New Mexico Geological Society

Downloaded from: https://nmgs.nmt.edu/publications/guidebooks/30



The Mississippian System of north-central New Mexico

Augustus K. Armstrong and B. L. Mamet
1979, pp. 201-210. https://doi.org/10.56577/FFC-30.201

in:

Santa Fe Country, Ingersoll, R. V. ; Woodward, L. A.; James, H. L.; [eds.], New Mexico Geological Society 30 th Annual Fall Field Conference Guidebook, 310 p. https://doi.org/10.56577/FFC-30

This is one of many related papers that were included in the 1979 NMGS Fall Field Conference Guidebook.

Annual NMGS Fall Field Conference Guidebooks

Every fall since 1950, the New Mexico Geological Society (NMGS) has held an annual Fall Field Conference that explores some region of New Mexico (or surrounding states). Always well attended, these conferences provide a guidebook to participants. Besides detailed road logs, the guidebooks contain many well written, edited, and peer-reviewed geoscience papers. These books have set the national standard for geologic guidebooks and are an essential geologic reference for anyone working in or around New Mexico.

Free Downloads

NMGS has decided to make peer-reviewed papers from our Fall Field Conference guidebooks available for free download. This is in keeping with our mission of promoting interest, research, and cooperation regarding geology in New Mexico. However, guidebook sales represent a significant proportion of our operating budget. Therefore, only *research papers* are available for download. *Road logs*, *mini-papers*, and other selected content are available only in print for recent guidebooks.

Copyright Information

Publications of the New Mexico Geological Society, printed and electronic, are protected by the copyright laws of the United States. No material from the NMGS website, or printed and electronic publications, may be reprinted or redistributed without NMGS permission. Contact us for permission to reprint portions of any of our publications.

One printed copy of any materials from the NMGS website or our print and electronic publications may be made for individual use without our permission. Teachers and students may make unlimited copies for educational use. Any other use of these materials requires explicit permission.

This page is intentionally left blank to maintain order of facing pages.

THE MISSISSIPPIAN SYSTEM OF NORTH-CENTRAL NEW MEXICO

AUGUSTUS K. ARMSTRONG
U.S. Geological Survey
345 Middlefield Road
Menlo Park, California 94025
and
BERNARD L. MAMET
Department of Geology
University of Montreal
Montreal, Quebec

INTRODUCTION

The generalized map of the total thickness of Mississippian rocks (fig. 1) shows disconnected areas of Mississippian rock that are remnants of extensive sheets; these sheets were dissected and beveled in northern and central New Mexico in Namurian (Chesterian) time and over the entire state by erosion on structurally active features in Pennsylvanian and Permian time.

Flooding of the state by Mississippian seas began in early Tournaisian time (pre-Zone 7) in the southwestern and south-central part of the state, forming the Escabrosa carbonate platform. By the end of Tournaisian (Osagean) time, epicontinental seas had flooded the northern and central parts of the state. Two low islands may have existed, the Zuni highlands and remnants of the transcontinental arch, the Pedernal highlands (fig. 1). The Espiritu Santo Formation (figs. 2-4) is composed of carbonate tidal deposits in the Sangre de Cristo, Sandia, Nacimiento and San Pedro mountains of north-central New Mexico (Armstrong, 1967; Armstrong and Mamet, 1977a, 1978; Vaughan and others, 1977). The Leadville Limestone is the time-stratigraphic equivalent in the San Luis basin and is an eastern extension of the Redwall Limestone of Arizona. The end of Tournaisian (Osagean) time is marked by a marine regression, a regional uplift, and extensive erosion of the Tournaisian (Osagean) carbonate deposits (figs. 2-4).

The geographic and stratigraphic extent of this hiatus at the end of the Tournaisian (Osagean) is shown in Figures 2-4. A major regional marine transgression occurred in middle Visean (Meramecian) time and is represented by the massive encrinites of the Hachita Formation in the southwestern part of the state, the deeper water carbonate rocks of the Rancheria Formation of Laudon and Bowsher (1949) in the southern San Andres and Sacramento mountains, and in north-central New Mexico by the Turquillo and Manuelitas members (Meramecian) of the Tererro Formation. Late Visean carbonate rocks of Zone 16i (Chesterian) also are distributed widely in disjunct outcrops. These are the Cowles Member of the Tererro Formation, the upper part of the Rancheria Formation, and the lower part of the Paradise Formation.

Marine sedimentation ceased in northern and central New Mexico at the end of Zone 16i time. In southwestern New Mexico, marine sedimentation continued into Zone 19. There, the Paradise Formation (fig. 2) is a series of shallow-water, shoaling to nearshore, oolitic carbonate rocks and plant-fossil-bearing, crossbedded sandstone and siltstone. The Helms Formation to the east is a deeper-water facies of the Paradise Formation (Armstrong and Mamet, 1978).

The Log Springs Formation (Armstrong, 1955) of the San Pedro, Nacimiento, Jemez and Sandia mountains unconformably overlies the Arroyo Penasco Group, and in turn, is truncated by limestone of Pennsylvanian (Zone 20) age (fig. 3). The Log Springs Formation is composed of terrigenous, red-brown, iron-rich shale, siltstone and lithic to arkosic conglomerate formed of angular cobbles of Precambrian and Mississippian rocks. It is interpreted as being post-Zone 16i and pre-Zone 20, or Namurian (Chesterian) in age, and represents in part a regolith and tectonically derived sediments washed into small basins adjacent to uplifted, faulted and tectonically active highlands (figs. 2-4).

THE ARROYO PEISiASCO GROUP

Espiritu Santo Formation

The Del Padre Sandstone Member (Sutherland, 1963) of the Espiritu Santo Formation (Baltz and Read, 1960) has been observed in all the sections in north-central New Mexico. Its maximum known thickness is 15 m at Lujan Canyon. Studies by Armstrong and Mamet (1974, 1977a) show that the carbonate rocks of the Espiritu Santo Formation consist of dolomite, dedolomite and coarse-grained poikilotopic calcite with corroded dolomite rhombs. Where the rocks are not dolomitized, stromatolitic algal mats, Spongiostromata mats, echinoderm wackestone, kamaenid mudstone rich in birdseyes, oncolitic-bothrolitic mats and related features are visible. This association suggests very shallow-water sedimentation and intertidal to supratidal carbonate blankets.

The microfauna usually is unrecognizable in the dolomite and dedolomite; however, chert beds usually preserve the outline of foraminiferal tests, and stratigraphically useful microfossil assemblages can be detected. The most important taxa are: abundant *Calcisphaera laevis* Williamson, *Endothyra* sensu stricto, *Latiendothyra* of the group *L. parakosvenis, Septabrunsiina parakrainica* Skipp, Holcomb, and Gutschick, *Septatournayella pseudocamerata* Lipina *in* Lebedeva and *Spinoendothyra spinosa* (Chernysheva). The assemblage clearly indicates Zone 9 and is late Tournaisian in age.

In the region under study, carbonate rocks of the Espiritu Santo everywhere rest on the Del Padre Sandstone Member. The maximum thickness of the Espiritu Santo is 29 m in the Nacimiento Mountains.

Tererro Formation

Above the Espiritu Santo Formation is a collapse breccia that Baltz and Read (1960) named the Macho Member of the Tererro Formation. The mode of formation of this unit is difficult to assess. It could have been formed by subaerial exposure after deposition of the Espiritu Santo Formation, or it could be the result of dissolution by meteoric ground water

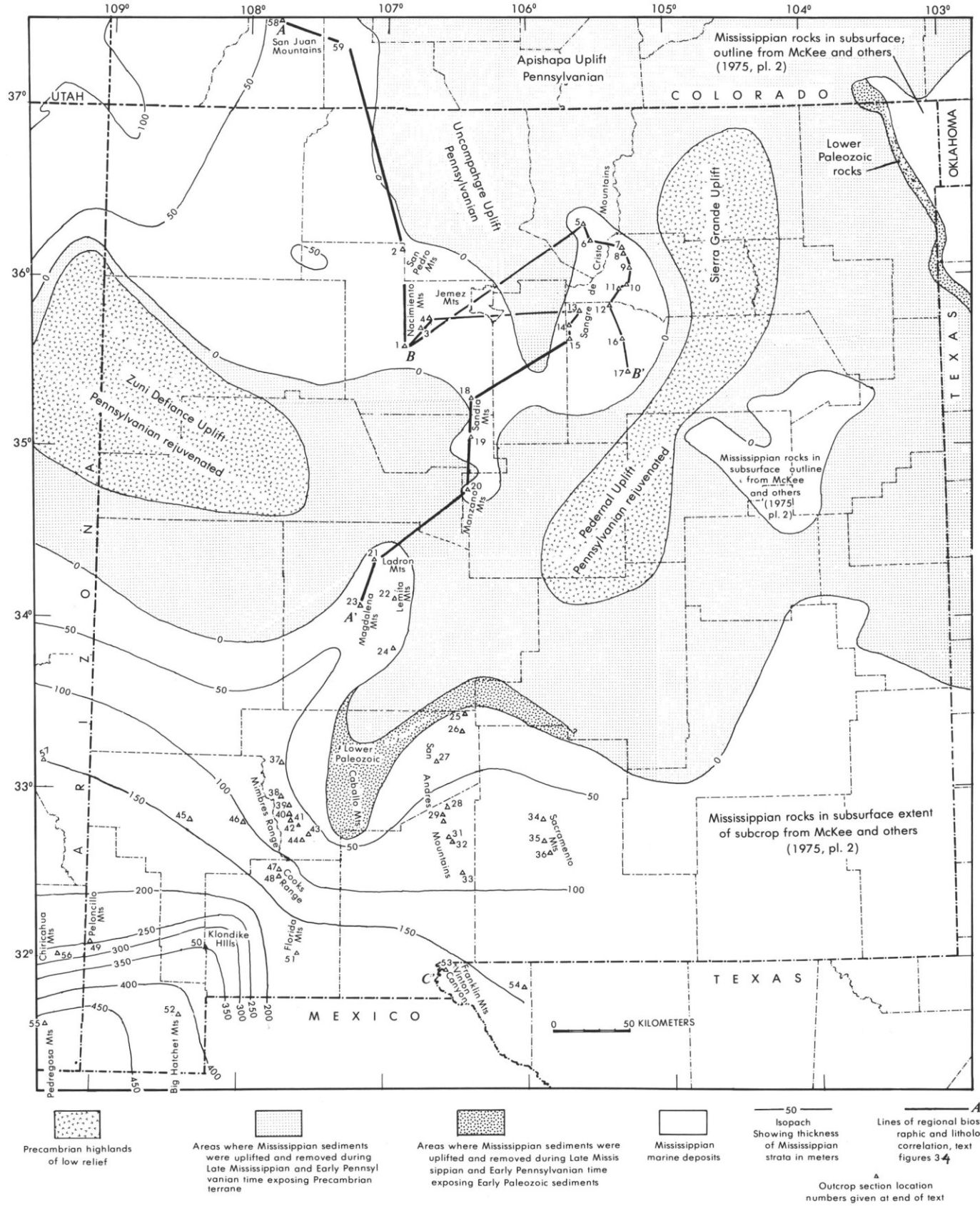


Figure 1. Location of Mississippian outcrop sections, pre-Pennsylvanian-Mississippian paleogeography, isopachs drawn on Mississippian strata, and location of lines of biostratigraphic correlation charts. Modified from Armstrong and others (1979).

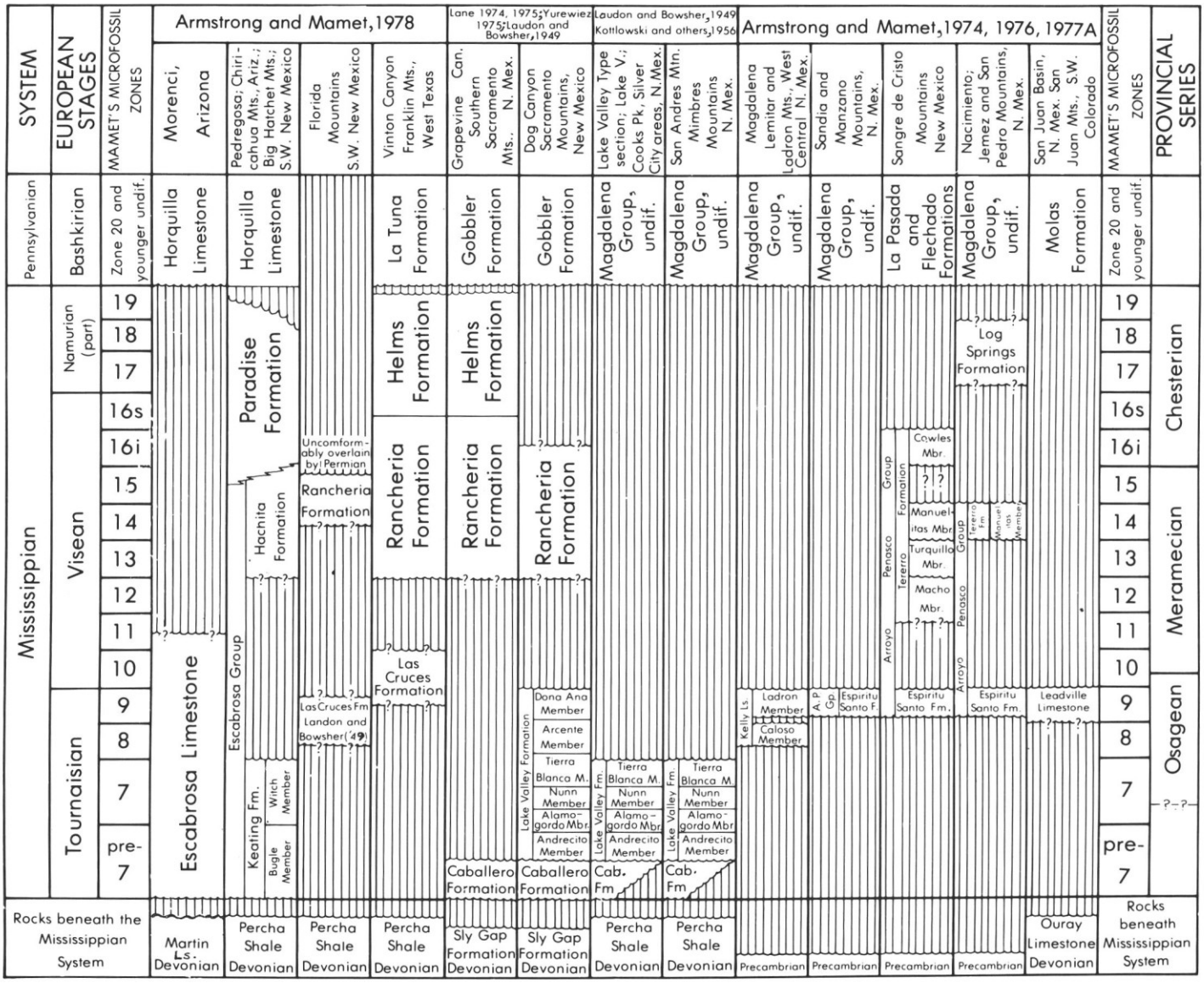


Figure 2. Correlation chart of Mississippian rocks of New Mexico. Modified from Armstrong and others (1979).

during the late Carboniferous (Armstrong, 1967). In the Tererro section, the lower 4.5 m of the Macho Member contain blocks of foraminiferal pelletoidal wackestone that yield Tournaisian *Spinoendothyra* assemblages, while the matrix of the block yields Visean *Eoendothyranopsis,* notably *Eoendothyranopsis macro* (Zeller) and *Eoendothyranopsis* of the group *E. ermakiensis* (Lebedeva). In this section, the formation of the breccia coincides with a hiatus that spans the entire zones 10-13 time. In other sections, such as those at Lujan Canyon and Turquillo, the breccia is overlain by algal mudstone that contains zones 12/13 microfossils. At all localities, the upper parts of the breccia contain collapsed blocks derived from the overlying Turquillo Member (Armstrong and Mamet, 1974); these blocks contain a middle Visean microfauna.

Most of the blocks of Espiritu Santo rocks observed in the base of the Macho Member have late Tournaisian microfossils. The matrix is much younger, middle to late Visean in age.

The Macho Member is not present in the Nacimiento Mountains or San Pedro Mountain, where the upper Visean Manuelitas Member (Baltz and Read, 1960) rests directly on the upper Tournaisian part of the Espiritu Santo Formation. In the Sandia and Jemez mountains, only the Espiritu Santo Formation of the Arroyo Pefiasco Group is present beneath the Pennsylvanian unconformity.

The Turquillo Member of the Tererro Formation is a thick-bedded mudstone-wackestone, rich in foraminifers and bothrolites. Where the Macho Member is absent, the Turquillo Member rests with disconformity on the eroded Espiritu Santo Formation. This relationship is observed at the Ponce de Leon Springs section east of Taos, where the Turquillo Member is 2.5 m thick. It is 2.5, 1.2, 3 and 4.5 m thick at Agua Zarca, Lujan Canyon, Gallinas Canyon and Mora Gap, respectively; in these four localities, the Turquillo Member rests on breccia of the Macho. At the Mora Gap section, the Turquillo includes widespread intraformational conglomerate.

Foraminifers are abundant in the Turquillo Member. In particular, *Eoendothyranopsis* of the group *E. spiroides* (Zeller), *E. scitula* (Toomey), *E. hinduensis* (Skipp *in* McKee and Gut-

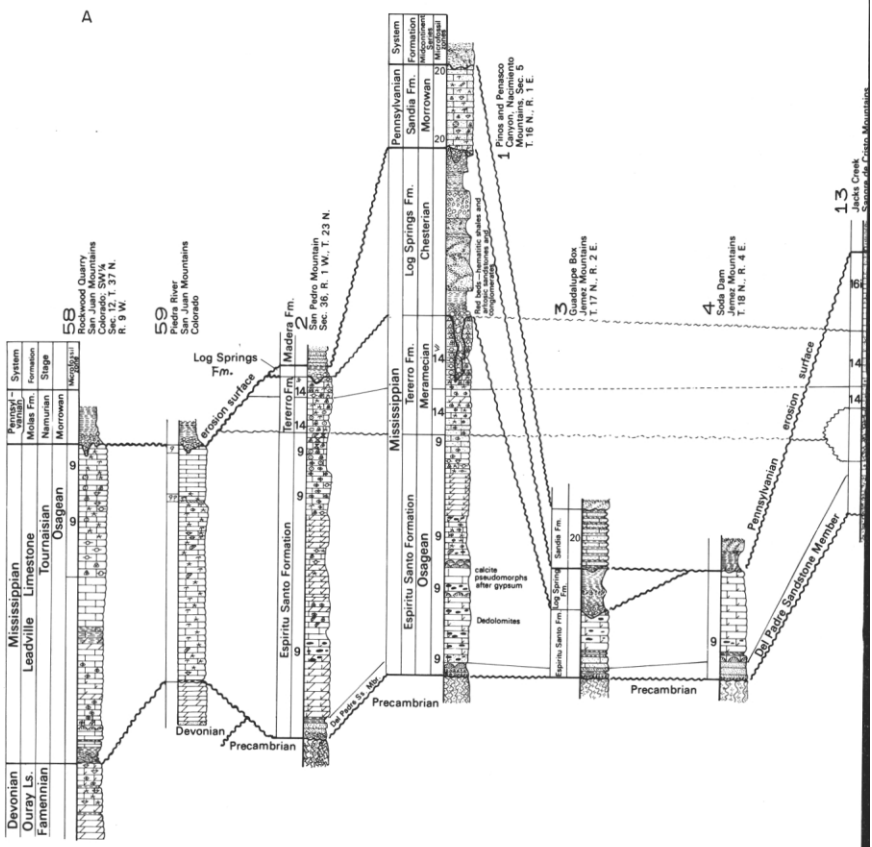


Figure 3. Regional biostratigraphic and lithologic correlation (A-A') for Mississippian strata from the San Juan Mountains of southwestern Colorado to the San Pedro, Nacimiento, Jemez, Sangre de Cristo, Sandia,

schick), E. prodigiosa (Armstrong) and primitive *Endothyranoxis* biseriamminids are present. The dasyclad *Koninckopora* is widespread. The fauna indicates the transition from Zone 12 to Zone 13.

The Manuelitas Member of the Tererro Formation (Baltz and Read, 1960) is composed of two readily identifiable units: thick-bedded oolitic-bothrolitic grainstone, and silty pelletoidal fine-grained grainstone-packstone with minor calcareous silt. The oolite ranges in thickness from 1 m (at Agua Zarca, Lujan Canyon and Jacks Creek) to 6 m and even 10 m (at Turquillo and Gallinas Canyon, respectively). The oolite is clearly transgressive and rests on the Espiritu Santo Formation, or the Macho or Turquillo members of the Tererro Formation.

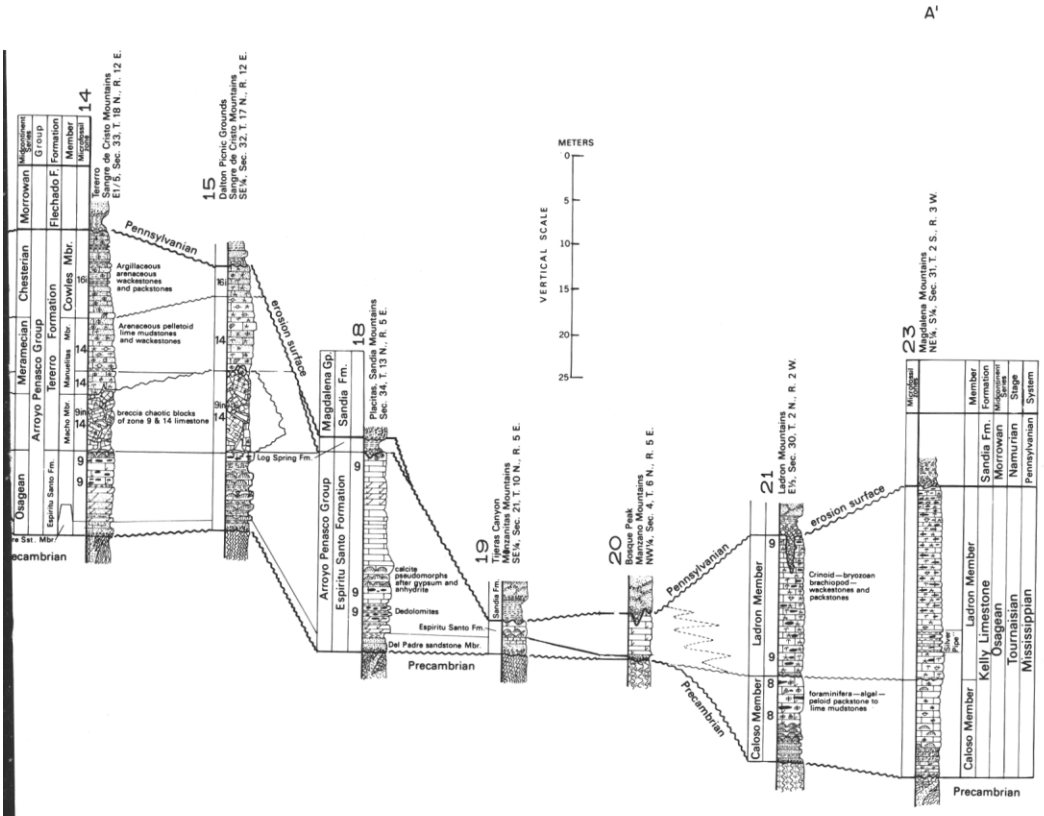
The finer-grained pelletoidal unit is considered here to be a lateral equivalent of the oolitic unit as they interfinger and their thicknesses are complementary; where the oolite unit is thin, the pelletoidal facies is thick. The pelletoidal facies reaches a maximum thickness of 8.5 m at the Dalton picnic ground section and at the Turquillo section.

The oolitic unit is rich in foraminifers. The association of *Eoendothyranopsis macra* (Zeller), *Eoendothyranopsis* of the group *E. ermakiensis* (Lebedeva), *E. prodigiosa* (Armstrong), *Endothyranopsis* of the group *E. compressa* (Rauzer-Chernoussova and Reitlinger) and *Globoendothyra paula* (Vissarionova) clearly indicates a St. Louis age equivalent (Zone 14). Algae are abundant and numerous broken thalli of the dasyclad *Koninckopora* are present. Stachein algae are represented by *Stacheia, Stacheoides,* and *Aoujgalia.*

The pelletoidal facies is poorer in foraminifers and contains mostly minute archaediscids (notably *Archaediscus krestovnikovi* Rauzer-Chernoussova and *Archaediscus? pachytheca* Petry k). Young forms of *Eoendothyranopsis, Endothyranopsis* and *Globoendothyra* also are found and are very scarce. It is difficult to give a precise age on such material; characteristic foraminiferal assemblages of zones 14 and 15 are composed of quite large indexes, which are not present as adult forms in the pelletoidal sieved fauna. As we already have suggested, the pelletoidal facies is probably a lateral equivalent of the oolitic facies (Zone 14). Moreover, the St. Louis megafauna listed by Fitzsimmons and others (1956) comes from that level, and it is, therefore, certain that the unit is not much younger than Zone 14.

The Cowles Member of the Tererro Formation (Baltz and Read, 1960) consists of recessive silt, calcareous silt, shale, pelletoidal fine-grained silty limestone and fine-grained ostracode mudstone. The Cowles Member is known only in the Sangre de Cristo Mountains, and everywhere in that region, rests on the Manuelitas Member; the contact appears paraconformable. The top of the formation is eroded everywhere and overlain unconformably by Pennsylvanian clastic rocks. Its apparent thickness is 0.5 m at Turquillo, 2.5 m at Rio Pueblo, 3 m at Mora Gap, 4.5 m at Coco City, 10 m at Jacks Creek and 10.1 m at Lujan Canyon.

Like that of the Manuelitas Member, the microfauna of the Cowles Member is composed almost exclusively of very small, rolled, abraded and often mud-filled foraminifers; these are mostly Archaediscidae with few Endothyridae and Eostaffellidae. The presence of primitive *Neoarchaediscus* and of *Zellerma* clearly clearly indicates that the Espiritu Santo Formation is



Manzano, Ladron and Magdalena mountains of northern New Mexico. Modified from Armstrong and Mamet (1977a) and Armstrong and others (1979).

younger than Meramecian and should be regarded as early Chesterian age equivalent. There is, therefore, no proof of the existence of Ste. Genevieve fauna between the Manuelitas Member and the Cowles Member.

Paleogeography

Armstrong and Mamet (1974) stated that the Arroyo Perlasco Group, although thin, spans a considerable part of Carboniferous time, and in this respect, is comparable to the condensed Amsden Formation of Wyoming.

The paleogeographic history of the succession is exceedingly complex and may be summarized as follows:

(1) The Del Padre Member transgression occurred from south to north on a peneplaned Precambrian craton. Few basal conglomerates are present. The sandstone and silt are clean and have little detrital feldspar. These arenites filled all the fractures and depressions, and transformed the region into a uniformaly flat platform, which was changed immediately into a carbonate sabkha.

(2) The Espiritu Santo Formation represents a succession of tidal flats and sabkhas leading to evaporites. Dolomite and dedolomite are abundant. Abundant chert or calcite pseudomorphs of gypsum blades indicate hypersaline conditions. Algae such as spongiostromids, stromatolites, kamaenid filaments *(Kamaena, Pseudokamaena, Palaeoberesella),* calcisphere cysts and orthonellid bushes are present in all the limestones.

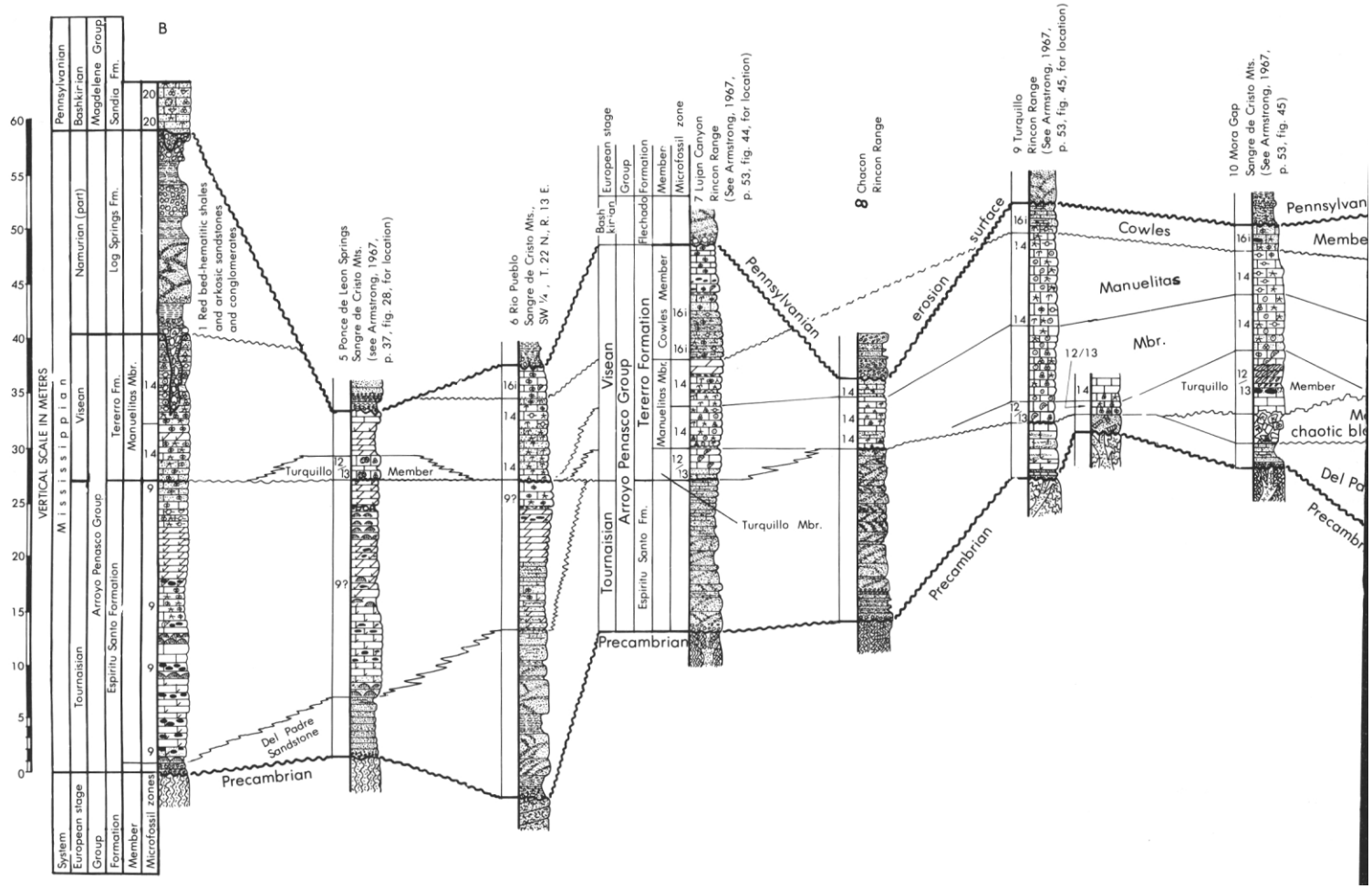
(3) The early Visean Macho Member regression left this 30.4-m-thick sequence of evaporites and carbonate deposits exposed to subaerial erosion. Percolation of ground water through these deposits formed a karst with a thick, continuous blanket of collapse breccia. This breccia probably was exposed during the whole length of the early Visean and formed a chaotic land surface. The Turquillo-Member transgression from the south shows this chaotic surface by erratic patterns of deposition.

The Turquillo and Espiritu Santo seas must have been quite similar, as shown by the proliferation of spongiostromid-stromatolite limestone. However, the Turquillo sea remained entirely normal marine where foraminifers thrived, associated with abundant red algae (stacheins) and dasyclads *(Koninckopora).*

(4) The Manuelitas-Member transgression overlapped the Turquillo, and the whole platform was covered by turbulent oolite banks. As in the preceding facies, the fauna and flora thrived; abundant blue-green algae thalli are observed as oolite nuclei or filled with mud. The sieved fauna and flora are characteristic of the associated pelletoidal fine-grained facies. Some silt, shale and fine-grained grainstone with abundant algal pellets also were deposited.

It is difficult to assess if a regression occurred after the Manuelitas Member was deposited. Zone 15 age equivalents have not been found. However, the basal part of the Cowles Member consists of calcareous silt and shale devoid of foraminifers, and the uppermost Meramecian could be condensed there. If Zone 15 is present, it is no more than a few meters thick. If it is absent, a paraconformity is plausible.

(5) Like most of the Chesterian formations of the American and Canadian Cordillera, the upper Visean Cowles Mem-



ber is composed of regressive facies. The end of this clean Visean carbonate-platform deposition is too abrupt and too widespread to be caused only by a regression and a change of source material; a climatic change also must have occurred.

(6) The paleogeography of the Cowles Member in the Sangre de Cristo Mountains is difficult to assess as the unit has been eroded deeply.

BIOSTRATIGRAPHIC CORRELATIONS

Detailed discussions of the paleoecology, and the stratigraphic and geographic distribution of the microfossil assemblage zones used to correlate the Mississippian rocks of north-central New Mexico can be found in Sando and others (1969), Mamet (1976), Armstrong and Mamet (1977b), and Gordon and Mamet (1978). Microfossil lists for the outcrop section A-A' (fig. 3) for the San Juan, San Pedro, Nacimiento, Jemez, Sandia and Ladron mountains can be found in Armstrong and Mamet (1974, 1976, 1977a). The following microfossil lists are for the Arroyo Pefiasco Group of the Sangre de Cristo Mountains.

jacks Creek section (13)
Tererro Formation
Manuelitas Member
Lower part, 11.6-14 m (oolitic facies): USGS loc. M1381

Aoujgalia sp.
Calcisphaera pachysphaerica (Pronina)
Endothyra of the group *E. bowman!* Phillips *emend* Brady *[E. irregularis* (Zeller)]
Endothyranopsis sp.
Eoendothyranopsis of the group *E. ermakiensis (Lebedeva)*
Eoendothyranopsis macro (Zeller)
Eoendothyranopsis prodigiosa (Armstrong)
Eoendothyranopsis aff. *E. scitula* (Toomey).
Globoendothyra payla (Vissarionova)
Stacheoides tenuis Petryk and Mamet

Age: Zone 14, late Meramecian age equivalent, late Visean.

Upper part, 14-18.3 m: USGS loc. M1382

Archaediscus sp.
Brunsia sp.
Calcisphaera sp.
Earlandia sp.
Diplosphaerina sp.
Endothyra of the group *E. bowman!* Phillips *emend* Brady *[E. irregularis* (Zeller)]
juvenile *Eoendothyranopsis* sp.
Eotuberitina sp.
Pseudoglomospira sp.

Age: Zone 14, late Meramecian age equivalent, late Visean.

Tererro section, Pecos River Canyon (14)
Espiritu Santo Formation
Upper part; 4.9-8.5 m: USGS loc. M1383

Calcisphaera laevis Williamson
Carbone//a sp.
Earlandia sp.
Endothyra sp.
Inflatoendothyra sp.
Inflatoendothyra "inflata" (Lipina) OBJ (I. *eospiroides* Skipp *in* McKee and Gutschick)
Latiendothyra of the group *L. parakosvensis* (Lipina) *[L. skippae* (Armstrong)]
Parathurammina of the group *P. cushmani* Suleimanov
Parathurammina suleimanovi Lipina
Pr/ace//a sp.
Septaglomospiranella sp.
Septatournayella sp.
Spinoendothyra bellicostata (Lipina)

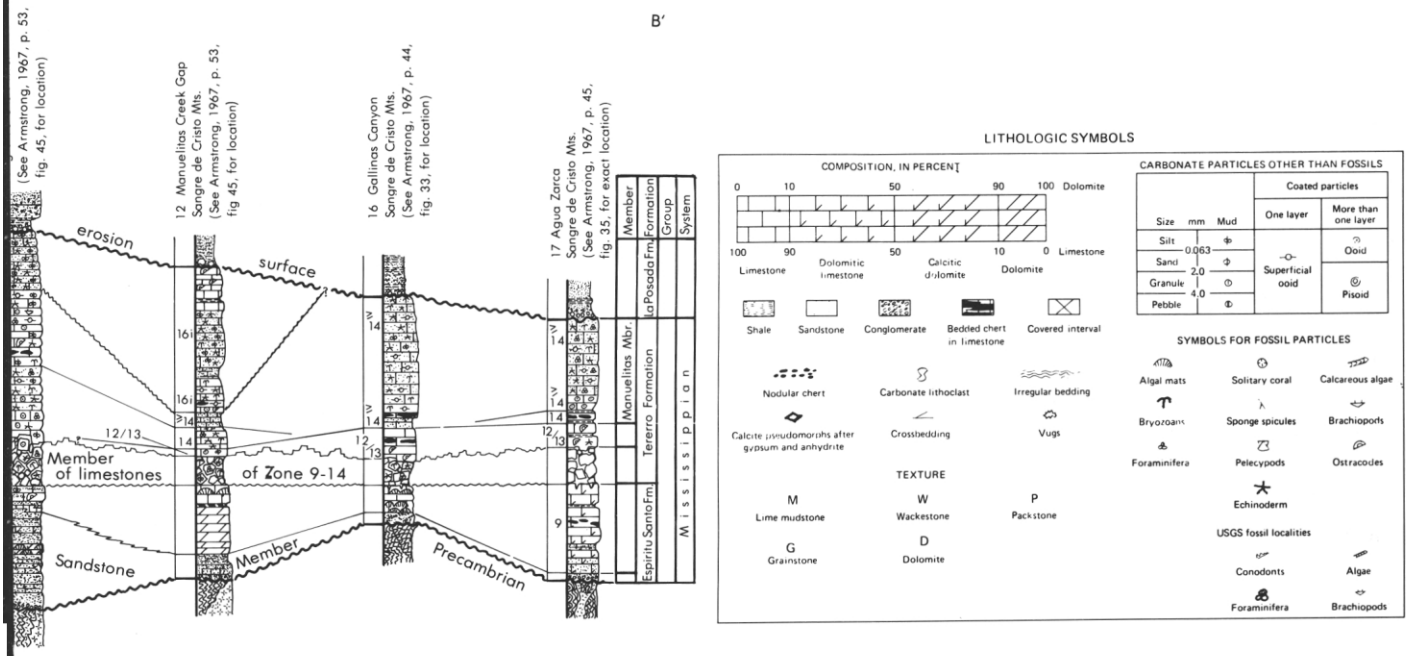


Figure 4. Regional biostratigraphic and lithologic correlation (B-B′) for Mississippian strata from the Nacimiento and Sangre de Cristo mountains of north-central New Mexico. Modified from Armstrong and others (1979).

Spinoendothyra spinosa (Chernysheva)
Tournayella sp.

Age: Zone 9, Osagean age equivalent, late Tournaisian.

Tererro Formation
Macho Member
9.7-12.2 m; blocks of Espiritu Santo Formation: USGS loc. M1384
Calcisphaera sp.
Carbone/la sp.
Endothyra sp.
Latiendothyra sp.
Spinoendothyra sp.
Spin otournayella sp.
Tournayella sp.
Age: Zone 9, as above.
Matrix:
Eoendothyranopsis aff. *E. macra* (Zeller)
Eoendothyranopsis scitula (Zeller)
Globoendothyra sp.
Tetrataxis sp.
Age: Zone 13 or 14, Meramecian age equivalent, middle to late Visean.

Manuelitas Member
Lower part (oolitic facies), 15.2-18.3 m: USGS loc. M1385
Calcisphaera pachysphaerica (Pronina)
Earlandia sp.
Endothyra sp.
Endothyra of the group *E. bowmani* Phillips *emend* Brady *[E. irregularis* (Zeller)]
Eoendothyranopsis sp.
Eoendothyranopsis of the group *E. ermakiensis* (Lebedeva)
Eoendothyranopsis macro (Zeller)
Eoendothyranopsis prodigiosa (Armstrong)
Globoendothyra sp.
Koninckopora sp.
Stacheoides sp.
Age: Zone 14, late Meramecian age equivalent, late Visean.
Upper part, 19.2-22.3 m: USGS loc. M1386
Archaediscus sp.
Archaediscus krestovnikovi Rauzer-Chernoussova
Archaediscus koktjubensis Rauzer-Chernoussova
Calcisphaera sp.
Endothyra sp.
Globoendothyra sp.
Parathurammina sp.
Priscella sp.
Vicinesphaera sp.
Age: Zone 14, late Meramecian age equivalent, late Visean.

Dalton picnic grounds section (15)
Macho Member
In the matrix, 18 m: USGS loc. M1387
Endothyra of the group *E. bowmani* Phillips *emend* Brady *[E. irregularis* (Zeller)]
Eoendothyranopsis sp.
Eoendothyranopsis macro (Zeller)
Priscella sp.
Age: Probably Zone 14?, late Merarnecian age equivalent, late Visean.

Manuelitas Member
18.3-25.6 m: USGS loc. M1388
Archaediscus sp.
Brunsia lenensis Bogush and Yuferev
Calcisphaera sp.
Earlandia sp.
Endothyra of the group *E. bowman/* Phillips *emend* Brady *[E. irregularis* (Zeller)]
juvenile *Eoendothyranopsis* sp.
Age: Zone 14, late Meramecian age equivalent, late Visean.

Ponce de Leon Springs section (5)
Espiritu Santo Formation
Upper part, 9.1 to 15.2 m: USGS loc. M1389
Calcisphaera sp.

Latiendothyrid ghosts
Parathurammina sp.
Tournayellid ghosts
Vicinesphaera sp.
Age: Probably Zone 9?, late Tournaisian?

Tererro Formation
Turquillo Member
25-26.8 m: USGS loc. M1390
"Biseriammina" cf. *B. windsorensis* Mamet
Calcisphaera sp.
Earlandia sp.
Endothyra sp.
Eoendothyranopsis of the group *E. spiroides* (Zeller)
Eoendothyranopsis scitula (Toomey)
Globoendothyra sp.
Koninckopora inflata (de Koninck)
Parathurammina sp.
Age: Zone 12/13, Meramecian age equivalent, middle Visean.

Rio Pueblo section (6)
Espiritu Santo Formation
Middle to upper part, 15.9-26.8 m: USGS loc. M1391
Calcisphaera sp.
Calcisphaera laevis Williamson
Earlandia sp.
Endothyra sp.
Latiendothyra sp.
Latiendothyra of the group *L. parakosvensis* (Lipina)
Parathurammina sp.
Parathurammina cushmani Suleimanov
Parathurammina suleimanovi Lipina
Vicinesphaera sp.
Age: Zone 9?, Osagean age equivalent, late Tournaisian?

Tererro Formation
Manuelitas Member
Middle part, 30.2-32.9 m: USGS loc. M1392
Calcisphaera sp.
Calcisphaera pachysphaerica (Pronina)
Earlandia sp.
Endothyra sp.
Endothyra of the group *E. bowman/* Phillips *emend* Brady *[E. irregularis* (Zeller)]
Eoendothyranopsis sp.
Age: Zone 14?, late Meramecian age equivalent?, late Visean?

Lujan Canyon section (7)
Tererro Formation Manuelitas Member
Lower part, 17.1-20.7 m: USGS loc. M1393
Aoujgalia sp.
Archaediscus sp.
Archaediscus krestovnikovi Rauzer-Chernoussova
Calcisphaera sp.
Earlandia sp.
Endothyra of the group *E. bowman/* Phillips *emend* Brady *[E. irregularis* (Zeller)]
Eoendothyranopsis sp.
Eoendothyranopsis of the group *E. ermakiensis* (Lebedeva)
Eoendothyranopsis macra (Zeller)
Eoendothyranopsis prodigiosa (Armstrong)
Globoendorhyra sp.
Stacheoides sp.
Tetrataxis sp.
Age: Zone 14, late Meramecian age equivalent, late Visean.

Upper part, 21.3-22.9 m: USGS loc. M1394
Archaediscus sp.
Earlandia sp.
Brunsia sp.
Endothyra sp.
Age: Zone 14, late Meramecian age equivalent, late Visean.

Cowles Member
Lower part, 26.2 m: USGS loc. M1395
Archaediscus sp.
Archaediscus of the group *A. krestovnikovi* Rauzer-Chernoussova
Archaediscus? pachytheca Petry k
cf. *Neoarchaediscus* sp. (primitive form)
Age: Zone 16inf, early Chesterian age equivalent, late Visean.

Chacon section, Rincon Range (8)
Tererro Formation
Manuelitas Member
Lower and middle part, 16.8-19.8 m: USGS loc. M1396
Aoujgalia sp.
Archaediscus sp.
Brunsia sp.
Brunsia lenensis Bogush and Yuferev
Earlundia vulgaris (Rauzer-Chernoussova and Reitlinger)
Endothyra of the group *E. bowman/* Phillips *emend* Brady *[E. irregularis* (Zeller)]
Eoendothyranopsis sp.
Eoendothyranopsis of the group *E. ermakiensis* (Lebedeva)
Eoendothyranopsis macra (Zeller)
Eoendothyranopsis cf. *E. prodigiosa* (Armstrong)
Eoendothyranopsis scitula (Toomey)
Eoendothyranopsis aff. *E. thompsoni* (Anisgard and Campau)
Globoendothyra sp.
Koninckopora sp.
Skippella sp.
Stacheoides sp.
Stacheoides tenuis Petryk and Mamet
Age: Zone 14, late Meramecian age equivalent, late Visean.

Upper part, 19.9-22.9 m: USGS loc. M1397
Archaediscus sp.
Calcisphaera sp.
Earlandia sp.
juvenile *Globoendothyra* sp.
Age: Zone 14, late Meramecian age equivalent, late Visean.

Turquillo sections, Rincon Range (9)
Tererro Formation
Turquillo Member, 65-A 16+, 5.5-6.7 m and 65-A2 16+, 1.5-2.7 m: USGS loc. M1398
Calcisphaera pachysphaera (Pronina)
Earlandia sp.
Endothyra of the group *E. bowman/* Phillips *emend* Brady
Eoendothyranopsis sp.
Eoendothyranopsis hinduensis (Skipp *in* McKee and Gutschick)
Eoendothyranopsis of the group *E. scitula* (Toomey)
Eoforschia sp.
Koninckopora sp. nov.
Globoendothyra sp.
Orthonella sp.
Paracalligelloides sp.
Palaeoberesella sp.
Proninella sp.
Septabrunsiina parakrainica Skipp, Holcomb and Gutschick
Skippella sp.
unnamed new genus
Age: Zone 12/13, Meramecian age equivalent, middle Visean.

Tererro Formation
Manuelitas Member
Lower part, 7.9-13.4 m (oolitic facies): USGS loc. M1399
Aoujgalia sp.
Calcisphaera pachysphaerica (Pronina)
Endothyra sp.
Eoendothyranopsis of the group *E. ermakiensis (Lebedeva)*
Eoendothyranopsis macro (Zeller)
Eoendothyranopsis prodigiosa (Armstrong)
Eoendothyranopsis aff. *E. thompsoni* Anisgard and Campau
Globoendothyra sp.
Globoendothyra paula (Vissarionova)
Koninckopora inflata (de Koninck)
Orthonella sp.
"Septabrunsiina" sp.
Stacheia sp.
Stacheoides tenuis Petry k and Mamet
Tetrataxis sp.
Age: Zone 14, late Meramecian age equivalent, late Visean.

Upper part, 13.7-21.9 m: USGS loc. M1400
Archaediscus sp.
Archaediscus krestovnikovi Rduzer-Chernoussova
Brunsia sp.
Brunsia lenensis Bogush and Yuferev
Calcisphaera pachysphaerica (Pronina)
Endothyra of the group *E. bowman!* Phillips *emend* Brady *[E. irregularis* (Zeller)]
juvenile *Eoendothyranopsis* sp.
juvenile *G/oboendothyra* sp.
Priscella sp.
Pseudoglomospira sp.
Age: Zone 14, late Meramecian age equivalent, late Visean.

Mora Gap section (10)
Tererro Formation
Turquillo Member
Lower part, 8.2 m: USGS loc. M1401
Calcisphaera sp.
Earlandia sp.
Endothyra sp.
Eoendothyranopsis sp.
Globoendothyra paula (Vissarionova)
Koninckopora mortelmansi Mamet
Age: Zone 12 or younger, Meramecian age equivalent, middle Visean.

Manuelitas Member
Lower part (oolitic facies), 10.4-15.2 m: USGS loc. M1402
Calcisphaera sp.
Earlandia sp.
Endothyra of the group *E. bowman/* Phillips *emend* Brady *[E. irregularis* (Zeller)]
Eoendothyranopsis of the group *E. errnakiensis* (Lebedeva)
Eoendothyranopsis macro (Zeller)
Eotuberitina sp.
Globoendothyra sp.
Stacheia sp.
Stacheoides tenuis Petry k and Mamet
Age: Zone 14, late Meramecian age equivalent, late Visean.

Tererro Formation Manuelitas Member
Upper part, 15.3-18.3 m: USGS loc. M1403
Archaediscus sp.
Archaediscus krestovnikovi Rauzer-Chernoussova
Archaediscus pachytheca Petry k
Aoujgalia sp.
Brunsia sp.
Brunsia lenensis Bogush and Yuferev
Calcisphaera pachysphaerica (Pronina)
Endothyra of the group *E. bowman/* Phillips *emend* Brady *[E. irregularis* (Zeller)]
juvenile *Eoendothyranopsis* sp.
juvenile *Globoendothyra* sp.
Globoendothyra paula (Vissarionova)
Stacheoides tenuis Petry k and Mamet
Age: Zone 14, late Meramecian age equivalent, late Visean.

Coco City (11)
Espiritu Santo Formation
Lower part, 8.8-9.1 m: USGS loc. M1404
Calcisphaera laevis Williamson
Earlandia sp.
Parathurammina of the group *P. cushmani* Suleimanov
Parathurammina of the group *P. suleimanovi* Lipina
Septaglomospiranella sp.
Spinoendothyra sp.
Age: Zone 9, late Tournaisian.

Tererro Formation
Macho Member
Block of the Espiritu Santo Formation, 12.8-13.7 m: USGS loc M1405
Calcisphaera sp.
Earlandia sp.
Endothyra sp. *Parathurammina* of the group *P. cushmani* Suleimanov
Parathurammina of the group *P. suleimanovi* Lipina
Septaglomospiranella sp.
Spinoendothyra sp.
Age: Zone 9, late Tournaisian.
N.B. report of *Endothyra macra* by Armstrong (1967, fig. 32) is to be discarded.

Tererro Formation
Manuelitas Member
Lower part (oolitic facies), 14.6-20.4 m: USGS loc. M1406
Calcisphaera pachysphaerica (Pronina)
Earlandia sp.
Endothyra sp.
Eoendothyranopsis ermakiensis (Lebedeva)
Eoendothyranopsis macro (Zeller)
Globoendothyra sp.
Stacheoides sp.
Stacheoides tenuis Petry k and Mamet
Age: Zone 14, late Meramecian age equivalent, late Visean.

Upper part, 20.7-25.6 m: USGS loc. M1407
Archaediscus sp.
Archaediscus krestovnikovi Rauzer-Chernoussova
Brunsia sp.
Brunsia lenensis Bogush and Yuferev
Calcisphaera pachysphaerica (Pronina)
Earlandia sp.
Endothyra of the group *E. bowman!* Phillips *emend* Brady *[E. irregularis* (Zeller)]
juvenile *Eoendothyranopsis macro* (Zeller)
Stacheoides sp.
Stacheoides tenuis Petry k and Mamet
Age: Zone 14, late Meramecian age equivalent, late Visean.

Manuelitas Creek Gap section (12)
Tererro Formation
Macho Member
8.2-9.1 m (in the matrix): USGS loc. M1408
Calcisphaera laevis (Williamson)
"Endothyra" rotayi (Lebedeva)
Eoendothyranopsis sp.
Glob oendothyra aff. *G. paula* (Vissarionova)
Priscella pr/sea (Rauzer-Chernoussova and Reitlinger)
Skippella sp.
Age: Probably Zone 12 or 13, Meramecian age equivalent, middl(Visean.

Manuel itas Member
Lower part 10.4 m (oolitic facies): USGS loc. M1409
Brunsia sp.
Eoendothyranopsis sp.
Globoendothyra paula (Vissarionova)
Priscella sp.
Stacheoides sp.
Age: Probably Zone 14, late Meramecian age equivalent, late Visean.

Upper part, 11.6-14 m: USGS loc. M1410
Archaediscus sp.
Archaediscus krestovnikovi Rauzer-Chernoussova
Archaediscus pachytheca Petry k
Calcisphaera sp.
Earlandia sp.
Endothyra of the group *E. bowman!* Phillips *emend* Brady *[E. irregularis* (Zeller)]
Stacheoides sp.
Age: Probably Zone 14, late Meramecian age equivalent, late Visean

Gallinas Canyon section (16)
Tererro Formation
Macho Member
In the matrix, 7 m: USGS loc. M1411
Biseriammina aff. *B. windsorensis* Mamet
Calcisphaera sp.
Earlandia sp.
Eoendothyranopsis sp.
Globoendothyra paula (Vissarionova)
Koninckopora inflata (de Koninck)

Palaeotextularia sp.
Planoendothyra sp.
Stacheoides sp.
Age: Probably Zone 12 or 13, Meramecian age equivalent (as at Ponce de Leon Springs), middle Visean.

Manuelitas Member
Upper part, 15.2-21 m: USGS loc. M1412
Archaediscus sp.
Archaediscus krestovnikovi Rauzer-Chernoussova
Archaediscus koktjubensis Rauzer-Chernoussova
Archaediscus? pachytheca Petry k
Brunsia sp.
Calcisphaera sp.
Earlandia sp.
Endothyra of the group *E. bowman/* Phillips *emend* Brady *[E. irregularis* (Zeller))
Age: Zone 14, late Meramecian age equivalent, late Visean.

Agua Zarca (17)
Espiritu Santo Formation
Upper part, 4.6-5.5 m: USGS loc. M1413
Calcisphaera laevis Williamson
Parathurammina of the group *P. cushmani* Suleimanov
Parathurammina of the group *P. suleimanovi* Lipina
Septatournayella sp.
Spinoendothyra sp.
Age: Zone 9, Osagean age equivalent, late Tournaisian.

Tererro Formation
Turquillo Member
Lower part, 11.6 m: USGS I. M1414
Calcisphaera sp.
Endothyra sp.
Eoendothyranopsis scitula (Toomey)
Globoendothyra of the group *G. baileyi* (Hall)
Globoendothyra paula (Vissarionova)
Priscella sp.
Skippella sp.
Age: Probably Zone 12/13?, Meramecian age equivalent, middle Visean.

Tererro Formation Manuelitas Member
Upper part, 17.7-20.7 m: USGS loc. M1415
A rchaediscus sp.
Brunsia sp.
Brunsia lenensis Bogush and Yuferev
Endothyra of the group *E. bowman/* Phillips *emend* Brady *[E. irregularis* (Zeller)]
juvenile *Eoendothyranopsis* sp.
Stacheoides sp.
Age: Zone 14, late Meramecian age equivalent, late Visean.

Locations of outcrop sections used in this report can be found in the following publications.

1-20. Armstrong (1967); Armstrong and Mamet (1974); Baltz and Read (1960); San Pedro, Nacimiento, Sangre de Cristo, Sandia, Manzano and Jemez mountains, New Mexico.
21-24. Armstrong (1958); Ladron, Magdalena and Lemitar mountains, and Coyote Hills, New Mexico.
25-33. Kottlowski and others (1956), Laudon and Bowsher (1949); San Andres Mountains, New Mexico.
34-36. Laudon and Bowsher (1941, 1949).
37-48. Laudon and Bowsher (1949); Mimbres and Cooks ranges, Silver City area, New Mexico.
49-52. Armstrong and Mamet (1978); Peloncillo, Big Hatchet and Florida mountains, Klondike Hills, New Mexico.
53-54. Lane (1974), Laudon and Bowsher (1949); Vinton Canyon, Franklin Mountains and Hueco Mountains, Texas.
55-57. Armstrong and Mamet (1978); Pedregosa Mountains, Arizona.
58-59. Armstrong and Mamet (1976); San Juan Mountains, Colorado.

REFERENCES

Armstrong, A. K., 1955, Preliminary observations on the Mississippian System of northern New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 39, 42 p.

– ---, 1958, The Mississippian of west-central New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 5, 32 p.

– ---, 1967, Biostratigraphy and carbonate facies of the Mississippian Arroyo Penasco Formation, north-central New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 20, 80 p.

Armstrong, A. K. and Mamet, B. L., 1974, Biostratigraphy of the Arroyo Pehasco Group, lower Carboniferous (Mississippian), north-central New Mexico: New Mexico Geological Society Guidebook 25, p.145-158.

----, 1976, Biostratigraphy and regional relations of the Mississippian Leadville Limestone in the San Juan Mountains, southwestern Colorado: U.S. Geological Survey Professional Paper 985, 25 p.

– ---, 1977a, Biostratigraphy and paleogeography of the Mississippian System in northern New Mexico and adjacent San Juan Mountains of southwestern Colorado: New Mexico Geological Society Guidebook 28, p.111-127.

1977b, Microfacies, microfossils and corals, Lisburne Group, arctic Alaska: U.S. Geological Survey Professional Paper 849, 144 p.

– ---, 1978, The Mississippian System of southwestern New Mexico and southeastern Arizona: New Mexico Geological Society Guidebook 29, p. 183-192.

Armstrong, A. K., Kottlowski, F. E., Stewart, W. J., Mamet, B. L., Baltz, E. H., Siemers, C. T. and Thompson, S., III, 1979, The Mississippian and Pennsylvanian (Carboniferous) Systems in the United States-New Mexico: U.S. Geological Survey Professional Paper 1110-W, in press.

Baltz, E. H. and Read, C. B., 1960, Rocks of Mississippian and probable Devonian age in Sangre de Cristo Mountains, New Mexico: American Association of Petroleum Geologists Bulletin, v. 44, p. 1749-1774.

Fitzsimmons, J. P., Armstrong, A. K. and Gordon, M., Jr., 1956, Arroyo Periasco Formation, Mississippian, north-central New Mexico: American Association of Petroleum Geologists Bulletin, v. 40, p. 1935-1944.

Gordon, M., Jr. and Mamet, B. L., 1978, The Mississippian-Pennsylvanian boundary: American Association of Petroleum Geologists Studies in Geology 6, p. 327-335.

Kottlowski, F. E., Flower, R. H., Thompson, M. L. and Foster, R. W., 1956, Stratigraphic studies of the San Andres Mountains, New Mexico: New Mexico Bureau of Mines and Mineral Resources Memoir 1, 132 p.

Lane, H. R., 1974, The Mississippian of southeastern New Mexico and West Texas-a wedge-on-wedge relation: American Association of Petroleum Geologists Bulletin, v. 58, p. 269-282.

----, 1975, Correlation of the Mississippian rocks of southern New Mexico and west Texas using conodonts, *in* Pray, L. C., ed., A guidebook to the Mississippian shelf-edge and basin facies carbonates, Sacramento Mountains and southern New Mexico region: Dallas Geological Society, Dallas, p. 87-98.

Laudon, L. R. and Bowsher, A. L., 1941, Mississippian formations of Sacramento Mountains, New Mexico: American Association of Petroleum Geologists Bulletin, v. 25, p. 2107-2160.

– ---, 1949, Mississippian formations of southwestern New Mexico: Geological Society of America Bulletin, v. 60, p. 1-87.

McKee, E. D. and Crosby, E. J., 1975, Paleotectonic investigations of the Pennsylvanian System in the United States, part 1: U.S. Geological Survey Professional Paper 853L, p. 233-243.

Mamet, B. L., 1976, An atlas of microfacies in Carboniferous carbonates of the Canadian Cordilleran: Geological Survey of Canada Bulletin 255, 131 p.

Sando, W. J., Mamet, B. L. and Dutro, J. T., Jr., 1969, Carboniferous megafaunal and microfaunal zonation in the northern Cordillera of the United States: U.S. Geological Survey Professional Paper 613-E, 29 p.

Sutherland, P. K., 1963, Paleozoic rocks: New Mexico Bureau of Mines and Mineral Resources Memoir 11, p. 22-46.

Vaughan, F., Eby, D. and Meyers, W. J., 1977, Calcitization of evaporites - do fabrics reflect diagenetic environment?: Geological Society of America Abstracts with Programs, v. 9, p. 1209.

Yurewicz, D. A., 1975, Basin margin sedimentation, Rancheria Formation, Sacramento Mountains, *in* Pray, L. C., ed., A guidebook to the Mississippian shelf-edge and basin facies carbonates, Sacramento Mountains and southern New Mexico: Dallas Geological Society, Dallas, p. 67-86.