The Upper Paleozoic Madera Group in the Manzano Mountains, New Mexico

By DONALD A. MYERS

CONTRIBUTIONS TO STRATIGRAPHY

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CONTENTS

ILLUSTRATIONS

CONTRIBUTIONS TO STRATIGRAPHY

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ABSTRACT

The Madera Limestone, of Middle and Late Pennsylvanian and Early Permian age, is raised to group rank in the Manzano Mountains, N. Mex., where it consists of three formations (ascending order): a sequence of massive cliff-forming limestone, named in this report the Los Moyos Limestone; a sequence of arkosic clastic rocks, shale, and locally cliff-forming limestones defined as members of the Wild Cow Formation, all of which are named in this report; and the Bursum Formation, a red-bed sequence newly assigned to the Madera Group in the southern Manzano Mountains.

INTRODUCTION

The Manzano Mountains lie along the east side of the Rio Grande Valley and extend about 45 miles south from the east side of Albuquerque to Abo Canyon and the A.T. & S.F. Railway. They are about 10 miles wide (fig. 1). The core of the mountain range is Precambrian metasedimentary and metavolcanic rocks that contain minor granitic intrusives. Middle Pennsylvanian rocks lie in depositional contact upon the Precambrian.

The sedimentary sequence here discussed is of Middle and Late Pennsylvanian and Early Permian age. The stratigraphic nomenclature proposed for these rocks is based on continuing fieldwork that began in 1962. Except where ruggedness of terrain made it physically impractical, I walked the distance covered by most of the contacts between the named units.

I thank Dr. Frank E. Kottlowski of the New Mexico State Bureau of Mines and Mineral Resources for his review of the manuscript.

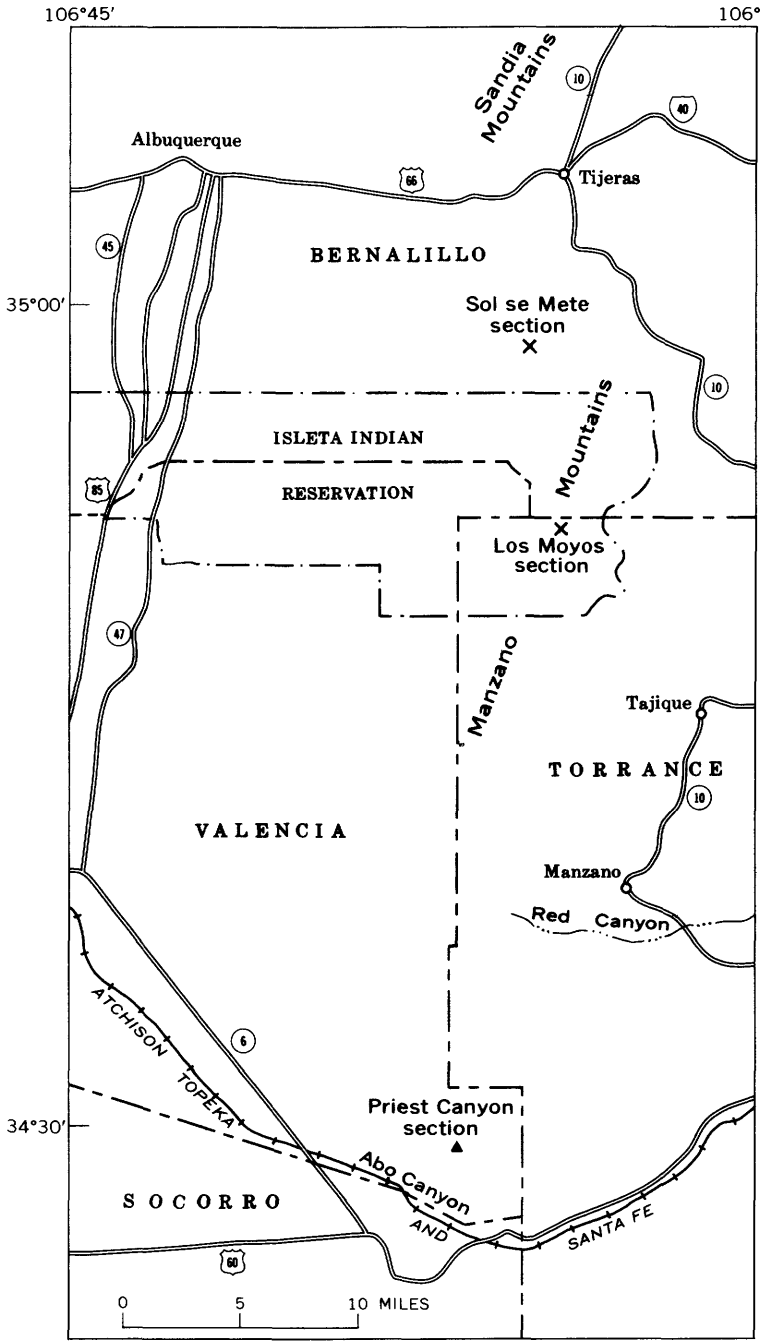


FIGURE 1.—Index map of the Manzano Mountains area showing location of described sections. Triangle indicates type section; × reference section.

MADERA GROUP

The term Madera was first used by Keyes (1903, p. 48), who wrote as follows:

> This great limestone formation forms a remarkable cornice on the Sandia mountains, clearly seen from the railroad station at Albuquerque. It is also an important part of the Manzano * * * ranges.
>
> In the Sandia Mountains the several formations have been more clearly differentiated than perhaps anywhere else. The basal conglomerate and associate sandstones have been called the Sandia quartzites. For the lower black limestone the name Placitos [sic.] is proposed * * *.
>
> The superior part of the great limestone formation—the blue to gray beds—contains an abundant fauna, that clearly points to an age of late Carboniferous. In the Sandia Mountains this formation is called the Madera limestone. It forms by far the most important portion of the Carboniferous in all of the ranges before mentioned.
>
> Above the great blue limestones of the Carboniferous comes in an important sandstone and then a sequence of shales and sandstones conspicuous for their remarkable red coloration * * *.
>
> In the Sandia Mountains the lower sandstone is called the Coyote sandstone—from Coyote Springs—and the upper member the Bernalillo shales.

As used by subsequent workers (for example, Read and others, 1944), the Madera Limestone includes Keyes' (1903) Placitos and Madera Limestones, Coyote Sandstone, and lower part of the Bernalillo Shales. The upper part of Keyes' Bernalillo Shales was apparently included in the Bursum Formation and in the basal part or all of the Abo Formation.

In the report area, rocks previously considered as the Madera Limestone and Bursum Formation are placed in the Madera Group, thereby redefining the upper contact of the Madera and raising its stratigraphic rank in the Manzano Mountains. The Bursum is included in the Madera Group because it is depositionally continuous with the underlying rocks. The group consists of all rocks that overlie the Sandia Formation of early Middle Pennsylvanian age and that underlie the Abo Formation of Early Permian age. It consists of rocks assigned to the fusulinid zones of *Beedeina* and *Triticites* and to the lower part of the zone of *Schwagerina*.

The Madera Group in the Manzano Mountains includes rocks previously assigned there to the Magdalena Group. The Magdalena Group, as originally defined by Gordon (1907, p. 806–812) in the Magdalena Mountains, consists of all rocks between the Mississippian System and the basal red beds of the Permian System. Thus the Magdalena Group was considered to be mostly of Pennsylvanian age until 1946 (Wilpolt and others), when the Permian Bursum Formation was added to the group. The Magdalena Group in the area of this report consisted of all Pennsylvanian

rocks and the Bursum Formation; its use in the Manzano Mountains is rejected. The Magdalena Group remains in good standing elsewhere.

Thompson (1942) defined and described several groups, formations, and members from the Pennsylvanian system in New Mexico. His descriptions of the various lithic units were from south-central New Mexico and his correlations between the various units were apparently mostly paleontologic. Few or no data have been published that demonstrate the cartographic continuity of Thompson's units. His units could not be recognized as lithologic entities in the Manzano Mountains.

The lower part of the Madera Group is a sequence of massive cliff-forming medium- to light-gray cherty limestone with minor amounts of interbedded gray to black shale and lenticular beds of grayish-orange sandstone and conglomerate. This part of the Madera is here named the Los Moyos Limestone.

The middle part of the Madera Group is here named the Wild Cow Formation. It is a rhythmic-bedded sequence of arkosic sandstone and conglomerate, gray shale that becomes red in the upper part, and light-olive-gray and light- to medium-gray locally cliff-forming limestone.

The upper part of the group is the Bursum Formation, a thin red-bed unit.

LOS MOYOS LIMESTONE

Los Moyos Canyon, the feature for which the limestone is named, is on the Isleta Indian Reservation in the Tajique and Bosque Peak quadrangles, Torrance County. The canyon is in secs. 11 and 12, T. 7 N., R. 5 E. (projected), where a nearly complete sequence of the Los Moyos is exposed (figs. 1, 2). However, as access to this area is difficult, the type section is designated as exposures on the walls of a ravine that drains into Priest Canyon through a hogback in the southwestern part of the Torreon 15-minute quadrangle, sec. 7, T. 3 N., R. 5 E., Valencia County (figs. 1, 2). The sequence in Los Moyos Canyon and a sequence exposed at Sol se Mete (Myers and McKay, 1970) in the Mount Washington quadrangle, sec. 29, T. 9 N., R. 5 E., Bernalillo County (figs. 1, 2), are designated as reference sections.

The Los Moyos Limestone is everywhere about 600 feet thick. The basal few feet of beds is gradational from the dark-colored calcareous shale and shaly limestone of the uppermost Sandia Formation. The lower 80–100 feet is cliff-forming olive- to medium-gray calcarenite containing large amounts of dark-brown

to black chert that weathers to a characteristic rusty brown. These basal beds are overlain by cliff-forming cherty gray limestone, thin beds of dark-colored shale, and minor amounts of grayish-orange to orange siltstone, sandstone, and conglomerate.

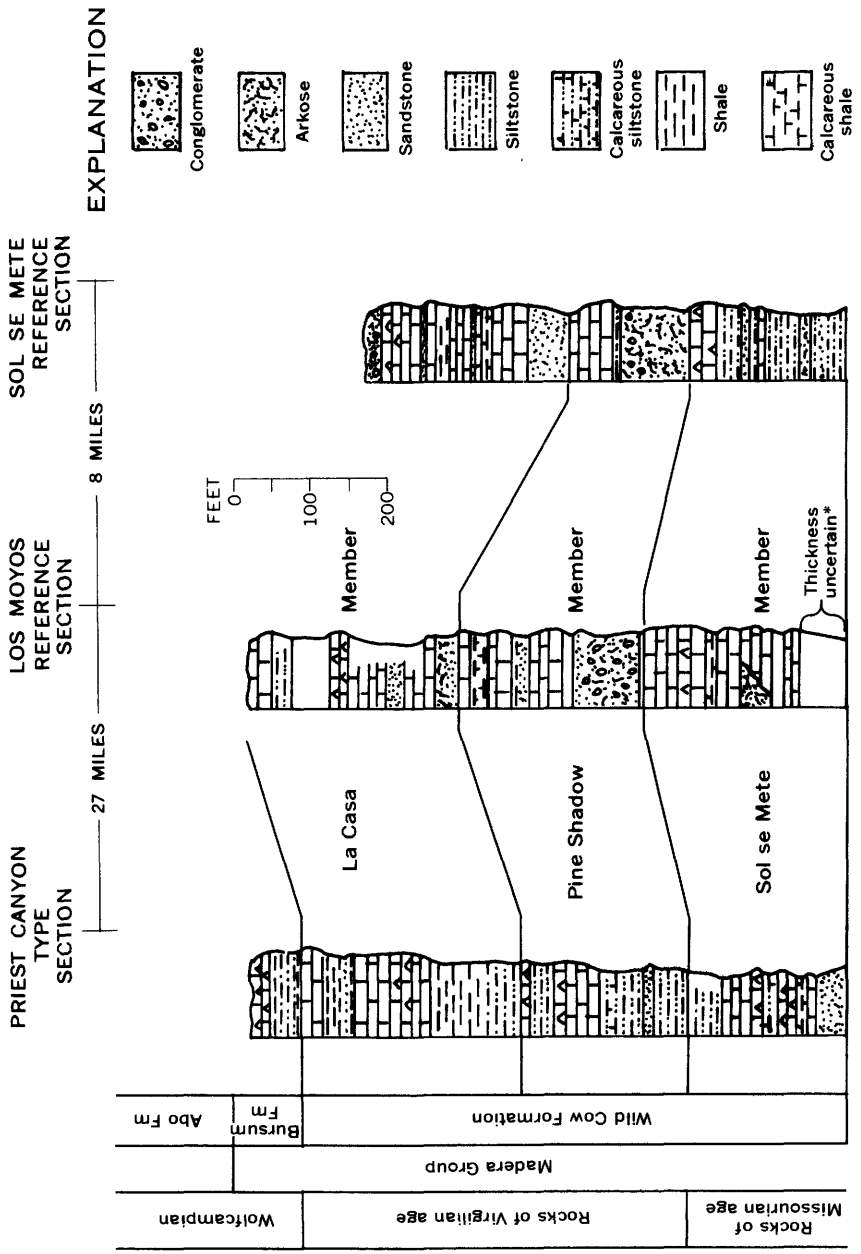
Sandy beds are present in the lower and upper parts of the limestone; they are less common in the middle part. They are lenticular and grade laterally into arenaceous and argillaceous limestone; they range in texture from siltstone to conglomerate, and, in places, they appear to be channel deposits.

The top of the Los Moyos is the top of a cliff-forming calcarenite that in most places contains nodular masses of brown-weathering black chert.

Age and correlation.—The lower 20 feet of the limestone contains *Fusulinella* cf. *F. famula* Thompson, 1948, *Fusulinella* aff. *F. devexa* Thompson, 1948, and a primitive species referred to the genus *Wedekindellina*. The occurrence of primitive species of *Wedekindellina* with *Fusulinella* in the lowermost beds of the Los Moyos suggests that rocks of earliest Des Moinesian age are present in the Manzano Mountains. In the Joyita Hills, about 20 miles southwest, Kottlowski and Stewart (1970, fig. 5, p. 14, 29) reported that the lower part of their Des Moines sequence was missing. Somewhat higher but still in the basal beds are found *Beedeina* aff. *B. arizonensis* (Ross and Sabins), 1965, *Eoschubertella* aff. *E. bluensis* Ross and Sabins, 1965, and other fusulinids that are apparently transitional between *Fusulinella* and *Beedeina*.

Fusulinids are generally sparse in the uppermost beds of the Los Moyos. Locally, *Eowaeringella* aff. *E. ultimata* (Newell and Keroher), 1937, has been found within 10 feet of the top; somewhat lower but still within 80 feet of the top, the fusulinids *Beedeina* cf. *B. sulphurensis* (Ross and Sabins), 1965, *Beedeina novamexicana* (Needham), 1937, *Beedeina rockymontana* (Roth and Skinner) 1930, *Beedeina* cf. *B. bowiensis* (Ross and Sabins) 1965, and *Wedekindellina ellipsoides* Dunbar and Henbest, 1942, have been found.

The Los Moyos was deposited during Des Moinesian and earliest Missourian time. It is approximately equivalent to the Strawn and Canyon (lowermost) Groups in north-central Texas and to the upper part of the Horquilla Limestone in southeast Arizona (Ross and Sabins, 1965). The Los Moyos is the lower gray limestone of Read, Wilpolt, Andrews, Summerson, and Wood (1944), the lower part of the Madera Limestone (Myers, 1966, 1967a, 1969, Myers and McKay, 1970, 1971, 1972), and is probably equivalent to the Gray Mesa Member of the Madera Limestone (Kelley and Wood, 1946).


EXPLANATION
Conglomerate
Arkose
Sandstone
Siltstone
Calcareous siltstone
Shale
Calcareous shale
PRIEST CANYON TYPE SECTION
27 MILES
LOS MOYOS REFERENCE SECTION
8 MILES
SOL SE METE REFERENCE SECTION
FEET
0
100
200
La Casa Member
Pine Shadow Member
Sol se Mete Member
Thickness uncertain*
Rocks of Missourian age
Rocks of Virgilian age
Wolfcampian
Madera Group
Wild Cow Formation
Bursum Fm
Abo Fm

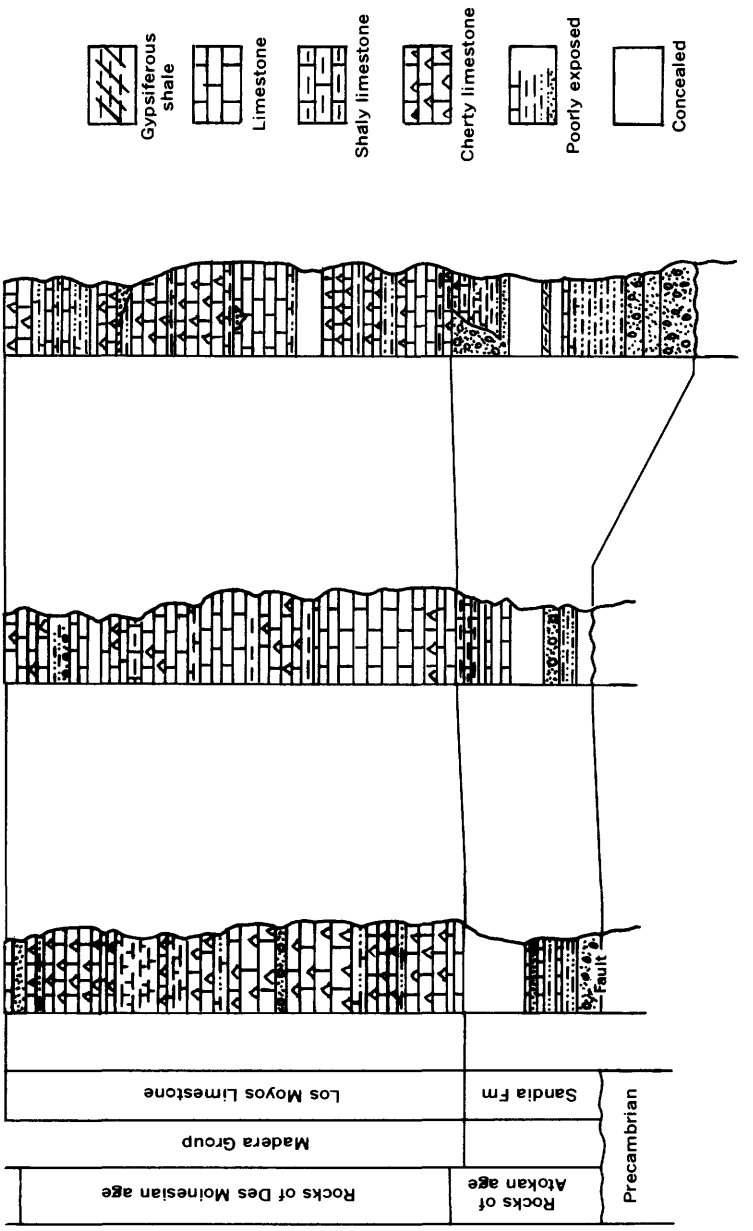


FIGURE 2.—Type and reference sections for the Los Moyos and Wild Cow Formations, Madera Group. Section of Wild Cow Formation in Los Moyos area is composite (Myers, 1966, sections 4, 5, 6). *Thickness of concealed basal interval represents maximum possible; minimum is about 50 feet less than shown.

WILD COW FORMATION

The name Wild Cow Formation is here proposed for the sequence of rocks that overlies the Los Moyos Limestone and underlies the red-bed–limestone sequence of the Bursum Formation. Where the Bursum cannot be recognized, the red beds of the Abo Formation overlie the Wild Cow Formation. The Wild Cow consists of rhythmic sequences of arkosic sandstone and conglomerate, gray to yellow siltstone and shale, and thin- to thick-bedded gray limestone. It is divided into three members, in ascending order: Sol se Mete, Pine Shadow, and La Casa. The type section of the formation and its three members is designated as exposures on the west side of Priest Canyon in an east-draining ravine that cuts through a hogback in sec. 7, T. 3 N., R. 5 E., Valencia County, in the Torreon Southwest quadrangle (figs. 1, 2). Reference sections are in the Tajique quadrangle (fig. 2) and in the vicinity of Sol se Mete (fig. 2) in the northern part of the Manzano Mountains (Myers and McKay, 1970). The name is taken from Wild Cow Spring in the NE¼ sec. 19, T. 4 N., R. 5 E., Torrance County, in the southwestern part of the Torreon 15-minute quadrangle. It is the arkosic limestone member of the Madera Limestone (Read and others, 1944), it is probably equivalent to the Atrasado Member of the Madera Limestone (Kelley and Wood, 1946), and it is units B, C, and D of the upper part of the Madera Limestone (Myers, 1966, 1967a, 1969; Myers and McKay, 1970, 1971, 1972).

SOL SE METE MEMBER

The basal sequence of rocks in the Wild Cow Formation is here named the Sol se Mete Member. The name is taken from a hill bearing that name in the SW¼ sec. 28, T. 9 N., R. 5 E., in the Mount Washington quadrangle, where there are good exposures. Inasmuch as Sol se Mete is on the Sandia Military Reservation and free access is not always possible, the type section is designated as exposures in Priest Canyon mentioned in the discussion of the Wild Cow Formation. The exposures on Sol se Mete are designated as a reference section.

The contact of the Sol se Mete Member with the underlying Los Moyos Limestone is marked by the base of a conglomerate, or coarse to fine sandstone, or siltstone. The thickness of the basal clastic unit ranges from about 15 to 100 feet or more. In many places the basal unit is arkosic and contains angular to subrounded fragments of metamorphic rock. Locally, petrified logs are common, some of which may be 8 feet or more in length. This basal conglomeratic unit is the Coyote Sandstone (Herrick, 1900, p. 115) and is the Coyote Sandstone Member of the Madera. Inas-

much as the Coyote is not a mappable unit, its use is herein abandoned.

The clastic unit is generally gradationally overlain by a poorly exposed sequence of calcareous gray shale that may contain nodules of limestone. Locally, near the top, minor amounts of red beds are present. The top of the member consists of 30–60 feet of gray limestone, locally cherty, that forms a cliff.

The thickness of the member averages about 200 feet, and it ranges from about 150 to about 300 feet. It appears to be thinnest in the southern part of the Manzano Mountains where much of the limestone has been replaced by siltstone and fine-grained sandstone.

The Sol se Mete contains species of *Triticites* that resemble those from the Canyon Group of north-central Texas (Myers, 1960, 1967b) and from the Missourian Series of the midcontinent region. It is unit B of the upper part of the Madera Limestone (Myers, 1966, 1967a, 1969; Myers and McKay, 1970, 1971, 1972).

PINE SHADOW MEMBER

The middle sequence of rocks in the Wild Cow Formation is here named Pine Shadow Member. The name is taken from Pine Shadow Spring near the head of Priest Canyon in the SW¼ sec. 16, T. 4 N., R. 5 E. The type section (fig. 2) is designated as exposures mentioned in the discussion of the Wild Cow Formation. Exposures near Sol se Mete (fig. 2; Myers and McKay, 1970, section 3) are designated as a reference section. In the central part of the Manzano Mountains, exposures in the Tajique quadrangle (Los Moyos section, fig. 2) are designated as reference section (Myers, 1966, section 5).

Throughout most of the Manzano Mountains, the base of the Pine Shadow is arkosic conglomerate that rests on the uppermost limestone of the Sol se Mete Member. The conglomerate, which weathers reddish brown, generally forms a steep slope and locally forms ledges. It is composed of cobble-sized rounded to subrounded fragments of metamorphic rocks in a poorly sorted arkosic matrix that contains fragments of fossil wood in many places. Bedding planes are commonly ripple marked. At the type section, and elsewhere in the southern part of the mountains, the basal unit is yellow to brown micaceous siltstone and fine sandstone that contains fragments of carbonized plant debris and sparse fragments of fossil wood. The basal clastic unit is generally 50–90 feet thick, although locally it may be as thin as 5 feet and as thick as 100 feet or more. The basal clastic beds are overlain

by relatively thin beds of yellow to gray siltstone and minor amounts of shale that become calcareous toward the top.

The uppermost beds of the member are ledge to cliff forming. At the reference section near Sol se Mete (fig. 2), they consist of limestone in a single bed about 50 feet thick. Farther south, in the Tajique area, they consist of three beds of limestone separated by sandstone and calcareous shale, and at the type section they consist of two beds of limestone separated by siltstone. The limestone is mostly light-olive-gray calcarenite and is locally cherty. It is generally 50–70 feet thick but locally is as much as 130 feet thick. In the central and southern parts of the mountains, it forms a conspicuous bluff and locally forms a cliff.

The Pine Shadow Member contains species of *Triticites* that resemble those from the lower part of the Virgilian Series of the midcontinent region. The fusulinids have affinities to those from the Graham Formation of north-central Texas (Myers, 1960), to the faunas from the Gaptank Formation of west Texas (Ross, 1965, beds G, H, I), and to the triticite fauna from the lower part of the Earp Formation in the Whetstone Mountains in southeast Arizona (Ross and Tyrrell, 1965). The Pine Shadow is unit C of the upper part of the upper Madera (Myers, 1966, 1967a, 1969; Myers and McKay, 1970, 1971, 1972).

LA CASA MEMBER

The sequence of rocks that overlies the Pine Shadow Member and underlies the Bursum Formation is here named the La Casa Member. The name is taken from La Casa Spring in the SW¼ NE¼ sec. 6, T. 3 N., R. 5 E., Torreon quadrangle, Valencia County. The type section is the same as that for the Wild Cow Formation. The member, about 290 feet thick at the type section, is at the top of the Wild Cow Formation.

At the type section (fig. 2) the member, in ascending order, consists of about 120 feet of poorly exposed siltstone and shale, about 100 feet of light-gray calcarenite, the lower 70 feet of which forms a pronounced ridge, and a thin sequence of red and gray shale and yellowish-green calcareous sandstone. The top of the member is a 30-foot-thick bed of light-olive-gray calcarenite.

Farther north, the basal clastic beds are arkosic and locally a conglomerate. The beds are somewhat thinner than at the type section; in the Tajique area they are about 30 feet thick, and in the Sol se Mete area, about 50 feet thick. The 100-foot-thick bed of limestone mentioned in the preceding paragraph has been replaced by alternating sequences of limestone, siltstone, sandstone, and shale, and the top beds of the member have been stripped by

recent erosion. The La Casa Member appears to thicken to the north, and if the preerosional surface were restored, the member would probably be about 320–350 feet thick in the vicinity of Sol se Mete.

The La Casa Member is unit D of the upper part of the upper Madera Limestone of Myers (1966, 1967a, 1969) and Myers and McKay (1970, 1971, 1972). Fusulinids from the member consist of species of *Triticites* that indicate deposition during middle and late Virgilian time. The member is approximately equivalent to the uppermost Graham and Thrifty Formations in north-central Texas, to the upper part of the Gaptank Formation in west Texas, and to the lower member of the Earp Formation in the Whetstone Mountains of Arizona (Ross and Tyrrell, 1965). Fusulinids similar to, but not conspecific with *Triticites creekensis* Thompson, 1954, have been found in the uppermost beds of the member. The presence of these fusulinids suggests that the uppermost beds may be of earliest Wolfcamp age.

BURSUM FORMATION

The uppermost formation of the Madera Group, the Bursum, gradationally overlies the La Casa Member of the Wild Cow Formation. The Bursum was described (Wilpolt and others, 1946) for 28–234 feet of red and green shale, arkose, arkosic conglomerate, and gray limestone in the northern part of the Oscura Mountains. The limestone contains *Schwagerina* and obese *Triticites ventricosus* (Wilpolt and others, 1946).

In the southern part of the Manzano Mountains, the Bursum is a sequence of lenticular red, arkosic, hematitic sandstone, red and locally green shale, and greenish-gray calcarenite; it forms a gently sloping surface to the east and southeast. Exposures of the formation are generally poor, as most of it is masked by surficial deposits. The top of the Bursum is the top of the highest marine limestone that underlies the Abo Formation. The thickness is in excess of 100 feet in the Priest Canyon area.

Northward from Priest Canyon the formation either becomes thinner or is replaced by the overlying Abo Formation. In the vicinity of Red Canyon and in the Torreon 7½-minute quadrangle, the Bursum is not a mappable unit, and the beds have been included with the La Casa Member of the Wild Cow Formation.

In the northern half of the Manzano Mountains, the Bursum is absent in most places. Field evidence suggests that north of Pine Shadow Spring many of the red beds of the Bursum have been replaced by gray shale and limestone. If such replacement has oc-

curred, then the uppermost beds of the La Casa Member include Bursum equivalents in the northern Manzano Mountains.

Fusulinids described by Thompson (1954, p. 18) include *Schwagerina pinosensis* Thompson, 1954, from the Bursum in Abo Canyon at the south end of the Manzano Mountains. On the basis of these and other fusulinids from the Bursum described by Thompson (1954), that formation is determined to be of Wolfcamp age.

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