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THE UNIVERSITY OF OKLAHOMA

THE STRATIGRAPHY OF THE LOWER GOBBLER FORMATION

SACRAMENTO MOUNTAINS, NEW MEXICO

By

Robert E. Benne

1975

THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

THE STRATIGRAPHY OF THE LOWER GOBBLER FORMATION SACRAMENTO MOUNTAINS, NEW MEXICO

A THESIS

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

MASTER OF SCIENCE

By

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Norman, Oklahoma

1975

THE STRATIGRAPHY OF THE LOWER GOBBLER FORMATION

SACRAMENTO MOUNTAINS, NEW MEXICO

A THESIS

APPROVED FOR THE SCHOOL OF GEOLOGY AND GEOPHYSICS

By

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ABSTRACT

The lower Gobbler Formation (lower and middle Pennsylvanian; Morrowan through lower Desmoinesian Series) is exposed along the west face of the Sacramento escarpment, in south-central New Mexico. The Lower Gobbler Formation contains as much as 700 feet of limestones, sandstones, shales, siltstones, and conglomerates. This part of the formation can be subdivided into four time-stratigraphic intervals.

The lowest subdivision is termed the lower Morrowan interval and is early to middle Morrowan in age. This interval is composed of a basal siltstone, intermittent limestones, sporadic sandstones, and shales. Overlying this interval is the upper Morrowan interval, which is middle through late Morrowan in age. The upper Morrowan interval includes primarily sandstones, limestones, and shales. Two distinct facies are present within the overlying Atokan interval, and both are terrigenous in nature. The northern, largely arenaceous facies is made up of sandstones, interbedded shales, siltstones, and some carbonate mudstones. The southern argillaceous facies consists of shales, thin interbedded and intermittent medium-bedded limestones. The upper subdivision, the lower Desmoinesian interval, encompasses parts of two distinct facies. The northern terrigenous facies is composed of thin cyclic interbeds of shales, siltstones, and sandstones, with a few limestones and medium- to very thick-bedded sandstones. The southern carbonate facies is composed of grain-supported limestones and interbedded shales and carbonate mudstones.

The depositional environments of the lower Gobbler Formation range from shallow marine (shelf) to nonmarine (deltaic).

The lower Gobbler Formation encompasses an early Pennsylvanian transgression (Morrowan) to the northeast, an early-middle Pennsylvanian regression (late Morrowan through early Desmoinesian) to the southwest and a middle Pennsylvanian transgression (early Desmoinesian) again to the northeast. These sea level changes were probably related to the uplift of the Pedernal landmass and the subsidence of the Orogrande Basin.

ACKNOWLEDGEMENTS

The author is grateful for the guidance provided by Dr. Patrick K. Sutherland, who supervised this thesis. Professor Sutherland helped originate the project, made two lengthy trips to the field, identified the megafossil collections, and provided detailed assistance and helpful criticism during the preparation of the manuscript.

Drs. Charles J. Mankin and Charles W. Harper read the text and made helpful suggestions for its improvement.

The author expresses thanks to other faculty members, fellow graduate students, and the staffs of the School of Geology and Geophysics and the Oklahoma Geological Survey for their help in the analysis, preparation, and production of specific data.

Appreciation is extended to the New Mexico State Bureau of Mines and Mineral Resources and its director, Dr. Frank E. Kottlowski, for financial support, field transportation, field implements, aerial photographs, and access to restricted printed material concerning the thesis area.

The writer is thankful to the American Association of Petroleum Geologists for a grant provided to help defray thesis preparation costs.

The author is grateful for the assistance provided by the Amoco Production Research Center, especially Dr. H. Richard Lane for analyzing and preparing conodont collections and Dr. George A. Sanderson for preparing and identifying fusulinid collections. Thanks are expressed to Dr. James L. Wilson, Rice University, for providing an unpublished stratigraphic section of the investigated strata from Nigger Ed Canyon. All three men provided helpful discussion and previous data relevant to the thesis project.

The author appreciates helpful discussion and field checking companionship from John Van Wagoner, Tom DeKeyser, and William K. Dahleen.

Appreciation is extended to the author's relatives. Mrs. Gene Seely allowed the author to use her cabin in Cloudcroft, New Mexico, for the duration of the field work. Mr. William Miller and his wife Marilyn assisted (and rescued) the author in many ways. Mr. and Mrs. Earl L. Benne and Mr. and Mrs. Murrel W. Pennington helped the author transport rock collections, and provided helpful assistance toward the completion of the thesis.

The author appreciates the use of the facilities of Union Oil Company of California for drafting purposes.

A special thanks is extended to my wife Pamela Sue, who provided moral support, encouragement, and understanding throughout the project. Pam was also physically involved as a field assistant, typist, chief editor, etc., etc.

The author is indebted to Jo Scott for typing the rough draft, Sharon Pyle and Tudie Hudson for typing the final copy, Hugh G. White for proofreading, and Polly Hewitt for the reproduction of this text.

CONTENTS

	Page
ABSTRACT	iii
ACKNOWLEDGMENTS	iv
TABLES, ILLUSTRATIONS, PLATES	vi
INTRODUCTION	1
Purpose of Investigation	5
Methods of Investigation	6
STRATIGRAPHY	9
Previous Investigations of the Lower Gobbler Formation	9
Methods of Differentiating Intervals	10
Pre-Pennsylvanian Surface	12
Lower Morrowan Interval	15
Upper Morrowan Interval	17
Atokan Interval	21
Lower Desmoinesian Interval	24
DEPOSITIONAL ENVIRONMENTS	30
Regional Geologic Setting	30
Lower Morrowan Interval	31
Upper Morrowan Interval	33
Atokan Interval	34
Lower Desmoinesion Interval	35
SUMMARY AND CONCLUSIONS	39
REFERENCES CITED	42
APPENDIX	49
Introduction to Stratigraphic Sections	49
Terminology	50
PLATES	52
Measured Section 6, Indian Wells	57
Measured Section 3, Alamo Canyon	67
Measured Section 1, Mule Canyon	80
Measured Section 4, Muleshoe Canyon	91
Measured Section 2, Deadman Canyon	104
Measured Section 7, Escondido	119
Measured Section 8, Nigger Ed	126
Measured Section 5, Grapevine Canyon	132

TABLES

Table		Page
1	Biostratigraphic evidence	8

ILLUSTRATIONS

Figure		
1	Physiography and Pennsylvanian paleogeology of Otero County	2
2	Index map of stratigraphic section of the thesis area	4
3	Isometric stratigraphic cross section	29
4	Generalized isometric stratigraphic cross section	38

CROSS SECTION . . . . . In Pocket

PLATES

Plate	
I	52
II	54
III	56

INTRODUCTION

The Sacramento Mountains, located in south-central New Mexico, constitute a sharply asymmetrical escarpment at the eastern edge of the Basin and Range province of the western United States. The range is fault-block controlled and tilted about one degree to the east, with altitudes along the crest commonly exceeding 9000 feet above sea level. The range is arbitrarily bounded by the Pecos River (east), the Otero Mesa (south), the Tularosa Basin (west), and the Sierra Blanca igneous complex (north).

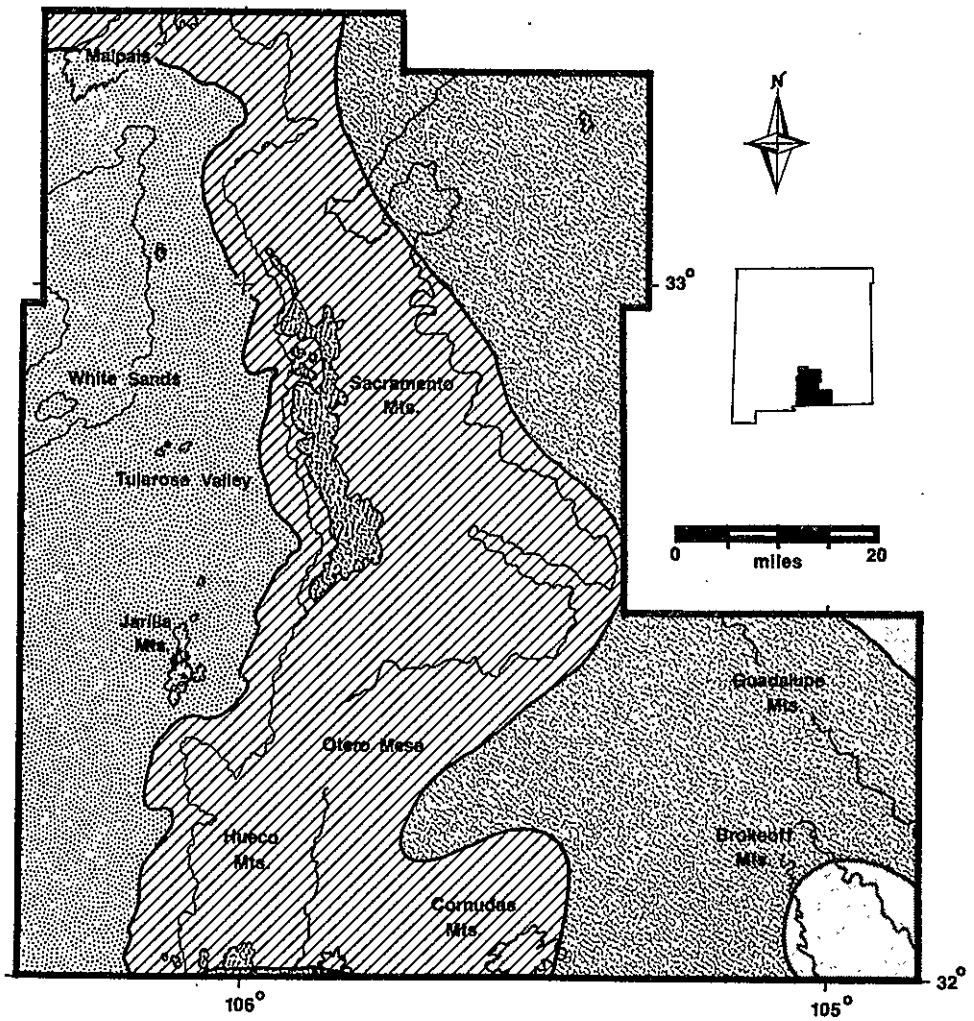
Stratigraphically, the range displays about 8000 feet (aggregate thickness) of sedimentary rocks. The exposed rock of the escarpment ranges in age from late Precambrian to Cretaceous, with Tertiary igneous rocks intruded as sills and dikes.

The Pennsylvanian strata include a complex assemblage of shales, sandstones, and limestones. The thickness of the Pennsylvanian in the Sacramento Mountains ranges from less than 2000 feet to approximately 3000 feet. Lateral and vertical changes, many of which are cyclic, occur commonly. In general, the Pennsylvanian is thought to be representative of a shelf environment (see Figure 1).

The lowest 1200-1600 feet of strata of Pennsylvanian age are known as the Gobbler Formation. The interval studied includes approximately the lower one-third of this formation, extending upward from the

PHYSIOGRAPHY AND PENNSYLVANIAN PALEOGEOLOGY

Otero County, New Mexico



Orogrande Basin

Sacramento Shelf

Pedernal Landmass

Delaware Basin

Pennsylvanian Outcrop

PALEOGEOLOGIC CONTACT

PHYSIOGRAPHIC CONTACT

SOURCE: New Mexico Bureau of Mines-Memoir 17-1966
New Mexico State Geologic Map-1965

Figure 1

Mississippian contact to the base of the Bug Scuffle Limestone Member of the formation. This interval varies in thickness from approximately 300 to 700 feet and ranges in age from Morrowan through early Desmoinesian (see Plate I). The depositional environment ranges from terrestrial to marine. Common rock types in this segment are shales, siltstones, sandstones, conglomerates, and limestones. Gray to black shale makes up an appreciable amount of the section. Siltstone is found in the basal part of the formation and in the northern deltaic facies of the Bug Scuffle Limestone Member (Pray, 1954). The sandstone is commonly cross-laminated and locally contains plant fossils. Thin conglomerates are common sporadically throughout the section. The limestones are argillaceous, silty, and commonly associated with chert.

Pennsylvanian sediments (Morrowan through lower Desmoinesian) crop out along the escarpment in a slightly arcuate-linear pattern for approximately 25 miles. Most elevations within this interval range from 5000 to 6480 feet above sea level. The stratigraphic section measured can be found in parts of Townships 16, 17, 18, and 19 South, and Ranges 10 and 11 East (see Figure 2 and the index map on the Cross Section). The lower part of the Gobbler Formation is mostly covered by talus from the overlying Bug Scuffle Member. Rare exposures are found in the canyons dissecting the escarpment at roughly right angles. Lateral tracing on the slopes was restricted by talus and colluvium. The studied units are most commonly expressed topographically as poorly exposed slopes between the underlying Mississippian and overlying Bug Scuffle cliffs or ledges. Some sandstone and limestone units within the investigated interval form minor cliffs or ledges. The attitudes

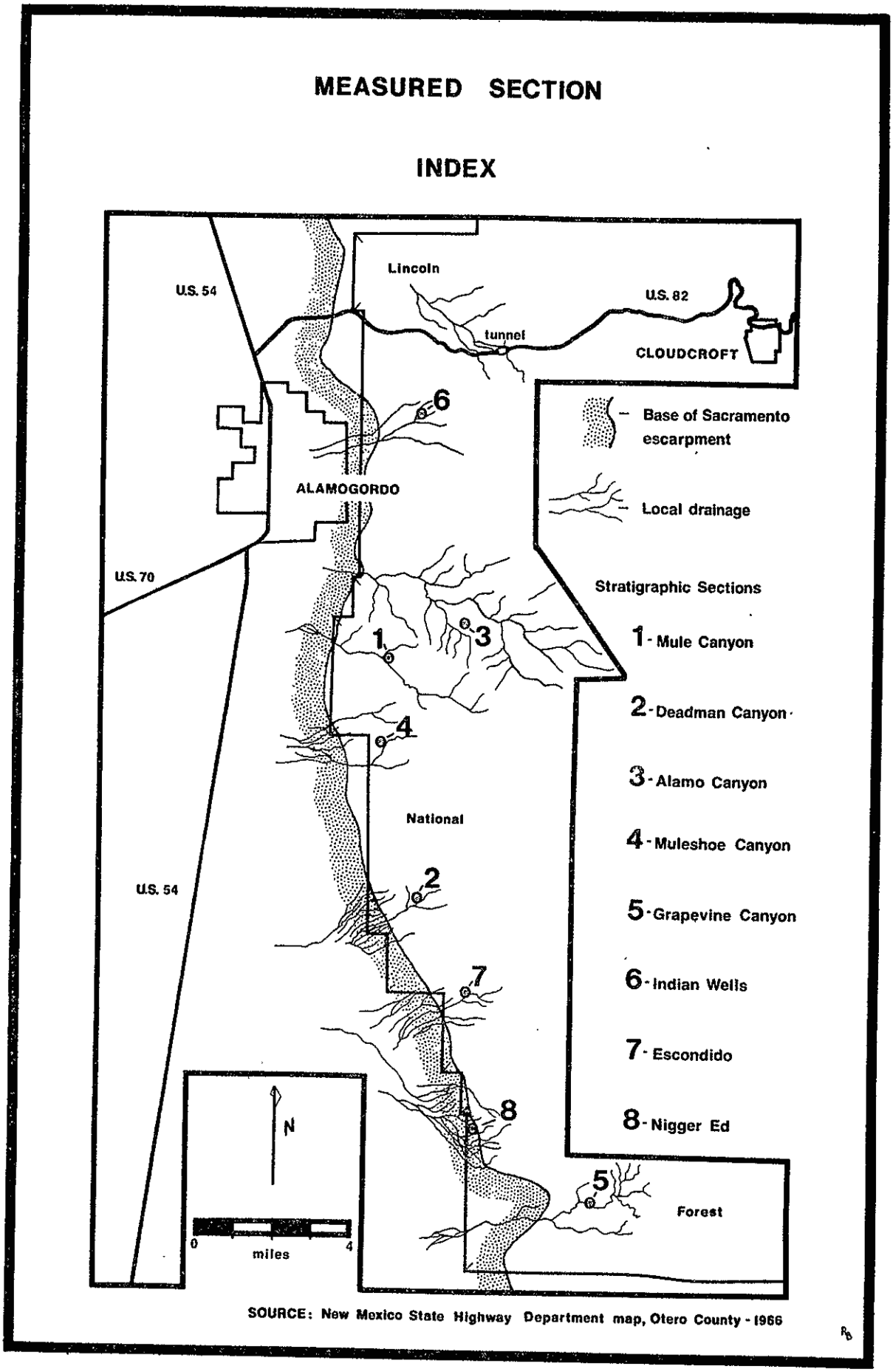

MEASURED SECTION
INDEX
Lincoln
U.S. 54
U.S. 82
tunnel
CLOUDCROFT
6
Base of Sacramento escarpment
ALAMOGORDO
Local drainage
U.S. 70
Stratigraphic Sections
1
3
1 - Mule Canyon
2 - Deadman Canyon
4
3 - Alamo Canyon
4 - Muleshoe Canyon
National
2
5 - Grapevine Canyon
U.S. 54
7
6 - Indian Wells
7 - Escondido
8
8 - Nigger Ed
5
Forest
N
0
miles
4
SOURCE: New Mexico State Highway Department map, Otero County - 1966

Figure 2

of the lower Gobbler units are variable and range from N85°E - N80°W strike and 34°SE, 50°NE, and 25°W dip, with the latter reverse dip found in Grapevine Canyon on the flank of a local anticline. The sections are free of intense faulting or folding.

Previous general investigations dealing with the Pennsylvanian sediments originated with G. H. Girty's general observations on this part of the section east of Alamorgordo, published in 1908. N. H. Darton (1922) differentiated and termed the Pennsylvanian in the Sacramento Mountains the Magdalena Formation. M. L. Thompson (1942) included the Sacramento area in his classification of the Pennsylvanian System of New Mexico, based on fusulinid zones.

Regional studies dealing with some aspects of the Pennsylvanian-Permian of south-central New Mexico have been made by Frank E. Kottlowski (1960), Richard F. Mayer (1966), and James L. Wilson (1970). The regional geology and stratigraphy of the Sacramento Mountains has been described by Lloyd C. Pray (1961). This work has provided an important basis for a wide variety of further investigations by Pray and others. These studies have concentrated most heavily on the Mississippian bioherms and also on the stratigraphy and depositional environments of the late Pennsylvanian (Virgilian) and the lower Permian. Little additional work has been done on the stratigraphy of the lower part of the Pennsylvanian System except for a few Mississippian studies which have overlapped into the lower Gobbler Formation (see p. 9 and 10)

Purpose of Investigation

The general purpose of this study was to set up a litho stratigraphic and possibly a biostratigraphic framework for lower Pennsylvanian

strata in the Sacramento Mountains. Recognition of correlations, facies changes, depositional environments, relative ages and unconformities within the formation were pursued.

Methods of Investigation

Field work was largely completed in a 2½ month period in the summer of 1974. Preliminary reconnaissance and later field checking of the thesis area necessitated an additional ½ month of field work.

A total of eight detailed stratigraphic sections were measured along the face of the Sacramento escarpment. Two partial sections were also measured. Lithologic samples and fossil collections were made from each measured section. The Mississippian-Pennsylvanian boundary was traced an appreciable distance in each of the stratigraphic sections, where practical, except in the Nigger Ed Canyon area and Deadman Canyon area.

From the 255 lithologic samples collected, 70 thin sections and 233 polished slabs were prepared. Binocular and petrographic microscope studies were made on these samples. The description of the lithologic samples can be found in the Appendix.

Megafossils were collected where observed in the process of measuring the stratigraphic sections. Identification of these specimens was made by P. K. Sutherland. Detailed conodont samplings were made from limestones throughout the Deadman Canyon section, and isolated samples were taken from three other sequences. These conodont samples were prepared and described by H. R. Lane. Fusulinids were collected when observed in the field and later, cut lithologic samples produced a few additional fusulinids. Fusulinids were found in six

different stratigraphic sections. The fusulinid samples were prepared and identified by G. A. Sanderson. Faunal listings can be found in the Appendix. Diagnostic fossils are listed in Table 1 (page 8).

Specific field techniques and parameters are described in the introduction to the measured sections (see Appendix).

TABLE I

BIOSTRATIGRAPHIC EVIDENCE FOR ZONATION OF LOWER GOBBLER INTERVALS

SECTION / AGE OF INTERVAL	Indian Wells	Alamo Canyon	Mule Canyon	Muleshoe Canyon	Deadman Canyon	Escondido	Nigger Ed	Grapevine Canyon
Lower Desmoinesian	49-Fusulinids 44-Brachiopods 39-Fusulinids	70-Brachiopods	44-Fusulinids 42-Brachiopods 41-Brachiopods	70-Fusulinids 68-Brachiopods Corals 44-Fusulinids	32-Fusulinids 31-Conodonts Brachiopods 29-Conodonts 27-Conodonts Fusulinids 19-Conodonts	31-Brachiopods	21-Fusulinids	43-Brachiopods Corals 39-Fusulinids
Atokan	34-Fusulinids			44-Brachiopods	15-Conodonts 14-Brachiopods 13-Conodonts 6-Conodonts 3-Conodonts			
Upper Morrowan	22-Brachiopods	27-Brachiopods 23-Brachiopods	J-Conodonts Brachiopods	32-Brachiopods	44-Conodonts 43-Brachiopods 36-Conodonts 27-Conodonts			
Lower Morrowan		AREA Conodonts			8-Conodonts			AREA Conodonts

IDENTIFIED BY:
Conodonts: H.R. LANE
Fusulinids: G.A. SANDERSON
Brachiopods & Corals:
P.K. SUTHERLAND

STRATIGRAPHY

Previous Investigations of the Lower Gobbler Formation

A small number of publications have dealt with investigations of the Gobbler Formation. However, in most of these studies, this formation has been analyzed only in partial detail. L. C. Pray (1952, 1959, 1961) has published several excellent studies describing the general geology of the Sacramento Mountains, including a general description of the Gobbler Formation. He designated the type section for the Gobbler Formation in Mule Canyon. Pray (1952) observed that:

1) The relief of the pre-Pennsylvanian erosion surface decreases toward the south and the amount and coarseness of the detrital material in the lower part of the Gobbler Formation decreases correspondingly.
2) The lower part of the Gobbler Formation (200-500 feet), below the cliff-forming Bug Scuffle Limestone Member, weathers to a less steep slope.
3) The most common rock types in this interval are quartz sandstones (probably nonmarine), dark limestones, and black to gray shales.

H. R. Lane (1974), in his work on Mississippian conodonts of southeastern New Mexico, confirmed that the hiatus of the basal

unconformity increases in magnitude to the north in the Sacramentos. Lane set up a conodont zonation for the area that takes in the lowermost part of the Gobbler Formation and concluded that the basal part of this formation is earliest Morrowan.

W. J. Meyers' (1974) work on the Lake Valley Formation (Mississippian), Sacramento Mountains, discussed the lowermost overlying Pennsylvanian units in the northern part of the study area. He made a petrographic study of these basal units.

G. B. Asquith (1974) described the petrography and petrogenesis of several of the Tertiary igneous dikes and sills that are found in the lower Gobbler Formation.

D. A. Yurewitz's thesis project (1973 University of Wisconsin at Madison) on the Rancheria Formation included a discussion on the unconformable contact between the Mississippian Rancheria and the Gobbler Formation. J. Van Wagoner is in the process of working on the deltaic portion of the Bug Scuffle Limestone Member in the northern part of the thesis area as a dissertation project at Rice University. His analysis will carry down into the lower part of the Gobbler Formation.

Methods of Differentiating Intervals

The lower Gobbler Formation was subdivided into four intervals using primarily biostratigraphic and secondarily lithostratigraphic criteria. It was not possible to subdivide these intervals into reliable regional lithologic members because of rapid facies changes (vertical and lateral) and the lack of continuous lateral exposures.

A reliable regional datum could not be discerned by either biostratigraphic or lithostratigraphic means. Individual units could not be walked out laterally and could not be traced using aerial photographs. Some marker beds are present but these are geographically restricted. The Mississippian-Pennsylvanian boundary was not utilized as a datum, due to the erratic character of this erosional surface. The Bug Scuffle Limestone Member is present in the six southern sections, but was not chosen for a datum, since the base of this member rises stratigraphically in the formation to the north. It is believed that the use of either one of the aforementioned possible datums would distort or bias the interpretation.

A combination of generalized time-bounded intervals from key sections, corresponding lithologic correlations, and scattered faunal evidence was used to form the intervals.

The biostratigraphic correlations are based on conodont zonation in the Deadman Canyon section, fusulinid zonation in the Muleshoe Canyon section, and scattered conodont, fusulinid, brachipod, and coral identifications throughout the studied stratigraphic sections (see Table I, page 8). Conodonts occur in abundance in the middle and upper parts of the Deadman Canyon section. Fusulinds occur most commonly in the upper parts of the stratigraphic interval studied. It was not feasible to sample more sections for complete conodont or fusulinid sequences. Brachiopods, corals, and other megafossils were collected where possible at scattered localities throughout the section. Megafossils do not occur commonly enough to form a framework for the recognition of regional faunal zones.

The lithostratigraphic correlations are based on the recognition of marker beds, relative thicknesses, characteristic features of units, lateral correlations, position in lithologic sequence and similar lithologies.

These intervals do not imply complete coincidence with the system or series subdivision on a regional scale, but are an attempt to display the data and conclusions on a local scale.

Pre-Pennsylvanian Erosion Surface

The Mississippian-Pennsylvanian contact has been described by Pray (1952) and others, as a well-marked unconformity throughout the Sacramento Mountains. He noted the field exposure of the contact itself was expressed as a major disconformity with local relief as much as 100 feet (channel cuts).

The Mississippian strata below the basal unconformity are placed in three formations within the thesis area. As interpreted by Lane (1974), these formations in the Sacramento Mountains have a wedge-on-wedge relation. The upper constituents of the northern wedge, termed Caballero-Lake Valley, include the Tierra Blanca through Dona Ana members (of the Lake Valley Formation) in the investigated area. The Tierra Blanca member, Osage in age, is found at the northernmost stratigraphic section (see unit 6-1, Appendix). The Dona Ana member, last Osage - early Meramec in age, is found at the Alamo Canyon section (see unit 3-1, Appendix). These two limestones are similar in physical appearance and only with detailed faunal evidence can they be differentiated for certain. In the remaining localities of the stratigraphic section in the thesis area, the southern Mississippian wedge, termed the Las

Cruces-Rancheria-Helms wedge, is represented. Only the Rancheria and Helms Formations are present in the studied area. The Rancheria ranges from Meramec through middle-late Chester in age. In three of the stratigraphic sections measured, this formation is found immediately underlying the Pennsylvanian strata (see units 1-16, 4-7, 2-1, Appendix). The Helms Formation is late Chester in age and is present in the two southernmost stratigraphic sections (see 8-1, 5-1, Appendix). The Rancheria commonly can be differentiated from the Helms and the Lake Valley Formation members in the field by its topographic expression. The upper Rancheria forms a steep slope with minor, medium-bedded, limestone ledges. The Helms is commonly exposed as a slope of thin-bedded limestone with interbedded shales and siltstones. The Lake Valley members are exposed as steep ledges and cliffs and are very thick-bedded. The upper southern wedge constituents can be readily segregated from the upper north wedge units by lithologies (see respective aforementioned units in Appendix).

This study supports the disconformable nature of the contact between the Mississippian and Pennsylvanian strata. This contact is, however, difficult to detect in many areas because of extensive cover and the lack of discordance; but usually, its approximate position can be delimited. The actual contact surface has been observed in only a few localities. These are sections 4 (Muleshoe Canyon), 8 (Nigger Ed), and 5 (Grapevine Canyon). Locally this unconformity varies in erosional relief, hiatal gap, and lithologic change between adjacent strata.

The relief between the Pennsylvanian and Mississippian ranges from negligible to as much as plus 60 feet where channelling has taken place. Commonly the contact surface undulates within limits of 0.5

feet of relief or less. A channel observed in the western part of Alamo Canyon cuts down 60 feet into Mississippian strata (see Plate III, Number 4). Pray (1959) reported 100 feet of relief, shown by a channel cut, in the same area.

The hiatal gap between the Mississippian and Pennsylvanian increases from the south to the north. In the most southern section studied (Grapevine Canyon), Lane determined that at least the Adetognathus unicornis and Rhachistognathus muricatus and possibly the Kladognathus - Cavusgnathus naviculus conodont zones are missing. This is essentially the late Chester series, with possibly some late to middle-late Chester missing (Lane, 1974). Overlying Pennsylvanian beds are earliest Morrowan, containing the Rhachistognathus primus conodont zone.

In the most northern section studied (Indian Wells), Meyers (1974) confirms Pray's conclusion that the Pennsylvanian overlies the Tierra Blanca member of the Lake Valley Formation. With Sutherland's analysis of Morrowan brachiopods in the lower Pennsylvanian (at least 100 feet of Morrowan present) at this locality, and Lane's conodont age assignment of at least post late Osage - early Meramec missing at his Alamo Canyon section, the hiatal gap in the northern part of the Sacramento Mountains could be immense. At Alamo Canyon, Lane found a faunal unit corresponding to the combined Gnathodus texanus - Taphrognathus varians - Apatognathus zones of Collinson et al (Lane, 1974). And by Lane's reassessment of his collections, an age of late Osage - early Meramec was assigned (Lane, 1974). Lane's earliest Morrowan conodont zone was also found in Alamo Canyon overlying

Mississippian strata. With an apparent increasing time gap northward (the Indian Wells section being approximately 4.5 miles north of the Alamo Canyon section of Lane), the probable time gap ranges from at least late Osage to early Morrowan in the northernmost section.

In the north, basal Pennsylvanian siltstones overlie massive to thick-bedded limestones. In the south, the basal Pennsylvanian consists commonly of silty shale with a thin basal conglomerate locally present, overlying Mississippian interbedded limestone and shale.

Lower Morrowan Interval

Definition. The Lower Morrowan interval is approximately 55 to 95 feet thick and is bounded below by the Mississippian-Pennsylvanian unconformity. The upper boundary is arbitrarily placed at the sharp contact (seen in sections 6, 1, 4, 7) between a distinctive limestone (packstone, with a 4-6 inch median black chert band) and an overlying sandstone (orthoquartzite), or the variable covered interval (up to 6 feet) between these units (see Cross Section or Figure 3).

Biostratigraphy. The lower Morrowan interval is approximately early to middle Morrowan in age, based on local conodont information. Lane, in an analysis of conodonts from the Deadman Canyon section, has recognized two established zones. The lowest occurrence of conodonts is earliest Morrowan in age. This corresponds with the *Rhachistognathus primus* Zone of Lane and Straka (1974). This fauna was also found in the lowest Pennsylvanian in the Deadman Canyon Branch of Alamo Canyon, Dog Canyon, and Grapevine Canyon by Lane (1974). This zone is present in at least the lower 30 feet of the interval and could range higher

stratigraphically. The uppermost sample of conodonts collected from this interval corresponds to the Neognathodus bassheri symmetricus Zone of Lane and Straka (1974). In northwestern Arkansas this zone is mostly early Morrowan in age but extends into the middle Morrowan.

Foraminifera, largely of the Eostaffella and Millerella types, were common in some of the lower limestones, but were not studied in detail.

Brachiopods, corals, and other fauna were found sparingly, but could not be utilized for correlation or age approximations.

Lithostratigraphy. The lower Morrowan interval is characterized by a basal siltstone, intermittent limestone, and sporadic sandstone. The siltstones are confined largely to the lower one-fourth of the interval. They are typically pale olive in color, rhymitically bedded and bioturbated.

Limestones occur intermittently in this interval throughout the length of the escarpment, but are much more numerous in the southern sections. Most common are packstones and wackestones, with minor occurrences of carbonate mudstones and grainstones. These limestones (which are commonly partially recrystallized and silicified) contain an appreciable amount of chert in the form of nodules, stringers, and bands.

The sandstones are generally laterally extensive, and thin to the south. Most are cross-bedded (tabular and trough) orthoquartzites, having plant fragments, a basal conglomeratic zone, and channelling relationships into underlying layers (see Plate III, Number 3).

The lower Morrowan interval has moderate to small amounts of black-gray, fissile shale, which thins to the south.

Unique units of this lower interval include a thin bedded, arenaceous, limestone pebble conglomerate (see 2-15); an oolitic grainstone (see 4-14 and Plate II, Number 3); and a subarkosic sandstone with an opaline matrix (see 4-17).

Correlations. The basal siltstone can be correlated in all the sections where exposed. A thin-medium bedded, limestone pebble, arenaceous conglomerate and orthoquartzitic sandstone sequence occurring in the middle of the interval can be recognized in sections in the middle and northern parts of the escarpment. A breccia-conglomerate, with chert and limestone pebbles, occurs in the southernmost section and occurs in the same stratigraphic positions as the aforementioned sequence.

The upper boundary of the lower Morrowan interval can readily be followed along the length of the Sacramentos by a packstone unit with a distinctive median 4 to 6-inch black chert band. This unit ranges in thickness from 4 to 12-feet, increasing to the south. To the north this limestone is channelled locally by an overlying sandstone unit (see Plate II, Number 5).

Generally, position in sequence, relative thicknesses, similar lithologies, key marker beds, and the Rhachistognathus primus conodont occurrences were used in correlating within this lower Morrowan interval (see Figures 3, 4, and Cross Section).

Upper Morrowan Interval

Definition. The upper Morrowan interval is approximately 55 to 150 feet thick. This interval is bounded by the sharp basal contact of an orthoquartzite (present in five sections) or by a variable covered

interval (up to 6 feet) at the top of the distinctive packstone unit that makes the upper boundary for the lower Morrowan interval. Brachiopod-conodont age determinations of latest Morrowan to earliest Atokan (from Deadman Canyon) make possible the arbitrary selection of an upper boundary of the upper Morrowan interval at the contact between a ledge-forming packstone to wackestone (below) and an overlying shale sequence with thin interbeds of limestone. These lithologic units can be recognized in one section (8) to the south. However, to the north, the overlying shales change facies into sandstones. The base of this sandstone facies is chosen for the upper boundary in the northern sections because late Morrowan brachiopods are present immediately below. Usually this facies is marked by thin basal conglomerates and appears to channel the underlying beds (see Figures 3 and 4).

Biostratigraphy. The upper Morrowan interval is middle through late Morrowan in age. Conodonts were obtained from this part of the Pennsylvanian section, and the correlation with two established conodont zones was made by Lane. Lower units within this interval were barren of conodonts at the conodont reference section (Deadman Canyon). Conodonts were recovered from an isolated sample at the Mule Canyon section, approximately in the middle of the upper Morrowan interval. These fauna probably correspond to the Idiognathus sinuosis Zone of Lane and Straka (1974). This could dictate an early-middle Morrowan age. Conodonts collected approximately three-fourths the distance above the base of this interval at Deadman Canyon (2-41) were assigned a general age of late to very late Morrowan. Near the top of the upper Morrowan interval in Deadman Canyon, conodonts corresponding to the Idiognathoides n. sp.

Zone of Lane and Straka (1974) were recovered. Lane previously regarded this zone as being earliest Atokan in age, but now states that Idiognathoides fossatus (Branson and Mehl) ranges down into the uppermost Morrowan. The latter interpretation is accepted in this thesis.

Brachiopods were collected from scattered localities, within this upper Morrowan interval, in the five northern sections. From Deadman Canyon, unit 2-1 (upper part of this interval), Sutherland identified brachiopods with a late Morrowan age. In Muleshoe Canyon, brachiopods from near the top of the interval were assigned a definite Morrowan age. Brachiopods, from the isolated conodont-sampled unit in Mule Canyon, confirmed the conodont age assignment. Two separate brachiopod collections from Alamo Canyon, from approximately one-third the distance above the base of this interval, were designated as probable late Morrowan in age by Sutherland. From the Indian Wells section, brachiopods collected from the middle part of the upper Morrowan interval, could be identified only as being of Morrowan age.

Foraminifera of the textularid, Eostaffella and Millerella types were common in most of the limestones within this interval, but were not analyzed in detail.

Lithostratigraphy. The upper Morrowan interval consists largely of wackestones to grainstones, subgraywackes to orthoquartzites, and minor amounts of shales. The limestones are typically partially silicified or recrystallized, have appreciable amounts of chert segregations, and are dominant in the southern sections.

The sandstones within the upper Morrowan interval are largely restricted to the northern part of the thesis area, especially in strati-

graphically higher portions. Sandstones in the northeastern part of the studied area range from subgraywackes to protoquartzites to orthoquartzites. The nonorthoquartzites are generally very fine to medium-grained, thin-bedded, have finely divided plant material, mica or glauconite grains, and shale or silt partings. The lower and southern arenite occurrences are orthoquartzites. These typically contain plant fragments, coarse angular grains, tabular crossbedding, have a thin basal conglomeratic zone, and sometimes display local channelling (see Plate III, Numbers 5 and 6).

The shales of this interval are commonly black, bituminous to calcareous, and have fissile to laminated bedding. They are generally silty and micaceous to the north and fossiliferous to the south.

Diorite and camptonite sills are common within the upper Morrowan interval, especially in the northern sections (see Cross Section).

Unique units within this interval include a limestone intraformational conglomerate (see 3-42) and, in three sections, occurrences of silicified shale (see 5-31).

Correlations. This interval is generally poorly exposed and has apparent rapid facies changes within it, making correlation difficult. The boundaries readily correlate, especially in relation to the strata outside this upper Morrowan interval, with the exception of the upper boundary south of Deadman Canyon. Within the interval, the basal orthoquartzite correlates in five sections along the escarpment. Another sequence of sandstone (mainly orthoquartzites), generally 35 to 45 feet stratigraphically higher, can be traced in the northern five sections.

In the southern portion of the thesis area, a 20 foot thick, ledge-forming packstone-wackestone can be recognized in four sections, within the middle part of the interval (see Figures 3, 4, and Cross Section).

In general, correlations were made by recognizing key marker beds, position in lithologic sequence, similar lithologies, relative thicknesses, and by faunal evidence.

Atokan Interval

Definition. The Atokan interval varies in thickness from approximately 65 to 155 feet. The lower boundary for the Atokan interval is the previously described upper boundary of the upper Morrowan interval.

The upper boundary of this interval is derived from faunal age determinations. In Deadman Canyon, conodonts from unit 2-15 suggest a late Atokan age assignment, and from unit 2-19, definite early Desmoinesian conodonts were recovered. This narrows a possible time boundary to within a stratigraphic interval of 20 feet. The boundary was arbitrarily placed at the top of unit 2-15 because this ledge-forming packstone-wackestone has a distinctive arenaceous layer (approximately 1-1.5 feet) capping it. Overlying this unit, an admixture of shales, thin interbeds of carbonate mudstones-wackestones, and siltstones is common. Boundary extensions to the north and south were largely arbitrary and dependent on thickness of the sequence, similar lithologies, and isolated fusulinid information.

Biostratigraphy. Fossil collections were scattered in the Atokan interval, and a good, continuous zonation could not be discerned. Conodonts collected from Deadman Canyon, in the basal part of the interval (2-3, 2-6, 2-13), were determined to be no earlier

than early Atokan in age by Lane. Conodonts recovered from the upper part of the interval (2-15) were assigned a late Atokan age.

Brachiopods were collected at scattered localities, and sparse, poorly preserved collections were the rule within this interval. A particularly well preserved collection from 2-14 (near the upper part of the interval) was assigned a definite Atokan age by Sutherland.

Tentative fusulinid age assignments by Sanderson related a late Atokan age for fauna found in the upper part of the interval from the Indian Wells section (6-34). Also, the same assignment is tentatively possible for fusulinids collected in Grapevine Canyon from the upper part of the interval (5-39).

Lithostratigraphy. The Atokan interval has two dominant facies (see Cross Section and Figures 3 and 4). To the north, a terrigenous, largely arenaceous facies exists. Orthoquartzites overlain by intermixed thin shales, siltstones, and some silty carbonate mudstones are typical lithologies for this facies. To the south, the interval is characterized by an argillaceous facies. Shales with interbeds of thin limestones and intermittent argillaceous carbonate mudstones to packstones are common lithologies for this southern facies.

The terrigenous strata of the Atokan interval are dominant along most of the escarpment. The shales are brown to gray to black, micaceous and silty in the northeast portion of the investigated area. To the southwest, the shales are commonly medium gray to black, have limestone stringers, and are locally fossiliferous. The siltstones are laminated, argillaceous, and calcareous. They are interbedded with shales and carbonate mudstones, and occur commonly in the upper part of

the interval to the northeast. The arenites are also confined to the northeastern portion of the thesis area. These sandstones are usually orthoquartzitic except for one unit (6-32) in the north which is a protoquartzite. The orthoquartzites have medium to very coarse angular grains, tabular cross-bedding, and inverse grading (for the entire unit). Conglomerates are commonly associated with the orthoquartzites, and are variable in content and textures. Some are arenaceous, having granule-sized quartz clasts with a ferrugenious coating on the grains. Others have an argillaceous, silty matrix with quartz pebbles or pebble-sized clay galls. There is a limestone intraformational-type conglomerate in the northern portion of the thesis area, which has a limestone matrix with an admixture of clay, bioclastic, and quartz grains. This unit has a distinctively banded top surface.

The carbonates of the Atokan interval are generally mudstones to wackestones with some packstone (especially to the south and upper part of the interval). The limestones usually have shale partings or interbeds, are thin-bedded, and form steep to moderate slopes.

Diorite and camptonite sills are common to this part of the Pennsylvanian section, but are confined to the northern part of the studied area.

Correlations. The orthoquartzite beds of the Atokan interval can be traced across three sections in the northern portion of the thesis area. A distinctive conglomerate (with a color-banded top surface) above the orthoquartzite sequence can be recognized distinctly in the two northernmost sections, and can be extended two sections southward by a similar occurrence of an arenaceous conglomerate.

Above this sandstone-conglomerate sequence, a shale interval of variable thickness (usually 10 feet) could be postulated as correlating across the escarpment by its position in sequence within this interval (see Figures 3, 4, and Cross Section).

Correlations made within this interval were not laterally definite. In general, however, the Atokan interval can be correlated and differentiated from the other intervals by the following criteria: 1) the general terrigenous character of the strata, 2) an abundance of covered intervals and gentle talus slopes, associated with the argillaceous content of the strata (expecially in the southern portion), and 3) the general absence of chert within the carbonate strata.

Lower Desmoinesian Interval

Definition. The lower Desmoinesian interval is bounded below by the previously described upper boundary of the Atokan interval. The upper boundary of the lower Desmoinesian interval is arbitrary and undoubtedly varies in age laterally. It is placed at the base of the local Bug Scuffle Limestone Member and this transgressive lithologic contact rises stratigraphically to the north. As defined by Pray (1961), this member is almost totally devoid of other rock types, ranges from predominantly mudstones to grainstones, is thick to very thick-bedded, and forms sheer, conspicuous cliffs along the face of the escarpment. The upper boundary of the lower Desmoinesian interval was designated topographically where a sheer cliff of limestone appeared in the stratigraphic sections, hence is not exact in all sections due to varying amounts of talus at the base of this cliff. This is not a time-stratigraphic boundary.

The Bug Scuffle Limestone Member is confined to the southern three-fourths of the thesis area. The thickness of the lower Desmoinesian interval capped by the Bug Scuffle Limestone Member ranges from approximately 25 feet (in the southernmost section) to 375 feet (in Mule Canyon). The Bug Scuffle Limestone Member changes facies to the north and is absent between Mule Canyon north-northeast to Fresnal Box Canyon (see Figure 2-where the term "tunnel" is). Replacing this carbonate facies is a terrigenous facies composed largely of shales and quartz sandstones, with only minor amounts of limestones. The basal part of this terrigenous facies (as described by Pray) is not defined. The base of an interbedded dark shale and carbonate mudstone sequence is chosen as an arbitrary upper boundary in the two northernmost sections. This unit (see 3-73) is characterized by its weathered appearance of thin white streaks on a dark gray surface. The thickness of the lower Desmoinesian interval in these two sections varies from approximately 225 to 245 feet (see Cross Section).

Biostratigraphy. Scattered faunal occurrences were collected from the lower Desmoinesian interval. Limited conodont fauna were collected within this interval at Deadman Canyon. From unit 2-19 (lower part of the interval), conodonts recovered were assigned by Lane as early Desmoinesian in age.

Megafossils were collected from this interval in most sections. From Grapevine Canyon, unit 5-42, Sutherland identified corals and brachiopods as being early Desmoinesian in age. Unit 7-31 (Escondido section) brachiopods were assigned an early Desmoinesian age. In Deadman Canyon, brachiopods and corals collected from the upper part of the

interval were determined to be definitely Desmoinesian. Brachiopods from the lower and middle part of the interval in Muleshoe Canyon were not specifically diagnostic, but probably represent a Desmoinesian age. Brahiopod collections from Mule Canyon (middle and upper portion of the interval) are probably Desmoinesian in age. A definite Desmoinesian brachiopod collection was procured from the top part of the interval in the Alamo Canyon section. Poorly preserved brachiopods and corals from the Indian Wells section (middle portion of the interval) were identified by Sutherland as probable Desmoinesian.

Fusulinids were collected from a sequence of limestones in Muleshoe Canyon (approximately the upper 360 feet of strata). This collection extends into the Bug Scuffle Limestone Member (approximately the upper 230 feet of the aforementioned section). Collections were obtained in the basal part of the Bug Scuffle Limesone Member from three other sections. Fusulinids were commonly found in the southern facies as low as approximately 50 feet below the Bug Scuffle in four sections. All of these fusulinid collections are Desmoinesian in age, as identified by Sanderson. He also tentatively postulates that the fusulinids within this facies become younger to the north (coinciding with the stratigraphic rise of the Bug Scuffle Limestone Member to the north).

Fusulinids recovered from the northern terrigenous facies are restricted to the Indian Wells section. Collections from the lower and middle parts of the interval were identified as Desmoinesian in age by Sanderson.

Lithostratigraphy. There are two definite facies within the lower Desmoinesian interval. A terrigenous facies is dominant.

It is best developed in the northern portion of the studied area and thins to the south (in the lower part of the interval). It is characterized by thin interbeds of shales, siltstones, sandstones, with minor limestones and medium to very thick-bedded sandstones. The carbonate facies is associated with the Bug Scuffle Limestone Member and is best developed in the upper portion of the lower Desmoinesian interval in the southern sections. It is characterized by wackestones, packstones, and grainstones, with interbeds of thin shales.

The thin interbeds of shales, siltstones, and sandstones of the terrigenous facies are especially dominant in the lower part of the lower Desmoinesian interval. These strata are cyclic with the shales silty and micaceous, the siltstones slightly calcareous, argillaceous, and micaceous, and the sandstones (largely protoquartzites) micaceous, and cross-bedded (small scale and minor) with varying percentages of glauconite and feldspar grains. The medium to very thick-bedded arenites are from subarkosic to protoquartzitic to orthoquartzitic in nature and occur in the upper part of the interval. These sandstones are generally poorly sorted, medium-grained, micaceous, glauconitic, slightly limy, and have minor cross-bedding.

The carbonates of the southern facies typically are grain-supported, have interbeds of shale, and minor amounts of glauconite, mica, and quartz grains. To the south these carbonates are bioturbated and slightly silty.

Correlations. Regional correlations were difficult within the lower Desmoinesian interval, due to the large amounts of fine-grained cyclic terrigenous rocks and interfingering facies changes. This is especially true in the lower and the northern portions of the interval.

The medium to very thick-bedded sandstones of the upper portion of the northern facies can be traced between two sections. A sequence of packstone to wackestones (approximately 3-5 feet thick) in the upper portion of the interval can be recognized in the three northernmost sections of southern carbonate facies. Characteristic of this sequence is the first occurrence of phylloid algae and fusulinids together (see Plate II, Number 1). The upper boundary of the northern facies correlates across two sections and is extended tentatively one section further south. The base of the Bug Scuffle Limestone Member correlates in the six southern sections. Tentative fusulinid correlations are possible in the upper part of the interval in the south facies (see Figures 3, 4, and Cross Section).

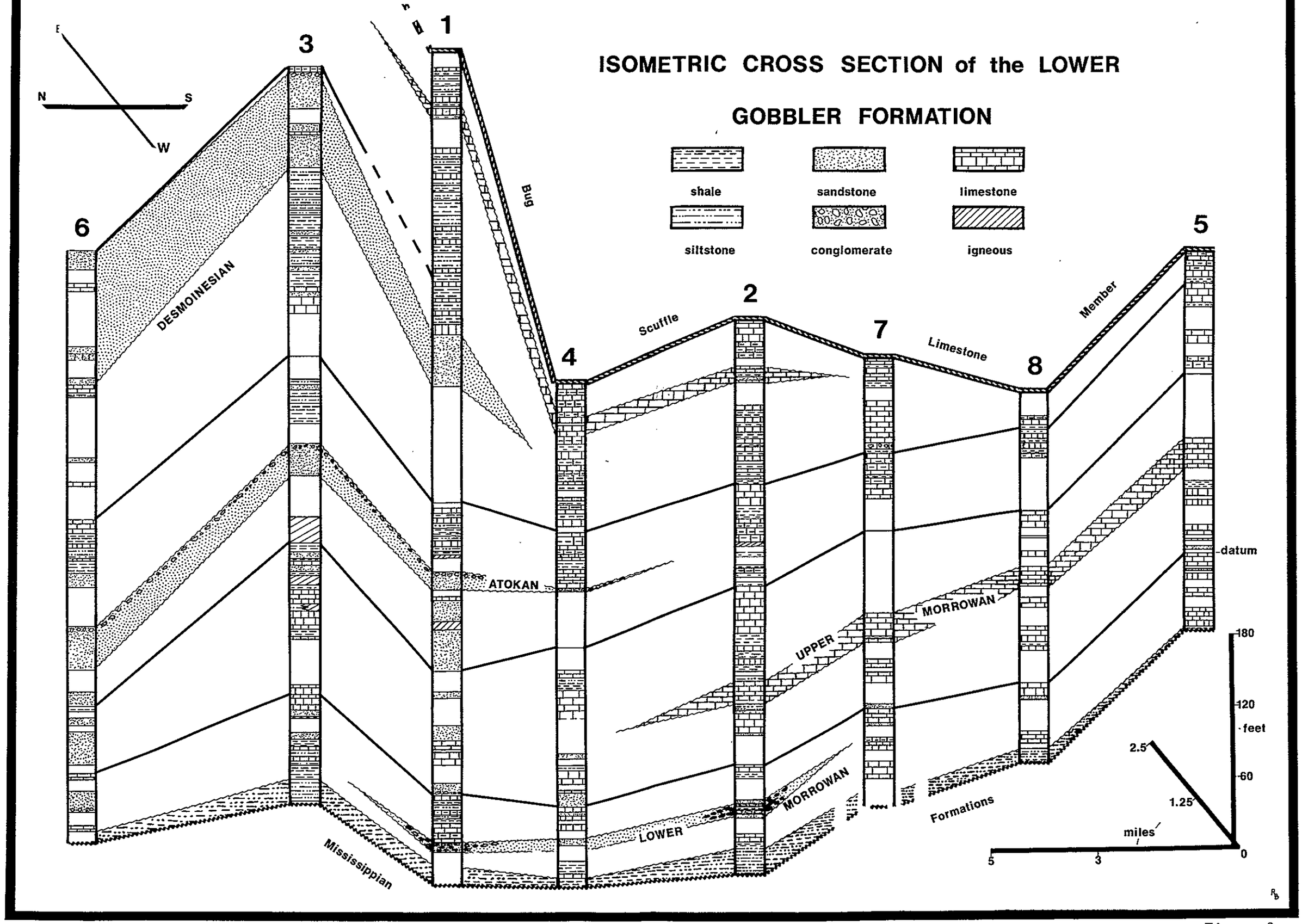

ISOMETRIC CROSS SECTION of the LOWER
GOBBLER FORMATION
shale
sandstone
limestone
siltstone
conglomerate
igneous
E
N
S
W
1
2
3
4
5
6
7
8
Bug
Scuffle
Member
Limestone
DESMOINESIAN
ATOKAN
MORROWAN
UPPER
MORROWAN
LOWER
Mississippian
datum
180
120
feet
60
0
2.5
1.25
miles
5
3
Formations

Figure 3

DEPOSITIONAL ENVIRONMENTS

Regional Geologic Setting

The underlying MIssissippian strata are believed to be a continuation of shelf sedimentation, common to the Paleozoic of south-central New Mexico. Negative areas during the late Mississippian were the Pderegosa Basin (to the southwest) and the Delaware Basin (to the east). The Penasco Dome (to the north) is the only discernable positive area present during late Mississippian time. The pre-Pennsylvanian strata were eroded and tilted to the south by regional uplift. This uplift was pre-Pennsylvanian in origin or concurrent with the Pedernal uplift of early Pennsylvanian time (see Figure 1).

The Pedernal landmass was a north-south structural element located east of the present day Sacramento Mountains. In relation to the thesis area, Kottlowski (1960) has postulated that the present day area of Sierra Blanca, located approximately 36 miles north of Alamorgordo, was a highland area of the Pedernal landmass. The Pedernal landmass was the dominant terrigenous source for the south-central New Mexico area throughout Pennsylvanian time. The late Mississippian Penasco Dome (the southern edge located in north-central New Mexico) probably provided little if any influx of terrigenous sediment to the south.

The Orogrande Basin was the dominant depocenter during the entire Pennsylvanian epoch in south-central New Mexico (see Figure 1).

At times during the early-middle Pennsylvanian, this basin could have connected with the Delaware Basin (to the east), the San Mateo, Lucero, and possibly Estancia Basins (from northwest to north respectively), and the Pedregosa Basin (to the southwest). For the eastern section of the Orogrande Basin, corresponding with the thesis area, Pray (1961) believed the shorelines were oriented north-south during most of the Pennsylvanian (pre-Virgilian). Kottlowski (1968) has postulated an east-west shoreline during the earliest part of the Pennsylvanian for this area.

Lower Morrowan Interval

The lower Morrowan interval has depositional environments ranging from nonmarine to shallow marine. The strata of this interval represent a transgression of shallow Pennsylvanian seas over the Mississippian sediments. Uplift of the Pedernal landmass (located northeast of the thesis area) occurred possibly prior to, and probably at times concomitant with, the transgression. This sea advanced to the northeast, along an irregular north-northwest to southeast shoreline. This encroachment was not steady and regressive fluctuations occurred (see Figures 3 and 4).

The basal Pennsylvanian siltstone overlies the Mississippian as a blanket deposit. Local basal channelling or the filling of karst depressions in the Mississippian is common in the northern area. A concordant contact between these systems exists in the southern and basinward areas. However, there is a hiatus here, as shown by conodont assessment, basal conglomerates in the Pennsylvanian, and mud crack casts in the Helms formation (see Plate III, Number 2). This

siltstone is gray-brown, subangular, laminated, and has marine fossils in the southwest (basinward), but becomes gray, angular, bioturbated (see Plate II, Number 6), and has plant fossils to the northeast (landward). These criteria indicate a marginal marine environment for this siltstone and the basal portion of the lower Morrowan interval.

The intermittent limestones of the lower Morrowan interval are more numerous in the southern part of the studied area. The limestones are generally dark packstones to wackestones, are partially silicified or recrystallized, have appreciable amounts of chert segregations, and are slightly silty. Features (more rare than common) such as an oolitic grainstone, herringbone crossbedding in an arenaceous wackestone, and the presence of glauconite grains in some limestones seem to indicate a shallow marine to near shore environment.

The clastic terrigenous strata of the lower Morrowan interval are sporadic in nature, but are confined to definite horizons. These beds are more numerous in the northern part of the thesis area. The shales are calcareous to bituminous and probably marine. The sandstones are generally orthoquartzitic, coarse-grained, cross-bedded, have plant fossils, and sometime display channelling. The cross-bedding is trough or tabular and the foresets have bimodel dips, generally to the northeast or northwest. These characteristics are indicative of distributary channels or estuarine deposits. A unique sandstone unit near the top of this lower Morrowan interval is subarkosic with potassium-feldspar grains. This probably indicates nearness to an intrusive igneous source. The terrigenous rocks of the lower Morrowan interval generally have angular grains. This suggests proximity to a source.

Thin-bedded, limestone-pebble conglomerates are interpreted as representative of deposition in a nearshore environment.

Upper Morrowan Interval

The upper Morrowan interval has depositional environments ranging from nonmarine to shallow marine. The strata of this interval appear in general to be a continuation of the lower Morrowan transgression. However, there seems to be more prominent fluctuations of regression, progradation, or stillstand conditions within this interval. The Pedernal landmass could have experienced rejuvenation during the regressive pulses.

The limestones of this interval range from wackestones to packstones to grainstones. These carbonates are typically dark, partially silicified or recrystallized, and have chert nodules. These limestones and associated cherts sometime have reddish, brownish, or greenish tinges in color, suggesting as shallow marine to nearshore environment of deposition.

Mottled textures, glauconite grains, algal fragments, (Dvinella, among others) and shale partings and interbeds are fairly common characteristics of these upper interval limestones. These features tend to indicate a nearshore-marginal marine environment.

Delicate fossils, such as bryozoans, are rarely found intact. This would seem to suggest either turbid conditions, or the fragments of these delicate forms are allogenic. There are definite bioturbation features found in the limestones, but these features seem to be restricted to the northern sections. Generally these criteria tend to suggest a probable pattern of slow sedimentation or possible stillstand conditions. However, brachiopods found in growth position might

suggest rapid deposition. The bioturbation present could be due to soft bottom sediment conditions.

The terrigenous strata of this interval are largely confined to the northern part of the studied area (especially the sandstone faction). The shales are dark, calcareous to bituminous, micaceous, and sometimes silicified. The shales are probably (shallow?) marine deposits. The sandstones are generally orthoquartzitic, have angular coarse grains, plant fragments, and display channelling. They also display planar cross-bedding with the foresets bimodally oriented to the northeast and northwest. These arenites are probably representative of a deltaic distributary channel deposit. In the northeastern part of the thesis area, protoquartzites and subgraywackes are common. These "dirty" arenites have marine fossil fragments and are slightly calcareous, micaceous, and silty. These criteria seem to relate an interdeltaic environment of deposition.

Atokan Interval

Depositional environments within the Atokan interval range from nonmarine to shallow marine. During this time regressive conditions were dominant and the Pedernal landmass probably experienced rejuvenation or possibly epeirogenesis. Deltaic processes are believed to be the dominant sedimentation factor in the northern part of the studied area. This regressive or progradational state was not steady, and periodic minor transgressive and stillstand conditions existed (see Figure 4).

The arenaceous facies is characterized by orthoquartzites with angular, medium to very coarse grains, tabular cross-bedding,

and inverse grading. The foresets of the cross-bedding have a bimodal distribution to the northeast and southwest. These arenites are also slightly micaceous and ferrigenous. Associated with these arenites are conglomerates (basal and lateral) which are arenaceous and in one case contain clay galls. These characteristics, coupled with the lenticular geometry of the sandstones (see Cross Section in pocket) are interpreted as being indicative of a deltaic distributary channel deposit. The overlying sequence of thin interbeds of silty shales, siltstones, and argillaceous-silty carbonate mudstones is probably interdeltaic. This sequence has appreciable amounts of mica flakes, plant material, and bioturbation features.

The shale facies is best developed in the central and southern portions of the Atokan interval. The shales are medium gray to black, locally fossiliferous, and have interbeds of thin limestones. These sediments appear to be representative of a restricted shallow marine environment.

The limestones of this interval are confined to the upper portion of the stratigraphic column. Silty carbonate mudstones are found in the north. These are probably shallow (tidal flat?) marine deposits. Wackestones to packstones with some isolated grainstones probably represent minor transgressive fluctuations. The presence of appreciable amounts of algal fragments (especially Dvinella) in some limestones implies a shallow sedimentary environment.

Lower Desmoinesian Interval

Depositional environments within the lower Desmoinesian interval range from nonmarine to shallow marine. There are two

sedimentary facies within the interval. A northern terrigenous facies is confined to the lower portions of the entire interval and upper portions in the north. And a southern carbonate facies is confined to the upper portion of the interval and climbs in the stratigraphic section from south to north. The northern facies is interpreted as a deltaic-regressive sequence. The deltaic facies appears to trend from a northeast to west direction. This facies is believed to be a continuation of the Atokan regression. The southern facies is a transgressive sequence, probably rising from the west-southwest to the northeast. The two facies display interfingering relationships (see Figure 4).

The thin cyclic interbeds of shales, siltstones, and sandstones are indicative of delta fringe deposits. These strata are micaceous, glauconitic, and have small scale cross-bedding, brachiopods, and plant fossils. This cyclic sequence is best developed in the three northernmost sections and interfingers to the south. The medium to very thick-bedded sandstones of the northern, upper portion of the interval are characteristically medium-grained, poorly sorted, cross-bedded, micaceous, glauconitic, and lenticular. These criteria are suggestive of deltaic distributary or inter-deltaic deposits. The Pedernal landmass could have experienced rejuvenation through the early Desmoinesian in coincidence with this regressive facies.

The grain-supported carbonates with minor carbonate mudstones and interbedded shales of the southern facies represent shallow marine to nearshore deposition. This sequence is commonly bioturbated, silty, has various amounts of glauconite, mica, and quartz grains, and contains algal and coral fossils. These criteria substantiate a shallow

sedimentary environment. Brachiopods found in growth position may suggest rapid sedimentation. The Bug Scuffle Limestone Member displays basal channelling in the southernmost section. Relief on the order of 6 feet was recorded with limestone boulders admixed in the overlying limestone conglomerate. This could mark a diastem where regressive conditions were modified to transgressive processes (see Plate III, Number 1).

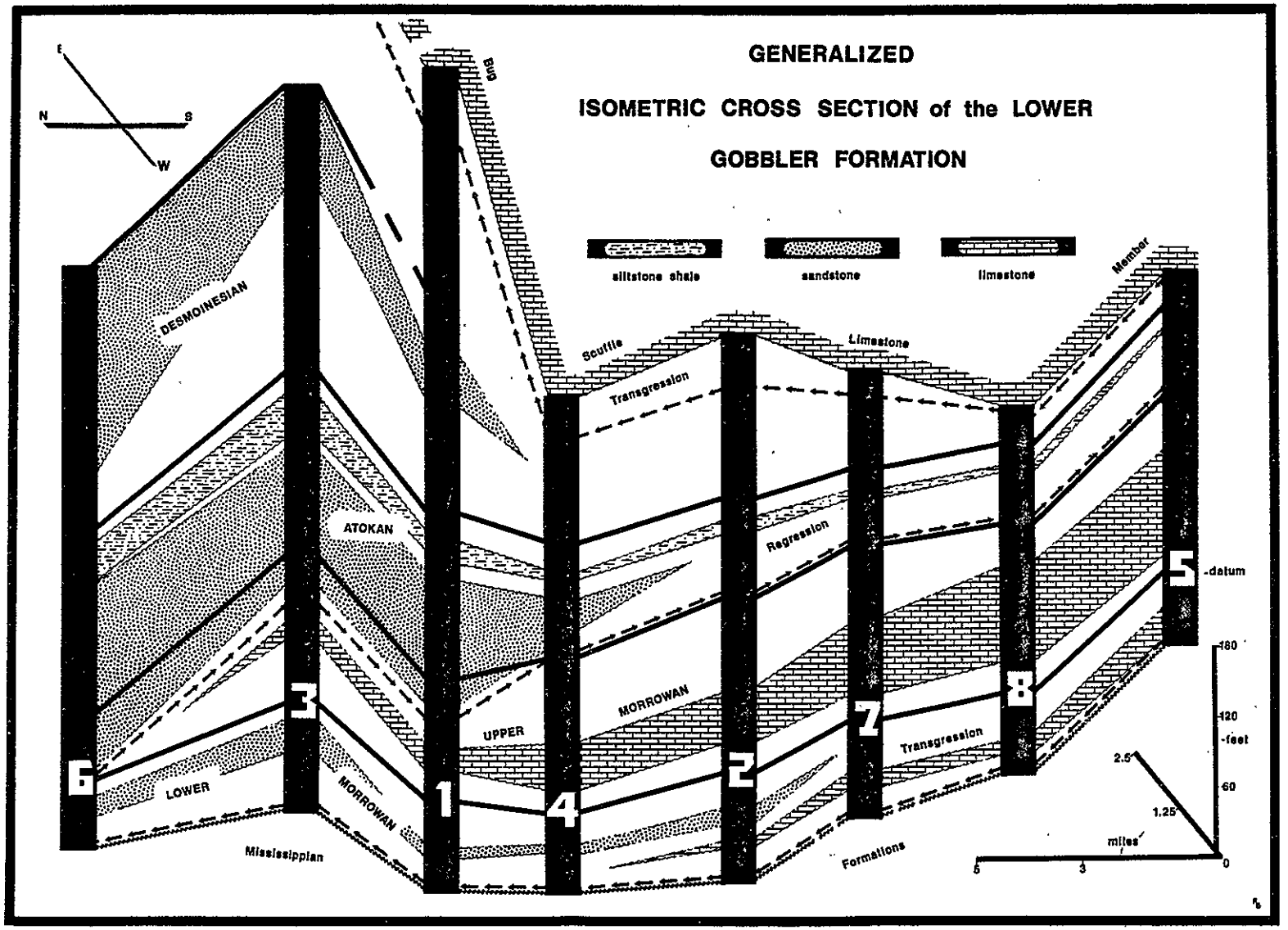

GENERALIZED
ISOMETRIC CROSS SECTION of the LOWER
GOBBLER FORMATION
E
N
S
W
siltstone shale
sandstone
limestone
DESMOINESIAN
ATOKAN
MORROWAN
LOWER
UPPER
MORROWAN
Mississippian
Scuffle
Limestone
Member
Transgression
Regression
Transgression
Formations
datum
180
120
feet
60
2.5
1.25
miles
5
3
0
1
2
3
4
5
6
7
8

Figure 4

SUMMARY AND CONCLUSIONS

The lower Gobbler Formation is composed of approximately 300 to 700 feet of sandstones, limestones, shales, conglomerates, and siltstones. It can be subdivided into four generalized time-stratigraphic intervals ranging in age from Morrowan through early Desmoinesian. The strata within these intervals were deposited in environments ranging from shallow marine (shelf) to interdeltaic. Complex facies changes are common within these intervals and correspond with the varying transitional environments.

The lower Morrowan interval is characterized by a basal siltstone, shales, intermittent limestones, and sporadic sandstones. This interval is early to middle Morrowan in age. The depositional environments of the lower Morrowan interval range from shallow marine (shelf) to nonmarine (deltaic or estuarine). The strata of this interval represent a marine transgression. This encroachment rose to the northeast, following an irregular north-northwest to southeast shoreline.

The upper Morrowan interval is largely composed of limestones, sandstones, and shales. This interval is middle through late Morrowan in age. The depositional environments range from shallow marine (shelf) to nonmarine (deltaic). Overall the upper Morrowan interval is a continuation of the lower Morrowan transgressions. However, stillstand and regressive trends were present during this time. The transgression

encroached from the southwest, while the regressive pulses originated from the northeast.

The Atokan interval has two facies, both being terrigenous in nature. A northern, largely arenaceous facies contains orthoquartzites overlain by interbedded shales, siltstones, and carbonate mudstones. The southern argillaceous facies is composed of shales with thin interbedded limestones and some sporadic limestones. This interval is representative of shallow marine (restricted) to deltaic sedimentation. During Atokan time regressive conditions were dominant.

The lower Desmoinesian interval contains two facies. A northern terrigenous facies, consisting of cyclic interbeds of shales, siltstones, and sandstones, with medium-to very thick-bedded sandstones is dominant within this interval. It is largely regressive or progradational (to the southwest) in nature. A southern carbonate facies, associated with the Bug Scuffle Limestone Member (extending less than 50 feet down below this arbitrary boundary) is composed of grain-supported limestones, and some carbonate mudstones and shales. This facies trends with the Bug Scuffle and rises stratigraphically to the north. The southern carbonate facies transgresses to the east-northeast. These two facies are largely simultaneous deposits, with the transgressive facies eventually predominating, especially in the south and extreme north (Fresnal Canyon - see Figure 2 - the "tunnel" locality). The lower Desmoinesian interval has environments ranging from shallow marine (shelf) to nonmarine (deltaic).

Within the lower Gobbler Formation, there are two distinct transgressions separated by a regression. The encroachments seem to

be originating from the Orogrande Basin following an irregular north-northwest to southeast shoreline. The regressive condition is probally concomitant with rejuvenation or epierogenic pulses of the Pedernal landmass to the east-northeast.

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APPENDIX

Introduction to Stratigraphic Sections

In the measurement of the stratigraphic sections, field methods described by Kottlowski (1965, pp. 59-91) were employed. The most common technique for vertical measure was the Abney level held on top of a five-foot Jacob's staff, graduated into feet and tenths of feet. Occasionally the Brunton compass eye height and steel tape measurement methods were used.

Field descriptions were compiled at the outcrop and were completed in the laboratory. Data record were 1) lithology, 2) classification of modifier of lithology, 3) color (fresh/weathered), 4) clastic grain parameters (size, roundness, sorting, contacts), 5) compositional adjective (example: cement, detrital minerals, etc.), 6) bedding thickness, 7) modifier of bedding or internal texture (example: wavy, bioturbated, mottled, etc.), 8) unique characteristics (example: contact relationships, chert nodules, weathering traits, etc.), 9) topographic and exposure expression, 10) fossil occurrences (abundance and type), 11) attitude of strata, and 12) unit thickness. The data is presented in this appendix with the aforementioned format.

Each measured section was assigned an arbitrary number. This section number is followed by a unit number. The unit number was painted on the surface of selected cliff-forming units with yellow

highway paint. Measurements begin at the base of the sections. When the unit number is followed by a lower-cased letter or is underlined, it means that additional beds were discovered or the original unit has been subdivided.

The general location for the measured section is given according to township, range, and section. A four-wheel drive vehicle or motorcycle is recommended for access to all of the sections.

Locations of stratigraphic sections and most horizonal distances were derived from aerial photographs, forest maps, a county highway map, and the geologic map of Pray (1961).

Rock samples, averaging 10 cubic inches, were collected from most units. All rock specimens were slabbed and about 70 thin sections made. In the listing of each descriptive lithology, the field data was modified where possible by either slab or thin section data, based on binocular and/or petrographic microscope examination. The thin section date is designated by brackets.

Megafossil collections were made where possible with particular emphasis on brachiopods and corals. Limestone samples to be processed for conodonts were taken at regular intervals (where possible) in Deadman Canyon and at scattered localities elsewhere. Fusulinid samples were taken wherever examples were seen in the field. Faunal lists (in brackets) for each stratigraphic section follow each lithographic unit description.

Terminology

The Wentworth (1972) classification for terrigenous sedimentary rocks was used, in addition to the more specific classifi-

cations by Dunham (1962) for carbonate rocks and Pettijohn (1957) for sandstones.

Descriptive modifiers are placed in order of increasing importance adjacent to the noun, in the lithic descriptions.

The weathered and fresh color determinations were made using the Rock Color Chart distributed by the Geological Society of America.

Features such as sorting and roundness are described using procedures outlined by Folk (1968). The bedding thickness parameters are those proposed by Ingram (1954).

A unit, as used in this investigation, is defined as having a distinct lithologic character, which is recognizable in the field and differs from superjacent and subjacent unit. In some instances, the author has subdivided a single lithologic entite, on the basis of bedding character changes. A unit may change laterally as well as vertically.

PLATE I

1. Alamo Canyon Section (3). View is toward the north, from Long Ridge. The Bug Sucffle Limestone Member is present at this locality as a detrital facies (deltaic). Studied interval (right-median side of photo) ranges from eroded dome position (lower left side of photo) up to just below light colored unit (right median side of photo).
2. Muleshoe Canyon Section (4). View is toward the east, from the Tularosa Basin. Note Mississippian bioherm (left side of picture). The Bug Scuffle Limestone Member is represented at this locality (and commonly along the escarpment) as a steep-sloped cliff. Studied interval ranges from bioherm up to base of the Bug Scuffle cliff (caps escarpment).

PLATE II

1. Unit 4-50, Packstone-wackestone. Unique marker bed of Desmoinesian age, in the middle part of the escarpment. Phylloid algae are the dominant allochems. Magnification X 3.5, polarized light.
2. Unit 2-25, Silicified limestone. Sponge spicules are dominate. Magnification X 6.5, polarized light.
3. Unit 4-14, Grainstone. Coated grains and oolites are cemented by microspar calcite. Pelmatazoan, foraminifera, and ostracode allochems are common to this limestone. Magnification X 4.2, crossed nicols.
4. Unit 1-26, Packstone. Datum bed for the lower Gobbler Formation. Characteristic foraminifera of Morrowan age. Conditions of being slightly recrystallized and also commonly slightly silicified are typical to the limestones of the Lower Gobbler Formation. Magnification X 4.2, crossed nicols.
5. Unit 6-53, Subarkose. Note feldspar grain in the center showing twinning. Opaque grains are glauconite; large white grains are quartz. Magnification X 4.2, crossed nicols.
6. Unit 2-6, Siltstone. Bioturbated and burrowed. Magnification X 1, polarized light.

PLATE III

1. Atokan - Desmoinesian contact, Grapevine Canyon (5). Hammer and six-inch ruler mark this local diastem (?). The contact is angular and has as much as six feet of relief in local channels. The lower stratum is a packstone, loaded with Pseudozaphrentoides (coral). The upper stratum is a limestone conglomerate with clasts as large as two feet in diameter.
2. Helms Formation, mudcracks, Grapevine Canyon (5). Six-inch ruler lies upon surface of a carbonate mudstone bed. Polygonal patterns are mud crack casts.
3. Lower Morrowan sandstones and conglomerates, Mule Canyon (1). Note cobble-sized mudstone clast behind hammer handle. Dark part of hammer handle is six inches in length.
4. Channel sand, Lower Morrowan, Alamo Canyon "west" locality. Notice trough cross-bedding. Hammer head is 7 inches long.
5. Channel sand, Upper Morrowan, Mule Canyon (1). Note sets of planar cross-bedding. Ruler is six inches in length.
6. Channel sand, Upper Morrowan, Indian Wells (6). Six-inch ruler marks planar cross-bedding.

Stratigraphic Section 6

Indian Wells

General Location

The section was measured trending northeast in the SW¼ of Section 11, T.16.S, R.10.E., Otero County, New Mexico.

Description of Locality

The section is located 3.75 miles northeast along paved and gravel roads, from a point on U.S. 54, 3.25 miles north of its intersection with U.S. 70. Local landmarks and directions are: turn east off of U.S. 54 on Indian Wells Street and proceed east 1.75 miles to its intersection with Scenic Drive; proceed east through the intersection and turn south along alley for 0.18 miles; turn east, cross bridge after 0.3 miles; proceed east 1.5 miles following gravel road to its end. Proceed northeast on foot to first north trending tributary.

The section begins in the aforementioned trending tributary. Measurement is offset early to the next north trending tributary. The section trends generally north to north-northwest.

General Remarks

The section was measured August 10-15, 1974. The section is generally poorly exposed, especially in the upper portion.

The general attitude of the strata is N 29° E with dips averaging 15° to the northwest.

	Approximate Thickness (in feet)
Lower Desmoinesian Interval	223
Atokan Interval	155
Upper Morrowan Interval	55
Lower Morrowan Interval	57
Total	490

Unit	Lithology	Thickness (ft.)
6-54	Limestone, wackestone-packstone and Shale; olive black/buff; thin bedded, rhythemitric, shale partings; distinct white on black banding or streaks; forms a slope, fair exposure; trace (debris)	5.0
Lower Desmoinesian Interval		
6-53	Sandstone, calcarous subarkose; light olive gray/medium gray-buff; medium-very coarse grained, angular-subrounded, poor sorting, [point-concavo-convex contracts]; glauconite; thin-thin medium bedded; forms a ledge, good exposure; moderate (brachiopod, coral)	15.0
6-52	Covered	12.0
6-51	Limestone, grainstone-packstone, arenaceous; medium olive black-gray/medium gray-buff; glauconite; thin medium bedded, minor crossbedding; coated grains; forms a ledge, good exposure; abundant (brachiopod, pelmatazoan, bryozoan, coral) N7°E 14°NW	5.3
6-50	Covered; probably siltstone	45.0

Unit	Lithology	Thickness (ft.)
6-49	Sandstone, ferrugenic calcareous protoquartzite; grayish orange-light olive gray/buff; coarse-granule grained, subangular, poor sorting, [point contacts]; glauconite, ferrugenic; thin medium bedded, minor crossbedding; forms a ledge, good exposure; moderate (pelmatazoan, bryozoan, brachiopod, fusulinid, ostracode)	4.8
6-48	Limestone, mudstone, and Siltstone; light gray-yellowish brown/buff; laminated-thin bedded; poor exposure; unfossiliferous	5.5
6-47	Covered	15.0
6-46	Sandstone, calcareous subgraywacke; grayish orange-light gray/buff; medium-coarse grained, subangular, fair-poor sorting, [concavo-convex contacts]; glauconite, feldspar, ferrugenic; thin-thin medium bedded; coated grains (?), minor conglomerate at the base; a ledge constituent, good exposure; trace (pelmatazoan, bryozoan, fusulinids)	6.5
6-45	Limestone, packstone-wackestone, slightly silty; medium olive gray-light olive brown/medium dark gray-buff; partially recrystallized or silicified; thin medium bedded, algal "texture"; forms a minor ledge, good exposure; moderate-abundant (pelmatazoan, brachiopod, gastropod, bryozoan, algae, coral)	5.0
6-44	Siltstone and Shale, limy; light gray /light tan-buff; fissile-thin bedded, poor exposure; moderate (brachiopod, pelmatazoan) [brachiopod: Neospirifer sp., Desmoinesia sp., Beecheria sp., Composita sp.]	5.0
6-43	Covered; probably 6-44	60.0

Unit	Lithology	Thickness (ft.)
6-42	Sandstone, ferrugenous calcareous protoquartzite; dark yellowish brown-moderate brown/light tan-buff; very fine-medium grained, subrounded, fair sorting; mica, bioclasts; thin-thin medium bedded, bioturbated; faint color banding; forms a ledge, good exposure; moderate (brachiopod, pelmatazoan) N70°E 13°NW	5.2
6-41	Covered	13.0
6-40	Limestone, packstone; olive black-olive gray/buff; thin bedded; moderate (foraminifera, pelmatazoan, bryozoan, brachiopod)	0.4
6-39	Limestone, grainstone; olive black-light gray/buff; thin bedded; forms a minor ledge, good exposure; moderate (fusulinid, brachiopod, pelmatazoan)	0.6
6-38	Siltstone, calcareous; mica; laminated-thin bedded; rare exposure; trace (pelmatazoan, brachiopod) [brachiopod: Linoproductus sp.]	3.0
6-37	Covered	10.0
6-36	Sandstone, protoquartzite, calcareous; medium olive-yellowish gray/buff; fine-medium grained, subrounded, fair sorting; glauconite, mica, ferrugenic; thin bedded, bioturbated; minor bench, fair exposure; moderate-abundant (coral, brachiopod, pelmatazoan, bryozoan, plant)	2.2
6-35	Covered	10.3
	Partial thickness of Lower Desmoinesian Interval	223.0

Unit	Lithology	Thickness (ft.)
Atokan Interval		
6-34	Limestone, grainstone; olive gray/buff; glauconite, mica, quartz; thin bedded, shale partings; forms a bench, good exposure; abundant (fusulinid, coral, pelmatazoan, foraminifera, gastropod, bryozoan) [brachiopod: Linoproductus sp.]	9.0
6-33	Limestone, mudstone, Siltstone and Shale; medium gray-light gray/buff; fissile-thin bedded; partially covered, poorly exposed; trace (pelmatazoan)	30.0
6-32	Sandstone, protoquartzite, ferrugenous, calcareous; moderate yellowish brown/buff; fine-medium grained, subangular, fair-good sorting; glauconite; thin bedded, burrowed, bioturbated, shale partings; forms a bench, good-fair exposure; trace (debris)	14.0
6-31	Covered; probably shale	44.0
6-30	Conglomerate, arenaceous, limy; grayish black-olive gray-grayish red/yellow-buff; medium-pebble grained, subangular, poor sorting, floating-concavo-convex contacts; thin bedded, blocky; top surface has retangular colored bands; forms a broken minor ledge, fair-good exposure; trace (pelmatazoan, coral) offset to the next west tributary	1.0
6-29	Covered	5.0

Unit	Lithology	Thickness (ft.)
6-28	Sandstone, orthoquartzite, ferrugenic; very light gray-yellowish gray/buff; medium-very coarse-granule grained, subangular, poor sorting, [stylotitic contacts]; mica; very thick bedded, cross-bedding, graded bedding; rill marks (?) on surface, top 2-3 ft. darker and coarser; forms a ledge; trace (brachiopod) N27°E 14°NW	33.0
6-27	Covered	16.0
6-26	Sandstone, orthoquartzite, ferrugenic; grayish orange-dark yellowish orange/buff; fine-coarse grained, subangular, poor sorting; very thick bedded, cross-bedding; forms a ledge, good exposure; trace (plant)	10.0
6-25	Shale; black/buff; mica; fissile bedded; forms a slope, fair exposure; unfossiliferous	7.0
	Partial thickness of Atokan Interval	155.0
Upper Morrowan Interval		
6-24	Covered	7.0
6-23	Sandstone, protoquartzite, ferrugenic; grayish orange-moderate brown/buff; fine-medium grained, angular, poor sorting; glauconite, mica; thin bedded; forms a minor ledge, fair exposure; abundant-moderate (pelmatazoan, bryozoan, brachiopod, plant) N27°E 14°NW	2.2

Unit	Lithology	Thickness (ft.)
6-22	Sandstone, protoquartzite, ferrugenious calcareous; grayish red, grayish orange/ buff; mica, glauconite; laminated-thin bedding, shale partings; distinct alternating color banding from pinkish white to maroonish purple; forms a slope, fair exposure; moderate (pelmatazoan, bryozoan, brachiopod) [brachiopod: Sandia welleri (Mather), Punctospirifer sp., Anthracospirifer newberryi (sutherland & Harlow), Cleiothyridina sp.]	7.5
6-21	Covered; probably 6-22	4.0
6-20	Sandstone, orthoquartzite, calcareous; yellowish gray/buff; medium-very coarse grained, subrounded fair sorting, concavo-convex to stylolitic contacts; limestone grains; medium-very thick bedded, crossbedding; forms an intermittent ledge, fair exposure; unfossiliferous	22.0
6-19	Limestone, grainstone; medium gray/buff; thin bedded; sharp upper contact; forms a discontinuous bench, rare exposure; moderate (pelmatazoan)	0.8
6-18	Limestone, wackestone; brownish black-dark gray/buff; thin bedded, wavy; forms a minor "ledge", rare exposure; abundant (foraminifera, pelmatazoan, brachiopod, bryozoan, sponge spicules)	0.22
6-17	Shale and interbedded Limestone, wackestone; gray-black/dark gray-buff; fissile bedded-shale, thin bedded-limestone, nodular; slope constituent, fair exposure; trace (brachiopod)	2.2
6-16	Covered; probably shale	3.0
	Partial thickness of Upper Morrowan Interval	55.0

Unit	Lithology	Thickness (ft.)
Lower Morrowan Interval		
6-15	Limestone, packstone-grainstone; dark yellowish brown, medium olive gray/buff; glauconite; medium bedded, shale partings; light bluish gray chert stringers; forms a bench, fair exposure; moderate-abundant (bryozoan, pelmatazoan, foraminifera, coral)	4.6
6-14	Limestone, packstone; olive black-gray/buff; thin bedded; coated grains, black-blue gray chert nodules and layers; forms a bench and ledge, fair-good exposure; moderate (gastropod, pelmatazoan, brachiopod) N35°E 20°NW	2.2
6-13	Covered	8.5
6-12	Sandstone, orthoquartzite, ferrugenious; grayish orange, pale brown/buff; medium coarse grained, subangular, fair sorting, concavo-convex to stylolitic contacts; thin-medium bedded; crossbedding; basal conglomerate 6 in. thick; forms a ledge and bench, fair exposure; trace (plant) N80°W 25	15.5
6-11	Shale; black/buff; fissile-laminated bedded; forms a slope, rare exposure; unfossiliferous	2.0
6-10	Covered; probably shale	9.0
6-9	Limestone, packstone; medium olive gray-dusky yellow/buff; glauconite; thin bedded, mottled; forms a ledge, good exposure; abundant (brachiopod, bryozoan, pelmatazoan, pelecypod, coral, algae) N15°E 14°W offset east to next tributary	1.2

Unit	Lithology	Thickness (ft.)
6-8	Limestone, wackestone; olive black-grayish orange/buff; partially silicified or recrystallized; thin bedded, shale partings, algal "mat", wavy; forms a ledge, fair-good exposure; abundant-moderate (pelmatazoan, brachiopod, bryozoan, foraminifera) [brachiopod: Antracospirifer sp.]	2.0
6-7	Covered; probably black shale	1.3
6-6	Limestone, packstone; dark yellowish brown/grayish orange-buff; ferrugenic coatings; thin bedded, mottled; coated grains; forms a minor ledge, fair exposure; moderate (bryozoan, pelmatazoan, brachiopod, foraminifera, algae)	2.3
6-5	Shale, arenaceous, silty; black/orange-brown-buff; fissile bedded; slope constituent, poor exposure; unfossiliferous	0.15
6-4	Shale, arenaceous; black, tan-brown/olive, maroon, gray-buff; fissile-laminated bedded; forms a ledge, poor exposure, trace (brachiopod)	0.8
6-3	Covered, talus; could be siltstone	6.5
6-2	Limestone, silicified; medium light gray-light gray/tan, green, blue-buff; thin-medium bedded, nodular, wavy; coated grains, limonite crystals and concretions, fissures; forms a discontinuous ledge, fair exposure; moderate (pelmatazoan) N6°E 20°W	3.0
	Partial thickness of Lower Morrowan Interval	57.0

Unit	Lithology	Thickness (ft.)
Tierra Blanca Member (Mississippian)		
6-1	Limestone, grainstone; yellowish gray/ buff; partially recrystallized; medium-very thick bedded; light bluish gray chert nodules, limonite replacement; forms a cliff, good exposure; abundant (pelmatazoan, brachiopod) N7°E 14°W	5.0

Stratigraphic Section 3

Alamo Canyon

General Location

The section was measured trending north-northeast in the W/2 of Section 6, T.16.S., R.11.E., Otero County, New Mexico.

Description of Locality

The section is located 7.7 miles east along paved, gravel, and dirt-arroya bottom roads from a point on U.S. 54, 1.5 miles north of its intersection with U.S. 70. Local landmarks and directions are: 2.5 miles from highway intersection turn east on 1st. Street; proceed east one mile and turn southeast on Canyon Road; proceed 1.8 miles southeast and a large water tank (silver) can be seen on the south side of the road; proceed southeast another 1.0 mile and turn east into Alamo Canyon; proceed as far as possible by vehicle or foot for approximately 3.9 miles.

The section begins in a northeast trending main tributary and follows this tributary in the lower half, then trends in a northeast direction.

General Remarks:

The section was measured July 3-14, 1974. This section in general is well exposed, but the largest amount of igneous sills and dikes were found at this local, undoubtedly altering the true nature of the strata.

The general attitude of the strata is N70°W with dips averaging 27° to the northeast.

	Approximate Thickness (in feet)
Lower Desmoinesian Interval	241
Atokan Interval	155
Upper Morrowan Interval	124
Lower Morrowan Interval	91
Total	612

Unit	Lithology	Thickness (ft.)
3-73	Limestone, wackestone-packstone, and Shale; olive black/buff; thin bedded, rhythmetric, shale partings; distinct white on black banding; forms a slope, fair exposure; trace (debris)	5.0
Lower Desmoinesian Interval		
3-72	Limestone, mudstone, and interbedded Shale, silty; dark gray-grayish black/ buff; laminated bedded-shale, thin bedded-limestone; silt partings; forms a slope, fair exposure; unfossiliferous	1.5
3-71	Conglomerate, arenaceous, limy; gray-black-grayish orange/buff; fine-pebble grained, angular-subrounded, poor sorting, floating-point contacts; feldspar grains, glauconite, limestone pebbles; thin bedded; forms a minor ledge, fair exposure, moderate (pelmatazoan, bryozoan, algae)	0.2

Unit	Lithology	Thickness (ft.)
3-70	Limestone, packstone, silty; dark yellowish brown/buff; thin bedded, shale partings; gradation lower contact; forms a discontinous ledge, fair-good exposure; abundant (brachiopod, pelmatazoan, bryozoan) [brachiopod: Kozlowskia haydenensis (Girty), Neospirifer sp., Buxtonia sp., Linoproductus sp., Phricodothyris sp., Crurithyris sp., Punctospirifer sp., Anthracospirifer sp.]	3.1
3-69	Conglomerate, limy; moderate yellowish brown/buff; medium-granule grained, subangular, poor sorting; limy matrix, glauconite, limestone and quartz granules; thin bedded; forms a ledge, good exposure; moderate (bryozoan, coral, brachiopod, pelmatazoan)	2.1
3-68	Sandstone, protoquartzite, limy; light olive gray/buff; fine-medium grained, subrounded, fair sorting; glauconite, mica; thin-thick bedded, silty-shale partings, crossbedded; forms a ledge, good exposure; trace (brahiopod)	29.9
3-67	Covered, probably 3-66 or 3-68	11.8
3-66	Sandstone, protoquartzite; dark yellowish brown/buff; medium-coarse grained, subangular, poor sorting; glauconite, mica, limestone grains; laminated-thin bedded; forms a slope, poor exposure; trace (plant)	7.0
3-65	Sandstone, protoquartzite, ferrugenious and Limestone, packstone; dark-moderate yellowish brown/buff; fine grained, subrounded, fair-good; ferrugenious coatings; thin bedded; clay galls and nodules; caps top of ledge, fair exposure; abundant (brachiopod, gastropod, pelmatazoan, coral)	2.0

Unit	Lithology	Thickness (ft.)
3-64	Sandstone, protoquartzite, ferrugenious, micaceous; dark yellowish brown/buff; fine-medium grained, angular, fair sorting, point contacts ; glauconite, mica, ferrugenious coatings, limestone grains; medium-very thick bedded, cross-bedded; forms a ledge, good exposure; trace (plant)	30.0
3-63	Siltstone, argillaceous; tan-gray/ buff; mica; laminated-thin bedded; clay nodules and galls; forms bottom of ledge, fair exposure; trace (plant)	23.0
3-62	Shale, silty, and Partially Covered; tan-gray/buff; mica; fissile-laminated bedded; forms a slope, poor exposure; trace (brachiopod)	49.0
3-61	Limestone, packstone, and Siltstone, limy; medium dark gray-tan/buff; fine-coarse grained; glauconite, mica, ferrugenious coatings; thin bedded-limestone, laminated-siltstone, shale partings; forms a slope, fair exposure; trace-moderate (pelmatazoan, brachiopod, bryozoan, coral)	27.0
3-60	Limestone, packstone, arenaceous; grayish black-olive black/buff; mica, glauconite, feldspar grains; thin bedded, coated grains; caps ledge, good exposure; moderate-trace (brachiopod, coral, pelmatazoan, foraminifera)	2.4
3-59	Limestone, grainstone; rose-pale reddish brown-light gray/buff; glauconite, mica; medium bedded, cross-bedded; basal contact is a weathered yellow zone, arenaceous in upper portion; forms a ledge, good exposure; abundant (pelmatazoan, brachiopod, bryozoan, coral) N80°W 21°N	11.0

Unit	Lithology	Thickness (ft.)
3-58	Limestone, packstone; grayish brown/buff; ferrugenic coatings, glauconite; medium bedded; coated grains; forms bottom of ledge, good exposure; moderate-abundant (brachiopod, pelmatazoan, foraminifera, bryozoan)	4.7
3-57	Covered; probably shale	49.7
	Partial thickness of Lower Desmoinesian Interval	241.0
Atokan Interval		
3-56	Siltstone, limy, Shale and Limestone, mudstone; olive gray-grayish black/buff; fine grained; mica; fissile-thin bedded, bioturbated; sand casts; forms a slope, fair exposure; trace (pelmatazoan, sponge spicules, debris) N48°W 21°NE	20.0
3-55	Conglomerate, limy, argillaceous; grayish black-olive black/buff; fine-pebble grained, angular, poor sorting, floating contacts; limy matrix, quartz pebbles, feldspar grains, glauconite; thin bedded; forms a minor ledge, fair exposure; trace (coral, pelmatazoan)	0.86
3-54	Shale; gray-black/buff; fissile bedded; forms a slope, fair exposure; unfossiliferous	17.1
3-53	Covered; probably shale	12.0
3-52	Conglomerate, arenaceous, limy; grayish black-olive gray-grayish red/yellow-buff; medium-pebble grained, subangular, sorting, concavo-convex to stylolitic contacts; mica; very thick bedded, cross-bedded; top 3 ft. weathers rust-maroon; forms a massive ledge, good exposure; unfossiliferous N53°W 39°NE offset 5-70 yards west	28.0

Unit	Lithology	Thickness (ft.)
3-51	Covered; probably shale	4.9
3-50	Sandstone, orthoquartzite; yellowish gray/buff; medium-granule grained, sub-angular, fair-poor sorting, concavo-convex to stylolitic contacts; mica; very thick bedded, cross-bedded; top 3 ft. weathers rust-maroon; forms a massive ledge, good exposure; unfossiliferous N53°W 39°NE offset 50-70 yards west	28.0
3-49	Covered; probably black shale	33.7
3-48	Igneous sill	21.0
3-47	Conglomerate, arenaceous, argillaceous; light olive gray/buff; fine-pebble grained, angular, poor sorting, point to stylolitic contacts; mica, clay pebble-clasts; laminated-thin bedded; clay galls; slope constituent, poor exposure; trace (plant)	1.1
	Partial thickness of Atokan Interval	155.0
Upper Morrowan Interval		
3-46	Sandstone, subgraywacke; medium olive gray/dusky yellowish green-maroon, buff; very fine-medium grained, subangular, poor sorting, [concavo-convex to stylolitic contacts]; mica, limestone grains; thin bedded, shale partings; forms a slope, fair exposure; trace (bryozoan, pelmata-zoan, plant)	1.6
3-45	Shale and Partially Covered; black/ buff; fissile-laminated bedded; forms a slope, fair-poor exposure; unfossiliferous	4.5

Unit	Lithology	Thickness (ft.)
3-44	Sandstone, orthoquartzite; yellowish gray/buff; medium-granule grained, angular, poor sorting, concavo-convex contacts; some limestone grains; thin-medium bedded, graded; minor ledge former, fair exposure; unfossiliferous	6.7
3-43	Shale; grayish black/yellowish brown-buff; fissile bedded; slope constituent, poor-fair exposure; unfossiliferous	0.2-0.5
3-42	Conglomerate, limestone; olive gray-medium gray/buff; partially silicified, pyrite; thin bedded, wavy, nodular; intraformational; forms a minor ledge, fair-good exposure; moderate (pelmatazoan, brachiopod, pelecypod, bryozoan)	1.9
3-41	Shale, slightly limy; grayish black/buff; mica; fissile-laminated bedded; forms a slope, poor exposure; moderate (brachio-pods)	1.9
3-40	Limestone, packstone; olive gray-dark gray/buff; glauconite; thin bedded; coated grains; forms a minor ledge, good exposure; abundant (pelmatazoan, brachiopod, pelecypod, bryozoan)	3.0
3-39	Sandstone, subgraywacke; olive gray/maroon-buff; very fine-medium grained, subangular, fair sorting, floating-point contacts ; mica; thin bedded, burrowed, bioturbated, shale partings; limestone nodules; forms a slope, fair exposure; tract (brachiopod, plant) N16°W 50°NE	3.6
3-38	Shale, limy; medium gray/olive-maroon, buff; pyrite; laminated bedding; forms a slope, good exposure; unfossiliferous	3.1
3-37	Igneous sill	9.6

Unit	Lithology	Thickness (ft.)
3-36	Shale, slightly silty and limy; olive gray-dark gray/buff; mica; laminated bedding; slope constituent, fair exposure; unfossiliferous	1.8
3-35	Covered; probably 3-36	1.5
3-34	Limestone, grainstone; medium dark gray-olive gray/buff; medium bedded; forms a ledge, good exposure; abundant (pelmatazoan, bryozoan, brachiopod)	2.9
3-32	Limestone, packstone-grainstone; olive gray-medium gray/buff; partially recrystallized; thin bedded; forms a minor ledge, fair exposure; moderate (pelmatazoan, debris)	1.78
3-31a	Sandstone, subgraywacke, limy, and Siltstone; olive gray-olive black/buff; silty-very fine grained; quartz and limestone grains, mica; laminated-thin bedded, mottled; forms a slope, fair exposure; tract (plant) offset measurement	10.0
3-31	Igneous dike, camptonite; light greenish gray-moderate yellowish green/brown-green-buff; dike trends along minor fault possibly	10.0
3-30	Limestone, packstone; dark gray-medium gray/buff; glauconite; thin bedded; caps ledge, poor-good exposure; moderate (pelmatazoan, debris)	0.5

Unit	Lithology	Thickness (ft.)
3-29	Limestone, packstone; medium dark gray-olive gray/buff; glauconite, pyrite; thin bedded, shale partings; intraformational conglomeratic basal zone (arenaceous, limy matrix), has a distinct 1 ft. thick tan-rust weathered zone at 5 ft. above base; forms a ledge, good exposure; abundant (pelmatazoan, brachiopod, wood, bryozoan)	12.4
3-28	Limestone, packstone; olive gray/medium gray-buff; thin bedded, mottled; forms a ledge, good exposure; abundant (pelmatazoan, foraminifera, coral, bryozoan)	2.0
3-27	Limestone, wackestone, and Shale; olive black/medium dark gray-buff; mica; thin bedded-limestone, laminated bedded-shale, nodular, wavy; slope constituent, fair exposure; abundant (brachiopod, pelmatazoan, sponge spicules) [brachiopod: Antiquatonia coloradoensis (Girty), Desmoinesia sp.; coral: Amplexocarinia corrugata (Mather)]	1.3
3-26	Limestone, packstone; brownish black/dark gray-buff; mica, ferrugenic coating on grains; thin bedded, mottled; bituminous; slope constituent, fair exposure; moderate (foraminifera, pelmatazoan, brachiopod, algae)	0.8
3-25	Limestone, wackestone, silty, and Shale; brownish black/dark gray-buff; mica, pyrite; fissile-thin bedded; slope constituent, poor exposure; trace (brachiopod, pelmatazoan)	2.8
3-24	Limestone, packstone; medium dark gray/green, red, buff; partially silicified, mica, glauconite; thin bedded, algal mat (?); slope constituent, poor exposure; trace (pelmatazoan, brachiopod) N52°W 21°NE	0.87

Unit	Lithology	Thickness (ft.)
3-23	Limestone, wackestone; olive black/ medium dark gray-buff; partially silicified and recrystallized; thin bedded, nodular, wavy; forms a slope, poor exposure; abundant (brachiopod, pelmatazoan) [brachiopod: Antiquatonia coloradoensis (Girty), Linoproductus sp., Spirifer cf. goreii (Mather), Buxtonia (?) sp., Phricodothyris sp.]	1.2
3-22	Partially Covered, Shale and Siltstone; gray-black/light green-buff; fissile-thin bedded; covered part-probably shale; forms a slope, poor exposure; trace (brachiopod)	4.7
3-21	Shale, silicified; moderate bluish gray-brownish black/buff; mica; laminated-thin bedded; forms a slope, poor exposure; trace (brachiopod)	0.87
3-20	Covered; probably gray shale	28.0
3-19	Limestone, packstone; olive gray/medium gray-buff; partially silicified, glauconite; thin bedded; iron concretions, blue-gray chert stringers; forms a minor ledge, fair exposure; moderate-abundant (pelmatazoan, foraminifera, brachiopod, ostracode, debris)	2.5
3-18	Covered; probably gray shale	5.7
	Partial thickness of Upper Morrowan Interval	124.0

Unit	Lithology	Thickness (ft.)
Lower Morrowan Interval		
3-17	Limestone, packstone; olive black/medium gray-buff; partially silicified, glauconite; thin bedded; iron stained concretions, coated grains; slope constituent, fair exposure; abundant (coral, bryozoan, pelmatazoan, foraminifera, brachiopod, algae) N71°W 24°NE	0.4
3-16	Limestone, packstone; olive black/ medium dark gray-buff; partially silicified and recrystallized; thin bedded; caps ledge, good exposure; abundant (pelmatazoan, brachiopod, coral, foraminifera, bryozoan, algae)	1.1
3-15	Limestone, packstone; olive black/ medium gray-buff; thin-medium bedded; bioturbated; black chert seam and nodules; ledge constituent, good exposure; moderate (pelmatazoan, foraminifera, sponge spicules, algae (?))	5.2
3-14	Limestone, packstone; olive black/medium gray-buff; partially recrystallized and silicified; thin bedded, shale partings, mottled; dark gray chert nodules; ledge constituent, good exposure; moderate (foraminifera, pelmatazoan, bryozoan, brachiopod, pelecypod, algae) N60°W 20°NE	4.1
3-13	Limestone; olive gray/medium gray-buff; partially silicified; medium bedded; gray chert nodules; forms a ledge, good exposure; moderate (brachiopod, foraminifera, bryozoan, pelmatazoan, gastropod, coral, algae) N75°W 27°NE	3.2

Unit	Lithology	Thickness (ft.)
3-12	Limestone, packstone, arenaceous; olive black/medium gray-buff; mica; thin bedded; forms a slope, fair exposure; trace (debris)	0.6
3-11	Sandstone, subgraywacke, argillaceous; olive gray, moderate pale yellowish brown/medium gray-buff; fine-medium grained, angular, poor sorting, floating contacts; some portions have an opaline matrix, glauconite, mica, limestone grains; laminated-thin bedded, bioturbated; bituminous; forms a slope, fair exposure; trace (brachiopod) N73°W 25°NE	5.8
3-10	Shale, arenaceous; black/dark gray-buff; glauconite, mica; fissile-laminated bedded, burrowed; sand casts; forms a slope, good-fair exposure; moderate (brachiopod)	3.0
3-9	Covered; probably 3-10	11.7
3-8	Sandstone, orthoquartzite, calcareous; yellowish gray/buff; medium-very coarse grained, subangular, poor sorting, floating-stylolitic contacts; glauconite, mica; laminated-thin bedded; slope constituent, fair exposure; trace (pelmatazoan, plant) N70°W 26°NE	4.2
3-7	Shale; black/dark gray-buff; mica; fissile bedded; slope constituent, poor exposure; unfossiliferous	0.54
3-6	Shale, silty and slightly limy; olive black/medium dark gray-buff; mica; laminated bedding, nodular; forms a slope, fair exposure; unfossiliferous	0.56

Unit	Lithology	Thickness (ft.)
3-5	Limestone, mudstone, argillaceous-silty, and Shale; olive black/medium gray-buff; thin bedded-limestone, laminated bedding-shale; forms a slope, poor exposure; trace (brachiopod, debris) N70°W 36°NE	18.2
3-4	Shale; black/dark gray, brown, yellow-buff; laminated-fissile bedded; caliche veins; forms a slope, poor exposure; trace (brachiopod)	10.0
3-3	Siltstone, limy and argillaceous; yellowish gray-pale olive/pale greenish yellow-buff; partially silicified, glauconite; thin-laminated bedded, nodular; coated grains, gypsum-caliche replacement veins; forms a slope, poor-fair exposure; trace-abundant (pelmatazoan, bryozoan, pelecypod, brachiopod, plant)	19.9
3-2a	Sandstone, orthoquartzite; conglomeratic zones; found in the "west" Alamo Canyon locality	60.0
3-2	Covered; probably 3-3	3.0
	Partial thickness of Lower Morrowan Interval	91.0
Tierra Blanca Member (Mississippian)		
3-1	Limestone, grainstone; light olive gray/olive gray-yellowish gray, light gray; [stylolitic contacts]; partially recrystallized; medium-very thick bedded; white-moderate bluish gray chert nodules; resistant cliff, good exposure; moderate (pelmatazoan) N60°W 27°NE	5.0

Stratigraphic Section 1

Mule Canyon

General Location

The section was measured trending approximately east-west in the NW/4 Section 15, T.17.S, R.10.E, Otero County, New Mexico.

Description of Locality

The section is located 5.25 miles southeast along paved and dirt roads, from a point on U.S. 54, 0.65 miles south of its intersection with U.S. 70. Local land marks and directions are: turn east off of U.S. 54 and proceed east, passing Country Club and gravel pit operation, for 0.95 miles; turn south and proceed 0.35 miles; veer in a southeast direction for 1.5 miles; turn east and follow road for 0.95 miles to its end / local surroundings include a cement-lined pond, wooden shack ruins, and the base of the escarpment; walk 1.5 miles east through the main canyon.

The section begins in a minor northeast trending tributary coinciding with the easternmost exposure of Mississippian beds. The section trends N80°E with only one minor offset to the next tributary to the southeast, occurring in the middle part of the section.

General Remarks

The section was measured June 15-21, 1974. This section essentially coincides with Pray's type section of

the Pennsylvanian in this mountain range. It is poorly exposed in the basal portion and intervals underlying thick sandstone units, but fair to well exposed in other parts of the section.

The general strike of the strata averages from N35°W to N33°E with dips ranging from 4° to 25° to the northeast and southwest respectively.

	Approximated Thickness (in feet)
Lower Desmoinesian Interval	371
Atokan Interval	141
Upper Morrowan Interval	103
Lower Morrowan Interval	75
Total	690

Unit	Lithology	Thickness (ft.)
Bug Scuffle Limestone Member		
1-50	Limestone, packstone; olive black-grayish black-light bluish gray/medium gray-buff; partially silicified; thin-medium bedded; distinct ledge and cliff former, well exposed; moderate (fusulinid, pelmatazoan, debris)	5.0
Lower Desmoinesian Interval		
1-49	Covered; probably shale	11.0

Unit	Lithology	Thickness (ft.)
1-42	Interbedded Shale, Siltstone and Limestone, mudstone; olive black-brownish black/ medium dark gray-buff; mica; thin bedded-limestone, laminated bedding-silstone, fissile bedded-shale; 1 ft. thick limestone units at 25, 30, 50, 71 and 90 ft. above the base; forms a slope, fair exposure; trace (brachiopod) [brachiopod: Echinaria sp.] N76°E 6°NW	144.0
1-41	Silstone, limy; light olive gray-moderate yellowish brown/medium dark gray-buff; very fine-medium grained; ferrugenous grains (bioclastic); thin bedded; friable surface; forms a blocky slope, poor-fair exposure; abundant (brachiopods) [brachiopod: Neospirifer sp., Linoproductus sp., Buxtonia (?) sp., Composita sp.] E-W 9°S	5.1
1-40	Sandstone, orthoquartzite; grayish orange-yellowish gray-white/buff; medium-very coarse grained, subrounded, fair sorting, concavo-convex to stylolitic contacts; some limestone grains, glauconite; medium-very thick bedded; cross-bedded; distinctive cliff former, good exposure; trace (plant) N39°E 6°SE	54.5
1-39	Covered, talus	103.0
	Partial thickness of Lower Desmoinesian interval	371.0

Atokan Interval

1-38	Interbedded Silstone, Shale and Limestone, mudstone; grayish black-olive black/medium dark gray-buff; mica; laminated thin bedding; gradational lower contact; forms a slope, fair exposure; trace (sponge spicules)	34.0

Unit	Lithology	Thickness (ft.)
1-37	Shale, silty, limy, and interbedded Siltstone, argillaceous; grayish black-dark gray-olive gray/medium dark gray-buff; pyrite, mica; laminated-thin bedding, bioturbated; forms a ledge, good exposure; trace (sponge spicules) N2°W 5°SW	5.8
1-36	Igneous sill, camptonite; light olive gray-moderate yellowish green/brown-buff; white phenocrysts; forms a ledge, fair exposure	3.0
1-35	Covered, talus; probably contains a sandstone with conglomeratic upper portion-approximately 15 ft. thick	31.5
1-34	Limestone, grainstone; light olive brown-olive gray/greenish gray-buff; glauconite; medium bedded; coated grains; forms a broken ledge, good exposure; moderate (pelmatazoan, brachiopod, algae) N4°E 12°NW	3.4
1-33	Sandstone, protoquartzite (?); grayish yellow/green-buff; fine-medium grained, subrounded, good sorting; mica; thin bedded; forms a steep slope, fair exposure N2°E 12°SE	17.8
1-32	Igneous sill, camptonite; light olive gray, moderate yellowish green/brown-buff; forms a blocky slope, poor exposure N11°E 10°NW	8.1

Unit	Lithology	Thickness (ft.)
1-31	Sandstone, orthoquartzite, calcareous; pale olive-light gray/buff; fine-medium grained, subangular, poor sorting, stylolitic contacts; mica; thin-very thick bedded; cross-bedded; forms a resistant ledge, good exposure; trace (plant) N37°E 7°SE	33.0
	Partial thickness of Atokan interval	141.0
Upper Morrowan Interval		
1-30m	Covered	16.0
1-30l	Sandstone, sub-protoquartzite; yellowish gray/buff; fine-medium grained, sub-angular, fair sorting, floating to point contacts; limestone and quartz grains, glauconite, mica, ferrugenic coatings on some grains; very thick bedded, cross-bedded; clay galls; forms a ledge, fair exposure; trace (plant)	10.0
1-30j	Limestone, packstone; olive gray/medium gray-buff; partially silicified, glauconite; thin bedded, shale partings; forms a steep slope, good exposure; moderate (brachiopod, pelmatazoan, coral, ostracode, algae) [conodonts: Upper 6 in. *Idiognathodus sinuosis* (Ellison & Graves)(left), *Idiognathodus sinuosis* (Ellison & Graves) (right), *Adetognathus gigantus* (right), *Adetognathus gigantus* (left), *Adetognathus* sp., *Hindeodella* sp.; brachiopod: *Antracospirifer newberryi* (Sutherland & Harlow), *Buxtonia grandis* (?) (Sutherland & Harlow), *Antiquatonia* cf. *coloradoensis* (Girty), *Desmoinesia* sp., *Linoproductus* sp.; coral: *Rhynchopora magnicosta* (Mather)]	6.0

Unit	Lithology	Thickness (ft.)
1-30h	Limestone, wackestone; olive black/ medium dark gray-buff; thin bedded; slope constituent, poor exposure; moderate (coral, brachiopod, pelmatazoan, sponge spicules)	0.5
1-30g	Limestone, packstone; grayish black/ black-buff; partially silicified; thin-medium bedded, bioturbated; black chert stringers; forms a broken ledge, good-fair exposure; abundant (brachiopod, coral, bryozoan, pelmatazoan, debris) N2°E 3°NW	7.2
1-30f	Limestone, packstone and Shale; olive black-olive gray-light olive brown/ medium gray-brown-buff; partially silicified; thin bedded-limestone, fissile-laminated bedded-shale; forms a steep slope, fair exposure; moderate (brachiopod, bryozoan, pelmatazoan, debris)	3.2
1-30e	Covered; probably 1-f	1.3
1-30d	Limestone, packstone; brownish black-olive black/dark gray-buff; partially silicified; medium bedded, mottled; bitumenous, black-bluish gray chert nodules and layers; forms a ledge, fair exposure; moderate (coral, brachiopod, pelmatazoan, foraminifera, bryozoan, algae)	4.7
1-30c	Covered, talus; probably shale	22.2

Unit	Lithology	Thickness (ft.)
1-30b	Sandstone, protoquartzite, calcareous; olive gray/medium gray-medium dark gray-buff; medium-coarse grained, subangular, poor sorting, floating to point contacts; partially silicified, mica, glauconite; thin bedded, crossbedded; forms a resistant ledge, good exposure; abundant-moderate (pelmatazoan, brachiopod, plant) N37°E 7°SE	1.0
1-30a	Limestone, packstone; black-olive black-grayish black/dark gray-light gray-buff; partially silicified; thin-medium bedded, mottled, shale partings; blue or grayish black chert nodules; forms a ledge, fair-good exposure; moderate (pelmatazoan, foraminifera, bryozoan, brachiopod, algae, debris) N10°W 6°SW	12.3
1-29	Sandstone, orthoquartzite; pale yellowish brown-yellowish gray/buff; medium-coarse grained, subrounded, fair sorting, concavo-convex to stylolitic contacts; chert grains; very thick bedded, tabular crossbedding; local discontinuous ledge, fair-good exposure; trace (plant) N35°W 3°SW	10.5
1-28	Conglomerate, arenaceous; dark-moderate yellowish brown-olive black/buff; medium-cobble grained, subangular, poor sorting, point to stylolitic contacts; limestone cobbles, bioclastic, chert, and quartz grains, glauconite, feldspar; thin bedded; channels lower strata; local ledge constituent, fair-good exposure; tract (pelmatazoan, plant)	1.6
	Partial thickness of Upper Morrowan interval	103.0

Unit	Lithology	Thickness (ft.)
Lower Morrowan Interval		
1-27	Limestone, wackestone; dark gray/ tingy green-buff; thin bedded; is channelled; locally a ledge constituent, poor exposure, trace (debris)	0.2
1-26	Limestone, packstone; olive gray/dark gray-buff; partially recrystallized and silicified; medium bedded; medium black chert seam; forms a cliff, good exposure; moderate (pelmatazoan, brachiopod, foraminifera, debris) N65°E 4°SE	4.6-7
1-25	Siltstone, argillaceous and limy, and Shale; grayish black-olive black/ medium dark gray-buff; fine-medium grained, subrounded, fair sorting; mica; fissile thin bedded, bioturbated; forms a slope, poor-fair exposure; trace (pelmatazoan, brachiopod)	12.2
1-24	Covered; probably 1-25	2.0
1-23	Limestone, packstone, arenaceous, silty, Shale and Siltstone; dark gray-dark yellowish orange/medium gray-buff; glauconite, pyrite, mica, ferrugenic coatings; thin bedded-limestone and siltstone, fissile bedded-shale; herringbone crossbedding; forms a slope, fair exposure; moderate (brachiopod, bryozoan, pelmatazoan) N17°W 4°NE	11.0

Unit	Lithology	Thickness (ft.)
1-22	Conglomerate, arenaceous, slightly limy; olive gray-moderate yellowish brown/medium dark gray-buff; medium-pebble grained, subangular, poor sorting, concavo-convex to stylolitic contacts; ferrugenic coatings, limestone pebbles, bioclastic and quartz grains; medium bedded, graded; coated grains; forms a steep slope, poor exposure; tract-moderate (pelmatazoan, brachiopod, pelecypod) N23°W 6°SW offset to the north 15-30 ft.	2.6
1-21	Sandstone, orthoquartzite, slightyly limy; light olive gray, yellowish gray, pale yellowish brown/buff; medium-very coarse grained, subangular, poor sorting, stylolitic contacts; chert, limestone grains; thin bedded, graded, minor trough crossbedding; basal conglomeratic zone 10 in. thick; forms a steep slope, poor exposure; tract (pelmatazoan, plant, brachiopod) N51°W 25°W	4.83
1-20	Sandstone, protoquartzite (?), slightly limy; yellowish gray-pale yellowish brown/buff; medium-very coarse grained, subangular, poor sorting; limestone grains, friable; laminated bedding; slope constituent, poor exposure; unfossiliferous	0.14
1-19	Limestone, wackestone; dark gray-olive gray/buff; thin bedded, nodular, wavy slope constituent, poor exposure; trace (pelmatazoan)	0.33

Unit	Lithology	Thickness (ft.)
1-18	Conglomerate, arenaceous, slightly limy; light olive gray-yellowish gray-pale yellowish brown/buff; medium-cobble grained, angular-subrounded, poor sorting; limestone, mudstone cobbles, quartz grains, friable; thin bedded; slope constituent, poor exposure; unfossiliferous	1.0
1-17	Covered, talus, colluvium; possible igneous sill 3 ft. thick at 21 ft. above base; proceeded out of minor tributary trending N75°E	30.1
1-16a	Siltstone; pale olive-light olive gray/reddish brown-buff; medium-coarse grained, subrounded, fair sorting; partially silicified; laminated-thin bedded, bioturbated; is found in channels or pre-Pennsylvanian valleys, fair exposure; trace (pelmatazoan, plant)	10.0
	Partial thickness of Lower Morrowan interval	75.0
Rancheria Formation (Mississippian)		
1-16	Limestone, wackestone; light gray-medium gray/buff; thin bedded; gray-tan chert nodules, vuggy; forms a minor ledge, good exposure; moderate (pelmatazoan, brachiopod) N13°W 4°SW	1.5

Unit	Lithology	Thickness (ft.)
1-15	Limestone, packstone-grainstone; miedum gray-olive gray/medium gray-buff; thin bedded; basal protion is friable, gray-blue, red, brown, and black chert stringers and nodules, 1-4 in. zone on upper surface is vuggy, weathers a rust-orange color, has iron concretions, and silicified corals; forms a ledge, good exposure; abundant (pelmatazoan, bryozoan, coral, brachiopod) N18°W 6°SW measured up minor tributary through Mississippian	7.7

Stratigraphic Section 4

Muleshoe Canyon

General Location

The section was measured, trending north in the west-central part of Section 27 and the NE/4 part of Section 28, T.17.S, R.10.E., Otero County, New Mexico.

Description of Locality

The section is located 6.3 miles southeast along gravel and dirt roads, from a point on U.S. 54, 5.0 miles south of its intersection with U.S. 70. Local landmarks and directions are: turn east off the U.S. 54, turn south at intersection and proceed 0.55 miles; turn east at water tank and proceed east 0.5 miles; veer northeast and proceed along dirt road for 0.15 miles past water wells, to minor arroya. If possible follow east trending rough road 1.0 mile and veer northeast for another 0.5 miles to roads end.

The section begins in Muleshoe Canyon, in the major northeast trending tributary. The section is offset to the west in minor tributaries where advantageous. The measurement trends in a northern direction.

General Remarks

The section was measured July 16-21, 23-28, 1974. This section is well exposed in the lower and especially upper portion. It is poorly exposed in the middle portion.

The general strike of the strata is N30^{o}E and

N50°W with dips averaging 8° and 10° to the northwest and southwest respectfully.

	Approximate Thickness (in feet)
Lower Desmoinesian Interval	123
Atokan Interval	95
Upper Morrowan Interval	132
Lower Morrowan Interval	67
Total	417

Unit	Lithology	Thickness (ft.)
Bug Scuffle Limestone Member		
4-71	Limestone, grainstone; olive gray/light olive gray-buff; thin-thick bedded; forms a ledge-cliff, good exposure; moderate (fusulinid, foraminifera, coral, pelmatazoan, debris)	5.0
4-70	Limestone, wackestone-packstone; olive black/medium dark gray-buff; partially recrystallized; thin-thick bedded, wavy, shale partings; forms a slope with minor ledges, fair exposure; moderate (pelmatazoan, fusulinid, phylloid algae, debris)	33.0
4-69	Covered	7.0
4-68	Limestone, wackestone, slightly silty; brownish black/medium dark gray-buff; thin bedded, shale partings; forms a ledge, good-fair exposure; moderate-abundant (pelmatazoan, brachiopod, fusulinid, gastropod, sponge spicules) [brachiopod: Antiquatonia hermosana (Girty), Koslowskia haydenensis (Girty), Composita sp.; corals: Pseudozaphrentoides sp.]	17.0

Unit	Lithology	Thickness (ft.)
4-67	Covered; probably 4-66	55.0
4-66	Limestone, wackestone-packstone, slightly silty; brownish black/medium gray-buff; pyrite; thin bedded, bioturbated, shale partings; forms a steep slope, poor exposure; trace (pelmatazoan, fusulinid, sponge spicules)	20.0
4-65	Limestone, packstone-wackestone; olive black-dark gray/buff; minor pyrite and mica; thick bedded, faintly mottled; chert nodules and stringers; forms a ledge, good exposure; moderate (pelmatazoan, brachiopod, coral, sponge spicules, debris)	5.0
4-64	Covered	9.0
4-63	Limestone, grainstone; light olive gray/medium light gray-buff; partially recrystallized; thick bedded; coated grains; forms a ledge, good exposure; abundant-moderate (coral, brachiopod, pelmatazoan, fusulinid, bryozoan)	4.0
4-62	Limestone, mudstone; dark gray/buff; thin bedded, shale partings; forms a slope, poor exposure; trace (brachiopod)	4.2
4-61	Covered; probably 4-62	17.0
4-60	Limestone, wackestone-packstone, slightly silty; olive black-gray-brownish black/medium gray-buff; partially silicified; thin bedded, shale partings, mottled, bioturbated; black chert nodules and stringers; forms a steep slope, fair exposure; trace-moderate (brachiopod, pelmatazoan, fusulinid, sponge spicules, coral, bryozoan)	10.0

Unit	Lithology	Thickness (ft.)
4-59	Shale and interbedded Limestone, mudstone; dark gray/buff; fissile-laminated bedded-shale, thin bedded-limestone, nodular, wavy; round limestone nodules; forms a slope, fair exposure; unfossiliferous	5.0
4-58	Limestone, packstone-grainstone; olive gray/olive gray-medium gray-buff; partially silicified; very thick bedded, mottled; coated grains ; forms a ledge, good exposure; moderate (pelmatazoan, brachiopod, fusulinid, foraminifera, sponge spicules, bryozoan, algae)	6.5
4-57	Limestone, mudstone, and Shale; dark gray-olive black/buff; thin bedded-limestone, fissile-laminated bedded-shale, nodular, wavy; forms a slope, fair exposure; moderate (coral)	4.0
4-56	Limestone, packstone; olive black/medium gray-buff; thin bedded; forms a ledge, good exposure; trace (pelmatazoan, fusulinid, brachiopod, debris)	2.0
4-55	Limestone, wackestone-packstone; olive black/medium gray-buff; partially recrystallized; thin bedded; bluish chert nodules; forms a cliff, good exposure; moderate (pelmatazoan, coral, bryozoan, fusulinid, foraminifera, gastropod)	34.0
4-54	Limestone, wackestone-packstone; brownish black-olive black/dark gray-buff; thin bedded; chert nodules and stringers; forms a ledge, good exposure; trace-moderate (pelmatazoan, foraminifera, fusulinid, algae)	2.8

Unit	Lithology	Thickness (ft.)
4-53	Limestone, packstone; olive black/medium dark gray-buff; partially recrystallized; thin bedded; ledge constituent, good exposure; moderate-abundant (fusulinid, pelmatazoan, bryozoan)	1.2
Lower Desmoinesian Interval		
4-52	Limestone, mudstone-wackestone and interbedded Shale; dark gray-olive black/medium dark gray-buff; mica; thin bedded-limestone, fissile-laminated bedded-shale; forms a cliff, fair exposure; trace (debris)	32.0
4-51	Shale; dark gray-grayish black/buff; fissile-laminated bedded; thin limestone stringers; forms a slope, good exposure; unfossiliferous	1.6
4-50	Limestone, wackestone-packstone; olive gray/medium gray-buff; thin to medium bedded; forms a cliff, good exposure; abundant (pelmatazoan, fusulinid, phylloid algae, brachiopod, bryozoan)	9.2
4-49	Limestone, wackestone and interbedded Shale; grayish black/dark gray-buff; mica; thin bedded-limestone, fissile-laminated bedded-shale; forms a ledge, fair exposure; trace (pelmatazoan, brachiopod, coral, debris) [brachiopod: Linoproductus planiventralis (Hoare)] N21°E 2°SE	33.0
4-48	Limestone, packstone, slightly silty; dark gray, olive black/medium gray-buff; thin bedded; forms base of cliff, good exposure; abundant (pelmatazoan, foraminifera, coral)	2.8
4-47	Shale, slightly silty; dark gray/buff; laminated bedding; forms a slope, poor exposure; unfossiliferous	1.5

Unit	Lithology	Thickness (ft.)
4-46	Covered, talus; probably 4-45 or shale	7.0
4-45	Limestone, mudstone-wackestone; olive black-grayish black/medium dark gray-buff; mica; thin-medium bedded, shale partings; forms a steep slope, fair-good exposure; trace (debris, brachiopod) [brachiopod: Linoproductus planiventralis (Hoare)]. N40°E 8°NW	17.5
4-44	Limestone, grainstone-packstone; medium dark gray/medium light gray-buff; thin-massive bedded, shale partings; forms a cliff, good exposure; abundant (fusulinid, bryozoan, coral, gastropod, nautioloid, pelmatazoan, brachiopod) [brachiopod: Hustedia sp., Rhynchopora sp., Composita sp., Kowlowskia cf. haydenensis (Girty), Pustula (?) sp.] N80°W 4°NE	18.1
	Partial thickness of Lower Desmoinesian Interval	123.0
Atokan Interval		
4-43	Limestone, wackestone, slightly silty; olive black, grayish black/medium dark gray-buff; thin bedded, shale partings, mottled; forms a steep slope, fair exposure; trace-moderate (coral, brachiopod, pelmatazoan)	23.0
4-42	Limestone, slightly silty; olive black-dark gray-brownish black/medium gray-buff; quartz grains, glauconite, mica; thin bedded; coated grains; forms bottom of ledge, good exposure; moderate (pelmatazoan, brachiopod, algae)	1.0

Unit	Lithology	Thickness (ft.)
4-41	Shale, slightly limy; gray-black/buff; mica; fissile-laminated bedded; thin limestone stringers; forms a slope, good exposure; unfossiliferous	9.2
4-40	Limestone, mudstone, slightly silty and interbedded Siltstone, argillaceous and limy; dark gray-olive black/medium dark gray-buff; mica; thin-thick bedded, shale partings, bioturbated; forms a steep slope, fair exposure; trace (debris) N2°W 2°SW	15.3
4-39	Sandstone, calcareous protoquartzite; moderate yellowish brown-medium gray/buff; medium-very coarse grained, angular, poor sorting, stylolitic contacts; mica, feldspar, quartz, bioclastic grains, limy matrix; thin bedded; gradational basal contact; ledge constituent, good exposure, trace (pelmatazoan)	0.7
4-38	Conglomerate, arenaceous and limy; light olive gray-yellowish brown/buff; granule-fine grained, angular-subrounded, poor sorting, concavo-convex contacts; limestone, quartz, feldspar grains, limy matrix; thin bedded; ledge constituent, fair exposure; trace (pelmatazoan)	1.4
4-37	Conglomerate, arenaceous; dark yellowish orange/dark yellowish brown-buff; fine-granule grained, angular, poor sorting, point to concavo-convex contacts; feldspar, bioclastic, quartz grains, limonitic-limy matrix; thin bedded; forms bottom of ledge, fair exposure; trace-moderate (pelmatazoan, brachiopod)	1.1
4-36	Covered; probably some shale	43.0

Unit	Lithology	Thickness (ft.)
4-35	Conglomerate, limy, arenaceous; moderate yellowish brown, dusky orange-black/buff; fine-granule grained, subrounded, poor sorting, concavo-convex to stylolitic contacts; limonitic-limy matrix, quartz, limestone, chert grains; thin bedded; at bottom of slope, poor exposure; trace (coral, pelmatazoan)	0.5
	Partial thickenss of Atokan Interval	95.0
Upper Morrowan Interval		
4-34	Igneous sill, camptonite; light olive gray-moderate greenish yellow/brown-green-buff; at bottom of slope, poor exposure	0.68
4-33	Covered; probably shale	17.0
4-32	Limestone, packstone; olive black-dark gray/medium dark gray-buff; partially silicified; very thick bedded, shale partings; top weathers rusty orange, has silicified shale partings; forms a ledge, good exposure; moderate (pelmatazoan, brachiopod, bryozoan, sponge spicules) [brachiopod: Rhipidomella cf. trapezoidea (Sutherland & Harlow), Neochonites sp., Antiquatonia cf. coloradoensis (Girty), Hustedia sp., Derbyia sp., Anthracospirifer sp., Zia cf. novamexicana (Sutherland & Harlow)] N2°E 2°NW offset to first main tributary east of large Mississippian bioherm	12.4
4-31	Shale, silicified; olive black/olive green-rust-buff; fissile-thin bedded; forms a slope, poor exposure; trace (debris) N25°E 6°NW	5.0

Unit	Lithology	Thickness (ft.)
4-30	Limestone, wackestone-packstone; medium dark gray-olive black/medium gray-buff; partially recrystallized or silicified; thin-very thick bedded, faintly mottled; chert nodules; forms a cliff, good exposure; moderate (foraminifera, pelmatazoan, brachiopod)	18.0
4-29	Covered; probably black shale	33.0
4-28	Sandstone, slightly limy, orthoquartzite; light olive gray-grayish orange/dusky red, copper, buff; fine-medium grained, subangular, fair sorting, concavo-convex contacts ; mica; medium bedded, minor crossbedding; to the west grades into silty shale; ledge former, fair exposure; trace (plant) N60°W 9°SW	3.9
4-27	Limestone, packstone; olive black/ medium light gray; limonite replacement or stain on bioclastic grains; thin bedded; forms a broken ledge, good exposure; trace-moderate (pelmatazoan, foraminifera, debris)	2.0
4-26	Covered; probably shale	1.0
4-25	Limestone, packstone; olive black/medium dark gray-buff; limonite replacement or stain on bioclastic grains; thin bedded, mottled, nodular; forms a minor ledge, fair-poor exposure; trace-moderate (foraminifera, pelmatazoan, brachiopod, bryozoan)	1.0
4-24	Covered; probably 4-23	0.5

Unit	Lithology	Thickness (ft.)
4-23	Shale, silicified, and Siltstone; medium gray-medium bluish gray-brownish gray/maroon-buff; mica, pyrite; fissile-thin bedded, bottled; forms a slope, fair exposure; trace (plant) N22°E 8°NW	6.0
4-22	Limestone, packstone-grainstone; olive black/dark gray-buff; partially re-crystallized; thin-medium bedded, shale partings, forms a steep slope, fair-good exposure; moderate (coral, pelmatazoan, foraminifera, bryozoan, brachiopod, algae) N85°E 5°NW	10.1
4-21	Igneous sill, camptonite; light olive gray-moderate greenish yellow/brown-buff; forms a discontinuous ledge, fair-good exposure N10°W 7°SW	5.1
4-20	Limestone, packstone; grayish black/ medium dark gray-buff; pyrite; thin bedded, mottled, shale partings; forms a minor ledge, poor exposure; moderate (brachiopod, pelmatazoan, foraminifera, algae, debris) [brachiopod: Phricodothyris sp., Composita sp.] N30°E 9°NW	3.0
4-19	Sandstone, orthoquartzite; light olive gray/buff; fine-very coarse grained, sub-angular, poor sorting, concavo-convex to stylolitic contacts; mica; thick bedded, minor crossbedding, inverse grading; forms two ledges, good exposure; unfossili-ferous N32°W 11°SW	12.0

Unit	Lithology	Thickness (ft.)
4-18	Limestone, packstone; olive gray/ medium gray-buff; thick bedded, nodular in parts; gray-blue medium chert band and nodules; forms a weak continuous ledge, good exposure; trace-moderate (pelmatazoan, foraminifera, brachiopod, bryozoan)	5.0
	Partial thickness of Upper Morrowan Interval	132.0
Lower Morrowan Interval		
4-17	Sandstone, subarkose; grayish olive/ buff; medium-coarse grained, angular, fair sorting, [floating to stylolitic contacts]; feldspar grains, opaline martix; thin bedded; channels lower strata; forms a ledge, fair-good exposure; trace (plant) N18°W 11°SW	2.1 - 3.5
4-16	Limestone, packstone; black-olive black/medium dark gray-buff; thin-medium bedded, mottled; gray olive-gray blue chert layers and nodules, is channelled; forms a discontinous slope, poor exposure; moderate (pelmatazoan, brachiopod, debris) N26°W 10°SW	4.0 - 5.4
4-15	Covered	4.0
4-14	Limestone, grainstone; olive gray-medium gray/dusky yellow-pale olive-grayish olive; [microspar calcite cement]; thin bedded, nodular, shale partings; coated grains, colites, chert nodules; forms a discontinuous ledge, good exposure; moderate-abundant (foraminifera, ostracode, pelmatazoan, algae coatings) N15°E 13°NW	5.1
4-13	Covered	6.9

Unit	Lithology	Thickness (ft.)
4-12	Sandstone, orthoquartzite; greenish gray/maroon-dark green, buff; very fine-coarse grained, subangular, poor sorting, floating contacts; partially recrystallized, opaline martix; medium-thick bedded; forms a ledge, poor exposure; unfossiliferous N29°E 6°NW	6.5
4-11	Covered; probably shale	11.0
4-10	Shale; grayish black/grayish black, maroon, rust buff; partially silicified, mica; fissile-thin bedded; forms a slope, fair exposure; trace (debris) offset west to next north trending tributary	10.5
4-9	Limestone, packstone; olive black-medium dark gray/light gray-buff; partially recrystallized; thin bedded; forms a ledge, good exposure; moderate (brachiopod, coral, foraminifera, bryozoan, pelmatazoan, pelecypod) N3°E 4°NW	2.9
4-8	Siltstone and interbedded Shale; light olive gray-grayish black/olive gray-buff; partially silicified, mica, pyrite; fissile-thin bedded, bioturbated; forms a steep slope, fair exposure; trace (debris)	9.0
	Partial thickness of Lower Morrowan Interval	67.0
Rancheria Formation (Mississippian)		
4-7	Limestone, packstone; olive black/medium gray-buff; thin bedded, "rhythmitic"; coated grains; caps cliff, good exposure; abundant (brachiopod, pelmatazoan, pelecypod	1.1

Unit	Lithology	Thickness (ft.)
4-6	Shale; medium dark gray/buff; laminated bedding; ledge constituent, poor exposure; trace (brachiopod)	0.2
4-5	Limestone, packstone-grainstone; medium dark gray/light gray-buff; thin-thick bedded, vuggy, shale partings; dark gray-pale blue chert nodules; forms a cliff, good exposure; abundant-moderate (pelmatazoan, brachiopod, coral, bryozoan, pelecypod, algae)	8.5

Stratigraphic Section 2

Deadman Canyon

General Location

The section was measured trending approximately northeast in the central part of Section 14, T.18.S., R.10.E., Otero County, New Mexico.

Description of Locality

The section is located 4.35 miles east along dirt roads, from a point on U.S. 54, 8.93 miles south of its intersection with U.S. 70. Local land marks and directions are: turn east off U.S. 54 at Dog Canyon exit, proceed east past houses for 3.25 miles; turn south at intersection and veer southeast 1.10 miles; walk, roughly due east 1.9 miles.

The section begins in a northeast trending main tributary and a little over half of the lower part of the section is measured in this tributary. The remaining part of the section is offset along the southeast slope of the main tributary.

General Remarks

The section was measured June 23-30 and August 1-4, 1974. This locality has the best exposed lower Pennsylvanian section that was measured.

The strike of the strata is generally N22°W with dips averaging 4° to the northeast.

	Approximate Thickness (in feet)
Lower Desmoinesian Interval	138
Atokan Interval	84
Upper Morrowan Interval	147
Lower Morrowan Interval	90
Total	459

Unit	Lithology	Thickness (ft.)
Bug Scuffle Limestone Member		
2-32	Limestone, packstone; light gray-dark gray/tan-buff; partially silicified; thin-thick bedded, mottled, shale partings; moderate (algae, pelmatazoan, sponge spicules, brachiopod, fusulinid, ostracode) N38°W 5°SW	5.0
Lower Desmoinesian Interval		
2-31	Limestone, packstone; dark gray-olive gray/ buff; thin bedded; [coated grains]; forms a slope, poor-fair exposure; moderate (coral, ostracodes, pelecypod, sponge spicules, brachiopod, bryozoan, pelmatazoan) [conodont: 12 ft. from base. Idiognathodus sp.; brachiopod: Echinaria cf. E. knighti (Dunbar & Condra), Calliprotonia n. sp. A (Sutherland & Harlow); coral: Pseudozaphrentoides sp.]	17.0
2-30	Covered; probably 2-29 offset south 25 ft.	2.0

Unit	Lithology	Thickness (ft.)
2-29	Limestone, packstone-grainstone; light gray-olive gray/buff; thin-medium bedded; minor shale interbeds, [coated grains]; forms two ledges, good exposure; abundant (foraminifera, algae, sponge spicules, pelmatazoan, brachiopod, bryozoan) [conodont: top 1 ft. Idiognathodus delicatus (Gunnell), basal 1 ft. Idiognathodus delicatus (Gunnell)]	13.0
2-28	Covered; probably 2-27	6.1
2-27	Limestone, packstone-wackestone, and Shale interbeds; grayish black-olive black/medium dark gray-buff; thin bedded-limestone, laminated bedded-shale, nodular; [coated grains]; slope former, poor exposure; abundant (phylloid algae, fusulinid, ostracode, bryozoan, brachiopod, sponge spicules, pelmatazoan) [conodont: Idiognathodus delicatus (Gunnell)]	7.1
2-26	Limestone, packstone; grayish black-brownish black/medium dark gray-buff; "laminated" bedding; [coated grains]; minor ledge former, good-fair exposure; abundant (fusulinid, pelecypod, bryozoan, ostracode, pelmatazoan, coral, algae, sponge spicules, brachiopod)	0.75
2-25	Limestone, wackestone-packstone; dark gray-olive gray/buff; "laminated" bedding, banded; bituminous; slope constituent, fair-good exposure; abundant-moderate (fusulinid, pelmatazoan, sponge spicules)	0.26
2-24	Limestone, packstone-grainstone; olive gray/dark gray-medium dark gray; thin bedded, mottled; forms a ledge, good exposure; moderate (foraminifera, brachiopod, ostracode, algae) N58°W 1°NE	2.6

Unit	Lithology	Thickness (ft.)
2-23	Sandstone, protoquartzite (?); light greenish yellow/light bluish green-buff; fine-medium grained, subangular, poor sorting; feldspar grains (?); thin bedded; forms a discontinuous minor ledge, fair exposure; unfossiliferous	2.0
2-22	Limestone, packstone-grainstone; light gray-light olive gray/buff; partially silicified; thin bedded; [oolites]; [coated grains], bituminous; forms a discontinuous minor ledge, fair exposure; abundant-moderate (brachiopod, sponge spicules, pelmatazoan, bryozoan, pelecypod, coral)	1.4
2-21	Covered; probably black shale	19.8
2-20	Shale, slightly silty and limy, and interbeded Limestone, wackestone; dark gray-olive gray-reddish brown-buff; mica; laminated bedded-shale, thin-medium bedded limestone; bituminous; forms a slope, fair exposure; trace (foraminifera, brachiopod, sponge spicules) N22°W 12°NE	45.0
2-19	Limestone, packstone-wackestone; dark gray-olive gray/buff; medium bedded; black chert nodules and stringers; forms a minor ledge, good exposure; moderate (sponge spicules, brachiopod, pelmatazoan, algae, foraminifera, ostracode) [conodont: 1-2 ft. above base. Gnathodus coloradoensis n. subsp., Gnathodus n. sp., Idiognathodus delicatus (Gunnell), Neognathodus colombiensis (Stibane), Spathognathodus minutus (Ellison), Ligonodina sp., Hindeodella sp.] N44°W 3°NE	2.6
2-18	Shale, limy; dark gray/gray-buff; fissile-laminated bedded; forms a slope, fair exposure; abundant (brachiopod) offset to the south to east-west tributary	4.6

Unit	Lithology	Thickness (ft.)
2-17	Limestone, packstone; dark gray-olive gray/buff; thin-medium bedded, shale partings; forms a resistant ledge, good exposure; trace-moderate (brachiopod, sponge spicules, foraminifera) N2°W 1°NE	3.0
2-16	Shale; dark gray-black/buff; mica; fissile-laminated bedded; bituminous; slope former, fair exposure; trace (sponge spicules) offset south 20 ft.	9.0
	Partial thickness of Lower Desmoinesian Interval	138.0
Atokan Interval		
2-15	Limestone, packstone to wackestone-mudstone; dark gray-olive gray/buff; thin-thick bedded; shale partings, top 1-1.5 ft. arenaceous; forms a resistant cliff, good exposure; moderate (gastropod, pelmatazoan, sponge spicules, brachiopod, bryozoan, algae) [conodont: 1-1.5 ft. below top. Neognathodus cf. N. colombiensis (Stibane), Neognathodus colombiensis (Stibane), Spathognathodus minutus (Ellison), Idiognathodus delicatus (Gunnell), 2-3 ft. above base. Idiognathodus delicatus (Gunnell), Idiognathodus magnidicus (Stauffer & Plummer), Neognathodus colombiensis (Stibane), Spathognathodus orphanus (Merrill), Ozarkodina delicatula (Stauffer & Plummer), Synprioniodina microdentata (Ellison), Hindeodella sp., Ozarkodina sp.] N15°W 4°NE	17.0
2-14	Shale; dark gray/buff; fissile-laminated bedded; forms a slope, good exposure; abundant (brachiopod, coral) [brachiopod: Sandia brevis (Sutherland & Harlow), Buxtonia sp., Desmoinesia sp., Antiquatonia sp.] offset approximately 50 ft. south	11.0

Unit	Lithology	Thickness (ft.)
2-13	Limestone, mudstone, argillaceous; black-dark gray/buff; pyrite; thin bedded, wavy; shale partings 0.2 ft. thick, has a 1-3 in. grainstone layer near top; [coated grains-from grainstone]; forms a steep slope, good exposure; trace (brachiopod) from grainstone (foraminifera, brachiopod, pelmatazoan, bryozoan) [conodont: top 1 ft. Idiognathodus parvus (Dunn), Idiognathodus delicatus (Gunnell), Idiognathoides fossatus (Branson & Mehl)(right), Neognathodus colombiensis (Stibane); brachiopod: Buxtonia sp.]	19.0
2-12	Igneous sill, camptonite; light olive gray-moderate greenish yellow/brown-buff; forms a ledge, fair-good exposure; offset in direction of dike (ENE) N1°W 1°SW	3.0
2-11	Covered; probably shale	5.1
2-10	Shale, limy; dark gray/buff; fissile-laminated bedded; forms a slope, poor exposure; unfossiliferous	3.5
2-9	Covered; probably shale	6.5
2-8	Shale; medium gray/dark gray-buff; fissile-laminated bedded; forms a slope, poor exposure; unfossiliferous	4.0
2-7	Covered; probably shale	2.0
2-6	Shale; dark gray/buff; fissile-laminated bedded; thin limestone, wackestone stringers; slope former, poor exposure; abundant (brachiopod) [conodont: 4-5 ft. above base. Idiognathodus parvus (Dunn); brachiopod: Neochonetes (?) sp., Derbyis sp., Anthracospirifer curvilateralis (Easton), Punctospirifer sp., Composita sp., Neospirifer (?) sp., Rhipidomella sp.]	9.0

Unit	Lithology	Thickness (ft.)
2-5	Covered; probably shale	1.0
2-4	Shale; dark gray/buff; fissile bedded; thin limestone stringers; forms a slope, poor exposure; trace (brachiopod) offset into main tributary	2.8
2-3	Limestone, packstone; dark gray-olive gray/buff; partially recrystallized ; thin-thick bedded, bioturbated, nodular; forms a discontinous ledge, poor exposure; moderate (brachiopod, pelmatazoan, sponge spicules, bryozoan) [conodont: basal 1 ft. Idiognathodus parvus (Dunn), Spathognathodus minutus (Ellison)]	4.6
	Partial thickness of Atokan Interval	84.0
Upper Morrowan Interval		
2-2	Limestone, packstone; dark gray-olive gray/dark gray-buff; thin bedded, bioturbated; forms a ledge, good exposure; moderate (brachiopod, bryozoan, pelmatazoan, foraminifera, sponge spicules, ostracode)	1.5
2-1	Shale and Limestone, wackestone-packstone; dark gray-olive gray/dark gray-buff; thin bedded-limestone, fissile-laminated bedded-shale, nodular; coated grains limestone in 6 in. thick bed 2.5 ft. up; forms a steep slope, good exposure; abundant-moderate (bryozoan, brachiopod, sponge spicules, pelmatazoan, ostracode, algae) [brachiopod: Spirifer goreii (Mather), Neospirifer sp., Anthracospirifer curvilateralis (Easton), Antiquatonia coloradoensis (?)(Girty), Hustedia gibbosa (?)(Lane), Desmoinesia sp., Spiriferellina (?) sp.; coral: Amplexocorinia corrugata (Mather)]	5.42

Unit	Lithology	Thickness (ft.)
2-44	Limestone, packstone; dark gray-olive gray/ dark gray-buff; thin bedded; [coated grains], bituminous; caps ledge, good exposure; abundant (pelmatazoan, brachiopod, bryozoan, sponge spicules, foraminifera) [conodont: Idiognathoides fossatus (Branson & Mehl)(right)]	0.6
2-43	Limestone, wackestone to packstone to mudstone; olive gray-olive black/medium light gray-light olive gray-buff; thick bedded; forms a resistant ledge, good exposure; abundant (foraminifera, sponge spicules, pelmatazoan, brachiopod, ostracode, nautiloid). offset to northern face of slope	30.0
2-42	Shale and partially covered; black/buff; fissile-laminated bedded; forms a slope, poor exposure; unfossiliferous	10.0
2-41	Limestone, packstone; olive black-grayish black/medium dark gray-buff; [partially silicified and recrystallized]; thick bedded, mottled; black chert nodules and layers, [oolites]; forms a ledge, good exposure; trace-moderate (foraminifera, brachiopod, pelmatazoan, sponge spicules, bryozoan) [conodont: Approx. 1 ft. below top. Streptognathodus angustus (Dunn), Adetognathus gigantus (Gunnell)(right)]	5.3
2-40	Shale; black/green-maroon, buff; laminated-thin bedded; forms a slope, poor exposure; unfossiliferous	5.6
2-39	Covered	5.0

Unit	Lithology	Thickness (ft.)
2-38	Siltstone; light olive gray-dusky yellow-medium bluish gray/pale olive-dusky reddish buff; fine-coarse grained, subangular, fair-poor sorting, [floating-point contacts]; mica; thin bedded; forms a minor ledge, fair exposure; trace (plant, brachiopod)	4.0
2-37	Shale; black/buff; fissile-laminated bedded; forms a slope, fair exposure; unfossiliferous	2.0
2-36	Limestone, packstone; olive gray, medium dark gray-dark gray-light medium bluish gray/reddish gray-buff; partially silicified; thin-very thick bedded, bioturbated; slightly bituminous, black chert stringers and nodules, brachiopod in growth position; forms a bench and ledge, good exposure; trace-moderate (brachiopod, bryozoan, sponge spicules, foraminifera)	15.0
2-35	Covered; probably black shale	2.8
2-34	Limestone, packstone; light olive gray-dusky yellow-olive gray/buff; partially silicified, pyrite; thin bedded; forms a ledge, fair exposure; moderate (foraminifera, pelmatazoan, brachiopod, algae, bryozoan, gastropod, ostracode)	1.4
2-33	Siltstone, slightly arenaceous and argillaceous; light olive gray-dusky yellow/light olive gray-buff; coarse grained, subangular, fair-poor sorting, [floating-stylolitic contacts]; pyrite; fissile-laminated bedded, bioturbated; slightly bituminous, shale partings 0.1 ft. thick; forms a steep slope, fair exposure; trace (brachiopod)	5.0
2-32	Covered	1.5

Unit	Lithology	Thickness (ft.)
2-31	Sandstone, orthoquartzite; light olive gray-dusky yellow/buff; fine-very coarse grained, subangular, poor sorting, [concavo-convex-stylolitic contacts]; [some calcite cement]; thick bedded; forms a ledge, fair-good exposure; trace (plant)	5.3
2-30	Limestone, packstone; dark gray/medium dark gray-dark gray; pyrite; thin bedded, mottled; shale partings 1/2 in. thick, black chert nodules; forms a ledge, good exposure; moderate (foraminifera, pelmatazoan)	11.0
2-29	Sandstone, orthoquartzite; light olive gray/dusky yellow, light grayish red, rust-buff; very fine-coarse grained, subangular, poor sorting, concavo-convex contacts; thin bedded; bituminous inclusions; forms a ledge, fair exposure; unfossiliferous	2.0
2-28	Covered	30.0
	Partial thickness of Upper Morrowan Interval	147.0
Lower Morrowan Interval		
2-27	Limestone, packstone; olive gray-dark gray/ medium gray-buff; partially silicified; thin bedded; [coated grains]; forms a ledge, good exposure; moderate-trace (coral, bryozoan, brachiopod, pelecypod, gastropod, foraminifera, pelmatazoan) [conodont: Neognathodus bassleri symmetricus (Lane), Hindeodella sp.]	1.8
2-26	Shale; black/buff; fissile-laminated bedded; forms a slope, fair exposure; unfossiliferous	1.0

Unit	Lithology	Thickness (ft.)
2-25A	Conglomerate, arenaceous; olive black-black/dark gray-buff; coarse silt size/fine-granule sand size grains, subangular, poor sorting, [concavo-convex to stylolitic contacts]; limestone and quartz granules; thin bedded; bituminous, irregular basal contact; caps ledge, good exposure; trace (pelmatazoan, brachiopod)	0.1
2-25	Limestone, silcified; light olive gray-olive gray, light bluish-light medium bluish gray/light olive gray-medium bluish gray-buff; thick bedded; upper contact sharp and irregular; forms a ledge, good exposure; trace-moderate (sponge spicules, pelmatazoan, pelecypod)	3.1
2-24	Shale; black/buff; fissile-laminated bedded; unfossiliferous	6.0
2-23	Covered; lower 5 feet probably limestone	18.0
2-22	Conglomerate, arenaceous, slightly limy; light olive gray-olive gray/light olive gray-buff; fine-pebble grained, angular, poor sorting, [floating-stylolitic contacts]; limestone pebbles, chert and quartz grains, mica, blauconite; thin bedded; ledge constituent, fair exposure; trace (brachiopod, pelmatazoan)	1.0
2-21	Sandstone, slightly limy; grayish orange/buff; medium-very coarse grained, subangular, poor sorting; thin bedded; ledge constituent, fair exposure; unfossiliferous	0.4
2-20	Siltstone, slightly arenaceous; grayish black-medium dark gray-olive gray/black-buff; coarse grained, subangular, fair sorting, concavo-convex contacts; mica, glauconite, pyrite; laminated-thin bedded, bioturbated; bituminous; forms a ledge, fair exposure; unfossiliferous	2.2

Unit	Lithology	Thickness (ft.)
2-19	Conglomerate, arenaceous; light olive gray/buff; granule to fine grained, subangular, poor sorting, [point to concavo-convex contacts]; limestone and quartz granules, mica; thin bedded; forms a minor bench, fair exposure; trace (plant, brachiopod)	1.0
2-18	Shale, black-gray/buff; fissile bedded; unfossiliferous	0.9
2-17	Igneous dike, camptonite; light olive gray-moderate greenish yellow/brown-buff; discontinuous, fair exposure;	
2-16	Sandstone, slightly limy; grayish orange/ buff; fine-very coarse grained, subangular, poor sorting; mica; thin bedded; forms a discontinuous ledge, fair exposure; trace (brachiopod, plant)	4.3
2-15	Conglomerate, arenaceous, slightly argillaceous; olive gray/grayish black-medium gray-buff; medium-pebble grained, angular, poor sorting, [point-long-stylolitic contacts]; limestone pebbles, quartz grains, mica; thin bedded; gradation upper contact, coated grains ; forms a ledge, fair exposure; moderate (plant, coral, brachiopod, pelmatazoan, bryozoan, foraminifera, pelecypod)	1.4
2-14	Conglomerate, arenaceous and slightly argillaceous; black-dark yellowish brown, light olive gray/dusky buff; medium-granule grained, angular, poor sorting, [floating-long contacts]; limestone and quartz granules; thin bedded; forms a ledge, fair exposure; trace (plant, brachiopod)	2.0

Unit	Lithology	Thickness (ft.)
2-13	Shale; black/gray-red, yellow-buff; fissile bedded; slope constituent, fair exposure; unfossiliferous	1.0
2-12	Sandstone, orthoquartzite; grayish orange/ buff; medium-very coarse grained, sub-angular, fair sorting; thin bedded, graded; minor discontinuous ledge, fair exposure; unfossiliferous	2.0
2-11	Shale; black/green-buff; mica; becomes slightly silty upwards; slope constituent, fair exposure; unfossiliferous	1.0
2-10	Covered; probably 2-11	10.0
2-9	Limestone; grayish black-olive black/medium light gray-buff; pyrite; thin bedded, mottled; forms a bench, good exposure; trace-moderate (coral, brachiopod, bryozoan, foraminifera, plematazoan) N28°E 4°NW	1.5
2-8	Limestone, packstone; grayish black-olive black/dark gray-buff; glauconite , [partially recrystallized], pyrite; thin-medium bedded; forms a weak ledge, good exposure; moderate (brachiopod, foraminifera, pelmatazoan, bryozoan, sponge spicules) [conodont: Rhachistognathus primus (Dunn), Adetognathus gigantus (Gunnell)(right), Adetognathus gigantus (Gunnell)(left), Adetognathus sp., Hindeodella sp.]	3.5
2-7	Shale; black/buff; forms a slope, poor exposure; unfossiliferous	2.0

Unit	Lithology	Thickness (ft.)
2-6	Siltstone, slightly limy, arenaceous and argillaceous; grayish black-olive black, dusky yellowish brown/black-gray-maroon-buff; coarse grained, rounded-angular, fair sorting, [floating to point contacts]; mica; thin bedded, bioturbated; bituminous; forms a bench, good exposure; trace (sponge spicules, brachiopod, pelmatazoan)	6.0
2-5	Siltstone, argillaceous to arenaceous; grayish black-olive black/olive black-buff; coarse grained, subangular to subrounded, fair sorting, [floating to point contacts]; mica; fissile-laminated bedded, bioturbated, rhythmitic; bituminous; steep slope constituent, good exposure; trace (brachiopod)	13.5
2-4	Shale; black/buff; mica; fissile bedded; forms a slope on one side of stream cut, good but intermittent exposure; moderate (brachiopod)	2.0
2-3	Siltstone, slightly limy; olive gray-olive black/light olive gray; coarse grained, angular, well sorted, [point contacts]; partially silicified and recrystallized ; medium bedded, faint internal laminations; black plant markings on surface; stream cut bench, good-fair exposure; trace-moderate (plant, pelmatazoan)	3.6
2-2	Covered	1.0
	Partial thickness of Lower Morrowan Interval	90.0

Unit	Lithology	Thickness (ft.)
Rancheria Formation (Mississippian)		
2-1	Limestone, grainstone; light olive gray/ olive gray-yellowish gray; [sparry calcite cement], partially recrystallized; medium to very thick bedding; [coated grains], slightly vuggy; resistant bench in stream cut, good exposure; moderate (pelmatazoan, brachiopod, bryozoan, debris) [conodont: Gnathodus bilineatus (Roundy), Gnathodus texanus (Roundy), Cavusgnathus sp.] N14°E 1°NW	5.0

Stratigraphic Section 7

Escondido

General Location

The section was measured trending approximately northeast in the SW¼ of Section 25 and the NE¼ of Section 36, T.18.S., R.10.E., Otero County, New Mexico.

Description of Locality

The section is located 13.4 miles northeast along various dirt roads, from a point on U.S. 54, 19.9 miles south of its intersection with U.S. 70. Local land marks and directions are: turn east off U.S. 54 and proceed east, stop sign and military fence gate mark this turn; veer to right fork after 3.6 miles, continue east; abandoned bunkers, fences, concrete pads, and storage tank at 0.3 miles mark this route; veer north around pond; turn north at intersection 2.3 miles from pond; proceed in a NNE direction for 1.2 miles and turn north at intersection; cross arroya, and road will end within 2 miles; walk approximately 4 miles to the NNE.

The section begins on the southern and western slope of Moore Ridge. The section trends gennerally N55°E.

General Remarks

The section was measured August 6-7, 1974. This section is poorly exposed, with limestone ledges, commonly the only visible strata. The Mississippian-Pennsylvanian "contact-interval" could not readily be determined at this locality, hence no attempt was

made to define definite Mississippian (probably Ranchera (?)) rocks.

The strike of strata is gemerally N12°W with dips averaging 15° to the northwest.

	Approximate Thickness (in feet)
Lower Desmoinesian Interval	80
Atokan Interval	64
Upper Morrowan Interval	147
Lower Morrowan Interval	80
Total	371

Unit	Lithology	Thickness (ft.)
Bug Scuffle Limestone Member		
7-34	Limestone, packstone; olive black/ medium dark gray-buff; thin bedding, bioturbated; black chert nodules and stringers, limestone in 1 ft. thick beds, shale partings in less than .2 ft. beds; slope former, semi-fair exposure; trace-moderate (algae, pelmatazoan)	5.0
Lower Desmoinesian Interval		
7-33	Limestone, mudstone-wackestone, Shale slightly silty; olive gray/medium light gray-buff; thin bedded, bioturbated; sporadic black chert nodules; intermittent ledge and slope, fair exposure, partially covered; moderate (coral, pelmatazoan)	18.5
7-32	Shale; black-gray/buff; fissile bedded; slope former, fair exposure, unfossiliferous	1.2

Unit	Lithology	Thickness (ft.)
7-31	Limestone, mudstone and Shale; olive gray (limestone), black (shale)/buff; thin bedded (limestone), fissile-laminated bedding (shale); small bulbular sand casts; slope former, semi-fair exposure; moderate (brachiopod) [brachiopod: Linoproductus cf. L. platyumbonus (Dunbar & Condra), Neospirifer cameratus (Morton), Orbiculoidea sp.]	7.5
7-30	Covered, talus;	10.0
7-29	Limestone, grainstone; olive gray/medium gray-buff; thin bedded; caps ledge, fair-good exposure; abundant (coral, brachiopod, pelmatazoan, foraminifera, pellets)	1.4
7-28	Limestone, packstone and Shale; olive black/medium dark gray-buff; medium-very thick bedded (limestone), fissile-laminated bedded (shale); gray-blue chert stringers, limestone in 3-1 ft. thick beds, shale in less than 0.2 ft. beds; forms a resistant ledge, good exposure; abundant (coral, brachiopod, pelmatazoan, algae)	35.5
7-27	Conglomerate, limestone; light olive gray-olive gray/buff; medium-pebble grained, rounded, poor sorting, floating contacts; limestone grains; thin bedded; intraformational, blue-gray chert nodules and stringers; forms base of ledge, good exposure; trace-moderate (pelmatazoan, coral, bryozoan, sponge spicules, brachiopod, algae)	2.1
	Partial thickness of Lower Desmoinesian Interval	80.0

Unit	Lithology	Thickness (ft.)
Atokan Interval		
7-26	Limestone, packstone, slightly silty and Shale; olive black (limestone), black (shale)/medium dark gray-buff; thin bedded (limestone), fissile-laminated bedding (shale); limestone in 1.0-0.4 ft. beds, shale in less than 0.4 ft. beds; forms a slope, fair-poor exposure; moderate (brachiopod, sponge spicules, coral)	19.4
7-25	Covered, probably 7-24	2.0
7-24	Shale, limy; black/buff; fissile-laminated bedded; limestone, mudstone stringers; unfossiliferous	1.0
7-23	Limestone, grainstone; olive gray-black/ medium light gray-buff; partially recrystallized; thin-thick bedded; coated grains, lineation partings; forms a ledge, good-fair exposure; abundant (brachiopod, coral, pelmatazoan, foraminifera) [brachiopod: Neospirifer sp.]	8.5
7-22	Covered, talus; probably shale and interbedded, thin bedded limestone	93.0
	Partial thickness of Atokan Interval	64.0
Upper Morrowan Interval		
7-21	Limestone, wackestone, slightly silty; olive gray, olive black/medium gray-buff; partially recrystallized; thin-thick bedded, bioturbated; has "string-streak" weathered surface, stylolites, green chert layers and nodules; ledge former, good exposure; moderate (brachiopod, coral, pelmatazoan)	26.0
7-20	Covered, talus;	16.0

Unit	Lithology	Thickness (ft.)
7-19	Limestone, grainstone-packstone; olive gray/medium gray-buff; partially silicified; very thick bedded; blue-gray, black chert nodules and stringer; forms a ledge, fair exposure; trace-moderate (algae, foraminifera, brachiopod, coral, pelmatazoan)	9.4
7-18	Covered, talus;	4.0
7-17	Limestone, packstone and Chert; olive gray (limestone), black (chert)/medium gray-buff; partially silicified; thin bedded; bluish-light olive-maroon chert nodules and layers; steep slope constituent, poor exposure; moderate-abundant (pelmatazoan, sponge spicules, algae, foraminifera)	1.6
7-16	Limestone, packstone; olive gray/medium gray-buff; glauconite; thin bedded; stream cut bench, poor exposure; moderate (pelmatazoan, coral, bryozoan, brachiopod, algae)	1.5
7-15	Covered, talus;	1.0
7-14	Limestone, packstone; light olive gray/ medium gray-buff; partially silicified; thin-very thick bedded, faintly mottled; stringlike bands of rust-orange on weathered surface; forms a ledge, fair exposure; abundant (foraminifera, pelmatazoan, bryozoan, coral, algae)	6.3
7-13	Covered, talus;	17.5

Unit	Lithology	Thickness (ft.)
7-12	Sandstone, orthoquartzite; light olive gray-yellowish gray/buff; medium-coarse grained, angular-subrounded, fair-good sorting, [concavo-convex, stylolitic contacts]; partially recrystallized , [heavy minerals]; thin-medium bedded; stream cut ledge, semi-poor exposure; trace (plant) offset east to west minor tributary on 7-11	5.5
	Partial thickness of Upper Morrowan Interval	147.0
Lower Morrowan Interval		
7-11	Limestone, packstone; brownish black/dark gray-buff; partially silicified; medium-very thick bedded; blue chert layers and nodules; forms a ledge, fair-good exposure; moderate-abundant (foraminifera, bryozoan, coral, algae) N3°W 16°NE	12.5
7-10	Covered; probably shale	0.5
7-9	Sandstone, orthoquartzite; light olive gray/buff; fine-very coarse grained, angular-subangular, poor sorting, stylolitic contacts; minor calcite cement, heavy minerals; thin bedded; discontinuous bench, poor exposure; trace (plant)	1.3
7-8	Covered	11.0
7-7	Limestone, packstone and Chert; black (chert), olive black (limestone)/medium light gray-buff; silicified in spots; thin bedded; chert layer 7/8 of total, fractured; chert caps ledge, semi-rare exposure; abundant (pelmatazoan, coral, bryozoan, foraminifera)	0.2

Unit	Lithology	Thickness (ft.)
7-6	Limestone, wackestone-packstone; olive black/medium gray-buff; thin-medium bedded, mottled; fractured, blue-gray, black chert nodules and layers; forms a broken ledge, fair exposure; abundant (coral, brachiopod, pelmatazoan, bryozoan) N14°W 14°NE	6.1
7-5	Limestone, packstone-grainstone; black-olive black/medium gray, yellowish pinkish buff; thin bedded, faint banding; forms a minor ledge, fair-poor exposure; abundant (coral, pelmatazoan, foraminifera, bryozoan, pellets)	3.1
7-4	Covered, talus	10.0
7-3	Limestone, packstone; light olive gray/ olive gray-buff; partially silicified; thick bedded; gray blue, black chert layers and nodules; ledge former, good exposure; abundant (coral, brachiopod, pelmatazoan, bryozoan, foraminifera, sponge spicules)	5.0
7-2	Limestone, packstone; olive gray/medium dark gray-buff; partially silicified; very thick bedded; black chert layers and nodules; forms a broken ledge, fair exposure; moderate-abundant (algae, coral, brachiopod, pelmatazoan, sponge spicules, foraminifera) N15°E 16°SE	7.2
7-1	Covered, talus;	5.0
	Partial thickness of Lower Morrowan Interval	80.0

Stratigraphic Section 8

Nigger Ed

General Location

The section measured trends approximately east-west in the NW/4 Section 18, T.19.S., R.11.E., Otero County, New Mexico.

Description of Locality

The section is located 11.3 miles northeast along various dirt roads, from a point on U.S. 54, 19.9 miles south of its intersection with U.S. 70. Local land marks and directions are: turn east off of U.S. 54 and proceed east, stop sign and military fence gate mark this turn; veer to right fork after 3.6 miles, continue east; abandoned bunkers, fences, concrete pads, and storage tank at 0.3 miles mark this route; veer north around pond; turn north at intersection 2.3 miles from pond; proceed in a NNE direction for 1.2 miles and turn north at intersection; cross arroya, and road will end within 2 miles; walk 2.2 miles in a N75°E direction.

The section begins on the southern slope of Nigger Ed Canyon, roughly west of Table Top Butte. The section trends generally N58°E.

General Remarks

The section was measured August 8, 1974. It is poorly exposed with resistant limestone ledges commonly the only visible strata. The writer later visited a locality 0.5 miles

to the north, and noted a sandstone-limestone interval interpreted as being part of unit 8-5.

This section is close to the frontal fault of the escarpment. At the northern locality, faulting was noticed and the lower Gobbler stratigraphic section appeared to be distorted. Detailed measurement of the section at this northern locality was not procured.

The strike of strata is generally N30°E with dips averaging 30° to the southeast.

	Approximate Thickness (in feet)
Lower Desmoinesian Interval	31
Atokan Interval	69
Upper Morrowan Interval	142
Lower Morrowan Interval	66
Total	308

Unit	Lithology	Thickness (ft.)
Bug Scuffle Limestone Member		
8-21	Limestone, wackestone-packstone, slightly silty, and Shale; light olive gray/light olive gray-buff-limestone, black/buff-shale; partially silicified; fissile-thin bedded-shale; brachiopod in growth position; massive cliff former, excellent exposure; moderate (pelmatazoan, fusulinid, brachiopod, algae)	5.0

Unit	Lithology	Thickness (ft.)
Lower Desmoinesian Interval		
8-20	Covered	20.0
8-19	Limestone, mudstone to wackestone, slightly silty, interbedded Shale, partially covered; grayish black/dark gray-buff; thin bedded-limestone, fissile bedded-shale; limestone in 1.5 ft. thick beds, shale in 1 ft. thick beds; forms a slope, poor-fair exposure; trace (debris)	35.0
	Partial thickness of Lower Desmoinesian Interval	31.0
Atokan Interval		
8-18	Covered, talus	45.0
	Partial thickness of Atokan Interval	69.0
Upper Morrowan Interval		
8-17	Limestone, packstone-wackestone; olive black/medium gray-buff; partially silicified; thin-medium bedded; black chert stringers; ledge former, good exposure; trace (foraminifera, pelmatazoan, coral)	15.0
8-16	Covered; two limestone beds approximately 2 ft. thick each within this interval	20.0
8-15	Limestone, mudstone-wackestone; olive gray-medium dark gray/medium gray-buff; thin bedded; forms a ledge, fair-poor exposure; trace (brachiopod, pelmatazoan)	6.5
8-14	Covered, talus;	9.0

Unit	Lithology	Thickness (ft.)
8-13	Limestone, packstone-wackestone; olive gray/medium gray-buff; glauconite grains; thin-thick bedded; green-tan-black chert bands and nodules and black chert stringers 9-19 ft. up, coated grains, limestone (mudstone-wackestone, slightly silty) grains; ledge former, good exposure; moderate (pelmatazoan, bryozoan, coral, brachiopod, foraminifera)	19.0
8-12	Covered, talus;	7.5
8-11	Limestone, packstone-wackestone; olive gray/olive gray-medium gray-buff; partially silicified; thin-medium bedded; forms a discontinuous ledge, fair exposure; moderate-trace (coral, bryozoan, brachiopod, foraminifera, pelmatazoan)	10.0
8-10	Covered-partially covered, Shale; black/buff; fissile bedded; forms a talus slope, shale is exposed intermittently; unfossiliferous	14.0
8-9	Limestone, grainstone-packstone; dusky yellowish brown-grayish orange/dark gray-light gray-buff; thin bedded, mottled; forms minor broken ledge, good-fair exposure; trace (pelmatazoan, bryozoan, foraminifera)	1.0
8-8	Limestone, packstone; medium olive gray/medium dark gray-buff; glauconite grains; thin-medium bedded; black chert layer 3 ft. up; ledge former, good exposure; moderate (coral foraminifera, bryozoan, brachiopod)	5.0
8-7	Shale; gray-black/light gray-red-black; fissile-laminated bedded; forms a slope, partially covered at top; unfossiliferous	3.0

Unit	Lithology	Thickness (ft.)
8-6	Limestone, wackestone, slightly silty; olive black/medium gray-buff; thin bedded; fractured; minor ledge former, intermittent exposure; trace-abundant (foraminifera, bryozoan, pelmatazoan, brachiopod)	3.0
8-5	Covered; probably contains a sandstone bed overlain by a limestone approximately 15 ft. thick	63.5
	Partial thickness of Upper Morrowan Interval	142.0
Lower Morrowan Interval		
8-4	Limestone, grainstone; olive gray/light olive gray-buff; sparry calcite cement ; thin-medium bedded; [coated grains]; forms a ledge, good exposure; trace (pelmatazoan, bryozoan, debris) N4°E 34°SE	10.5
8-3	Covered; probably shale	4.0
8-2	Siltstone, arenaceous and limy, and interbedded Limestone, mudstone and Shale; light olive gray/light olive gray-buff; medium-coarse grained, subangular, fair-good sorting, floating-point contacts; calcite cement; thin bedded, banded, bioturbated; concordant contact with 8-1, upward coarsening; forms a slope, fair exposure; trace (debris) N3°E 24°SE	15.0
	Partial thickness of Lower Morrowan Interval	66.0

Unit	Lithology	Thickness (ft.)
Helms Formation (Mississippian)		
8-1	Siltstone, limy and slightly arenaceous and interbedded Shale and Limestone, mudstone; medium dark gray-olive gray-light olive gray/medium gray-buff; medium-coarse grained, subrounded, good sorting, floating-point contacts; calcite cement; fissile-thin bedded, finely laminated banding; siltstone in 1 ft. thick beds and shale in 0.3 ft. thick beds; forms a slope, fair exposure; unfossiliferous	5.0

Stratigraphic Section 5

Grapevine Canyon

General Location

The section was measured on the northern slope of Grapevine Canyon in the NW¼, Section 27, T.19.S., R.11.E., and SW¼, Section 22, T.19.S., R.11.E., Otero County, New Mexico.

Description of Locality

The section is located 14.5 miles east along various dirt roads, from a point on U.S. 54, 19.9 miles south of its intersection with U.S. 70. Local land marks and directions are: turn east off of U.S. 54 and proceed east, stop sign and military fence gate mark this turn; veer to right fork after 3.6 miles, continue east; abandoned bunkers, fences, concrete pads, and storage tank at 0.3 miles mark the route; veer north around pond at 2.5 miles; turn north at intersection 2.3 miles from pond; proceed in a NNE direction for 1.2 miles and turn east at intersection; proceed east 4 miles and then veer left in gravel arroya; 0.1 miles further follow main tributary and proceed east to northeast 0.5 mile; walk up tributary approximately 0.75 of a mile.

The section begins along the lowest part of the northern slope adjacent the tributary. The section trends NNW and is offset in small tributaries where advantageous. The uppermost part of the section is measured in the main tributary west of the origin, where the Bug Scuffle is cut by the tributary.

General Remarks

The section was measured July 21 and August 10-11, 1974. It is well exposed in the basal and upper portions, but is poorly exposed in the middle portion, with limestone ledges generally the only visible strata.

The general strike of the strata is N25°W with dips averaging 25° to the southwest.

	Approximated Thickness (in feet)
Lower Desmoinesian Interval	26
Atokan Interval	75
Upper Morrowan Interval	148
Lower Morrowan Interval	65
Total	314

Unit	Lithology	Thickness (ft.)
Bug Scuffle Limestone Member		
5-44 (5-g)	Conglomerate, limestone, slightly silty and shale; light olive gray/medium gray-buff; medium-pebble grained, subrounded, poor sorting, floating contacts; limestone grains; fissile-thin bedded; intraformational, basal contact channelled as much as 4-5 ft.; ledge constituent, good exposure; moderate (coral, brachiopod, foraminifera)	5.0

Unit	Litholoty	Thickness (ft.)
Lower Desmoinesian Interval		
5-43 (5-f)	Limestone, packstone; pale brown-olive gray/olive gray buff; glauconite; thin-thick bedded, mottled; channelled upper contact; ledge former, good exposure; abundant (brachiopod, pelmatazoan, coral, foraminifera, bryozoan) [brachiopod: Antiquatonia cf. coloradoensis (Girty); coral: Pseudozaphrentoides sp.] offset west approximately 50 ft. on 5-43	11.0-15.0
5-43 (5-e)	Shale and Limestone, wackestone-mudstone; black (shale), dark gray (limestone)/buff; mica; fissile-laminated bedding-shale, thin bedded-limestone; forms a wall, good exposure; moderate-abundant (coral, brachiopod, pelmatazoan)	15.0
	Partial thickness of Lower Desmoinesian Interval	26.0
Atokan Interval		
5-41 (5-d)	Limestone, grainstone-packstone; medium olive gray-dusky yellow/medium olive gray-buff; partially silicified, quartz, glauconite grains; thin-medium bedded; ledge former, good exposure; abundant (pelmatazoan, bryozoan, coral, brachiopod, algae)	4.8
5-40 (5-c)	Limestone, wackestone-packstone, slightly silty; olive black-grayish orange/light gray-buff; thin bedded, bioturbated, burrowed; stream cut slope, good exposure; trace (brachiopod, algae, worm, debris)	1.1

Unit	Lithology	Thickness (ft.)
5-39 (5-b)	Limestone, packstone, slightly silty; partially silicified; thin-very thick bedded; coarser grained in basal portion of unit; forms a ledge, good exposure; abundant (pelmatazoan, bryosoan, brachiopod, foraminifera, fusulinid, debris) N15°E 14°NW	11.3
5-38 (5-a)	Shale and Limestone, wackestone with packstone microlenses, argillaceous, slightly silty; dark gray-yellowish olive brown/ dark gray-buff; mica; fissile bedded-shale, thin bedded-limestone; stream cut slope, fair-good exposure; moderate (pelmatazoan, brachiopod, bryozoan, foraminifera) [brachiopod: Neospirifer sp.] offset west to main tributary on the base of 5-38	2.2
5-37	Covered	20.0
5-36	Limestone, wackestone, slightly silty; olive black/medium dark gray-buff; thin bedded; small black chert nodules; forms a ledge, fair exposure; trace (pelmatazoan, brachiopod)	10.3
5-35	Covered	10.0
5-34	Limestone, grainstone; light gray-dark gray/medium dark gray-buff; partially recrystallized; thin bedded; forms a minor ledge, good exposure; abundant (pelmatazoan, brachiopod, bryozoan, debris)	1.3

Unit	Lithology	Thickness (ft.)
5-33	Limestone, mudstone, and Shale; grayish black (limestone) gray-black (shale)/buff; thin bedded-limestone, fissile-laminated bedded-shale; forms discontious minor ledges and slopes, poor exposure; moderate (coral)	9.0
	Partial thickness of Atokan Interval	75.0
Lower Morrowan Interval		
5-32	Covered	55.0
5-31	Shale, silicified; dark reddish brown, moderate reddish brown, moderate yellowish brown/buff; thin bedded, internal laminations; caps bench, good exposure; trace [sponge spicules]	0.3
5-30	Limestone, packstone, slightly silty; pale reddish brown-yellowish gray/medium light gray-buff; partially silicified; thin-thick bedded; brachiopod in growth position; forms a minor bench, good exposure; moderate (brachiopod, coral, bryozoan, algae, pelmatazoan, foraminifera)	24.5
5-29	Limestone, silicified, wackestone; dark reddish brown, light olive gray/pale greenish yellow-buff; thin bedded; stream cut minor ledge, poor exposure; trace (brachiopod)	1.5
5-28	Covered	9.0
5-27	Shale; black/maroon-buff; fissile-laminated bedded; blocky slope, poor exposure; minor-trace (debris)	7.0

Unit	Lithology	Thickness (ft.)
5-26	Limestone, packstone-grainstone; dark reddish brown-light olive brown/dark reddish brown-buff; partially recrystallized, ferrugenic coating or cement; thin bedded; coated grains, color bands; stream cut slope, poor-fair exposure; moderate (coral, brachiopod, pelmatazoan, bryozoan, foraminifera)	5.2
5-25	Covered	3.5
5-24	Limestone, grainstone; pale yellowish brown-light olive gray-light gray/yellowish gray-buff; partially recrystallized; thin bedded; blue gray-black chert nodules; forms a minor ledge, semi-fair exposure; trace-moderate (algae, foraminifera, bryozoan, pelmatazoan)	5.0
5-23	Covered	15.0
5-22	Limestone, grainstone, slightly silty; light olive gray-brown/light gray-buff; thin bedded; has a pitted (weathered) surface, dusky-very dark red dissemanations; forms a minor bench, good exposure; moderate (foraminifera, algae, brachiopod, pelmatazoan) offset north to intersection of northwest slope and a northeastern branch of main tributary on unit 5-16	9.5
5-21	Covered	5.0
5-20	Limestone, grainstone-packstone; medium olive gray/dark gray-buff; thin bedded; forms a minor bench, fair-good exposure; moderate (pelmatazoan, foraminifera, pellets, debris)	1.0
5-19	Covered	4.0

Unit	Lithology	Thickness (ft.)
5-18	Limestone, packstone; brownish black-olive black/medium dark gray-buff; partially recrystallized, pyrite; thin bedded; blue gray-black chert layers and stringers; forms a minor ledge, fair exposure; trace-moderate (foraminifera, brachiopod, pelmatazoan, bryozoan)	2.0
5-17	Partially Covered and Sandstone, ferrugenic protoquartzite; dark reddish brown/grayish red purple-buff; very fine-fine grained, [subangular], fair-good sorting, [floating-concavo-convex contacts]; partially recrystallized, biotite, feldspar, [glauconite], pyrite grains; thin bedded; discontinuous minor ledge, poor exposure; unfossiliferous	8.0
	Partial thickness of Upper Morrowan Interval	148.0
Lower Morrowan Interval		
5-16	Limestone, packstone; yellowish gray-olive gray/light olive gray-buff; partially silicified and recrystallized; medium-very thick bedded; blue gray-black chert layers 3 ft. up, light gray chert 8 ft. up; ledge former, fair exposure; trace-moderate (brachiopod, coral, foraminifera, bryozoan, debris)	17.0
5-15	Partially Covered and Sandstone, orthoquartzite; moderate yellowish brown-grayish orange pink-pale red/light buff; fine-coarse grained subangular, fair-poor sorting, concavo-convex-stylolitic contacts; glauconite, feldspar, heavy minerals, biotite, limonite; thin bedded, faint banding, minor cross-bedding; discontinuous ledge, poor exposure; trace (plant)	1.5

Unit	Lithology	Thickness (ft.)
5-14	Limestone, wackestone-packstone; olive gray-light olive gray/medium gray-buff; partially silicified and recrystallized; thin-medium bedded; blue-gray to black chert nodules and stringers; ledge former, fair exposure; trace (sponge spicules, pelmatazoan, foraminifera, bryozoan)	4.5
5-13	Covered	7.0
5-12	Breccia-Conglomerate, limy, slightly silty; olive gray-dark gray-dark yellowish brown/dark gray-buff; fine-pebble grained, angular-subrounded, poor sorting, floating-point or stylolitic contacts; partially silicified, black chert pebbles, limestone grains and pebbles; thin-medium bedded; intraformational (?), chert stringers 2 ft. up; forms a minor ledge, fair exposure; trace (bryozoan, foraminifera, brachiopod, coral)	6.0
5-11	Covered	8.0
5-10	Limestone, packstone-wackestone, slightly silty; olive black-olive gray/medium gray-buff; partially silicified, pyrite; thin-medium bedded; chert nodules in round tube-like layers, coated grains, brachiopod in growth position; ledge former, good exposure; abundant (bryozoan, pelmatazoan, foraminifera, sponge spicules, brachiopod, coral)	4.3
5-9	Limestone, packstone-wackestone; brownish black-light olive gray/dark gray-medium light gray-buff; partially silicified, pyrite; thin-medium bedded, mottled; black chert nodules and layers; forms a ledge, good exposure; abundant (foraminifera, pellets, brachiopod, coral, pelmatazoan, bryozoan, sponge spicules, algae)	5.3

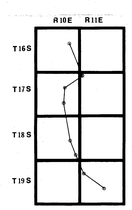
Unit	Lithology	Thickness (ft.)
5-8	Shale; black/maroon, yellowish brown, buff; fissile bedded; forms a slope, poor exposure; unfossiliferous	0.9
5-7	Limestone, packstone-wackestone; olive gray-grayish black/medium gray-buff; partially silicified; thin bedded; slope constituent, good exposure; trace-moderate (brachiopod, pelmatazoan)	0.95
5-6	Limestone, packstone; brownish black-olive black/dark gray-medium gray-buff; partially silicified; thin bedded, slightly mottled; fractured; ledge former, good exposure; moderate-abundant (brachiopod, pelmatazoan, bryozoan, sponge spicules, algae) N35°W 22°SW	3.9
5-5	Shale; very light gray/maroon, greenish gray, pale yellowish orange; fissile bedded; forms a slope, rare exposure; trace (brachiopod)	1.0
5-4	Limestone, packstone, slightly arenaceous; olive black/dark gray-medium gray, light blue green, buff; partially silicified, glauconite, quartz grains; thin bedded, algal structures, mottled; friable 1 in. layer capping the unit; ledge former, fair exposure; moderate-abundant (brachiopod, coral, pelmatazoan, bryozoan, foraminifera, algae, sponge spicules)	0.8
5-3	Shale and interbedded Siltstone; medium light gray-pale reddish brown/light gray, yellowish brown, maroon, pale yellowish orange; mica; fissile-laminated bedding; black splotches on surface; slope constituent, semi-rare exposure; trace (brachiopod, plant)	1.2

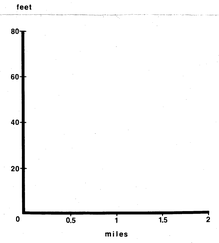
Unit	Lithology	Thickness (ft.)
5-2	Conglomerate, limy-arenaceous; light olive brown-light medium olive gray/brownish black-pale yellowish orange, buff-yellowish orange; medium-cobble grained, subangular, poor sorting, concavo-convex-stylolitic contacts; quartz and limestone grains, chert cobbles; thin bedded; abrupt basal contact; slope constituent, semi-rare exposure; unfossiliferous	0.4
	Partial thickness of Lower Morrowan Interval	65.0
Helms Formation (Mississippian)		
5-1	Limestone, mudstone and shale, slightly silty and limy; olive gray-light olive gray/ light olive gray-light buff; [micro-clastic micrite]; thin bedded, wavy, faint-fine banding; mud crack casts, limestone in 1 ft. thick beds, shale in 0.6 ft. thick beds; talus ledge unless stream cut, good-excellent exposure; unfossiliferous; started measurement in main tributary floor trending north-northwest N10°W 27°SW	5.0

LOWER GOBBLER FORMATION CROSS SECTION

SACRAMENTO MOUNTAINS

OTERO COUNTY, NEW MEXICO





Conglomerate
Sandstone
Siltstone
Shale
Covered
Grainstone
Packstone
Wackestone
Mudstone (carbonate)
Igneous

Coral
Brachiopod
Fusulinid
Conodont
Unit Number
Lithologic Correlation (dash where approx.)
Interval Boundary
Diagrammatic Facies
Unconformity

NORTH

SOUTH

1 2 3 4 5 6 7 8

LOWER DESMOINESIAN

TERRIGENOUS

CARBONATE

ATOKAN

ARGILLACEOUS

ARENACEOUS

UPPER MORROWAN

LOWER MORROWAN

datum

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