST	SAN ANDRES	1938	05100	035	0001695277	1977
PRENTICE, NORTHWEST	SAN ANDRES	1969	05164	048	0000683329	1977
WBD	SAN ANDRES	1969	05288		0000507986	1977
SABLE, NORTH	SAN ANDRES	1970	05230		0000036466	1977
PRENTICE	SAN ANDRES	1974	05240		0000233964	1977
WASSON, NORTH	SAN ANDRES	1974	05265		0000048420	1977

HENSHAW, WEST	GRAYBURG	1956	02745	189	0004338378	1977	
SAMS RANCH	GRAYBURG	1963	01683	010			0000654159
BROWN	QUEEN	1942	00765	005	0000069757	1977	
COYOTE	QUEEN	1959	00835	025	0000356666	1977	
CAPROCK	QUEEN	1940		009	0071710693	1977	
CEDAR POINT	QUEEN	1956	02770	007	0000008198	1977	
SULIMAR	QUEEN	1968	02031	008	0001888526	1977	
LUCKY LAKE, SOUTH	QUEEN	1972		007	0000093905	1977	
DOUBLE L	QUEEN	1969	01929	010	0001575342	1977	
DRICKEY	QUEEN	1953	02871	019	0000322022	1974	
DRICKEY, SOUTH	QUEEN	1954	03132				
ROUND TANK	QUEEN	1969	01506	004	0000005353	1977	
VEST RANCH	QUEEN	1971	02142		0000155979	1977	
CHAVES, SOUTHEAST	QUEEN	1972	02107				0000170223
RACE TRACK	SAN ANDRES	1964	02186	103	0000023808	1977	
TOBAC, WEST	SAN ANDRES	1966	04242	004	0000000355	1977	
MANY GATES	SAN ANDRES	1967	03261		0000000989	1977	
PECOS	SAN ANDRES	1961	01128	018	0000013673	1977	
BITTER LAKE, SOUTH	SAN ANDRES	1960	00880	012	0000121422	1977	
BITTER LAKE, WEST	SAN ANDRES	1960	00763	040	0000011276	1977	
BUTTON MESA	SAN ANDRES	1960	04032	010	0000000860	1977	
CHISUM	SAN ANDRES	1951	02028	005	0000047969	1977	
TOWER	SAN ANDRES	1970	04148	017	0000002036	1977	
CHISUM, EAST	SAN ANDRES	1969	02155	039	0000075914	1977	
GALLINA	SAN ANDRES	1966	04053	015	0000014691	1977	
LONESOME	SAN ANDRES	1975	04118	130	0000002812	1977	
WINDMILL	SAN ANDRES	1959	02514	018	0000000993	1977	
DEXTER	SAN ANDRES	1955	01338	010	0000002318	1977	
DIABLO	SAN ANDRES	1962	02060	032	0000019732	1977	
LESLIE SPRING	SAN ANDRES	1964	01484	018	0000008739	1977	
LINDA	SAN ANDRES	1963	01023	021	0000071075	1977	
ACME	SAN ANDRES	1951	01975	005	0000210769	1977	
COMANCHE	SAN ANDRES	1936	01254	010	0000015077	1977	
BITTER LAKE	SAN ANDRES	1946	01247	005	0000000090	1977	
CATO	SAN ANDRES	1966	03496	030	0013944240	1977	
TWIN LAKES	SAN ANDRES	1965	02569	073	0000341870	1977	

TOM - TOM	SAN ANDRES	1967	03954	020	0000415593	1977	
CHAVEROO, NORTHEAST	SAN ANDRES	1967			0000010542	1975	
CHAVEROO	SAN ANDRES	1965	04184	040	0018385897	1977	
SIETE	SAN ANDRES	1968	03712	040	0000134608	1977	
DOUBLE L	SAN ANDRES	1969	03373	010			
CATO, NORTH	SAN ANDRES	1977			0000000304	1977	
CHAVEROO, SOUTH	SAN ANDRES	1977			0000000159	1977	
SULIMAR	SAN ANDRES	1976			0000002399	1977	
ROUND TANK	SAN ANDRES	1962	02960		0000059837	1977	
L E RANCH	SAN ANDRES	1963	02089		0000001730	1977	

Eddy County, New Mexico

BIG EDDY	BONE SPRING	1970	08565	008	0000026816	1977	
PALMILLO	BONE SPRING	1965	06422	006	0000002481	1977	
MAROON CLIFFS	BONE SPRING	1959	06786	050	0000014946	1974	
AVALON	BONE SPRING	1977					0000026107
SHUGART	BONE SPRING	1961	08135		0000103357	1977	
PENLON	BONE SPRINGS	1977			0000004742	1977	
COTTON DRAW	BRUSHY CANYON	1959	07184	016	0000032000	1977	
GLENN	CASTILE	1952	00878	005	0000001716	1977	
CARLSBAD, SOUTH	CHERRY CANYON	1975			0000079958	1977	
SAND DUNES	CHERRY CANYON	1970	06012	024	0000275024	1977	
NASH DRAW	CHERRY CANYON	1976			0000017677	1977	
MAROON CLIFFS	DELAWARE	1961			0000000703	1977	
SULPHATE DRAW	DELAWARE	1963	02313	004	0000004469	1977	
TECOLOTE PEAK	DELAWARE	1959	02512	002	0000003293	1977	
MALAGA, NORTH	DELAWARE	1954	04678	006	0000014663	1977	
MALAGA, WEST	DELAWARE	1952	02300	005	0000000363	1977	
MALAGA	DELAWARE	1951	02774	014	0000752787	1977	
REVELATION	DELAWARE	1968	03624	012	0000014266	1977	
ESPERANZA	DELAWARE	1969	02042	003	0000257890	1977	
CARLSBAD, SOUTH	DELAWARE	1974	04456	008	0000012905	1977	
WASHINGTON RANCH	DELAWARE	1974	01354	010			0000008374
U. S.	DELAWARE	1953	06890	030	0000024932	1977	
SCANLON	DELAWARE	1966	03238	004	0000004929	1977	
SHUGART	DELAWARE	1958	04970	024	0000900093	1977	
LOVING	DELAWARE	1958	02444	010	0000000281	1977	

BLACK RIVER	DELAWARE	1937	01943	010	0000061439	1977	
BURTON	DELAWARE	1966	03189	002	0000003779	1977	
DARK CANYON	DELAWARE	1952	01876	005	0000069964	1977	
CASS DRAW	DELAWARE	1960	02349	003	0000016897	1977	
BIG EDDY	DELAWARE	1968	05142	023	0000054998	1977	
BRUSHY DRAW	DELAWARE	1958	03210	006	0000257616	1977	
WELCH	DELAWARE	1957	02082	006	0000129468	1977	
PECOS	DELAWARE	1961			0000037222	1977	
SANTO NINO	DELAWARE	1951	03960	010	0000009705	1977	
CARLSBAD	DELAWARE	1955	02634	008	0000024257	1977	
INDIAN DRAW	DELAWARE	1973		014	0000565720	1977	
CORRAL CANYON	DELAWARE	1960	03643	006	0000239746	1977	
ELBOW CANYON	DELAWARE	1976			0000005799	1977	
FOREHAND RANCH	DELAWARE	1977			0000010582	1977	
COMBS	DELAWARE	1977					0000013101
CEDAR CANYON	DELAWARE	1976			0000006457	1977	
BRYNES TANK	DELAWARE	1977					0000000900
YARROW	DELAWARE	1977					0000007641
SULFATE, SOUTHWEST	DELAWARE	1977			0000009885	1977	
ROSS DRAW	DELAWARE	1975					0000020257
PENLON	DELAWARE						0000393913
INDIAN FLATS	DELAWARE	1976			0000025526	1977	
QUAHADA RIDGE	DELAWARE MTN.	1954	06112	006	0000024939	1977	
PARALLEL	DELAWARE MTN.	1953	07003	030	0000225524	1977	
DAUGHERITY	GRAYBURG	1938	01800	010	0000041980	1977	
DAYTON, EAST	GRAYBURG	1944	01606	019	0000090975	1977	
ATOKA	GRAYBURG	1957	00950	005	0000350781	1977	
MILLMAN	GRAYBURG	1951	01883	006	0000289580	1977	
SQUARE LAKE	GRAYBURG	1941	02700	015	0022037266	1977	
DAYTON	GRAYBURG	1940	01000	020	0000205776	1977	
HIGH NITRO	GRAYBURG	1975	02362	008			0000059772
ANDERSON	GRAYBURG	1940	02520	015	0001269659	1974	
PREMIER	GRAYBURG	1936	03090	020	0003386803	1974	
LEO EAST	GRAYBURG	1958	03666	024	0000002368	1974	
DOG CANYON	GRAYBURG	1960	01353	008	0000109038	1977	
CAVE	GRAYBURG	1940	02383	005	0002204304	1977	
HENSHAW	GRAYBURG SAN ANDRES	1940	02682	015	0000114045	1977	
LOCO HILLS	GRAYBURG SAN ANDRES	1939		065	0042374395	1977	
CEMETARY	GRAYBURG SAN ANDRES	1975			0000001585	1977	

POWER	GRAYBURG SAN ANDRES	1970	03410	021	0000325201	1977	
SHUGART	GRAYBURG, QUEEN, YATES	1937		056	0016280656	1977	
ARTESIA	GRAYBURG, SAN ANDRES	1923	01875	035	0023586947	1977	
SQUARE LAKE, NORTH	PREMIER GRAYBURG	1959	03633	033	0002055363	1977	
VANDAGRIFF	QUEEN	1953	01374	010			0007973132
TURKEY TRACK, EAST	QUEEN	1950	02235	009	0000223759	1977	
HIGH LONESOME	QUEEN	1939	01775	010	0003902465	1977	
TURKEY TRACK	QUEEN	1943		025	0001386201	1977	
BENSON, NORTH	QUEEN	1955	02844	010	0002073632	1977	
ARKANSAS JUNCTION	QUEEN	1961	04452	020			0005611260
SAND TANK	QUEEN	1964			0000014047	1974	
LOCO HILLS	QUEEN	1949	02200	015	0000039372	1974	
CULWIN	QUEEN	1959	03325	010	0000192459	1974	
SQUARE LAKE	QUEEN	1976					0000059296
SCANLON DRAW	QUEEN	1961	01983		0000000614	1977	
ROBINSON NORTH	QUEEN	1961	03628		0000003400	1974	
RED LAKE, EAST	QUEEN GRAYBURG	1959	01560	007	0000676836	1977	
LEO, SOUTH	QUEEN GRAYBURG	1958	02846	014	0000055560	1977	
LEO	QUEEN GRAYBURG	1939	03250	010	0000321371	1977	
MILLMAN, EAST	QUEEN GRAYBURG	1958	01760	005	0004812421	1977	
BEAR DRAW	QUEEN GRAYBURG SAN ANDRE	1961	01917		0000000554	1977	
RED LAKE	QUEEN GRAYBURG SAN ANDRE	1924		015	0006914404	1977	
LOCO HILLS	QUEEN GRAYBURG SAN ANDRE	1976			0000083754	1977	
SHUGART, NORTH	QUEEN SAN ANDRES SEVEN R	1938		031	0002531375	1974	
RED LAKE NORTH	QUEEN-GRAYBURG	1958	01472	041	0000049364	1974	
GRAYBURG	QUEEN-SAN ANDRES - SEVEN	1929	03600		0077844797	1977	
TURKEY TRACK, WEST	SAN ANDRES	1951	02747	005	0000000728	1977	
TAMANO	SAN ANDRES	1963			0000046462	1977	
THREE MILE	SAN ANDRES	1968	00895	338	0000001576	1977	
LOGAN DRAW	SAN ANDRES	1947	01709	020	0000025545	1977	
MILLMAN, EAST	SAN ANDRES	1959	02413	017	0000005809	1977	
MILLMAN, NORTH	SAN ANDRES	1966	02612	008	0000003657	1977	
ATOKA	SAN ANDRES	1941	01485	010	0004167645	1977	
DAYTON	SAN ANDRES	1956	01786	020	0000006282	1977	
HILLS	SAN ANDRES	1958	02460	005	0000000351	1977	
CAVE, WEST	SAN ANDRES	1956	02435	010	0000008539	1977	
EAGLE CREEK	SAN ANDRES	1959	01284	031	0001537826	1977	
CROW FLAT	SAN ANDRES	1963	02607	015	0000000107	1977	

LOCO HILLS, SOUTH	SAN ANDRES	1958	03834	036	0000016172	1974
FOREST	SAN ANDRES	1946	02632	027	0000506831	1974
MALJAMAR	SAN ANDRES	1963	04307	023		
NICHOLS	SAN ANDRES	1948	02919	019	0000183105	1974
GRAYBURG KEELY	SAN ANDRES	1948	03290	020	0000992316	1974
TURKEY TRACK	SEVEN RIVERS	1949	01635	010	0000112979	1977
RED LAKE, SOUTH	SEVEN RIVERS	1964			0000003790	1977
MCMILLAN, WEST	SEVEN RIVERS	1961			0000000867	1977
HIGH LONESOME	SEVEN RIVERS	1956	01219	031	0000000353	1977
MILLMAN, EAST	SEVEN RIVERS	1959	01038		0000284304	1977
CAR	SEVEN RIVERS	1962			0000000462	1977
PALMILLO	SEVEN RIVERS	1925	01495	010	0000029154	1977
MCMILLAN	SEVEN RIVERS	1949	00350	007	0000013565	1974
ANGELL	SEVEN RIVERS	1954	01114	011	0000016824	1974
HACKBERRY	SEVEN RIVERS	1961	02050		0000055639	1974
MCMILLAN	SEVEN RIVERS QUEEN	1938		010	0000329084	1977
MCMILLAN EAST	SEVEN RIVERS QUEEN	1964	01344	006	0000016419	1977
MCMILLAN, WEST	SEVEN RIVERS QUEEN	1961	00520		0000008553	1977
MAROON CLIFFS	TANSILL	1959	02179	020	0000026336	1977
PARALLEL	TANSILL (WINKLER)	1959	02358	003	0000007746	1977
MAGRUDER	YATES	1955	00550	002	0000009861	1977
PCA	YATES	1939	01500	010	0000821716	1977
RED HILLS	YATES	1956	01630	044	0000033327	1977
BURTON	YATES	1934	01160	015	0000003557	1977
BENSON, EAST	YATES	1960	02098	024	0000089157	1977
RUSSELL	YATES	1942	00785	010	0002383520	1977
SALADAR	YATES	1956	00633	020	0000157967	1977
GETTY	YATES	1927	01365	010	0001821983	1977
BARBER	YATES	1937	01400	005	0001609822	1977
BENSON	YATES	1943	01725	008	0000245434	1977
CEDAR HILLS	YATES	1951	00542	003	0000251863	1977
LUSK, WEST	YATES	1944	02460	010	0000083324	1977
HACKBERRY	YATES	1953	02047	006	0000023649	1974
BENSON SOUTH	YATES	1960	01742	027	0000233837	1974
CULWIN	YATES	1959	02582	080	0000091622	1974
FREN, NORTH	YATES - SEVEN RIVERS	1972	01744		0000001134	1974
EMPIRE	YATES SEVEN RIVERS	1945	00350	010	0001063423	1977
EMPIRE, EAST	YATES SEVEN RIVERS	1961	00786		0000205857	1977

AID	YATES SEVEN RIVERS	1941	00850	005	0000150577	1977	
DOS HERMANOS	YATES SEVEN RIVERS	1955	01631	005	0001382298	1977	
INDIAN BASIN	YESO	1970			0000003386	1977	
TUBB	YESO	1946	06090	020			0394144841
ATOKA	YESO	1977			0000007771	1977	
FIVE MILE	YESO	1968	02507		0000001864	1977	

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LUSK, EAST	BONE SPRING	1975			0000316041	1977
YOUNG	BONE SPRING	1965	08708	008	0000011331	1977
WILSON	BONE SPRING	1967	09410		0000012660	1977
PEARL	BONE SPRING	1955	08198	030	0000004235	1977
TEAS	BONE SPRING	1962	09408	031	0000127456	1977
BUFFALO	BONE SPRING	1963	04434	015	0000007717	1977
LUSK	BONE SPRING	1960	08759	018	0000014069	1977
GRAMA RIDGE	BONE SPRING	1966	10675	036	0000017053	1977
LEA, SOUTH	BONE SPRING	1964	10064	010	0000014476	1977
OSUDO	BONE SPRING	1964	07888	013	0000007282	1977
EK	BONE SPRING	1975	08994	064	0000136633	1977
SAND DUNES	BONE SPRING	1975	08606	024	0000027697	1977
BELL LAKE, NORTH	BONE SPRING	1963			0000000778	1977
MIDWAY	BONE SPRING	1963			0000008194	1977
BELL LAKE	BONE SPRING	1955	08670	024	0000392222	1977
VACUUM, SOUTH	BONE SPRING	1958	08504	010	0000178671	1977
LEA	BONE SPRING	1960	09480	070	0002412492	1977
VACUUM NORTH	BONE SPRING	1963	08807	023	0000005803	1974
ANTELOPE RIDGE	BONE SPRING	1977			0000008101	1977
QUAIL RIDGE	BONE SPRING	1961	10118		0001150682	1977
SCHARB	BONE SPRING	1962	10152	042	0005448666	1977
GRAMA RIDGE, WEST	BONE SPRINGS	1976			0000018044	1977
SALT LAKE	BONE SPRINGS	1976			0000029611	1977
ROCK LAKE	BONE SPRINGS	1976			0000000650	1977
PADUCA, NORTH	DELAWARE	1967	04795	005	0000056887	1977
PADUCA, EAST	DELAWARE	1967	04851		0000051420	1977
EL MAR	DELAWARE	1959	04609	008	0005199561	1977
CORBIN	DELAWARE	1960	04720	040	0000000356	1977
MASON, EAST	DELAWARE	1961	04443		0000357672	1977
JENNINGS	DELAWARE	1956	04621	003	0000071860	1977

MASON, NORTH	DELAWARE	1954	04115	010	0003394889	1977
BRADLEY	DELAWARE	1958	05302	006	0000011329	1977
JAL, WEST	DELAWARE	1963	07510	020	0000032244	1977
BATTLE AXE	DELAWARE	1963	04226	008	0000243186	1977
PADUCA	DELAWARE	1960	04670	016	0010603467	1977
CORBIN, WEST	DELAWARE	1976			0000024474	1977
DOUBLE X	DELAWARE	1961	04914		0000788840	1977
TRISTE DRAW	DELAWARE	1961	05062		0000433061	1977
CRUZ	DELAWARE	1961	05095	005	0000373756	1977
LUSK	DELAWARE	1961	04712		0000175615	1977
SALADO DRAW	DELAWARE	1962	05005	035	0000576201	1977
TRIPLE X	DELAWARE	1973	05020		0000192833	1977
QUERECHO PLAINS	DELAWARE SANDSTONE	1959	06860	011	0000024571	1977
SKAGGS	GRAYBURG	1937	03800	050	0008418858	1977
SAND HILLS	GRAYBURG	1952	04292	010	0000023689	1977
TEAGUE	GRAYBURG	1957	03685	004	0000013814	1977
MALJAMAR, NORTH	GRAYBURG	1939	03880	010	0000198154	1974
ROBERTS	GRAYBURG	1943	04195	015	0002164368	1974
ROBERTS WEST	GRAYBURG	1945	04192	015		
ANDERSON RANCH WEST	GRAYBURG	1962	04044		0000000346	1977
ARROWHEAD	GRAYBURG & QUEEN	1938	03650	050	0026746148	1977
MALJAMAR, SOUTH	GRAYBURG - SAN ANDRES	1939	04645	010	0000080078	1977
VACUUM	GRAYBURG - SAN ANDRES	1929	04400	095	0170607638	1977
MONUMENT	GRAYBURG - SAN ANDRES	1935	03818	022	0184461833	1974
MALJAMAR	GRAYBURG SAN ANDRES	1926	03960	050	0113644833	1977
EUNICE MONUMENT	GRAYBURG SAN ANDRES	1929		100	0328019877	1977
HOBBS	GRAYBURG-SAN ANDRES	1928	04050	100	0234053742	1977
ROBINSON	GRAYBURG-SAN ANDRES	1927		050	0001655401	1974
MALJAMAR EAST	GRAYBURG-SAN ANDRES	1949	04340	030	0000019720	1974
YOUNG	QUEEN	1945	03765	010	0002150667	1977
BISHOP CANYON	QUEEN	1950	04108	008	0000179496	1977
MONUMENT, NORTHEAST	QUEEN	1961			0000010310	1977
PEARSALL	QUEEN	1940	03800	010	0002503006	1977
CORBIN, SOUTH	QUEEN	1957	04379	120	0000139713	1977
DOLLARHIDE	QUEEN	1952	03670	029	0004596544	1977
CORBIN	QUEEN	1938	04225	012	0001364472	1977

EUMONT	QUEEN	1953					1145853903
E-K, EAST	QUEEN	1957	04838	008	0000967009	1977	
LEONARD, SOUTH	QUEEN	1950	03438	002	0001262679	1977	
HUME	QUEEN	1956	03950	021	0001389090	1977	
MALJAMAR	QUEEN	1939	03135	020			0004658474
VACUUM	QUEEN	1957	03890	026			0002745484
LOVINGTON	QUEEN	1963	04300	012			0001449947
QUERECHO PLAINS, EAST	QUEEN	1963	04330	005			0000199035
75120	QUEEN	1969					0000097536
75160	QUEEN	1969	04584	010			0000151386
73600	QUEEN	1928	03630				0010578311
LEONARD	QUEEN	1948					
PEARL, WEST	QUEEN	1959		010	0000117837	1974	
MESA	QUEEN	1962	03408	005	0001547940	1977	
CAPROCK NORTH	QUEEN	1954	03000	030	0000021128	1974	
SEVEN RIVERS	QUEEN	1954					
EIDSON	QUEEN	1976			0000000510	1977	
REEVES	QUEEN	1977			0000013170	1977	
PEARL, EAST	QUEEN	1961	04832		0000006159	1977	
HUME, WEST	QUEEN	1962	03927		0000063233	1977	
VACUUM	QUEEN	1961	03933		0000192590	1974	
SHINNERY	QUEEN	1973	04014		0000035765	1977	
PEARL	QUEEN (PENROSE)	1956		028	0018320876	1977	
PENROSE - SKELLY	QUEEN - GRAYBURG	1936		050	0018179270	1977	
HARDY	QUEEN - GRAYBURG	1936	03710	025	0002621502	1974	
QUAIL	QUEEN - PENROSE	1967	05126		0000298569	1977	
QUERECHO PLAINS	QUEEN - PENROSE	1961	03910		0000368462	1977	
ARROW	QUEEN-YATES-SEVEN RIVERS	1929	02900		0000038964	1974	
LANGLIE-MATTIX GAS	QUEEN-YATES-SEVEN RIVERS	1929					0074469493
PEARL	SAN ANDRES	1967	05250		0000058612	1977	
LITTMAN	SAN ANDRES	1953	04321	020	0000442379	1977	
EUNICE	SAN ANDRES	1961	04100		0000030926	1977	
SANMAL	SAN ANDRES	1955	04571	010	0000091699	1977	
BRUNSON, EAST	SAN ANDRES	1966			0000001535	1977	
HOUSE	SAN ANDRES	1950	04276	020	0000420047	1977	
GARRETT, WEST	SAN ANDRES	1960	05089	268	0000001232	1977	
CARTER, SOUTH	SAN ANDRES	1955	05020	010	0001709857	1977	
SAWYER	SAN ANDRES	1947	04926	025	0000810782	1977	
E-K	SAN ANDRES	1955		034	0000002870	1977	
BRONCO, SOUTH	SAN ANDRES	1969	04636	032	0000000376	1977	

CORMAC	SAN ANDRES	1969	04408	011	0000004821	1977	
EUNICE, SOUTH	SAN ANDRES	1969			0000538072	1977	
LEA	SAN ANDRES	1972	05855	010	0000093302	1977	
LOVINGTON	SAN ANDRES	1939	04595	050	0011989074	1977	
MIDWAY	SAN ANDRES	1960	09001	034	0000011248	1977	
RANGER LAKE	SAN ANDRES	1967	04833	010	0000000629	1977	
BISHOP CANYON	SAN ANDRES	1959	04884	006	0000263547	1977	
LOVINGTON, WEST	SAN ANDRES	1944	04700	050	0010426660	1977	
BUTTON MESA, SOUTH	SAN ANDRES	1964	04177	017	0000102992	1977	
GARRETT	SAN ANDRES	1947	05541	020	0000044898	1977	
FOSTER	SAN ANDRES	1957	04460	011	0000063955	1977	
ECHOLS	SAN ANDRES	1959	04945	035	0000000415	1977	
CROSSROADS	SAN ANDRES	1950	04860	010	0000174919	1977	
BOUGH	SAN ANDRES	1964	04746	024			0002709002
BOUGHJINK	SAN ANDRES	1964					0002322726
75600	SAN ANDRES	1965	04904	028			0000802082
FLYING M	SAN ANDRES	1964	04502	016	0005687964	1977	
HOBBS, EAST	SAN ANDRES	1951	04449	015	0004414526	1977	
JENKINS	SAN ANDRES	1959	04846	020	0000045026	1977	
SAWYER, WEST	SAN ANDRES	1969	04944	016	0001956963	1977	
SPENCER	SAN ANDRES	1969	04988	024	0000555940	1977	
YOUNG	SAN ANDRES	1956	04048	027	0000063025	1974	
SAWYER	SAN ANDRES	1959	04926	020			0017121480
CROSSROADS, WEST	SAN ANDRES	1958	04804	044	0000015681	1974	
MESCALERO	SAN ANDRES	1962	04063	067	0005089629	1977	
CARTER	SAN ANDRES	1953	05815	015	0000001123	1974	
SAWYER SOUTH	SAN ANDRES	1958	04950	028	0000016321	1971	
ALLISON, EAST	SAN ANDRES	1977			0000003443	1977	
ARKANSAS JUNCTION, WEST	SAN ANDRES	1976			0000000625	1977	
CALUMET	SAN ANDRES	1976			0000001609	1977	
ARKANSAS JUNCTION	SAN ANDRES	1966	04952	024	0000107633	1977	
DICKINSON	SAN ANDRES	1975	04174		0000012461	1977	
PEARL	SEVEN RIVERS	1958	04085	013	0000061574	1977	
LUSK	SEVEN RIVERS	1965	03848	010	0000269779	1977	
LEONARD	SEVEN RIVERS	1948	03430	010	0000060604	1976	
BOWERS	SEVEN RIVERS	1946	03150	020	0003781515	1977	
TONTO	SEVEN RIVERS	1944	03565	008	0000236611	1977	
BOWERS, SOUTH	SEVEN RIVERS	1960	03150	010			0000270199

HOBBS, EAST	SEVEN RIVERS	1953	03852	014	0000016375	1977	
PEARL, EAST	SEVEN RIVERS	1959	04048				0000552829
WATKINS	SEVEN RIVERS	1943	03564	010	0000075433	1975	
WILSON WEST	SEVEN RIVERS	1948	03936	010	0000868919	1977	
JALCO	SEVEN RIVERS		03200				
LANGMAT	SEVEN RIVERS	1955					
LYNCH	SEVEN RIVERS YATES	1929	03675	017	0014346472	1977	
LYNCH, NORTH	SEVEN RIVERS YATES	1929	03660	015	0000315095	1974	
EUNICE, SOUTH	SEVEN RIVERS-QUEEN	1930	03720	050	0024630872	1977	
LANGLIE-MATTIX	SEVEN RIVERS-QUEEN	1935	03375		0097692420	1977	
CUSTER	TANSILL	1959	03608	018	0000008812	1977	
FOWLER	UPPER YESO	1970			0002946379	1977	
VACUUM	YATES	1957	03067	014	0000324031	1977	
QUERECHO PLAINS	YATES	1963	03344	008	0000005247	1977	
MALJAMAR	YATES	1959			0000001338	1977	
MALJAMAR, SOUTH	YATES	1957	03212	017	0000000910	1977	
HALFWAY, NORTH	YATES	1965			0000000599	1977	
GEM, EAST	YATES	1968	03110	040	0000269459	1977	
LUSK	YATES	1942	02540	010	0000391791	1977	
BAISH	YATES	1935	02362	006	0000599631	1977	
QUAIL RIDGE, SOUTH	YATES	1969		022	0000018900	1977	
HALFWAY	YATES	1939	02495	003	0000936772	1977	
WILSON WEST	YATES	1963	03940	013	0000003055	1977	
JALMAT	YATES	1953					1531569760
SAN SIMON, NORTH	YATES	1957	03800		0000368899	1977	
LYNCH-MIDDLE	YATES	1957	03513	015	0000072089	1977	
GEM	YATES	1954	03243	013	0000019728	1977	
TEAS, WEST	YATES	1959	03220	012	0001101161	1977	
SAN SIMON	YATES	1943	03935	020	0000103670	1977	
JALMAT	YATES	1953			0057819325	1977	
CORBIN	YATES	1952	03443	010	0000047445	1977	
VACUUM	YATES	1964	03056	030			0000074382
SALT LAKE	YATES	1941	02990	010	0000563887	1977	
LUSK, EAST	YATES	1942	02620	013	0000089501	1977	
LUSK, SOUTH	YATES	1957	02495	020	0000006083	1977	
LEA	YATES	1929	03570	015	0000084656	1977	
QUAIL RIDGE	YATES	1968	03952	006			0000207085
TONTO, WEST	YATES	1960	03259	004	0000583813	1977	
E-K	YATES	1963	03536	006	0000007394	1974	

JALCO	YATES		02985				
LANGMAT	YATES		02880				
RHODES	YATES	1957	03000				0000023092
TEAS	YATES & SEVEN RIVERS	1951		010	0002008467	1977	
RHODES	YATES - SEVEN RIVERS	1927	03000	025	0008504784	1977	
RHODES	YATES - SEVEN RIVERS	1929					0178754259
SAN MIGUEL	YATES AND SEVEN RIVERS	1959	03613	017	0000074233	1977	
TONTO, SOUTH	YATES AND SEVEN RIVERS	1961	03001	021	0000158509	1977	
EUMONT	YATES SEVEN RIVERS	1953		025	0064964933	1977	
SCARBOROUGH	YATES SEVEN RIVERS	1975		500	0015239555	1977	
COOPER JAL	YATES SEVEN RIVERS	1927	03300	040	0031592995	1974	
E-K	YATES SEVEN RIVERS QUEEN	1954	04375	021	0005492102	1977	
WATKINS	YATES SEVEN RIVERS QUEEN	1947	04217	015	0000259985	1977	
EAVES	YATES SEVEN RIVERS QUEEN	1929	03150	060	0006706253	1974	
WILSON NORTH	YATES-SEVEN RIVERS	1951	03990	020	0000029242	1977	
EAVES	YATES-SEVEN RIVERS	1928					
HARRISON	YESO	1945	05015	025	0000010334	1977	
MONUMENT	YESO	1948	05695	020	0008611482	1977	
DRINKARD	YESO	1944	06400	100	0073080856	1977	
HOUSE	YESO	1951	06760	020			0001179183
BLINEBRY	YESO	1974		110	0036823181	1977	
WARREN	YESO	1950	06765	015	0000394726	1977	
BLINEBRY	YESO	1945	05560	060	0025767323	1973	
BLINEBRY	YESO	1945	05470	050			0408113895
TERRY	YESO	1952	05840	020	0011028220	1974	
VACUUM	YESO GLORIETA	1962	06394	035	0043736178	1977	

Roosevelt County, New Mexico

ALLISON	SAN ANDRES	1964		020	0000000118	1977	
ALLISON, NORTH	SAN ANDRES	1964		010	0000000848	1977	
MILNESAND, WEST	SAN ANDRES	1963	04554	010	0000048781	1977	
CLR	SAN ANDRES	1962	04600	012	0000020075	1977	
PRAIRIE, SOUTH	SAN ANDRES	1962	04804	031	0000381694	1977	
TODD, NORTHWEST	SAN ANDRES	1971	04231		0000010341	1977	
PRAIRIE	SAN ANDRES	1959	04858	032	0000000407	1977	
BLUITT	SAN ANDRES	1952	04610	050			0003614029
BLUITT, EAST	SAN ANDRES	1968	03860	019	0000006136	1974	
MILNESAND	SAN ANDRES	1958	04554	048	0008290615	1977	

TODD, NORTHWEST	SAN ANDRES	1971	04231				0000085984
TOMAHAWK	SAN ANDRES	1977			0000025503	1977	
BLUITT	SAN ANDRES ASSOCIATED	1969			0002190084	1977	
BLUITT	SAN ANDRES NEW	1969					0000169294
TODD	SLAUGHTER ZONE, LOWER SA	1965		040	0002418564	1977	
TODD	SLAUGHTER ZONE, UPPER SA	1963	04536	010			0009154230
BAKER	SAN ANDRES	1966	04191	006			0000454467

Table 4.--Cumulative oil and gas production for selected stratigraphic units from the Permian Basin of west Texas and southeastern New Mexico[1]

Producing Formation	No. of Pools	Cumulative oil production[2] (bbls)	Cumulative gas production[3] (Mcf)
Bone Spring Ls.	36	10,836,946	26,107
Capitan Fm.	0	0	0
Castile Fm.	10	177,449	0
Delaware Mountain Gp.[4]	228	147,838,929	444,186
Goat Seep Ls.	0	0	0
Grayburg Fm.	173	3,257,310,434	17,265,940
Queen Fm.	179	527,719,866	1,254,017,480
Rustler Fm.	5	1,019,685	0
San Andres Ls.	435	3,605,905,136	36,433,294
Seven Rivers Fm.	91	921,401,640	823,028
Tansill Fm.	12	229,717	0
Victorio Peak Ls.	0	0	0
Yates Fm.	159	609,064,948	1,710,628,578
Yeso Fm.	15	202,411,700	803,437,919
Total all units	1343	9,283,916,450	3,823,076,532

[1] Data from Table 3, Petroleum Data System (PDS), University of Oklahoma. Data may not be complete as it includes only those pools and production data reported through the PDS system.

[2] Most data current through 1977. Some fields only reported through earlier years, however; see Table 3 for reporting years, by field or pool.

[3] Most data current through 1977 but some fields may be reported only through earlier years.

[4] Includes production from the Bell Canyon, Cherry Canyon, and Brushy Canyon Formations and the Lamar Ls.

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PART II

UPPER PALEOZOIC BIOHERMS IN THE NORTHERN SACRAMENTO MOUNTAINS

ROBERT B. HALLEY

UPPER PALEOZOIC BIOHERMS
IN THE NORTHERN SACRAMENTO MOUNTAINS

Introduction

Exposures of Upper Paleozoic strata in the northern Sacramento Mountains offer a superb opportunity to view varied carbonate lithologies, local facies changes, and the products of diagenesis within a variety of shelf and slope carbonate buildups. Similar buildups occur in the subsurface in nearby New Mexico, Texas and Utah basins and are known to be excellent hydrocarbon reservoirs. They have been targets of exploration in the area for the last quarter century.

We will visit three types of mounds and discuss their similarities and differences in the field. On Day IV, we will study phylloid algal mounds, structures which are widespread throughout the United States (Wray, 1968). We will compare a Virgilian mound (Pennsylvanian), which is largely a carbonate mud accumulation, with a Wolfcampian mound (Permian) that contains copious amounts of submarine cement. On Day V, we will visit an Osagean (Mississippian) buildup composed of a muddy core facies and crinoidal sand flank beds. This mound is similar to Lower Carboniferous mounds of Europe, known as Waulsortian Mounds and named from occurrences near Waulsort, Belgium.

The exposures provide a cross-sectional view of the rocks, but it is not possible to develop a regional picture of facies realtionships in a few days as may be done for the Permian Basin. The Permian part of this field course visits an area where erosion and evaporite solution produced outcrops that may be relatively easily related to a paleogeographic framework. In contrast, strata in the northern Sacramento Mountains dip into the subsurface a few miles to the east of the outcrops, and they are downfaulted below the Tularosa Valley to the west.

The northern Sacramento Mountain area was closer to sources of terrigenous clastic sediments than the Carlsbad area during the late Paleozoic. The Pedernal land mass repeatedly shed material south and west to the Alamogordo area. Some of the tectonism which occurred during this time is evidenced in the Sacramento Mountains by Late Paleozoic faulting. Some tectonism may also be reflected in the sediments themselves, which show evidence of repeated, relative sea level changes, probably of both tectonic and eustatic origin.

In the northern Sacramento Mountains we will continue to investigate many of the themes developed in the Carlsbad area, but now in a considerably different setting. These themes include facies relationships, faunal and lithologic variation, reef models, marine cementation, subaerial exposure, porosity and permeability development and preservation. They are themes which are increasingly incorporated into modern exploration scenarios and are well illustrated by the outcrops we will visit.

Summary of Significance to Petroleum Exploration

The general geology of the northern Sacramento Mountains has been worked out by Pray (1952, 1961) and Otte (1959b), who provided the framework for many later, more detailed studies. Pray (1959) summarizes work in the area before 1950. Excellent general field guides to the area have been published by Pray (1959) and Butler (1977). Pray (1975) has recently edited a field guide to shelf-edge and basin facies limestones in the Sacramento Mountains. Figure 1 indicates the position of our field stops on a generalized stratigraphic section for the northern Sacramento Mountains.

Several processes discussed and developed at outcrops in the Permian Reef complex will again be evoked to explain observations on these older bioherms. The significance of these processes varies from buildup to buildup, and the internal structure and composition of the bioherms reflect these differences. Some buildups are cement-rich, some mud-rich, some contain shallow-water fossils, some deep-water

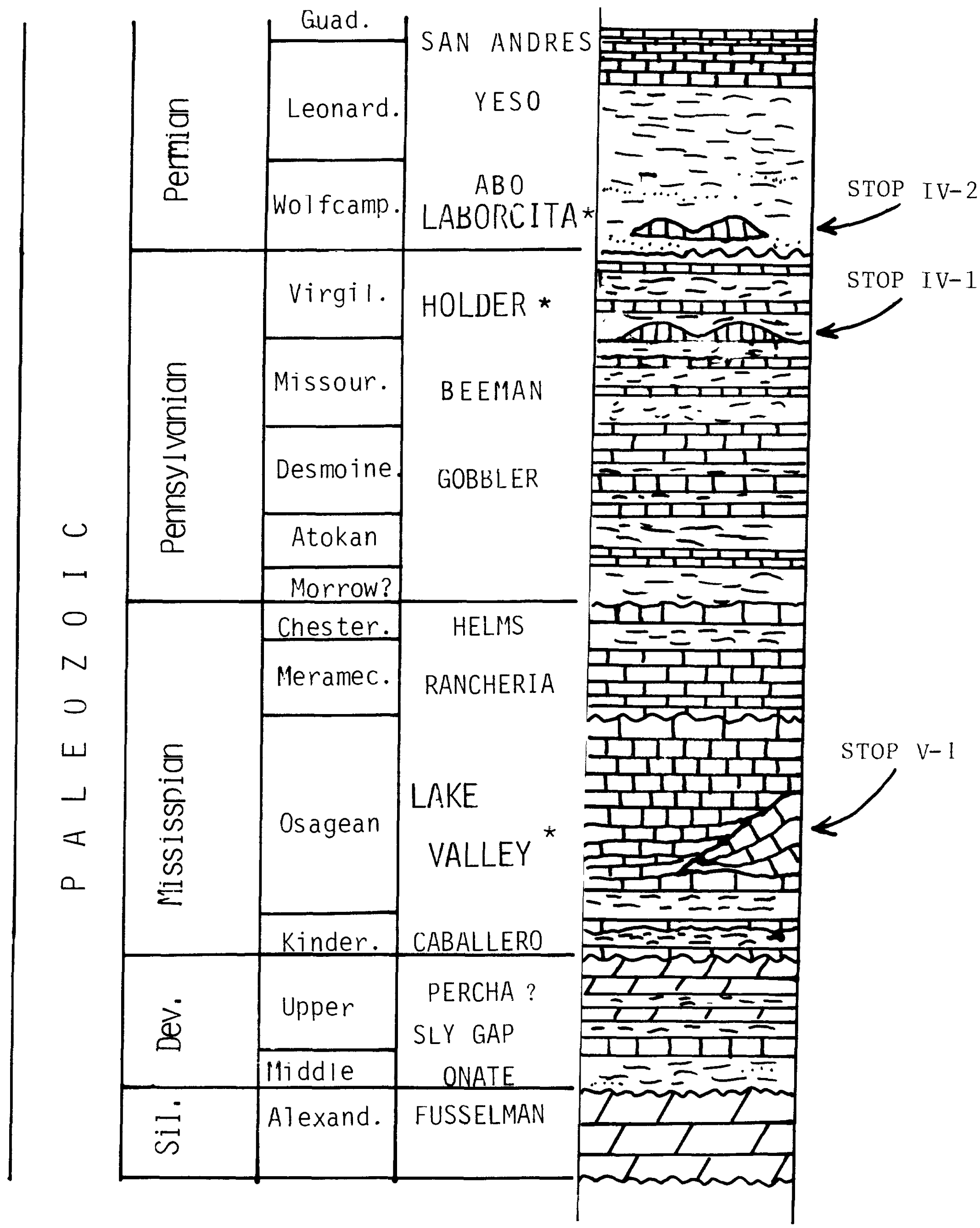


Figure 1. Partial stratigraphic column of the northern Sacramento Mountains showing field trip stops. Section is generalized after Pray (1961) and AAPG Geologic Road Map, Eastern Colorado and New Mexico.

fossils. We will try to extract as much interpretive data as possible from bioherm outcrops. Such observations will help to interpret similar rocks in the subsurface.

In contrast to the Capitan Reef, which does not produce oil in the subsurface, bioherms similar to those we visit in the Sacramento Mountains do form excellent reservoirs. Phylloid algal limestones, like those at Virgil and Yucca mounds, form reservoir rocks at Aneth Field (Elias, 1963; Irwin, 1963; Peterson and Ohlen, 1963), Ismay Field (Choquette and Traut, 1963), New Lucia Field (Toomey and Winland, 1973), Lusk Field (Thornton and Gaston, 1968), several fields in the "Horseshoe Atoll" (Vest, 1970), and Saunders and Conley fields (Kerr, 1969). These studies show, in some cases, direct association of subsurface porosity and the presence of phylloid algae. Porosity takes the form of shelter pores beneath algal blades in mudstones and wackestones, intergranular porosity in algal plate grainstones, and secondary porosity in leached algal plate mudstones. In some cases porosity and permeability are provided by fracturing or dolomitization in this facies. Several of the associated lithologies also provide excellent reservoir rock, some of which are oolitic, crinoidal and fusulinid grainstones. It is significant that production from many fields appears to be from the shelf-edge buildups themselves and not from fore-reef or back-reef facies. Fields along the Abo Trend (LeMay, 1972) and the Kemnitz-Townsend Trend (Malek-Aslani, 1970) occur at the shelf edge, a position occupied by the tight Capitan Limestone in younger units to the south. Early submarine cementation is a major factor in the lack of oil production from the Capitan reef.

The retention of porosity in the subsurface is still a topic of considerable study. We see little matrix porosity in outcrops of Late Paleozoic mounds (although vugs are characteristic of the lower Virgil Mound). The original porosity in these carbonate sediments was very high (40-85%), and the processes involved in such great porosity loss have not been well documented. One of the best documented cases of porosity loss in carbonate sands comes from studies of the crinoidal sand of the Lake Valley Formation.

Hydrocarbon reservoirs in rocks similar to those that occur in the Lake Valley appear to be rare. Pray (1958) reported that cores from the La Pan Field of Clay County, Texas, are similar to lithologies associated with Muleshoe Bioherm. La Pan Field may therefore be a buildup similar to Muleshoe Bioherm. Meyers (1974) showed that cementation and porosity loss in Lake Valley non-biohermal sediments are linked to periods of subaerial exposure. As much as 60% of the original porosity was lost within about five million years of sediment deposition. Almost all the rest was lost within 20-30 million years. Cementation took place during two episodes of subaerial exposure (Meyers, 1978).

It is interesting to note that early subaerial exposure is credited with producing leached porosity in many phylloid algal mounds (Wilson, 1975). Apparently, exposure and fresh-water diagenesis act as a double-edged sword, i.e., under some circumstances exposure helps produce reservoir rocks; in other cases exposure destroys reservoir properties. The particular circumstances which control the products of exposure are not well understood. Factors that probably exert considerable influence on the diagenetic history of these rocks include rate of transgression or regression, duration of exposure, climate, original sediment mineralogy and local paleohydrology.

Even less well understood are later diagenetic processes which may affect these limestones in the subsurface. The Holder and Laborcita mounds had been buried to at least 2500 feet and the Lake Valley bioherms as deeply as 6500 feet by the end of the Paleozoic. Processes, such as compaction, pressure-solution cementation, fracturing, cementation by dolomite and anhydrite, are known to occur at depth but are undocumented in these rocks.

Finally, one wonders what has been the effect of uplift and the current episode of exposure on these rocks. Might some of the differences between the rocks we see in outcrop and their subsurface counterparts be due to their Cenozoic uncovering?

Or was the character of these rocks essentially fixed during their burial?

Again, it should be emphasized that we will not develop a regional picture of sedimentary facies in the Sacramento Mountains as we do in the Guadalupe Mountains. Generalized paleogeographic maps for the Osagian and Virgilian Stages of the area are outlined in Figure 2 . We will review principles of carbonate deposition as they apply to late Paleozoic bioherms and formulate new questions which have particular significance to petroleum exploration.

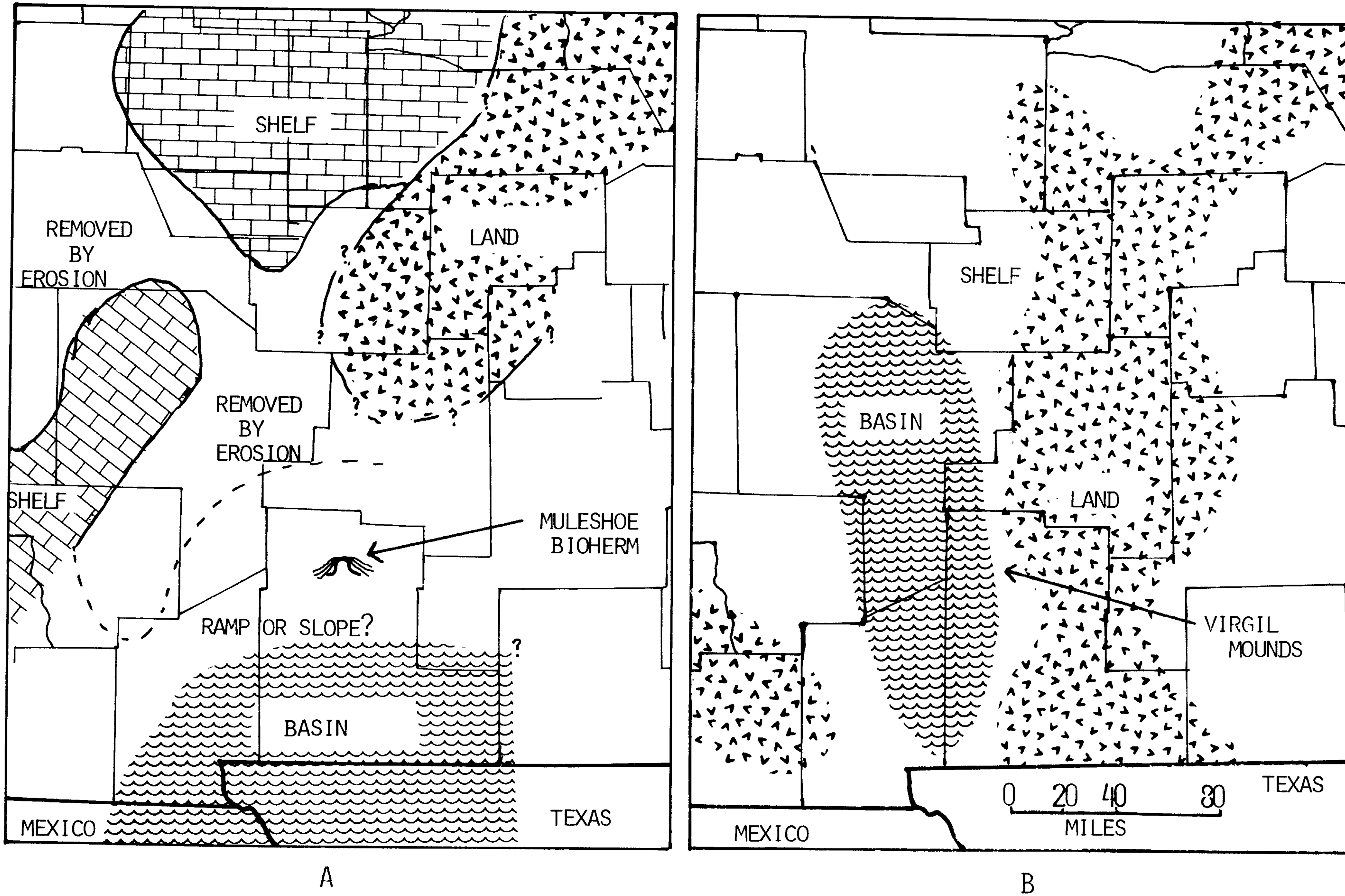


Figure 2. Generalized paleogeography of southeastern New Mexico during A) Late Osagean time after Armstrong (1962, 1967) and Wilson (1975b); B) Virgilian time after Backman (1975) and Meyer (1966).

CARLSBAD TO ALAMOGORDO ROADLOG
DAY IV

Mileage	Cumulative Mileage From Carlsbad	Cumulative Mileage From Alamogordo	Description
0.0	0.0	181.4	Leave Carlsbad traveling north on US 285 from its junction with US 62-180 in downtown Carlsbad traveling toward Artesia, N.M.
21.3	21.3	160.1	Junction with NM 137. Continue north on US 285. As we travel northward, we cross several "reef" zones in the subsurface. Just a few miles north of here, our route crosses the trend of the San Andres reef zone (Miller, 1969) and further to the north, we cross the Abo reef trend about 5 miles south of Artesia (LeMay, 1972). In general, these trends parallel the Capitan Reef trend in the subsurface along the northern end of the Delaware Basin.
0.8- 2.8	22.1- 24.1	159.3- 157.3	Low roadcuts through thin-bedded dolomites (with evaporite crystal casts) and redbeds of the restricted lagoon facies of the Yates and Seven Sisters Formations, similar to outcrops visited in Dark Canyon and Rocky Arroyo on Day III.
5.6	29.7	151.7	Junction with NM 381. Hills visible 6 miles to the east form the McMillan Escarpment and are composed of the Permian Artesia Group (undivided Tansill, Yates and Seven Sisters Fms.).
9.4	39.1	142.3	Junction with NM 335, continue north on US 285 toward Artesia.
4.1	43.2	138.2	Entering Artesia, N.M.
1.5	44.7	136.7	Turn left at junction with US 82 (US 83 on maps published prior to 1968) traveling west toward Cloudcroft. Road traverses 20 miles of Quaternary alluvium, good time for a nap or reading detailed descriptions of future stops.
21.3	66.0	115.4	Hope Village center.
6.9	72.9	108.5	Chaves County line.
5.7	78.6	102.8	Junction with NM 13, continue west on US 82.
0.2	78.8	102.6	Roadcut in Quaternary alluvium.
0.3- 13.3	79.1- 92.1	102.3- 89.3	Scattered outcrops of dark grainstones of the San Andres Formation.
1.7	93.8	87.6	Junction with NM 24 on left. Continue on US 82 west into foothills on the east side of the Sacramento Mountains. Hillsides and roadcuts for the next 45 miles are either limestones of the San Andres Fm. or red and yellow terrigenous clastics of the Yeso Fm. US 82 slowly climbs the east side of the Sacramento Mts. (almost a dip slope), gradually cutting deeper into the San Andres limestones and into the Yeso below. As elevation increases, we will pass through several vegetation zones, from open desert scrub to alpine conifer forest.
12.4	106.2	75.2	Village of Elk, N.M.
2.3	108.5	72.9	Mule Canyon Road on left.
0.8	109.3	72.1	Otero County line.
0.2	109.5	71.9	Enter Lincoln National Forest.
8.6	118.1	63.3	Mayhill town limit. For the next 10 miles, valley is floored by the Yeso Fm., and the San Andres Fm. occurs on the surrounding higher areas.

0.4	118.5	62.9	Junction with NM 130 on left.
10.3	128.8	52.6	Junction with Springs Canyon Road on right.
1.1	129.9	51.5	Entering town of Winsatt, N.M.
4.1	134.0	47.4	Cloudcroft Ski Area on left.
1.9	135.9	45.5	Junction with NM 24 on right.
1.3	137.2	44.2	Cloudcroft town center, elevation about 8700 feet. US 82 drops rapidly, some 4000 feet in the next 20 miles, down the west face of the Sacramento Mts.
0.2	137.4	44.0	Alluvium exposed in roadcut to left and right.
0.2	137.6	43.8	Lower San Andres Fm.
1.7	139.3	42.1	Yeso Fm. on right. US 82 drops through over 1200 feet of Yeso Fm. in next 5 miles.
1.5	140.8	40.6	Lower Yeso redbeds typical of the next 3 miles.
3.2	144.0	37.4	Gradational contact of Yeso Fm. (marine) with underlying Abo Fm. (nonmarine) occurs in this general area.
0.6	144.6	36.8	Mountain Park, N.M.
0.9	145.5	35.9	High Rolls, N.M. and junction with West Side Road. High Rolls is a lead and copper mining district with ores occurring in arkose beds of the Abo Fm. (Jerome and others, 1965).
1.0	146.5	34.9	East side of tunnel and Fresnal Box Canyon walls composed of the Bug Scuffle Limestone Member of the Gobbler Fm. (Middle Pennsylvanian). On this side (east side) of the Fresnal Fault, the Laborcita, Holder and Beeman Formations are missing, but they are present on the west side of the fault.
0.3	146.8	34.6	OPTIONAL STOP. Fresnal Box Canyon vista on right. Effects of drag from the Fresnal Fault Zone on Bug Scuffle Ls. Member may be viewed to the west on the north side of the canyon. Fresnal faults in this area were active during the latest Pennsylvanian and earliest Permian. Delgado and Pray (1977) estimate as much as 1600 feet of displacement, down to the west, along the fault zone in this area.
	Figure 3		
0.7	147.5	33.9	Dry Canyon ahead and to the left (south).
0.8	148.3	33.1	Tertiary dike and sill intruding Laborcita Fm. on right.
0.8	149.1	32.3	Covered, unconformable contact between Laborcita and Holder Fms. at approximately this point.
0.5	149.6	31.7	View ahead of flank beds dipping eastward off Virgil bioherms.
0.7	150.3	31.1	STOP IV-1, Virgil Bioherm. Lincoln National Forest boundary sign and parking area on left. The west flank of the bioherm is strikingly exposed to the north of the road. Beds with apparent dips of almost 45° at the west end give way to less steeply dipping strata and massive units in the center of the bioherm outcrop. Faint bedding near the center suggests the escarpment does not expose core facies or that the bioherm core is very similar to flanking beds. The 60-80-ft.-thick feature is typical of many such bioherms in the area and shares features in common with many late Paleozoic buildups.
	Figures 4 and 5		Plumley and Graves (1953) first figured the Virgilian bioherms and emphasized their geometry, orientation and biological origin. They appear as elongate bodies up to one mile long and 200 feet thick. They tend to parallel the mountain front. As we traverse the outcrop here, it

will become apparent that the bioherm, while beautifully exposed, does not weather in a manner that allows easy interpretation of the composition of these limestones. Parks (1958, 1962), Wray (1959, 1963) and Konishi and Wray (1961) established the importance of platy algae in these limestones and have refined the taxonomy of the platy or phylloid (leaf-shaped) algae (Pray and Wray, 1963). Phylloid algal limestones are widespread in the United States (Wray, 1968), and bioherms composed of such algal limestones are widespread in Late Pennsylvanian and Wolfcampian strata of southern New Mexico (Wilson, 1977).

Cline (1959) emphasized the cyclic nature of Virgilian rocks in this area, and Wilson (1967) related these shelf cycles to basinal cycles in the Orogrande Basin. Shelf cycles consist of a variable sandstone and shale lower member with local channel-fill conglomerates which grade upward into normal marine limestone and shale. These in turn pass upward into shallow-water limestones (grainstones and bioherms) which cap the shelf cycles. Wilson (1967) interpreted these cycles to be the result of repeated sea level fluctuations, which periodically exposed the shelf and bioherms to subaerial weathering and diagenesis. Wilson drew on conceptual models of cyclic deposition and evidence from the Holder Fm. to develop the idea of shelf and basin reciprocal sedimentation. This important model promotes alternate sites of basin and shelf sedimentation during sea level low and high stands, respectively. During lowered sea level, most sediment bypasses the exposed shelves and is deposited in adjacent basins. During sea level high stands, these sediments are deposited on the shalves along with shallow-water limestones, while the basins receive little sediment and are "starved." The reciprocal sedimentation concept has been widely applied in shelf/basin sediment dynamics, and we will discuss its application to the Permian Basin.

Pray (1961) defined the La Luz anticline, which runs approximately NNW through this area and had a pronounced local influence on Late Pennsylvanian sedimentation (Wilson, 1969). Bioherms developed with long axes approximately parallel to the axis of the La Luz anticline, which was a subtle structural feature at the time but developed more strongly during later deposition of the Holder Formation.

Inspection of the bioherm proceeds up a gully around the west end of the feature, up-flanking beds eastward to the top of the mound. Before reaching the mound proper, the climb traverses marine shales and limestones of the upper Beeman Formation and enters the Holder Formation approximately 60 feet below the base of the bioherm. The limestones include oolitic and algal grainstones and algal boundstones separated by slope-forming shales.

The bioherm is composed in large part of mud (micrite) and phylloid algal plates. The phylloid algae are usually poorly preserved as molds or replaced by blocky calcite with all traces of original microstructure lost. They are probably of diverse origin, some being green calcareous algae and some being red calcareous algae. Their poor state of preservation suggests they were originally aragonitic. Wray (1975, 1977) has suggested that the closest living analogues to some of the phylloid algae may be a family of red calcareous algae known as the Squamariacean algae. Today, "squamies" are subtle but widespread coral reef inhabitants.

A great many other organisms are evident in the biohermal rocks, including stromatolites, sponges, tubular encrusting foraminifera, stromatoporoids, and corals, all of which are capable of producing reef structures, but none of which appear to be abundant enough on outcrop to account for the bulk of the carbonate buildup. Volumetrically, mud is the most important constituent of the bioherm. Wray (1959) suggests the mud had been trapped by a thicket of phylloid algae, probably in a relatively low-energy setting. Ball and others (1977) question the mound-building capabilities of phylloid algae. Parks (1977) briefly reported that algal plate mudstones were uncommon in four cores taken through the bioherm. The upper bioherm contained calcirudites of sponge, stromatoporoid, tubular foraminifera, and other clasts. The lower part of the mound contained more mud and calcarenite and rare-to-abundant masses of fibrous calcite. Earlier outcrop studies by Otte and Parks (1963) suggest 30-50% of the lowest third of the bioherm is composed of botryoidal fibrous calcite, a replacement after aragonite submarine cement. The material is beautifully illustrated by the authors and was interpreted as fossil remains of a Stromatactis-like organism, following similar interpretations of fibrous cements from Europe. Otte and Parks (1963) point out that fibrous calcites weather indistinctly in the Virgil reef and are difficult to observe in outcrop, but are strikingly accentuated by weathering at Stop IV-3.

The lower third of the bioherm is also vuggy in outcrop with irregular voids up to several inches across scattered throughout the rocks. The origin of these vugs is problematic. Parks (1977) considered several mechanisms for producing the vugs, including subaerial solution (Wilson, 1975), submarine solution, decay of pre-existing soft-bodied organisms, sheltered porosity, dewatering contraction and gas bubbles. He concluded that vugs were the product of a combination of decay and gas generation.

Small fractures and in situ brecciation (compactional) are common in some portions of the bioherm and are evidence of early lithification. Wilson (1975) suggests this early cementation and vuggy leaching took place during a sea level low stand and are the result of early meteoric water diagenesis. This explanation seems particularly likely in light of the cyclic nature of Holder sediments overlying the bioherm and the transgression/regression model that explains their origin (Wilson, 1967).

The abundant evidence of submarine cement illustrated by Otte and Parks (1963) and Parks (1977) suggests that early submarine cement should be considered as the lithifying agent in these buildups. Less obvious micritic submarine cements may also be present in the bioherm sediments, cements which appear identical to detrital micrite. Such cements are common in Holocene reefs, are composed of high-Mg calcite, and appear as a micritic matrix in the reef rock (Macintyre, 1977). It is intriguing to imagine what role submarine cement may have had in creating vuggy porosity in these reefs. In a sense, portions of the bioherm are really "lithoherms," following the terminology used by Neumann and others (1977) to emphasize the role of subsea cementation during growth of the structure. This role is nicely illustrated by substituting submarine cement for "Stromatactis" and quoting from Otte and Parks (1963), "(Submarine cement) functioned as both a sediment-binding and a framework-building organism in the construction of the bioherms and may be quite widespread in other late Paleozoic bioherms of the western United States."

This has proven to be a rather prophetic statement in light of the now widely recognized submarine cements present in reefs of all ages.

0.3 150.6 30.8 Cattle guard in road and view straight ahead of the Tularosa Basin. In the basin, to the south, lie the outskirts of Alamogordo and the dunes of White Sands National Monument beyond. Across the basin rise the San Andres Mts. Pray (1959) estimates as much as 7000 feet of vertical displacement has occurred along the faults which formed the front of the Sacramento Mts.

0.3 150.9 30.5 OPTIONAL STOP, Yucca Mound. An unused dirt trail leads north of US 82 about 300 yards until it intersects the gully to the right (east). Route turns up gully at intersection until Yucca Mound is reached, about 100 yards after leaving the trail. The beds exposed in the gully below the mound and the mound itself have been studied in considerable detail by Toomey and others (1977a, 1977b).

Exposed in the gully bottom are beds interpreted to represent facies which are basinward and slightly older than the mounds. These include shales, some of which show evidence of penecontemporaneous deformation (slumping?), crossbedded grainstones composed of material presumably transported from mound areas (e.g., sands composed almost entirely of fragments of tubular foraminifera), and small mounds (12-15 feet in diameter) composed of plumose algae and foraminifera.

The core facies of the mound is well exposed and consists of mud and algal plates, and a great variety of other fossils, including sponges, foraminifera, pelecypods, and dasyclad (calcareous green) algae.

Mound geometry can be seen by climbing the steep slope on the north side of the gully and looking south across the canyon that transects the mound. Beds immediately above the mound are nearly horizontal on top of and east of the

Figure 6 buildup, but dip steeply over the western edge.

The bioherm is a complex of two mounds, as pointed out by Toomey and others (1977b), and in detail includes a complex variety of carbonate lithologies. One mound overlies and

			is basinward of the other, showing that the complex as a whole built seaward and is regressional in character. However, the presence of stratigraphic breaks in the complex, interpreted to be of subaerial origin, emphasize the complex history which gave rise to this generally regressive sequence. Toomey and others (1977b) estimate the position of the mound to be ½ mile east of the shelf edge. The shelf at this point was narrow (a few miles?) with the Orogrande Basin to the west and the Pedernal Uplift to the east.
			Submarine cements have not been identified in the Yucca Mound and appear not to have been important in mound development here.
3.2	154.1	27.3	Junction of US 82 with US 54-70. Turn right (north) toward Tularosa.
2.2	156.3	25.1	Junction with NM 545. Continue straight ahead. The town high on the alluvial fan two miles to the east is La Luz, at the mouth of La Luz Canyon. The strata exposed in the escarpment of the Sacramento Mts. dip to the north, so that increasingly younger beds lie at the base of the mountains to our right as we approach Tularosa. East of Alamogordo, these beds are Mississippian or older in age. At the last stop and east of us now, they are Pennsylvanian, and east of Tularosa they will be Permian in age.
7.0	163.3	18.1	Tularosa city limits.
0.6	163.9	17.5	Bear east (right) on US 70 toward Roswell.
0.8	164.7	16.7	Turn left (north) onto Bookout Road.
0.3	165.0	16.4	Cross bridge over canal.
0.5	165.5	15.9	Right turn onto Bookout NE (east).
0.9	166.4	15.0	Sharp right turn (south) in road, park at safe distance around turn.
0.1	166.5	14.9	STOP IV-2, Laborcita Lithoherms. Hilltops ¼ mile to the NE are capped by strikingly banded limestones of Wolfcampian age. From this distance, it can be seen that the dark bands (cement-rich) pinch and swell along the face of the outcrop. In contrast, the light bands (mud-rich) are of rather even thickness and drape over the topography of the dark bands. This is strong evidence for the excellent mound-building capabilities of cement. Walk to the lithoherms via a meandering route over beds of the Laborcita Formation of Otte (1959a, 1959b). Here, these beds include red and green sandstones, siltstones and mudstones with some spectacular polymict conglomerates and thin limestones. The lithoherms have been described in increasing detail by Otte (1954, 1959a, 1959b), Otte and Parks (1963), Cys and Mazzullo (1977), and Mazzullo and Cys (1979). Because of their proximity to underlying nonmarine beds, the lithoherms are thought to be nearshore marine buildups, perhaps analogous to fringing reefs. Otte (1959) estimates the lithoherms to have stood as much as 60 feet above the surrounding bottom. Again, we use the term "lithoherm" (Neumann and others, 1977) to describe these mounds in order to emphasize the inferred role of submarine cement in mound development.
	Figure 7		
			Weathering of these mounds has left internal structure easily visible. A number of components may be readily recognised

Figure 8

in outcrop. These include: (1) grey, commonly well laminated lime mud; (2) dark calcite cement, which fractures to reveal a blocky structure but may be viewed in low angle light to reveal a relict fibrous habit; (3) phylloid algal fragments; (4) fractures; (5) scattered sand pockets, some graded; (6) some coarsely crystalline, white, pore-filling calcite, and (7) brown dolomite. The dark calcite cement derives its color from submicroscopic inclusions of organic matter, which is apparently not extractable (Plumley and Graves, 1963). On outcrop, some areas of the lithoherms may be seen to be extremely rich in this dark cement. In places, it forms an anastomosing network with lighter-colored sediments infilling voids within the cement framework. Cys and Mazzullo (1977) and Mazzullo and Cys (1979) estimate this cement to account for 50-85% of the mound volume. They interpret the cement to be a marine cement that grew on the sea floor and within voids in the mound. It is interesting to compare these figures with estimates of 30-40% in-place coral in modern and Pleistocene coral reefs. It would appear that there is considerably more cement framework in the Laborcita lithoherms than there is coral framework in many coral reefs.

At several locations along the exposure of the lithoherm, the contact between a dark, cement-rich layer and a lighter, mud-rich layer may be observed in considerable detail at close range. Note that this contact is not erosional (and that the relief on the cement-rich bands is not erosional), but rather the contact appears to be a sharp change in the character of sedimentation. It is quite clear from these outcrop relationships that it is the marine cement in these mounds that has been responsible for their reef-like growth. These exposures provide the best evidence, in the writers' opinions, of ancient examples of lithoherms, and they are certainly the most extreme case of submarine cementation in mounds that we will observe on this trip.

Turn around and retrace route backwards to junction of US 54-70 with US 82.

12.4	178.9	2.5	Junction of US 54-70 with US 82. Continue straight ahead toward Alamogordo.
2.5	181.4	0.0	Junction of US 54-70 with 10th Street, Alamogordo, N.M.

END OF DAY IV.

Mileage	Cumulative Mileage From Alamogordo	Cumulative Mileage From El Paso	Description
0.0	0.0	96.9	Leave Alamogordo traveling south on US 54-70 from junction with 10th Street.
1.9	1.9	95.0	Railroad overpass, merge left.
0.4	2.3	94.6	Turn left on US 54 to El Paso.
4.8	7.1	89.8	Turn left on ranch road (dirt) over railroad tracks and stop to observe Muleshoe Bioherm.
2.0	9.1	87.8	Turn right (south) at "T" in road.
0.1	9.2	87.7	Road to left leads to Donald Taylor Ranch house and permission should be requested to travel ranch roads to the foot of the mountains.
0.9	10.1	86.8	Turn left (east) on well graded road leading up alluvial fan toward the mouth of San Andres Canyon.
0.4	10.5	86.4	End of well graded road. Busses and rental cars must stop here. Trip continues via 4-wheel-drive vehicles.
0.7	11.2	85.7	Continue east on trail approximately 0.6 miles to mouth of San Andres Canyon. At canyon mouth, turn left on old road that leads downslope to the northwest.
0.3	11.5	85.4	Old corral ahead on left. Find even older road which leads to the right (north) toward Muleshoe Bioherm.
0.4	11.9	85.0	End of old ranch road and mouth of Muleshoe Canyon. Begin approach to Muleshoe Bioherm from here on foot.

STOP V-1, Muleshoe Bioherm. At the start of the walk, we may observe the arched appearance of eroded flank beds on the southwest side of the bioherm. Below this arch is exposed a small portion of core facies that will be our final objective. From the entrance to Muleshoe Canyon, route travels up the wash about 200 yards, then begins to climb out of the wash on the north side of the canyon, angling eastward toward a point that will bring us to the same elevation as the base of the bioherm but several hundred yards east of it and standing on non-biohermal sediments. The approach to the bioherm climbs out of the wash over Silurian and Devonian rocks of the Fusselman, Onate, Sly Gap and Percha(?) Formations. About 60 feet of Mississippian Caballero Formation unconformably overlies the Devonian and underlies the biohermal Lake Valley Formation. On reaching an elevation equal to that of the base of the bioherm escarpment and a position about one-third of a mile east of the bioherm, we can observe typical interbioherm lithologies of the Lake Valley Formation. From this point, a westward traverse along the base of the bioherm leads us from normal horizontally-bedded Lake Valley sediments into increasingly steeply dipping biohermal flank beds, blocks of core rubble, and finally into bioherm core facies beneath the "arch" viewed earlier from below.

Figure 9

The bioherm has been studied in increasing detail for over 40 years with general descriptions by Laudon and Bowsher (1941, 1949), who subdivided the Lake Valley Formation into six members. Muleshoe Bioherm occurs in the second, third and forth members from the base of the Lake Valley, rises above the last two members of the Lake Valley and above the level of the overlying Rancheria Formation and protrudes into the base of overlying Pennsylvanian deposits of the Gobbler Formation (Pray, 1958, 1961). Bioherms about five miles to the north are decidedly elongate in a north-south direction and are not as thick as Muleshoe Bioherm. Muleshoe is estimated to have stood more than 300 feet above the general bottom level and may have developed on a relatively deep portion of a shelf that became more shallow to the north. Armstrong (1962, 1967) has suggested that a starved basin lay to the south, and tidal flat deposits are found 160 miles to the north. Land formed by the Pedernal Uplift lay about 80 miles northeast. Muleshoe Bioherm appears almost circular in plan and may have formed in deeper water than the bioherms to the north. Wilson (1975) stated that most geologists acquainted with Mississippian bioherms believe they accumulated below wave base and perhaps below the photic zone. Again, it is tempting to make comparisons between these bioherms and the lithoherms of the Straights of Florida described by Neumann and others (1977).

Note that the faunal components of the bioherm did not require light for their survival. The common forms we will see in the flanking beds are crinoids, brachiopods, bryozoans, and solitary corals. In contrast to other bioherms observed on this trip, calcareous algae are absent. Other typically shallow-water forms, such as massive corals, clams and calcareous sponges, are rare or absent. The crinoidal grainstones of the flank beds are poorly sorted and contain articulated columns several inches long, which suggest flanking crinoidal beds formed in close proximity

Figure 10

to where the crinoids lived. These biogenic sediments appear not to have been transported far from their source. As we approach the core facies of the bioherm, the slope of these flank beds increases to nearly 40°.

The core facies has been studied in great detail by Pray (1958, 1965a, 1965b, 1969) and Lohmann and Meyers (1977). Approximately two-thirds of the core consists of mud. The major faunal component is fenestrate bryozoa. Local cement-rich pockets in the core facies contain bryozoan fragments coated with banded, isopachous cement, which is cloudy when viewed in thin section. This cement was interpreted as marine in origin by Pray (1965a, 1965b). The cloudy cements contain inclusions of microdolomite, as

Figure 11

illustrated by Lohmann and Meyers (1977), and are believed to be diagenetically altered high-Mg calcite marine cement.

The origin of Muleshoe Bioherm and similar Lower Carboniferous mud mounds had been the topic of considerable conjecture. Are the muddy cores the result of currents piling up fine-grained sediment? The circular plan view of some mounds would make this possibility unlikely. How much sediment may have been trapped or baffled by bryozoan fronds or crinoid thickets? What was the source of the mud? Why are the flank beds so distinct and sharply separate from the core facies? What role did submarine cement play in building these mounds? Many of these questions cannot be answered very satisfactorily. Volumetrically, cement is not nearly as important in the core facies of

Muleshoe Bioherm as it is in the Laborcita lithoherms. Submarine cement by itself did not build Muleshoe Bioherm, but it would take only a small amount to act as a binding agent to hold the core facies together. If this were the case, then the next question is why did the cement form here, localized in this mound? The sandy flank beds evoke clear visions of crinoidal meadows on the sides of the bioherm, but why not on the top or in the center, where the core facies predominates? Was the central position of the bioherm dominated by some mud-producing organism that decayed so completely that no trace is left behind? Or, was the center isolated from nutrient-rich currents, which fed animals on the sides of the bioherm? Wilson (1975: p. 165-167) suggests formation through a combination of hydrologic accumulation and baffling by crinoids and bryozoa to form the muddy core facies. Gentle currents winnowed the sides of the bioherm.

Again, it is interesting to draw comparisons between these mounds and modern lithoherms in the Straights of Florida. The processes involved in their formation include (1) hydrologic accumulation, (2) biogenic sediment contribution and biologic entrapment of sediment, and (3) subsea lithification by marine cement. An organic framework, typical in modern reefs, is absent in these Mississippian mounds and is not a requirement for mound growth. Although organisms and hydrologic regime are not directly comparable between modern lithoherms and Muleshoe Bioherm, a combination of the three processes active in modern lithoherms could probably account for the features we see in these Mississippian buildups.

The diagenesis in non-biohermal Lake Valley sediments has been studied in considerable detail during the last 10 years. Using cathodoluminescent petrography, Meyers (1974) found five generations of cement in crinoidal grainstones like those we observe off the flanks of Muleshoe Bioherm. Most of this cement occurs as syntaxial overgrowths on crinoidal sands. Marine cements like those in the bioherm core facies are rare in interbioherm areas. The syntaxial, clear overgrowths are interpreted to have formed in a freshwater aquifer that occupied Lake Valley sediments during periods of sea level change and regional subaerial exposure. Careful examination of cements at post-Lake Valley unconformities revealed three cement zones to be pre-Rancheria Formation and two more to be post-Rancheria but pre-Gobbler deposition. These two periods of subaerial exposure led to a great porosity loss in these sediments and resulted in 90-95% of the total intergranular cement in Lake Valley grainstones (Meyers, 1978).

From outcrop of core facies beneath the Muleshoe "arch," hike back downslope to vehicles.

OPTIONAL STOP. Retrace route east along the base of the bioherm escarpment about 150 yards to a prominent gully. Cross gully and scramble up dipslope, angling westward to top of bioherm. CAUTION! The route is considerably more steep and more difficult than that below. Use careful judgment in making this climb. Excellent exposures of steep flank beds are crossed during the ascent and the

			exposure gives one a real "feel" for the original depositional slope. On top there are well exposed examples of core mudstones, submarine cements and clastic dikes. The best exposures are above the cliffs in the southwest side of the bioherm. Cross the top of the bioherm to the north side for excellent view of the upper Lake Valley members lapping the sides of the bioherm and the unconformable relationships between the Lake Valley, Rancheria and Gobbler Formations. A descent can be made down the gully between the bioherm and surrounding strata of the north side. Contour around the base of the bioherm to the southwest side, and then descend the slope to Muleshoe Canyon and back to the vehicles.
			Retrace route back to US 54.
4.8	16.7	80.2	Junction of ranch road and US 54. Turn left (south) on US 54.
5.2	21.9	75.0	Isolated buttes to the right are of varied origin. The closest is composed of Tertiary intrusives. Those beyond are outcrops of the Hueco and Yeso Formations. The San Andres Mts. are the prominent range in the background. This block-faulted range exposes a complete south-central New Mexico Paleozoic section from Precambrian basement on the east through Permian San Andres Formation on the west side of the range.
9.5	31.4	65.5	Stabilized reddish sand dunes in valley floor. Jarilla Mts. ahead on right expose Pennsylvanian and Permian sediments and Cretaceous and Tertiary intrusives. Southern end of the Sacramento Mts. and the Otero Mesa are in the distance to the left. The Otero Mesa is composed of the Yeso and Hueco Fms.
14.5	45.9	51.0	Orogrande town limit.
0.2	46.1	50.8	Orogrande Post Office.
4.3	50.4	46.5	Directly west are the Organ Mts., a southern extension of the San Andres Mts. They expose large areas of Cretaceous and Tertiary volcanics and some Precambrian intrusives and Paleozoic sediments.
18.0	68.4	28.5	North end of Franklin Mts. at about 1 o'clock.
			To the right are the Hueco Mts. in the distance. The bulk of the Hueco Mts. is Pennsylvanian and Permian, but the highest peaks are Cretaceous and Tertiary intrusives.
7.7	76.1	20.8	Texas state line and El Paso city limit. Note: we are really quite a way from El Paso at this point.
8.7	84.8	12.1	Junction with Texas 2529. Take 45° left turn onto McCombs Street for airport or Caballero Motel. Continue straight ahead for downtown El Paso. This route goes to the airport.
2.0	86.8	10.1	Bear right onto Railroad Drive.
3.1	89.9	7.0	Take overpass (Marshall Road).
3.3	93.2	3.7	Take left on Fred Wilson Road.
1.8	95.0	1.9	Fred Wilson Road makes a sharp right.
1.9	96.9	0.0	Left turn to entrance of El Paso airport.

END OF DAY V.

Figure 3 . View from Fresnal Box Canyon Vista showing downdrag on Bug Scuffle Limestone Member of the Gobbler Formation on the eastern side of the Fresnal Fault.

Figure 4 . View of Virgil Bioherm from south side of Dry Canyon. Note steeply dipping flank beds in massive, cliff-forming limestones. Beds which cap the bioherm drape over the west end of the exposure.

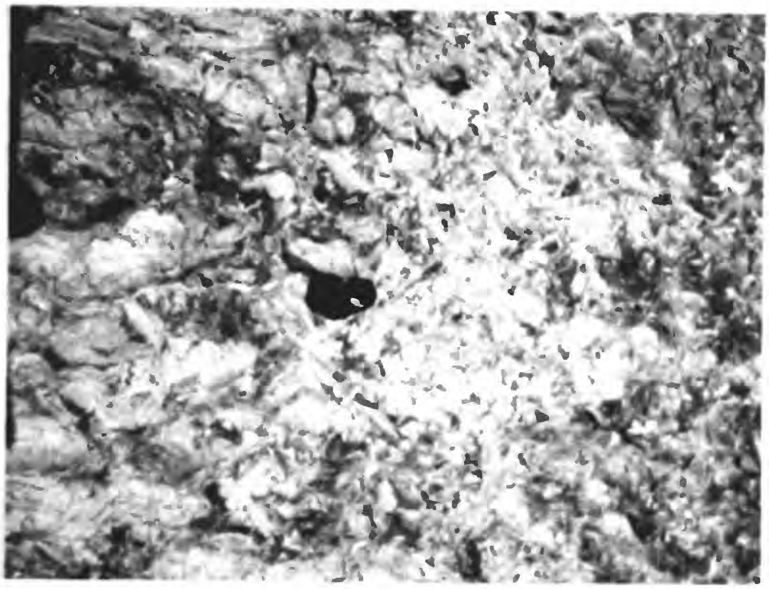
Figure 5 . Field trip route (dashed) for STOP IV-1, around west end of Virgil Bioherm.

Ht C-90%
Orig C-100%

Figure 6 . Yucca Mound looking across gully to southeast. Dark line indicates break in slope from landward (left) to seaward (right) side of the mound.

Figure 7 . Laborcita lithoherms illustrating mounded dark bands (cement-rich) and draping light bands (mud-rich). Field route for STOP IV-2 indicated by dashed line.

Figure 8 . Mottled and lumpy texture of lithoherm core consisting of patches of light mud (some well laminated beneath hand lens) and dark cement.



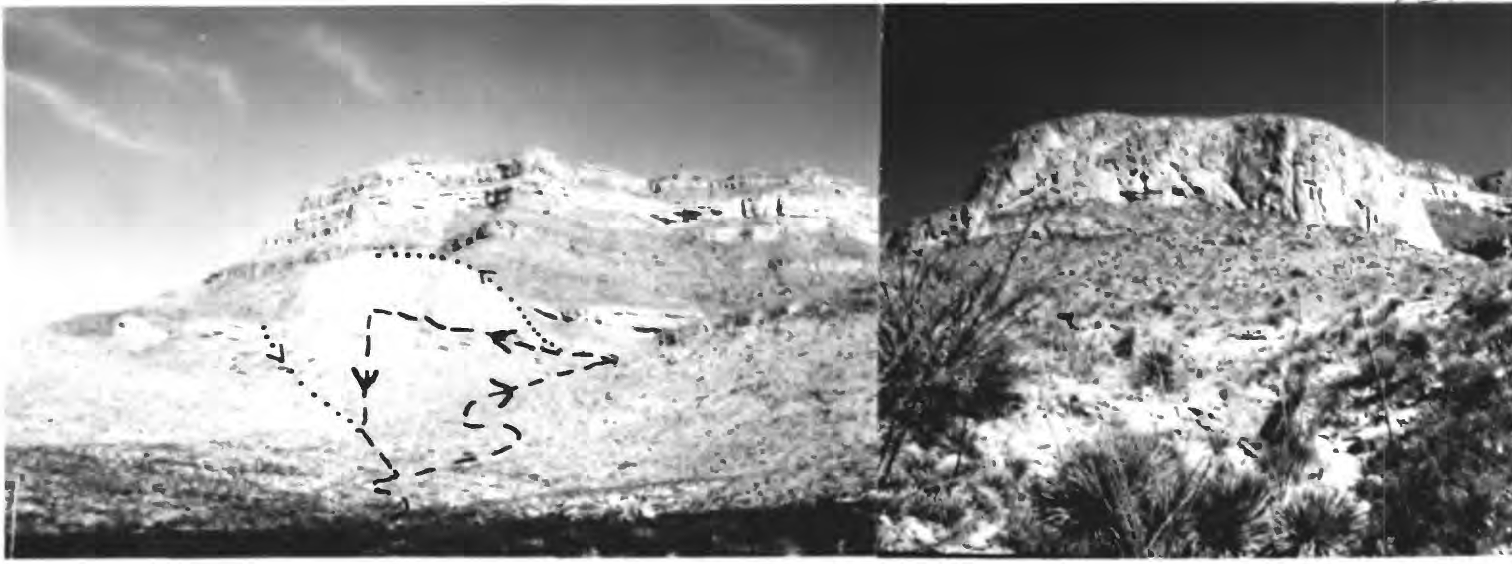


Figure 9 . Left: field trip route for STOP V-1 (dashed, see roadlog for details) and optional route (dotted). Right: detail of Muleshoe Bioherm illustrating arched and dipping flank beds exposed in southwestern escarpment. Core facies is exposed beneath center of arch.

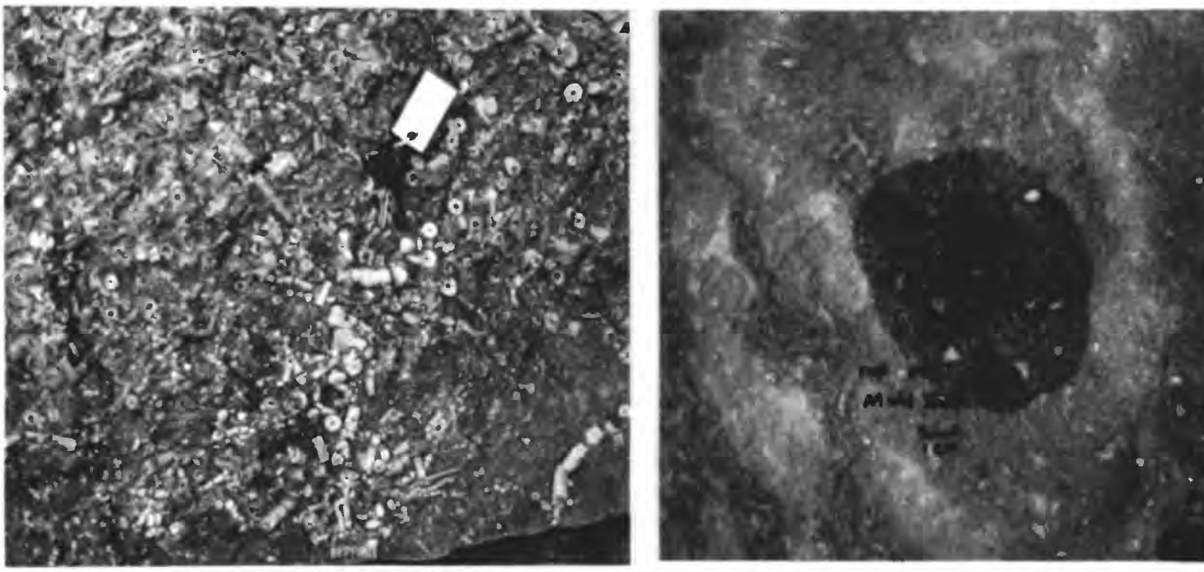


Figure 10. Left: typical outcrop (bedding plane) of Muleshoe crinoidal grainstone illustrating poor sorting and articulated sections of crinoid columnals. Right: Labyrinthine appearance of bryozoan fragments coated with marine cement. Outcrop of core facies on top of bioherm.

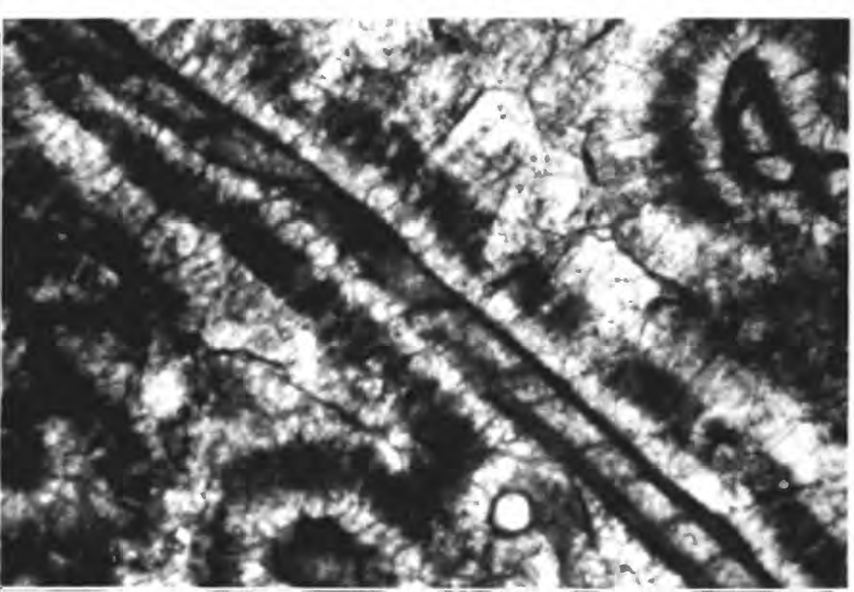


Figure 11. Photomicrograph of bryozoan fragments coated with banded, cloudy cement. This cement is interpreted as syndepositional, marine cement. Field of view is 3 mm.

Table 1.--Oil and gas production, by county, for selected Osagean (Mississippian), Virgilian (Pennsylvanian) and Wolfcampian (Permian) units in the Permian Basin of Texas and New Mexico.

Field or pool name	Producing formation	Discovery year	Prod. depth (ft)	Prod. interval (ft)	Cumulative oil prod. (bbls)	Year reported	Cumulative gas prod. (cu ft.)
		Chaves County, New Mexico					
TOBAC	BOUGH C	1964	09058	010	0015805542	1978	
HAYSTACK	CISCO	1971					0007222306
LONE	WOLFCAMP	1953	07774	038	0000124020	1974	
APACHE SPRINGS	WOLFCAMP	1955	07929	007	0000009630	1978	
		Eddy County, New Mexico					
PARRISH RANCH	CISCO	1964	07744	010	0000004168	1974	
INDIAN HILLS	CISCO	1963	07316	016			
AVALON	CISCO	1973	09280	050			
ANTELOPE SINK	CISCO	1968	06148	054			0003039272
CEDAR LAKE	CISCO	1963			0000006710	1978	
BOYD	CISCO	1972	07138	062			0000289664
ATOKA, WEST	CISCO	1973					0000192520
FORDINKUS	CISCO	1969					0000097620
SPRING	CISCO (UPPER PENN)	1966	08004	024			0037759496
DARK CANYON	CISCO CANYON	1964	09255	034			0000008250
ROCKY ARROYO	L WOLFCAMP	1971	06563				0001007098
CARLSBAD, SOUTH	WOLFCAMP	1973					0000504791
SHUGART	WOLFCAMP	1961	09615		0000012018	1977	
CORRAL DRAW	WOLFCAMP	1975	09648	022			0000035902
CARLSBAD	WOLFCAMP	1967	09656				0000573458
DAGGER DRAW	WOLFCAMP	1965	07554	010			0000182310
WINCHESTER	WOLFCAMP	1973					0002507467
BURTON FLAT, NORTH	WOLFCAMP	1975	08806	026			0003379611
CARLSBAD, EAST	WOLFCAMP	1975					0001691838
WINCHESTER, NORTH	WOLFCAMP	1976			0000005750	1977	
LOGAN DRAW	WOLFCAMP	1974	06582				0000755363
CEMETARY	WOLFCAMP	1975					0000016666
PHANTOM DRAW	WOLFCAMP	1975	10621	028			0000526750
WINCHESTER	WOLFCAMP	1966	09112	040	0000180620	1978	

REMUDA	WOLFCAMP	1960	11111	043	0000066726	1978	
PADUCA	WOLFCAMP	1967	12785				0002939958
BIG EDDY	WOLFCAMP	1962	10690				0000249210
PENASCO	WOLFCAMP	1960	05740	010	0000061980	1978	
LOCO HILLS	WOLFCAMP	1960	08685	012	0000078078	1978	
EMPIRE	WOLFCAMP	1954	07390	040	0000091832	1978	
CANYON	WOLFCAMP	1959		012	0000078000	1978	
MCMILLAN	WOLFCAMP	1964	08179	039	0000010374	1978	
HENSHAW	WOLFCAMP	1961	08753		0006008892	1978	
PARKWAY	WOLFCAMP	1971	09622		0000001404	1978	
LA HUERTA	WOLFCAMP	1974	09007	024	0000009914	1978	
EMPIRE, SOUTH	WOLFCAMP	1974			0000780086	1978	
BLACK RIVER	WOLFCAMP	1974					0000104826
AVALON	WOLFCAMP	1975					0000034700
ROCKY ARROYO, SOUTH	WOLFCAMP	1975					0002832808
CEMETARY, NORTH	WOLFCAMP	1975					0000048762
CORRAL DRAW	WOLFCAMP	1975					0000224022
BURTON FLAT, EAST	WOLFCAMP	1976					0000191378
PADUCA, SOUTH	WOLFCAMP	1977					0000616608

Lea County, New Mexico

HIGHTOWER		1972			0000003446	1978	
LA RICA		1972			0000037504	1978	
TOWNSEND	ABO	1973	08724		0000073908	1978	
BRUNSON, SOUTH	ABO	1975			0000080568	1978	
MONUMENT, NORTH	ABO	1977			0000012282	1978	
FLYING M	BOUGH	1963	09421	014	0000014466	1975	
FLYING M, SOUTH	BOUGH	1965	09067	010	0001103213	1975	
ALLISON	BOUGH	1954	09670	030	0042182286	1978	
RANGER LAKE	BOUGH	1970	09939	039	0000402720	1978	
INBE, EAST	BOUGH C	1967	10000		0000103246	1974	
LANE	BOUGH C	1962	09650	025	0001347532	1974	
LANE SOUTH	BOUGH C	1962	09668		0001830129	1974	
ALLISON, EAST	BOUGH C	1961	09659		0000020766	1974	
INBE	BOUGH C	1962	09862	011	0031966608	1978	
CROSSROADS	BOUGH LS.	1949	09750	015	0004135516	1978	
CAPROCK, EAST	CISCO	1970					0000148081
JENKINS	CISCO	1963	09737	018	0004197066	1978	
MESCALERO, NORTH	CISCO	1968	08900	022	0000924924	1978	
TOWNSEND	CISCO	1972	10794	076	0000015818	1978	
PETERSON	CISCO	1971	07632	035			0000675574
VACUUM	CISCO	1976			0000036128	1978	
KEMNITZ, SOUTH	CISCO	1977			0000007946	1978	
KEMNITZ, WEST	CISCO	1957			0000005110	1978	
HUME	CISCO	1977			0000004126	1978	

KEMNITZ	CISCO PENN	1957	11446	030	0000792100	1978	
VACUUM, NORTHWEST	CISCO PENN	1968	11712	013	0000240276	1978	
VACUUM, NORTH	LOWER WOLFCAMP	1967	10689		0003557332	1978	
KEMNITZ	LOWER WOLFCAMP	1956	10742	038	0029721828	1978	
CERCA	LOWER WOLFCAMP	1969	10360	005	0000303258	1978	
MORTON	LOWER WOLFCAMP	1964	10383	012	0003113142	1978	
LANE	PENN	1956	09802	008	0000391368	1974	
FOUR LAKES	PENN	1956	10227	040	0004698104	1978	
SAUNDERS, SOUTH	PENN	1951	10587	020	0000430232	1978	
ANDERSON RANCH	PENN	1954	12362	010	0000000334	1978	
RANGER LAKE	PENN	1956	10312	033	0009183608	1978	
MESCALERO	PENNSYLVANIAN VIRGIL SER	1951		015	0001778860	1978	
HIGHTOWER	PERMO PENN	1950	08660	030	0001204376	1978	
TULK, SOUTH	UPPER WOLFCAMP	1962	09652		0000302528	1978	
KEMNITZ, SOUTH	UPPER WOLFCAMP	1965	10189	018	0000062478	1978	
BAUM	WOLFCAMP	1955	09940	011	0000155794	1974	
CHAMBERS	WOLFCAMP	1955	10581	015	0000265022	1974	
ANDERSON RANCH, SOUTH	WOLFCAMP	1962	09660	006	0000051299	1974	
INBE	WOLFCAMP	1963	08960	018	0000018607	1974	
FAIRVIEW MILLS	WOLFCAMP	1975					0000094981
YOUNG	WOLFCAMP	1965	10502	041	0000332772	1978	
MOORE	WOLFCAMP	1952	08198	040			0004362780
LEA, SOUTHEAST	WOLFCAMP	1968					0003767274
OSUDO, SOUTH	WOLFCAMP	1967	10215				0000038880
RED HILLS	WOLFCAMP	1965	13440	227			0046904118
TULK	WOLFCAMP	1951	09700	025	0003811736	1978	
TULK, NORTH	WOLFCAMP	1952	09564	034	0000009358	1978	
VACUUM	WOLFCAMP	1962	09518	138	0009505314	1978	
VACUUM, SOUTH	WOLFCAMP	1960	10011	016	0000243434	1978	
VACUUM, EAST	WOLFCAMP	1964			0000103236	1978	
ECHOLS	WOLFCAMP	1960	09446	010	0000022052	1978	
FIELD RANCH	WOLFCAMP	1924	09466	014	0000170060	1978	
SANMAL	WOLFCAMP	1965	10800	078	0000232944	1978	
SHOE BAR	WOLFCAMP	1966	10282		0000118734	1978	
TATUM	WOLFCAMP	1957	10285	031	0001223798	1978	
TONTO	WOLFCAMP	1962	13325		0000012216	1978	
TONTO	WOLFCAMP	1959	11396	029	0000003826	1978	
LOVINGTON	WOLFCAMP	1952	10148	015	0000161070	1978	
BRONCO	WOLFCAMP	1954	09607	035	0003141378	1978	
BUFFALO	WOLFCAMP	1954	10597	012	0000096684	1978	
DENTON	WOLFCAMP	1950	09395	053	0068792800	1978	
DENTON, EAST	WOLFCAMP	1968	09560	008	0000041014	1978	
DENTON, SOUTH	WOLFCAMP	1960	10000	008	0000484630	1978	
DOGIE DRAW	WOLFCAMP	1968	12248	913	0000112140	1978	
LUSK	WOLFCAMP	1964	11672	026	0000012774	1978	
LUSK, SOUTH	WOLFCAMP	1966	10719	020	0000002846	1978	
MALJAMAR	WOLFCAMP	1961	10390		0000478652	1978	
CAPROCK, EAST	WOLFCAMP	1953	08400	018	0000514052	1978	
GLADIOLA, SOUTH	WOLFCAMP	1955	09688	018	0000255524	1978	

GLADIOLA	WOLFCAMP	1951	09555	020	0007330930	1978	
ANDERSON RANCH	WOLFCAMP	1953	09664	047	0006449220	1978	
AUSTIN	WOLFCAMP	1964	10357	010	0000126320	1978	
BAGLEY, EAST	WOLFCAMP	1955	09994	012	0000037520	1978	
BAGLEY, NORTHEAST	WOLFCAMP	1966	08848	017	0000535856	1978	
BAISH	WOLFCAMP	1962	09808		0001327488	1978	
BAISH, NORTH	WOLFCAMP	1962	10834		0000145092	1978	
KING	WOLFCAMP	1951	10126	030	0001168826	1978	
SAUNDERS	WOLFCAMP	1950	09865	831	0056950368	1978	
MESCALERO, NORTH	WOLFCAMP	1960	08350	015	0000122994	1978	
JENKINS	WOLFCAMP	1960	09604	010	0000476192	1978	
KNOWLES, SOUTH	WOLFCAMP	1961	10001	115	0000004490	1978	
LANE	WOLFCAMP	1955	09648	014	0002056958	1978	
LEAMEX	WOLFCAMP	1958	10622	054	0000649288	1978	
OSUDO	WOLFCAMP	1964	10236	030	0000326160	1978	
TOWNSEND	WOLFCAMP	1952	10410	029	0037189734	1978	
ANDERSON RANCH, NORTH	WOLFCAMP	1962		035	0010763696	1978	
CAUDILL	WOLFCAMP	1956	10285	022	0003577712	1978	
BAGLEY, NORTH	WOLFCAMP	1962	08668		0000622144	1978	
CORBIN, SOUTH	WOLFCAMP	1967	10350		0000147476	1978	
VACUUM, NORTHWEST	WOLFCAMP	1969	09855	010	0001014764	1978	
WILSON	WOLFCAMP	1968	10396	010			0000038314
BAGLEY	WOLFCAMP	1969	08840	012	0000003112	1978	
CINDY	WOLFCAMP	1969			0000030120	1978	
CORBIN, EAST	WOLFCAMP	1970	10290	020	0000011402	1978	
MORTON, EAST	WOLFCAMP	1969	10628	017	0002493042	1978	
HUMBLE CITY	WOLFCAMP	1973			0000061718	1978	
SHOE BAR, NORTH	WOLFCAMP	1973	10456		0001404462	1978	
LUSK, EAST	WOLFCAMP	1973	10732		0000404962	1978	
AIRSTRIP	WOLFCAMP	1975	10656	123	0000164612	1978	
BAGLEY, SOUTHEAST	WOLFCAMP	1975			0000051418	1978	
ROCK LAKE	WOLFCAMP	1974	11692		0000005462	1978	
DAISEY	WOLFCAMP	1976			0000055290	1978	
TRINITY	WOLFCAMP	1977			0000043206	1978	
JAL, WEST	WOLFCAMP	1976			0000005302	1978	
LAZY J	WOLFCAMP - PENN	1952	09580	020	0011882512	1978	

Roosevelt County, New Mexico

ALLISON, WEST	BOUGH C	1962	09793	004	0000088667	1974	
PRAIRIE, EAST	BOUGH C	1961	09698		0000010113	1974	
PETERSON, SOUTH	CISCO	1972	07706		0000001964	1975	
PRAIRIE, SOUTH	CISCO	1960	09653	019	0005777356	1978	
TANNEYHILL	CISCO	1972	07602	004			0001012664
PETERSON, SOUTH	CISCO	1972	07706		0000031966	1978	
SQUYRES	PENN	1961	08380		0000010198	1978	
BLUITT	WOLFCAMP	1959	08022	036			0019795776
TODD	WOLFCAMP	1970			0000782832	1978	
PRAIRIE, SOUTH	WOLFCAMP	1976			0000029080	1978	

Andrews County, Texas

HUTEX	DEAN	1959	09595	125	0001062344	1977
LOWE	DEAN	1962	09330	030	0000018989	1977
ANDREWS, SOUTH	WICHITA	1960	08116	012	0000002548	1977
BLOCK 11, SOUTHWEST	WOLFCAMP	1952	07950	025	0000081204	1977
C-RANCH	WOLFCAMP	1954	10008	030	0000002810	1977
DOLLARHIDE, EAST	WOLFCAMP	1956	08350	025	0000001220	1977
FULLERTON, EAST	WOLFCAMP	1968	08542	011	0000004663	1977
FULLERTON	WOLFCAMP	1947	08098	030	0000216492	1977
INEZ, NORTH	WOLFCAMP	1965	10346	296	0000044922	1977
MABEE, NORTH	WOLFCAMP	1954	09966	151	0000007101	1977
MAGUTEX	WOLFCAMP	1965	09944	032	0000004453	1977
MARTIN	WOLFCAMP	1951	07956	014	0000137541	1977
MEANS, EAST	WOLFCAMP	1957	09724	033	0000125719	1977
MIDLAND FARMS, EAST	WOLFCAMP	1962	09316	022	0000005641	1977
PAN-ROD	WOLFCAMP	1965	09893	075	0000042646	1977
TRIPLE-N	WOLFCAMP	1955	08518	045	0000031667	1977
GLASCO	WOLFCAMP	1966	10151	014	0000027890	1977
ANDREWS, SOUTH	WOLFCAMP	1953	09183	030	0011771585	1977
ANDREWS	WOLFCAMP	1953	08596	012	0016824634	1977
BAKKE	WOLFCAMP	1956	08492	046	0016720049	1977
BLOCK 12	WOLFCAMP	1955	07618	043	0000048762	1977
BLOCK 41	WOLFCAMP	1964	09413	022	0000137731	1977
DEEP ROCK, SOUTH	WOLFCAMP	1961	08510	034	0000550644	1977
DEEP ROCK	WOLFCAMP	1957	08583	026	0000172286	1977
EMMA	WOLFCAMP	1967	08393	004	0000041578	1977
FASKEN	WOLFCAMP	1952	08571	025	0005525287	1977
FUHRMAN	WOLFCAMP	1964	08530	042	0000011317	1977
FULLERTON, SOUTH	WOLFCAMP	1955	08245	045	0003582452	1977
HUTEX, NORTH	WOLFCAMP	1965	10058	008	0000574838	1977
INEZ	WOLFCAMP	1962	09316		0000057651	1977
MCFARLAND	WOLFCAMP	1955	09134	126	0004457311	1977
MEANS, SOUTH	WOLFCAMP	1956	09378	036	0002639839	1977
MIDLAND FARMS	WOLFCAMP	1954	09539	030	0009767097	1977
NOLLEY	WOLFCAMP	1951	09227	073	0020028840	1977
PARKER, SOUTH	WOLFCAMP	1965	08644	056	0000143351	1977
PARKER, WEST	WOLFCAMP	1965	08640	040	0000563615	1977
PARKER	WOLFCAMP	1953	08554	068	0001735910	1977
SHAFTER LAKE	WOLFCAMP	1951	08405	050	0011834952	1977
UNIVERSITY BLOCK 9	WOLFCAMP	1953	08430	018	0022535521	1977
UNIVERSITY BLOCK 13	WOLFCAMP	1961	08262	010	0000687442	1977
WEMAC, SOUTH	WOLFCAMP	1962	08786	010	0001560502	1977
WEMAC	WOLFCAMP	1953	08708	164	0002962128	1977

PARKER	WOLFCAMP DETRITAL	1959	08895	010	0000315521	1977
WEMAC, NORTH	WOLFCAMP REEF	1957	08783	040	0000627631	1977
FASKEN	WOLFCAMP, NORTH	1956	08290	120	0000228111	1977
MARTIN, WEST	WOLFE	1968	07798	032	0000016934	1977

Borden County, Texas

REINECKE	CISCO	1950	06791	044	0055619555	1977
HOBO	PENNSYLVANIAN	1951	07100	007	0010600601	1977
GAIL, SOUTH	PERMIAN	1948	06490	030	0000091999	1977
HOBO	WOLFCAMP	1954	06393	041	0000022773	1977
REINECKE	WOLFCAMP	1954	06484	015	0000002190	1977
CANNING	WOLFCAMP	1950	05912	025	0000268289	1977
VON ROEDER	WOLFCAMP	1964	06063		0000554269	1977
ZANT-BORDEN	WOLFCAMP	1973	08392		0000008003	1977

Cochran County, Texas

LEVELLAND, NORTH	WOLFCAMP	1967	08325		0000005473	1977

Coke County, Texas

DAVID	CISCO	1955	04358	005	0000000376	1977
MCCUTCHEN	CISCO	1950	03940	015	0000973646	1977
MCCUTCHEN, WEST	CISCO	1951	03985	013	0000058945	1977
WENDKIRK	CISCO	1953	03696	005	0003451937	1977
WENDKIRK, NORTH	CISCO SAND	1960	03723	008	0000026198	1977
FORT CHADBOURNE	COOK	1961	02925	008	0000003937	1977
WENDKIRK, EAST	SWASTIKA	1961	03632	009	0000146498	1977
BLACKWELL	WOLFCAMP	1942	03823	007	0000013234	1977
MILLICAN, WEST	WOLFCAMP	1972	05718	016	0000003758	1977

Crane County, Texas

EDWARDS 04	CISCO	1962	08135	006	0000014788	1977	
J. CLEO THOMPSON	CISCO	1964	08030	043	0000482837	1977	
DUNE, EAST	CISCO LIME	1952	03856	011	0000018589	1977	
DAWSON	WOLFCAMP	1955					
BLOCK 31, NORTHWEST	WOLFCAMP	1962	07708	002	0000074719	1977	
DUNE, EAST	WOLFCAMP	1956	08280	010	0000001673	1977	
EDWARDS 04	WOLFCAMP	1962	07892	012	0000018555	1977	
H. E. A.	WOLFCAMP	1954	07890	100	0000038804	1977	
JAX	WOLFCAMP	1956	04445	065	0000029469	1977	
LEA, SOUTH	WOLFCAMP	1960	06010	084	0000022299	1977	
SAGE CANYON	WOLFCAMP	1965	08316	050	0000003375	1977	
SAND HILLS, NORTHWEST	WOLFCAMP	1963	06031	042			0001610328

SAND HILLS, WEST	WOLFCAMP	1960	05670	045			0000647333
SAND HILLS	WOLFCAMP	1961	05435	100	0000002500	1975	
MCKEE	WOLFCAMP	1958	05420	070	0000004325	1975	
DUNE	WOLFCAMP	1957	07710	050	0006730800	1977	
EDWARDS 04, SOUTH	WOLFCAMP	1967	07925	003	0002002569	1977	
MCKEE	WOLFCAMP	1958	05320	070	0000126620	1977	
ROEPKE	WOLFCAMP	1968	06058	229	0000032003	1977	
SAND HILLS	WOLFCAMP	1958	05684	080	0001297740	1977	

Crockett County, Texas

SHANNON	CISCO	1953	06440	008	0000001936	1977	
CLARA COUCH	CISCO	1955	05460	040	0000064277	1977	
CLARA COUCH	CISCO LIME	1947	05800	167			
TIPPETT	HUECO	1967	04930	050	0000025752	1977	
TIPPETT, WEST	HUECO	1968	05012	191	0001040078	1977	
OZONA, SOUTHWEST	WOLFCAMP	1967	08101	012			0000749560
TIPPETT, EAST	WOLFCAMP	1962	06040	040			0000102004
TIPPETT	WOLFCAMP	1950	06065				
DONHAM	WOLFCAMP	1964	06347	095	0000000282	1977	
EL CINCO, EAST	WOLFCAMP	1962	05220	010	0000030179	1977	
K C A	WOLFCAMP	1958	06379	010	0000004477	1977	
OLSON	WOLFCAMP	1959	05790	013	0000008436	1977	
TIPPETT, EAST	WOLFCAMP	1955	06155	016	0000114377	1977	
TIPPETT, NORTH	WOLFCAMP	1961	06224	004	0000012528	1977	
TIPPETT	WOLFCAMP	1966	05016	028	0000043085	1977	
VAUGHN	WOLFCAMP	1962	05320	020	0000000557	1977	
CLARA COUCH	WOLFCAMP	1947	05512	015			
MORRISON	WOLFCAMP	1966	03596	872			0000687346
TIPPETT	WOLFCAMP	1947	06100	056			
TIPPETT, SOUTH	WOLFCAMP	1968	06260	006	0000004213	1975	
TIPPETT, WEST	WOLFCAMP	1967	05060				0009555493
EULEEONOE	WOLFCAMP	1973	04520				
CLARA COUCH	WOLFCAMP	1947	05670	020	0000268016	1977	
TIPPETT	WOLFCAMP	1947	06100	015	0003559679	1977	
TIPPETT, WEST	WOLFCAMP	1968	05108	139	0000353130	1977	
TIPPETT, WEST	WOLFCAMP	1968	05487	009	0000571209	1977	
TIPPETT, NORTH	WOLFCAMP	1970	05940	004	0000277136	1977	
TIPPETT, SOUTH	WOLFCAMP DETRITAL	1959	05728				0008352995
TIPPETT, SOUTH	WOLFCAMP, LO	1968	06322	012	0000007743	1977	
TIPPETT, WEST	WOLFCAMP, LO.	1967	05564	002	0001343028	1977	
TIPPETT	WOLFCAMP, LOWER	1954	06292	038			
TIPPETT	WOLFCAMP, LOWER	1954	06292	036	0000063685	1977	
TIPPETT	WOLFCAMP, UPPER	1954	05950	028			
TIPPETT	WOLFCAMP, UPPER	1954	05950	028	0000501842	1977	

Dawson County, Texas

ACKERLY, NORTH	CISCO	1972	08766		0000922490	1977
SPARENBURG	DEAN	1964	08762		0000032737	1977
ACKERLY	DEAN	1955	08215	037	0000126032	1977
TEX-HAMON	DEAN	1967	09555		0002238875	1977
ACKERLY, NORTH	DEAN SAND	1957	08200	112	0000121972	1977
ACKERLY, NORTHWEST	DEAN SAND	1960	09580	096	0000077854	1977
ACKERLY, SOUTH	DEAN SAND	1954	08282	066	0000001080	1977
ACKERLY	DEAN SAND	1954	08172	035	0024260431	1977
PATRICIA	WOLFCAMP	1964	09270		0000002068	1977
BLOCK 35	WOLFCAMP	1965	08429	004	0000672349	1977
SCHMIDT	WOLFCAMP	1961	09381		0000333438	1977
TRIPLE D	WOLFCAMP	1958	08497	006	0000961649	1977
TRIPLE D, SOUTH	WOLFCAMP	1963	08528		0000189106	1977
WALLS	WOLFCAMP	1954	08624	028	0000231913	1977

Dickens County, Texas

DUCK CREEK	TANNEHILL	1957	04564	002	0000233626	1977
CROTON CREEK, EAST	TANNEHILL	1969	04574		0000973811	1977
GIRARD, NORTH	TANNEHILL	1972	04402	003	0000021301	1977
CROTON CREEK, SOUTH	TANNEHILL	1968	04679		0000848506	1977
CROTON CREEK	TANNEHILL	1958	04660	004	0000323972	1977
GIRARD	TANNEHILL	1953	04401	010	0000248235	1977

Ector County, Texas

COWDEN, NORTH	CISCO	1966	08895	005	0000310033	1977
DONNELLY	CISCO	1955	08684	041	0000178164	1977
COWDEN	CISCO	1955	08846	012	0004009026	1977
COWDEN, SOUTH	CISCO	1966	08648	005	0000966020	1977
HARPER, SOUTHEAST	CISCO	1966	08584	052	0000518015	1977
ADDIS	WOLFCAMP	1953	08230	017	0000086394	1977
COWDEN	WOLFCAMP	1961	08224	020	0000032002	1977
MAC-BORING	WOLFCAMP	1952	08650	114	0000359780	1977
P-BAR	WOLFCAMP	1956	10020	032	0000000743	1977
POOL	WOLFCAMP	1956	09870	050	0000056252	1977
POOL	WOLFCAMP	1956	09870	014	0000105387	1977
TXL	WOLFCAMP	1946	07795	070	0000008151	1977
FASKEN, SOUTH	WOLFCAMP	1960	08475	020	0000292023	1977
GOLDSMITH, WEST	WOLFCAMP	1968	07720	220	0000010768	1977
JORDAN, SOUTH	WOLFCAMP	1960	06695	037	0000236866	1977

JORDAN	WOLFCAMP	1960	06790	056	0000071705	1977
MOOSE	WOLFCAMP	1954	09492	030	0000327450	1977
SONNY B	WOLFCAMP	1963	07018	044	0000593650	1977
WHEELER	WOLFCAMP	1959	07604	116	0002315710	1977
YARBROUGH & ALLEN	WOLFCAMP	1954	07470	030	0000064932	1977
COWDEN, SOUTHEAST	WOLFCAMP	1969	08237	030	0000036825	1977
MAC-BORING	WOLFCAMP -G-	1952	09640	022	0000006502	1977
TXL	WOLFCAMP, NORTH	1959	07535	212	0004073149	1977
		Edwards County, Texas				
ROCKSPRINGS	CISCO	1960	02364			0000466096
		Fisher County, Texas				
BENNETT	CAMP COLORADO	1958	03865	015	0000068178	1977
ROTAN	CAMP COLORADO	1937	03372		0001021880	1977
ROBY, NORTH	CISCO	1955	03810	004	0000380666	1977
SATURDAY	CISCO LOWER	1956	04462	012	0000012914	1977
ROBY-GOOLSBY	CISCO SAND	1956	03887	004	0000002630	1977
ROBY	COOK	1949	03510	006	0000005278	1977
IDA	FLIPPEN	1953	03213	020	0000061337	1977
PALAVA	FLIPPEN	1955	03408	006	0000012944	1977
RALLEN	FLIPPEN	1951	03516	022	0000107865	1977
ROBY	FLIPPEN	1948	03536		0000128295	1977
SYLVESTER, SOUTH	FLIPPEN	1961	03104	004	0000003611	1977
OMAR	FLIPPEN	1970	03506		0000017203	1977
LONGWORTH	FLIPPEN	1953	03612	010	0000061830	1977
MCCAULLEY, NORTH	FLIPPEN	1965	03228	033	0000010175	1977
PARDUE	FLIPPEN	1968	03107		0000174684	1977
ROTAN, NORTH	FLIPPEN	1964	03962	002	0000002987	1977
TOLAR	FLIPPEN	1969	03135		0000042675	1977
CATHY	FLIPPEN	1970	03104		0000057955	1977
ROUND TOP	FLIPPEN LIME	1953	03405	002	0000015232	1977
ROBY	FLIPPEN LOWER	1952	03553	006	0000033786	1977
ROTAN	FLIPPEN SAND	1962	03950	032	0000303101	1977
BOMAR	HOPE LIME	1965	03556	014	0000011199	1977
ROTAN, EAST	HOPE LIME	1964	03801	005	0000275922	1977
HALF MOON	HOPE LIME UPPER	1970	03601	003	0000104504	1977
ROTAN	HOPE LIME, UPPER	1962	03940	004	0002178595	1977
DOWELL	NOODLE CREEK	1952	03443	005	0000008790	1977
EIVANS	NOODLE CREEK	1956	02015	009	0000001125	1977
HARGROVE	NOODLE CREEK	1955	03725	007	0000107752	1977
HOWARD, SOUTH	NOODLE CREEK	1964	03384	005	0000013434	1977
PAUL HUNTER	NOODLE CREEK	1957	03219	011	0000000607	1977
SYLVESTER, SOUTH	NOODLE CREEK	1962	02853	004	0000001098	1977
WEEMS	NOODLE CREEK	1956	03633	013	0000000686	1977
ROUND TOP	NOODLE CREEK	1969	02970		0000028458	1977

BARBARA MOORE	NOODLE CREEK	1962	03886	004	0000184781	1977	
ESKOTA	NOODLE CREEK	1955	02545	004	0001865424	1977	
RAVEN CREEK	NOODLE CREEK	1955	02657	003	0000920007	1977	
ROUGH DRAW	NOODLE CREEK	1961	03816	008	0010098543	1977	
ROBY, NORTHWEST	SWASTIKA	1966	03930	006			0000258248
ROUND TOP, NORTHWEST	SWASTIKA	1961	03976	005	0000000206	1975	
KEELER-WIMBERLY, NORTH	SWASTIKA	1972	03679	006	0000000111	1975	
BLOCKLINE	SWASTIKA	1951	03679	003	0000009209	1977	
ROBY	SWASTIKA	1948	03560		0000018952	1977	
ROBY-BARNES	SWASTIKA	1956	03962	020	0000011180	1977	
JIM-LEW	SWASTIKA	1971	03634	002	0000000159	1977	
ROUND TOP	SWASTIKA	1956	03984	006	0000000662	1975	
BLOCKLINE, WEST	SWASTIKA	1972	03663	006			
JUDY GAIL	SWASTIKA	1954	03749	002	0000774779	1977	
KEELER-WIMBERLY, NORTH	SWASTIKA	1968	03704	001	0000092126	1977	
KEELER-WIMBERLY, NORTH	SWASTIKA	1966	03688		0000067704	1977	
LA PALOMA	SWASTIKA	1965	03835	015	0000251868	1977	
NEWMAN	SWASTIKA	1957	03781	006	0002358919	1977	
PARDUE	SWASTIKA	1949	03743	008	0007109806	1977	
ROUND TOP, NORTHWEST	SWASTIKA	1961	03976	005	0000452457	1977	
ROUND TOP	SWASTIKA	1956	03984		0001332966	1977	
TERRY	SWASTIKA	1963	04945	020	0000069955	1977	
TOLAR	SWASTIKA	1950	03793	011	0004940310	1977	
ANDY, SOUTH	SWASTIKA	1969	03904	003	0000029386	1977	
TOLAR, EAST	SWASTIKA	1970	03757	003	0000016076	1977	
MCCAULLEY, WEST	WOLFCAMP	1948	03160	015	0000001152	1977	

Gaines County, Texas

JENKINS, SOUTHEAST	WOLFCAMP	1964	08946	014	0000008987	1977
NORMAN	WOLFCAMP	1957	09142	035	0000029585	1977
PENCE	WOLFCAMP	1955	09416	008	0000000097	1977
WASSON, NORTH	WOLFCAMP	1961	09267	015	0000042084	1977
AMROW, NORTH	WOLFCAMP	1963	10013		0000020409	1977
BOTTENFIELD	WOLFCAMP	1962	09361		0000134955	1977
NORMAN, SOUTH	WOLFCAMP	1970	09194		0000381161	1977
NORMAN, SOUTH	WOLFCAMP	1970	09347		0000143453	1977
ALSABROOK	WOLFCAMP	1953	09125	040	0001053164	1977
BOTTENFIELD	WOLFCAMP	1952	09200	056	0004180299	1977
BRO	WOLFCAMP	1955	09758	014	0000063299	1977
D. E. B.	WOLFCAMP	1960	09200	017	0005313432	1977
D. E. B.	WOLFCAMP	1960	09400	034	0001160787	1977
HUAT, EAST	WOLFCAMP	1962	10196		0000078112	1977
HUAT	WOLFCAMP	1962	09800		0000654854	1977
SEMINOLE, WEST	WOLFCAMP	1958	09118	032	0000431507	1977
SEMINOLE	WOLFCAMP	1956	09120	063	0000444289	1977
TOBY-JO	WOLFCAMP	1954	09242	010	0002977752	1977
WASSON, EAST	WOLFCAMP	1960	08680	011	0000364815	1977
WASSON	WOLFCAMP	1956	08448	057	0004695236	1977

BALE	WOLFCAMP	1971	09799	007	0000104890	1977
BALE, EAST	WOLFCAMP	1972	10005		0000845261	1977
SEMINOLE	WOLFCAMP LIME	1963	09259	009	0000900936	1977
KAY	WOLFCAMP REEF	1959	10349	022	0001629351	1977
SEMINOLE	WOLFCAMP REEF	1962	09162		0000900247	1977
HUAT	WOLFCAMP, LOWER	1962	09990		0000039780	1977
WESCOTT	WOLFCAMP, LOWER	1962	10226		0000001656	1977
WASSON, EAST	WOLFCAMP, LOWER	1961	08765		0000478366	1977
WASSON, EAST	WOLFCAMP, MIDDLE	1964	08733	019	0000071184	1977

Garza County, Texas

ROCKER A, SOUTH	WOLFCAMP	1957	05422		0000014496	1977
RED LOFLIN, NORTH	WOLFCAMP	1961	06042		0000012877	1977
TOBE	WOLFCAMP	1951	04660	050	0000047949	1977

Glasscock County, Texas

CALVIN, NORTH	DEAN	1966	07596	010	0000295016	1977
CLYDE REYNOLDS	WOLFCAMP	1964	08154	016	0000002795	1977
GARDEN CITY, SOUTH	WOLFCAMP	1964	07642	007	0000000656	1977
MCDOW	WOLFCAMP	1953	07140		0000000523	1977
CARTER	WOLFCAMP	1957	08374	211	0000024638	1977
CITATION	WOLFCAMP	1971	07226	018	0000010396	1977
BLALOCK LAKE	WOLFCAMP	1966	08215	015	0000255769	1977
GARDEN CITY, WEST	WOLFCAMP	1966	07920	044	0001058752	1977
BLALOCK LAKE, EAST	WOLFCAMP	1971	07914	043	0000409906	1977
BLALOCK LAKE, SOUTH	WOLFCAMP	1974	08246		0000597436	1977
GORDON STREET, SOUTH	WOLFCAMP, LO	1960	09220	009	0000606205	1977
GARDEN CITY, SOUTHEAST	WOLFE	1968	07986	013	0000007791	1977

Haskell County, Texas

TULL	CISCO	1955	01841	005	0000023346	1977
WEDEKING, SOUTH	CISCO	1958	02604	005	0000061293	1977
WEDEKING	CISCO	1958	02600	004	0000058535	1977
HUMPHREY-CHAPMAN	CISCO	1946	02542	023	0001003271	1977
CLEAR FORK, WEST	COOK	1957	01542	015	0000327114	1977
M. M. C.	FLIPPEN	1963	01598	004	0000007516	1977
WOLF CAMP	HOPE	1964	01472	008	0000300369	1977
LIVENGOOD	KING SAND	1955	02337	007	0000162749	1977
STAMFORD, NORTHWEST	KING SAND	1957	02326	010	0000081257	1977
PARDUE, NORTH	KING SAND	1953	02107	008	0000026069	1977
LIVENGOOD, SOUTH	KING UPPER	1956	02308	007	0000395011	1977
SLOPOKE	SWASTIKA	1957	02795	013	0000060342	1977
STAMFORD, WEST	SWASTIKA	1951	02485	009	0002350018	1977
WOLF CAMP	SWASTIKA	1963	01639		0000747512	1977
STAMFORD, WEST	SWASTIKA, UPPER	1957	02488		0000000353	1977

Hockley County, Texas

LEVELLAND	CISCO LIME	1971	09380	014	0000074636	1977
ROPES, WEST	CISCO SAND	1953	09875	033	0006388475	1977
D-L-S	WOLFCAMP	1953	08507	012	0000059909	1977
HOBLITZELLE	WOLFCAMP	1954	08318	092	0000011397	1977
MORELAND	WOLFCAMP	1958	08505	040	0000006422	1977
PENTECOST	WOLFCAMP	1959	08594	034	0000003607	1977
ROPES, WEST	WOLFCAMP	1955	08775	050	0000001946	1977
MARGARET BENSON	WOLFCAMP	1969	08228		0000069899	1977
LEVELLAND, NORTHEAST	WOLFCAMP	1965	08444	026	0000256052	1977
SLAUGHTER	WOLFCAMP	1965	09318	111	0000150778	1977
CLAUENE	WOLFCAMP, LOWER	1963	08778		0000000704	1977

Howard County, Texas

MOSS LAKE	CISCO	1966	07932	025	0000013818	1977
BROOKING, NORTHEAST	CISCO	1965	08942	006	0000495610	1977
MODESTA, SOUTH	CISCO	1967	08940	003	0000437431	1977
VEALMOOR	CISCO	1952	07500	075	0000055671	1977
WRIGHT RANCH	CISCO REEF	1969	09000	004	0000004799	1977
MODESTA, NORTH	DEAN	1968	08279	145	0000004101	1977
BROOKING, NORTHEAST	DEAN	1970	08123	101	0000006890	1977
HUTTO	WOLFCAMP	1950	07370	060	0000104609	1977
LUTHER, NORTH	WOLFCAMP	1967	07792	012	0000001065	1977
ODANIEL	WOLFCAMP	1957	06172	030	0000017488	1977
VAN GRIS	WOLFCAMP	1954	06675	027	0000088932	1977
VEALMOOR, EAST	WOLFCAMP	1950	06960	050	0000019213	1977
VINCENT, NORTH	WOLFCAMP	1958	06255	020	0000069771	1977
HOWARD-GLASSCOCK	WOLFCAMP	1970	07441	035	0000178721	1977
MORGAN RANCH	WOLFCAMP	1971	07300	023	0000000142	1977
HUTTO, SOUTH	WOLFCAMP	1964	07421	054	0002568229	1977
VEALMOOR, NORTHEAST	WOLFCAMP	1965	06816	015	0000345712	1977
STOLHAN	WOLFCAMP	1972	06646	008	0000165782	1977
MOSS CREEK	WOLFCAMP, LOWER	1971	08053	029	0000001021	1977
HUTTO, SOUTH	WOLFCAMP, UPPER	1969	07030	037	0000348271	1977
HOWARD-GLASSCOCK	8915 WOLFCAMP	1966	09042	009	0000005991	1977

Irion County, Texas

DOVE CREEK	CISCO	1965	05980	038	0000003485	1975
DOVE CREEK	CISCO	1965	05980	015	0000020863	1977
BROOKS, SOUTH	CISCO	1973	05896		0000002790	1977
O. H. TRIANGLE	WOLFCAMP	1956	05890	022	0000001655	1977

ROCKER B, EAST	WOLFCAMP	1967	06806	288	0000001524	1977
S. W. T.	WOLFCAMP	1960	05530	020	0000000481	1977
TANKERSLEY	WOLFCAMP	1951	05464	030	0000046971	1977
SHERWOOD	WOLFCAMP	1968	05404	005	0000000381	1977
WARDLAW THREE	WOLFCAMP	1974	06630		0000010700	1977
MERTZON	WOLFCAMP	1964	06780	073	0000070399	1977
TANKERSLEY	WOLFCAMP	1966	05216	013	0000219758	1977
ARDEN, SOUTHEAST	WOLFCAMP	1974	06332		0000054232	1977
SUGG-IRION	WOLFCAMP	1974	05723		0000026407	1977
TANKERSLEY	WOLFCAMP LOWER	1969	05517			

Kent County, Texas

COGDELL, EAST	COGDELL SAND	1952	04538	035	0000263479	1977
ROUGH DRAW, NORTH	NOODLE CREEK	1963				
WALLACE RANCH, NORTHEAST	NOODLE CREEK	1968	03841		0000074831	1977
ROUGH DRAW, NORTH	NOODLE CREEK	1963	04140	014	0001471419	1977
WALLACE RANCH	NOODLE CREEK	1963	03868		0000345424	1977
ANDREW NOODLE CREEK	NOODLE CREEK	1969	04010		0000972082	1977
ATKINS-FLEMING	NOODLE CREEK	1972	04259		0000034418	1977
TONI C	NOODLE CREEK	1972	03922		0000240548	1977
BROWNING	TANNEHILL	1974	04517		0000053118	1977
COGDELL	WOLFCAMP	1950	04910	040	0000972858	1977

King County, Texas

MASTERSON RANCH	BUNGER SAND	1960	04015		0000001848	1977
TOM B.	BUNGER SAND	1952	04100		0000892845	1977
BATEMAN RANCH	CISCO	1943	03700	025	0009267975	1977
BATEMAN RANCH	CISCO	1943	03700		0001074321	1977
BATEMAN RANCH	CISCO	1943	05100		0003403445	1977
BATEMAN RANCH	CISCO	1943	05300		0001296125	1977
BUZZARD PEAK	TANNEHILL	1969	02696		0000001489	1977
BLOCK F	TANNEHILL	1957	03139	001	0000381741	1977
BUZZARD PEAK	TANNEHILL	1956	02666	007	0000168245	1977
SPRINGER	TANNEHILL	1964	03492	004	0000403828	1977
VALLEY VIEW	TANNEHILL	1967	02506		0000104209	1977
BIG N	TANNEHILL	1971	02867	007	0000865736	1977
CROTON	TANNEHILL	1972	03106		0000303491	1977
BUZZARD PEAK	TANNEHILL, UPPER	1957	02673	008	0000046590	1977
REUTINGER	TANNEHILL, UPPER	1960	02982	014	0000870972	1977

Knox County, Texas

EARL WISDOM	CISCO	1950	01685	014	0000159870	1977
GOREE	CISCO	1956	01624	004	0003721008	1977
A P C	TANNEHILL	1959	02324	005	0000203733	1977
BUCKSTACK	TANNEHILL	1959	01864	010	0000004323	1977

CARTER-GIFFORD	TANNEHILL	1957	02304	005	0000013081	1977
CHRISTIE-STEWART	TANNEHILL	1956	01749	006	0000033653	1977
FAYE	TANNEHILL	1959	02034	008	0000039382	1977
FAYE	TANNEHILL	1958	02056	004	0000103293	1977
FETSCH	TANNEHILL	1963	02103	006	0000013086	1977
FEW	TANNEHILL	1957	02412	010	0000012357	1977
GOLDEN	TANNEHILL	1957	01686	021	0000235106	1977
GOREE, NORTHEAST	TANNEHILL	1960	01643	006	0000257556	1977
GOREE-MALONEY	TANNEHILL	1961	01692	004	0000017548	1977
HENRY-HAMILTON	TANNEHILL	1967	02416	005	0000041338	1977
HOLDER	TANNEHILL	1963	01852	007	0000005473	1977
J. E. K.	TANNEHILL	1957	02308	003	0000005644	1977
JUNGMAN	TANNEHILL	1959	02124	004	0000020676	1977
KNOX CITY, NORTH	TANNEHILL	1957	02252		0000008064	1977
KNOX CITY	TANNEHILL	1957	02296	006	0000309479	1977
L-M	TANNEHILL	1957	01870	010	0000135322	1977
L. O. C.	TANNEHILL	1957	01867	004	0000030811	1977
MCCARTY	TANNEHILL	1957	02162		0000001206	1977
MUNDAY, EAST	TANNEHILL	1958	01960	006	0000035697	1977
PARTRIDGE	TANNEHILL	1958	02055	005	0000001479	1977
PEPPER	TANNEHILL	1956	02084	002	0000162954	1977
PLUMLEE, NORTH	TANNEHILL	1960	01913	003	0000056392	1977
REED	TANNEHILL	1957	02186	004	0000052132	1977
S-B	TANNEHILL	1957	02080	003	0000047769	1977
SAINT MARY	TANNEHILL	1957	01801	008	0000009514	1977
STRICKER	TANNEHILL	1958	02099	012	0000052835	1977
TEXOMA, NORTHEAST	TANNEHILL	1956	01700	017	0000171321	1977
TEXOMA, NORTHEAST	TANNEHILL	1960	01783	003	0000026154	1977
TEXOMA	TANNEHILL	1956	01659	005	0000009651	1977
FRIERSON	TANNEHILL	1956	01981	010	0000003526	1977
GOREE, SOUTHWEST	TANNEHILL	1961	01679		0000006577	1977
JARVIS, NORTHEAST	TANNEHILL	1967	02037	003	0000034844	1977
GASS	TANNEHILL	1971	01848		0000018149	1977
VOSS	TANNEHILL	1965	01940	004	0000003706	1977
GOREE	TANNEHILL	1958	01799		0000035363	1977
AJAX	TANNEHILL	1956	02085	010	0000163998	1977
BOOE	TANNEHILL	1966	01995	006	0000053938	1977
BOOE	TANNEHILL	1963	02110	018	0000141632	1977
COFFMAN	TANNEHILL	1962	01542	007	0000015294	1977
GOREE, SOUTH	TANNEHILL	1956	01604	002	0000383365	1977
GOREE, WEST	TANNEHILL	1956	01908	002	0000247792	1977
HACKATHORN, EAST	TANNEHILL	1965	02000	010	0000238921	1977
HACKATHORN	TANNEHILL	1957	02033	003	0000786872	1977
J. R. K.	TANNEHILL	1956	01816	015	0000263484	1977
JARVIS	TANNEHILL	1957	02067	008	0000518184	1977
KNOX CITY, NORTHWEST	TANNEHILL	1957	02320	005	0000142853	1977
PERMAYES	TANNEHILL	1957	01903	010	0000230347	1977
PLUMLEE, NORTHWEST	TANNEHILL	1960	02064	006	0000074025	1977
PLUMLEE	TANNEHILL	1957	01908	013	0000739583	1977
TEXOMA, EAST	TANNEHILL	1956	01706	004	0000425184	1977

TWO TEE	TANNEHILL	1958	02570	007	0000598185	1977
VOSS, SOUTH	TANNEHILL	1963	01940		0000168886	1977
VOSS, SOUTHEAST	TANNEHILL	1959	01958	010	0000141458	1977
VOSS	TANNEHILL	1956	02012	020	0007674988	1977
PLUMLEE	TANNEHILL	1957	02022	006	0002237047	1977
GOREE, NORTHWEST	TANNEHILL	1974	01856		0000021017	1977
REED	TANNEHILL, LOWER	1960	02202		0000233288	1977
GOREE, WEST	TANNEHILL, UPPER	1957	01822	006	0000128825	1977
KNOX CITY	TANNEHILL, UPPER	1958	02258			1977
REED	TANNEHILL, UPPER	1960	02073		0000155998	1977
A & K	WOLFCAMP	1957	02220	007	0000002797	1977
BIG FOUR	WOLFCAMP	1957	02179	006	0000070687	1977
BODE, EAST	WOLFCAMP	1965	01971	003	0000110550	1977

Martin County, Texas

SULPHUR DRAW, NORTH	DEAN	1967	09569	527	0000000325	1977
SULPHUR DRAW, WEST	DEAN	1968	09291	689	0000006860	1977
LENORAH, WEST	DEAN	1970	09336	140	0000006119	1977
HILL RANCH	DEAN	1961	08462	040	0000034707	1977
MABEE	DEAN	1967	09747	459	0000164081	1977
SULPHUR DRAW	DEAN	1966	09442	029	0005452494	1977
LACAFF	DEAN	1969	09490	267	0005075937	1977
BLOCK H A	DEAN	1974	09646		0000010060	1977
BREEDLOVE, SOUTH	DEAN	1974	09234		0000091874	1977
TARZAN	DEAN WOLFCAMP	1966	09846	020	0000007895	1977
BREEDLOVE	WOLFCAMP	1960	10074	010	0000002829	1977
GORDON STREET, WEST	WOLFCAMP	1960	09220	015	0000032659	1977
GORDON STREET	WOLFCAMP	1959	09292	005	0000036491	1977
GORDON STREET	WOLFCAMP	1965	08685	020	0000031027	1977
STANTON	WOLFCAMP	1960	08600	050	0000005437	1977
BREEDLOVE, SOUTHEAST	WOLFCAMP	1962	09292	012	0000195794	1977
GLASS, NORTH	WOLFCAMP	1953	09382	026	0000410051	1977
GORDON STREET	WOLFCAMP	1965	09340	039	0000158714	1977
WOLCOTT	WOLFCAMP	1959	09128	018	0000060036	1977
BREEDLOVE	WOLFCAMP -B-	1962	10114	010	0000041528	1977

Midland County, Texas

MIDLAND, EAST	DEAN WOLFCAMP	1966	09544	021		1977
SPRABERRY	DEAN WOLFCAMP	1966	09022	031	0002217266	1977
AZALEA	WOLFCAMP	1962	09870	026	0000133631	1977
MIDLAND, SOUTH	WOLFCAMP	1947	08500	070	0000161519	1977
NOBLES	WOLFCAMP	1958	09800	052	0000021099	1977
RUTH SCHARBAUER	WOLFCAMP	1955	09000	080		1977
HI-LONESOME	WOLFCAMP	1951	09125	170	0000263549	1977
PARKS	WOLFCAMP	1966	09839	020	0000050895	1977
WARFIELD	WOLFCAMP	1961	09443	014	0000050076	1977
HALLANAN	WOLFCAMP	1955	09734	024	0000032198	1977

SWEETIE PECK	WOLFCAMP, LO.	1950	09849	164	0000103493	1977	
VIREY	WOLFCAMP, LOWER	1956	09095	014	0000027302	1977	
WAR-SAN	WOLFCAMP, LOWER	1956	09795	031	0000431925	1977	
VIREY	WOLFCAMP, UPPER	1958	09234	045	0000049115	1977	

Mitchell County, Texas

STERLING, NORTHWEST	WOLFCAMP	1968	08700	020	0000003947	1977	
RAY ALBAUGH	WOLFCAMP	1966	04426	034	0000080967	1977	

Nolan County, Texas

HYLTON, NORTHWEST	BRECKENRIDGE	1962	03930	008	0000042587	1977	
AULD	CISCO	1957	04194	010	0000011015	1977	
BECKHAM, WEST	CISCO	1959	03890	005	0000049890	1977	
GROUP	CISCO	1958	04170		0000407844	1977	
GROUP	CISCO	1953	04099	007	0001944132	1977	
SWEET	CISCO	1966	04037		0000164195	1977	
J. A. M.	CISCO REEF	1958	03680	005	0000185615	1977	
GROUP	CISCO SAND	1953	04049				
GROUP	CISCO SAND	1958	04170				
MARY NEAL	CISCO SAND	1953	04072	015	0000029583	1977	
DORIS	COOK	1971	03965	022	0000008920	1977	
HAT TOP MOUNTAIN, NORTH	COOK LIME	1965	03479	006	0000000545	1977	
E. A.	COOK SAND	1961	03750	009	0000083221	1977	
DIVIDE	FLIPPEN	1953	03726	030	0000093402	1977	
WATTS, NORTH	GARDNER	1967	05613		0000475967	1977	
WATTS, SOUTH	GARDNER	1966	05401		0000317950	1977	
WATTS, SOUTH	GARDNER LIME	1966	05360		0000000604	1977	
WATTS	GARDNER LIME	1954	05432	006	0001271497	1977	
WATTS, SOUTH	GARDNER SAND	1966	05401		0000003582	1977	
WATTS	GARDNER SAND	1954	05548	006	0001689681	1977	
FAVER	GUNSIGHT	1951	03904	022	0000001613	1977	
HARDROCK	KING SAND	1960	04290	005	0000108680	1977	
DIVIDE	KING SAND	1953	03726	010	0000068326	1977	
HALE	NOODLE CREEK	1955	02935	006	0000000439	1977	
SWEETWATER, SOUTH	SWASTIKA	1965	04056	002	0000453442	1977	
BECKHAM	TANNEHILL	1957	03600	012	0000944508	1977	
NENA LUCIA	WOLFCAMP SAND	1958	06036	009	0000073130	1977	

Pecos County, Texas

SHEFFIELD, SOUTHWEST	CISCO	1966	07428	013	0000013740	1977	
HOKIT, NORTHWEST	CISCO	1963	06963	002			0002753176
SHEFFIELD	CISCO	1962	06622	032			0001384338
SHEFFIELD, NORTHWEST	CISCO	1957	07035	020	0000172478	1975	
PHIL HAYES	CISCO	1960	05909	020	0000119804	1977	
SHEFFIELD	CISCO	1957	06662	013	0000029127	1977	

SHEFFIELD, SOUTHWEST	CISCO	1966	07398	017	0000644313	1977	
TIPPETT, WEST	HUECO	1969	04900		0000005482	1975	
COYANOSA	LAMAR	1959	04782	018	0000080456	1977	
LINTERNA	WOLFCAMP	1966	16447	024			0000239374
PUCKETT	WOLFCAMP	1958	14580	090			0000325711
GOMEZ, NORTH	WOLFCAMP	1970	15619	075			0000080966
PUCKETT, NORTH	WOLFCAMP	1971	06830	040			0000018887
PECOS GRANDE	WOLFCAMP	1971	16447	112			
HEINER, SOUTH	WOLFCAMP	1967	04967	072	0000000485	1977	
HOKIT, NORTH	WOLFCAMP	1961	06595	010	0000147133	1977	
MAC DER	WOLFCAMP	1944	04750		0000001800	1977	
MCKENZIE MESA	WOLFCAMP	1965	06490	022	0000002935	1977	
PRIEST & BEAVERS, WEST	WOLFCAMP	1965	06854	020	0000003683	1977	
ROJO CABALLOS	WOLFCAMP	1964	10942	006	0000002906	1977	
ROXIE	WOLFCAMP	1966	08950	335	0000033666	1977	
WINDY MESA	WOLFCAMP	1966	07051	023	0000000447	1977	
CHENOT	WOLFCAMP	1970	04770	034	0000005100	1977	
ATHEY	WOLFCAMP	1965	11300	050			0006026649
CHENOT	WOLFCAMP	1958	04968	128	0000015572	1975	
GREY RANCH	WOLFCAMP	1967	08931	005			0000095281
PECOS VALLEY	WOLFCAMP	1950	05165	230			
SURVEY 16	WOLFCAMP	1967	10349	279			0062693544
HOKIT, NORTH	WOLFCAMP	1961	06595	012	0000004345	1975	
PUTNAM	WOLFCAMP	1960	04666	025			0020082579
GOMEZ	WOLFCAMP	1969	15314	664			0001080450
HUBER	WOLFCAMP	1971	05091				0000397585
DOUBLE L	WOLFCAMP	1973	04904				
GREY RANCH, WEST	WOLFCAMP	1974	09063				0000579391
ATHEY	WOLFCAMP	1967	11263	275	0001154612	1977	
ATHEY	WOLFCAMP	1966	11614	074	0001146035	1977	
PECOS-SHEARER, WEST	WOLFCAMP	1968	05012	113	0000015250	1977	
PECOS VALLEY	WOLFCAMP	1959	05186	111	0000101793	1977	
ATHEY, EAST	WOLFCAMP	1967	11508	068	0000548767	1977	
COYANOSA	WOLFCAMP	1970	11614		0003116072	1977	
COYANOSA	WOLFCAMP DETRITAL	1962	09412				0105725800
ABELL	WOLFCAMP DETRITAL, E.	1964	04890	004	0000017824	1977	
HOKIT, NORTHWEST	WOLFCAMP REEF	1962	06548	006			0002753675
HOKIT, NORTHWEST	WOLFCAMP, LO.	1964	06610	038	0000003199	1977	
HERSHEY	WOLFCAMP, LOWER	1961	13208	078			
HOKIT, NORTHWEST	WOLFCAMP, LOWER	1964	06610	038	0000002893	1975	
MCPEC	WOLFCAMP, LOWER	1956	04630	045	0000003891	1977	
TIPPETT, SOUTH	WOLFCAMP, UPPER	1958	05804	042	0000315776	1977	

Reagan County, Texas

CENTRALIA DRAW	DEAN	1955	07841	019	0000010923	1977	
ROCKER B, SOUTH	DEAN	1962	06420	127	0000010976	1977	
ROCKER B, SOUTHWEST	DEAN	1962	07004	026	0000012705	1977	
SANTA RITA, SOUTH	DEAN	1965	07283	633	0000000753	1977	
CALVIN	DEAN	1970	07370	162	0000002807	1975	

BIG LAKE	DEAN	1956	06904	120	0000046698	1977	
CALVIN	DEAN	1965	07370	162	0020013733	1977	
BARBEE	WOLFCAMP	1966	07920	009	0000025675	1977	
BARNHART	WOLFCAMP	1959	07458	074	0000017877	1977	
SAUNDERS	WOLFCAMP	1958	08848	152	0000009700	1977	
SEVEN D	WOLFCAMP	1951	07570	025	0000103130	1977	

Reeves County, Texas

BALMORHEA	WOLFCAMP	1963	09120	018			0000187399
ROJO CABALLOS, WEST	WOLFCAMP	1968	15393	136			0000062576
CABLE	WOLFCAMP	1953	10882		0000004657	1977	
VERHALEN	WOLFCAMP	1947	09917	120	0000004184	1977	
WORSHAM-BAYER	WOLFCAMP	1964	11010	010	0000000583	1977	
BARILLA	WOLFCAMP	1969	10117	113			0000241540
HOBAN	WOLFCAMP	1968	10345	075	0000085167	1977	

Schleicher County, Texas

VELREX	CANYON	1964	06395	065	0000001258	1975	
VELREX	CISCO	1961	06364	012			
F & H	CISCO	1958	02612	006	0000973313	1977	
VELREX	HENDERSON UPPER	1968	06311		0000000171	1975	
H. A. T.	WOLFCAMP	1953	03400	004	0000007908	1977	
VELREX, SOUTHWEST	WOLFCAMP	1966	05602	029	0000000290	1977	
FLYING ANCHOR	WOLFCAMP	1959	06437				0003181993
VELREX, SOUTHWEST	WOLFCAMP	1966	05612		0000000233	1975	
WESTERN EMPIRE	WOLFCAMP	1973	07712				0000006570
ELDORADO	WOLFCAMP	1948	04072	020	0000237105	1977	

Scurry County, Texas

TONTO	CISCO	1968	05036		0000035716	1977	
TONTO	CISCO	1970	05049		0000016006	1977	
FULLER, SOUTHEAST	CISCO	1957	05032	004	0000865732	1977	
TONTO, NORTHEAST	CISCO	1966	05046		0001213705	1977	
RIDE	CISCO LIME	1955	06795	006	0000243184	1977	
GEORGE PARKS	CISCO SAND	1951	06130		0000150701	1977	
KELLY-SNYDER	CISCO SAND	1952	06180	082	0014554570	1977	
BROWN	CISCO SD.	1951	06180	041	0000091763	1977	
DIAMOND M	WOLFCAMP	1952	05310	025	0002577169	1977	
DIAMOND M	WOLFCAMP	1963	04660		0000173331	1977	
COGDELL	WOLFCAMP SAND	1954	05309	010	0000101857	1977	

Sterling County, Texas

DECK	CISCO	1972	07984	030	0000022471	1977	
CONGER	CISCO	1974	06973		0000235126	1977	
CREDO, EAST	WOLFCAMP	1966	07460	012	0000093700	1977	
MULBERRY	WOLFCAMP	1966	05118	010	0000002531	1977	
STERLING, NORTHEAST	WOLFCAMP	1966	04479	005	0000001507	1977	
TRIPLE M	WOLFCAMP	1964	05963	010	0000011619	1977	
TRIPLE M	WOLFCAMP	1963	06318	011	0000005112	1977	
W. A. M., SOUTH	WOLFCAMP	1966	05962	014	0000004740	1977	
W. A. M.	WOLFCAMP	1964	05068	004	0000001858	1977	
CREDO, SOUTHEAST	WOLFCAMP	1967	07206				
TRIPLE M	WOLFCAMP	1974	06531				0000002086
CREDO	WOLFCAMP	1962	07334	026	0003195340	1977	
ROSE CREEK	WOLFCAMP	1966	05086	020	0000249132	1977	
TRIPLE M	WOLFCAMP	1963	06694	018	0000192201	1977	
CREDO, SOUTHEAST	WOLFCAMP	1967	07244	008	0000251057	1977	
CREDO, EAST	WOLFCAMP	1969	07064	043	0000572689	1977	
TRIPLE M	WOLFCAMP, LO.	1963	06888	020	0000576789	1977	
TRIPLE M	WOLFCAMP, LOWER	1963	06888	007			
ALBAUGH-COLE	WOLFCAMP, LOWER	1969	06970	056	0000101555	1977	
CREDO	WOLFCAMP, LOWER -B-	1962	07430	014	0002369977	1977	
W. A. M., SOUTH	WOLFCAMP, NORTH	1969	05989	094	0000002814	1977	
CREDO	WOLFCAMP, UP.	1965	07278	042	0000090303	1977	
TRIPLE M	WOLFCAMP, UPPER	1963	06746	036	0002770616	1977	
CREDO, NORTH	WOLFO	1968	07330	034	0000015187	1977	

Stonewall County, Texas

FLAT TOP 166	CISCO LOWER	1963	03871	014	0000025245	1977
CRACKERJACK	CISCO SAND	1974	04634		0000045486	1977
TRI-STAR	GUNSIGHT	1973	03033		0000002813	1977
BROWNIE	HOPE LIME	1966	03958		0000049665	1977
FLAT TOP, SOUTH	NOODLE CREEK	1951	02685	013	0000898802	1977
FLAT TOP, SOUTH	SWASTIKA	1959	03438	005	0000025029	1977
FLAT TOP 113	SWASTIKA	1958	03112	001	0000015740	1977
FLAT TOP 123	SWASTIKA	1965	03162	008	0000005482	1977
FLAT TOP 124	SWASTIKA	1954	03291	001	0000008598	1977
FLAT TOP 140	SWASTIKA	1951	03378	041	0000108892	1977
FLAT TOP 162	SWASTIKA	1956	03486	008	0000107663	1977
MOUTRAY MOORE	SWASTIKA	1950	03659	003	0000052426	1977
ANTOINETTE	SWASTIKA	1969	03448		0000000813	1977
BIGGS	SWASTIKA	1959	03202	012	0000227583	1977
FLAT TOP 145	SWASTIKA	1962	03320	001	0000042279	1977
FLAT TOP 147	SWASTIKA	1959	03406	006	0000047619	1977

BERTHA	TANNEHILL	1955	03182	005	0000047703	1977	
CLARICE	TANNEHILL	1955	02646	003	0000106832	1977	
HAMRICK	TANNEHILL	1958	02653	006	0000058919	1977	
METCALF	TANNEHILL	1963	03424	002	0000215160	1977	
PEACOCK, NORTHWEST	TANNEHILL	1971	03446	008	0000049447	1977	
OLD GLORY, NORTHWEST	TANNEHILL	1966	02768		0001274746	1977	
GLORIA GAY, WEST	TANNEHILL	1958	03102	010	0000234602	1977	
GUEST	TANNEHILL	1968	03016		0000357377	1977	
MULLEN RANCH	TANNEHILL	1958	03229	005	0000359707	1977	
PEACOCK, NORTH	TANNEHILL	1960	03480	010	0000546516	1977	
S. L. C.	TANNEHILL	1958	02464	006	0000713587	1977	
V. G. O.	TANNEHILL	1966	02487	012	0000149822	1977	
WILLFOND CREEK	TANNEHILL	1971	02623	002	0000499994	1977	
BEN, SOUTH	TANNEHILL	1973	03705		0000432744	1977	
GLORIA GAY, WEST	TANNEHILL, LO.	1959	03136	005	0000063433	1977	
CAROL ANN	TANNEHILL, LOWER	1959	02654	005	0000357941	1977	
E. O. C	TANNEHILL, LOWER	1968	02487		0000188019	1977	
CLARICE	TANNEHILL, MID.	1966	02636	008	0000046169	1977	
S. L. C.	TANNEHILL, UPPER	1959	02366	010	0000043479	1977	
CAROL ANN	TANNEHILL, UPPER	1958	02648	008	0000235937	1977	

Sutton County, Texas

EIGHT MILE DRAW	CISCO	1974	05860				0000034432
MIERS, EAST	CISCO A	1968	04279				0003868313
WALLACE	WOLFCAMP	1973	04210				
STEEN	WOLFCAMP	1954	04185	020	0000026206	1977	
SAWYER	WOLFCAMP	1973	05460	010			
WALLACE, WEST	WOLFCAMP	1962	03700				
MIERS, EAST	WOLFCAMP	1973	03164				

Terrell County, Texas

BROWN-BASSETT	WOLFCAMP	1962	09200	036			0000000255
BROWN-BASSETT	WOLFCAMP	1961	06221	037			0002314717
HOGE RANCH	WOLFCAMP	1949	05250				
K M	WOLFCAMP	1974	09668	167			0002242765

Terry County, Texas

MOUND LAKE	CISCO	1948	09400	050	0000058553	1977	
STATEX	CISCO REEF	1952	10032	021	0002534118	1977	
COROCO	WOLFCAMP	1957	10032	020	0000016167	1977	
ADAIR, NORTHEAST	WOLFCAMP	1954	08846	018	0001275820	1977	
ADAIR	WOLFCAMP	1950	08505	060	0043105493	1977	
TOKIO, SOUTH	WOLFCAMP	1953	09860	030	0002442162	1977	
WELLMAN	WOLFCAMP	1950	09712	350	0039415596	1977	

Tom Green County, Texas

DEVILS COURTHOUSE	CISCO	1955	03830	014	0000218373	1977	
KENNEMER, EAST	CISCO	1965	05735	008	0000024961	1977	
SUSAN PEAK	CISCO CANYON	1948	04724	025			
SUSAN PEAK	CISCO CANYON	1950	04535	025	0001745033	1977	
CARGILE	WOLFCAMP	1957	05684	035	0000052386	1977	
JU-JAN-JAC	WOLFCAMP	1964	04549	011	0000021010	1977	
MUNN-GREEN	WOLFCAMP	1975	06883		0000000459	1977	

Upton County, Texas

AMACKER-TIPPETT	CISCO	1956	09060	053	0000117124	1977	
HAZEL	CISCO	1956	09998	074	0000000766	1977	
WILLRODE	CISCO	1955	08795	020	0000584231	1977	
BENEDUM	DEAN	1955	07893	014	0000009372	1977	
AMACKER-TIPPETT	WOLFCAMP	1954	09090	058			0000000043
NEAL RANCH	WOLFCAMP	1972	10218	040	0000001024	1975	
AMACKER-TIPPETT	WOLFCAMP	1959	10200	063	0000006029	1977	
AMACKER-TIPPETT, SOUTH	WOLFCAMP	1958	08507	008	0000135152	1977	
BLOCK 42	WOLFCAMP	1964	08433	002	0000002007	1977	
BLOXOM	WOLFCAMP	1965	09003	065	0000025711	1977	
BUG	WOLFCAMP	1957	09597	024	0000043621	1977	
CORBETT, SOUTH	WOLFCAMP	1954	06363	005	0000004754	1977	
CROCKETT, EAST	WOLFCAMP	1953	05638	013	0000001072	1977	
DAVIS	WOLFCAMP	1961	07630	043	0000004143	1977	
JACK HERBERT	WOLFCAMP	1962	09206	056	0000020182	1977	
KING MOUNTAIN, EAST	WOLFCAMP	1965	08628	046	0000001292	1977	
NEAL RANCH	WOLFCAMP	1948	10020	040	0000164203	1977	
RANCHEL	WOLFCAMP	1952	09765	095	0000012257	1977	
SHIRK	WOLFCAMP	1956	07170	024	0000001860	1977	
UPLAND	WOLFCAMP	1945	09100		0000000755	1977	
WILSHIRE	WOLFCAMP	1948	07680	100	0000038801	1977	
WINDHAM	WOLFCAMP	1952	09038	032	0000001494	1977	
HELUMA	WOLFCAMP	1973	07169			1977	
DAVIS	WOLFCAMP	1959	09885	051			0000804621
J. S. L.	WOLFCAMP	1973	08645				
ADAMC	WOLFCAMP	1961	08103	016	0000253094	1977	
AMACKER-TIPPETT, NORTH	WOLFCAMP	1967	08914	014	0000472846	1977	
AMACKER-TIPPETT	WOLFCAMP	1954	09090	058	0002013874	1977	
B. F. P.	WOLFCAMP	1964	08616	004	0000076480	1977	
BLOCK 4	WOLFCAMP	1952	09506	066	0000157113	1977	
PEGASUS	WOLFCAMP	1952	09948	244	0000097444	1977	

Ward County, Texas

BLOCK 17	LAMAR LIME	1963	05014	020	0000150969	1977	
LOCKRIDGE	WOLFCAMP	1967	12314	034			0000119724
MONAHANS	WOLFCAMP	1968	07109	033	0000045030	1977	
R. O. C.	WOLFCAMP	1973	10389		0000013857	1977	
BLOCK 16	WOLFCAMP	1969	11615	016			0002991708
WAR-WINK, SOUTH	WOLFCAMP	1974	12908				0000089161
WICKETT	WOLFCAMP	1962	08060	029	0000399269	1977	
BOSTWICK	WOLFCAMP	1967	10040	006	0000002520	1977	
LOCKRIDGE	WOLFCAMP	1974	12345		0000003886	1977	

Winkler County, Texas

MONAHANS, NORTH	CISCO	1966	08196	084	0000073109	1977	
KEYSTONE, SOUTHEAST	WOLFCAMP	1968	07643	065	0000017415	1977	
KEYSTONE	WOLFCAMP	1966	07068	005	0000010572	1977	
WINKLER, SOUTH	WOLFCAMP	1967	08768	020	0000001697	1977	
WAR-WINK	WOLFCAMP	1969	12808	601	0000002163	1977	
EMPEROR	WOLFCAMP	1960	07255	016			0003303930
FLYING W	WOLFCAMP	1955	08190	070	0000673611	1977	
WHEELER, NORTHWEST	WOLFCAMP	1960	07656	144	0000107673	1977	
EVETTS	WOLFCAMP	1974	12808		0000000543	1977	

Yoakum County, Texas

FITZGERALD	WOLFCAMP	1959	09262	016	0000111750	1977
LIMITED	WOLFCAMP	1964	09698	008	0000012183	1977
VENIS	WOLFCAMP	1954	10010	050	0000006947	1977
BRAHANEY	WOLFCAMP	1957	09028	087	0000305738	1977
BRONCO, EAST	WOLFCAMP	1964	09013	003	0000228218	1977
BRONCO	WOLFCAMP	1954	09436	183	0000317760	1977
NANNIE MAY	WOLFCAMP	1961	08772		0000554986	1977
REA	WOLFCAMP	1964	09001	017	0000167300	1977
WRD	WOLFCAMP	1968	08916		0000486832	1977
READ	WOLFCAMP	1967	08961		0000241482	1977

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