THE PETROLOGY AND STRATIGRAPHY OF THE EARP FORMATION, PIMA AND COCHISE COUNTIES, ARIZONA

by

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I hereby recommend that this dissertation prepared under my direction by Richard B. Lodewick entitled Petrology and Stratigraphy of the Earp Formation, Pima and Cochise Counties, Arizona be accepted as fulfilling the dissertation requirement of the degree of Doctor of Philosophy

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SIGNED: Richard B. Fodewich

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ABSTRACT

Stratigraphic and petrologic studies show that the Earp Formation of Pennsylvanian and Permian age in southeastern Arizona and southwestern New Mexico consists of fluvial clastic rocks that interfinger with supratidal, intertidal, and subtidal marine carbonate rocks. The clastics encroached initially from the northwest into the shallow Earp sea during Missouri time and continued migrating eastward during Virgil and Wolfcamp time.

Clastic-ratio and isopach maps, a convex-upward geometry shown by a thinning of the overlying Colina Limestone, and primary sedimentary structures show that the clastic-dominated portion of the Earp Formation was deposited as a delta.

In the carbonate lithologies, three environments of deposition are recognizable: supratidal, intertidal, and subtidal. The supratidal environment is characterized by pelmicrites filled with sparry calcite surrounded by a micrite envelope; dessicated, interlaminated carbonates of algal origin (biomicrites); the absence of fossils; evidence of dedolomitization; and "bird's-eye" structure (dismicrite). The intertidal environment is characterized by pelmicrites, biomicrites, micrites, and biosparites. The subtidal environment is illustrated by fusulinid biomicrites and biomicrites that have delicate tests preserved.

INTRODUCTION

Area and Purpose of Investigation

Parts of southeastern Arizona and southwestern New Mexico are included within the area of this investigation (Figure 1). The northern and western boundary is the Waterman Mountains, the southern boundary the Naco Hills, and the eastern boundary the Big Hatchet Mountains.

The purpose of this investigation was to study the petrology and stratigraphy of the Earp Formation in order to obtain better correlation and to interpret the environment of deposition of the formation.

Methods

Each section was measured with a Jacob's staff, and at least one sample was collected from each lithologic unit. If a unit was more than 10 feet thick, a sample was taken every 5 feet. Approximately 800 samples were collected.

Thin sections were made of each fusulinid zone and of most lithologic units. Thin sections were valuable not only for petrographic analysis, but also for recognition of sedimentary structures that are not discernible megascopically. All rock descriptions are based on the classification proposed by Folk (1959; 1968).

In order to supplement the thin-section petrography and to illustrate the textural relations in selected samples, Plexiglas peels were made. The method used was that employed by Frank (1965) in which a flat etched surface flooded with ethylene dichloride is placed

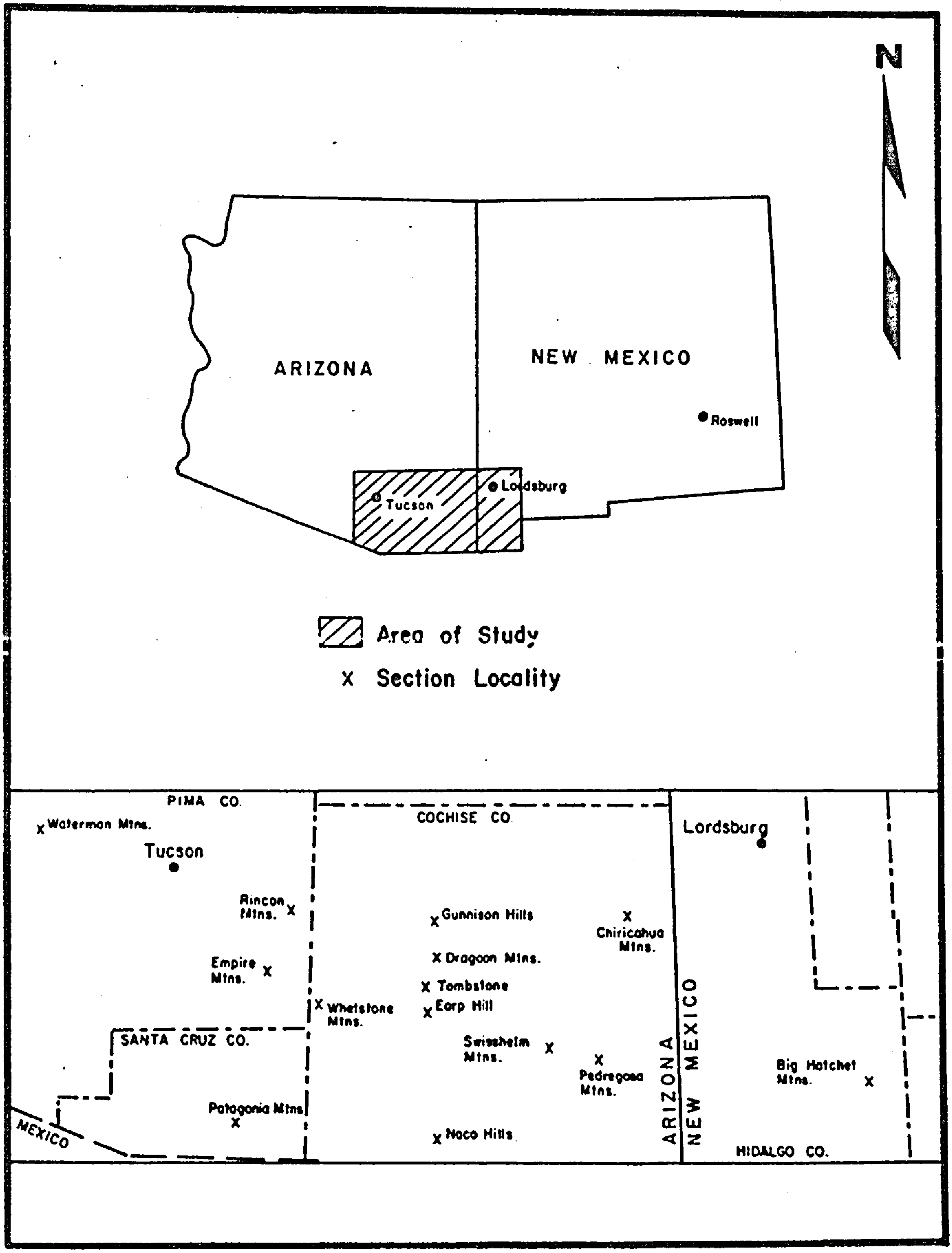

Figure 1. Index Map Showing Area of Study and Location of Stratigraphic Sections

in contact with a piece of 1/16 inch thick Plexiglas. The Plexiglas peel is removed from the sample after a 45 to 60 minute drying time.

The staining technique to distinguish between the different carbonates was that of Dickson (1965). The colors produced are pink to red for calcite, mauve to purple to royal blue for ferroan calcite, no color for dolomite, and pale to deep turquoise for ferroan dolomite.

Several samples from the Waterman Mountains were examined for conodonts. Samples weighing about 350 grams were dissolved in 10 percent acetic acid and required two to five days for sufficient digestion. The insoluble residues were floated in tetrabromoethane to allow the heavier conodonts to settle out.

Heavy minerals were recovered from representative clastic units in each section. A separation was also made from the Supai Formation in order to compare the two formations. Samples of 100 to 300 grams weight were ground with a mortar and pestle and the carbonate dissolved using 10 percent hydrochloric acid. If the sample was not entirely disaggregated, it was allowed to soak overnight in distilled water and Calgon. Separation from the lighter fraction was made in tetrabromoethane, and the heavy minerals were mounted on a petrographic slide. At least 300 non-opaque grains were counted for each slide.

In order to identify the minerals in units with particles too fine for optical identification, X-ray diffraction techniques were employed using a Norelco X-ray diffraction unit with a scanning goniometer.

Previous Studies and Summary of Nomenclature

The Earp Formation was originally defined by Gilluly, Cooper, and Williams (1954, p. 19) from its type locality on Earp Hill, southeast of Tombstone, Arizona. They also described a more complete section in the Gunnison Hills (1954, p. 21). The Earp Formation is one of six formations named when these workers elevated the Naco Formation of Ransome (1904) to group rank. Previously, the strata included in the Earp Formation had been measured and described by Gilluly (in Butler, Wilson, and Rasor, 1938, p. 16) as the orange dolomite member of the Naco Formation. Bryant (1955) described the Earp Formation in most of its outcrop areas and later he (Bryant, 1957; 1968) discussed its lithology and possible marker beds. Gilluly (1956) again described the Earp. Epis (1956) reported on the geology of the Pedregosa Mountains and included a measured section of the Earp. Layton (1957) described the Earp as probably being the lower clastic member of the Andrada Formation in the Rincon Mountains. McClymonds (1957; 1959) mapped and measured the Earp in the Waterman Mountains. Sabins (1957a; 1957b) reported on the stratigraphy of the Earp Formation in the Chiricahua Mountains. Tyrrell (1957) described the lithology of the Earp in the Whetstone Mountains and reported on the fusulinids there. Havenor and Pye (1958) reported on the paleogeography of the Earp, and Havenor (1959) discussed its lithology, age, and correlation. Gillerman (1958) described the Paleozoic strata in the Peloncillo Mountains, New Mexico. Galbraith (1959) included the Earp as part of the Andrada Formation in the Empire Mountains. Kottlowski (1960; 1962) discussed the age and correlation of the Earp in southeastern Arizona and southwestern New

Mexico. Graybeal (1962) described the Earp and other upper Paleozoic rocks in the southern part of the Whetstone Mountains. Sabins and Ross (1963) studied the fusulinids of the Earp Formation in the northern Chiricahua Mountains. Dubin (1964) reported on the fusulinids in the Earp Formation at the type locality. Hayes and Landis (1965) discussed the Earp in the Mule Mountains. Ross and Tyrrell (1965) described the fusulinids of the Earp in the Whetstone Mountains. Zeller (1965) described the stratigraphy and probable environment of deposition of the Earp Formation as part of his study of the stratigraphy of the Big Hatchet Mountains in southwestern New Mexico. Dirks (1966) mapped an area in the Guadalupe Mountains in extreme southeastern Arizona and measured sections of the Earp Formation. The environment of deposition of the red chert-pebble conglomerate in the Earp Formation in Arizona was investigated by Rea (1967), and later with Bryant (Rea and Bryant, 1968) he published a paper on this red chert-pebble conglomerate.

STRATIGRAPHY AND PETROLOGY OF THE EARP FORMATION

Regional Relations

The Earp Formation is one of the most lithologically diverse formations in southeastern Arizona. It consists of closely interbedded chemical and terrigenous rocks. The base of the formation is arbitrarily chosen ". . . where the thin shaly limestones and reddish shales become dominant over the more massive limestones characteristic of the Horquilla" (Gilluly and others, 1954, p. 18). The top of the Earp Formation is chosen where the thin-bedded clastic rocks of the Earp merge into the dominantly dark gray and black limestones of the Colina. The tendency of the Earp to weather to gentle slopes is in contrast to the cliffy topography usually developed on the Colina.

In the central portion of the study area, a clastic unit is present in the middle of the formation. This unit includes a distinctive chert-pebble conglomerate. In the Empire Mountains, the Earp is almost wholly clastic. In the Chiricahua, Pedregosa, and Guadalupe Mountains, there is no middle clastic unit, but an upper clastic unit about 300 feet thick is present. In the Big Hatchet Mountains, the rocks are again dominantly clastic. The thickness of the Earp Formation ranges from 448 feet in the Empire Mountains to 1,649 feet in the Chiricahua Mountains. Determination of true thicknesses locally is uncertain due to shearing along incompetent bedding planes.

Facies Relations

General Statement

The rocks in the Earp Formation represent an intricate interplay of marine and nonmarine depositional environments. Some of the "sub-environments" of the marine and nonmarine deposits can be recognized from deposit geometry, megascopic and microscopic sedimentary structures, and petrographic analysis.

Deltaic Facies

The primary structures, geometry, and the presence of a fluvial environment indicate that the more clastic portion of the Earp Formation is a delta.

As a delta consists of closely interlocking marine and non-marine beds, all must be considered parts of a single entity. Dunbar and Rogers (1957, p. 74) stated: "Although a very large part of the delta is made of entirely marine or entirely nonmarine beds, these are so intimately associated with each other and with littoral deposits that all must be considered parts of a genetic whole." Barrell's (1912, p. 381) definition of a delta is: "A delta may be defined as a deposit partly sub-aerial built by a river into or against a body of permanent water."

In establishing evidence as to whether or not beds are of deltaic origin, it is therefore helpful to be able to recognize a fluvial environment in which rivers would serve as a transport medium for deltaic sedimentation. A distinctive chert-pebble conglomerate in the Earp Formation has been shown by Rea (1967) to have been deposited at least partly in stream channels. Cross-bedding, imbrication, graded bedding, and the presence of a channel cross section all serve as evidence of a river system in which the chert-pebble conglomerate was deposited. Some of the evidence Pepper, De Witt, and Demarest (1954, p. 50) gave in distinguishing the Red Bedford Delta in Ohio from a river valley or coastal plain was upward convexity as seen in cross section perpendicular to sediment transport and terrigenous beds almost surrounded by marine strata.

A configuration of the isopachs and clastic-ratio lines of the Earp Formation (Figures 2-6) shows a tonguelike extension running southeast from the northwest corner of the study area. The clastic-ratio maps show carbonate sediments surrounding on three sides a peninsular extension of sediments with a high clastic content. This is interpreted as marine sediments surrounding a deltaic lobe. Pepper and others (1954, p. 51) showed the upward convexity of the Red Bedford Delta by demonstrating a thinning of the marine Berea sand over the delta. Butler (1969, Figure 36) showed the overlying marine Colina Limestone thinning over the area of the proposed Earp delta. Furthermore, the clastic ratio of the overlying Colina Limestone increases over the Earp clastic tongue (Butler, 1969, Figure 39). This could be explained by an incorporation of Earp clastics in the Colina as the Colina sea lapped up on the side of an Earp delta.

As shown by the isopach maps (Figures 2, 3, and 4), the thickness of sediments around the lobe is much greater near its edge, forming a wedge. Fisk (1955, p. 395) stated: "Regional subsidence accompanying deltaic deposition enables the platform to develop as a wedge, much thicker near the edge of the continental shelf than would be expected

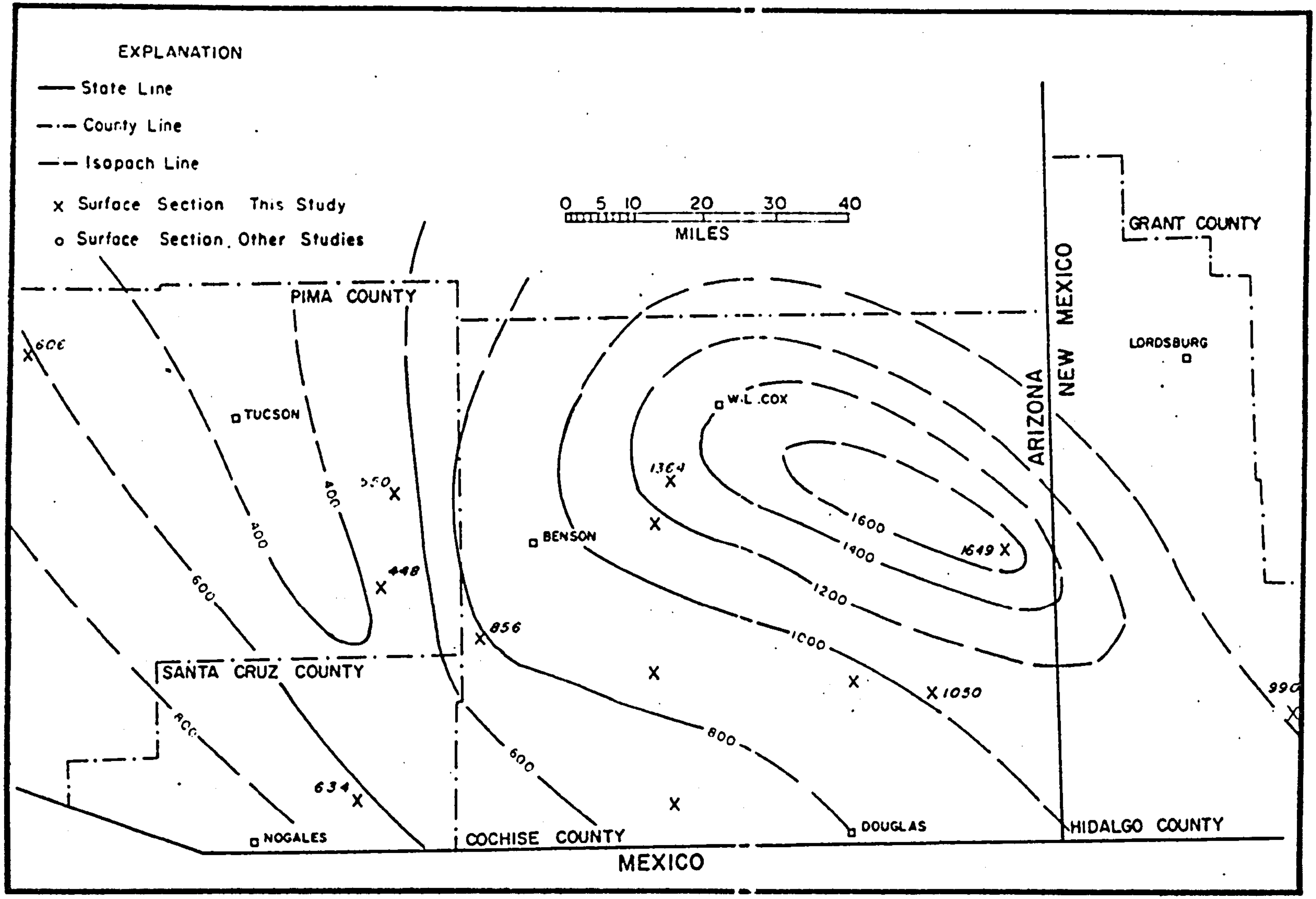

Figure 2. Total Earp Iscpach Map

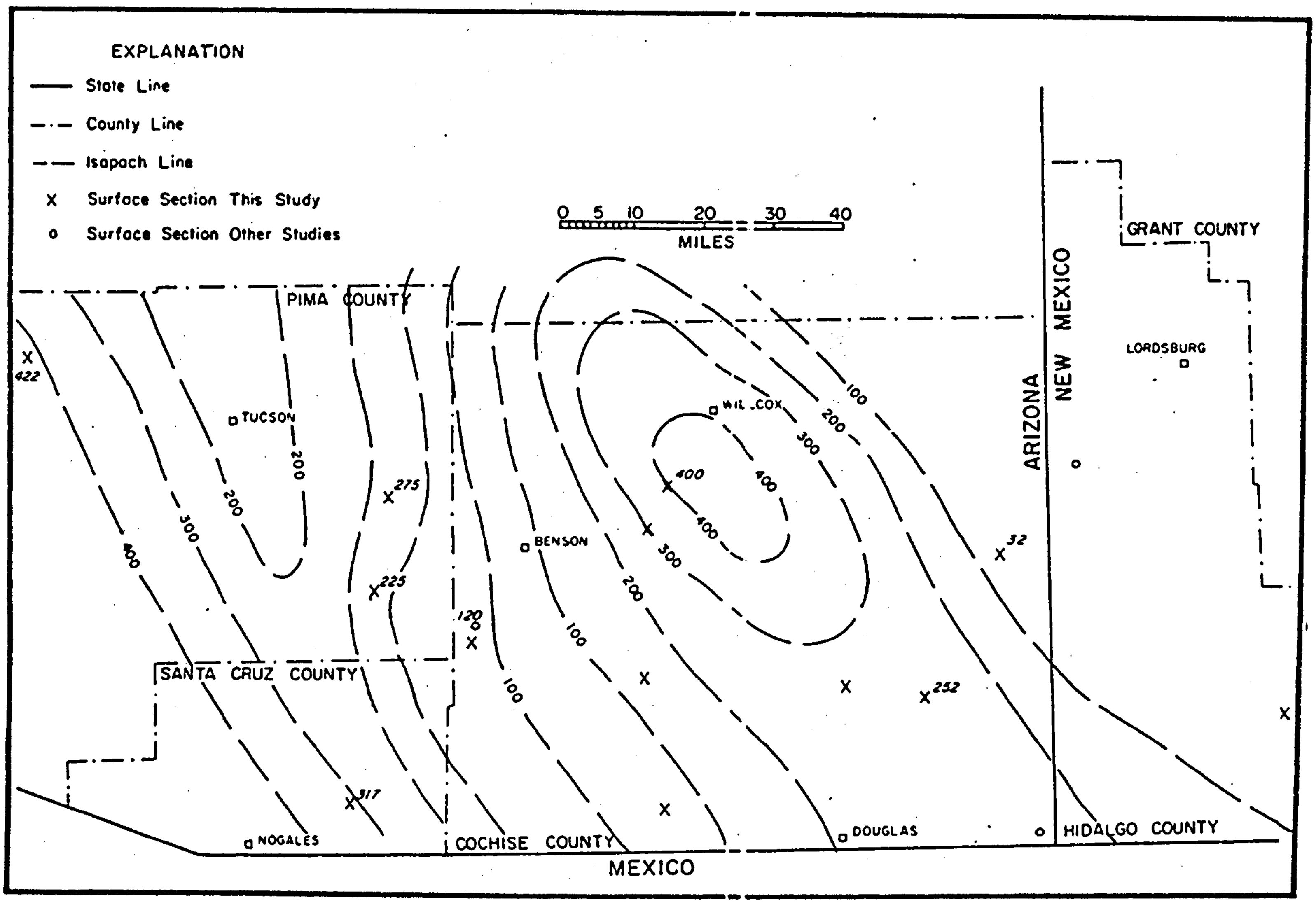

Figure 3. Virgil Stage Isopach Map

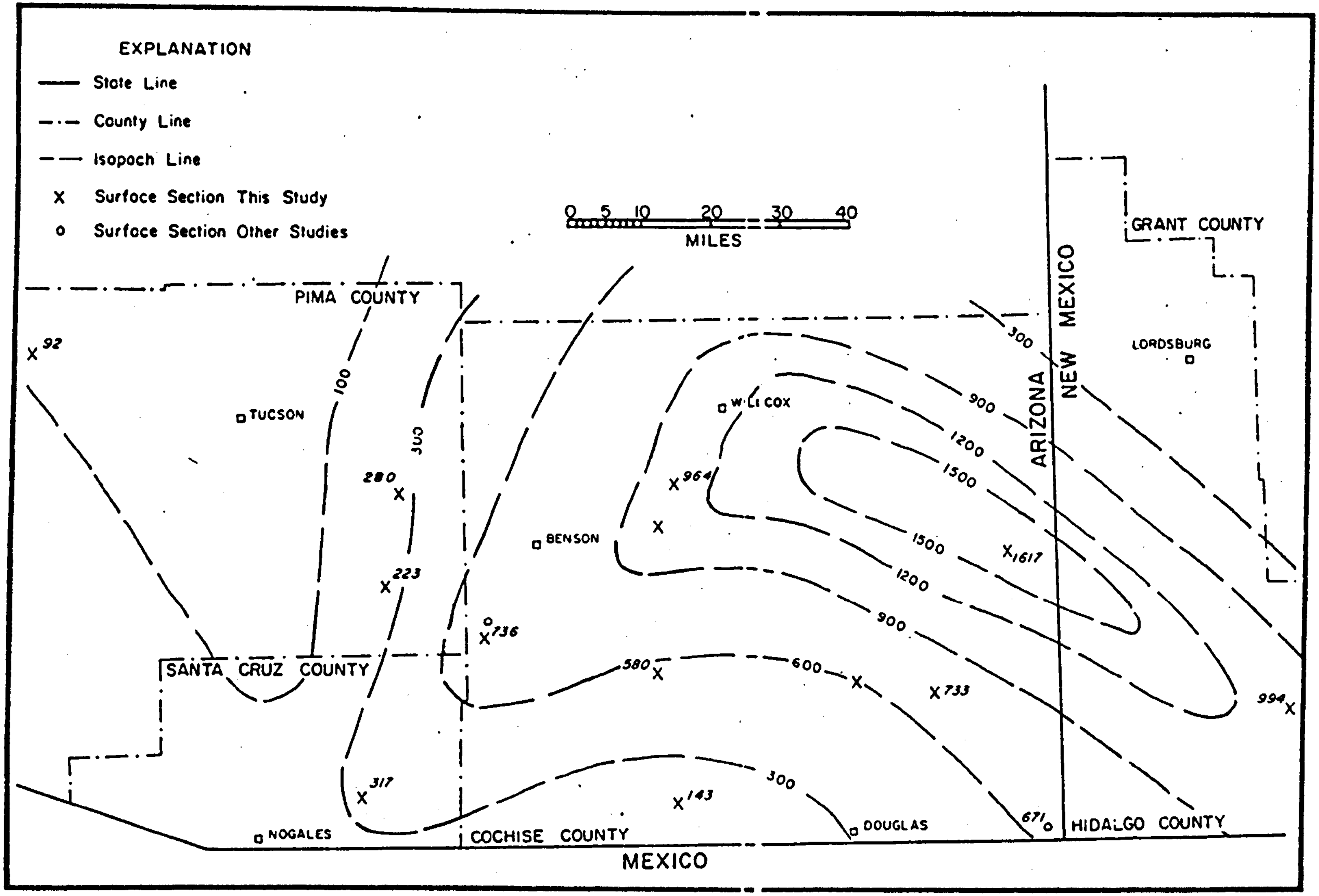

Figure 4. Wolfcamp Stage Iscpach Map

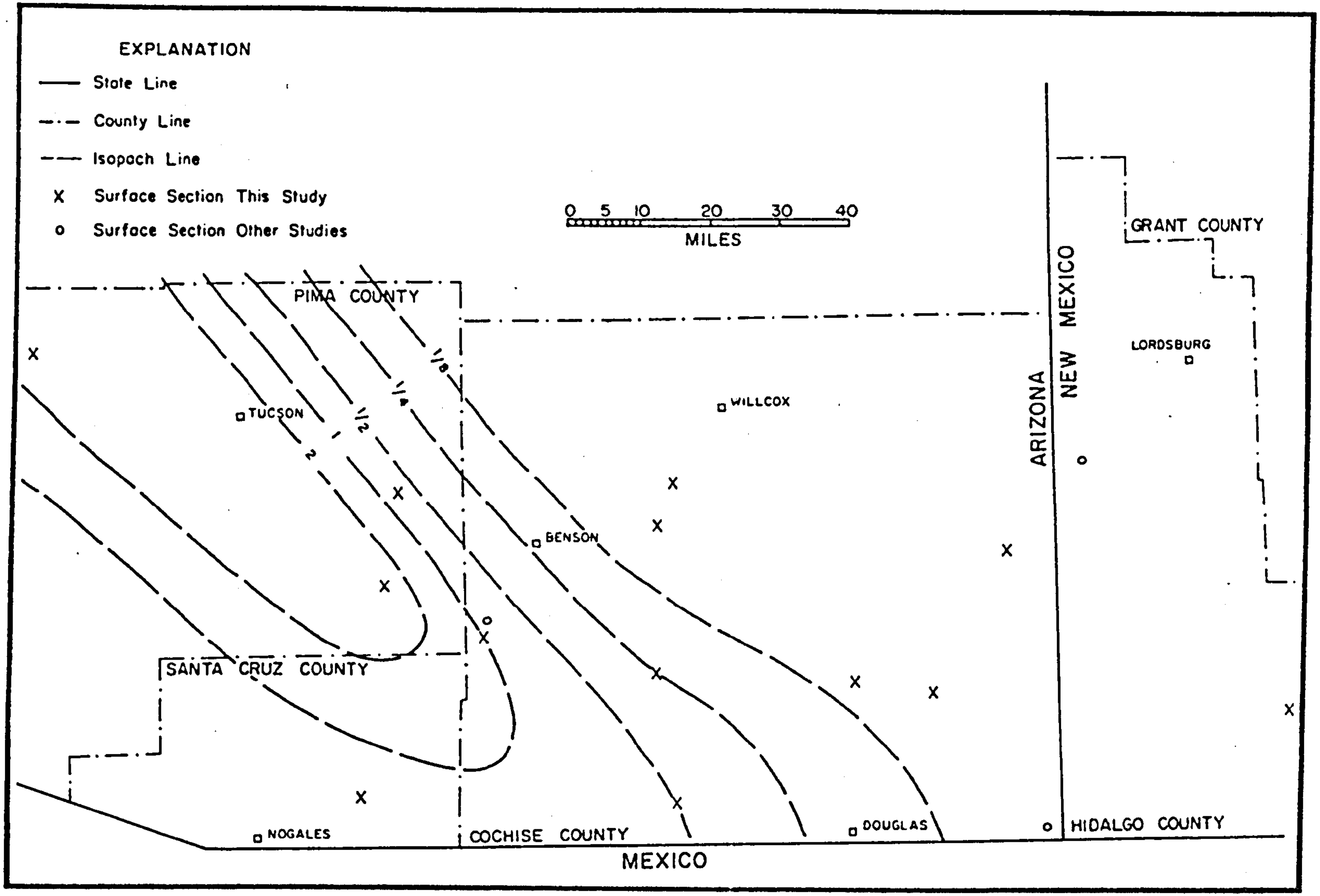

Figure 5. Virgil Stage Clastic-ratio Map

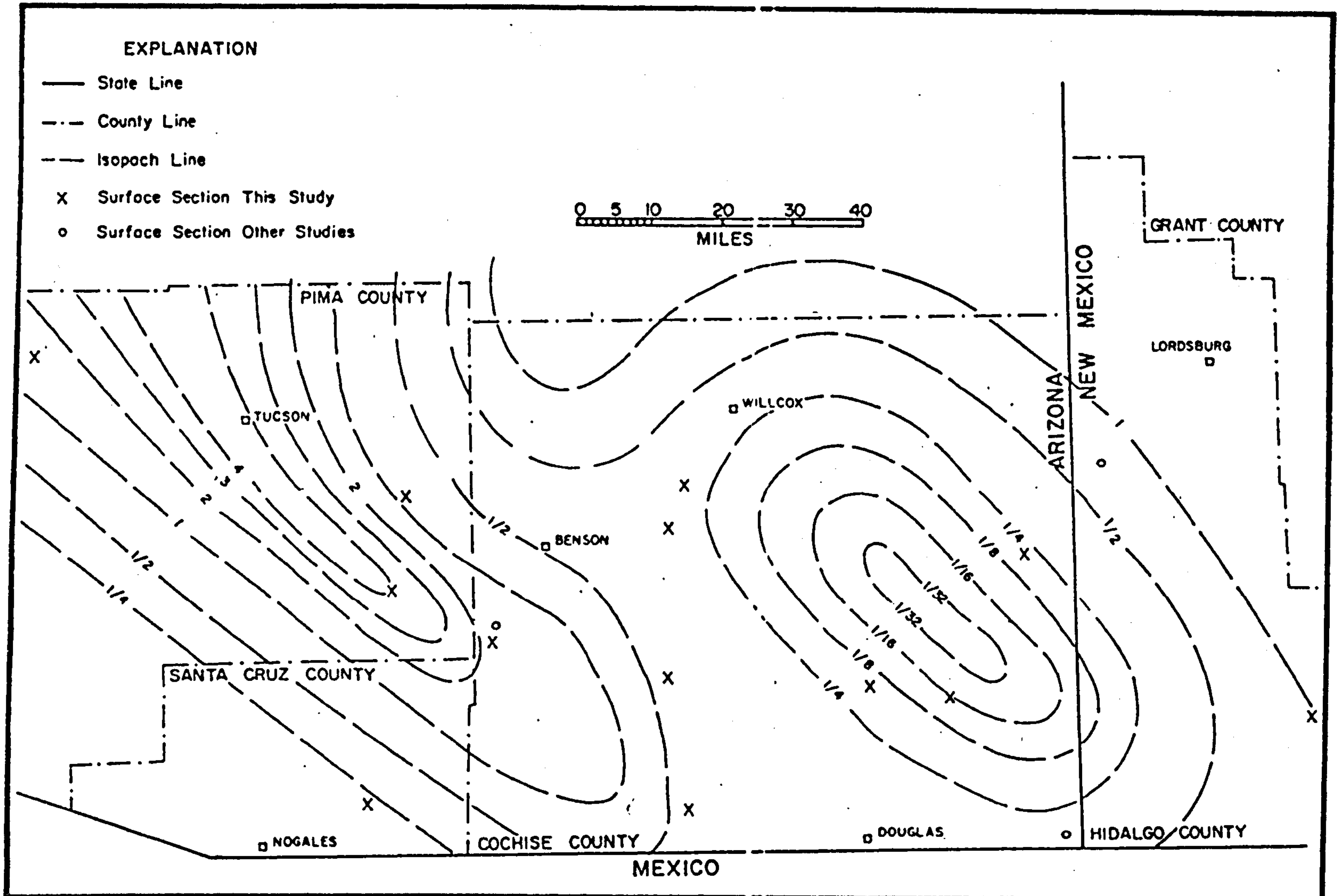

Figure 6. Wolfcamp Stage Clastic-ratio Map

from the depth of water into which it is prograding." It therefore seems that the clastic tongue has characteristics that fit more closely a deltaic environment than any other.

Other deltaic subenvironments can be recognized in the sedimentary structures displayed in the Earp Formation other than the fluvial environment discussed above. Figure 7 shows the distribution and surface relationships of "typical" deltaic environments as interpreted by Coleman and Gagliano (1965, Figures 8 and 9) and by Greensmith (1966, Figure 2). Figure 8 shows the occurrence of sedimentary structures found in the Earp and their frequency as found by Coleman and Gagliano (1965) in the Mississippi River deltaic plain. No statistical study as to the frequency of occurrence of the structures at each section location was made. However, most of the laminated types were invariably found in the clastic sediments present in each section studied.

Parallel laminations (Figure 9) occur commonly in the Earp Formation and are not diagnostic of specific subenvironments except that they occur most commonly in the on-delta or deltaic plain environment.

Types of cross-lamination have been defined by McKee and Weir (1953). All of these types are found in the Earp Formation. Cross-laminated types (Figure 10) seem to be associated more closely with the delta-front environment than with the other deltaic environments. The distributory mouth bar and distributory channel environments have more simple and trough-type cross-laminations than do other deltaic environments (Coleman and Gagliano, 1965).

Wave-ripple laminations were distinguished from other types by the ripple index and the ripple-symmetry index. Ripple marks were

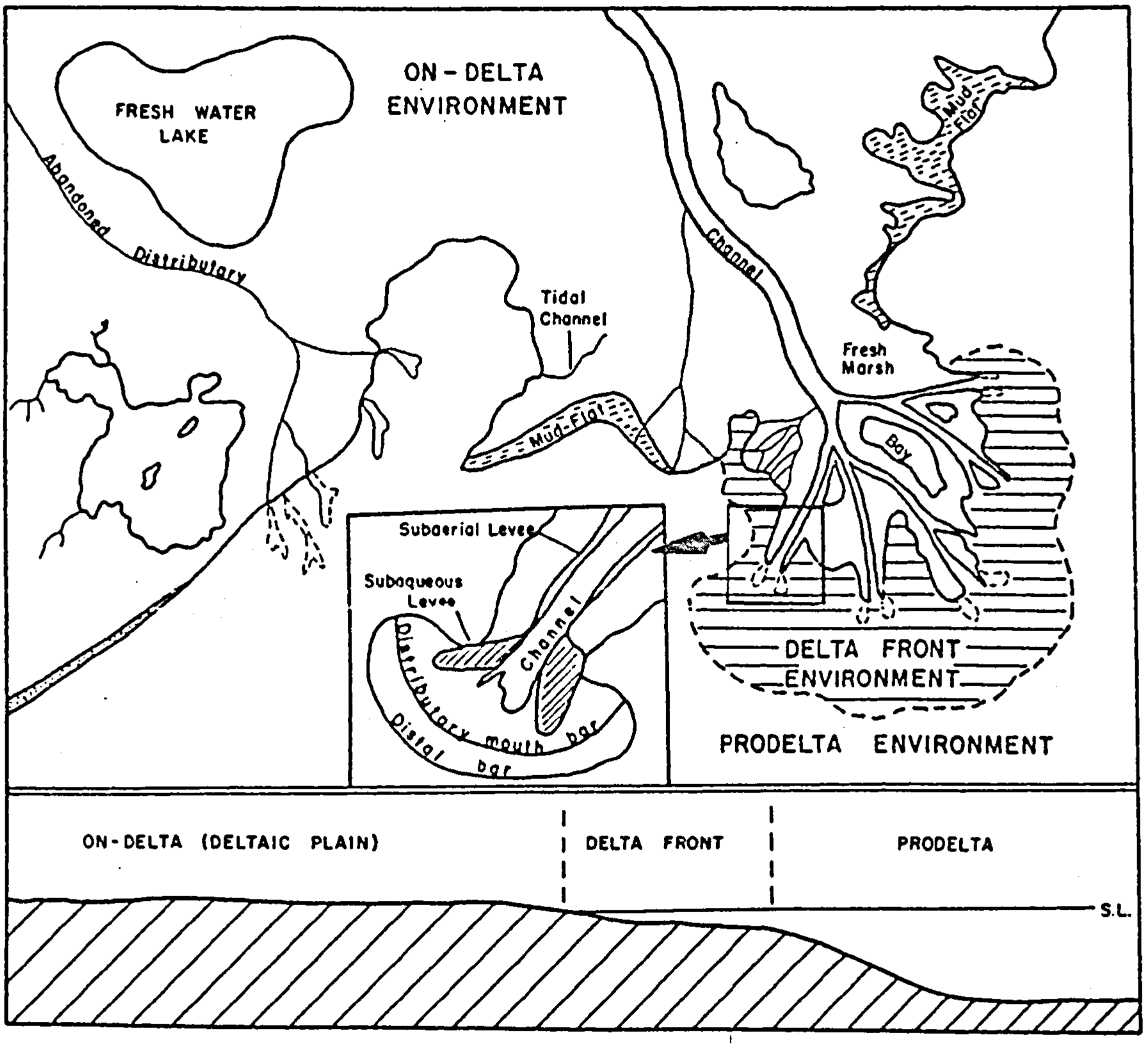

Figure 7. Typical Distribution and Surface Relationships of Deltaic and Related Environments.--Modified from Coleman and Gagliano (1965) and Greensmith (1966).

DEPOSITIONAL ENVIRONMENT / SEDIMENTARY STRUCTURES	PRODELTA	DELTA FRONT				ON DELTA					
		DISTAL BAR	DISTRIBUTARY MOUTH BAR	DISTRIBUTARY CHANNEL	SUBAQUEOUS LEVEE	SUBAERIAL LEVEE	INTERDISTRIBUTARY BAY	MUDFLAT	LACUSTRINE	MARSH	SWAMP
Parallel Laminations	C	A	C	A	C	A	C	R-C	R-C	C-A	R-C
Cross-Laminations											
Simple			A	C	C						
Planar				C		R-C					
Trough	R	C	A	A	C		R				
Ripple Laminations											
Wave		C-A	R-C		R-C		C	R-C	R-C		
Ripple-drift					A-C	R					
Erosional Truncations		C	R-C	C-A	A	C		R-C			
Distorted Laminations											
Gas Heave			C		R-C						
Recumbent Folds		C	R-C	C	C-R	C					
Convolute Laminae				R	C-A	R					
Burrows	C-A	C-A		R			C-A	C-R	C		

Figure 8. Recognized Sedimentary Structures in the Earp Formation and Their Occurrence as Compared with the Mississippi River Delta

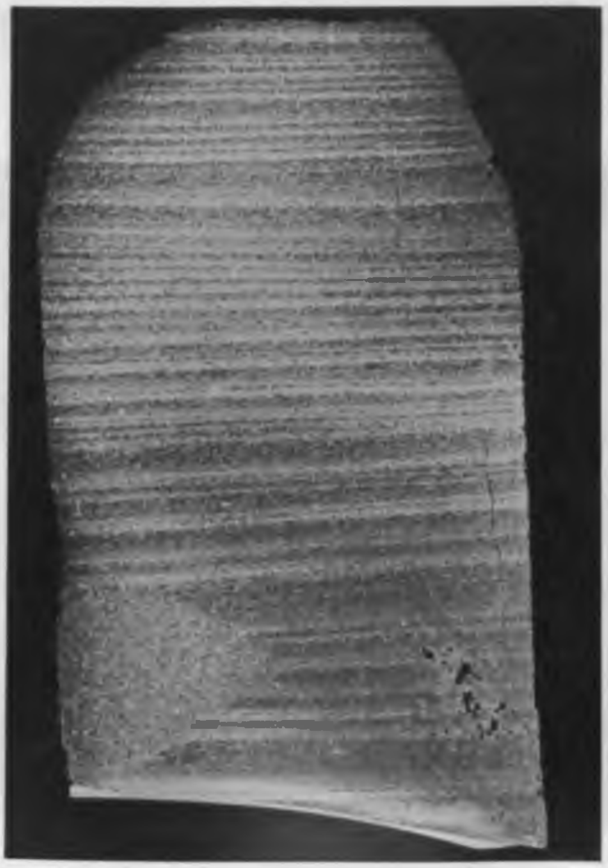

Figure 9. Parallel Laminations. 3.8X

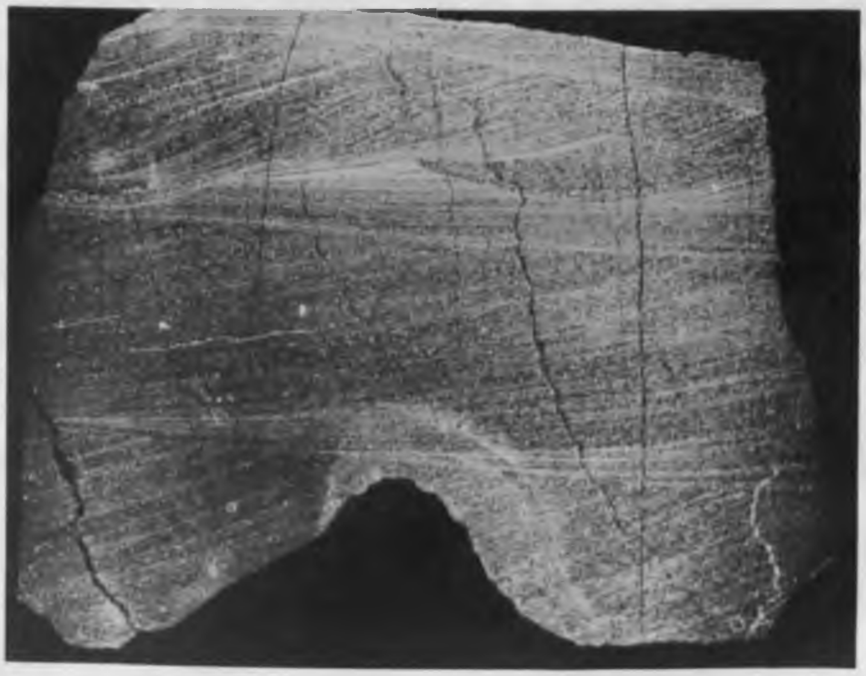

Figure 10. Cross-laminations. 41X

observed in the Big Hatchet Mountains, the Gunnison Hills, the Dragoon Mountains, and the Whetstone Mountains. Ripple indices and ripple-symmetry indices were calculated at each occurrence. The ripple indices varied from 10 to 5.8, and ripple-symmetry indices varied from 1.2 to 1.7. Tanner (1967, p. 97) showed that the ripple and ripple-symmetry indices that fall within the range of indices found in the Earp Formation indicated a wave-formed ripple. Figure 11 shows a typical wave-formed ripple mark of the Earp Formation. Ripple-drift cross-laminations are common in the Earp Formation. Especially common are "Type A" (Jopling and Walker, 1968) ripple-drift cross-lamination. The stoss-side laminations are eroded in this type (Figure 12). Ripple laminations occur most abundantly in the delta-front environment.

Erosional truncation is common in the delta-front environment and also in the subaerial levee portion of the on-delta environment. Figure 13 shows an erosion surface on which silt has been deposited. These small truncations are not recognizable on the weathered surfaces of the rocks in the Earp Formation. The small disconformities were observed only when thin sections had by chance been cut across them. It seems probable, therefore, that there are many more small, local erosional features in the Earp Formation than can be recognized megascopically.

Distorted laminations discussed by Coleman and Gagliano (1965) include gas heave, recumbent folds, and convolute laminae. These workers described the gas-heave type (p. 136) as "An accumulation of organics and fine clay in the bulbous central part of the structure." Figure 14 shows what is probably a structure of this sort without as much

Figure 11. Wave-formed Ripple Marks

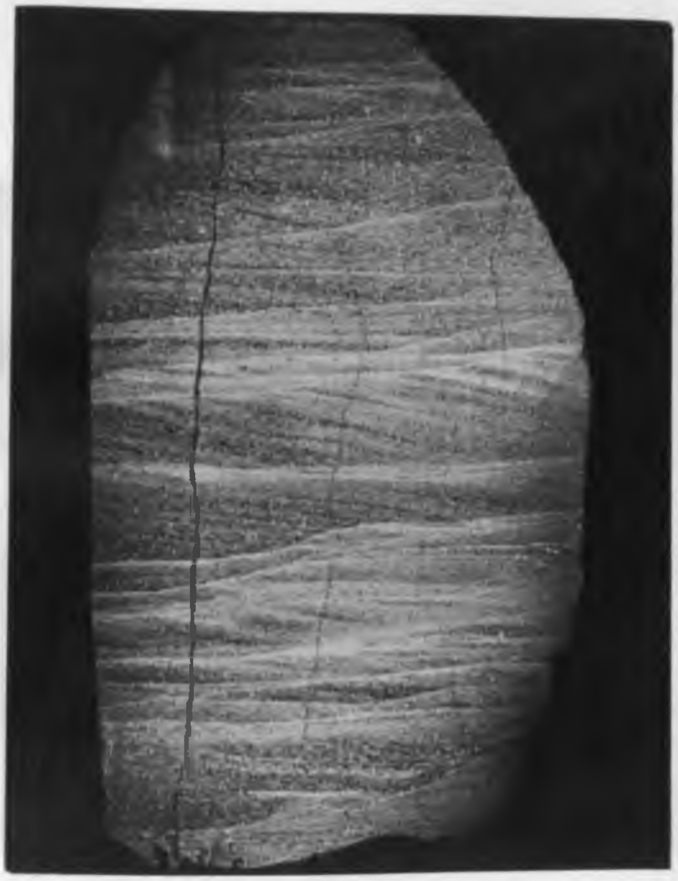

Figure 12. Ripple-drift Cross-laminations. 4.2X

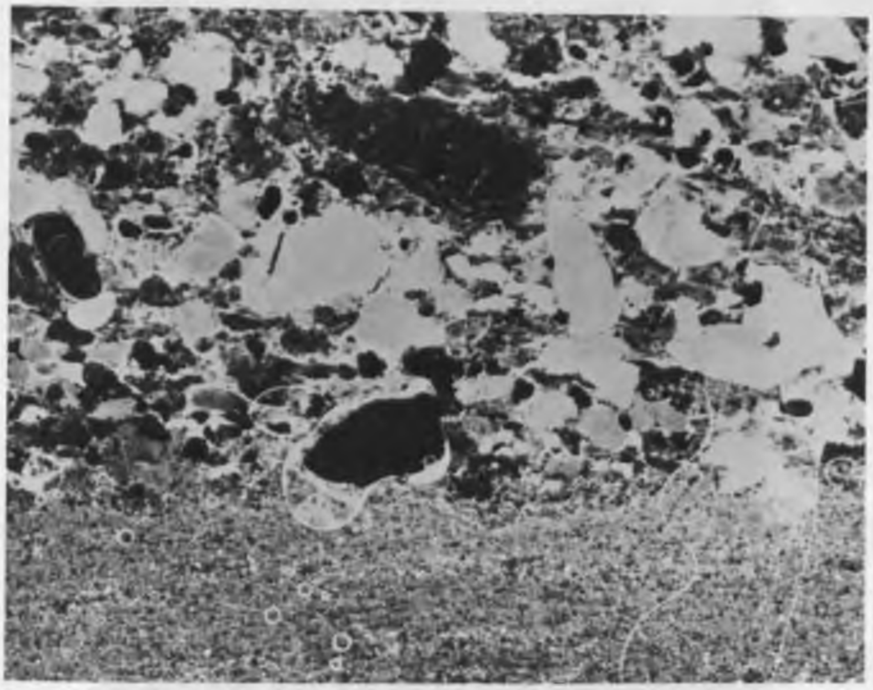

Figure 13. Erosional Truncation--Siltstone over Limestone. 15X

Figure 14. Gas-heave (?) Structure. 4.8X

organic material as Coleman and Gagliano (1965, Figure 2A) illustrate. The recumbent fold type of distorted laminations are small-scale folds whose axial planes attain a near-horizontal position. Figure 15 shows distorted laminations of this type. What is probably the convolute type of distorted laminations is represented in Figure 15. The distorted laminations are most common in the delta-front environment. The subaerial levee environment of the on-delta portion of the delta has abundant recumbent folding (Coleman and Gagliano, 1965).

Burrows are common to abundant in the prodelta, the distal bar portion of the delta-front, and the interdistributory bay portion of the on-delta environment. Figure 16 shows an example of a burrow in the Earp Formation.

A carbonate unit in the Big Hatchet Mountains may represent deposition in a fresh-water marsh or lake. Thin-section analysis (Figure 17) shows the unit to be an ostracod-bearing limestone. Shepard (1960, p. 80) stated "A dominance of Ostracoda over Foraminifera, along with a scarcity of Echinodermata, is suggestive of the fresh-water marshes and lakes on the subaerial portion of the delta."

The identification of clay-size material in a fine-grained rock may give an indication as to its environment of deposition. Representative samples of fine-grained sediments from all measured sections of the Earp Formation were X-rayed in order to identify the clay-size portion of the sample. All samples examined contained the clay mineral kaolinite. Other minerals identified were calcite, dolomite, and quartz. A quantitative analysis was not made, but quartz was always present. Shaw and Weaver (1965) noted that in shale there is an increase in quartz content

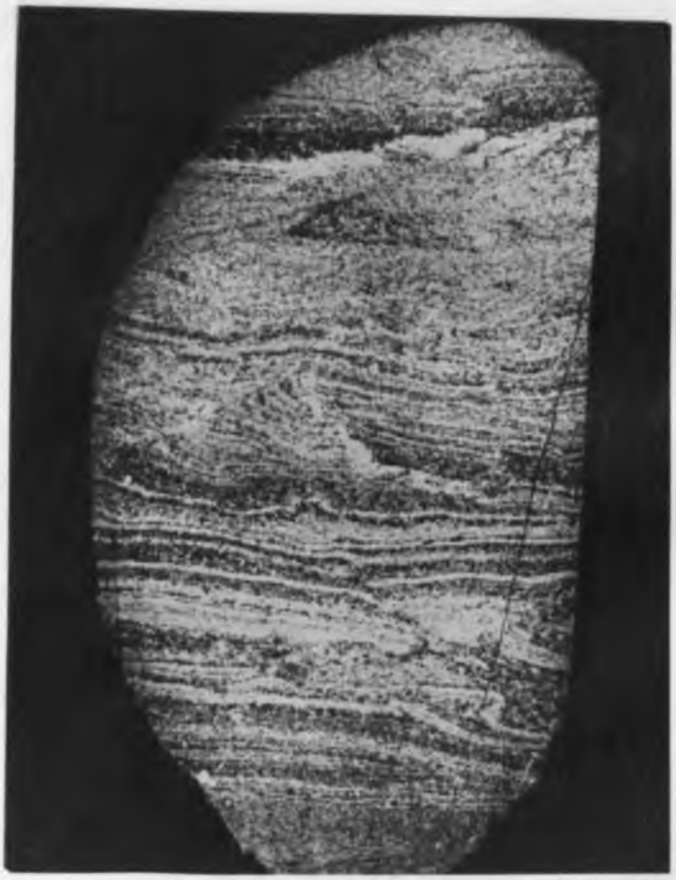

Figure 15. Recumbent Fold Structure. 4.4X

Figure 16. Worm (?) Burrow Breaking Cross-laminations. 4.1X

Figure 17. Ostracod Limestone. 75X

toward shore. As some of the sediments examined for clay minerals were silty, the quartz peaks could be attributed to the silt fraction of the sample.

Whether or not clay minerals are altered during transport or after deposition, it has been found that, in general, there is an increase in the amount of kaolinite landward (Grim, Dietz, and Bradley, 1949; Grim and Johns, 1954; Weaver, 1958, 1959; Milne and Earley, 1958). The presence of kaolinite, therefore, helps to substantiate the near-shore (deltaic) origin of the clastic sediments of the Earp Formation.

The widespread occurrence of kaolinite in the Earp Formation may indicate a common source. Although the possibility of diagenetic changes in clay minerals exists, Neiheisel and Weaver (1967) have shown that differing source areas can be delineated on the basis of different clay mineral occurrences.

Supratidal Facies

The supratidal carbonate facies is that facies which was deposited above high tide but which could have been flooded by abnormally high tides such as storm and spring tides. Therefore, this carbonate environment is subaerially exposed for long periods between inundations.

An examination of the constituents of the carbonate rocks in the Earp Formation indicates that supratidal conditions were widespread during Earp time. Some of the pelmicrites have pellets with an interior of sparry calcite and an outer micritic "envelope" (Figure 18). Friedman (1964) showed that under subaerial conditions the center of the grains may be dissolved by leaching and then filled with sparry calcite while

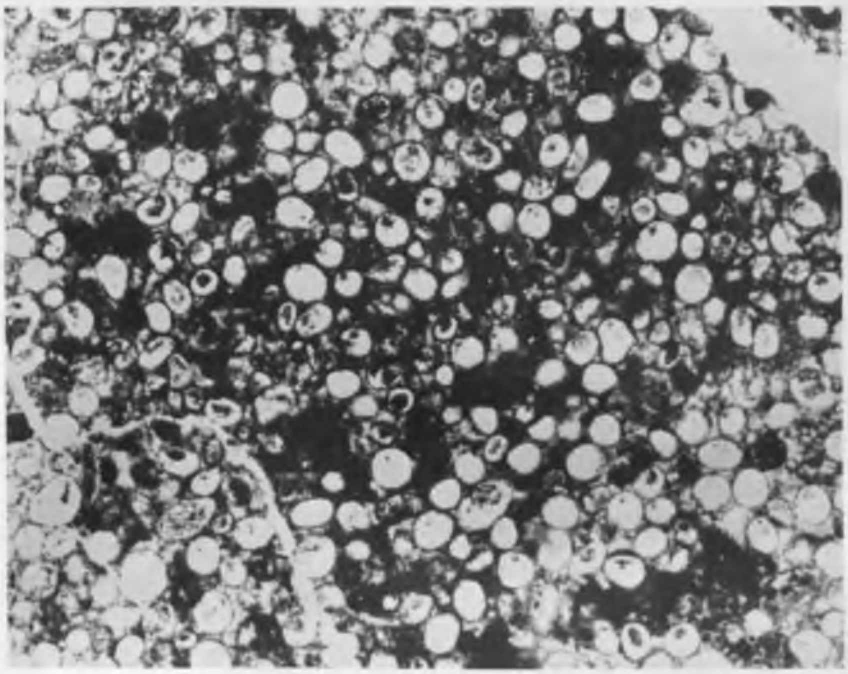

Figure 18. Spar-filled Pellets with Micrite Envelopes. 18.6X

the micrite envelope is preserved. Similar changes have been reported by Payton (1966) and Gutstadt (1968).

Interlaminations of dolomite, calcite, and bituminous films may indicate an algal origin for the limestone of the Earp Formation (Figure 19). Speaking of the bituminous film, Laporte (1967, p. 78) stated that "This organic film may represent the remains of an algal mat which covered the original sediments from time to time." Shinn, Ginsberg, and Lloyd (1965) described similar laminated deposits in the Bahamas and south Florida. They pictured a supratidal environment as being flooded by storms or monsoons, following which there are long periods of subaerial exposure. Evaporation during the interseasonal dry periods concentrates magnesium-rich sea waters that convert the carbonate layers between the algal films into dolomite. The finely laminated carbonates of the Earp Formation are very similar to the supratidal deposits of the Persian Gulf (Illing, Wells, and Taylor, 1965) and of the Bahamas (Shinn and others, 1965). Laporte (1967, p. 87) in discussing the laminated carbonates of the Manlius Formation commented:

> In accordance with Logan et al (1964), these organo-sedimentary structures are interpreted as having been formed by gelatinous films of filamentous blue-green and green algae living close to mean sea-level. The horizontal, slightly bituminous laminae of the supratidal facies represent broad, uninterrupted mats established in quiet water, just inches deep, following intermittent inundation of the supratidal flats.

Some of the horizontal laminated carbonates in the Earp Formation could have been deposited in an intertidal environment. Textoris and Carozzi (1966, p. 1383) suggest that if laminations are not crinkled, they have not been exposed to air over long periods of time as might be the case in the supratidal environment.

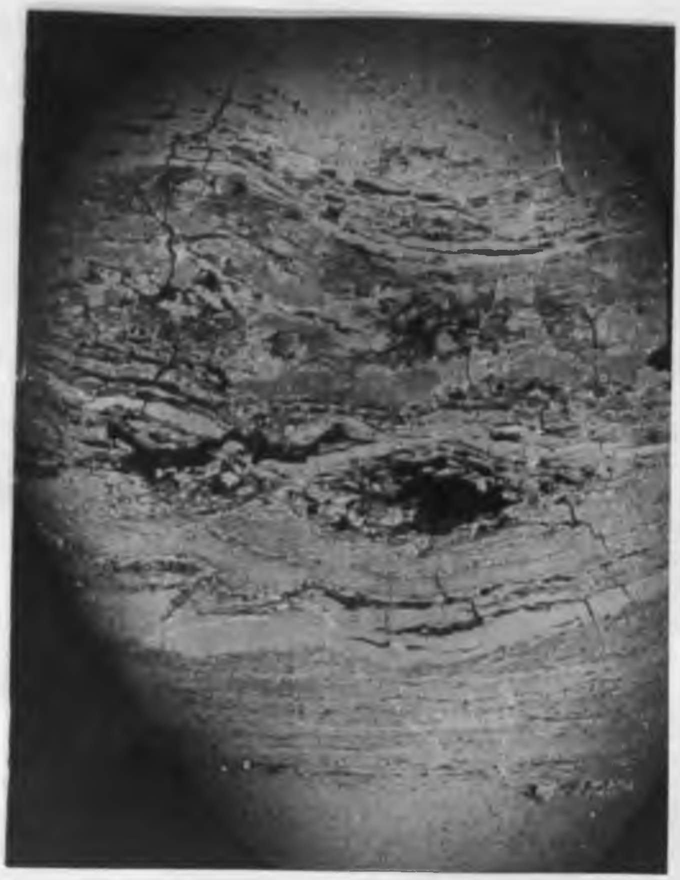

Figure 19. Laminated Algal Limestone. 40X

Dolomitization of the laminated carbonates could have occurred either by evaporation of groundwater that moved upward to the surface by capillarity (Shinn and others, 1965) or from magnesium-rich flood waters percolating downward (Deffeyes, Lucia, and Weyl, 1964).

Some of the micrites of the Earp Formation show evidence of dedolomitization as shown by the presence of calcite in crystal molds of dolomite. Lucia (1961) illustrated dedolomitization in the Permian Tansill Formation of west Texas. He described the process of leaching leading to dedolomitization as taking place on supratidal flats. The paragenesis includes dolomitization, precipitation and dissolution of evaporite minerals, and dedolomitization. First, lime mud was laid down and dolomitized. Later, with continuing evaporation, anhydrite crystals were formed. Then, the anhydrite and dolomite were leached and replaced by calcite. Schmidt (1965, p. 149) discussed the increase in calcite after dolomite as an unconformity is approached in the Jurassic Gigas Beds of northwestern Germany. He also noted that the replacement of dolomite by calcite followed the replacement of anhydrite by dolomite. Summerson (1966) discussed dolomite containing crystal molds of gypsum and related the occurrence to a penesaline, possibly supratidal environment. The dolomite in the crystal molds of gypsum could then have been dedolomitized as discussed.

Evidence that von Morlot proposed in 1848 for

$$CaCO_3 \cdot MgCO_3 + Ca^{++} \underset{\text{dolomitization}}{\overset{\text{dedolomitization}}{\rightleftharpoons}} 2CaCO_3 + Mg^{++}$$

was substantiated by field evidence from the Russian Platform (Tatarskiy, 1949). During the rainy season, waters rich in calcium sulfate flooded dolomitized rocks. After the dry season, it was found that dedolomitization had taken place near the surface, but dolomite at depth remained unaltered. The released magnesium ions had combined with sulfate ions to form a magnesium sulfate crust on the surface. In all acounts of dedolomitization, the presence of sulfate has been mentioned. There seem to have been two possible sources for the sulfate in the Earp Formation. Pyrite is abundant in some beds. Evamy (1967) describes the oxidation of pyrite releasing sulfate ions which then combine with calcium and ferrous ions to produce calcium sulfate and ferrous sulfate. Friedman and Sanders (1967, p. 301) proposed the presence of pyrite as a possible source for the sulfate in dedolomitization of carbonate rocks of the Fort Johnson member of the Tribes Hill Formation (Lower Ordovician), near Canajoharie, New York. Also, a connection exists between anhydrite and dedolomitization (Tatarskiy, 1949) which is shown as:

$$Ca \cdot Mg(CO_3)_2 + CaSO_4 — 2CaCO_3 + MgSO_4 .$$

The same reaction is shown by Chilingar (1956, p. 162).

Evamy (1967) shows dedolomitization, in some cases, as a result of not only direct replacement of dolomite rhombohedra but of leaching of calcite pseudomorph after dolomite followed by infilling by calcite (Figure 20). Calcite pseudomorphs after gypsum and dolomite are seen in the Earp Formation (Figure 21). From the above discussion, it seems probable that besides the spar-filled pellets and the laminated dolomites, the rocks showing dedolomitization represent another supratidal lithology. Most of the remaining dolomite without any evidence of an algal affinity or the dedolomitization process could have been formed in intertidal, supratidal or subtidal environments (Friedman, 1964, p. 777).

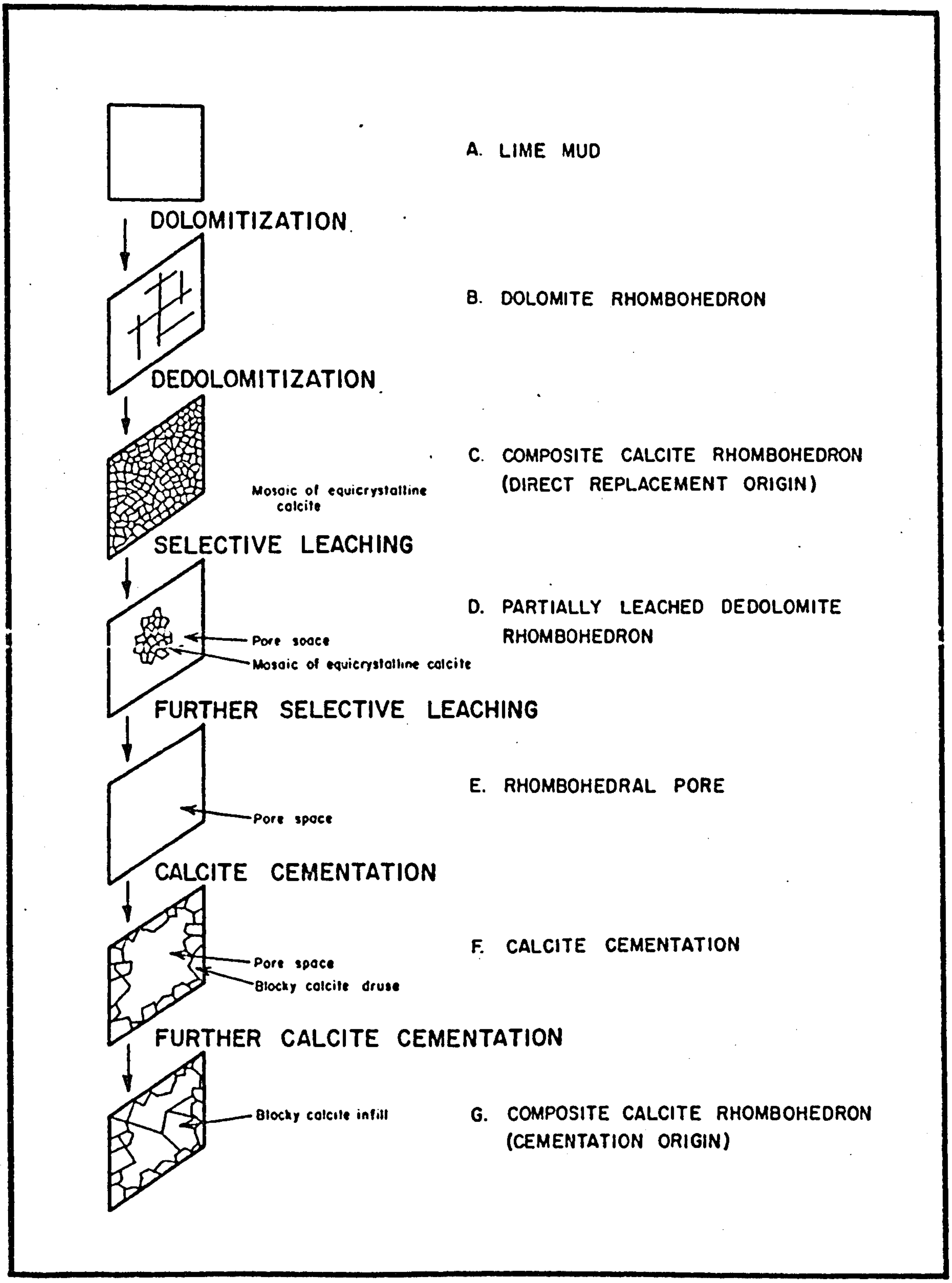

Figure 20. Diagenetic History of Certain Dedolomitized Limestones (schematic).--After Evamy, 1967.

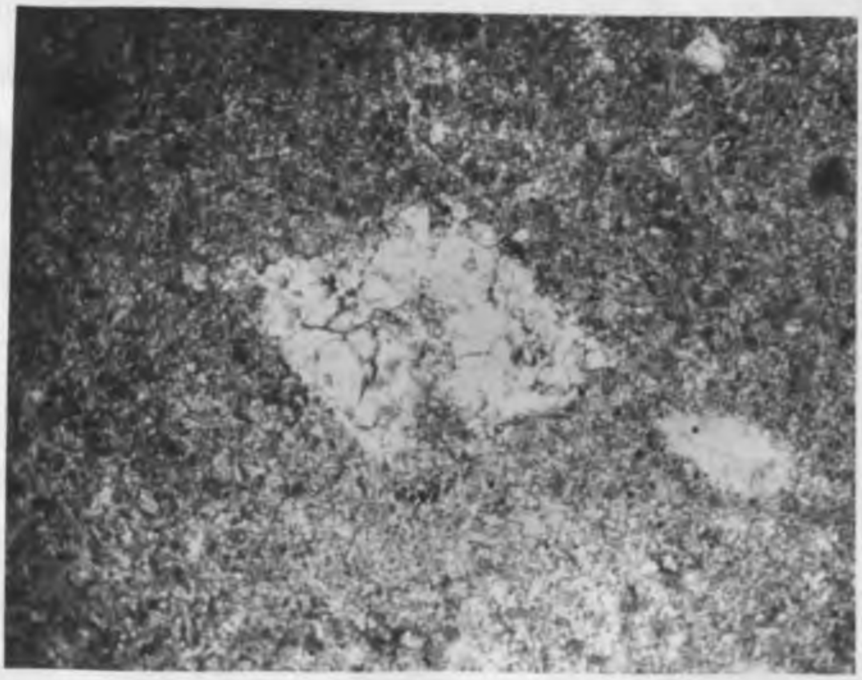

Figure 21. Calcite Pseudomorphs after Gypsum and Dolomite. 75X

It is not the purpose of this paper to discuss the enormous amount of literature on dolomite but to discuss dolomite as it appears in the Earp Formation and its relation to the various facies found. The origin of dolomite is not discussed unless it provides a clue to the interpretation of the paleoenvironments and stratigraphy of the Earp Formation. It does seem desirable at this point, however, to point out that no evidence for deposition of primary dolomite has been found in the Earp Formation.

The possibility exists that the Earp Formation included a sebkha-like environment. A sebkha is defined as an extensive flat area, just above normal high tide, rising imperceptibly landward. Such an area, of course, includes the supratidal facies. Illing and others (1965) described the sebkha environment as being landward from algally bound sediments. These sebkha sediments are interfingered with the terrigenous material making up what is here included as the Earp delta. The abundance of salt and gypsum associated with the sebkha environment described by Illing and others (1965) is not present in the Earp Formation. In fact, there is but little gypsum throughout the entire Earp Formation, and the climate is postulated as having been arid in Arizona during Permo-Pennsylvanian time (Winters, 1963, p. 17). The paucity of salt and gypsum could be explained by frequency of inundation by storm tides and rains which washed away the gypsum and evaporites (Shinn and others, 1965). This does seem probable, since the Supai Formation to the north, which is in part Earp equivalent, has an abundance of evaporites. Furthermore, Illing and others (1965, p. 95) indicated that much of the salt of the Persian Gulf area is blown away by the wind.

The presence of pyrite in the Earp Formation may be an explanation for the scarcity of gypsum. Iron oxide cubes after pyrite are found in some of the dolomitic lithologies. Since, as discussed above, the climate during Earp time was probably arid, the pyrite could have been the end product of the decomposition of gypsum. Braun and Friedman (1969, p. 117) stated:

> The presence of pyrite is environmentally significant. Dolomite forms together with iron sulfide (hydrotroilite) and ephemeral products such as H_2S and native sulfur during the decomposition of gypsum in hypersaline brines (Friedman, 1966). Pyrite disseminated through dolomite would represent the end product of this reaction.

The conversion of the pyrite to iron oxide could have been accomplished later during the exposure of the pyrite to air in the supratidal environment.

The presence of small discontinuities is well represented in the Earp Formation (Figures 22 and 23). Gutstadt (1968, p. 1298) described this feature as representing the supratidal nature of the Beck Spring Dolomite, and Aitken (1967) described the same feature as a supratidal indicator. Laporte (1969, p. 109) stated:

> Within the Manlius and some parts of the Coeymans, marginal to the Manlius, erosion surfaces are common. These surfaces have up to several inches of relief and are usually overlain by a thin layer of carbonate pebbles, or intraclasts, eroded from underlying sedimentary layers. The irregularities of the surfaces and the formation of coherent clasts indicate that Manlius and Coeymans sediments were temporarily subaerially exposed, dried out, indurated, and eroded. The erosion surfaces are usually associated with mudcracks so that some of the clasts may represent reworking of loose mudcracked layers. Erosion was probably accomplished during storms, abnormally high tides, or following later local subsidence of the subaerially exposed sediments.

The mudcracks can give rise to interclastic rocks, which are of some abundance in the Earp Formation. Intraclastic rocks can give

Figure 22. Discontinuity--Siltstone over Biomicrite. 3.9X

Figure 23. Discontinuity--Dismicrite over Biomicrite. 4.2X

rise to the limestone-pebble conglomerates (Roehl, 1967, p. 2606), which are associated with supratidal deposits in some of the Ordovician and Silurian carbonate sediments of the Williston basin. This mudcracking and subsequent breaking up have been observed in the supratidal environment of the Bahamas. When limestone-pebble conglomerates of the Earp Formation have the same composition as the underlying strata, they can best be interpreted as being supratidal or intertidal in origin. Baars (1963, p. 107-109) noted the possibility of limestone-pebble conglomerates resulting from the reworking of mudcrack polygons in an intertidal zone.

Figure 24 shows dessication cracks filled with silt and calcite. West, Brandon, and Smith (1968, p. 1086) stated:

> Dessication cracks have been produced experimentally in subaqueous conditions by Burst (1965) but, as discussed by Matter (1967), these only formed if more than 2% of swelling clay minerals were present. Here, the cracks often occur in fairly pure dolomites, and they are not better developed in the more argillaceous beds. It is very likely, therefore, that subaerial exposure of the laminated carbonates often took place.

Dismicrite or "birds-eye" structure has been interpreted as spar-filled cracks (Laporte, 1967, p. 80) or as having an algal-mat origin (Folk, 1959, p. 27). In any case, the possibility that the "birds-eye" structure is supratidal is very good.

In all the rock types discussed, there is a marked lack of fossils, except in algal-generated laminated carbonates. The lack of marine organisms indicates a supratidal environment. In all probability, therefore, the unfossiliferous dolomites that do not show an algal affinity are supratidal or high intertidal in origin. Laporte (1967, p. 81), when discussing the lack of marine fossils in the supratidal facies of

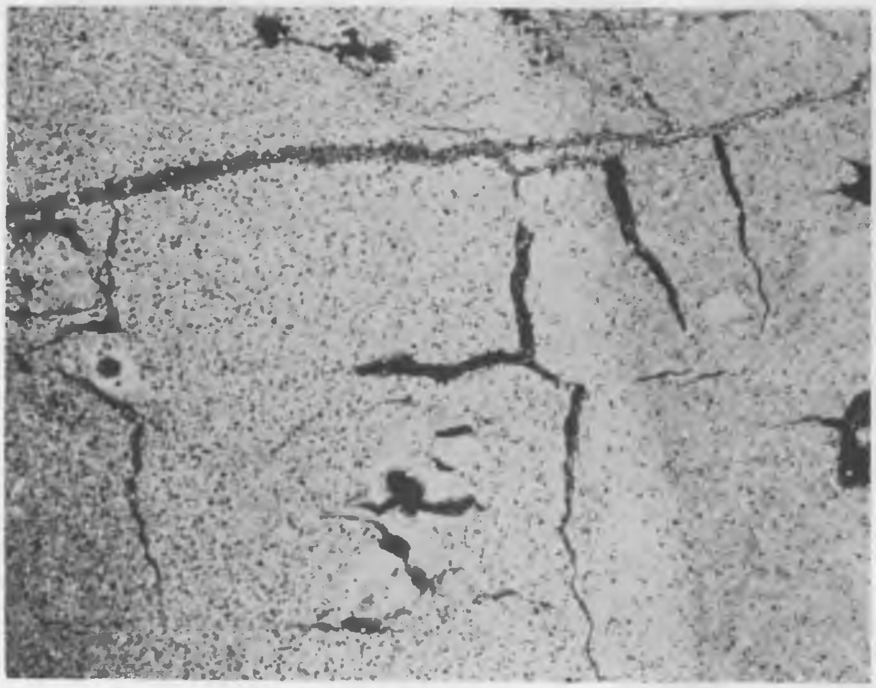

Figure 24. Photographs of Dessication Cracks. 14.4X

the Manlius Formation, stated:

> The lack of a preserved marine biota is interpreted to be an original trait of this facies and not the result of differential loss by dolomitization. This interpretation is believed to be correct because, even in those parts of this facies where the dolomite content is low, there are no fossils. Following the interpretation that this facies was deposited in the supratidal environment, it is to be expected that indigenous marine fossils would be absent except for those scattered remains thrown onto the flats from the nearby marine environment.

In summary, a portion of the Earp Formation seems to possess more features which show a supratidal carbonate environment than an intertidal or subtidal environment. Roehl (1967, p. 1998), speaking of the supratidal environment, stated that "No one sedimentary process or fabric is exclusively diagnostic but fortunately there are many diverse fabrics which as a group indicate the distinctive aspect of the environment."

Intertidal Facies

The intertidal facies is that facies which was formed between high and low tide, and the sediments of this facies would be flooded twice a day. The Earp Formation has within it certain characteristics that are indicative of the presence of an intertidal facies as well as the supratidal facies.

The Earp Formation has an abundance of carbonates identified as pelmicrites (Figure 25). Pelmicrites have been reported to represent intertidal deposits (Laporte, 1967; Schenk, 1967; Braun and Friedman, 1969). The modern analogs are the intertidal deposits of the Persian Gulf (Illing and others, 1965), the Bahamas (Black, 1933; Purdy and Imbrie, 1964; and Shinn and others, 1965), and Florida Bay (Ginsburg

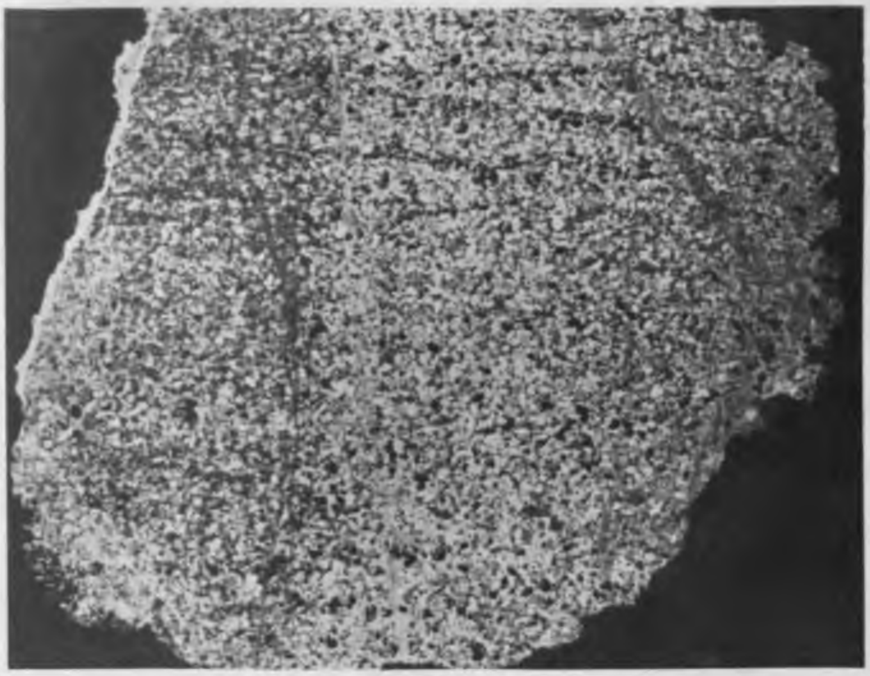

Figure 25. Pelmicrite. 5.2X

and others, 1954). The origin of the pellets can be attributed to erosional processes, or they are fecal in nature.

The limestone-pebble conglomerates have been discussed in the section on supratidal facies, and the likelihood of the conglomerates having an intertidal affinity was also discussed.

The Earp Formation also contains biomicrites (Figure 26). These rock types are invariably dolomitized to at least some extent. The skeletal mud facies of the Bahamas described by Purdy (1963) represents a modern-day analog. This type could be formed in the supratidal environment. Biomicrites have been designated as representing the intertidal environment by Laporte (1967) and Schenk (1967). Biomicrites are also present in the subtidal environment (Laporte, 1967, p. 85). Therefore, biomicrites may be found in both environments.

The lime-mud or micritic constituent of some of the limestones of the Earp Formation does not, in itself, represent a supratidal, intertidal, or subtidal condition. The micrite is compared to clay material (Folk, 1959, p. 10) and represents a low-energy environment. The sparry constituent of some of the limestones is representative of a limestone in which the lime mud or micrite has been washed out and therefore represents a higher energy condition of formation than do the micritic rocks. Biosparites could have formed in an intertidal zone where high-energy conditions existed. These conditions could be the result of washing or winnowing by wave action or tidal currents. Laporte (1967, p. 91) and Braun and Friedman (1969, p. 133) believe biosparites represent an intertidal zone. Therefore, the biosparites and biopelsparites found in the Earp Formation probably represent the intertidal facies.

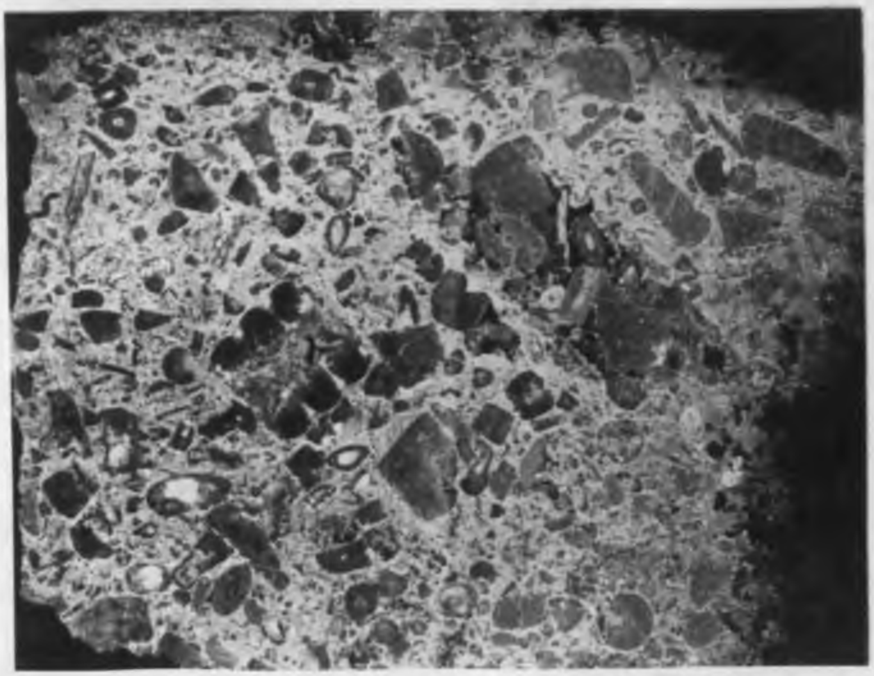

Figure 26. Crinoid Biomicrite. 51.X

Subtidal Facies

The subtidal zone is the most difficult to evaluate. Diagnostic characteristics of the environment below low tide are very few. The intertidal and subtidal zones commonly grade into one another over short distances (Roehl, 1967, p. 1979). Laporte (1967, p. 91) also illustrates the gradational relationship between the two environments. Roehl (1967, p. 1992) stated that "The infratidal deposits are perhaps the least diagnostic of fabric types."

Oolites in the Earp Formation are relatively rare. Just two samples out of 1,000 collected for this study contained oolites. Oolites probably represent a high-energy environment in the intertidal or subtidal environment and are formed by wave or current action. The absence of oolites is presumptive evidence that the environment which encompassed the depositional regime of the Earp Formation must have been one of low energy. Furthermore, the number of rock types which have a sparry calcite cement is low compared to the number composed of lime mud or having a lime-mud matrix. The presence of lime mud would also indicate the lack of sufficient energy to winnow it and produce voids later filled by sparry calcite. The cause for this could very well be a very low depositional slope. Low depositional slopes were apparently quite common in epeiric seas of the past. The preceding is discussed more fully in connection with interpretative maps.

The Earp Formation has an abundance of biomicrites which are found either in the intertidal or subtidal environments. In some of the biomicrites, however, delicate foraminifera, mollusk, and brachiopod shells are preserved. The intertidal environment had extensive burrowing animals (Roehl, 1967, p. 1992) which would have probably broken the more delicate tests. Also, the ebb and flow of tides and waves, even if of relatively low energy, would probably add to the shell breakage. Furthermore, Laporte (1962) showed that the fusuline and bioclastic facies of the Permian Cottonwood Limestone was deposited in shallow, offshore, poorly circulated waters. Also, in many of the biomicrites encountered, the fauna is varied. Braun and Friedman (1969, p. 130) stated:

> The micrite in this lithofacies indicates a low energy environment. The absence of oöids in this facies tends to confirm a low energy regime for the depositional environment. The abundant and varied fauna indicates a subtidal environment. The sediments were laid down at some distance from the turbulent zone in which oöids are formed and micrite particles taken into suspension. This lithofacies is subtidal.

The fusulinid biomicrites (Figure 27) in the Earp Formation may have further environmental significance. Laporte (1962, p. 541) stated "While the ecologic controls for fusulines are not known and undoubtedly vary according to species, the evidence is strong that fusulines are more typical of shallow water--perhaps water depths closer to 50 feet than 160-180 as suggested by Elias." It is interesting to note at this point that the sections that carry the most fusulinid biomicrites are the Chiricahua Mountains, Pedrogosa Mountains, and Quadalupe Canyon sections. These sections represent the deepest part of the Pedregosa basin during the time of Earp deposition. It is logical to assume, therefore, that this rock type probably represents the deepest offshore component of all the lithologies found in the Earp Formation.

Figure 27. Fusulinid Biomicrite. 10X

Age and Correlation

As noted above, lithologically, the base of the Earp Formation is placed where the shaly limestones and red shales become more abundant than in the underlying Horquilla Limestone. As for the top of the Earp, Bryant (1968, p. 39) stated that "The lower boundary of the Colina is usually distinct where the dark limestones supersede the clastic, varicolored beds of the Earp."

The age of the Earp Formation ranges from Late Pennsylvanian (Missouri) to early Permian (Wolfcamp). The Missouri age is based on Missouri conodonts found by Reid (1968) in the Waterman Mountains. The base of the Earp in the remainder of the sections, all of which are east of the Waterman Mountains, is of Virgil age. This is based on fusulinid evidence, where present, of the underlying Horquilla Limestone and the fact that the Permo-Pennsylvanian boundary lies within the Earp. The Virgil-Wolfcamp boundary progressively becomes lower in the section toward the east. In the Big Hatchet Mountains section the Earp is probably all Wolfcamp but may be part Leonard (Zeller, 1965, p. 49). Therefore, it is seen that the Earp Formation is time transgressive toward the east.

The top of the Earp is probably Wolfcamp with the possible exception of the Big Hatchet section, where Leonard fusulinids are in the Colina Limestone and late Wolfcamp fusulinids in the Horquilla (Zeller, 1965, p. 49). In all other areas where the overlying Colina can be dated, it contains the Wolfcamp-Leonard boundary. Fusulinid evidence suggests that the Wolfcamp-Leonard boundary lies within the Colina Limestone in the Guadalupe Canyon area (Dirks, 1966, p. 23).

In the type area, near Tombstone, Gilluly and others (1954, p. 41) dated the Colina as Wolfcamp and Leonard (?) on the basis of gastropods, brachiopods, and a cephalopod specimen. Knight (in Gilluly and others, 1954, p. 39), when speaking of gastropod collections from the Colina, stated:

> The restricted genus Omphalotrochus is highly characteristic of beds of Wolfcamp age occurring in the central Texas Permian as high as Leuders in the type Wolfcamp of the Glass Mountains, in the Hueco limestone of the Sierra Diablo, the Hueco and Sacramento Mountains, and of equivalent beds in southeastern California. Indeed, its range appears to coincide throughout the world with that of Pseudoschwagerina.

Wolfcamp fusulinids were found three feet above the base of the Colina in the Mule Mountains (Hayes and Landis, 1956, p. F30). In the Pedregosa Mountains, Epis (1956, p. 103) found Wolfcamp fusulinids near the base of the Colina. Therefore, in all likelihood, since the base of the Colina is Wolfcamp where dating is possible, the top of the Earp Formation is Wolfcamp also.

Since the Permo-Pennsylvanian boundary is found in the Earp Formation, the basis on which the boundary is drawn must be outlined. When speaking of the divisions of the Permian system, Oriel (1967, p. 29) stated:

> Wolfcamp series--The first and lowest of these subdivisions, the Wolfcamp series, includes the oldest rocks of the Glass Mountains region. It comprises beds that have been referred to the Wolfcamp formation (restricted) * * * the Wolfcamp fauna is characterized by the abrupt incursion of the fusulinid genera Schwagerina ss., Pseudoschwagerina, and Paraschwagerina, by the presence of the ammonoid genus Properrinites, the brachiopod genus Parakeyserlingina and other distinctive Permian genera.

The Missouri age of the base of the Waterman Mountains section has been discussed. No other fossils were found in the Waterman

Mountains section to date the upper portion of the unit. It is assumed that Earp deposition continued in the Waterman Mountains area because of the likelihood that the Colina is Wolfcamp.

The Colossal Cave section is badly faulted and thicknesses are questionable. However, a typical Virgil fusulinid assemblage, *Triticites whetstonensis*, *T. bensonensis*, and *T. coronadoensis*, is present. On this basis, the Virgil-Wolfcamp boundary was drawn. The thickness and lithologies used from the Colossal Cave section did not cause any anomalous effects.

In the Empire and Patagonia Mountains there was no fossil control on which to base time boundaries. In the Patagonia Mountains, a large *Triticites* sp. was found in the chert-pebble conglomerate. Since the chert-pebble conglomerate is probably Wolfcamp (Rea and Bryant, 1968, p. 817) and lies within a clastic zone which is also probably Wolfcamp, as discussed below, the boundary between Virgil and Wolfcamp is drawn at the base of the clastic unit. This boundary cuts the Patagonia Mountains section in half. The Virgil-Wolfcamp boundary is also drawn through the midpoint of the Empire Mountains section, since this section is directly north of the Patagonia Mountains section and the Earp sea transgressed from west to east as discussed above.

The Virgil-Wolfcamp boundary in the Whetstone Mountains was drawn on the basis of the last appearance of the upper Virgil fusulinid assemblage, *Triticites* cf. *bensonensis* and *T.* cf. *creekensis* or *T. ventricosus sacramentoensis*, and the beginning of the middle clastic member found in the mid-portion of the study area. The Whetstone Mountains section measured near Sands Ranch was not a complete section, so the one used by Rea (1967) measured in the Dry Canyon area was used. This section was modified in that the bottom 266 feet were assigned to the Horquilla Limestone. This was done because the bottom 266 feet had a scarcity of clastic interbeds and had a more massive Horquilla-like appearance.

In the Gunnison Hills, a section was measured at what was thought to be the same location that Gilluly and others (1954, p. 37) measured. About 400 feet from the base they collected fusulinids and stated "This sample contains Schwagerina aff. S. longissimordea (Beede) which indicates age equivalent to the Wolfcamp or Big Blue series of Permian(?) age. If this and the Triticites species of 94024 (F6189) are associated, the combined evidence would indicate basal Wolfcamp age." On this basis, the Virgil-Wolfcamp boundary was drawn 400 feet above the base of the Earp Formation. About three miles to the south in the Dragoon Mountains, an incomplete, faulted section was measured. Due to structural complexities, thicknesses were not used. Therefore, petrographic data for paleoenvironmental interpretation were used.

The Earp Formation of the type section in Earp Hill was considered entirely of Wolfcamp age on the basis of the fusulinid work of Dubin (1964). This section is probably incomplete for the following reasons:

1. The presence of 400 feet of Virgil strata in the Earp in the Gunnison Hills 25 miles north.
2. The presence of at least 280 feet of Virgil strata in the Naco Hills 20 miles to the south.

3. The presence of 120 feet of Virgil strata in the Whetstone Mountains 25 miles to the west.
4. The presence of Virgil strata in the Swisshelm Mountains 25 miles to the east.

It seems very unlikely that Virgil-Earp deposition was not going on in the type section when this deposition was going on in an area completely surrounding the type section. Also, Rea and Bryant (1968, p. 817) showed an average discrepancy in thickness of over 400 feet when comparing the distances of fusulinid occurrences from below the top of the type section and the tops of the sections in the Gunnison Hills and the Whetstone Mountains.

The Virgil-Wolfcamp boundary was drawn in the Naco Hills on the basis of the presence of a Virgil fusulinid assemblage, Triticites cellamagmus, T. cf. bensonensis, and T. creekensis. Since the base of the Naco Hills section is faulted, the Virgil portion of this section was not used in Virgil lithofacies or isopach maps.

The Virgil-Wolfcamp boundary in the Chiricahua Mountains section was drawn on the basis of the first appearance of Pseudoschwagerina. The Virgil-Wolfcamp boundary in the Pedregosa Mountains section was drawn on the basis of Schwagerina.

In the Guadalupe Canyon area, the base of the Earp is covered (Dirks, 1966) and the exposed portion of the section is all Wolfcamp. However, since there are Virgil fusulinids in the Pedregosa Mountains section four miles to the northwest, a Virgil-Wolfcamp age is probable for the Guadalupe Canyon area (Dirks, 1966, p. 14).

The Earp in the Big Hatchet Mountains section is probably all Wolfcamp, as the underlying upper Horquilla is of Wolfcamp age. Possibly the upper part of the Earp in the Big Hatchet Mountains is as young as Leonard.

In some localities, the Earp Formation has a unit within it that is more clastic than the other portions. This clastic zone is well developed in the middle of the Formation in the Gunnison Hills and the Whetstone, Rincon, and Patagonia Mountains. In the Chiricahua Mountains, the Pedregosa Mountains, and the Guadalupe Canyon area, the clastic zone is found in the upper 300 feet or so of the Earp. On the basis that the overlying Colina is probably of Wolfcamp age and Wolfcamp fusulinids, where present, are always below the clastic zone, the clastic zone is Wolfcamp. By stratigraphic position, the clastic "red bed" unit in the Chiricahua Mountains, the Pedregosa Mountains, and the Guadalupe Canyon area is later Wolfcamp in age than the middle clastic unit to the west.

From the above discussion as to the age boundaries within the Earp Formation, Figure 28 represents a correlation chart modified from Winters (1963, p. 15). The fact that the clastic portion of the Earp Formation is deltaic and that at least parts of the Supai Formation were being deposited during Earp time, and that the Supai Formation was a flood plain or delta (Winters, 1963, p. 19) strongly suggests that the Earp and Supai Formations are correlative. Sabins (1957a, p. 501) stated:

> Two positive areas were emergent early in the Pennsylvanian: the low Zuni Defiance area, and the higher Uncompahgre-San Luis area (Fig. 11). The red clastic sediments of the Supai formation were derived from these rising highlands and

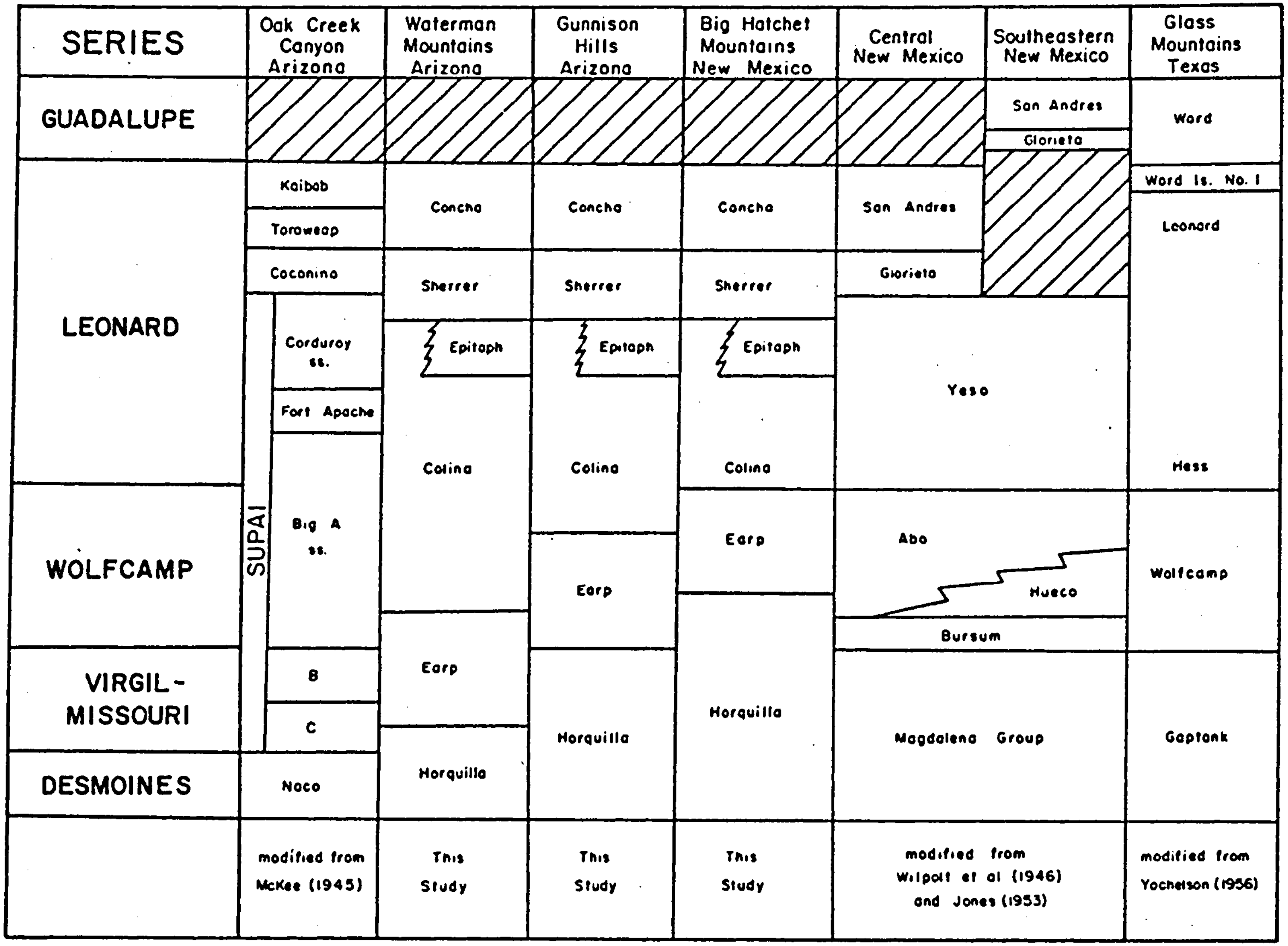

Figure 28. Correlation Chart of Permian Formations in the Southwestern U.S.-- Modified from Winters (1963).

> deposited in a deltaic environment that was intermixed with the limestone-depositing environment of the Naco group (undifferentiated). As the uplift of the positive areas was accelerated, the clastic sediments extended further southward until by late Pennsylvanian time they were interfingering with limestones of the Earp formation in southeast Arizona.

Furthermore, as discussed later, heavy mineral evidence suggests the same source for both the Supai and Earp Formations.

In New Mexico the red beds of the Abo Formation are of Wolfcamp age (Wilpolt and others, 1946). Thus the Earp Formation and the Abo Formation are, in part at least, correlative. Zeller (1965, p. 49) stated:

> It seems probable that the Abo, Earp, and Supai Formations are lithologically equivalent to one another, even though they differ in details. They all include deposits shed from land areas that lay predominantly toward the north and northwest during late Pennsylvanian and Wolfcamp time. From southeastern Arizona to southwestern New Mexico, the basal beds become younger, indicating that the land-derived clastic progressively encroached upon the sea in which the marine limestones of the Horquilla Formation were being deposited.

It therefore seems most probable that the Earp, Supai, and Abo Formations are correlative by both age and lithologic evidence.

Figures 29 and 30 (in pocket) show the correlation of the Earp Formation from the Waterman Mountains on the west to the Big Hatchet Mountains on the east. The correlation lines are based as much as possible on fossil evidence and not on lithologies. The Missouri-Virgil and Virgil-Wolfcamp boundaries have already been discussed. The red chert-pebble conglomerate discussed by Rea (1967) is a good marker bed in the Earp Formation and may represent an isochronous surface because of its distinctive lithology and its stratigraphic position within the more clastic middle portion of the Earp Formation. However, the mainly clastic portion of the Earp Formation is not always present in the middle portion of the section, and the chert-pebble conglomerate is not always present in the more clastic portions of the Earp. In any case, the chert-pebble conglomerate, where present, is a good marker bed and can be used, where present, to correlate lithologically sections of the Earp Formation.

Like the chert-pebble conglomerate, there are other lithologic characteristics of the Earp Formation which can be correlated within a rather restricted sense within the study area. As discussed above, in the Gunnison Hills, Whetstone Mountains, Colossal Cave area, and Patagonia Mountains, there is a well-developed clastic portion of the Earp present in the middle portion of the formation which is Wolfcamp in age. Where the chert-pebble conglomerate is present it always lies within this unit. Therefore, the middle clastic unit may be correlative in the areas where this unit is present.

In the Chiricahua and Pedregosa Mountains and the Guadalupe Canyon area there is a distinctive upper "red bed" unit. In each area, this unit lies above Wolfcamp fusulinids as does the middle clastic unit in the areas discussed above. Stratigraphic position, age, and lithologic similarity all indicate the upper clastic unit in the sections where it is present to be correlative.

It seems probable that the middle clastic units and the upper clastic units mentioned above represent deltaic lobes shifting from west to east in Wolfcamp time.

In the Empire Mountains and in the Big Hatchet Mountains, the sections are dominated by clastics. This is probably due to the presence of the Earp delta at these locations during a longer period of time than at the other localities.

From the comparisons in Table 1, it can be seen that some but

TABLE 1.--Comparison of limestone conglomerates in different sections

Section	Distance below top of section	Thickness	Probable age
Waterman Mountains	395'	2.0'	Virgil
Waterman Mountains	307'	6.0'	Virgil
Empire Mountains	328'	3.0'	Virgil
Patagonia Mountains	227'	1.5'	Wolfcamp
Dragoon Mountains	355'	1.0'	Wolfcamp
Earp Hills	458'	11.0'	Wolfcamp
Swisshelm Mountains	--	2.0'	Virgil
Guadalupe Canyon Area*	192'	8.0'	Wolfcamp
Big Hatchet Mountains	990'	4.0'	Wolfcamp

*After Dirks (1966).

not all of the limestone-pebble conglomerates are in approximately the same stratigraphic position. It seems that the use of limestone-pebble conglomerates for correlation is not practical.

Heavy Mineral Study

A heavy mineral separation was made from at least one terrigenous sample from each section. If the section had a middle or upper clastic unit, the sample was taken from it. If the section did not possess a definite clastic unit, such as the Empire and Big Hatchet Mountains sections, a sample was randomly selected. Also, a heavy mineral separation was made from one sample of the Supai Formation.

The heavy mineral suites from the samples could give an indication as to whether or not the depositional regime of the Earp Formation had the same or different source areas. The heavy mineral suite from the Supai Formation was examined in order to compare it with the suites from the Earp Formation.

All the samples studied had an opaque population of magnetite and leucoxene. Zircon, tourmaline, rutile, and apatite represent the major part of the non-opaque varieties with minor amounts of sphene and monazite.

A comparison of the major non-opaque assemblages from the sections reveals similar shapes. In each sample, zircon occurs in both rounded and euhedral forms (Figure 31). The euhedral zircons generally show slight abrasion of the corners. In all samples, rounded grains are abundant and euhedral ones scarce. Zircon to zircon plus tourmaline ratios (Figure 32) were plotted and show a rather tight grouping.

A modification of the shape-roundness analyses of tourmaline employed by MacKenzie and Poole (1962, p. 65) was used to compare tourmaline occurrences (Figure 33). Also, the pleochroic varieties of tourmaline were recorded on a triangular plot (Figure 34) modified from Scott (1965, p. 399). Both the shape-roundness analyses and pleochroic plots of tourmaline show a grouping that indicates a common source.

A comparison of the rounding of apatite grains is shown in Figure 35. The rounding is almost always greater than 0.4 on the

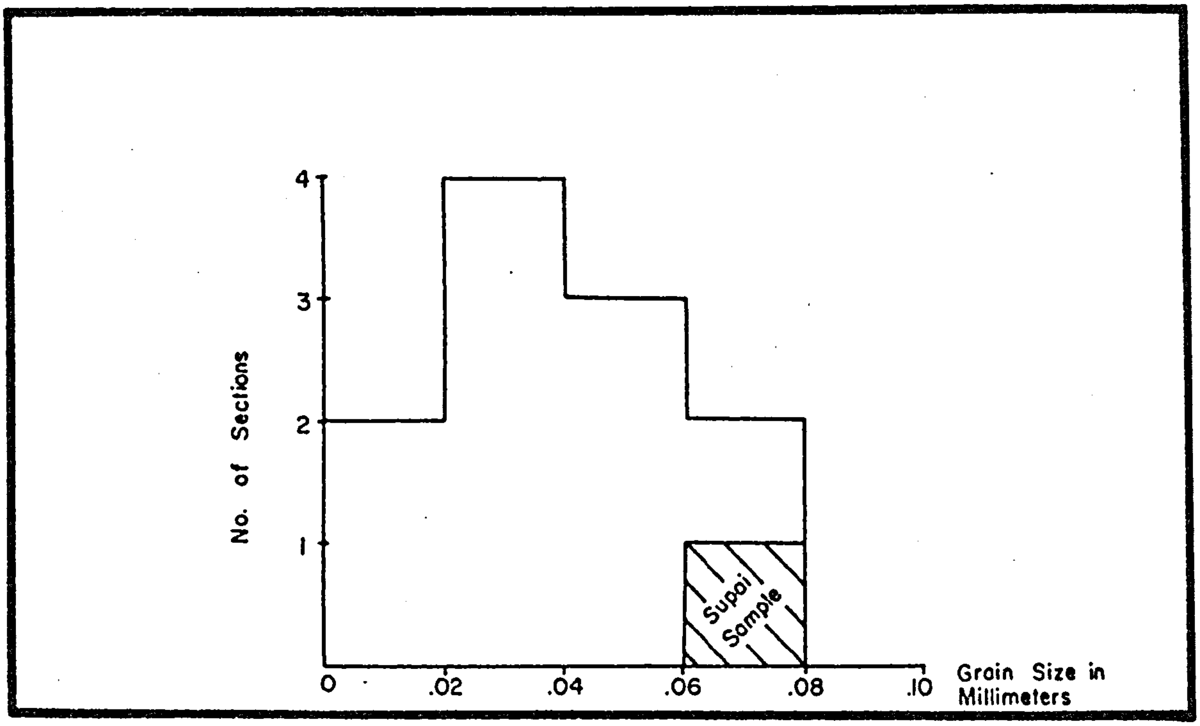

Figure 31. Euhedral/Rounded Zircon Ratio

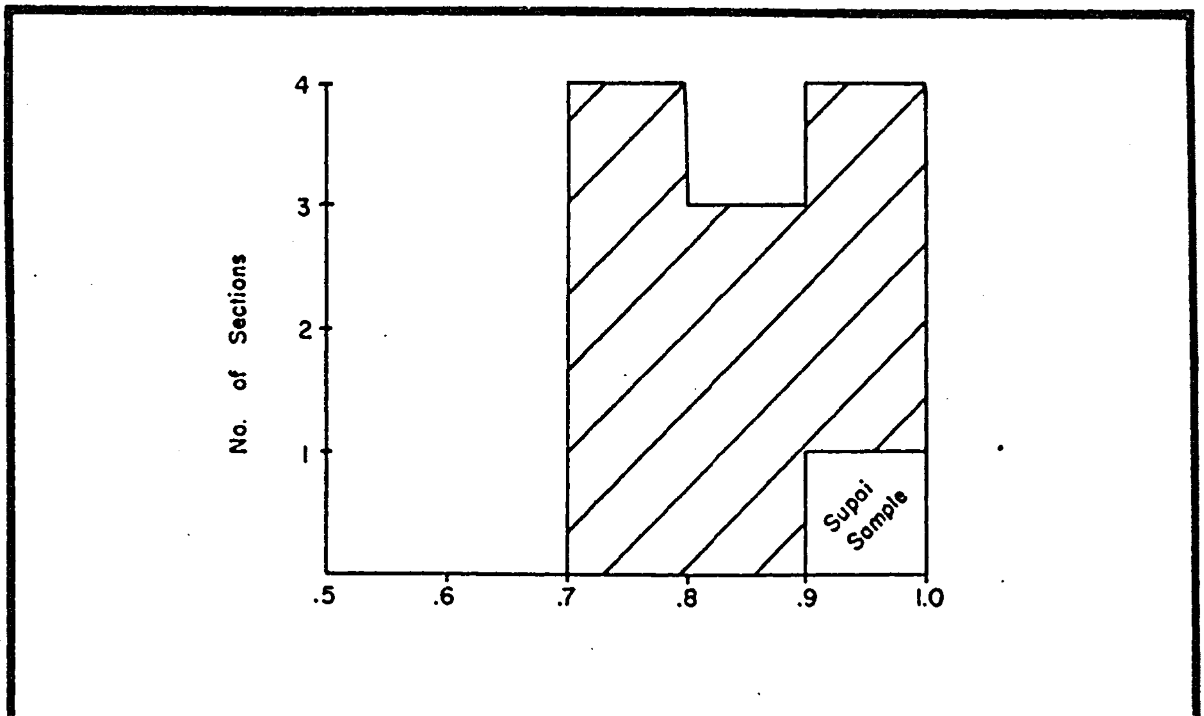

Figure 32. Zircon/Zircon + Tourmaline Ratio

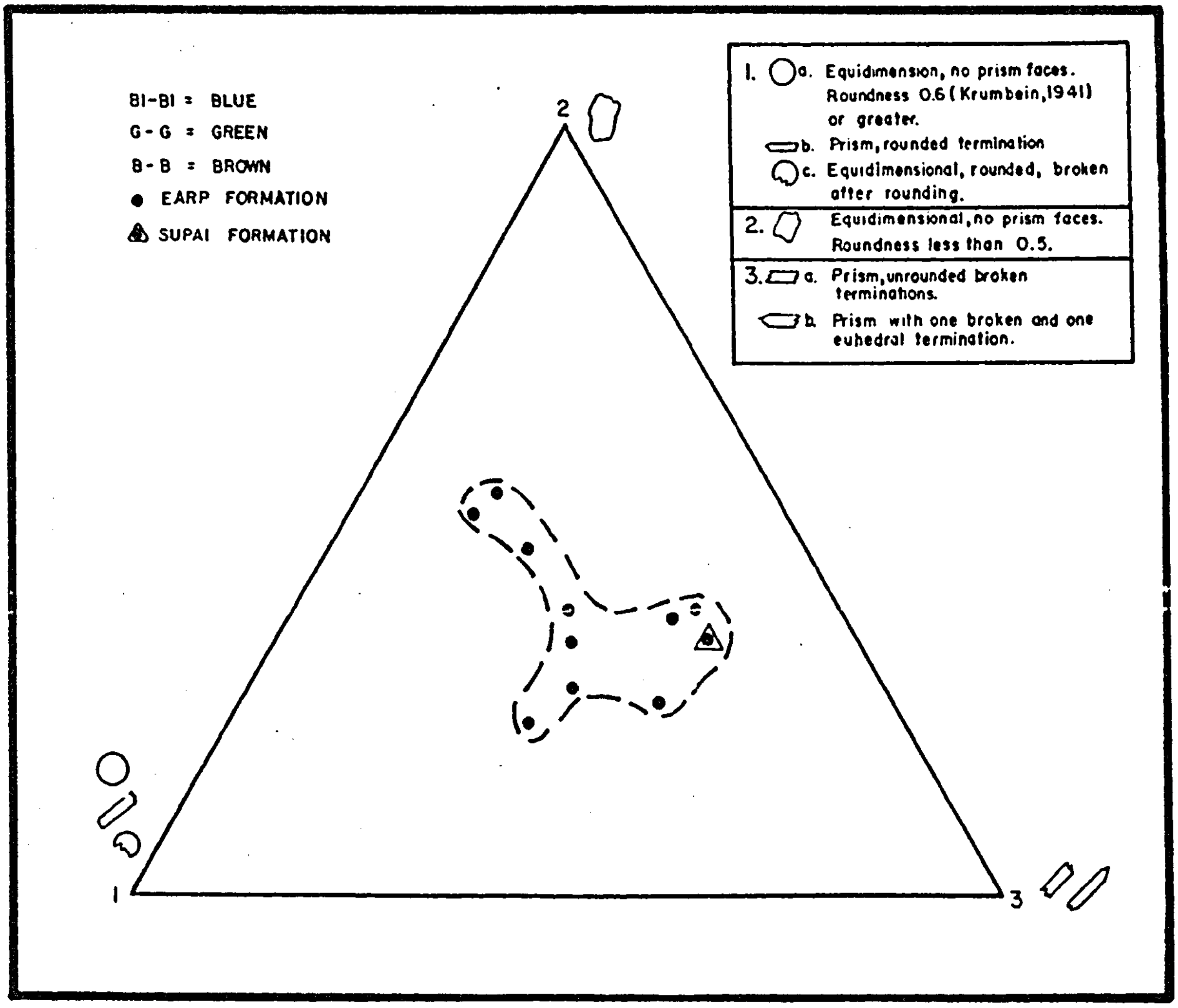

Figure 33. Triangular Plot of Tourmaline Shape-roundness Analyses.--Modified from Mackenzie and Poole (1962, Figs. 3 and 4).

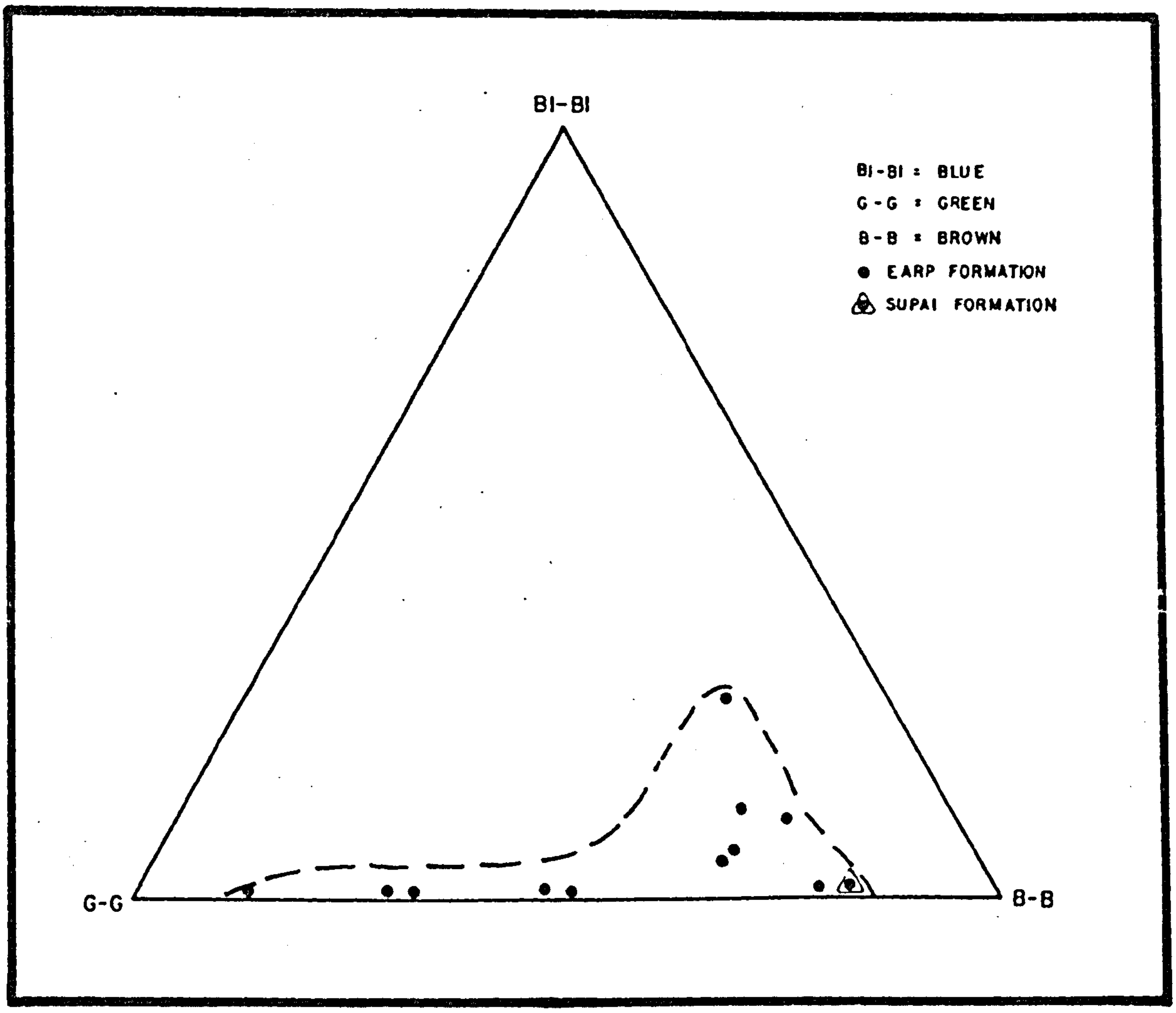

Figure 34. Triangular Plot of Tourmaline Pleochroic Varieties in the Earp Formation--Modified from Scott (1965, Fig. 8).

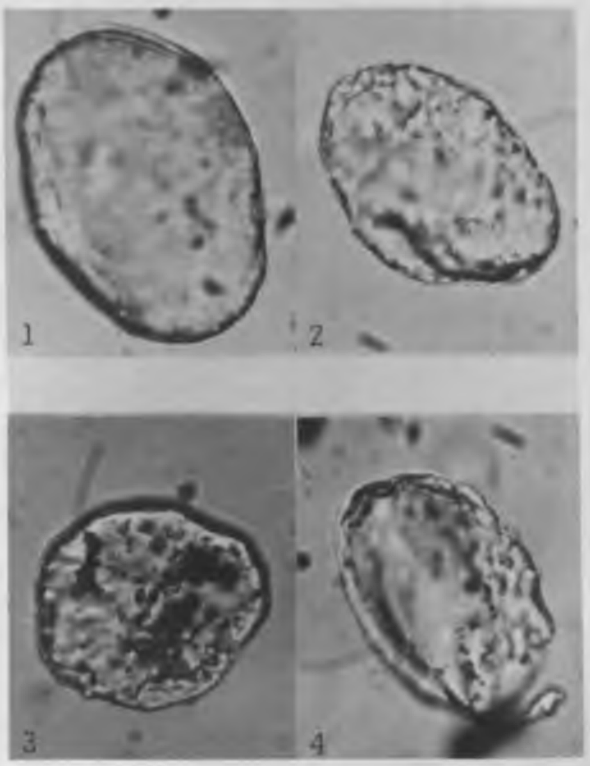

Figure 35. Photomicrographs of Typical Apatite Grains. 225X.

Grains from (1) Waterman Mountains; (2) Big Hatchet Mountains; (3) Naco Hills; and (4) Earp Hills.

Powers scale and the grains all exhibit distinctive unidentified black inclusions.

Rutile appears in all samples studied, and the grains most generally are subrounded. Each sample contained rutile of two colors; one a light amber, the other a reddish amber.

No distinctive varietal characteristics of anomalous ratios were noted that would indicate other than a common provenance for all the samples examined. On the other hand, all the samples probably were derived from reworked sediments and from an igneous source as shown primarily by the presence of both rounded and euhedral zircons. Also, the assemblage indicates an ultimate acid igneous source whether first-cycle or reworked sediments (Pettijohn, 1957, p. 512). The zircon and tourmaline plots show groupings well within the limits of groupings obtained from rocks with a known common source (MacKenzie and Poole, 1962, p. 65; Scott, 1965, p. 397, 399).

The significance of the single heavy mineral assemblage from the Supai Formation is, of course, conjectural. However, it may be noteworthy that the parameters of the Supai heavy mineral assemblage are closely comparable with those of the Earp. The assemblages in both formations are not incompatible with an Uncompaghre source. The Florida positive element just to the west of the Big Hatchet Mountains was probably emergent during Earp time. However, the heavy mineral assemblage from the Big Hatchets indicated no source other than that shared by the other sampled localities. The Florida high probably did not contribute sediments to the Big Hatchet Mountains area during Earp time. Kottlowski (1958, p. 84) stated: "The Florida islands during

Wolfcampian time seem to have been low islands and hills on the south margin of a large, low landmass stretching northward on which the Abo red beds were deposited, while to the south, southeast, and southwest, only a small amount of the continental debris washed into marine basins."

Origin and Mode of Deposition

Starting in Missouri time, an influx of deltaic clastic sediments overcame the dominance of the shallow-water carbonate environment in which the Horquilla Limestone was being deposited. The resulting limestone sequence of the Horquilla marked the base of the lithologies making up the Earp Formation.

Most of the Earp is composed of alternating marine and nonmarine sediments making up limestone-siltstone interbeds. In the central portion of the study area there is a middle clastic unit. In the eastern part of the study area there is an upper clastic unit. The clastic-dominated units reflect the position of the Earp delta over a longer period of time than the position indicated by the limestone-clastic lithologies.

The clastic-ratio and isopach maps of Virgil time (Figures 3 and 5) show a further encroachment by the Earp delta to the east overriding the Horquilla sea and clearly show the west-to-east transgression of the Earp Formation.

As discussed, the climate was arid and depositional slopes were very low. The terrigenous sediments of the Earp delta probably merged imperceptibly into a carbonate supratidal flat-sebkha environment and thence into a very shallow, semi-restricted sea. The slopes were probably so low that slight fluctuations of the sea level would vary the position of the shoreline by tens of miles. These shoreline fluctuations are documented by the alternating marine and nonmarine sequence of the Earp Formation.

During Wolfcamp time the Earp delta had grown to a size it was never to attain again (Figures 4 and 6). There were tectonic pulses in the north that increased the gradients of the streams bringing down the distinctive chert-pebble conglomerate from the northern Naco highlands. Later in Wolfcamp time the Earp delta, probably in the same manner as the Mississippi Delta, shifted to the east, depositing the upper clastic portion of the Earp Formation as found in the Chiricahua and Pedregosa Mountains and the Guadalupe Canyon area.

Interpretive Maps

Figures 36 through 40 are interpretive maps showing what is thought to be the extent of the Earp delta during Missouri, Virgil, and earlier and later Wolfcamp time. The extent of the delta is interpreted from the extent of the clastic or land-derived sediments. There could have been far more subaerially exposed material at certain periods during Earp time than is shown. Shaw (1964, p. 5) and Irwin (1965, p. 451) both emphasize that depositional slopes of epeiric seas common in the geologic past would average from 0.1 to 0.2 foot per mile. Irwin (1965, p. 445) stated:

> The familiar statement, "The present is the key to the past," may be a misleading one when considering epeiric sedimentation. We simply have no existing models of epeiric seas to guide our investigations, and although it is true that many similarities do pertain between the past and the present, it is equally true that many differences exist as well. Two important factors, neither of which is duplicated in a present-day setting but which easily may be overlooked, are "mobility" and "time." Nature is never static. In the geologic past, epeiric seas transgressed and regressed over the continents

> during numerous periods. These far-reaching movements required time."

Therefore, a very slight fluctuation in sea level could expose up to hundreds of square miles of previously submerged sediments, and the sebkha supratidal and intertidal couplet could have had widths of many tens of miles and possibly as much as a hundred miles.

The depositional framework of the Earp Formation could and probably did at different times closely resemble that depicted by West and others (1968, p. 1092).

Missouri Stage

The interpretive map for Missouri time (Figure 36) shows the Earp delta positioned in the Waterman Mountains-Tucson region only. The reason for this is that the only known sediments laid down as the Earp Formation during Missouri time were in the Waterman Mountains. The remainder of the shoreline stretching from west to east to where it is shown north of Lordsburg is put there by deduction. The delta is advancing and had to be placed to the north. The river systems are shown flowing from north to south mainly because, in the course of this study, no indication of other than a northerly source was seen. Isopach and clastic-ratio maps all show the Pedregosa basin in Missouri time with an influx of clastics from the northwest. McKee (1969, p. 88) showed that during the time of Earp deposition there was a southerly direction of sediment transport based on the following:

1. Current-vector maps based on average directions of cross-strata dips show a dominant southerly direction of sediment

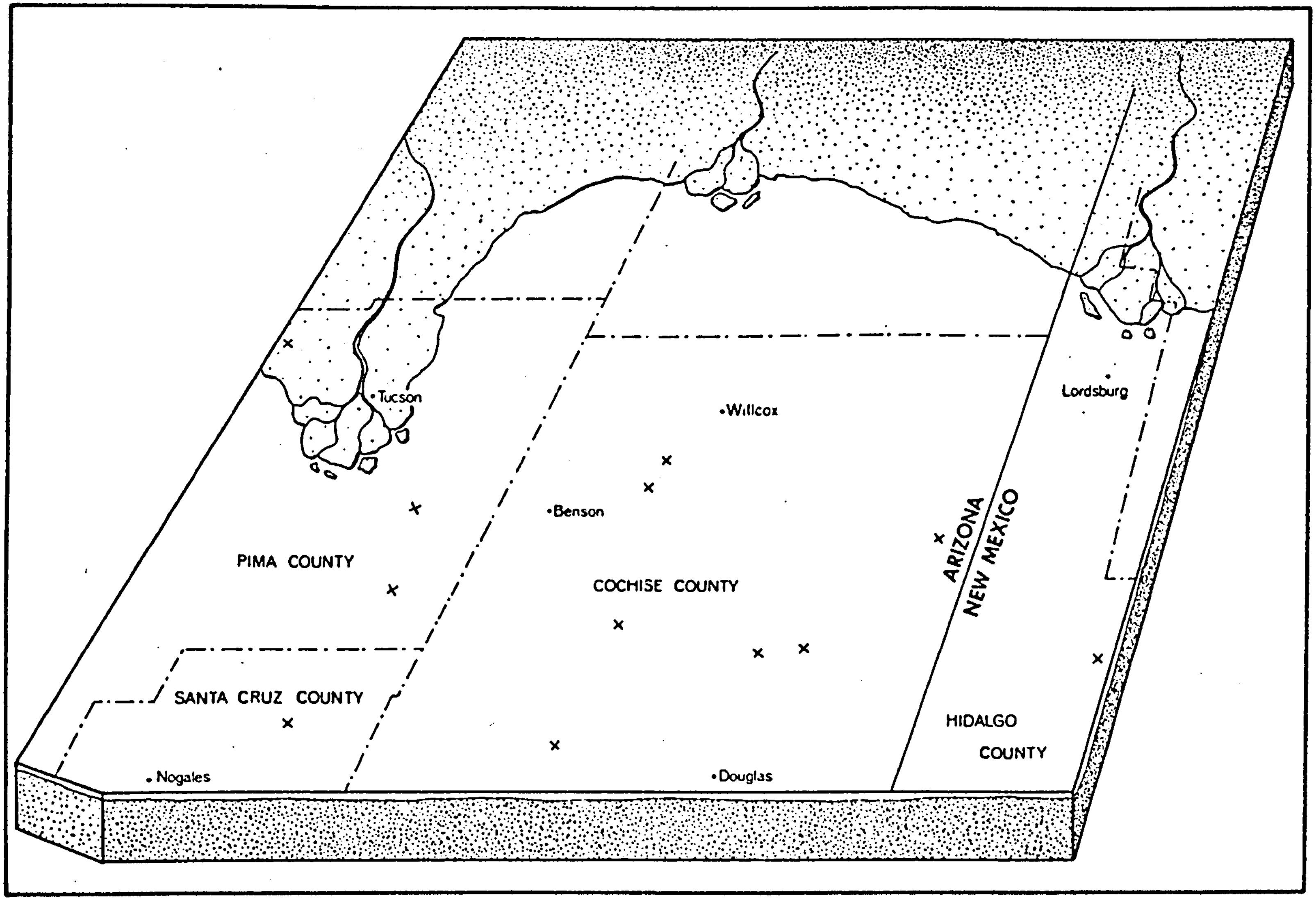

Figure 36. Missouri Stage Interpretive Map

transport and strongly suggest a nearby source in southern Utah.

2. Texture analyses show that coarse and very coarse grains are chiefly in sandstones to the north, whereas maximum grain sizes to the south are finer.

3. Finally a great increase of carbonate rock to the west in Grand Canyon and also southeast from Grand Canyon suggests that extensive marine environments were in those directions.

Rea (1967, p. 38) showed that directional structures in the chert-pebble conglomerate indicate a meandering stream system with the source to the north. The remainder of the sections studied were undergoing deposition of the marine Horquilla Limestone.

Virgil Stage

The Virgil clastic-ratio map (Figure 5) shows an influx of clastic material from the northwest to the southeast. This is interpreted as the encroachment of the Earp delta into the Horquilla sea. Again, the extent and configuration of the shoreline is dictated by the clastic ratios. As in the Missouri stage, the northern east-west shoreline is not definitive but is shown advancing as the Earp clastics encroached to the south (Figure 37).

Probably during Virgil time, tectonic pulses initiated uplifts of the Naco Formation that were to supply the chert in the chert-pebble conglomerate that was deposited by a meandering stream system in Wolfcamp time. Several bits of evidence support the assumption that these highs did exist, that they were highs during Wolfcamp time, and that from

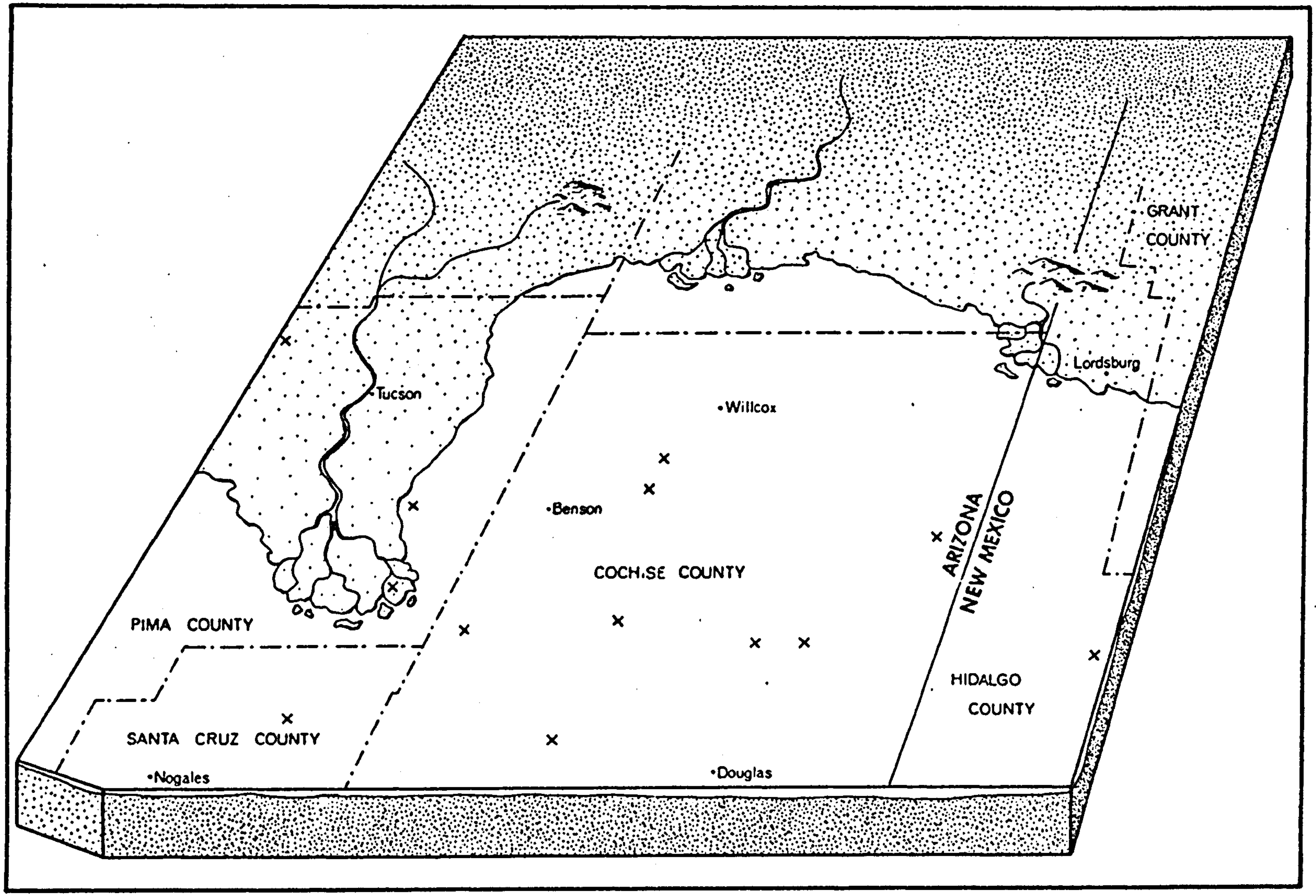

Figure 37. Virgil Stage Interpretive Map

these highs, chert from the eroding Naco Formation found its way into the Earp depositional regime.

First, the Pennsylvanian Naco Formation has as much as 30 percent chert to the north in the Winkelman-Superior area (Reid, 1966). Most of the chert is red. The red chert-pebble conglomerate does have gray and white chert, also found in the Naco in the above-mentioned areas. Erosion has removed a large part of the Naco in the Winkelman-Superior area. There are no known chert deposits that have the distinctive characteristics of the chert found in the Naco Formation in any sediments in southeastern Arizona except those found in the Earp Formation. There are Triassic(?) sediments on a Pennsylvanian erosion surface near Winkelman, Arizona (Reid, personal communication). If the Triassic(?) sediments are, in fact, Triassic, then there was erosion going on as late as Permian time. The eroded material would find its way southward by way of a stream system.

A major linear tectonic element, termed the "Deming Axis," had along its trend tectonic features that were active starting in Mississippian time (Turner, 1962, p. 59). The position of this axis runs north of the study area in an east-west direction through the Winkelman area. The erosion of the surface on the Naco Formation discussed above could have been one of the local expressions of the axis. The Burro uplift, northeast of the study area has Upper Cretaceous rocks lying directly on the Precambrian basement (Elston, 1958, p. 2516). This uplift may have been one of several tectonic pulses that could have provided material to the Pedregosa basin during Earp time. Turner (1962, p. 63), when speaking of the tectonic pulses of the Deming Axis, stated:

> The third significant pulse of Paleozoic orogenic movement in this region occurred prior to, or early in, Permian time. The result of this tectonism is illustrated on the paleogeologic map of figure 5. Through southeastern Arizona, most of southwestern New Mexico, and in the depositional basins of southeastern New Mexico and western Texas, there is little evidence for a break in sedimentation between Pennsylvanian and Permian times. However, the complex tectonic elements of the Ouachita structural belt reached their culmination at this time, and subsidiary deformation is recorded on the positive structural features to the northwest of this trend.

From the foregoing it seems quite likely that besides having a source area in the north that there were one or more source areas in uplifted highlands in an intermediate position between the far north and the Pedregosa basin area. About 100 miles east of the Big Hatchet Mountains in the Sacramento Mountains of New Mexico, the Wolfcamp Abo Formation rests unconformably on Pennsylvanian rocks (Pray, 1949, p. 1914). Several areas to the north could have contributed sediments to the Earp Formation. The Uncompahgre uplift in southwestern Colorado was positive during all of Permian time. Much of southeastern Utah was subjected to mild erosion that removed all or most of the Virgil rocks in Permian time (Baars, 1962, p. 159). The Defiance uplift along the Arizona-New Mexico border probably had late Pennsylvanian or early Permian erosion (Baars, 1962, p. 161).

Wolfcamp Stage

The earlier Wolfcamp interpretive map (Figure 38) is based mainly on the same parameters that have been discussed in connection with the Missouri and Virgil maps. The interpretation of the extent of the Earp delta is based on the extent of the middle clastic unit. The positive areas are more noticeable because stream velocities must have been greater to bring in the channel deposits which contain fragments

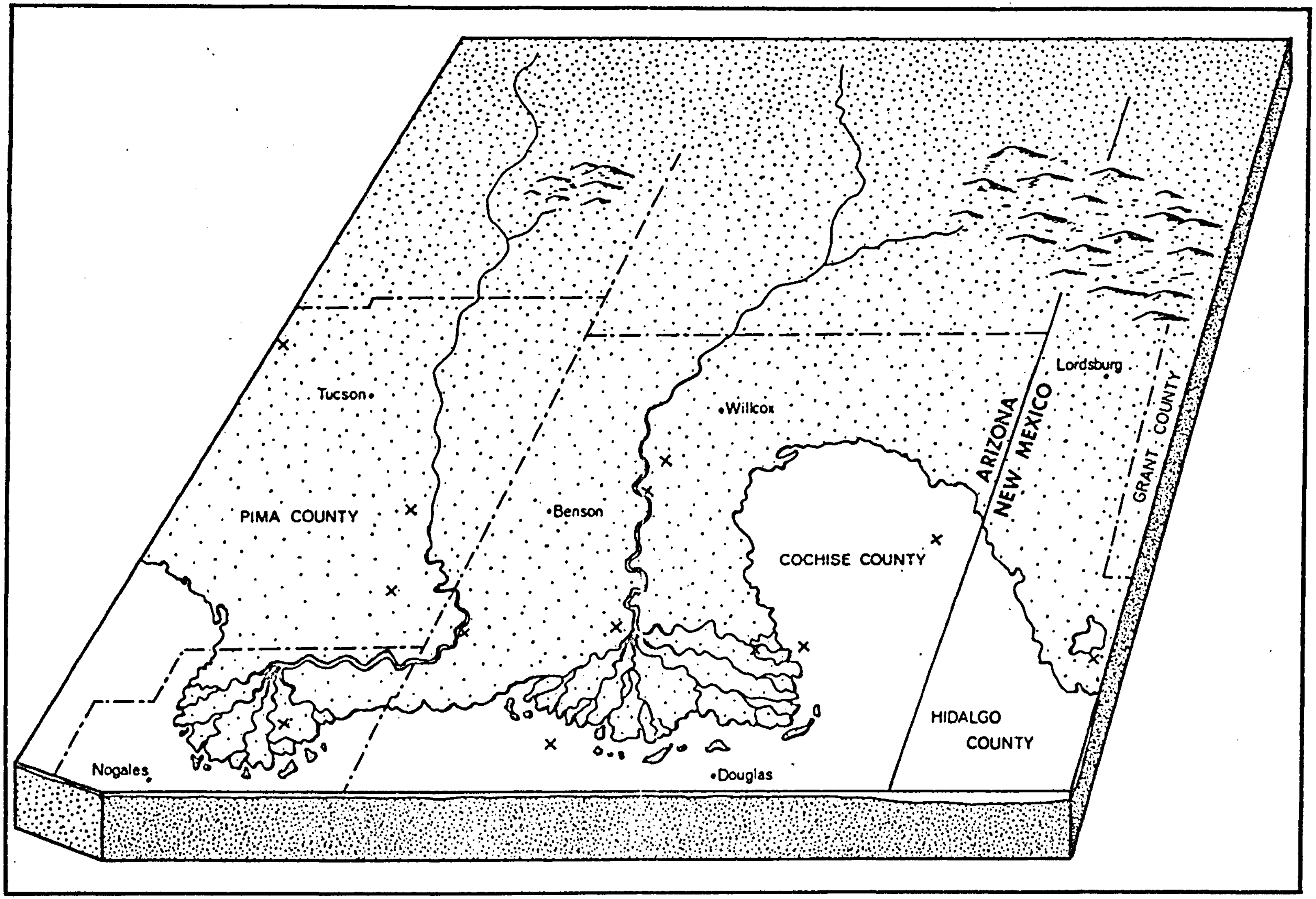

Figure 37. Earlier Wolfcamp Stage Interpretive Map

as large as cobble size. The Pedregosa basin was still receiving mostly carbonate sediments as is seen by the clastic-ratio map. The small lake shown in the Big Hatchet region is included on the basis of the ostracod-rich limestone unit in the section measured there. The most extensive development of the Earp delta probably occurred during earlier Wolfcamp time, based on the above discussion.

The placement of the shoreline as shown in later Wolfcamp time (Figure 39) was drawn on the basis of the upper clastic unit in the Chiricahua Mountains, Pedregosa Mountains, and Guadalupe Canyon area. This unit is interpreted as representing the shifting of the Earp delta to the east near the end of Wolfcamp time. A comparable shifting of deltaic sedimentation has been noted in the development of the Mississippi Delta. The energy of fluvial transport was probably much less because no coarse-grained sediments, such as found in the middle clastic unit in earlier Wolfcamp time, are present.

The remainder of the area is shown as marine because of the time-transgressive nature of the Earp Formation and the dominance of marine sediments above the middle clastic unit in the Gunnison Hills, Colossal Cave area, Whetstone Mountains, and Patagonia Mountains area. In the western part of the study area, Colina Limestone deposition was probably starting in later Wolfcamp time.

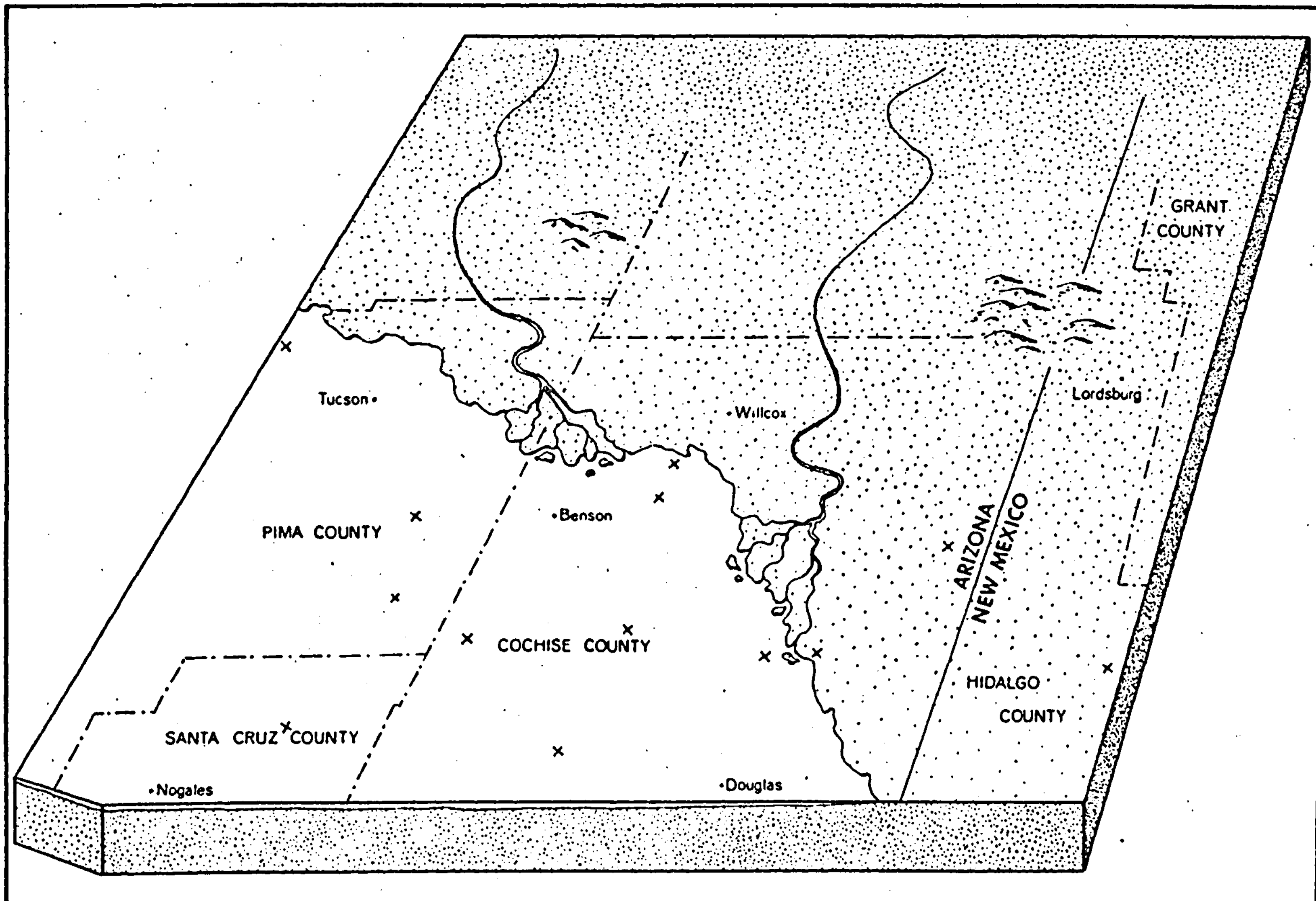

Figure 39. Later Wolfcamp Stage Interpretive Map

SUMMARY

A stratigraphic and petrologic study of fourteen sections of the Permo-Pennsylvanian Earp Formation reveals a complex interfingering of marine, nonmarine, and transitional environments of deposition.

The boundary between Virgil and Wolfcamp time in each section of the Earp Formation was based on:

1. The first appearance of Schwagerina or Pseudoschwagerina, where present.
2. When fusulinid control was not present, on projection from a nearby section with that control.

The presence of Missouri conodonts in the western part of the study area and the successive younger age of the Earp toward the east establish the west-to-east transgressive nature of the Earp Formation.

Heavy mineral suites in all sections were studied and the following results were noted in all these sections:

1. Similar zircon shapes,
2. Similar zircon to tourmaline ratios,
3. Similar tourmaline shapes and pleochroic values, and
4. Similar apatite shapes.

The results indicate a common source for the clastics in the Earp Formation. A heavy mineral separation from one sample of the Supai Formation showed parameters closely resembling those of the Earp. The findings may indicate a common source for the clastics of the Supai and Earp formations.

Evidence for the presence of a delta during Earp time includes:

1. Ratio lines showing a clastic tongue extending from northwest to the southeast, surrounded by carbonate (marine) sediments;
2. Isopach lines showing a thickening of the clastic tongue along its borders in the Colossal Cave, Empire Mountains, and Patagonia Mountains section;
3. A convex-upward geometry as shown by a thinning of the overlying Colina Limestone over the crest of the delta parallel to a line extending from the Waterman to the Empire Mountains; and
4. The presence of sedimentary structures comparable to those found in the Mississippi River Delta.

A supratidal carbonate environment is evidenced by the presence of interlaminated, desiccated rocks of probable algal origin in all sections; pellets with a micritic envelope filled with sparry calcite in all sections; unfossiliferous dolomite; dedolomitization; and "birdseye" structure.

An intertidal carbonate environment is demonstrated by presence of pelmicrites, biomicrites, micrites, and biosparites. A subtidal carbonate environment is probably evidenced by findings of fusulinid biomicrites and biomicrites with preserved delicate tests.

A deltaic, clastic-dominated portion of the Earp Formation is found in the middle portion of the sections in the central part of the study area. A deltaic, clastic-dominated portion of the Earp Formation is found in the upper portion of the sections in the eatern part of the study area. Therefore, stratigraphic position of the deltaic, clastic-dominated portion of the Earp Formation suggests that the Earp delta shifted from west to east during Earp time.

The above findings result in a picture of a delta, prograding into a supratidal to subtidal marine environment from west to east during Earp time.

APPENDIX

LOCATION AND DESCRIPTION OF STRATIGRAPHIC SECTIONS

Big Hatchet Mountains

Exposures are on northeasterly facing slope. Base of section is at the road in the NW1/4 NW1/4 NE1/4 sec. 26, T. 31 S., R 15 W., Big Hatchet Peak quadrangle, 15 minute series. Top of section in SW 1/4 NE1/4 NW1/4 sec. 26, T. 31 s., R. 15 W. Strike N. 35°-40° W.; dip 35°-50° SW.

Permian:

Colina Limestone (unmeasured):

Micrite: grayish-black (N 2), weathers orange (10YR 7/4) and medium gray (N 5); thickly bedded; forms cliff.

Pennsylvanian-Permian:

Earp Formation:

Unit No.		Thickness in feet	Cumulative thickness in feet
53	Covered.	266.0	994.3
52	Siltstone: light brownish gray (5YR 6/1), weathers grayish orange (10YR 7/4); calcitic cement; thinly bedded, ripple laminations; low ridge; partially covered; some anhydrite and dolomite.	4.0	728.3
51	Covered.	51.0	724.3
50	Siltstone: pale yellowish brown (10YR 6/2), weathers moderate yellowish brown (10YR 5/4); calcitic and dolomitic cement; finely to medium crystalline; very thinly bedded, ripple laminated; low, discontinuous ridge; less than 1% anhydrite.	5.5	673.3
49	Covered: float composed mostly of brown silty calcareous claystone.	95.0	667.8
48	Siltstone: pale yellowish brown (10YR 6/2), weathers moderate yellowish brown (10YR 5/4); calcitic and dolomitic cement; thinly to very thinly bedded, parallel and ripple laminated; outcrop mostly covered; less than 1% anhydrite.	5.5	572.8
47	Covered: probably brown silty calcareous claystone.	28.0	567.3

Unit No.		Thickness in feet	Cumulative thickness in feet
46	Calcitic silty dolomite: medium-gray (N 7), weathers pinkish gray (5YR 8/1); finely to medium crystalline; very thinly bedded, ripple and parallel laminations; ridge. . .	2.0	539.3
45	Covered.	13.5	537.3
44	Calcitic silty dolomite: grayish-red (5R 4/2), weathers moderate yellowish brown (10YR 5/4); finely to very finely crystalline; thinly to very thinly bedded, parallel and ripple laminations; low, discontinuous ridge.	2.0	523.8
43	Covered.	12.0	521.8
42	Silty calcitic dolomite: medium-gray (N 7), weathers pinkish gray (5YR 8/1); finely to very finely crystalline; thinly bedded, parallel laminations disrupted by burrowers(?); low ridge.	7.0	509.8
41	Covered.	11.0	502.8
40	Calcitic silty dolomite: medium-gray (N 5), weathers moderate yellowish brown (10YR 5/4) to grayish orange pink (10R 8/2); finely to medium crystalline; very thinly to thinly bedded; ridge.	4.5	491.8
39	Covered.	11.0	487.3
38	Silty calcitic dolomite: pinkish-gray (5YR 8/1), weathers same; finely to very finely crystalline; thinly bedded; slope; unit partially covered.	3.0	476.3
37	Silty calcitic dolomite: pale-red (5R 6/2), weathers light olive gray (5Y 6/1); finely to medium crystalline; ridge; some very fine grained quartz.	2.0	473.3
36	Siltstone: medium-gray (N 5), weathers very light gray (N 9); calcitic and dolomitic cement; very thinly and thinly bedded, parallel and ripple laminations; high ridge.	3.5	471.3

Unit No.		Thickness in feet	Cumulative thickness in feet
35	Covered.	5.0	467.8
34	Calcitic silty dolomite: medium light gray (N 6), weathers grayish orange (10YR 7/4); finely crystalline; very thinly and thinly bedded, parallel laminations; ridge. . . .	5.5	462.8
33	Covered: probably brown calcareous clay. .	50.0	457.3
32	Silty calcitic dolomite: light olive gray (5Y 6/1), weathers grayish orange (10YR 7/4); finely crystalline becoming medium crystalline near top; thinly bedded, parallel laminations often disrupted by burrows (?); low ridge; unit partially covered.	15.0	407.3
31	Calcitic sandy dolomite and dolomitic sandy microsparite: light olive gray (5Y 6/1), weathers moderate yellowish brown (10YR 5/4); finely to medium crystalline; thinly to very thinly bedded, parallel and ripple laminations in bottom and top 5 feet; ledge; unit partly covered; becomes more dolomitic at top; some anhydrite; more sandy in lower part of unit; sand very fine grains.	37.0	392.3
30	Covered: probably white calcareous silty clay.	16.5	355.3
29	Siltstone: pinkish-gray (5YR 8/1), weathers grayish orange (10YR 7/4), medium dark gray (N 4) and light gray (N 7); calcitic and dolomitic cement; thinly to very thinly bedded, ripple laminations in middle 5 feet of unit; ledge; very minor amounts of anhydrite; abundant very fine grained quartz. . .	51.0	338.8
28	Covered: probably white calcareous silty mudstone.	32.5	287.8
27	Quartzarenite: grayish orange pink (10OR 8/2), weathers grayish orange (10YR 7/4) and grayish black (N 2); calcitic and dolomitic cement; fine- to very fine grained, moderately sorted, angular to subangular; thinly to very thinly bedded; low intermittent ridge.	9.0	255.3

Unit No.		Thickness in feet	Cumulative thickness in feet
26	Covered.	18.0	246.3
25	Siltstone: light brownish gray (5YR 6/1), weathers pale yellowish brown (10YR 6/2) to moderate yellowish brown (10YR 5/4); calcitic and dolomitic cement; thinly bedded, ripple and parallel laminations; ridge.	4.0	228.3
24	Covered: probably white calcareous silty claystone.	15.5	224.3
23	Silty claystone: grayish-brown (5YR 3/2), weathers moderate brown (5YR 4/4); calcitic cement; thinly to very thinly bedded, few disturbed parallel laminations; low ridge. .	5.0	208.8
22	Covered.	10.5	203.8
21	Silty calcitic dolomite: medium light gray (N 6), weathers grayish orange (10YR 6/4); finely crystalline; thinly bedded, wavy and parallel laminations; ridge.	5.0	193.3
20	Covered.	4.0	188.3
19	Silty ostracod biomicrosparite: medium dark gray (N 4), weathers medium gray (N 5); thinly bedded; ridge; some foraminifera tests.	2.5	184.3
18	Quartzarenite: pale-red (10R 6/2), weathers grayish orange (10YR 7/4) and moderate brown (5YR 4/4); calcitic and dolomitic cement; fine- to very fine grained; moderately sorted, angular to subangular; thinly to very thinly bedded, parallel laminations sometimes interrupted by round inclusions of very fine sand; ridge.	4.3	181.8
17	Covered: probably white calcareous claystone.	32.0	177.5
16	Calcitic dolomite: brownish-gray (5YR 4/1), weathers light brown (5YR 6/4); finely to very finely crystalline; very thinly bedded, wavy, parallel, and ripple laminations; low ridge.	6.0	145.5

Unit No.		Thickness in feet	Cumulative thickness in feet
15	Siltstone: pale-red (10R 6/2), weathers grayish orange (10YR 7/4) and moderate brown (5YR 4/4); calcitic and dolomitic cement; thinly bedded, parallel and wavy laminations; low ridge; partly covered. . .	13.5	139.5
14	Siltstone: grayish-red (10R 4/2), weathers moderate brown (5YR 4/4); calcitic and dolomitic cement; very thinly bedded, poorly developed parallel laminations; low ridge.	9.0	126.0
13	Covered: probably white calcareous claystone.	20.0	117.0
12	Dolomitic silty microsparite: light olive gray (5Y 6/1); weathers very light gray (N 8); finely to very finely crystalline; thinly bedded; ridge.	7.0	97.0
11	Covered: probably nodular white calcareous silty claystone.	13.0	90.0
10	Siltstone: medium-gray (N 5), weathers light brown (5YR 6/4); calcitic cement; thinly bedded, indistinct parallel laminations; ridge; some anhedral dolomite grains.	1.0	77.0
9	Covered.	1.0	76.0
8	Silty calcitic dolomite: light olive gray (5Y 6/1), weathers brownish gray (5YR 4/1) and olive gray (5Y 5/1); finely to very finely crystalline; thinly bedded, parallel and ripple laminations; low discontinuous ridge; partially covered.	1.0	75.0
7	Covered: probably red calcareous shale. .	20.5	74.0
6	Calcitic dolomite: medium light gray (N 6), weathers pinkish gray (5YR 8/1); finely to medium crystalline; thinly bedded, cross-laminated; low ridge; desiccation cracks(?) filled with ferroan calcite.	10.0	53.5
5	Covered: probably white silty calcareous claystone.	18.0	43.5

Unit No.		Thickness in feet	Cumulative thickness in feet
4	Quartzarenite: medium-gray (N 5), weathers moderate yellowish brown (10YR 5/4); calcitic cement; fine- to very fine grained, moderately sorted, subangular to subrounded; thinly bedded, ripple laminations; ridge; less than 1% anhydrite.	3.5	25.5
3	Mudstone: very light gray (N 8) to bluish white (5B 9/1), weathers same and pinkish gray (5YR 8/1); weak calcitic cement; very thinly bedded; partly covered slope; some nodules.	15.0	22.0
2	Silty calcitic dolomite: moderate greenish yellow (10Y 7/4), weathers light olive gray (5Y 5/2); very finely to finely crystalline; thinly bedded, parallel and ripple laminated; low, discontinuous ridge.	3.0	7.0
1	Conglomerate: pebbles pale yellowish orange (10YR 8/6) and very pale orange (10YR 8/2) in a medium gray (N 5) dolomitic microsparite matrix, weathers moderate orange pink (5YR 8/4); thinly bedded; low, intermittent ridge; micrite pebbles up to 1 cm long and 4 mm wide, subround, poorly sorted; some fossil fragments.	4.0	4.0
	Total of Earp Formation:	994.3	

Horquilla Limestone (unmeasured):

Calcitic dolomite: light brownish gray (5YR 4/1) and brownish gray (5YR 4/1), weathers mottled medium light gray (N 7) and light brownish gray (5YR 6/1); finely to medium crystalline; thinly bedded; ledge; few oolites. . . . .

Chiricahua Mountains

About two miles NW of Portal. Base of section about 3,100 feet S. 55°W. of NE cor. sec. 22, T. 17 S., R. 31 E., Portal quadrangle, 15 minute series, offset approximately 660 feet southeast, 1,342 feet above base. Top of section about 700 feet N. 75° E. of SW cor. sec. 22, T. 17 S., R. 31 E. Strike N. 15°-55° W.; dip 45°-65° SW.

Permian:

Colina Limestone (unmeasured):

Micrite: medium-gray (N 5), weathers same and yellowish gray (5Y 8/1); thinly bedded; ridge; intersecting calcite veins.

Pennsylvanian-Permian:

Earp Formation:

Unit No.		Thickness in feet	Cumulative thickness in feet
135	Quartzarenite: medium dark gray (N 4), weathers medium light gray (N 6) and very pale orange (10YR 8/2); calcite cement, very fine grained, moderately sorted, subangular to subrounded; thinly bedded, parallel and cross laminations; poorly exposed ledge.	5.0	1649.0
134	Siltstone: yellowish-gray (5Y 7/2), weathers grayish orange (10YR 7/4) and pale yellowish brown (10YR 6/2); calcitic cement; thinly to very thinly bedded; poorly exposed ledge.		
133	Covered.	17.0	1641.0
132	Quartzarenite: very pale orange (10YR 8/2), weathers pale yellowish brown (10YR 6/2) and moderate yellowish brown (10YR 5/4); calcitic cement, very fine grained, moderately sorted, subrounded to subangular; thinly bedded, parallel and cross laminated; partly covered ledge.	4.0	1624.0
131	Covered: probably light-gray calcareous mud.	18.0	1620.0

Unit No.		Thickness in feet	Cumulative thickness in feet
130	Siltstone: pale-brown (5YR 5/2), weathers grayish orange (10YR 7/4); thinly bedded, parallel laminations; poorly exposed ledge.	22.0	1602.0
129	Quartzarenite: moderate-red (5YR 5/4) to grayish-red (5R 4/2), weathers light brown (5YR 6/4) to moderate brown (5YR 4/4); calcitic and dolomitic cement, very fine grained, moderately sorted, subrounded to rounded; thinly bedded, parallel and cross laminations; partly covered ledge.	20.0	1580.0
128	Covered.	20.0	1560.0
127	Quartzarenite: yellowish-gray (5Y 7/2), weathers grayish orange (10YR 7/4) and pale yellowish brown (10YR 6/2); calcitic cement, fine- to very fine grained, moderately sorted, subangular to subrounded; thinly bedded, parallel and cross laminations; poorly exposed ledge.	40.0	1540.0
126	Covered: probably red calcareous mudstone.	30.0	1500.0
125	Silty quartzarenite: yellowish-gray (5Y 7/2), weathers same and very pale orange (10YR 8/2); calcitic cement, very fine grain, moderately sorted, subangular to subrounded; thinly to very thinly bedded, parallel laminations; partly covered ledge and slope. . .	18.0	1470.0
124	Clayey siltstone; yellowish-gray (5Y 8/1), weathers same; calcitic cement; thinly bedded, parallel and cross laminations; poorly exposed ledge and slope.	17.0	1452.0
123	Covered: probably red calcareous claystone.	44.0	1435.0
122	Mudstone: pale-red (10YR 6/2), weathers same and grayish orange (10YR 7/4); calcitic cement; thinly to very thinly bedded; very poorly exposed slope.	19.0	1391.0
121	Covered.	10.0	1372.0

Unit No.		Thickness in feet	Cumulative thickness in feet
120	Clayey siltstone: grayish-orange (10YR 7/4), weathers same; calcitic cement; thinly to very thinly bedded, parallel laminations; poorly exposed ledge and slope.	20.0	1362.0
	Offset approximately 660 feet southeast		
119	Silty biopelmicrite: grayish-orange (10YR 7/4) and light-gray (N 7), weathers grayish orange (10YR 7/4); thinly bedded; low, poorly exposed ridge; algae and crinoid stem fragments; some fossil fragments replaced by dolomite.	2.0	1342.0
118	Silty dolomitic micrite: grayish-orange (10YR 7/4), weathers same and light gray (N 7); thinly bedded; low, poorly exposed ridge.	15.0	1340.0
117	Covered.	25.0	1325.0
116	Calcitic dolomite: mottled pale yellowish brown (10YR 6/2) and medium-gray (N 5), weathers dark yellowish brown (10YR 4/2) and dark yellowish orange (10YR 6/6); thinly bedded; low, partly covered ridge. . .	3.0	1300.0
115	Biopelmicrite: medium-gray (N 5), weathers very pale orange (10YR 8/2); thinly bedded; low, partly covered ridge; some ostracod, echinoid spine, and foraminifera fragments.	3.5	1297.0
114	Dolomite: light olive gray (5Y 6/1), weathers grayish orange (10YR 7/4); thinly bedded; low, partly covered ridge; some intersecting dolomite veins.	13.0	1294.5
113	Intraclastic biomicrudite: medium dark gray (N 4), weathers medium light gray (N 6); thinly bedded; low, partly covered ridge; intraclasts rounded; abraded fusulinid, ostracod, and algae fragments; some dolomite patches.	19.0	1281.5

Unit No.		Thickness in feet	Cumulative thickness in feet
112	Dolomite: medium dark gray (N 4), weathers pale yellowish brown (10YR 6/2); finely crystalline; thinly bedded; low, partly covered ridge; intersecting calcite veins. .	16.0	1262.5
111	Covered.	5.0	1246.5
110	Dolomite: mottle pale yellowish-brown (10YR 6/2) and light-gray (N 7), weathers grayish orange (10YR 7/4) and medium light gray (N 6); very finely crystalline; thinly bedded; partly covered ridge; intersecting calcite veins.	2.0	1241.5
109	Covered.	3.0	1239.5
108	Crinoid stem biomicrosparite: light-gray (N 7) to medium light gray (N 6), weathers olive gray (5Y 6/1) and pale yellowish brown (10YR 6/2); thinly bedded; ridge; *Pseudoschwagerina* sp.	9.0	1236.5
107	Covered.	36.0	1227.5
106	Biomicrosparite: medium dark gray (N 4), weathers light olive gray (5Y 6/1); thinly bedded; ridge and dip slope; unidentifiable fossil hash; some dolomite patches; intersecting calcite veins.	3.0	1191.5
105	Covered.	8.5	1188.5
104	Biomicrudite: medium dark gray (N 4) and medium-gray (N 5), weathers grayish orange (10YR 7/4) and medium light gray (N 6); thinly bedded; crinoid stem, pelecypod, and brachiopod fragments.	13.0	1180.0
103	Biomicrosparite: medium light gray (N 6), weathers same and pinkish gray (5YR 8/1); thinly bedded; ridge and dip slope partly covered with talus; foraminifera and algae fragments.	15.0	1167.0
102	Biopelsparite: medium-gray (N 5), weathers grayish orange (10YR 7/4); thinly bedded; ridge and dip slope badly covered by talus; algae and foraminifera fragments; some fossil fragments replaced by dolomite. . .	18.0	1152.0

Unit No.		Thickness in feet	Cumulative thickness in feet
101	Biomicrite: medium light gray (N 6), weathers same and grayish orange (10YR 7/4); thinly bedded; ridge and dip slope partly covered by talus; foraminifera, algae, and crinoid stem fragments.	16.0	1134.0
100	Biopelmicrite: medium-gray (N 5), weathers yellowish gray (5Y 8/1); thinly bedded; ridge and dip slope; abundant foraminifera and ostracod fragments; some dolomite patches.	3.0	1118.0
99	Biomicrite: medium light gray (N 6), weathers moderate yellowish brown (10YR 5/4) and medium light gray (N 6); thinly bedded; ridge and dip slope; undistinguishable fossil hash; some dolomite patches. . . .	5.0	1115.0
98	Calcitic biogenic dolomite: medium light gray (N 6), weathers grayish orange (10YR 7/4); finely to very finely crystalline; thinly bedded; ridge and dip slope; echinoid spines, foraminifera, algae, and shell fragments.	23.0	1110.0
97	Dismicritic dolomite: medium-gray (N 5), weathers grayish orange (10YR 7/4); finely to very finely crystalline; thinly bedded; ridge and dip slope; intersecting dolomite and calcite veins.	19.0	1087.0
96	Biomicrosparite: medium-gray (N 5), weathers same; thinly bedded; ridges and dip slope; ostracod, foraminifera and algae fragments, abundant crinoid stem fragments 1049-1050 feet; some anhedral and euhedral dolomite grains.	86.0	1068.0
95	Ferroan dolomite: moderate yellowish brown (10YR 5/4) and medium-gray (N 5), weathers grayish orange (10YR 7/4); finely crystalline; thinly bedded; ridge and dip slope; small calcite veinlets.	2.0	1042.0
94	Covered.	5.0	1040.0

Unit No.		Thickness in feet	Cumulative thickness in feet
93	Silty fossiliferous micrite: medium-gray (N 5), weathers same; thinly bedded; ridge; some algae gragments and dolomite grains.	5.0	1035.0
92	Silty dolomite: dark-gray (N 3), weathers grayish orange (10YR 7/4); very thinly crystalline; thinly to very thinly bedded; ridge; some small irregular "eyes" filled with fibrous quartz.	4.0	1030.0
91	Covered.	31.0	1026.0
90	Bituminous biomicrite: dark-gray (N 3), weathers medium dark gray (N 4); thinly bedded; ridge; foraminifera, algae, and shell fragments; <u>Schwagerina</u> <u>loringi</u>, <u>S</u>. providens.	3.0	995.0
89	Covered.	3.0	992.0
88	Biomicrite: medium dark gray (N 4), weathers light olive gray (5Y 6/1); thinly bedded; ridge; foraminifera and shell fragments; some dolomite patches; bituminous matter.	9.0	989.0
87	Pelmicrite: medium dark gray (N 4), weathers medium gray (N 5) and moderate yellowish brown (10YR 5/4); thinly bedded; ridge; few shell fragments.	9.0	980.0
86	Fossiliferous micrite: medium-gray (N 5), weathers pale yellowish brown (10YR 6/2); thinly bedded; ridge; some crinoid stem and ostracod fragments; scattered dolomite patches.	10.0	972.0
85	Covered.	9.0	962.0
84	Dolomitic biomicrite: medium dark gray (N 4), weathers grayish orange (10YR 7/4); thinly bedded; ledge; foraminifera, crinoid stem, ostracod fragments; some dolomite patches.	13.0	953.0
83	Dolomitic microsparite: light brownish gray (5YR 6/1), weathers moderate yellowish brown (10YR 5/4); thinly bedded; poorly exposed slope.	20.0	940.0

Unit No.		Thickness in feet	Cumulative thickness in feet
82	Biomicrite: dark-gray (N 3), weathers moderate yellowish brown (10YR 5/4); thinly bedded: ridge; some gypsum laths and dolomite patches; intersecting calcite veins; bituminous matter.	5.0	920.0
81	Biopelmicrite: medium dark gray (N 7), weathers pale yellowish brown (10YR 6/2) and light brown (5YR 5/6); thinly bedded; partly covered ridge; some pellets and fossil fragments surrounded by micritic envelope filled with sparry calcite; shell, algae, and foraminifera fragments; some dolomite patches.	18.0	915.0
80	Bituminous dolomite: dark-gray (N 3), weathers same; very finely crystalline; poorly exposed ridge and slope; few patches of calcite; intruded by lamprophyric dikes.	30.5	897.0
79	Biomicrite: medium dark gray (N 4) and dark-gray (N 3), weathers pale yellowish brown (10YR 6/2); thinly bedded; hogback; abundant bituminous matter; chert pods near middle of unit; algae, foraminifera, and shell fragments; Triticites creenkensis.	31.0	866.5
78	Covered: probably light-brown calcareous mudstone.	19.0	835.5
77	Biomicrite: dark-gray (N 3), weathers light olive gray (5Y 6/1); thinly bedded; hogback; algae, foraminifera, and shell fragments. .	10.0	816.5
76	Fusulinid biosparite: medium dark gray (N 4), weathers grayish orange (10YR 7/4); thinly bedded; hogback; abundant bituminous matter; *Schwagerina silverensis*, *S. compacta*, *S.* sp.	3.0	806.5
75	Covered.	4.0	803.5
74	Dolomite: mottled medium light gray (N 6) and light-brown (5YR 5/6), weathers very pale orange (10YR 8/2) and grayish orange (10YR 7/4); thinly bedded; low ridge; some calcite veins.	2.0	799.5

Unit No.		Thickness in feet	Cumulative thickness in feet
73	Siltstone: light olive-gray (5Y 6/1), weathers very pale orange (10YR 8/2) to grayish orange (10YR 7/4); ferroan calcite cement; thinly bedded; low, partly covered ridge.	6.0	797.5
72	Covered.	9.0	793.5
71	Biomicrite: medium dark gray (N 4), weathers grayish orange (10YR 7/4) and olive gray (5Y 4/1); thinly bedded; low, partly covered ridge; crinoid stem, algae, ostracod, and shell fragments; some small dolomite patches.	3.5	784.5
70	Covered: probably light-gray fossiliferous claystone.	5.0	781.0
69	Biomicrite: medium dark gray (N 4), weathers grayish orange (10YR 7/4 and olive gray (5Y 4/1); thinly bedded; ridge; foraminifera and algae fragments; few dolomite patches.	5.0	776.0
68	Covered.	5.0	771.0
67	Dolomitic biomicrite: dark-gray (N 3), weathers medium light gray (N 6); thinly bedded; low hogback; uniserial-biserial foraminifera, algae, ostracod, and crinoid stem fragments; few dolomite patches and silt-size quartz grains; _Schwagerina silverensis_, _Rugofusulina_ sp.	15.0	766.0
66	Covered: probably brown calcareous siltstone.	14.0	751.0
65	Siltstone: medium-gray (N 5), weathers pale yellowish brown (10YR 6/2); calcitic and dolomitic cement; thinly bedded, parallel and cross laminations; partly covered slope; clayey interlaminations.	5.0	737.0
64	Covered: probably white fossiliferous silty claystone.	11.0	732.0

Unit No.		Thickness in feet	Cumulative thickness in feet
63	Fusulinid biomicrite: medium-gray (N 5), weathers grayish orange pink (5YR 7/2); thinly bedded; ridge; Schwagerina silverensis, S. grandensis, Triticites creekensis, T. sp.	10.0	721.0
62	Intramicrudite: medium light gray (N 6), weathers mottled grayish orange (10YR 7/4) and medium light gray (N 6); thinly bedded; hogback; algae, foraminifera, and shell fragments; some small patches of dolomite.	39.0	711.0
61	Covered.	6.0	672.0
60	Calcitic biogenic dolomite: medium-gray (N 5), weathers dark yellowish orange (10YR 6/6); thinly bedded; low hogback; fossils, partically calcite and partially dolomite. .	15.0	666.0
59	Biomicrite: medium light gray (N 6), weathers same and light olive gray (5Y 6/1); thinly bedded; high ridge; abundant foraminifera and algae fragments.	15.0	651.0
58	Ferroan dolomite: medium light gray (N 6), weathers mottled dark yellowish orange (10YR 6/6) and moderate yellowish brown (10YR 5/4); finely crystalline; thinly bedded; ledge.	35.0	636.0
	Fault: erratic strikes.		
57	Covered: probably light-gray fossiliferous calcareous claystone.	25.0	601.0
56	Dolomitic biomicrite: dark-gray (N 3), weathers moderate yellowish brown (10YR 5/4); thinly bedded; ridge; fossil fragments are calcite; groundmass is dolomite; some silt-size quartz; bituminous matter. . . .	15.0	576.0
55	Covered.	5.0	561.0
54	Fusulinid biomicrite: medium dark gray (N 4), weathers same; thinly bedded; ridge; abundant bituminous material; some algae and shell fragments; Schwagerina compacta, S. silverensis, S. grandensis, Triticites creekensis, T. sp., T. cf. plummeri. . .	5.5	556.0

Unit No.		Thickness in feet	Cumulative thickness in feet
53	Calcitic dolomite: medium dark gray (N 4), weathers yellowish gray (5Y 8/1) and brownish gray (5YR 4/1); thinly bedded; high ridge; scattered silt-size quartz grains.	12.0	550.5
52	Fusulinid biogenic calcitic dolomite: medium dark gray (N 4), weathers same and pale yellowish brown (10YR 6/2); thinly bedded; ridge; bituminous matter; *Schwagerina compacta*.	3.0	538.5
51	Covered.	4.5	535.5
50	Biosparite: medium-gray (N 5), weathers pale yellowish brown (10YR 6/2), grayish orange (10YR 7/4), and light olive gray (5Y 6/1); thinly bedded; ridge; abundant small foraminifera; some small dolomite patches.	5.0	531.0
49	Fusulinid biomicrite: medium dark gray (N 4) and medium-gray (N 5), weathers light olive gray (5Y 6/1); thinly bedded; low hogback; some silt-size quartz and dolomite patches; abundant bituminous matter; *Triticites creekensis*, *Schwagerina silverensis*.	9.5	526.0
48	Silty biomicrite: medium-gray (N 5), weathers light olive gray (5Y 6/1); thinly bedded; high ridge; crinoid stem, algae, and foraminifera fragments; some fossil fragments filled with microcrystalline quartz; some dolomite patches.	10.0	516.5
47	Covered.	10.0	506.5
46	Biomicrite: medium dark gray (N 4), weathers light olive gray (5Y 6/1); thinly bedded; hogback; foraminifera, algae, echinoid spine fragments; some dolomite patches. .	15.0	496.5
45	Fusulinid biomicrite: dark-gray (N 3), weathers light olive gray (5Y 6/1); thinly bedded; hogback; bituminous matter and algae fragments; some chert pods; *Schwagerina grandensis*, *Triticites creekensis*.	16.0	481.5

Unit No.		Thickness in feet	Cumulative thickness in feet
44	Biomicrite: medium dark gray (N 4), weathers dark yellowish brown (10YR 4/2); thinly bedded; low, partly covered ridge; some dolomite patches; fossil fragments broken to silt-size particles; some bituminous matter.	15.5	465.5
43	Covered: probably white calcareous silty claystone.	22.0	450.0
42	Biomicrosparite: medium dark gray (N 4) to dark-gray (N 3), weathers yellowish gray (5Y 8/1) and light olive gray (5Y 6/1); thinly bedded; ridge; foraminifera and algae fragments; some bituminous matter. . . .	16.0	428.0
41	Covered: probably light-brown calcareous siltstone.	14.0	412.0
40	Biosparite: medium dark gray (N 4), weathers grayish orange (10YR 7/4); thinly to very thinly bedded; low, partly covered ridge; abundant small foraminifera fragments.	2.0	398.0
39	Covered.	2.0	396.0
38	Dolomitic biosparrudite: medium dark gray (N 4), weathers moderate yellowish brown (10YR 5/4); thinly bedded; low, partly covered ridge; fossil fragments rounded. .	2.0	394.0
37	Covered.	2.0	392.0
36	Silty micrite: medium dark gray (N 4), weathers light olive gray (5Y 6/1); thinly bedded; ridge; desiccation cracks; intersecting calcite veins.	11.0	390.0
35	Covered.	9.0	379.0
34	Silty biomicrite: medium dark gray (N 4), weathers yellowish gray (5Y 8/1); thinly to very thinly bedded; low, partly covered ridge; crinoid stem and shell fragments; some bituminous material.	2.0	370.0
33	Covered.	14.5	368.5

Unit No.		Thickness in feet	Cumulative thickness in feet
32	Micrite: medium dark gray (N 4), weathers grayish orange (10YR 7/4); thinly bedded; high ridge; few crinoid stem fragments; abundant intersecting calcite veins. . . .	2.0	354.0
31	Biopelsparite: medium light gray (N 6), weathers light gray (N 7) and yellowish gray (5Y 7/2); thinly bedded; high ridge; abundant fusulinids; Triticites sp.	12.0	352.0
30	Covered: probably light-gray calcareous claystone.	10.0	340.0
29	Micrite: medium dark gray (N 4), weathers medium light gray (N 6); thinly bedded; ridge; some silt-size quartz grains and dolomite patches; abundant intersecting calcite veins.	6.0	330.0
28	Dolomitic biomicrosparite: medium-gray (N 5), weathers moderate yellowish brown (10YR 5/4); thinly bedded; low hogback; crinoid stem and algae fragments; some bituminous matter.	5.0	324.0
27	Covered.	15.0	319.0
26	Biomicrite: medium dark gray (N 4), weathers light brownish gray (5YR 6/1); thinly bedded; low, partly covered ridge; abundant shell, crinoid stem, and algae fragments; some shell fragments replaced by dolomite; some dolomite patches near top of unit. . .	14.0	304.0
25	Covered: probably tan calcareous mudstone.	25.0	290.0
24	Microsparite: medium-gray (N 5), weathers dark yellowish brown (10YR 4/2); thinly bedded; low, partly covered ridge; scattered shell and algae (?) fragments.	10.0	265.0
23	Covered: probably light-brown calcareous mudstone.	10.0	255.0

Unit No.		Thickness in feet	Cumulative thickness in feet
22	Biomicrosparite: medium-gray (N 5) to medium dark gray (N 4), weathers medium gray (N 5) and very pale orange (10YR 8/2); thinly bedded; small hogback; foraminifera, ostracod, and algae (?) fragments; some patches of dolomite.	35.0	245.0
21	Covered.	10.0	210.0
20	Algae microsparite: medium-gray (N 5), weathers same and light olive gray (5Y 6/1); thinly bedded; ridge; Triticites pinquis, T. rhodesi.	5.0	200.0
19	Covered.	28.0	195.0
18	Foraminiferal biosparite: medium dark gray (N 4), weathers moderate yellowish brown (10YR 5/4); thinly bedded; ridge; some shell and algae fragments.	2.0	167.0
	Fault: erratic strikes.		
17	Covered.	40.5	165.0
16	Biomicrosparite: medium-gray (N 5), weathers grayish orange (10YR 7/4); thinly bedded; low, partly covered series of ridges; pelecypod fragments; abundant intersecting calcite veins.	22.5	124.5
15	Clayey siltstone: olive-gray (5Y 4/1); weathers yellowish brown (10YR 4/2); calcitic cement; very thinly bedded; low, partly covered ridge.	2.0	102.0
14	Biosparite: medium-gray (N 5), weathers medium light gray (N 6) and yellowish gray (5Y 8/1); thinly bedded; ridge; foraminifera and algae fragments; some dolomite patches.	8.0	100.0
13	Covered.	3.0	92.0
12	Biosparite: medium-gray (N 5), weathers same and yellowish gray (5Y 8/1); thinly bedded; partly covered ridge; foraminifera and algae fragments; few dolomite patches.	9.0	89.0

Unit No.		Thickness in feet	Cumulative thickness in feet
11	Biogenic dolomite: brownish-gray (5YR 4/1), weathers light olive gray (5Y 6/1); finely to very finely crystalline; thinly bedded; ledge; foraminifera, ostracod, and algae fragments.	10.0	80.0
10	Biosparite: light brownish gray (5YR 6/1), weathers same and yellowish gray (5Y 8/1); thinly bedded; ridge; ostracod, crinoid stem, foraminifera, and algae fragments. .	8.0	70.0
9	Silty micrite: medium dark gray (N 4), weathers light olive gray (5Y 6/1); thinly bedded, laminations; ridge; interlaminations of silt.	10.5	62.0
8	Biosparite: medium light gray (N 6), weathers light gray (N 7); thinly bedded; low, partly covered ridge; uniserial and biserial foraminifera, crinoid stem, and algae fragments; few patches of dolomite.	2.0	51.5
7	Covered.	2.0	49.5
6	Biosparite: medium light gray (N 6), weathers light gray (N 7); thinly bedded; ridge; uniserial-biserial foraminifera, algae, and wood fragments.	8.0	47.5
5	Covered.	7.5	39.5
4	Foraminiferal biosparite: medium light gray (N 6), weathers same and moderate yellowish brown (10YR 5/4); thinly bedded; low, partly covered ridge; biserial and uniserial foraminifera, algae fragments; _Pseudoschwagerina_ sp., _Schubertella kingi_.	2.0	32.0
3	Dismicritic dolomite: medium-gray (N 5), weathers moderate yellowish brown (10YR 5/4); thinly bedded; ridge; some irregular stringers of bituminous matter.	5.0	30.0
2	Dolomite: medium-gray (N 5), weathers same and moderate yellowish brown (10YR 5/4); medium crystalline; thinly bedded; slope.	15.0	25.0

Unit No.		Thickness in feet	Cumulative thickness in feet
1	Ferroan dolomite: medium-gray (N 5), weathers same and moderate yellowish brown (10YR 5/4); coarsely crystalline; thinly bedded; slope; some bituminous matter.	10.0	10.0
	Total of Earp Formation	1649.0	

Horquilla Limestone (unmeasured):

Dismicrite: medium-gray (N 5), weathers same; thinly bedded; slope; abundant intersecting calcite veins.

Colossal Cave Area

SE1/4NE1/4 and NE1/4NE1/3 sec. 4, T. 16 S., R. 17 E., Rincon Valley quadrangle, 15 minute series. Exposures on northerly facing slopes on south side of Posta Quemada Canyon and southerly facing slopes on north side of Posta Quemada Canyon. Strike S. 75°-80° E.; dip 20°-30° SE on south side of canyon and 20°-30° NE on north side of canyon.

Permian:

Colina Limestone (unmeasured):

Dolomite: dark-gray (N 3), weathers medium light gray (N 6); finely crystalline; thinly to thickly bedded; cliff; some intersecting calcite veins.

Pennsylvanian-Permian:

Earp Formation:

Unit No.		Thickness in feet	Cumulative thickness in feet
57	Covered.	35.0	555.0
56	Biomicrite: yellowish-gray (5Y 8/1), weathers grayish orange (10YR 7/4); thinly to very thinly bedded; partly covered ridge; foraminifera, crinoid stem and algae (?) fragments; few micritic intraclasts; unit becomes slightly silty near top.	4.0	520.0
55	Covered.	4.0	516.0
54	Pelletiferous dolomite: pinkish-gray (5YR 8/1), weathers grayish orange (10YR 7/4); thinly bedded; ledge; some intersecting calcite veins.	2.5	512.0
53	Dolomite: medium light gray (N 6), weathers same and pale yellowish orange (10YR 8/6); thinly bedded; ledge; intersecting calcite veins; few slit-size quartz; unit brecciated near top.	2.0	509.5
52	Covered.	19.0	507.5

Unit No.		Thickness in feet	Cumulative thickness in feet
51	Dolomite: brownish-gray (5YR 4/1), weathers yellowish gray (5Y 8/1); thinly bedded; ledge; some intersecting calcite veins; few silt-size quartz.	5.0	488.5
50	Biogenic dolomite: medium-gray (n 5), weathers grayish orange (10YR 7/4); medium to finely crystalline; thinly bedded; ledge; some intersecting calcite and dolomite veins; shell and crinoid stem fragments. .	10.0	483.5
49	Covered: probably like unit 48.	1.0	473.5
48	Siltstone: light olive-gray (5Y 6/1), weathers grayish orange (10YR 7/4); dolomitic cement; thinly to very thinly bedded; partly covered ridge; some animal burrows (?).	3.0	472.5
47	Covered:	2.0	469.5
46	Algae biolithite (?): light-gray (n 7), weathers grayish orange (10YR 7/4); thinly bedded, interlaminations of bituminous matter; partly covered ridge; sparry calcite in irregular patches parallel with the bedding.	4.0	467.5
45	Covered.	10.0	463.5
44	Calcitic dolomite: very pale orange (10YR 8/2), weathers same; finely crystalline; thinly bedded; ledge; parallel laminations; abundant intersecting calcite veins. . . .	3.0	453.5
43	Intrasparite: medium-gray (N 5), weathers same and grayish orange pink (5YR 7/2); thinly bedded; ledge; intraclasts composed of parallel laminated micrite.	2.0	452.5
42	Silty microsparite: grayish-orange (10YR 7/4), weathers same; thinly bedded; ledge; abundant intersecting calcite veins. . . .	2.5	450.5
41	Covered.	4.5	448.0

Unit No.		Thickness in feet	Cumulative thickness in feet
40	Siltstone: pale red purple (5RP 6/2), weathers grayish orange (10YR 7/4); calcitic cement; thinly bedded; partly covered ridge.	3.0	443.5
39	Covered.	23.0	440.5
38	Calcitic dolomite: pale-pink (5RP 8/2), weathers grayish orange (10YR 7/4); thinly to very thinly bedded; ledge; abundant intersecting calcite veins.	3.0	417.5
37	Microsparite: medium-gray (N 5), weathers pinkish gray (5YR 8/1); thinly bedded; ledge; calcite veins.	0.5	414.5
36	Dolomitic biomicrosparite: medium dark gray (N 4), weathers pinkish gray (5YR 8/1; thinly bedded; ledge; foraminifera, algae and shell fragments; abundant calcite veins.	1.0	414.0
35	Siltstone: grayish orange-pink (5YR 7/2), weathers very pale orange (10YR 8/2) to grayish orange (10YR 7/4); dolomitic cement; thinly bedded, ripple laminations and liesegang rings; ledge.	2.0	413.0
34	Dolomite: very pale orange (10YR 8/2) to pale yellowish orange (10YR 8/6); weathers very pale orange (10YR 8/2); very finely crystalline; thinly bedded; ledge; abundant dolomite and calcite veins.	1.5	411.0
33	Covered.	3.0	409.5
32	Dolomite: very pale orange (10YR 8/2), weathers grayish orange (10YR 7/4); very finely crystalline; thinly bedded, parallel laminations; ridge; few calcite veins. . .	2.0	406.5
31	Silty dolomite: pinkish-gray (5YR 8/1), weathers grayish orange (10YR 7/4); very finely crystalline; thinly bedded; partly covered ridge; some small calcite patches.	2.0	404.5
30	Covered.	3.0	402.5

Unit No.		Thickness in feet	Cumulative thickness in feet
29	Dolomite: medium-gray (N 5), weathers very pale orange (10YR 8/2) and yellowish gray (5Y 8/1); very finely crystalline; thinly bedded; ridge; abundant intersecting calcite veins.	2.0	399.5
28	Covered.	3.0	397.5
27	Pelletiferous microsparite: medium light gray (N 6), weathers same; thinly bedded; ridge; distinctive rough weathered surface; some small dolomite patches.	5.5	394.5
26	Pebble conglomerate: moderate-red (5R 4/6) pebbles with moderate pink (5R 7/4) groundmass, weathers moderate brown (5YR 3/4) to light brown (5YR 5/6); calcitic and dolomitic cement; chert pebbles up to 5 mm in diameter, average 2 mm; poor sorting; thinly bedded; ridge.	3.0	386.0
25	Quartzarenite: moderate-red (5R 4/6), weathers pale red (5R 6/2); calcitic and dolomitic cement; fine- to very fine-grained; moderately sorted; subangular to subrounded; thinly bedded; slope; some feldspar grains.	5.5	382.0
24	Siltstone: moderate-red (5R 5/4) to pale-red (5R 6/2), weathers pale red (5R 6/2) to grayish orange pink (5YR 7/2); calcitic cement; thinly bedded, ripple laminations; partly covered slope; unit may be faulted.	25.0	376.5
23	Biomicrite: dark-gray (N 3), weathers medium gray (N 5); thinly bedded; partly covered ridge; fragmented algae plates, shell fragments and foraminifera; some bituminous matter; many intersecting calcite veins.	1.0	351.5
22	Covered.	8.0	350.5
21	Biomicrite: dark-gray (N 3), weathers medium gray (N 5); thinly bedded; partly covered ridge; fragmented algae plates, shell fragments and foraminifera; some bituminous matter; many intersecting calcite veins.	6.0	342.5

Unit No.		Thickness in feet	Cumulative thickness in feet
20	Covered.	5.0	336.5
19	Dolomitic micrite: dark-gray (N 3), weathers grayish orange (10YR 7/4); thinly bedded; partly covered ridge.	3.0	331.5
18	Covered.	13.0	328.5
17	Fossiliferous micrite: medium dark gray (N 4), weathers dark yellowish orange (10YR 6/6); thinly bedded; ledge; pelecypod and foraminifera fragments; some small patches of dolomite.	10.0	315.5
	Section shifted north 1,500 feet to north side of Posta Quemada Canyon behind cabin site.		
16	Fossiliferous microsparite: medium light gray (N 6), weathers grayish orange (10YR 7/4); thinly bedded; very poorly exposed ridge; some small patches of dolomite in thin section; shell, algae and crinoid stem fragments; abundant intersecting calcite veins.	30.0	305.5
15	Covered.	20.0	275.5
14	Fossiliferous dolomitic pelmicrite: mottled light gray (N 7) and pale yellowish orange (10YR 8/6) patches along fractures, weathers medium dark gray (N 4); thinly bedded; partly covered ledge; abundant intersecting calcite veins; some brecciated rock in veins; chert pods and stringers; <u>Triticites</u> whetstonensis.	11.5	255.5
13	Fossiliferous microsparite: medium dark gray (N 4), weathers dark gray (N 3); thinly bedded; partly covered ledge; some intersecting calcite veins; shell fragments and foraminifers; <u>Triticites</u> <u>bensonensis</u>, <u>T</u>. coronadoensis.	13.0	244.0
12	Calcitic dolomitic siltstone: grayish-red (5R 4/2), weathers same; thinly to very thinly bedded; partly covered ridge; some mottling caused by local concentrations of iron oxide.	11.0	244.0

Unit No.		Thickness in feet	Cumulative thickness in feet
11	Covered.	44.0	220.0
10	Pelmicrite: medium-gray (N 5), weathers dark greenish gray (5GY 4/1); thinly bedded; ledge; interesecting calcite veins, some intersecting calcite veins.	17.0	176.0
9	Fossiliferous micrite: medium dark gray (N 4), weathers light gray (N 7); thinly bedded; ledge; crinoid stem, foraminifera and echinoid spine fragments; few small patches of dolomite.	13.0	159.0
8	Dolomitic micrite: yellowish-gray (5Y 8/1), weathers very light gray (N 8); thinly to very thinly bedded; ledge; desiccation cracks; intersecting calcite veins; Triticites cf. T. plummeri.	6.0	146.0
7	Covered.	21.0	140.0
6	Pelletiferous dolomitic biosparite: mottled medium light gray (N 6) and grayish-orange (10YR 7/4), weathers same; thinly bedded; ridge; foraminifera, shell and algae(?) fragments; intersecting calcite veins.	4.0	119.0
5	Covered.	52.0	115.0
4	Fossiliferous microsparite: pinkish-gray (5YR 8/1), weathers dark greenish gray (5GY 4/1); thinly bedded; ridge; crinoid stem, algae(?) and foraminfera fragments; some small patches of dolomite; intersecting calcite veins; some chert pods. . . .	14.0	63.0
3	Covered.	7.0	49.0
2	Fossiliferous micrite: light brownish-gray (5YR 6/1), weathers medium gray (N 5); thinly bedded; partly covered ridge; chert pods, intersecting calcite veins; foraminifera and algae(?) fragments.	10.0	42.0
1	Covered.	32.0	32.0
	Total Earp Formation	550.0	

Horquilla Limestone (unmeasured):

Pelletiferous biosparite: pinkish-gray (5YR 8/1), weathers grayish orange (10YR 7/4); thinly to thickly bedded; cliff; shell and crinoid stem fragments; abundant intersecting calcite veins.

Dragoon Mountains

Extreme northeastern tip of Dragoon Mountains just west of Golden Rule mine. Base of section in saddle 1,800 feet S. 30° E. of NW cor. sec. 23, T. 17 S., R. 23 E., Cochise quadrangle, 15 minute series. Top of section at base of cliff 2,000 feet S. 3° E. of same corner. Strike N. 50° W.; dip 65°-25° SW.

Permian:

Colina Limestone (unmeasured):

Dolomitic biopelmicrosparite: pinkish-gray (5YR 8/1), weathers grayish orange (10YR 7/4); thickly bedded; cliff.

Pennsylvanian-Permian:

Earp Formation:

Unit No.		Thickness in feet	Cumulative thickness in feet
79	Covered: probably white calcareous claystone.	5.0	455.5
78	Siltstone: pinkish-gray (5YR 8/1), weathers light brown (5YR 5/6); calcitic and dolomitic cement; thinly bedded, cross-laminations; ledge.	2.0	450.5
77	Algae biolithite: interlaminated light-gray (N 7) and pinkish-gray (5YR 8/1), weathers yellowish gray (5Y 8/1); thinly and very thinly bedded; ledge; interlaminations of calcite-rich layers and dolomite-rich layers; some laminations of silt-size quartz. . . .	2.0	448.5
76	Sandy siltstone: pinkish-gray (5YR 8/1), weathers moderate yellowish brown (10YR 5/4) and grayish orange (10YR 7/4); calcitic and dolomitic cement; thinly bedded; cross-laminated; ledge.	2.0	446.5
75	Siltstone: yellowish-gray (5Y 8/1), weathers light brownish gray (5YR 6/1); calcitic and dolomitic cement; thinly to very thinly bedded; ledge.	2.0	444.5

Unit No.		Thickness in feet	Cumulative thickness in feet
74	Sandy calcitic dolomite: grayish orange pink (5YR 7/2), weathers light brown (5YR 6/4); thinly bedded, parallel laminations; lege; clayey interlaminations.	2.0	442.5
73	Covered: probably white calcareous claystone.	7.0	440.5
72	Microsparite: dark yellowish orange (10YR 6/6), weathers very pale orange (10YR 8/2) and light gray (N 7); thinly to very thinly bedded; partly covered ledge; some small irregular dolomite patches; iron oxide cubes after pyrite in top three feet of unit. . . .	19.0	433.5
71	Covered.	9.0	414.5
70	Microsparite: medium-gray (N 5), weathers very pale orange (10YR 8/2) and grayish orange (10YR 7/4); thinly bedded; partly covered ridge; few small irregular patches of quartz and dolomite; iron oxide cubes after pyrite.	19.0	405.5
69	Microsparite: very light gray (N 8), weathers pinkish gray (5YR 8/1); thinly bedded, parallel laminations; poorly exposed ledge; few laminae of silt-size quartz.	17.0	396.5
68	Gypsiferous siltstone: dark greenish gray (5GY 4/1), weathers same; very thinly bedded; very poorly exposed slope; desiccation cracks filled with quartz and sparry calcite; iron oxide cubes after pyrite. . .	8.0	379.5
67	Microsparite: light-gray (N 7), weathers yellowish gray (5Y 8/1); thinly bedded; partly covered ledge; some small patches of anhedral dolomite and quartz; scattered iron oxide cubes after pyrite.	3.0	371.5
66	Quartzarenite: greenish-black (5GY 2/1), weathers very pale orange (10YR 8/2) to grayish orange (10YR 7/4); dolomitic and calcitic cement; fine-grained, moderately sorted; subangular to subrounded; thinly bedded; poorly exposed ledge; few feldspar and mica grains.	7.0	368.5

Unit No.		Thickness in feet	Cumulative thickness in feet
65	Microsparite: medium-gray (N 5), weathers medium light gray (N 6); thinly bedded; partly covered ridge; scattered anhedral dolomite grains and fine silt-size quartz. .	2.0	361.5
64	Covered.	6.0	359.5
63	Microsparite: light brownish gray (5YR 6/1), weathers same; thinly bedded; low, partly covered ridge; few smal anhedral dolomite grains.	13.0	353.5
62	Covered.	5.0	340.5
61	Algae dolobiolithite: medium light gray (N 6), weathers pale red (5R 6/2) and pale yellowish orange (10YR 8/6); very thinly bedded; sparry calcite in irregular patches parallel with the bedding; dessication cracks filled with sparry calcite.	5.0	335.5
60	Covered.	9.5	330.5
59	Ferroan dolomite: very pale orange (10YR 8/2) to grayish-orange (10YR 7/4), weathers to grayish orange (10YR 7/4); thinly bedded; partly covered ridge.	2.0	321.0
58	Dolomitic pelmicrosparite: very pale orange (10YR 8/2), weathers grayish orange (10YR 7/4); thinly bedded; ledge; some silt-size quartz.	3.0	319.0
57	Microsparite: light-gray (N 7) and grayish orange pink (5YR 7/2), weathers light gray (N 7); thinly bedded; ledge; some silt-size quartz.	10.0	316.0
56	Covered.	4.0	306.0
55	Fossiliferous crinoidal microsparite: pinkish-gray (5YR 8/1), weathers very pale orange (10YR 8/2) and medium light gray (N 6); thinly bedded; partly covered ridge; some patches of silt-size quartz.	2.0	302.0
54	Covered.	5.0	300.0

Unit No.		Thickness in feet	Cumulative thickness in feet
53	Ferroan dolomite: light-brown (5YR 6/4) and moderate-red (5R 5/4), weathers light brown (5YR 6/4); finely crystalline; thinly bedded; partly covered ridge; some gypsum; brecciated, fractures filled with quartz and sparry calcite.	3.0	295.0
52	Covered.	5.0	292.0
51	Siltstone: medium-gray (N 5), weathers light brown (5YR 5/6); calcitic and dolomitic cement; very thinly and thinly bedded, cross-laminations; low, partly covered ridge. . .	2.0	287.0
50	Covered.	5.0	285.0
49	Biomicrosparite: brownish-gray (5YR 4/1), weathers medium gray (N 5) and medium light gray (N 6); thinly bedded; ridge; some small dolomite patches and silt-size quartz.	2.0	280.0
48	Sandy siltstone: light brownish gray (5YR 6/1), weathers moderate yellowish brown (10YR 5/4); dolomitic cement; very thinly bedded, cross-laminations; ridge; clayey interlaminations.	3.0	278.0
47	Covered.	13.0	275.0
46	Fossiliferous micrite: medium dark gray (N 4), weathers same; thinly bedded; ridge; few patches of dolomite; crinoid stem and algae fragments; unit becomes a biomicrite near top two feet.	11.5	262.0
45	Covered.	5.0	250.5
44	Microsparite: medium light gray (N 6), weathers same and light olive gray (5Y 6/1); thinly bedded; ridge; some scattered silt-size quartz.	3.0	245.5
43	Sandy siltstone: grayish orange pink (10YR 8/2), weathers moderate yellowish brown (10YR 5/4); calcitic and dolomitic cement; thinly bedded; partly covered ridge. . . .	5.0	242.5
42	Covered.	4.0	237.5

Unit No.		Thickness in feet	Cumulative thickness in feet
41	Sandy mudstone: medium light gray (N 7), weathers light brown (5YR 5/6); dolomitic cement; thinly bedded, parallel laminations; ledge; clayey, silty, and sandy interlaminations.	6.0	233.5
40	Siltstone: pinkish-gray (5YR 8/1), weathers moderate yellowish brown (10YR 5/4); ferroan dolomitic and dolomitic cement; thinly bedded, parallel and cross-laminations; ledge; clayey interlaminations.	6.0	233.5
39	Pelmicrosparite: medium dark gray (N 4), weathers medium light gray (N 6) and grayish orange (10YR 7/4); thinly to very thinly bedded; low, partly exposed ridge; some very fine grained quartz and feldspar. . . .	2.0	227.5
38	Covered.	9.0	225.5
37	Crinoidal microsparite: brownish-gray (5YR 4/1), weathers medium dark gray (N 4); thinly to very thinly bedded; ledge; some small patches of anhedral dolomite. . . .	12.0	216.5
36	Claystone: pale red purple (5RP 6/2), weathers dark yellowish orange (10YR 6/6) and very pale orange (10YR 8/2); dolomitic cement; thinly bedded; partly covered ridge.	2.0	204.5
35	Covered.	5.0	202.5
34	Silty quartzarenite: very pale orange (10YR 8/2), weathers grayish orange (10YR 7/4) and dark yellowish brown (10YR 4/2); dolomitic cement; very fine grained arenite and coarse-grained silt, moderately sorted, subangular to subrounded; thinly bedded; parallel clayey interlaminations; ledge. . .	20.0	197.5
33	Covered: probably light-red dolomitic quartzarenite.	10.0	177.5

Unit No.		Thickness in feet	Cumulative thickness in feet
32	Quartzarenite: interlaminated light-red (5R 6/6) and pinkish-gray (5YR 8/1), weathers grayish orange (10YR 7/4); dolomitic cement; fine- to very fine grained, moderately sorted, subrounded to rounded; thinly bedded, parallel laminations; ledge; few calcite grains; clayey interlaminations.	7.0	167.5
31	Covered.	5.0	160.5
30	Ferroan dolomite: light greenish gray (5GY 8/1), weathers dark yellowish orange (10YR 6/6); very finely crystalline; thinly bedded; partly covered ridge.	1.0	155.5
29	Covered.	18.0	154.5
28	Intraclastic dolomite: moderate orange pink (10R 7/4) and medium dark gray (N 4), weathers grayish orange (10YR 7/4); very finely crystalline; thinly bedded; intraclasts of silty dolomite; dessication cracks (?) filled with silt-size quartz, calcite, and dolomite.	15.0	136.5
27	Calcitic silty dolomite: pale red purple (5RP 6/2), weathers pale yellowish brown (10YR 6/2) and grayish orange (10YR 7/4); finely to medium crystalline; thinly bedded, parallel laminations; ledge.	21.0	121.5
26	Pebble conglomerate: pebbles pale red purple (5RP 6/2) in pale-pink (5RP 8/2) to pale-purple (5P 6/2) matrix, weathers pale red purple (5RP 6/2); calcitic cement; dolomite and calcitic dolomite pebbles subrounded, average 2 mm in diameter; very poor sorting; thinly bedded; ledge.	1.0	100.5
25	Covered.	3.0	99.5
24	Intraclastic dolomite: grayish red purple (5RP 4/2), weathers grayish orange (10YR 7/4); very thinly bedded; ridge; plant (?) fragments in intraclasts; desiccation cracks (?) filled with calcite.	1.0	96.5

Unit No.		Thickness in feet	Cumulative thickness in feet
23	Mudstone: medium-gray (N 5), weathers same; silica cement; very thinly bedded; poorly exposed slope; indistinct parallel laminations.	3.0	95.5
22	Dolomite: light-brown (5YR 6/4), weathers grayish orange (10YR 7/4); very finely crystalline; thinly bedded; ledge; desiccation cracks (?) filled with silt-size quartz and sparry calcite.	3.0	92.5
21	Calcitic dolomite: light brownish gray (5YR 6/1), weathers yellowish gray (5Y 8/1); thinly bedded; ridge.	1.0	89.5
20	Covered.	2.0	88.5
19	Calcitic dolomite: grayish orange pink (10R 8/2), weathers light brown (5YR 6/4) and light gray (N 7); finely crystalline; thinly bedded; ledge; crinoid stems and chert pods in upper one foot of unit.	3.0	86.5
18	Covered.	4.0	83.5
17	Biogenic dolomite: grayish red purple (5RP 1/2), weathers gray (5Y 8/1) and grayish orange (10YR 7/4); finely crystalline; thinly bedded; ledge; shell and crinoid stem fragments; silica replacement in some shell fragments; chert pods in upper two feet of unit.	7.0	79.5
16	Dolomitic biomicrosparite: light brownish gray (5YR 6/1), weathers very pale orange (10YR 8/2); very thinly bedded; low, partly covered ridge; crinoid stem and shell fragments; some fossil fragments replaced by silica.	0.5	72.5
15	Covered.	5.0	72.0
14	Calcitic biogenic dolomite: pale red purple (5RP 6/2), weathers very pale orange (10YR 8/2) and grayish orange (10YR 7/4); thinly bedded; ridge; some fine silt-size quartz; shell and crinoid stem fragments; abundant intersecting calcite veins.	4.0	67.0

Unit No.		Thickness in feet	Cumulative thickness in feet
13	Covered.	4.0	63.0
12	Dolomitic microsparite: grayish orange pink (5YR 7/2), weathers very pale orange (10YR 8/2); thinly to very thinly bedded, parallel laminations; low, partly covered ridge. . .	1.0	59.0
11	Covered.	5.0	58.0
10	Silty dolomitic microsparite: grayish-pink (%R 8/2), weathers grayish orange (10YR 7/4); thinly to very thinly bedded; partly covered ridge; scattered chert pods. . . .	5.0	53.0
9	Covered.	10.0	48.0
8	Calcitic silty biogenic dolomite: grayish orange pink (10R 8/2), weathers same; thinly bedded; partly covered ridge; some calcite veins.	4.0	38.0
7	Interlaminated chert and claystone: greenish-black (5GY 2/1) and pale reddish brown (10R 5/4), weathers same; thinly to very thinly bedded; ridge; calcite veins. . . .	3.0	34.0
6	Covered.	5.0	31.0
5	Biomicrosparite: pale-pink (5RP 9/2), weathers same and dark yellowish brown (10YR 4/2); thinly bedded; partly covered ridge; chert pods in upper two feet; some small patches of dolomite.	7.0	26.0
4	Covered.	5.0	19.0
3	Calcitic dolomitic claystone: grayish orange pink (5YR 7/2) to light-brown (5YR 6/4), weathers light brown (5YR 5/6) and dark yellowish brown (10YR 4/2); thinly bedded; ridge.	1.0	14.0
2	Dolomitic microsparite: moderate orange pink (5YR 8/4), weathers pale yellowish orange (10YR 8/6); thinly bedded; ridge; few gypsum grains and fine silt-size quartz.	3.0	13.0

Unit No.		Thickness in feet	Cumulative thickness in feet
1	Crinoidal calcitic dolomite: pale red purple (5RP 6/2), weathers pale pink (5RP 8/2); thinly bedded; slope; crinoid fragments in calcite.	10.0	10.00
	Total of Earp Formation:	455.5	

Fault: additional beds of Earp Formation below fault.

Earp Hill

Type section of the Earp Formation; lower part from saddle to conspicuous mottled pink and white biomicrosparite in NW1/4 NE1/4 SE1/4 sec. 5, T. 21 S., R. 23 E., Tombstone quadrangle, 15 minute series. Upper part from conspicuous grayish-red biomicrosparite to cliff formed by Colina Limestone in NE1/4 NW1/4 SW1/4 sec. 4, T. 21 S., R. 23 E. Strike N. 80° W. to N. 65° W.; dip 45°-70° NE.

Permian:
Colina Limestone (unmeasured):

Microsparite: medium-gray (N 5), weathers medium light gray (N 6); thickly and thinly bedded; cliff.

Pennsylvanian-Permian:

Earp Formation:

Unit No.		Thickness in feet	Cumulative thickness in feet
73	Calcitic dolomite: pale-brown (5YR 5/2) and grayish-red (5R 4/2), weathers pale yellowish brown (10YR 6/2); finely crystalline; thinly bedded; ledge; unit becomes a micrite near the top.	7.0	580.5
72	Micrite: dark-gray (N 3), weathers medium gray (N 5) and moderate reddish orange (10R 6/6); thinly bedded; ledge; some silt-size quartz grains near top of unit.	12.0	573.5
71	Mudstone: light brownish gray (5YR 6/1), weathers same; calcitic cement; very thinly bedded, parallel laminations; very poorly exposed slope.	7.0	561.5
70	Silty biomicrosparite: medium dark gray (N 4), weathers pale reddish brown (10R 5/4); thinly bedded; poorly exposed ridge; abundant algae and shell fragments. . . .	1.0	554.5
69	Mudstone: light brownish gray (5YR 6/1), weathers same; calcitic cement; very thinly bedded, parallel laminations; very poorly exposed slope.	19.0	553.5

Unit No.		Thickness in feet	Cumulative thickness in feet
68	Biomicrosparite: medium dark gray (N 4), weathers dark yellowish brown (10YR 4/2); thinly to thickly bedded; ledge; fossil hash includes foraminifera, pelecypods, and algae fragments.	6.5	534.5
67	Intrasparite: grayish-red (5R 4/2), weathers light brown (5YR 6/4); thinly bedded; ledge; intraclasts up to 2.5 mm in diameter, well rounded, composed of micrite and pellets; some oolites; few dolomite patches. . . .	7.5	528.0
66	Covered.	3.5	520.5
65	Dolomite: brownish-gray (5YR 4/1), weathers light olive gray (5Y 6/1); finely crystalline; thinly to very thinly bedded; ledge; some silt-size quartz grains.	1.5	517.0
64	Covered.	13.0	515.5
63	Dismicrite: brownish-gray (5YR 4/1), weathers light gray (N 7); thinly bedded; ledge; "eyes" average 0.2 mm in diameter.	2.0	502.5
62	Silty calcitic dolomite: moderate-brown (5YR 3/2), weathers pale yellowish brown (10YR 6/2); very finely to finely crystalline; thinly bedded; ledge.	2.0	500.5
61	Dolomite: grayish-brown (5YR 3/2), weathers grayish orange (10YR 7/4); finely to very finely crystalline; thinly bedded; ledge; some silt-size quartz grains.	2.0	498.5
60	Calcitic dolomite: moderate-brown (5YR 3/4), weathers yellowish brown (10YR 6/2); finely crystalline; thinly bedded; ledge; few calcite veins.	2.0	496.5
59	Clayey siltstone: grayish-red (10R 4/2), weathers very pale orange (10YR 8/2); dolomitic cement; thinly to very thinly bedded, parallel laminations of silt and clay; ledge.	2.0	494.5
58	Covered: probably red calcareous clayey siltstone.	5.0	492.5

Unit No.		Thickness in feet	Cumulative thickness in feet
57	Clayey siltstone: grayish-red (10R 4/2), weathers very pale orange (10YR 8/2); dolomitic cement; thinly to very thinly bedded, parallel laminations of silt and clay; ledge.	2.5	487.5
56	Covered: probably pink micrite.	15.0	485.0
55	Calcitic dolomite: pale reddish brown (10R 5/4), weathers very pale orange (10YR 8/2); thinly bedded, parallel laminations; low, poorly exposed ridge.	3.0	470.0
54	Covered.	5.0	467.0
53	Biosparite: mottled dusky red (5R 3/4) and light gray (N 7), weathers light gray (N 7); thinly bedded; ledge; fossil debris well rounded; includes abraded fusulinids. . . .	2.0	462.0
52	Covered.	6.0	460.0
51	Fossiliferous intrasparrudite: mottled grayish red (5R 4/2) and very light gray (N 8), weathers pale yellowish brown (10YR 6/2) and pale yellowish orange (10YR 8/6); thinly bedded; ledge; some chert pods; intraclasts partly dolomitized micrite and pellet aggregate.	5.0	454.0
50	Covered.	5.0	449.0
49	Fossiliferous microsparite: light-gray (N 7), weathers yellowish gray (5Y 8/1); thinly bedded; ridge; some small foraminifera and shell fragments; very small patches of dolomite.	3.0	444.0
48	Dolomitic intramicrudite: mottled reddish brown (10R 5/4) and light-gray (N 7), weathers moderate reddish orange (10R 6/6) and grayish orange pink (10R 8/2); thinly to thickly bedded; cliff; dolomite and calcite matrix; intraclasts of micrite; some fossil fragments.	22.0	441.0

Section offset approximately 2,000 feet west

Unit No.		Thickness in feet	Cumulative thickness in feet
47	Biomicrosparite: grayish-red (5R 4/2), weathers grayish red (10R 4/2) and very pale orange (10YR 8/2); thinly bedded; ridge; some patches of dolomite giving unit a mottled appearance; few foraminifera fragments.	2.0	419.0
46	Covered.	8.0	417.0
45	Clayey dolomite: dark reddish brown (10R 3/4), weathers pale reddish brown (10R 5/4); thinly to very thinly bedded, parallel laminations of interlaminated dolomite and clay; poorly exposed ridge; some calcite veins. .	2.0	409.0
44	Covered.	8.0	407.0
43	Calcitic clayey dolomite: grayish-red (10R 4/2), weathers very pale orange (10YR 8/2); thin to very thinly bedded, parallel laminations of concentrations of brown clay; ledge.	1.5	399.0
42	Pelsparite: pale-red (5R 6/2) and light-gray (N 7), weathers moderate brown (5YR 4/4); thinly bedded; ridge; crinoid stems and algae fragments; abundant chert pods at tops of unit; few fine-grained, sand-size quartz grains; parts of unit dolomitic giving mottled appearance.	4.5	398.0
41	Covered.	10.0	393.5
40	Dolomitic microsparite: mottled pale reddish brown (10R 5/4) and moderate reddish brown (10R 4/6), weathers moderate reddish brown (10R 4/6); thinly to thickly bedded; ledge; abundant chert pods near top of unit.	5.0	383.5
39	Biomicrosparite: light brownish gray (5YR 6/1), weathers yellowish gray (5Y 8/1); thinly bedded; ledge; abundant crinoid stems and bryozoan fragments.	9.0	378.5
38	Covered: probably red and purple calcareous siltstone and claystone.	39.0	369.5

Unit No.		Thickness in feet	Cumulative thickness in feet
37	Intraclastic biosparite: medium-gray (N 5), weathers light olive gray (5Y 6/1); thinly to very thinly bedded; ridge; algae, crinoid stems, gastropod remains; intraclasts of micrite.	2.0	330.5
36	Covered: probably pink calcareous claystone.	28.0	328.5
35	Biomicrosparite: medium light gray (N 6), weathers medium gray (N 5); thinly to very thinly bedded; poorly exposed ridge. . . .	11.0	300.5
34	Covered.	17.0	289.5
33	Alternating sandy microsparite and calcitic quartzarenite: medium light gray (N 6), weathers light gray (N 7) and pinkish gray (5YR 8/1); very fine grained, moderately sorted, angular to subangular; thinly bedded, ripple laminations; ridge.	2.0	272.5
32	Covered: probably orange and red calcareous siltstone.	18.0	270.5
31	Quartzarenite: grayish-red (5R 4/2), weathers pale reddish brown (10R 5/4); calcitic and dolomitic cement; very fine grained, moderately sorted, angular to subangular; thinly bedded, sinusoidal ripple laminations; low, poorly exposed slope; worm (?) burrows. .	5.0	252.5
30	Covered.	5.0	247.5
29	Fossiliferous microsparite; medium-gray (N 5) and light brownish gray (5YR 6/1), weathers grayish orange (10YR 7/4), dusky red (5R 3/4), and medium gray (N 5); thinly bedded; ridge; some scattered sand-size quartz and fusulinids.	3.0	242.5
28	Covered: probably red calcareous siltstone.	7.0	239.5
27	Quartzarenite: grayish-red (5R 4/2), weathers pale red (5R 6/2); dolomitic cement; very fine grained, moderately sorted, angular to subangular; thinly bedded, ripple laminations; poorly exposed rdige.	0.5	232.5

Unit No.		Thickness in feet	Cumulative thickness in feet
26	Covered.	6.0	232.0
25	Calcitic dolomite and dolomitic micrite: mottled dusky red (5R 3/4) and light gray (N 7), weathers medium light gray (N 6) and light red (5R 6/6); thinly bedded; ridge.	1.0	226.0
24	Covered: probably purple calcareous siltstone.	21.0	225.0
23	Pelletiferous micrite: medium dark gray (N 4), weathers same; thinly bedded; ledge; some dolomite patches and fossil hash; some intersecting calcite veins; locally abundant brachiopods.	6.0	204.0
22	Covered: probably red calcareous siltstone.	11.0	198.0
21	Pebble conglomerate: grayish-red (5R 4/2), light brownish gray (5YR 6/1), and medium-gray (N 5), weathers medium gray (N 5) to medium dark gray (N 4); calcitic cement; thinly bedded; poorly exposed slope; fragments up to 5 mm in diameter and average 2 mm, fragments predominantly micrite; some fossil fragments; local concentrations of silt-size quartz, poorly sorted, rounded and subrounded.	1.0	187.0
20	Siltstone: dark reddish brown (10R 3/4), weathers moderate red (5R 4/6); calcitic cement; thinly bedded, ripple laminations; poorly exposed slope; rock friable; abundant red clayey material.	3.5	186.0
19	Covered: probably red calcareous siltstone.	30.0	182.5
18	Siltstone: grayish-red (5R 4/2), weathers pale red (10R 6/2); calcitic cement; thinly bedded; poorly exposed slope; rock very friable.	5.0	152.5
17	Covered: probably red calcareous siltstone and shale.	25.0	147.5

Unit No.		Thickness in feet	Cumulative thickness in feet
16	Pebble conglomerate: light-gray (N 7), medium light gray (N 6), and moderate-red (5R 4/6), weathers same and moderate reddish orange (10R 6/6); calcitic cement; thinly to thickly bedded; ridge; fragments up to 5 cm in diameter but average 2 mm; fragments predominantly micrite with some claystone; unit grades from coarse fragments at base to finer at the top, poorly sorted, rounded and subrounded.	11.0	122.5
15	Covered.	4.0	111.5
14	Intrasparite: light-gray (N 7), weathers grayish orange (10YR 7/4); thinly bedded; ridge; some crinoid, foraminifera, algae fragments, and very fine grain and silt-size quartz grains.	2.0	107.5
13	Siltstone: dark reddish brown (10R 3/4) and moderate reddish brown (10R 4/6), weathers pale reddish brown (10R 5/4); calcitic cement; thinly bedded, parallel and ripple laminations; slope.	7.0	105.5
12	Fossiliferous microsparite: mottled dusky red (5R 3/4) and medium light gray (N 6), weathers light gray (N 7) and light brown (5YR 6/4); thinly bedded; ledge; fusulinids and other foraminifera.	6.0	98.5
11	Covered: probably red calcareous siltstone.	32.0	92.5
10	Fossiliferous siltstone: mottled dark reddish brown (10R 3/4) and light-gray (N 7), weathers moderate reddish orange; calcitic cement; thinly bedded, parallel laminations; low, poorly exposed ridge.	3.5	60.5
9	Biosparite: light-gray (N 7), weathers pale yellowish brown (10YR 6/2); thinly to very thinly bedded; low, poorly exposed ridge; fossil fragments well rounded, red clayey envelope.	5.0	57.0
8	Covered: probably red calcareous siltstone.	8.5	52.0

Unit No.		Thickness in feet	Cumulative thickness in feet
7	Biopelsparite: light-gray (N 7), weathers light brown (5YR 5/6); thinly bedded; ridge; fossil fragments well rounded, some silt-size quartz grains.	1.5	43.5
6	Covered: probably red calcareous mudstone.	19.0	42.0
5	Fossiliferous dolomitic microsparite: light-gray (N 7), weathers pale yellowish brown (10YR 6/2); thinly bedded; ridge; shell hash and fusulinids.	3.0	23.0
4	Covered: probably red calcareous shale. .	6.0	20.0
3	Quartzarenite: dark reddish brown (10R 3/4), weathers moderate reddish orange (10R 6/6); calcitic cement; very fine grained, well sorted, subangular to subrounded; thinly bedded; partially covered ridge.	2.5	11.5
2	Covered: probably brown calcareous shale.	4.0	9.0
1	Fossiliferous microsparite: light-gray (N 7), weathers medium light gray (N 6) and light brown (5YR 6/4); thinly to thickly bedded; low ridge; algal and shell fragments. . . .	5.0	5.0
	Total of Earp Formation:	580.5	

Horquilla Limestone (unmeasured):

Micrite: light-gray (N 7), weathers medium light gray (N 6); thinly bedded; low ridge.

Empire Mountains

Exposures on northwesterly facing slopes of south end of Eagle Bluff. Base of section about 1,800 feet S. 16° E. of NW cor. sec. 33, T. 17 S., R. 17 E., Empire Mountains quadrangle, 15 minute series. Top of section about 3,000 feet S. 40° E. of same corner. Strike N. 20° E.; dip 30°-40° SE.

Permian:

Colina Limestone (unmeasured):

Dolomitic microsparite: pinkish-gray (5YR 8/1), weathers pale pink (5RP 8/2) and grayish orange pink (10R 8/2); thinly bedded; some silt-size quartz grains; ledge. Unit becomes medium-crystalline dolomite 10 feet from base and into dark-gray Colina micrite 25 feet from base.

Pennsylvanian-Permian:

Earp Formation:

Unit No.		Thickness in feet	Cumulative thickness in feet
38	Silty microsparite: very pale orange (10YR 8/2), weathers light brown (5YR 5/6) and greenish gray (5GY 6/1); thinly bedded; ledge.	9.0	447.5
37	Siltstone: pale red purple (5RP 6/2), weathers same and grayish orange (10YR 7/4); calcitic cement; thinly bedded; ledge.	8.0	438.5
36	Covered.	25.0	430.5
35	Micrite: very pale orange (10YR 8/2) and grayish orange pink (5YR 7/2), weathers very pale orange (10YR 8/2) and grayish orange (10YR 7/4); thinly bedded; ledge; few patches of dolomite.	3.0	405.5
34	Covered.	14.0	402.5
33	Claystone: grayish-black (N 2), weathers yellowish gray and medium dark gray (N 4); silica cement; very thinly bedded; poorly exposed slope.	0.5	388.5
32	Covered: probably gray calcareous shale. .	20.0	388.0

Unit No.		Thickness in feet	Cumulative thickness in feet
31	Siltstone: brownish-gray (5YR 4/1), weathers very pale orange (10YR 8/2); dolomitic cement; thinly to very thinly bedded; indistinct parallel and cross-laminations; poorly exposed ridge.	0.5	368.0
30	Claystone: dark-gray (N 3), weathers very pale orange (10YR 8/2); calcitic and dolomitic cement; very thinly bedded, indistinct parallel laminations; poorly exposed slope.	0.5	367.5
29	Covered.	13.0	367.0
28	Sandy siltstone; medium dark gray (N 4) to brownish gray (5YR 4/1), weathers very light gray (N 8); calcitic cement; thinly bedded, cross-laminations; poorly exposed ridge.	1.0	354.0
27	Covered.	7.0	353.0
26	Quartzarenite: medium-gray (N 5), weathers yellowish gray (5Y 8/1); calcitic and dolomitic cement; very fine grained, moderately sorted, angular to subangular; thinly bedded, parallel laminations; low, poorly exposed ridge.	1.0	346.0
25	Covered.	7.0	345.0
24	Siltstone: yellowish-gray (5Y 8/1), weathers grayish orange (10YR 7/4); calcitic and dolomitic cement; thinly to very thinly bedded, parallel and cross-laminations; low, partly covered ridge.	0.5	338.0
23	Covered.	14.0	337.5
22	Siltstone: medium light gray (N 6), weathers pinkish gray (5YR 8/1); calcitic cement; thinly to very thinly bedded, parallel and cross-laminations; poorly exposed ridge. .	0.5	323.5
21	Covered.	1.0	323.0

Unit No.		Thickness in feet	Cumulative thickness in feet
20	Siltstone: light greenish gray (5GY 8/1), weathers grayish orange (10YR 7/4); calcitic and dolomitic cement; thinly bedded, parallel laminations; ridge.	1.0	322.0
19	Claystone: dark-gray (N 3), weathers medium gray (N 5) and very light gray (N 8); calcitic cement; thinly bedded, indistinct parallel laminations; very poorly exposed slope.	10.0	321.0
18	Siltstone; light brownish gray (5YR 6/1), weathers yellowish gray (5Y 8/1); calcitic and dolomitic cement; thinly bedded, indistinct parallel and sinusoidal laminations; low, partly covered ridge; worm(?) burrows.	1.5	311.0
17	Covered.	12.0	309.5
16	Quartzarenite: grayish-orange (10YR 7/4), weathers pale yellowish brown (10YR 6/2); calcitic cement; very fine grained, moderately sorted, subangular to subrounded; thinly bedded, parallel laminations; low ridge.	1.5	297.5
15	Covered.	11.0	296.0
14	Siltstone: dark yellowish brown (10YR 4/2), weathers pale yellowish brown (10YR 6/2); calcitic cement; thinly bedded, parallel and cross-laminations; low ridge.	1.0	286.0
13	Quartzarenite: yellowish-gray (5Y 8/1) and light brownish gray (5YR 6/1), weathers moderate yellowish brown (10YR 5/4); calcitic cement; very fine grained and coarse silt-size, poorly sorted, subangular to angular; thinly bedded, ripple laminated; very poorly exposed slope.	35.0	285.0
12	Claystone: brownish-black (5YR 2/1), weathers pinkish gray (5YR 8/1) and yellowish gray (5Y 8/1); calcitic cement; thinly to very thinly bedded, parallel laminations; partly covered slope.	5.0	250.0

Unit No.		Thickness in feet	Cumulative thickness in feet
11	Mudstone: brownish-black (5YR 2/1), weathers pinkish gray (5YR 8/1) and yellowish gray (5Y 8/1); calcitic cement; thinly to very thinly bedded; partly covered slope.	6.0	245.0
10	Sandy siltstone: very pale orange (10YR 8/2), weathers dark yellowish brown (10YR 4/2); calcitic and dolomitic cement; thinly bedded, cross-laminations; poorly exposed slope.	7.0	239.0
9	Clayey micrite: grayish-black (N 2), weathers medium light gray (N 6); thinly bedded, indistinct parallel laminations; ridge. . .	5.0	232.0
8	Siltstone: yellowish-gray (5Y 8/1) and medium dark gray (N 4), weathers grayish orange (10YR 7/4) and moderate brown (5YR 4/4); calcitic and dolomitic cement; thinly bedded, parallel and ripple laminations; very poorly exposed slope.	10.0	225.0
7	Mudstone: alternating bands of dark greenish gray (5GY 4/1) and brownish gray (5YR 4/1), weathers to alternating bands of light greenish gray (5G 8/1) and light olive gray (5Y 6/1); calcitic and dolomitic cement; thinly and very thinly bedded, parallel and ripple laminations; very poorly exposed slope.	30.0	215.0
6	Clayey siltstone; medium-gray (N 5) and light brownish gray (5YR 6/1), weathers moderate yellowish brown (10YR 5/4) and pale yellowish brown (10YR 6/2); thinly to very thinly bedded; mostly covered slope.	10.0	185.0
5	Siltstone: very pale orange (10YR 8/2), weathers moderate yellowish brown (10YR 5/4) and dark yellowish orange (10YR 6/6); dolomitic cement; thinly bedded, parallel laminations; partly covered slope; partly brecciated.	15.0	175.0

Unit No.		Thickness in feet	Cumulative thickness in feet
4	Conglomerate: dark greenish gray (5G 4/1), pinkish gray (5YR 8/1), and dark reddish brown (10R 3/4), weathers yellowish gray (5Y 8/1) and moderate pink (5R 7/4); calcitic cement; thinly bedded; low ridge; limestone pebbles range from 1.5 cm to 4.0 mm, some sand-size quartz; poorly sorted; rounded and subrounded; surface weathers rough.	3.0	160.0
3	Silty claystone; brownish-black (5YR 2/1), weathers same and dusky yellow (5Y 6/4); calcitic cement; very thinly bedded and laminated, parallel laminations; very poorly exposed slope; some round microcrystalline quartz inclusions.	57.0	157.0
2	Sandy siltstone: light greenish gray (5GY 6/1), weathers light brown (5YR 5/6); silica cement; thinly bedded; very poorly exposed slope; very fine quartz sand.	15.0	100.0
1	Quartzarenite: light greenish gray (5GY 6/1) and medium light gray (N 6), weathers light brown (5YR 5/6) and grayish orange (10YR 7/4); calcitic cement, dolomitic cement in bottom 12 feet of unit; very fine grained, well-sorted, angular to subangular; thinly bedded, indistinct and cross-laminations; poorly exposed slope.	85.0	85.0
	Total of Earp Formation:	447.5	

Horquilla Limestone (unmeasured):

Sandy mud-shale: dark greenish gray (5G 4/1), weathers greenish gray (5GY 6/1); calcitic, dolomitic and silica cement; laminated and thinly laminated, parallel and cross-laminations; partly covered slope, very siliceous in places.

Gunnison Hills

About five miles west-southwest of Cochise. Base of section about 2,200 feet S. 83° E. of NW cor. sec. 33, T. 15 S., R. 23 E., Dragoon quadrangle, 15 minute series. Top of section about 4,100 feet S. 53° E. of same corner. Strike N. 30°-50° W.; dip 40°-50° NE.

Permian:

Colina Limestone (unmeasured):

Micrite: grayish-black (N 2), weathers medium gray (N 5); thinly bedded; ridge.

Pennsylvanian-Permian:

Earp Formation:

Unit No.		Thickness in feet	Cumulative thickness in feet
112	Quartzarenite: light-gray (N 7), weathers grayish orange (10YR 7/4) and pale brown (5YR 5/2); calcitic cement; fine- and medium-grained, subrounded to subangular, poorly sorted; thinly bedded, parallel and cross-laminations; ledge.	10.0	1364.0
111	Micrite: medium-gray (N 5), weathers light gray (N 7) and very light gray (N 8); thinly bedded; ridge.	4.0	1354.0
110	Covered: probably red calcareous quartzarenite.	5.0	1350.0
109	Quartzarenite: pale red purple (5RP 6/2), weathers grayish orange pink (5YR 7/2); calcitic cement; very fine grained, angular to subangular, moderately sorted; thinly bedded, parallel and ripple laminations; poorly exposed ridge.	1.0	1345.0
108	Covered: probably gray silty biomicrite. .	15.0	1344.0
107	Fossiliferous micrite: dark-gray (N 3), weathers medium light gray (N 6); thinly bedded; series of small ridges; intersecting calcite veins; unidentified fossil hash.	20.0	1329.0
106	Covered: probably gray micrite.	15.0	1309.0

Unit No.		Thickness in feet	Cumulative thickness in feet
105	Biomicrite: medium dark gray (N 4), weathers medium light gray (N 6); thinly bedded; ledge; intersecting calcite veins; ostracod and unidentified shell fragments.	19.0	1294.0
104	Covered: probably brown calcareous siltstone.	15.0	1275.0
103	Quartzarenite: yellowish-gray (5YR 8/1), weathers light brownish gray (5YR 6/1) and grayish orange (10YR 7/4); calcitic cement; fine- to very fine grained, subangular to subrounded, moderately sorted; thinly bedded, parallel and cross laminations; poorly exposed slope..	12.0	1260.0
102	Covered: probably brown calcareous siltstone.	15.0	1248.0
101	Micrite: medium dark gray (N 4), weathers medium light gray (N 6) and pinkish gray (5YR 8/1); thinly bedded; ledge; few scattered chert pods; abundant intersecting calcite veins; few scattered brachiopod shells near center of unit.	25.0	1233.0
100	Quartzarenite: medium light gray (N 6), weathers pale brown (5YR 5/2) and pale red (5R 6/2); calcitic cement; fine-grained, angular to subangular, moderately sorted; thinly bedded, parallel and ripple laminations; poorly exposed slope; iron oxide cubes after pyrite; ripple marks.	34.0	1208.0
99	Fossiliferous micrite: medium-gray (N 5), weathers light olive gray (5Y 6/1) and light gray (N 7); thinly and very thinly bedded; ledge; echinoid spines, crinoid stems, and shell fragments.	26.0	1174.0
98	Siltstone: pale yellowish brown (10YR 6/2), weathers grayish orange (10YR 6/2) and dark yellowish orange (10YR 6/6); calcitic and dolomitic cement; thinly to very thinly bedded, parallel and cross-laminations; partly covered ridge; iron oxide cubes after pyrite.	1.0	1148.0

Unit No.		Thickness in feet	Cumulative thickness in feet
97	Covered: probably brown calcareous siltstone.	22.0	1147.0
96	Silty micrite: light olive gray (5Y 6/1), weathers yellowish gray (5Y 8/1); thinly bedded, parallel laminations; ledge; chert stringers.	6.0	1125.0
95	Micrite: medium dark gray (N 4), weathers medium gray (N 5); thinly bedded; ledge; abundant intersecting calcite veins. . . .	15.0	1119.0
94	Siltstone: pale-red (10R 6/2), weathers same and moderate red (5R 5/4); dolomitic cement; very thinly bedded, parallel and cross-laminations; poorly exposed slope. .	25.0	1104.0
93	Biopelmicrite: medium dark gray (N 4), weathers medium gray (N 5); thinly bedded, parallel and cross-laminations; ledge; crinoid stem, echinoid spine, and brachiopod fragments; abundant intersecting calcite veins.	12.5	1079.0
92	Covered: probably red calcareous sandstone.	40.0	1066.5
93	Quartzarenite: pale-red (10YR 6/2), weathers pale yellowish brown (10YR 6/2); calcitic cement; fine-grained, subangular to subrounded, moderately sorted; thinly bedded, parallel and cross-laminations; poorly exposed ridge; iron oxide cubes after pyrite.	1.0	1026.5
90	Covered: probably red calcareous sandstone.	20.0	1025.5
89	Quartzarenite: pale-red (5R 6/2), weathers grayish orange (10YR 7/4) and light brown (5YR 6/4); calcitic cement; very fine grained, angular to subangular, moderately sorted; thinly bedded, parallel and cross-laminations; partly covered ridge.	5.0	1005.5
88	Covered: probably brown calcareous sandstone.	30.0	1000.5

Unit No.		Thickness in feet	Cumulative thickness in feet
87	Quartzarenite: pale red purple (5RP 6/2), weathers pale yellowish brown (10YR 6/2); calcitic and dolomitic cement; fine- to medium-grained, subangular, moderately sorted; thinly bedded, parallel and cross-laminations; ledge; some small layers of chert pebbles.	4.0	970.5
86	Conglomerate: pale-red (5R 6/2), grayish-red (5R 4/2), and very light gray (N 8), weathers grayish orange (10YR 7/4) and dusky red (5R 3/4); calcitic cement, sand matrix; chert and limestone and sandstone pebbles and cobbles, round to subrounded, very poorly sorted; thinly bedded; ridge; some limestone pebbles are of same lithologies as those in beds below.	8.0	966.5
85	Covered: probably brown and red calcareous siltstone.	35.0	958.5
84	Biomicrite: pinkish-gray (5YR 8/1) and light brownish gray (5YR 6/1), weathers pinkish gray (5YR 8/1) and light gray (N 7); thinly to very thinly bedded; poorly exposed slope; abundant chert pods near top of unit; crinoid stems, echinoid spines, and shell fragments; some fragments replaced by red chert. . .	30.0	923.5
83	Covered: probably light-gray micrite. . . .	24.0	893.5
82	Biomicrite: light-gray (N 7) becoming medium dark gray (N 4) near top of unit, weathers light gray (N 7) and yellowish gray (5Y 8/1); thinly bedded; partly covered ledgy slope; abundant chert pods near middle of unit; brachiopod, crinoid stems, and rugose coral fragments replaced by chert.	19.0	869.5
81	Siltstone: grayish-pink (5R 8/2) to moderate-pink (5R 7/4), weathers grayish orange pink (5YR 7/2); calcitic cement; thinly bedded; partly covered slope; some chert pods. . .	11.0	850.5
80	Biomicrite: mottled pale red (10R 6/2) and light-gray (N 7), weathers light gray (N 7); thinly bedded; ledgy slope; brachiopod and crinoid-stem fragments; abundant intersecting calcite veins; some chert pods.	14.0	839.5

Unit No.		Thickness in feet	Cumulative thickness in feet
79	Covered: probably reddish-brown calcareous mudstone.	25.0	825.5
	Offset approximately 300 feet southeast.		
78	Microsparite: very pale orange (10YR 8/2), weathers grayish orange (10YR 7/4) and grayish orange pink (5YR 7/2); thinly bedded; poorly exposed slope; some chert pods.	4.5	800.5
77	Fossiliferous micrite: medium light gray (N 5) to light-gray (N 7), weathers light gray (N 7) and pale yellowish brown (10YR 6/2); thinly bedded; poorly exposed ledgy slope; brachiopod, crinoid stem, and echinoid spine fragments replaced by chert; some scattered chert pods.	22.0	796.0
76	Covered: probably white calcareous claystone.	10.0	774.0
75	Biomicrite: pale-red (5R 6/2), weathers pale yellowish brown (10YR 6/2); thinly bedded; ledgy slope; spiriferid brachiopods, crinoid stems, and rugose corals, laminated algae (?) material near middle of unit.	10.0	764.0
74	Covered: probably brown calcareous siltstone.	15.0	754.0
73	Biomicrite: dark-gray (N 3) becoming mottled medium gray (N 5) and moderate-red (5R 5/4) near top, weathers medium light gray (N 6); thinly to thickly bedded; partly covered ledgy slope; abundant fusulinids in first 10 feet, crinoid stems, rugose corals, and echinoid spines replaced by chert; chert pods near middle of unit. . . .	35.0	739.0
	Offset approximately 660 feet southeast.		

Unit No.		Thickness in feet	Cumulative thickness in feet
72	Calcitic dolomite: very pale orange (10YR 8/2) and grayish-orange (10YR 7/4), weathers grayish orange pink (5YR 7/2) and light brown (5YR 5/6); thinly bedded, horizontal and cross-laminations; ledge; abundant chert pods and stringers.	2.0	704.0
71	Biomicrite: light-gray (N 7), weathers same and grayish orange (10YR 7/4); thinly bedded; ledge; crinoid stem, shell, and echinoid spine fragments; some chert stringers.	5.0	702.0
70	Covered.	15.0	697.0
69	Algae biolithite (?): dark-gray (N 3), weathers medium light gray (N 6); thinly to very thinly bedded, parallel laminations; ledge; chert stringers; dark bituminous (?) films separating laminations.	2.0	682.0
68	Micrite: medium light gray (N 6), weathers pale yellowish brown (10YR 6/2); thinly to thickly bedded; ledge.	5.0	690.0
67	Covered.	19.0	675.0
66	Siltstone: grayish-red (5R 4/2), weathers grayish orange (10YR 7/4) and moderate brown (5YR 4/4); calcitic cement; thinly bedded; poorly exposed ridge.	1.0	656.0
65	Covered: probably brown calcareous siltstone.	4.0	655.0
64	Biomicrite: mottled light gray (N 6) and yellowish-gray (5Y 8/1), weathers same; thinly bedded; poorly exposed ridge; distinctive nodular appearance.	5.0	651.0
63	Covered: probably light-brown calcareous mudstone.	10.0	646.0
62	Biomicrite: pale-brown (5YR 5/2), weathers medium light gray (N 6); thinly bedded; partly covered ridge; algae and brachiopod shell fragments.	5.0	636.0

Unit No.		Thickness in feet	Cumulative thickness in feet
61	Covered.	10.0	631.0
60	Siltstone: medium-gray (N 5), weathers same and light brownish gray (5YR 6/1); dolomitic cement; thinly bedded; partly covered ridge.	3.0	621.0
59	Covered: probably interbedded pink calcareous claystone and gray algae (?) biomicrite.	50.0	618.0
58	Biomicrite: grayish orange pink (10R 8/2), weathers pinkish gray (5YR 8/1) and grayish orange (10YR 7/4); thinly bedded; ridge; crinoid stems and spiriferid brachiopods replaced by red chert.	3.0	568.0
57	Covered.	5.0	565.0
56	Biomicrite: pale-red (5R 6/2), weathers light gray (N 7); thinly bedded; ridge; unidentified fossil hash.	2.0	560.0
55	Siltstone: very light gray (N 8), weathers same and light brownish gray (5YR 6/1); calcitic cement; thinly bedded, parallel laminations; partly covered ridge.	15.0	558.0
54	Quartzarenite: pinkish-gray (5YR 8/1), weathers light brownish gray (5YR 6/1) and brownish gray (5YR 4/1); calcitic and dolomitic cement; fine-grained, moderately sorted; subrounded to subangular; thinly to very thinly bedded, parallel and cross-laminations; partly covered ridge.	1.5	543.0
53	Covered.	6.0	541.5
52	Silty micrite: brownish-gray (5YR 4/1), weathers grayish orange (10YR 7/4); thinly bedded; partly covered ridge.	2.0	535.5
51	Covered.	3.0	533.5

Unit No.		Thickness in feet	Cumulative thickness in feet
50	Algae biolithite (?): medium-gray (N 5) and brownish-gray (5YR 4/1), weathers same and dark yellowish orange (10YR 6/6); thinly bedded, parallel laminations; partly covered ridge; dark, bituminous (?) films separating laminations.	2.0	530.5
49	Fossiliferous micrite: pale-red (5R 6/2), weathers light brownish gray (5YR 6/1); thinly bedded; partly covered ridge; unidentified fossil hash.	2.0	528.5
48	Covered: some white calcareous claystone float.	14.0	526.5
47	Biomicrite: medium light gray (N 6), weathers light gray (N 7); thinly bedded; partly covered ridge; crinoid stems, echinoid spines, and shell fragments.	3.0	512.5
46	Covered: some brown micrite float.	14.0	509.5
45	Micrite: light brownish gray (5YR 6/1), weathers same and light gray (N 7); thinly bedded; ledge.	5.0	495.5
44	Covered.	10.5	490.5
43	Biomicrite: medium light gray (N 6), weathers yellowish gray (5Y 8/1) and moderate orange pink (10R 7/4); thinly bedded; partly covered ledge; crinoid stems and brachiopod shell fragments.	9.0	480.0
42	Quartzarenite: pinkish-gray (5YR 8/1), weathers same, yellowish gray (5Y 8/1) and brownish gray (5YR 4/1); calcitic cement; fine-grained, moderately sorted, subangular to subrounded; thinly to very thinly bedded, parallel and cross-laminations; partly covered ledge.	14.0	471.0
41	Mudstone: light-gray (N 7), weathers yellowish gray (5Y 8/1); calcitic cement; very thinly bedded; mostly covered slope.	15.0	457.0

Unit No.		Thickness in feet	Cumulative thickness in feet
40	Biomicrite: medium-gray (N 5), weathers light gray (N 7) and yellowish gray (5Y 8/1); thinly bedded; poorly exposed slope; crinoid stems, echinoid spines, and shell fragments.	15.0	442.0
39	Covered.	20.0	427.0
38	Fossiliferous micrite: medium dark gray (N 4), weathers medium light gray (N 6); thinly bedded; partly covered ledge; crinoid stem and brachiopod shell fragments; abundant intersecting calcite veins; some chert strings in top six feet of unit.	25.0	407.0
37	Quartzarenite: pale red purple (5RP 6/2), weathers pale pink (5RP 8/2) and very pale orange (10YR 8/2); calcitic cement; fine-grained, moderately sorted, subangular to subrounded; thinly bedded; poorly exposed ridge.	2.0	382.0
36	Covered: probably brown calcareous siltstone.	30.0	380.0
35	Biomicrite: medium dark gray (N 4), weathers medium light gray (N 6); thinly bedded; ridge; unidentified fossil hash.	2.0	350.0
34	Covered: probably white calcareous claystone.	3.0	348.0
33	Calcitic dolomite: light-brown (5YR 6/4), weathers grayish orange (10YR 7/4) and pale red (5R 6/2); finely to very finely crystalline; very thinly bedded; poorly exposed ridge.	0.5	345.0
32	Covered: probably purple calcareous mudstone.	19.0	344.5
	Offset approximately 880 feet southeast.		
31	Biomicrite: medium light gray (N 6), weathers same, light gray (N 7), and pale red purple (5RP 6/2); thinly bedded; ledge; crinoid stems, shell fragments, abundant fusulinids, and chert stringers in top three feet of unit.	10.0	325.5

Unit No.		Thickness in feet	Cumulative thickness in feet
30	Quartzarenite: pale-red (10R 6/2), weathers light gray (N 7) and moderate orange pink (10YR 7/4); calcitic cement; very fine grained, moderately sorted, subrounded to subangular; ledge; distinctive blocky appearance.	5.0	315.5
29	Covered: some light-gray calcareous claystone.	17.0	310.5
28	Biomicrite: grayish red purple (5RP 4/2), weathers light gray (N 7); thinly bedded; ledge; unidentified fossil hash.	5.0	293.5
27	Covered: some purple calcareous shale. .	4.0	288.5
26	Siltstone: moderate-red (5R 5/4), weathers pale red (5R 6/2); calcitic cement; thinly to very thinly bedded; poorly exposed slope.	1.0	284.5
25	Covered.	11.0	283.5
24	Crinoid-stem biomicrite: mottled moderate orange pink (10R 7/4) and light-gray (N 7); thinly bedded; partly covered slope; distinctive pitted weathered surface.	10.0	272.5
23	Fossiliferous micrite: light-gray (N 7) weathers same and moderate orange pink (10YR 7/4); thinly bedded; partly covered ridge; shell fragments; abundant intersecting calcite veins.	19.0	262.5
22	Dolomite: pale-red (10R 6/2), weathers light brown (5YR 6/4); finely crystalline; thinly bedded, horizontal laminations; partly covered ridge.	2.5	243.5
21	Covered.	15.0	241.0
20	Silty biosparite: mottled moderate orange pink (10R 7/4) and very pale orange (10YR 8/2), weathers pale red purple (5RP 6/2) and yellowish gray (5Y 8/1); thinly bedded; ridge; crinoid stems, echinoid spines, and shell fragments.	8.0	226.0

Unit No.		Thickness in feet	Cumulative thickness in feet
19	Siltstone: light-brown (5YR 6/4), weathers same and pale yellowish brown (10YR 6/2); calcitic cement; thinly bedded; partly covered ridge.	1.0	218.0
18	Covered.	10.0	217.0
17	Intramicrudite: mottled pale red (5R 6/2) and medium light gray (N 6), weathers pale yellowish brown (10YR 6/2) and pale red (10R 6/2); thinly bedded; ridge; intraclasts rounded, up to 2 cm in diameter, average 1 cm in diameter.	4.0	207.0
16	Crinoid-stem biomicrosparite: medium light gray (N 6) to pale yellowish brown (10YR 6/2); thinly bedded; poorly exposed low ridge; some echinoid spines and shell fragments.	2.0	203.0
15	Covered.	7.0	201.0
14	Fusulinid biomicrite: medium-gray (N 5), weathers same and light olive gray (5Y 6/1); thinly bedded; ridge; some crinoid stems and shell fragments.	10.0	194.0
13	Micrite: light-gray (N 7), weathers pale yellowish brown (10YR 6/2) and yellowish gray (5Y 8/1); thinly bedded; poorly exposed ridge; some chert pods.	3.0	184.0
12	Covered: some brown calcareous siltstone.	9.0	181.0
11	Siltstone: light-gray (N 7), weathers light brownish gray (5YR 6/1); calcitic cement; thinly bedded, parallel and cross-laminations; poorly exposed ridge.	2.0	172.0
10	Covered.	4.0	170.0
9	Biomicrite: mottled medium gray (N 5) and moderate-red (5R 5/4), weathers light gray (N 7) and yellowish gray (5Y 8/1); thinly bedded; poorly exposed series of ridges; crinoid stems, shell and coral fragments; unit becomes darker near top.	14.0	166.0

Unit No.		Thickness in feet	Cumulative thickness in feet
8	Covered: some red calcareous shale. . . .	24.0	152.0
7	Siltstone: pale reddish brown (10R 5/4), weathers same, and medium gray (N 5) and grayish orange (10YR 7/4); calcitic cement; thinly bedded; low, poorly exposed ridge; badly fractured.	1.0	128.0
6	Covered: some red calcareous sandstone.	21.0	127.0
5	Quartzarenite: pale red purple (5RP 6/2), weathers grayish red purple (5RP 4/2); dolomitic and calcitic cement; very fine grained, moderately sorted, subrounded and subangular; thinly bedded, parallel laminations; poorly exposed ridge; abundant intersecting fractures.	1.0	106.0
4	Micrite: light brownish gray (5YR 6/1), weathers medium light gray (N 6) and yellowish gray (5Y 8/1); thinly bedded; poorly exposed slope; abundant intersecting calcite veins.	7.0	105.0
3	Calcitic dolomite: light-brown (5YR 6/4), weathers grayish orange (10YR 7/4) and moderate reddish orange (10R 6/6); thinly bedded; poorly exposed ledge; some chert stringers and intersecting calcite veins. .	2.0	98.0
2	Biomicrite: medium light gray (N 6), weathers same and pinkish gray (5YR 8/1); thinly bedded; series of partly covered ledges; abundant intersecting calcite veins; abundant crinoid stems and unidentified fossil hash; fossil content increases near top of unit.	78.0	96.0
1	Quartzarenite: light brownish gray (5YR 6/1), weathers pale red (5R 6/2); calcitic cement; very fine grained, moderately sorted, subangular to subrounded; thinly bedded; partly covered slope.	18.0	18.0
	Total Earp Formation:	1364.0	

Horquilla Limestone (unmeasured):

Biomicrite: medium dark gray (N 4), weathers medium light gray (N 6) and light brownish gray (5YR 6/1); thinly bedded; slope; fusulinids, crinoid stems, and shell fragments; intersecting calcite veins.

Naco Hills

About five miles southwest of Bisbee. Base of section about 2,500 feet N. 32° E. of SW cor. sec. 26, T. 23 S., R. 23 E., Bisbee quadrangle, 15 minute series. Top of section about 2,300 feet N. 13° E. of same corner. Strike N. 10°-20° E.; dip 10°- 20° NW.

Permian:

Colina Limestone (unmeasured):

Fossiliferous microsparite: dark-gray (N 3), weathers medium gray (N 5); thinly bedded; ledge; few silt-size quartz grains; crinoid stems, pelecypods, echinoid spines.

Pennsylvanian-Permian:

Earp Formation:

Unit No.		Thickness in feet	Cumulative thickness in feet
44	Quartzarenite: grayish-pink (5R 8/2) to moderate-pink (5R 7/4), weathers grayish pink (5R 8/2); dolomitic cement; fine- to very fine grained, moderately sorted, angular to subangular; thinly bedded; low, partly covered ridge.	13.0	425.0
43	Biopelmicrite: medium-gray (N 5) to brownish-gray (5YR 4/1), weathers light gray (N 7); thinly bedded; ledge; abundant gastropods, brachiopods, crinoid stems and echinoid spines; some algae fragments and foraminifera.	10.0	412.0
42	Pelmicrite: medium light gray (N 6) to brownish gray (5YR 4/1), weathers light brown (5YR 5/6) to very pale orange (10YR 8/2); thinly bedded; low ridge, mostly covered, in middle of unit; lower five feet of pellets composed of spar with micritic envelope; upper five feet has some silt-size quartz grains.	15.0	402.0
41	Covered.	4.0	387.0

Unit No.		Thickness in feet	Cumulative thickness in feet
40	Intramicrite: medium-gray (N 5), weathers light brownish gray (5YR 6/1) to pinkish gray (5YR 8/1); thinly bedded; low, partly covered ridge; intraclasts rounded micrite particles with scattered dolomite patches; some of micrite matrix washed out and replaced by spar.	2.0	383.0
39	Covered.	4.0	381.0
38	Silty dolomitic microsparite: pale-red (5R 6/2), weathers same to moderate orange pink (10R 7/4); thinly bedded; ledge; intersecting calcite veins.	2.0	376.0
37	Covered.	6.0	374.0
36	Algae biolithite: medium-gray (N 5), weathers pinkish gray (5YR 8/1) to medium light gray (N 6); thinly bedded, subparallel laminations; ledge; alternating dolomite-rich and calcite-rich laminae.	2.0	368.0
35	Calcitic dolomite: light brownish gray (5YR 6/1), weathers pale red (10R 6/2) to grayish orange pink (10R 8/2); finely crystalline; thinly bedded, parallel laminations; ledge; scattered silt-size quartz grains.	1.0	366.0
34	microsparite: medium-gray (N 5), weathers pinkish gray (5YR 8/1) to grayish orange pink (5YR 7/2); thinly bedded; partly covered ledge; some rhombohedral outlines filled with sparry calcite; some intersecting calcite veins.	11.5	365.0
33	Covered.	4.0	353.5
32	Silty calcitic dolomite: pale red purple (5RP 6/2), weathers pinkish gray (5YR 8/1); finely crystalline; thinly bedded; partly covered ledge.	4.0	349.5
31	Covered.	6.0	345.5

Unit No.		Thickness in feet	Cumulative thickness in feet
30	Silty fossiliferous pelmicrosparite: medium dark gray (N 4), weathers yellowish gray (5Y 8/1) to pinkish gray (5YR 8/1); thinly bedded; partly covered ridge; some pellets of sparry calcite surrounded by micritic envelope; some shell fragments.	3.0	339.5
29	Covered.	10.0	336.5
28	Dolomitic siltstone: grayish red purple (5RP 4/2), weathers pale red (10R 6/2) to pale red (5R 6/2); dolomitic and calcitic cement; thinly bedded, crenulated laminations; low, partly covered ridge; dolomiticiinterlaminations.	9.0	326.5
27	Covered.	3.0	317.5
26	Silty dolomite: light-gray (N 7), weathers very pale orange (10YR 8/2) to grayish orange (10YR 7/4); medium crystalline; thinly bedded; low, partly covered ridge; some patches of calcite.	5.0	314.5
25	Intraclastic dolomite: medium-gray (N 5) and pale-red (10R 6/2), weathers pale red (10R 6/2) and yellowish gray (5Y 7/2); finely crystalline; thinly bedded; ledge; intraclasts up to 2 cm in diameter, average 1 cm; voids between clasts are sparry calcite. .	1.5	309.5
24	Covered.	17.0	308.0
23	Calcitic dolomite: pale red purple (5RP 6/2), weathers grayish orange pink (5YR 7/2); finely crystalline; thinly bedded; ledge; few silt-size quartz grains; abundant chert pods.	5.0	291.0
22	Silty calcitic biogenic dolomite: moderate-red (5R 5/4), weathers grayish orange pink (10R 8/2) and moderate orange pink (10R 7/4); medium crystalline; thinly bedded; ledge; lower part of unit friable with loose fusulinids; <u>Triticites</u> <u>cellamagnus</u>, <u>T</u>. cf. <u>bensonensis</u>, <u>T</u>. <u>creekensis</u>.	2.5	286.0

Unit No.		Thickness in feet	Cumulative thickness in feet
21	Algae biolithite (?): light brownish gray (5YR 6/1), weathers pinkish gray (5YR 8/1); thinly bedded; partly covered ledge; irregular areas of spar tend to have a horizontal orientation; thin, irregular stringers of very fine grained, silt-size quartz; abundant thin lenses and pods of chert; crinoid stems and echinoid spines replaced by chert. . .	8.0	283.5
20	Covered.	8.0	269.5
19	Dolomite: pale-red (5R 6/2), weathers light brown (5YR 6/4); finely crystalline; thinly bedded; low, partly covered ridge; few silt-size quartz grains; abundant intersecting calcite veins.	2.0	261.5
18	Covered: probably red calcareous siltstone.	22.0	259.0
17	Siltstone: brownish-gray (5YR 4/1), weathers moderate orange pink (10R 7/4); calcitic cement; thinly bedded, parallel laminations; low, partly covered ridge; clayey interlaminations.	2.0	237.5
16	Covered: probably red calcareous siltstone.	45.0	235.5
15	Biomicrite: light brownish gray (5YR 6/1), weathers pale reddish brown (10R 5/4); thinly bedded; low, partly covered ridge; brachiopod and algae fragments and foraminifera.	4.0	190.5
14	Covered: probably red calcareous siltstone.	20.0	186.5
13	Silty quartzarenite: medium light gray (N 6), weathers pale red (5R 6/2); calcitic and dolomitic cement; fine- to very fine grained, poorly sorted, angular to subangular; thinly bedded; ridge; some gypsum laths. . . .	1.0	166.5
12	Covered: probably red calcareous siltstone and shale.	34.0	165.5

Unit No.		Thickness in feet	Cumulative thickness in feet
11	Quartzarenite: grayish red puprle (5RP 4/2), weathers pale red (10R 6/2); calcitic cement; very fine grained, moderately sorted, angular to subangular; thinly bedded; partly covered ledge; some iron oxide "blebs."	6.0	131.5
10	Covered: probably red calcareous siltstone.	14.5	125.5
9	Fossiliferous micrite: dark-gray (N 3), weathers pale yellowish brown (10YR 6/2); thinly bedded; ridge; algae and crinoid stem fragments; some dolomite patches and silt-size quartz grains; abundant intersecting calcite veins.	3.0	111.0
8	Quartzarenite: pale-red (5R 6/2), weathers same; calcitic and dolomitic cement; fine- to very fine grained, moderately sorted, subangular to subrounded; thinly bedded, cross-laminations; mostly covered slope; clayey interlaminations.	47.5	108.0
7	Covered: probably light-brown calcareous siltstone.	15.0	60.5
6	Biomicrosparite: medium-gray (N 5), weathers light olive gray (5Y 6/1); thinly bedded; poorly exposed series of low ridges; foraminifera, algae, and shell fragments; some silt-size quartz.	7.0	45.5
5	Siltstone: pale-red (5R 6/2), weathers pale red (10R 6/2); calcitic and dolomitic cement; thinly bedded, parallel laminations; very poorly exposed slope; clayey interlaminations; some crinoid stems.	21.5	38.5
4	Biopelsparrudite: light-gray (N 7), weathers same; thickly bedded; ledge; abundant algae and shell fragments; some silt-size quartz.	2.0	17.0

Unit No.		Thickness in feet	Cumulative thickness in feet
3	Silty quartzarenite: pale-red (5R 6/2), weathers same; calcitic and dolomitic cement; fine- to very fine grained, moderately sorted, angular to subangular; thinly bedded, parallel laminations; partly covered slope.	3.0	15.0
2	Covered: probably red calcareous siltstone and shale.	10.0	12.0
1	Dolomitic fossiliferous micrite: medium light gray (N 6), weathers same and light gray (N 7); thinly bedded; ledge; some silt-size quartz; some algae and shell fragments, more abundant near top of unit; dessication (?) cracks filled with silt-size quartz.	2.0	2.0
	Total of Earp Formation:	425.0	

Fault: additional beds of Earp Formation below fault.

Patagonia Mountains

South slope of ridge, one-half mile south of American Peak, W1/2 SE1/4 NE1/4 and SW1/4 NE1/4 NE1/4 sec. 16, T. 23 S., R. 16 E., Harshaw quadrangle, 7.5 minute series. Exposures are on south-facing slopes. Strike N. 70° W. to N. 70°-80° W.; dip 20°-50° N.

Permian:

Colina Limestone (unmeasured):

Micrite: medium dark gray (N 4), weathers medium light gray (N 6); thinly to thickly bedded; ledge.

Pennsylvanian-Permian:

Earp Formation:

Unit No.		Thickness in feet	Cumulative thickness in feet
68	Silty dolomite: pale red purple (5RP 6/2) to very pale orange (10YR 8/2), weathers to grayish orange (10YR 7/4); thinly to very thinly bedded; ridge.	3.0	633.5
67	Covered.	19.0	630.5
66	Dolomitic dismicrosparite: medium light gray (N 6), weathers light gray (N 7); thinly bedded; ledge.	4.0	611.5
65	Silty dolomite: medium light gray (N 6), weathers very pale orange (10YR 8/2) and grayish orange (10YR 7/4); thinly and very thinly bedded, indistinct ripple laminations; ledge.	2.0	607.5
64	Sandy pelletiferous biosparite: dark-gray (N 3), weathers light gray (N 7) and yellowish brown (10YR 5/4); thinly bedded; ledge; oolites, foraminifera and algae fragments.	4.0	605.5
63	Covered.	19.0	601.5

Unit No.		Thickness in feet	Cumulative thickness in feet
62	Fossiliferous pelsparite: medium dark gray (N 4), weathers medium light gray (N 6) and grayish orange (10YR 7/4); thinly to very thinly bedded; ledge; abundant intersecting calcite veins; shell and foraminifera fragments; desiccation cracks; scattered medium-grained quartz and oolites.	39.0	582.5
61	Covered.	20.0	543.5
60	Calcitic pelletiferous dolomite: light olive gray (5Y 6/1), weathers yellowish gray (5Y 8/1); very finely crystalline; thinly to very thinly bedded; ledge; some fine-grained quartz.	3.5	523.5
59	Dolomitic micrite: dark-gray (N 3), weathers yellowish gray (5Y 8/1); thinly bedded; ridge; abundant intersecting calcite veins; small brecciated zones along veins. . . .	2.0	520.0
58	Covered.	31.0	518.0
57	Quartzarenite: moderate-brown (5YR 4/4), weathers light brown (5YR 6/4) and brownish gray (5YR 4/1); calcitic and dolomitic cement; fine- to very fine grained; moderately sorted, angular to subangular; thinly bedded, tabular planar cross crossbedding; "limonite" cubes after pyrite in upper part of unit.	8.0	487.0
56	Conglomerate: grayish-red (5R 4/2), medium-gray (N 5) and very light gray (N 8), weathers pale reddish brown (10R 5/4); calcitic cement; sand matrix; pebbles of red and white round to subround chert and micrite pebbles; pebbles average 4 cm in diameter; very poor sorting; thinly bedded, tabular planar crossbedding; ridge; <u>Triticites</u> sp.	2.5	479.0
55	Covered.	14.0	476.5
54	Siltstone: light brownish gray (5YR 6/1), weathers grayish orange (10YR 7/4); calcitic and dolomitic cement; thinly to very thinly bedded, poorly developed parallel laminations; ledge; few gypsum laths.	2.5	462.5

Unit No.		Thickness in feet	Cumulative thickness in feet
53	Intrasparrudite: dark reddish brown (10R 3/4), pale-red (10R 6/2) and light-gray (N 7), weathers medium light gray (N 6), light olive gray (5Y 6/1) and moderate red (5R 5/4); thinly bedded; ledge; intraclasts up to 12 cm by 3 cm, average 1 cm by 3 cm composed of micrite and pelmicrite, rounded to subrounded.	1.5	460.0
52	Siltstone: pale-brown (5YR 5/2), weathers moderate brown (5YR 4/4); calcitic and dolomitic cement; thinly bedded, parallel laminations; ledge; some gypsum.	2.0	458.5
51	Covered.	29.0	456.5
50	Conglomerate: grayish-red (5R 4/2), medium-gray (N 5) and very light gray (N 8), weathers pale reddish brown (10R 5/4); calcitic cement; sand matrix; pebbles of red and white round to subround chert and micrite pebbles; pebbles average 4 cm in diameter; very poor sorting; thinly bedded, tabular planar crossbedding; ridge; <u>Triticites</u> sp.	11.0	427.5
48	Dolomitic micrite: light brownish gray (5YR 6/1) to brownish-gray (5YR 4/1), weathers light brownish gray (5YR 6/1); thinly to very thinly bedded; ridge; desiccation cracks filled with silt.	2.0	412.0
47	Silty calcitic dolomite: pale-brown (5YR 5/2), weathers grayish orange (10YR 7/4); thinly bedded; partly covered ridge; few chert pods near middle of unit.	2.0	410.0
46	Covered.	8.0	408.0
45	Pelletiferous dolomitic microsparite: light brownish gray (5YR 6/1), weathers pinkish gray (5YR 8/1); thinly bedded; ridge. . . .	2.0	400.0
44	Covered.	15.0	398.0

Unit No.		Thickness in feet	Cumulative thickness in feet
43	Fossiliferous dolomitic microsparite: medium light gray (N 6); weathers same and yellowish gray (5Y 8/1); thinly to very thinly bedded; partly covered ridge; some shell and foraminifera fragments.	3.5	383.0
42	Biomicrite: medium-gray (N 5), weathers light olive gray (5Y 6/1); thinly to very thinly bedded; ledge; shell, crinoid stem, algae, and foraminifera fragments.	13.0	379.5
41	Silty dolomitic intraclastic microsparite: light brownish gray (5YR 6/1) to brownish-gray (5YR 4/1), weathers yellowish gray (5Y 8/1); thinly bedded; ledge; has some angular pieces of micrite.	2.0	366.5
40	Covered.	18.0	364.5
39	Biomicrite: light brownish gray (5YR 6/1), weathers yellowish gray (5Y 8/1); thinly bedded; ledge; algae and foraminifera fragments.	6.0	346.5
38	Clayey colomitic dismicrite: medium light gray (N 6) with streaks of pale reddish brown, weathers light gray (N 7) and grayish red (10R 4/2); thinly bedded; ledge; some wood (?) fragments.	5.0	340.5
37	Covered.	5.0	335.5
36	Siltstone: pale reddish brown (10R 5/4), weathers pale yellowish brown (10YR 6/2); calcitic cement; thinly bedded; ledge; iron oxide cubes after pyrite near top of unit.	11.0	330.5
35	Silty calcitic dolomite: pale yellowish brown (10R 5/4), weathers moderate yellowish brown (10YR 5/4); thinly bedded; ridge; some anhydrite.	3.0	319.5
34	Covered.	41.0	316.5

Unit No.		Thickness in feet	Cumulative thickness in feet
33	Pelmicrite: brownish-gray (5YR 4/1), weathers medium gray (N 5); thinly bedded; ridge; some pellets filled with sparry calcite with micrite envelopes, in part ooid shaped.	3.0	275.5
32	Covered.	13.0	272.5
31	Silty biogenic dolomite: dark yellowish orange (10YR 6/6), weathers grayish orange (10YR 7/4); thinly bedded; ridge; algae (?) and crinoid stem fragments.	5.5	259.5
30	Covered.	1.0	254.0
29	Silty pelletiferous microsparite: medium light gray (N 6), weathers light olive gray (5Y 6/1); thinly bedded; ridge.	2.0	253.0
28	Calcitic dolomitic siltstone: moderate yellowish brown (10YR 5/4), weathers very pale orange (10YR 8/2); thinly bedded; partly covered ledge; some "blebs" of calcite averaging 0.25 mm in diameter; some chert pods and stringers; unit very coarse silt to very fine sand near top.	9.0	251.0
27	Covered.	6.0	242.0
26	Silty micrite: medium light gray (N 6), weathers light gray (N 7); thinly bedded; ledge; few algae (?) fragments; some chert pods and stringers.	5.0	236.0
25	Siltstone: pale-red (5R 6/2), weathers very pale orange (10YR 8/2), grayish orange (10YR 7/4), and dark gray (N 3); calcitic cement; thinly to very thinly bedded, poorly developed parallel laminations.	3.0	231.0
24	Pelmicrosparite: medium light gray (N 6), weathers medium light gray (N 7); thinly bedded; ledge; some pellets filled with sparry calcite in micritic envelope. . . .	6.0	228.0
23	Fossiliferous micrite: medium light gray (N 6), weathers medium gray (N 7); thinly bedded; ledge; foraminifera and shell fragments. .	4.5	222.0

Unit No.		Thickness in feet	Cumulative thickness in feet
22	Silty pelletiferous intrasparite: medium-gray (N 6), weathers medium gray (N 5); thinly bedded; ledge; silt fills dessication crack, intraclasts of micrite; some chert pods	5.5	217.5
21	Siltstone: pale-brown (5YR 5/2) and medium-gray (N 5), weathers grayish orange (10YR 7/4) and dark gray (N 3); calcitic and dolomitic cement; thinly bedded, parallel and ripple laminations; partly covered ledge; some gypsum	34.5	212.0
20	Silty calcitic dolomite: medium-gray (N 5), weathers grayish orange (10YR 7/4); thinly bedded, parallel and ripple laminations; ledge	6.0	177.5
19	Silty dolomitic pelletiferous micrite: medium-gray (N 5), weathers light olive gray (5Y 6/1) and olive gray (5Y 4/1); thinly bedded; ridge; abundant chert stringers near base of unit, some gypsum	14.0	171.5
18	Dolomitic calcitic siltstone: medium dark gray (N 4) to brownish-gray (5YR 4/1), weathers grayish orange (10YR 7/4); thinly bedded; partly covered ledge	9.0	157.5
17	Siltstone: brownish-gray (5YR 4/1), weathers light gray (N 7) and yellowish gray (5Y 8/1); calcitic and dolomitic cements; partly covered ledge; thinly bedded; some sparry fossil fragments; some chert pods	10.0	148.5
16	Covered	6.0	138.5
15	Silty intraclastic biomicrosparite: brownish-gray (5YR 4/1), weathers very pale orange (10YR 8/2); thinly bedded; very poorly exposed ridge; some algae (?) fragments and foraminifera	2.0	132.5
14	Covered	6.5	130.5

Unit No.		Thickness in feet	Cumulative thickness in feet
13	Silty microsparite: brownish-gray (5YR 4/1), weathers very pale orange (10YR 8/2); thinly bedded; very poorly exposed ridge; some gypsum.	11.0	124.0
12	Siltstone: medium light gray (N 6) to pale yellowish brown (10YR 6/2), weathers light yellowish gray (5Y 8/1) to very pale orange (10YR 8/2); calcite cemented; irregular areas of dolomite cement; thinly bedded, parallel laminations in bottom and middle part of unit; poorly exposed ledge with possible interbeds of limestone; chert pods in bottom of unit; few iron oxide cubes after pyrite near top of unit.	50.5	113.0
11	Covered.	6.0	62.5
10	Silty dolomitic intramicrite: light-gray (N 7) and pale yellowish orange (10YR 8/6), weathers yellowish gray (10YR 7/4); thinly bedded; ridge; some shell and crinoid stem fragments.	1.5	56.5
9	Silty brachiopod biomicrite: light-gray (N 7) and pinkish-gray (5YR 8/1), weathers very light gray (N 8) and very pale orange (10YR 8/2); thinly bedded; ledge; brachiopods partially replaced by silica.	2.5	55.0
8	Covered.	7.0	52.5
7	Siltstone: interlaminated medium light gray (N 6) and brownish-gray (5YR 6/1), weathers grayish orange (10YR 7/4) and dusky yellowish brown (10YR 2/2); calcitic and dolomitic cement; thinly bedded, crude parallel laminations; ledge.	2.5	45.5
6	Covered.	7.5	43.0
5	Siltstone: medium dark gray (N 4), weathers very pale orange (10YR 8/2) and grayish orange (10YR 7/4); calcitic cement; thinly bedded; ridge; some anhydrite.	2.0	35.5
4	Covered.	2.5	33.5

Unit No.		Thickness in feet	Cumulative thickness in feet
3	Siltstone: medium dark gray (N 4) to brownish-gray (5YR 4/1), weathers light gray (N 7) and pinkish gray (5YR 8/1); calcitic cement; thinly bedded; ridge. . .	4.0	31.0
2	Covered.	11.0	27.0
1	Biomicrosparite: medium light gray (N 6) to light brownish gray (5YR 6/1); thinly bedded; ledge; abundant shell and crinoid stem fragments.	16.0	16.0
	Total of Earp Formation:	633.5	

Horquilla Limestone (unmeasured):

Fossiliferous micrite: light brownish gray (5YR 6/1), weathers light gray (N 7) and yellowish gray (5Y 8/1); thinly bedded; ledge; some ostracods, crinoid stem fragments and chert pods.

Pedregosa Mountains

Base of section 3,000 feet S. 54° E. of NW cor. sec. 19, T. 20 S., R. 30 E., Pedregosa Mountains quadrangle, 15 minute series. Offset approximately 250 feet south at 350 feet above base. Top of section 2,500 feet S. 12° E. of same corner. Strike N. 55° E.; dip 20°-40° NW.

Permian:

Colina Limestone (unmeasured):

Micrite: medium dark gray (N 4), weathers medium light gray (N 6) and grayish orange (10YR 7/4); thickly bedded; cliff; some small dolomite patches.

Pennsylvanian-Permian:

Earp Formation:

Unit No.		Thickness in feet	Cumulative thickness in feet
93	Covered.	8.0	929.0
92	Quartzarenite: grayish-red (10YR 4/2), weathers same; calcitic and dolomitic cement; fine- to very fine grained, moderately sorted, subrounded to subangular; thinly bedded, cross-laminations; low, poorly exposed ridge; some anhydrite. . .	3.0	921.0
91	Covered: probably red calcareous siltstone and mudstone.	50.0	918.0
90	Siltstone: pale yellowish brown (10YR 6/2), weathers light brown (5YR 5/6); calcitic and dolomitic cement; thinly bedded; low, poorly exposed ridge.	2.5	868.0
89	Covered.	40.0	965.0
99	Quartzarenite: pale-brown (5YR 5/2), weathers light brown (5YR 5/6) and grayish orange (10YR 7/4); calcitic and dolomitic cement; fine-grained, well-sorted, angular to subangular; thinly bedded; low, poorly exposed ridge; some anhydrite.	3.0	825.5
87	Covered: probably red calcareous siltstone.	10.0	822.5

Unit No.		Thickness in feet	Cumulative thickness in feet
86	Siltstone: grayish-red (10R 4/2), weathers same; calcitic and dolomitic cement; thinly bedded, clayey interlaminations; low, very poorly exposed ridge.	3.0	812.5
85	Covered: probably red calcareous siltstone and mudstone.	60.0	809.5
84	Claystone: dark yellowish orange (10YR 6/6), weathers dark yellowish orange (10YR 6/6) and very dark red (5R 2/6); calcitic cement; thinly to very thinly bedded; forms low, very poorly exposed ridge; abundant intersecting calcite veins.	4.0	749.5
83	Covered: probably red calcareous siltstone.	20.0	745.5
82	Ferroan dolomite: dark-gray (N 3), weathers grayish orange (10YR 7/4); finely to very finely crystalline; thinly bedded; ledge; some intersecting calcite veins; some biomicritic structures filled with coarsely crystalline dolomite.	12.0	725.5
81	Biosparite: brownish-gray (5YR 4/1), weathers to brownish black (5YR 2/1); thinly bedded; ledge; fossil fragments rounded; some abraded fusulinid tests, crinoid stems and shell fragments; poorly washed micrite matrix.	8.0	713.5
80	Covered.	26.5	705.5
79	Dolomitic biomicrite: medium-gray (N 5), weathers moderate yellowish brown (10YR 5/4); thinly to very thinly bedded; covered ledge; shell, foraminifera and algae fragments; some chert pods near top of unit. .	7.0	675.0
78	Biosparite: medium-gray (N 4), weathers grayish orange (10YR 7/4); thinly bedded; partly covered ledge; shell, foraminifera, and algae fragments; abundant intersecting calcite veins.	8.0	672.0
77	Covered.	9.0	664.0

Unit No.		Thickness in feet	Cumulative thickness in feet
76	Fossiliferous micrite: medium-gray (N 4), weathers same and light brown (5YR 5/6); thinly bedded; covered ledge; some dismicrite structures.	6.0	655.0
75	Algae (?) biosparite: medium-gray (N 5), weathers yellowish gray (5Y 8/1) and grayish orange (10YR 7/4); thinly to very thinly bedded; partly covered ledge; foraminifera and crinoid stem fragments. . . .	11.0	649.0
74	Biomicrosparite: medium-gray (N 5), weathers light gray (N 7) to light olive gray (5Y 6/1); thinly bedded; ledge; crinoid, foraminifera, algae fragments.	10.5	638.0
73	Crinoidal biosparite: pale-brown (5YR 4/2), weathers grayish orange (10YR 7/4); thinly bedded; ledge; some foraminifera, algae, and shell fragments.	14.0	627.5
72	Covered: probably red calcareous siltstone.	17.0	613.5
71	Biogenic calcitic dolomite: pale yellowish brown (10YR 6/2), weathers very pale orange (10YR 8/2); finely to medium crystalline; thinly bedded; ledge; foraminifera, algae (?), and shell fragments.	9.0	596.5
70	Covered.	15.0	587.5
69	Biomicrite: medium-gray (N 5), weathers medium light gray (N 6) and dark yellowish orange (10YR 6/6); thinly to very thinly bedded; poorly exposed ridge; fragments of shells, foraminifera, and algae; some dolomite.	1.0	572.5
68	Covered.	18.0	571.5
67	Fossiliferous dismicrite: medium-gray (N 5), weathers medium light gray (N 6) and dark yellowish orange (10YR 6/6); thinly bedded; ledge; fragments of pelecypods, foraminifera; abundant intersecting calcite veins; pelletiferous(?).	8.0	553.5

Unit No.		Thickness in feet	Cumulative thickness in feet
66	Biomicrite: medium dark gray (N 4), weathers medium light gray (N 6); thinly bedded; ledge; fragments of foraminifera and algae..	10.0	545.5
65	Covered.	12.0	535.5
64	Fossiliferous pelsparite: medium dark gray (N 4), weathers medium light gray (N 6); thinly bedded; ledge; fossil fragments of algae and foraminifera; some small patches of dolomite.	14.0	523.5
63	Fossiliferous microsparite: medium-gray (N 5), weathers pale brown (5YR 5/2); thinly bedded; ledge; fragments of foraminifera and crinoid stems; abundant chert pods.	6.0	509.5
62	Covered.	12.0	503.5
61	Pelletiferous dolomite: pale yellowish brown (10YR 6/2), weathers moderate yellowish brown (10YR 5/4); finely crystalline; ledge; algae (?) fragments; intersecting fractures filled with dolomite; some chert pods.	11.0	491.5
60	Ferroan dolomite: medium dark gray (N 4), weathers light olive gray (5Y 6/1); finely to medium crystalline; thinly bedded; ledge; some fossil "ghosts."	7.0	480.5
59	Biomicrosparite: dark-gray (N 3), weathers moderate yellowish brown (10YR 5/4); thinly bedded; ledge; fragments of shells, crinoid stems, and foraminifera; abundant organic material.	11.0	473.5
58	Covered.	23.0	462.5
57	Pelletiferous ferroan dolomite: dark yellowish orange (10YR 6/6), weathers grayish orange (10YR 7/4); finely crystalline; ridge; intersecting dolomite veins; some small calcite patches.	1.0	439.5
56	Covered: probably brownish-gray dolomite.	5.0	438.5

Unit No.		Thickness in feet	Cumulative thickness in feet
55	Dolomite: brownish-gray (5YR 4/1), weathers grayish orange (10YR 7/4); finely crystalline; thinly bedded; ledge; intersecting calcite veins.	12.0	433.5
54	Calcitic dolomite: olive-gray (5Y 4/1), weathers very light gray (N 8) and grayish orange (10YR 7/4); finely crystalline; thinly bedded; many interesecting calcite veins. .	10.5	421.5
53	Calcitic fossiliferous pellet dolomite: brownish-gray (5YR 4/1), weathers grayish orange (10YR 7/4); thinly bedded; ledge; pellets probably once micrite.	5.0	411.0
52	Dolomitic fossiliferous microsparite: medium light gray (N 6), weathers medium light gray (N 6) and grayish orange (10YR 7/4); thinly and very thinly bedded; ledge; some crinoid stems replaced by chert. . .	9.5	406.0
51	Fossiliferous pelmicrosparite: medium light gray (N 6), weathers medium gray (N 5); very thinly bedded; ledge; pellets composed of micrite; anastomosing calcite and dolomite veins.	7.0	396.0
50	Fossiliferous pelsparite: brownish-black (5YR 2/1), weathers pale brown (5YR 5/2); very thinly bedded; part of ledge; pellets composed mostly of micrite, some micrite envelopes surrounding sparry fossiliferous material.	0.5	389.5
49	Pelletiferous dolomite: light olive gray (5Y 6/1), weathers yellowish gray (5Y 8/1); finely to very finely crystalline; thinly to thickly bedded; low, partly covered ledge; pellets appear to be composed of what once was both sparry and micritic material. . .	7.0	389.0
48	Intra clastic calcitic dolomite: brownish-gray (5YR 4/1) to medium dark gray (N 4), weathers medium dark gray (N 4); thinly to thickly bedded; ridge; intraclasts of micrite; some algae (?) fragments.	9.0	382.0

Unit No.		Thickness in feet	Cumulative thickness in feet
47	Fusulinid biomicrite: grayish-black (N 2), weathers moderate yellowish brown (10YR 5/4); thinly to very thinly bedded; ridge; few crinoid stems; much organic material; Schwagerina grandensis, S. loringi. . . .	1.5	373.0
46	Micrite: medium-gray (N 5), weathers moderate yellowish brown (10YR 5/4); thinly bedded; low, very poorly exposed ridge; numerous intersecting calcite veins; few dolomite grains.	10.0	371.5
45	Pelletiferous intrasparrudite: medium dark gray (N 4), weathers light brownish gray (5YR 6/1) to light olive gray (5Y 6/1); thinly to very thinly bedded; low ridge; intraclasts composed chiefly of micrite but some with pelmicrite; some intraclasts are filled with sparry calcite with a micrite envelope.	2.0	361.5
44	Calcitic biogenic dolomite: light olive gray (5Y 6/1), weathers yellowish gray (5Y 8/1); finely crystalline; thinly bedded; partially covered low ridge.	9.0	359.5
43	Biomicrite: dark-gray (N 3), weathers yellowish gray (5Y 8/1); thinly to very thinly bedded; low, partially covered ridge; foraminifera, algae, and pelcypod fragments; abundant organic (?) material.	2.0	350.5
42	Covered.	20.0	348.5
41	Fusulinid biomicrudite: dark-gray (N 3), weathers pale yellowish brown (10YR 6/2); thinly to very thinly bedded; low, partially covered ridge; crinoid stems, other foraminifera fragments; abundant black organic (?) matter; Triticites pinguis.	2.0	328.5
40	Biomicrite: brownish gray-(5YR 4/1), weathers moderate yellowish brown (10YR 5/4); thinly bedded; partially covered ledge; foraminifera, algae, crinoid stem fragments; black organic (?) material.	12.0	326.5

Unit No.		Thickness in feet	Cumulative thickness in feet
39	Foraminiferal biomicrosparite: dark-gray (N 3), weathers light gray (N 7); thinly to very thinly bedded; ledge; very small amount of dolomitic replacement.	7.5	314.5
38	Covered.	7.0	307.0
37	Fossiliferous dolomitic pelsparite: medium-gray (N 5), weathers grayish orange (10YR 7/4); thinly bedded; ridge; ostracod and foraminifera fragments.	3.2	300.0
36	Covered.	8.0	296.8
35	Dolomitic biomicrosparite: medium-gray (N 5), weathers grayish orange (10YR 7/4); thinly to very thinly bedded; low, partly covered ridge; foraminifera and ostracod fragments.	1.0	288.8
34	Biogenic calcitic dolomite: light brownish gray (5YR 6/1), weathers pale yellowish brown (10YR 6/2); thinly bedded; partly covered ledge; ostracod and foraminifera fragments.	4.0	387.8
33	Covered: probably brownish-gray calcitic dolomite.	44.0	283.8
32	Fusulinid biomicrudite: dark-gray (N 3), weathers grayish orange (10YR 7/4); thinly to very thinly bedded; ledge; other fossil fragments include crinoid stems and other foraminifera; much bituminous material; <u>Schwagerina grandensis</u>.	7.0	239.8
31	Ferroan dolomite: medium dark gray (N 4), weathers grayish orange (10YR 7/4); very finely crystalline; thinly bedded; poorly exposed, low ridge.	15.0	232.8
30	Biosparite: medium-gray (N 5), weathers moderate yellowish brown (10YR 5/4); thinly to very thinly bedded; ledge; ostracod, foraminifera and algae fragments; some dolomite patches.	3.5	217.8

Unit No.		Thickness in feet	Cumulative thickness in feet
29	Fossiliferous micrite: medium dark gray (N 4), weathers brownish gray (5YR 4/1); thinly bedded; ledge; some crinoid stem and foraminifera fragments; some small dolomite patches.	9.0	214.3
28	Dolomitic intrasparite: medium-gray (N 5), weathers light gray (N 7); thinly bedded; ledge; fossil fragments of crinoid stems and foraminifera; some patches of microcrystalline quartz.	4.0	205.3
27	Covered.	16.0	201.3
26	Biomicrosparite: dark-gray (N 3) to medium light gray (N 6), weathers medium light gray (N 6); thinly bedded; ridge; some dolomite patches; fossil fragments of foraminifera and conodonts.	3.0	185.3
25	Covered: probably dark-gray biomicrosparite.	3.0	182.3
24	Biomicrosparite: dark-gray (N 3), weathers medium light gray (N 6); thinly to very thinly bedded; ridge; few patches of dolomite and chert; fossil fragments of crinoid stems and algae; some chert pods at top of unit. .	6.0	179.3
23	Covered: probably red calcareous siltstone.	16.0	173.3
22	Algal biomicrite: dark-gray (N 3), weathers light olive gray (5Y 6/1); thinly to very thinly bedded; ledge; crinoid, ostracod, pelecypod fragments.	12.0	157.3
21	Biomicrite: medium dark gray (N 4), weathers medium light gray (N 6) and yellowish brown (10YR 4/2); thinly bedded; ledge; fragments include foraminifera and algae; abundant intersecting calcite veins. . . .	8.0	145.3
20	Fusulinid biomicrosparrudite: light brownish gray (5YR 6/1), weathers medium dark gray (N 4); thinly bedded; ledge; some dolomite replacement, some intersecting calcite veins; _Schwagerina_ aff. _S_. _tersa_, _S_. _dunnensis_.	1.0	137.3

Unit No.		Thickness in feet	Cumulative thickness in feet
19	Covered: probably olive-gray calcitic dolomite.	15.0	136.3
18	Calcitic dolomite: light olive gray (5Y 6/1), weathers moderate yellowish brown (10YR 5/4); aphanocrystalline to very finely crystalline; very thinly bedded; low, poorly exposed ridge; some small patches of ferroan dolomite.	1.0	121.3
17	Covered: probably olive-gray biomicrite. .	4.3	120.3
16	Biomicrite: light olive gray (5Y 6/1), weathers light gray (N 7); thinly bedded; slope; poor exposures; fossil fragments include foraminifera, cirnoid stems, and algae (?).	1.0	116.0
15	Covered.	7.0	115.0
14	Biomicrite: pale yellowish brown (10YR 6/2), weathers grayish orange (10YR 7/4) and medium gray (N 5); thinly to very thinly bedded; partly covered, low ridge; very few fine grained silt-size quartz grains; fossil fragments include crinoid stems and algae fragments.	8.5	108.0
13	Covered.	14.5	99.5
12	Biomicrite: pale yellowish brown (10YR 6/2), weathers grayish orange (10YR 7/4) and medium gray (N 5); thinly to very thinly bedded; ridge; fossil fragments include algae, foraminifera, ostracods, crinoid stems, and plant (?) remains.	5.0	85.0
11	Fossiliferous microsparite: medium-gray (N 5), weathers same and yellowish gray (5Y 8/1); thinly to very thinly bedded; ridge; fossil fragments of ostracods, foraminifera, and crinoid stems; <u>Schubertella</u> sp. aff. <u>S</u>. <u>kingi</u>.	5.0	80.0
10	Covered.	10.0	75.0

Unit No.		Thickness in feet	Cumulative thickness in feet
9	Dolomitic biomicrite: dark-gray (N 3), weathers medium gray (N 5) and grayish orange (10YR 7/4); thinly to very thinly bedded; low, poorly exposed ridge; fossil fragments of algae, bryozoa, and crinoid stems; many intersecting calcite seams.	2.5	65.0
8	Covered: probably brown calcareous siltstone.	25.0	62.5
7	Dolomitic biomicrite: medium light gray (N 6), weathers same; very thinly bedded; slope; poor exposures; unit partly covered; fossil fragments of phylloid algae, foraminifera, bryozoa, and crinoid stems. . . .	5.0	37.5
6	Covered.	6.0	32.5
5	Biomicrosparite: light olive gray (5Y 6/1), weathers light gray (N 7); thickly bedded; ridge; fossil fragments include foraminifera, crionoid stems, and algae; unit has intersecting calcite veins.	3.0	26.5
4	Covered: rubble of yellowish-gray calcitic dolomite.	3.0	23.5
3	Dolomitic fossiliferous micrite: light olive gray (5Y 6/1), weathers light gray (N 7) with grayish orange (10YR 7/4) weathering calcite stringers; thinly bedded; ridge; ostracod shells filled with sparry calcite; pelecypod and gastropod fragments; many intersecting calcite stringers.	3.5	20.5
2	Calcitic dolomite: yellowish-gray (5Y 7/2), weathers same; finely crystalline; thinly bedded; low ledge; numerous small fractures filled with calcite; unit partially covered. .	12.0	17.0
1	Calcitic fusulinid biogenic dolomite: medium light gray (N 6) and dusky-yellow (5Y 6/4), weathers dark yellowish brown (10YR 4/2) and dark yellowish orange (10YR 6/6); finely crystalline; thinly bedded; low ledge; fossil fragments and fusulinids set in a calcitic dolomite matrix.	5.0	5.0

Unit No.		Thickness in feet	Cumulative thickness in feet
	Total of Earp Formation:	933.5	
	Alluvium		

Swisshelm Mountains

Low ridge north of old mining district in northern Swisshelm Mountains. Base of section about 2,800 feet No. 45° E. of SW cor. sec. 1, T. 20 S., R. 27 E, Squaretop Hills quadrangle, 15 minute series. Base of section about 2,700 feet N. 35° E. Strike N. 65°-45° E.; dip 10°-35° NW.

Alluvium:

Pennsylvanian-Permian:

Earp Formation:

Unit No.		Thickness in feet	Cumulative thickness in feet
40	Fossiliferous pelsparite: medium light gray (N 6) to medium light gray (N 5), weathers light gray (N 7) and brownish gray (5YR 4/1); thinly bedded; very poorly exposed dip slope: some foraminifera fragments; scattered irregular patch of dolomite.	10.0	315.0
39	Fossiliferous micrite: light-gray (N 7) and medium-gray (N 5), weathers medium light gray (N 6); thinly bedded; very poorly exposed dip slope; intersecting calcite veins; some ostracod and algae fragments. . . .	30.0	305.0
38	Covered.	20.0	275.0
37	Microsparite: medium-gray (N 5) to medium light gray (N 6), weathers light gray (N 7); thinly bedded; very poorly exposed dip slope; few anhedral dolomite grains. . . .	5.0	255.0
36	Covered.	10.0	250.0
35	Dolomitic biomicrite: grayish-red (10R 4/2) and medium light gray (N 6), weathers grayish orange (10YR 7/4); thinly bedded; ridge and dip slope; some fossil fragments replaced by iron oxide; few pellets; foraminifera, algae, and shell fragments; fossil fragments rounded.	8.0	240.0
34	Covered.	10.0	232.0

Unit No.		Thickness in feet	Cumulative thickness in feet
33	Biomicrosparite: medium light gray (N 6) to medium dark gray (N 4), weathers light brownish gray (5YR 6/1); thinly bedded; ledge and dip slope; uniserial foraminifera, algae, and shell fragments; some dolomite patches; fossil fragments replaced by iron oxide in upper part of unit.	10.0	222.0
32	Covered.	9.0	212.0
31	Biosparite: medium dark gray (N 4) and brownish-gray (5YR 4/1), weathers grayish orange (10YR 7/4) and light gray (N 7); thinly bedded; ledge; foraminifera, algae, and shell fragments; some scattered dolomite patches.	20.0	203.0
30	Biomicrite: medium-gray (N 5), weathers same; thinly bedded; ledges; algae, wood, crinoid stem fragments; <u>Triticites</u> sp., <u>T. creekensis</u>, <u>Leptotriticites</u> <u>fivensis</u>, <u>L. eoextentus</u>.	3.0	183.0
29	Covered.	18.0	180.0
28	Fossiliferous micrite: medium light gray (N 6), weathers same and light brownish gray (5YR 6/1); thinly bedded; ledge; some shell, algae, and foraminifera fragments; some dolomite patches.	3.0	162.0
27	Covered.	17.0	159.0
26	Biomicrite: medium light gray (N 6), weathers same and light brownish gray (5YR 6/1); thinly bedded; ledge; algae, shell fragments; <u>Leptotriticites</u> <u>koschmanni</u>.	5.0	142.0
25	Biomicrudite: medium dark gray (N 4), weathers same; thinly bedded; low ridge; ostracod, algae, and shell fragments; shell fragments rounded.	1.0	137.0
24	Covered.	14.0	136.0

Unit No.		Thickness in feet	Cumulative thickness in feet
23	Intramicrite: pale yellowish brown (10YR 6/2), weathers same; thinly bedded; ridge; intraclasts micrite; some scattered silt-size quartz.	1.0	122.0
22	Covered.	5.0	121.0
21	Biopelsparite: medium-gray (N 5), weathers dark yellowish brown (10YR 4/2); thinly bedded; ledge; fossil fragments rounded; some fragments sparry calcite with micritic envelope; some dolomite patches.	4.0	116.0
20	Covered.	8.0	112.0
19	Biomicrosparite: medium-gray (N 5); weathers dark yellowish brown (10YR 4/2); thinly bedded; ledge; algae, ostracod, foraminifera fragments; some dolomite patches. . .	6.0	104.0
18	Covered.	8.0	98.0
17	Fossiliferous intramicrudite: light brownish gray (5YR 6/1), weathers moderate brown (5YR 3/4) and light brown (5YR 5/6); thinly bedded; ledge; micritic intraclasts; brachiopod, algae, and ostracod fragments. . . .	4.0	90.0
16	Covered.	8.0	86.0
15	Silty pebble conglomerate: dark yellowish orange (10YR 6/6) and light-gray (N 7) pebbles in a light-gray (N 7) matrix, weathers light brownish gray (5YR 6/1) and light gray (N 7); calcitic and dolomitic cement; thinly bedded; very poorly exposed ridge; fragments up to one cm in diameter becoming one mm in diameter near top of unit: fragments of micrite and biomicrite; rounded. .	2.0	78.0
14	Covered.	9.0	76.0

Unit No.		Thickness in feet	Cumulative thickness in feet
13	Pebble conglomerate: dusky-red (5R 3/4), medium dark gray (N 4), and medium-gray (N 5), pebbles set in a medium-gray (N 5) matrix, weathers pale reddish brown (10R 5/4) and medium light gray (N 6); calcitic cement; thinly bedded; partly covered ledge; fragments up to 3 cm in diameter and average 1 cm; fragments predominantly micrite; some rounded fossil fragments. . .	8.0	67.0
12	Biomicrudite: medium light gray (N 6), weathers same and grayish brown (5YR 3/2); thinly bedded; poorly exposed ridge; foraminifera, crinoid stem, and algae fragments; fossil fragments rounded; some sparry calcite with a micritic envelope.	1.0	59.0
11	Covered.	19.0	58.0
10	Siltstone: moderate yellowish brown (10YR 5/4), weathers same; calcitic and dolomitic cement; thinly bedded; slope; some clay-size material.	2.0	39.0
9	Covered.	9.0	37.0
8	Fossiliferous microsparite: medium light gray (N 6), weathers same and grayish orange (10YR 7/4); thinly bedded; ledge; foraminifera, crinoid stem, and algae fragments.	3.0	28.0
7	Biomicrosparite: medium light gray (N 6) with dusky-red, weathers light brownish gray (5YR 6/1) and grayish orange (10YR 7/4); thinly bedded; ridge; unidentifiable fossil hash; fossil fragments coated with iron oxide.	2.0	25.0
6	Covered: probably purple calcareous shale.	7.0	23.0
5	Biomicrite: medium-gray (N 5), weathers brownish gray (5YR 4/1); thinly bedded; ledge; algae, shell, and crinoid stem fragments; desiccation cracks and intersecting calcite veins; some fossil fragments covered with iron oxide.	6.0	16.0

Unit No.		Thickness in feet	Cumulative thickness in feet
4	Biomicrudite: medium dark gray (N 4), weathers light gray (N 7) and grayish orange (10YR 7/4); thinly bedded; ledge; algae and spiny brachiopod fragments; few dolomite patches; intersecting calcite veins.	5.0	10.0
3	Dolomitic biopelmicrudite: brownish-gray (5YR 6/1) and medium-gray (N 5); weathers pale yellowish brown (10YR 6/2) and grayish orange (10YR 7/4); thinly bedded; ledge; algae and shell fragments.	1.5	5.0
2	Biopelmicrite: light brownish gray (5YR 6/1), medium light gray (N 6), weathers light brown (5YR 5/6); thinly bedded; ledge; abundant algae fragments; some silt-size quartz fragments and dolomite patches. . .	1.5	3.5
1	Biomicrite: light brownish gray (5YR 6/1), weathers same and grayish orange (10YR 7/4); thinly bedded; ledge; ostracod fragments and unidentified fossil hash; abundant calcite veins.	2.0	2.0
	Total Earp Formation:	315.0	

Alluvium:

Waterman Mountains

Southwest end of main mountain mass. Base of section about 1,400 feet S. 45° E. of NW cor. sec. 31, T. 12 S., R 9 E., Silver Bell Peak quadrangle, 15 minute series. Top of section about 2,300 feet S. 65° E. of same corner. Strike N. 10°-20° W.; dip 30°-45° NE.

Permian:

Colina Limestone (unmeasured):

Dolomite: dark-gray (N 3), weathers grayish orange (10YR 7/4) and very pale orange (10YR 8/2); very finely crystalline; thinly bedded, parallel laminations; ledge; worm (?) burrows filled with silt-size quartz grains.

Pennsylvanian-Permian:

Earp Formation:

Unit No.		Thickness in feet	Cumulative thickness in feet
52	Siltstone: very pale orange (10YR 8/2), weathers same; dolomitic cement; thinly bedded; mostly covered slope.	4.0	606.0
51	Clayey dolomite: dark-gray (N 3), weathers pale yellowish orange (10YR 8/6); thinly bedded, parallel and cross-laminations; ridge; intersecting calcite veins.	5.0	602.0
50	Siltstone: very pale orange (10YR 8/2), weathers same; dolomitic cement; thinly bedded; very poorly exposed slope. . . .	15.0	597.0
49	Dolomite: dark-gray (N 3), weathers grayish orange (10YR 7/4); thinly bedded, parallel laminations; ledge; few silt-size quartz grains; intersecting calcite veins. .	10.0	582.0
48	Intraclastic dolomite: dark-gray (N 3), weathers dark greenish gray (5GY 4/1); medium crystalline; thinly bedded ledge; intersecting calcite veins; very rough weathered surface.	20.0	572.0

Unit No.		Thickness in feet	Cumulative thickness in feet
47	Quartzarenite: very pale orange (10YR 8/2), weathers same; calcitic and dolomitic cement; fine- to very fine grained, moderately sorted, subangular to subrounded; thinly bedded; partly covered ledge. . . .	10.0	552.0
46	Clayey silty quartzarenite: grayish-red (5R 4/2), weathers pale red (5R 6/2); dolomitic cement; very fine grained, moderately sorted, subangular to subrounded; thinly bedded, parallel and cross-laminations; partly covered slope; clayey interlaminations.	26.0	542.0
45	Sandy siltstone: very pale orange (10YR 8/2), weathers same; dolomitic cement; thinly to very thinly bedded; very poorly exposed slope; very fine-grained quartz, subangular.	38.0	516.0
44	Silty dolomite: dark-gray (N 3), weathers grayish orange (10YR 7/4); finely crystalline; thinly bedded; ledge; weathered, pitted surface; numerous intersecting calcite veins.	27.5	478.0
43	Silty pelmicrite: dark-gray (N 3), weathers grayish orange (10YR 7/4); thinly bedded; ledge; numerous irregular voids and cracks (?) filled with silt-size quartz and microcrystalline quartz.	9.0	450.5
42	Dismicrite: grayish-black (N 2), weathers medium gray (N 5) to medium light gray (N 6); thinly bedded; very poorly exposed slope; some chert pods.	20.0	441.5
41	Covered.	19.0	421.5
40	Clayey micrite: grayish-black (N 2), weathers grayish orange (10YR 7/4); thinly bedded; partly covered ridge; few silt-size quartz grains.	2.0	402.5

Unit No.		Thickness in feet	Cumulative thickness in feet
39	Quartzarenite: pale-brown (5YR 5/2), weathers moderate yellowish brown (10YR 5/4); dolomitic cement; very fine and fine-grained; moderately sorted, subangular to subrounded; thinly bedded, parallel laminations; ridge; clayey interlaminations. .	2.0	400.5
38	Siltstone: very pale orange (10YR 8/2), weathers same; thinly bedded; mostly covered slope.	31.0	398.5
37	Siltstone: brownish-gray (5YR 4/1) to pale-brown (5YR 5/2), weathers light brown (5YR 5/6) and moderate yellowish brown (10YR 5/4); dolomitic cement; thinly bedded, parallel and cross-laminations; very poorly exposed slope; clayey interlaminations. .	75.0	367.5
36	Intrasparrudite: very dusky red (10R 2/2) to pale reddish brown (10R 5/4) to very pale orange (10YR 8/2), weathers light brownish gray (5YR 6/1); thinly bedded; ridge; intraclasts rounded micrite 4 cm to 0.5 mm in diameter.	2.0	292.5
35	Sandy siltstone: light brownish gray (5YR 6/1) to pale-brown (5YR 5/2), weathers dark yellowish brown (10YR 4/2), pale yellowish brown (10YR 4/2), and grayish orange (10YR 7/4); dolomitic cement, calcitic and dolomitic cement in middle of unit; thinly bedded, parallel and cross-laminations; partly covered series of ridges; clayey interlaminations.	80.0	290.5
34	Intrasparrudite: moderate-brown (5YR 4/4) and light-gray (N 7), weathers moderate brown (5YR 4/4) and light gray (N 7); thinly bedded; ridge; intraclasts rounded, micritic, and partly dolomitized, range from 0.8 mm to 2 cm in diameter; some silt-size quartz grains.	6.0	210.5
33	Covered.	2.0	204.5
32	Clayey silty micrite: light-gray (N 7), weathers grayish yellow (5Y 8/4); thinly bedded, parallel laminations; ridge; clayey interlaminations.	2.0	202.5

Unit No.		Thickness in feet	Cumulative thickness in feet
31	Covered.	2.0	200.5
30	Dolomitic micrite: light-brown (5YR 6/4), weathers grayish orange (10YR 7/4); thinly bedded; low, partly covered ridge.	3.0	198.5
29	Covered.	5.0	195.5
28	Dolomitic micrite: mottled light gray (N 7) and moderate-brown (5YR 4/4), weathers very pale orange (10YR 8/2); thinly bedded; ridge; intersecting calcite veins.	2.0	190.5
27	Covered.	4.0	188.5
26	Dolomitic dismicrosparite: light-gray (N 7), weathers pinkish gray (5YR 8/1) and yellowish gray (5Y 8/1); thinly bedded; poorly exposed, low ridge; few silt-size quartz grains.	3.5	184.5
25	Silty dolomite: light brownish gray (5YR 6/1) and greenish-gray (5GY 6/1), weathers grayish orange (10YR 7/4); very finely crystalline; thinly bedded; low ridge; abundant intersecting calcite veins.	3.0	181.0
24	Siltstone: light olive gray (5Y 6/1) and greenish-gray (5GY 6/1), weathers dark yellowish brown (10YR 4/2) and dusky yellowish brown (10YR 2/2); calcitic cement; thinly bedded; indistinct parallel laminations; very poorly exposed slope; clayey interlaminations.	10.0	178.0
23	Sandy pelsparite: light-gray (N 7), weathers light brownish gray (5YR 6/1); thinly bedded; low, partly covered ridge.	3.0	168.0
22	Silty microsparite: pale yellowish brown (10YR 6/2), weathers moderate yellowish brown (10YR 5/4); thinly bedded; very poorly exposed slope.	7.0	165.0

Unit No.		Thickness in feet	Cumulative thickness in feet
21	Sandy pelsparite: medium dark gray (N 4), weathers very pale orange (10YR 8/2) and grayish orange (10YR 7/4); thinly bedded, parallel laminations; ridge; fine- to very fine grained quartz, subrounded; sandy interlaminations.	3.0	158.0
20	Quartzarenite: greenish-gray (5GY 6/1), weathers yellowish gray (5Y 7/2); calcitic cement; very fine grained, well-sorted, subangular to subrounded; thinly bedded; indistinct parallel laminations; partly covered ridge.	13.0	155.0
19	Fossiliferous microsparite: mottled medium light gray (N 6) and grayish-orange (10YR 7/4) and medium light gray (N 6); thinly bedded; ridge; algae, foraminifera, and shell fragments; few anhedral patches of dolomite; some worm (?) burrows filled with sparry calcite.	2.0	141.0
18	Covered.	20.0	139.0
17	Dolomitic intrasparrudite: light brownish gray (5YR 6/1) and olive-gray (5Y 4/1), weathers grayish orange (10YR 7/4) and medium light gray (N 6); thinly bedded; ridge; some silt-size quartz grains, algae and shell fragments; intraclasts well-rounded.	7.0	119.0
16	Siltstone: light-gray (N 7), weathers grayish orange (10YR 7/4); thinly bedded; partly covered series of low ridges; worm (?) burrows filled with sparry calcite.	20.0	112.0
15	Covered.	10.0	92.0
14	Silty pelletiferous intrasparrudite: medium light gray (N 6) and moderate-brown (5YR 3/4), weathers grayish orange (10YR 7/4); thinly bedded; ridge; intraclasts micritic and well-rounded; some pellets filled with sparry calcite surrounded by micritic envelope; some algae fragments.	2.0	82.0

Unit No.		Thickness in feet	Cumulative thickness in feet
13	Biopelmicrite: mottled dusky red (5R 3/4) and pale-olive (10YR 6/2), weathers grayish purple (5P 4/2) and grayish yellow green (5GY 7/2); thinly bedded; ridge; algae and shell fragments.	2.0	80.0
12	Covered.	8.0	78.0
11	Dolomitic dismicrosparite: light olive gray (5Y 6/1), weathers grayish orange (10YR 7/4); thinly bedded; ridge; some silt-size quartz grains and gypsum grains.	2.0	70.0
10	Covered.	7.0	68.0
9	Intraclastic algae biosparrudite: medium light gray (N 6), weathers medium gray (N 5); thinly bedded; ledge; some chert pods. . .	5.0	61.0
8	Crinoidal biosparite: medium light gray (N 6), weathers medium gray (N 5); thinly bedded; ledge; some abraded fusulinid fragments; <u>Adetognathus</u> <u>giganta</u>, <u>A</u>. <u>lauta</u>.	4.0	56.0
7	Intraclastic biopelmicrite: light bluish gray (5B 7/1), weathers very pale orange (10YR 8/2), grayish orange (10YR 7/4), and medium gray (N 5); thinly bedded; ridge; crinoid stem and algae fragments.	2.0	52.0
6	Mudstone: dusky-brown (5YR 2/2) and pale-olive (10Y 6/2), weathers grayish red purple (5RP 4/2) and pale pink (5RP 8/2); very thinly bedded; partly covered slope. . . .	14.0	50.0
5	Silty microsparite: light olive gray (5Y 6/1), weathers grayish orange (10YR 7/4); thinly bedded; ridge; local concentrations of silt-size quartz grains filling worm (?) burrows.	3.0	36.0
4	Siltstone: light brownish gray (5YR 6/1), weathers same; calcitic and dolomitic cement; thinly bedded, indistinct parallel laminations; ridge; some gypsum laths. . .	9.0	33.0
3	Silty idsmicrosparite: grayish-red (5R 4/2), light-brown (5YR 6/4); thinly bedded; low ridge.	12.0	24.0

Unit No.		Thickness in feet	Cumulative thickness in feet
2	Siltstone: brownish-gray (5YR 4/1) and greenish-gray (5GY 6/1), weathers pale red (5R 6/2) and light brownish gray (5YR 6/1); calcitic and dolomitic cement; thinly bedded, indistinct cross-laminations; low ridge.	9.0	12.0
1	Covered.	3.0	3.0
	Total of Earp Formation:	606.0	

Horquilla Limestone (unmeasured):

Silty dolomitic dismicrite: medium light gray (N 6) to medium-gray (N 5), weathers yellowish gray (5Y 8/1) and grayish orange (10YR 7/4); thinly bedded; low ridge; some chert pods and worm (?) burrows.

Whetstone Mountains

Exposures on northeasterly facing slopes of spur in southern part of range just west of Sand's Ranch. Base of section about 1,200 feet S. 62° W. of NE cor. sec. 4, T. 20 S., R. 19 E, Mustang Mountain quadrangle, 7.5 minute series. Top of section about 2,200 feet S. 62° W. of same corner. Strike N. 5°-15° W.; dip 15°-20° SW.

Covered.

Pennsylvanian-Permian:

Earp Formation:

Unit No.		Thickness in feet	Cumulative thickness in feet
48	Silty biopelsparite: very light gray (N 8), weathers light gray (N 7) and pale yellowish brown (10YR 6/2); thinly bedded; ridge; foraminifera and shell fragments; <u>Triticites bensonensis</u>.	10.0	448.5
47	Silty dolomitic biopelsparite: medium dark gray (N 4) and moderate-red (5R 5/4), weathers moderate brown (5YR 4/4) and very pale orange (10YR 8/2); thinly bedded; partly covered ridge; shell, algae, and foraminifera fragments.	1.5	438.5
46	Covered: probably red calcareous sandstone.	16.0	437.0
45	Fossiliferous microsparite: medium light gray (N 6), weathers grayish orange (10YR 7/4) and yellowish gray (5Y 8/1); thinly bedded; partly covered ridge; shell and algae (?) fragments; few dolomite patches.	3.0	421.0
44	Mudstone: grayish-red (5R 4/2), weathers grayish orange pink (10R 8/2) and moderate reddish orange (10R 6/6); calcitic cement; thinly bedded, parallel and cross-laminations of silt and clay; worm(?) burrows.	25.0	418.0
43	Calcitic biogenic dolomite: light olive gray (5Y 6/1), weathers grayish orange (10YR 7/4); finely to coarsely crystalline; thinly bedded; ledge; crinoid stem and shell fragments.	3.0	393.0

Unit No.		Thickness in feet	Cumulative thickness in feet
42	Covered.	5.0	390.0
41	Biomicrosparite: light brownish gray (5YR 7/1), weathers to light gray (N 7) and grayish orange (10YR 7/4); thinly bedded; ledge; foraminifera, crinoid stem, algae, and shell fragments; some anhedral dolomite patches; Triticites southensis, T. bensonensis, T. coronadoensis.	14.0	385.0
40	Covered.	22.0	371.0
39	Fossiliferous microsparite: light-gray (N 7), weathers pinkish gray (5YR 8/1) and yellowish brown (10YR 5/4); thinly bedded; low, partly covered ridge; ostracod and foraminifera fragments.	2.5	349.0
38	Covered.	9.0	346.5
37	Biopelsparite: light-gray (N 7), weathers yellowish gray (5Y 8/1) and moderate red (5R 4/6); thinly bedded; ridge; some anhedral dolomite blebs.	4.0	337.5
36	Covered.	13.0	333.5
35	Dolomitic microsparite: light brownish gray (5YR 6/1), weathers grayish orange (10YR 7/4) and light gray (N 7); thinly bedded; partly covered ridge; some dolomite rhombs replaced by calcite.	1.0	320.5
34	Covered.	0.5	318.5
33	Clayey calcitic biogenic dolomite: light-red (5R 6/6), weathers light brown (5YR 6/4) and moderate orange pink (10R 7/4); thinly to very thinly bedded; low, partly covered ridge; abundant intersecting fractures. . .	1.5	318.0
32	Covered.	11.0	316.5

Unit No.		Thickness in feet	Cumulative thickness in feet
31	Fossiliferous intrasparite: medium-gray (N 5), weathers grayish orange (10YR 7/4), intraclasts very light gray (N 8) to pale reddish brown (10R 5/4); thinly bedded; ridge; intraclasts of micrite; foraminifera, crinoid stem, and algae fragments.	1.5	305.5
30	Biopelsparite: light-gray (N 7), weathers same and grayish orange (10YR 7/4) with intersecting dark yellowish orange (10YR 6/6 bands; thinly bedded; ridge; fossil fragments well rounded, some with micritic envelope filled with sparry calcite.	1.0	304.0
29	Algae biolithite: light-gray (N 7), weathers same and grayish orange (10YR 7/4); thinly bedded; ridge; laminae set off by bituminous film.	1.0	303.0
28	Covered.	27.0	302.0
27	Dolomitic biomicrosparite: mottled light brownish gray (5YR 4/1) and moderate-red (5R 5/4), weathers grayish orange (10YR 7/4) and very pale orange (10YR 8/2); thinly to very thinly bedded; ledge; some oolites; shell and algae fragments.	1.5	275.0
26	Clayey dolomitic fossiliferous micrite: medium light gray (N 6) with intersecting dusky-red (5R 3/4) bands following fractures, weathers light gray (N 7); thinly bedded; ledge; intersecting calcite fractures; some chert pods; crinoid stem and echinoid spine fragments.	5.0	273.5
25	Covered.	19.0	268.5
24	Dolomitic biomicrite: medium light gray (N 6), weathers mottled light gray (N 7) and dusky red (5R 3/4); thinly bedded; ledge; fusulinids, crinoid stem, and algae fragments; <u>Triticites coronadoensis</u>.	5.5	249.5
23	Covered.	22.0	244.0

Unit No.		Thickness in feet	Cumulative thickness in feet
22	Fossiliferous intrasparite: medium-gray (N 5), intraclasts weather very light gray (N 8) and pale reddish brown (10R 5/4) in grayish orange matrix; thinly to very thinly bedded; ridge; few clasts of pebble size, average 2.6 mm, composed of micrite; few abraded fusulinid and shell fragments.	1.5	222.0
21	Intraclastic biosparrudite: light brownish gray (5YR 6/1), weathers grayish orange (10YR 7/4); thinly bedded; ridge; algae and shell fragments rounded; some fragments filled with sparry calcite in a micritic envelope; micrite intraclasts.	2.0	220.5
20	Covered.	18.0	218.5
19	Dolomitic intraclastic biosparrudite: light brownish gray (5YR 6/1), weathers light olive gray (5Y 6/1); thinly bedded; ridge; fossil fragments rounded, filled with sparry calcite in a micritic envelope.	2.0	200.5
18	Covered.	33.5	198.5
17	Fossiliferous micrite: light brownish gray (5YR 6/1), weathers medium light gray (N 6); thinly bedded; partly covered ledge; scattered anhedral dolomite patches; some foraminifera and pelecypod fragments. . . .	13.0	165.0
16	Dismicrite: medium-gray (N 5) to medium light gray (N 6), weathers light gray (N 7) and grayish orange (10YR 7/4); thinly bedded; poorly exposed ledge; scattered algae (?) and shell fragments.	23.0	152.0
15	Covered.	29.0	129.0
14	Calcitic dolomite: light-brown (5YR 5/6), weathers grayish orange (10YR 7/4); very finely crystalline; thinly bedded; low, poorly exposed ridge; desiccation (?) cracks filled with quartz grains and sparry calcite.	0.5	100.0
13	Covered.	4.0	99.5

Unit No.		Thickness in feet	Cumulative thickness in feet
12	Micrite: medium dark gray (N 4), weathers medium light gray (N 6) and grayish orange (10YR 7/4); thinly bedded; ledge.	12.0	95.5
11	Covered.	6.0	83.5
10	Calcitic clayey dolomite: grayish-red (5R 4/2), weathers grayish orange (10YR 7/4) and dark yellowish orange (10YR 6/6); finely crystalline; very thinly bedded; low, poorly exposed ridge; worm (?) burrows; intersecting calcite veins.	1.5	77.5
9	Covered.	4.0	76.0
8	Pelsparite: medium dark gray (N 4), weathers light gray (N 7) and grayish orange (10YR 7/4); thinly bedded; partially covered ridge; some pellets filled with spar with micritic envelope; scattered silt-size quartz grains and patch of anhedral dolomite.	5.0	72.0
7	Silty biopelsparite: light-gray (N 7), yellowish gray (5Y 8/1), and grayish orange (10YR 7/4); thinly bedded; low, partially covered ridge; <u>Triticites</u> sp., <u>T</u>. <u>whetstonensis</u>.	4.0	67.0
6	Covered.	4.0	63.0
5	Fossiliferous intrasparite: medium light gray (N 6), weathers medium gray (N 5) and dark yellowish orange (10YR 6/6); thinly to very thinly bedded; ledge; crinoid stem, algae, and foraminifera fragments; micrite intraclasts up to 0.8 mm in diameter, average 0.5 mm; some patches of anhedral dolomite.	5.0	59.0
4	Biopelsparite: medium-gray (N 5), weathers grayish orange (10YR 7/4) to moderate orange (10R 7/4); thinly bedded; ledge; algae, crinoid stem, foraminifera fragments.	1.0	54.0
3	Covered.	7.0	53.0

Unit No.		Thickness in feet	Cumulative thickness in feet
2	Silty biosparite: medium-gray (N 5), weathers grayish orange (10YR 7/4) to very pale orange (10YR 8/2); thinly bedded; ledge; some small patches of anhedral dolomite: Triticites bensonensis.	3.0	46.0
1	Covered.	43.0	43.0
	Total of Earp Formation:	448.5	

Horquilla Limestone (unmeasured):

Biopelsparite: pale-red (10R 6/2) to medium light gray (N 6); weathers grayish orange (10YR 7/4); thinly bedded; ledge; scattered anhedral dolomite grains.

REFERENCES

Aitken, J. D., 1967, Classification and environmental significance of cryptalgal limestones and dolomites, with illustrations from the Cambrian and Ordovician of southwestern Alberta: Jour. Sed. Petrology, v. 37, p. 1162-1178.

Baars, D. L., 1962, Permian system of Colorado Plateau: Am. Assoc. Petroleum Geologists, v. 46, p. 149-218.

Baars, D. L., 1963, Petrology of carbonate rocks, in Shelf carbonates of the Paradox Basin: Four Corners Geological Society Symposium, 4th Field Conference, p. 101-129.

Barrell, J., 1912, Criteria for the recognition of ancient delta deposits: Geol. Soc. America Bull., v. 23, p. 377-446.

Black, Maurice, 1933, The algal sediments of Andros Island, Bahamas: Royal Soc. London Philos. Trans., ser. B, v. 122, p. 165-192.

Braun, M., and Friedman, G. M., 1969, Carbonate lithofacies and environments of the Tribes Hill Formation (Lower Ordovician) of the Mohawk Valley, New York: Jour. Sed. Petrology, v. 39, p. 113-135.

Bryant, D. L., 1955, Stratigraphy of the Permian System in southern Arizona: unpub. Ph.D. thesis, Univ. of Arizona, 209 p.

Bryant, D. L., 1957, Marker zones in Permian formations of southern Arizona, in Guidebook II Southern Arizona: Ariz. Geol. Soc., p. 38-42.

Bryant, D. L., 1968, Diagnostic characteristics of the Paleozoic formations of southeastern Arizona, in Guidebook III Southern Arizona: Ariz. Geol. Soc., p. 33-48.

Burst, J. F., 1965, Subaqueously formed shrinkage cracks in clay: Jour. Sed. Petrology, v. 35, p. 348-353.

Butler, B. S., Wilson, E. D., and Rasor, C. A., 1938, Geology and ore deposits of the Tombstone district, Arizona: Arizona Bur. Mines Bull. 158, 115 p.

Butler, W. C., 1969, The upper Paleozoic stratigraphy of Total Wreck Ridge, Pima County, Arizona: unpub. M.S. thesis, Univ. of Arizona, 138 p.

Chilingar, G. V., 1956, Dedolomitization: a review: Am. Assoc. Petroleum Geologists Bull., v. 40, p. 762-764.

Coleman, J. M., and Gagliano, S. M., 1965, Sedimentary structures Mississippi River deltaic plain, in Middleton, G. V., ed., Primary sedimentary structures and their hydrodynamic interpretation: Soc. Econ. Paleontologists and Mineralogists Spec. Pub. 12, p. 133-148.

Deffeyes, K. S., Lucia, F. J., and Weyl, P. K., 1964, Dolomitization: observations on the island of Bonaire, Netherlands Antilles: Science, v. 143, p. 678-679.

Dickson, J. A. D., 1965, A modified staining technique for carbonates in thin section: Nature, v. 205, p. 587.

Dirks, T. N., 1966, The upper Paleozoic stratigraphy of the Quimby Ranch area, southern Guadalupe Canyon quadrangle, Cochise County, Arizona: unpub. M.S. thesis, Univ. of Arizona, 79 p.

Dubin, D. J., 1964, Fusulinid fauna from the type area of the Earp Formation, Permo-Pennsylvanian, Cochise County, Arizona: unpub. M.S. thesis, Univ. of Arizona, 102 p.

Dunbar, C. O., and Rogers, J., 1957, Principles of stratigraphy: New York, John Wiley & Sons, Inc., 356 p.

Elston, W. E., 1958, Burro uplift, northeastern limit of sedimentary basin of southwestern New Mexico and southeastern Arizona: Am. Assoc. Petroleum Geologists Bull., v. 42, p. 2513-2517.

Epis, R. C., 1956, Geology of the Pedregosa Mountains, Cochise County, Arizona: unpub. Ph.D. thesis, Univ. of California Berkeley, 181 p.

Evamy, B. D., 1967, Dedolomitization and the development of rhombohedral pores in limestones: Jour. Sed. Petrology, v. 37, p. 1204-1205.

Fisk, H. N., 1955, Sand facies of Recent Mississippi delta deposits: 4th World Petroleum Cong. (Rome) Proc., Sec. 1-C, p. 377-398.

Folk, R. L., 1959, Practical petrographic classification of limestones: Am. Assoc. Petroleum Geologists Bull., v. 43, p. 1-38.

Folk, R. L., 1962, Spectral subdivision of limestone types, in Ham, W. E., ed., Classification of carbonate rocks--a symposium: Am. Assoc. Petroleum Geologists Mem. 1, p. 62-84.

Folk, R. L., 1968, Petrology of sedimentary rocks: Austin, Texas, Hemphills, 168 p.

Frank, R. M., 1965, An improved carbonate peel technique for high powered studies: Jour. Sed. Petrology, v. 35, p. 499.

Friedman, G. M., 1964, Early diagenesis and lithification in carbonate sediments: Jour. Sed. Petrology, v. 34, p. 77-813.

Friedman, G. M., and Sanders, J. E., 1967, Origin and occurrence of dolostones, in Chilingar, G. V., Bissel, H. J., and Fairbridge, R. W., eds., Carbonate rocks, origin, occurrence, and classification: New York, Elsevier Publishing Company, p. 267-348.

Galbraith, F. W., 1959, The Empire Mountains, Pima County, Arizona, in Guidebook II Southern Arizona: Ariz. Geol. Soc., p. 127-133.

Gillerman, Elliot, 1958, Geology of the central Peloncilla Mountains, Hidalgo County, New Mexico, and Cochise County, Arizona: New Mexico Bur. Mines and Mineral Resources Bull. 57, 152 p.

Gilluly, James, 1956, General geology of central Cochise County, Arizona (with sections on age and correlation by A. R. Palmer, J. S. Williams, and J. B. Reeside, Jr.): U.S. Geol. Survey Prof. Paper 281, 169 p.

Gilluly, James, Cooper, J. R., and Williams, J. S., 1954, Late Paleozoic stratigraphy of central Cochise County, Arizona: U.S. Geol. Survey Prof. Paper 266, 49 p.

Ginsburg, R. N., Isham, L. B., Bein, S. J., and Kuperberg, J., 1954, Laminated algal sediments of south Florida and their recognition in the fossil record: Coral Gables, Florida, Marine Lab., Univ. of Miami, unpub. Rept. 54-21, 33p.

Graybeal, F. T., 1962, The geology and gypsum deposits of the southern Whetsone Mountains, Cochise County, Arizona: unpub. M.S. thesis, Univ. of Arizona, 80 p.

Greensmith, J. T., 1966, Carboniferous deltaic sedimentation in eastern Scotland, in Shirley, M. L., ed., Deltas: Houston Geol. Society, p. 189-212.

Griffin, G. M., and Ingram, R. L., 1955, Clay minerals of the Neuse River estuary: Jour. Sed. Petrology, v. 25, p. 194-200.

Grim, R. E., Dietz, R. S., and Bradley, W. F., 1949, Clay mineral composition of some sediments from the Pacific Ocean off the California coast and the Gulf of California: Geol. Soc. Amer. Bull., v. 60, p. 1785-1808.

Grim, R. E., and Johns, W. D., 1954, Clay mineral investigation of sediments in the northern Gulf of Mexico, in Clays and clay minerals: Natl. Acad. Sci.-National Research Council Pub. 327, p. 81-103.

Gutstadt, A. M., 1968, Environments of the Beck Spring Dolomite: Jour. Sed. Petrology, v. 38, p. 1280-1289.

Havenor, K. C., 1959, The Pennsylvanian System of southeastern Arizona, in Guidebook II Southern Arizona: Ariz. Geol. Soc., p. 34-37.

Havenor, K. C., and Pye, W. D., 1958, Pennsylvanian paleogeography of Arizona, in Guidebook 9th Field Conference, Black Mesa Basin: New Mexico Geol. Soc., p. 78-81.

Hayes, P. T., and Landis, E. R., 1965, Paleozoic stratigraphy of the southern part of the Mule Mountains, Arizona: U.S. Geol. Survey Bull. 1201-F, 43 p.

Illing, L. V., Wells, A. J., and Taylor, J. C. M., 1965, Penecontemporary dolomite in the Persian Gulf, in Pray, L. C., and Murray, R. C., eds., Dolomitization and limestone diagenesis: Soc. Econ. Paleontologists and Mineralogists Spec. Pub. 13, p. 89-111.

Irwin, M. L., 1965, General theory of epeiric clear water sedimentation: Am. Assoc. Petroleum Geologists Bull., v. 49, p. 445-459.

Jones, T. S., 1953, Stratigraphy of the Permian basin of west Texas: West Texas Geol. Soc. Guidebook, p. 1-57.

Jopling, A. V., and Walker, R. G., 1968, Morphology and origin of ripple-drift cross lamination, with examples from the Pleistocene of Massachusetts: Jour. Sed. Petrology, v. 39, p. 971-984.

Kottlowski, F. E., 1958, Pennsylvanian and Permian rocks near the late Paleozoic Florida Islands, in Roswell Geol. Soc. Guidebook of the Hatchet Mountains and the Cooks Range-Florida Mountain areas, Grant, Hidalgo and Luna Counties, southwestern New Mexico, Eleventh Field Conference, p. 79-87.

Kottlowski, F. E., 1960, Summary of Pennsylvanian sections in southwestern New Mexico and southeastern Arizona: New Mexico Bur. Mines and Min. Res. Bull. 66, 187 p.

Kottlowski, F. E., 1962, Pennsylvanian rocks of southwestern New Mexico and southeastern Arizona, in Pennsylvanian System in the United States: Am. Assoc. Petroleum Geologists, p. 331-372.

Kottlowski, F. E., and Havenor, K. C., 1962, Pennsylvanian rocks of the Mogollon Rim area, Arizona, in Guidebook of the Mogollon Rim region, New Mexico Geol. Soc. 13th Field Conference, P. 77-84.

Laporte, L. F., 1962, Paleoecology of the Cottonwood Limestone (Permian), northern mid-continent: Geol. Soc. America Bull., v. 73, p. 521-544.

Laporte, L. F., 1967, Study of the Manlius Formation, New York: Am. Assoc. Petroleum Geologists Bull., v. 51, p. 73-103.

Laporte, L. F., 1969, Recognition of a transgressive carbonate sequence within an epeiric sea: Helderberg Group (Lower Devonian) of New York state, in Depositional environments in carbonate rocks: Soc. Econ. Paleontologists and Mineralogists Spec. Pub. 14, p. 98-119.

Layton, D. W., 1957, Stratigraphy and structure of the southwestern foothills of the Rincon Mountains, Pima County, Arizona: unpub. M.S. thesis, Univ. of Arizona, 87 p.

Logan, B. W., Rezak, R., and Ginsburg, R. N., 1964, Classification and environmental significance of algal stromatolites: Jour. Geology, v. 72, p. 68-83.

Lucia, F. J., 1961, Dedolomitization in the Transill (Permian) formation: Geol. Soc. America Bull., v. 72, p. 1107-1110.

McClymonds, N. E., 1957, Stratigraphy and structure of the southern portion of the Waterman Mountains, Pima County, Arizona: unpub. M. S. thesis, Univ. of Arizona, 157 p.

McClymonds, N. E., 1959, Paleozoic stratigraphy of the Waterman Mountains, Pima County, Arizona, in Guidebook II Southern Arizona: Ariz. Geol. Soc. p. 67-76.

McKee, E. D., 1945, Oak Creek Canyon: Plateau, v. 18, p. 25-32.

McKee, E. D., 1969, Paleozoic rocks of Grand Canyon, in Geology and natural history of the Grand Canyon region: Four Corners Geol. Soc. 5th Field Conference, p. 78-90.

McKee, E. D., and Weir, G. W., 1953, Terminology for stratification and cross stratification in sedimentary rocks: Geol. Soc. America Bull., v. 64, p. 381-390.

MacKenzie, D. B., and Poole, D. M., 1962, Provenance of Dakota Group sandstones of the western interior, in Early Cretaceous rocks of Wyoming, a symposium: Wyoming Geol. Soc. 17th Annual Field Conference, p. 62-71.

Matter, A., 1967, Tidal flat deposits in the Ordovician of western Maryland: Jour. Sed. Petrology, v. 37, p. 601-609.

Milne, I. H., and Earley, J. W., 1958, Effect of source and environment on clay minerals: Am. Assoc. Petroleum Geologists Bull., v. 42, p. 328-338.

Morlot, A. von, 1848, Sur l'origine de la dolomie (extrait d'une lettre d'A. von Morlot a E. de Beaumont): Acad. Sci. Paris comptes rendus, v. 26, p. 313.

Neiheisel, J., and Weaver, C. E., 1967, Transport and deposition of clay minerals, southeastern United States: Jour. Sed. Petrology, v. 37, p. 1084-1116.

Oriel, S. S., 1967, Base of the Permian System, Paleotectonic maps of the Permian System: U.S. Geol. Survey, Misc. Geol. Inv. Map 1-450, p. 26-28.

Payton, C. E., 1966, Petrology of the carbonate members of the Swope and Dennis Formations (Pennsylvanian), Missouri and Iowa: Jour. Sed. Petrology, v. 36, p. 576-601.

Pepper, J. F., De Witt, Wallace, Jr., and Demarest, D. F., 1954, Geology of the Bedford shale and Berea sandstone in the Appalachian Basin: U.S. Geol. Survey Prof. Paper 259, 111 p.

Pettijohn, F. J., 1957, Sedimentary rocks: New York, Harper and Row, Publishers, 718 p.

Powers, M. C., 1954, Clay diagenesis in the Chesapeake Bay area, in Clays and clay minerals: Natl. Acad. Sci.-Natl. Res. Council Pub. 327, p. 68-80.

Powers, M. C., 1957, Adjustment of land derived clays to the marine environment: Jour. Sed. Petrology, v. 27, p. 355-372.

Pray, L. C., 1949, Pre-Abo deformation in the Sacramento Mountains, New Mexico: Geol. Soc. America Bull., v. 60, p. 1914-1915.

Purdy, E. G., 1963, Recent calcium carbonate facies of the Great Bahama Bank. (2) Sedimentary facies: Jour. Geology, v. 71, p. 472-497.

Purdy, E. G., and Imbrie, John, 1964, Carbonate sediments, Great Bahama Bank: Geol. Soc. America Field Guidebook II, Miami Meeting, 66p.

Ransome, F. L., 1904, The geology and ore deposits of the Bisbee quadrangle, Arizona: U.S. Geol. Survey Prof. Paper 21, 168 p.

Rea, D. K., 1967, Stratigraphy of the red chert-pebble conglomerate in the Earp Formation, southeastern Arizona: unpub. M.S. thesis, Univ. of Arizona, 116 p.

Rea, D. K., and Bryant, D. L., 1968, Permian red chert-pebble conglomerate in Earp Formation, southeastern Arizona: Am. Assoc. Petroleum Geologists Bull., v. 52, p. 809-819.

Reid, A. M., 1966, Stratigraphy and paleontology of the Naco Formation in the southern Dripping Springs Mountains, near Winkelman, Gila County, Arizona: unpub. M.S. thesis, Univ. of Arizona, 184 p.

Reid, A. M., 1968, Biostratigraphy of the Naco Formation (Pennsylvanian) in south-central Arizona: unpub. Ph.D. dissert., Univ. of Arizona, 308 p.

Roehl, P. O., 1967, Carbonate facies, Williston basin and Bahamas: Am. Assoc. Petroleum Geologists Bull., v. 51, p. 1979-2032.

Ross, C. A., and Sabins, F. F., Jr., 1965, Early and Middle Pennsylvanian fusulinids from sotheast Arizona: Jour. Paleontology, v. 39, no. 2, p. 173-209.

Ross, C. A., and Tyrrell, W. W., Jr., 1965, Pennsylvanian and Permian fusulinids from the Whetstone Mountains, southeast Arizona: Jour. Paleontology, v. 39, p. 615-635.

Sabins, F. F., Jr., 1957a, Stratigraphic relations in Chiricahua and Dos Cabezas Mountains, Arizona: Am. Assoc. Petroleum Geologists Bull., v. 41, no. 3, p. 466-510.

Sabins, F. F., Jr., 1957b, Geology of the Cochise Head and western part of the Vanar quadrangles, Arizona: Geol. Soc. America Bull., v. 68, p. 1315-1342.

Sabins, F. F., Jr., and Ross, C. A., 1963, Late Pennsylvanian-Early Permian fusulinids from southeast Arizona: Jour. Paleontology, v. 37, no. 2, p. 323-365.

Schenk, P. E., 1967, The Macumber Formation of the Maritime provinces, Canada--A Mississippian analogue to Recent strandline carbonates of the Persian Gulf: Jour. Sed. Petrology, v. 37, p. 365-376.

Schmidt, Volkman, 1965, Facies, diagenesis, and related reservoir properties in the Gigas Beds (Upper Jurassic), northwestern Germany, <u>in</u> Pray, L. C., and Murray, R. C., eds., Dolomitization and limestone diagenesis, a symposium: Soc. Econ. Paleontologists and Mineralogists, Spec. Pub. no. 13, p. 124-168.

Scott, G. L., 1965, Heavy mineral evidence for source of some Permian quartzose sandstones, Colorado Plateau: Jour. Sed. Petrology, v. 35, p. 391-400.

Shaw, A. B., 1964, Time in stratigraphy: New York, McGraw-Hill Book Company, 365 p.

Shaw, D. B., and Weaver, C. E., 1965, The mineralogical composition of shales: Jour. Sed. Petrology, v. 35, p. 213-223.

Shepard, F. P., 1960, Mississippi Delta: Marginal environments, sediments, and growth, in Shepard, F. P., Phleger, F. B., and Van Andel, T. H., eds., Recent sediments, northwest Gulf of Mexico--a symposium: Am. Assoc. Petroleum Geologists, 394 p.

Shinn, E. A., Ginsberg, R. H., and Lloyd, R. M., 1965, Recent supratidal dolomite from Andros Island, Bahamas, in Pray, L. C., and Murray, R. C., eds., Dolomitization and limestone diagenesis: a symposium: Soc. Econ. Paleontologists and Mineralogists, Spec. Pub. 13, p. 112-123.

Summerson, C. H., 1966, Crystal molds in dolomite: their origin and environmental interpretation: Jour. Sed. Petrology, v. 36, p. 221-224.

Swann, D. H., 1964, Late Mississippian rhythmic sediments of Mississippi Valley: Am. Assoc. Petroleum Geologists Bull., v. 48, p. 637-658.

Tanner, W. F., 1967, Ripple mark indices and their uses: Sedimentology, v. 9, p. 89-104.

Tatarskiy, V. B., 1949, Distribution of rocks in which dolomite is replaced by calcite: Akad. Nauk., SSSR, Doklady, v. 69, p. 849-851.

Textoris, D. A., and Carozzi, A. V., 1966, Petrography of a Cayugan (Silurian) stromatolite mound and associated facies, Ohio: Am. Assoc. Petroleum Geologists Bull., v. 50, p. 1375-1388.

Turner, G. L., 1962, The Deming Axis, southeastern Arizona, New Mexico and Trans-Pecos Texas, in Guidebook of the Mogollon Rim region: New Mexico Geol. Soc. 13th Field Conference, p. 59-71.

Tyrrell, W. W., Jr., 1957, Geology of the Whetstone Mountains area, Cochise and Pima counties, Arizona: unpub. Ph.D. thesis, Yale Univ., 235 p.

Weaver, C. E., 1958, A discussion of clay minerals in sedimentary rocks, in Swineford, A., ed., Clays and clay minerals: Proc. 5th National Conference, Natl. Acad. Sci.-Natl. Research Council, p. 159-173.

Weaver, C. E., 1959, The clay petrology of sediments, in Swineford, A., ed., Clays and clay minerals: Proc. 6th National Conference, Natl. Acad. Sci.-Natl. Research Council, p. 154-184.

West, I. M., Brandon, A., and Smith, M., 1968, A tidal flat evaporitic facies in the Visean of Ireland: Jour. Sed. Petrology, v. 38, p. 1079-1093.

Wilpolt, R. H., MacAlpin, A. J., Bates, R. L., and Vorbe, G., 1946, Geologic map and stratigraphic sections of Paleozoic rocks of Joyita Hills, Los Pinos Mountains, and northern Chupadera Mesa, Valencia, Torrance and Socorro Counties, New Mexico: U.S. Geol. Survey Prelim. map 61, Oil and Gas Inv. Series.

Winters, S. S., 1963, Supai Formation (Permian), eastern Arizona: Geol. Soc. America, Mem. 89, 99 p.

Yochelson, E. L., 1956, Permian Gastropoda of the southwestern United States: Am. Mus. Natl. History Bull., v. 110, p. 173-276.

Zeller, R. A., Jr., 1965, Stratigraphy of the Big Hatchet Mountains area, New Mexico: New Mexico Bur. Mines and Mineral Resources, Mem. 16.

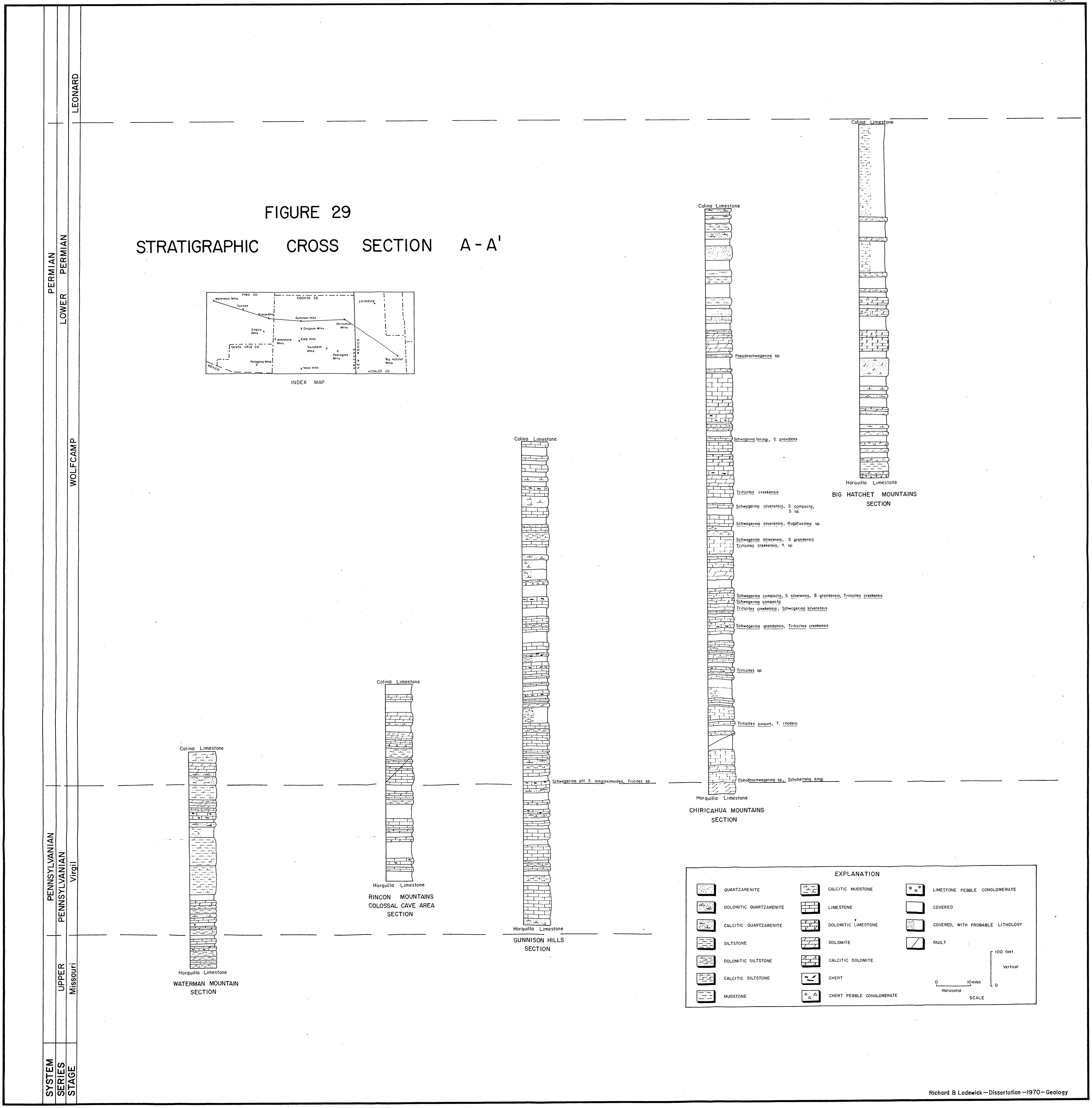
FIGURE 29
STRATIGRAPHIC CROSS SECTION A-A'
SYSTEM
SERIES
STAGE
PERMIAN
LOWER PERMIAN
LEONARD
WOLFCAMP
PENNSYLVANIAN
UPPER PENNSYLVANIAN
Virgil
Missouri
INDEX MAP
PIMA CO.
COCHISE CO.
SANTA CRUZ CO.
HIDALGO CO.
MEXICO
ARIZONA
NEW MEXICO
Waterman Mtns.
Tucson
Rincon Mtns.
Gunnison Hills
Chiricahua Mtns.
Lordsburg
Dragoon Mtns.
Empire Mtns.
Limestone Mtns.
Earp Hills
Swisshelm Mtns.
Pedregosa Mtns.
Patagonia Mtns.
Naco Hills
Big Hatchet Mtns.
Colina Limestone
Horquilla Limestone
WATERMAN MOUNTAIN SECTION
RINCON MOUNTAINS COLOSSAL CAVE AREA SECTION
GUNNISON HILLS SECTION
Schwagerina aff. S. longissimoidea, Triticites sp.
CHIRICAHUA MOUNTAINS SECTION
Pseudoschwagerina sp.
Schwagerina loringi, S. providens
Triticites creekensis
Schwagerina silverensis, S. compacta, S. sp.
Schwagerina silverensis, Rugofusilina sp.
Schwagerina silverensis, S. grandensis
Triticites creekensis, T. sp.
Schwagerina compacta, S. silverensis, S. grandensis, Triticites creekensis
Schwagerina compacta
Triticites creekensis, Schwagerina silverensis
Schwagerina grandensis, Triticites creekensis
Triticites sp.
Triticites pinguis, T. rhodesi
Pseudoschwagerina sp., Schubertella kingi
BIG HATCHET MOUNTAINS SECTION
EXPLANATION
QUARTZARENITE
DOLOMITIC QUARTZARENITE
CALCITIC QUARTZARENITE
SILTSTONE
DOLOMITIC SILTSTONE
CALCITIC SILTSTONE
MUDSTONE
CALCITIC MUDSTONE
LIMESTONE
DOLOMITIC LIMESTONE
DOLOMITE
CALCITIC DOLOMITE
CHERT
CHERT PEBBLE CONGLOMERATE
LIMESTONE PEBBLE CONGLOMERATE
COVERED
COVERED, WITH PROBABLE LITHOLOGY
FAULT
100 feet
Vertical
0
0
10 miles
Horizontal
SCALE
Richard B. Lodewick—Dissertation—1970—Geology

FIGURE 30

STRATIGRAPHIC CROSS SECTION B-B'

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