Pennsylvanian rocks of north-central New Mexico

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PENNSYLVANIAN ROCKS OF NORTH-CENTRAL NEW MEXICO

by
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INTRODUCTION

Pennsylvanian rocks are exposed in several locations between the Rio Grande valley and the San Juan Basin in north-central New Mexico (Fig. 1). The largest areas of outcrop are along the eastern flanks of the Nacimiento and San Pedro Mountains. Other outcrops are located in the valleys that dissect the Jernez Plateau, along the western margin of the southern Nacimiento Mountains, and in the Chama basin. The most complete section of Pennsylvanian rocks is exposed in the southeastern part of the area at Guadalupe Box where 950 feet of mostly marine sedimentary rocks rest unconformably on Mississippian strata. The Pennsylvanian rocks exposed at Guadalupe Box range in age from Morrow to Virgil. Progressively younger Pennsylvanian rocks rest on Precambrian crystalline rocks to the north and west in the Nacimiento and San Pedro Mountains (Wood and Northrop, 1946). In general, Pennsylvanian strata thin to a zero-edge along the north-trending crest of the Nacimiento Mountains and thicken toward the San Juan Basin and the Rio Grande valley. This thinning is due in part to onlapping deposition of sediments across a Pennsylvanian positive area and in part to erosion following uplift of the Nacimiento and San Pedro Mountains in Tertiary time.

Four Pennsylvanian formations have been recognized in north-central New Mexico. In ascending order, they are the Log Springs, Osha Canyon, Sandia, and Madera Formations. Of these, the Madera has the greatest areal extent.

LOG SPRINGS FORMATION

The Log Springs Formation was named by Armstrong (1955) for exposures in Los Pinos and Penasco Canyons in the southwestern Nacimiento Mountains. This formation rests unconformably on the Mississippian Arroyo Penasco Formation and is overlain unconformably by the Osha Canyon Formation. The Log Springs is 40 to 60 feet thick in the type area, consisting of 8 to 10 feet of dusky-red, silty, hematitic shale overlain by 30 to 40 feet of arkosic to conglomeratic, cross-bedded, argillaceous, dusky-red to mottled pale-orange sandstone. The lower shales of the Log Springs Formation are believed to be a residual soil. The higher sandstones appear to be in part derived from reworked residual soil and coarse detrital material stripped from elevated uplands of Mississippian limestone and exposed Precambrian terrain. The regolith of the Log Springs, as well as some of the sandstone, may have formed in Late Mississippian time, and the age of the unit may be Late Mississippian and (or) Early Pennsylvanian (Armstrong, 1967).

Other occurrences of the Log Springs Formation have been noted at Guadalupe Box, and possibly on the northwest side of San Pedro Mountain. Only the lower 2 to 5 feet of ferruginous shale is preserved at Guadalupe Box where the unit is discontinuous in outcrop, generally forming dark-red slopes (Armstrong, 1955; DuChene, 1973). At San Pedro Mountain, red shale and arkosic sandstone similar to the Log Springs is found as float near the Mississippian-Pennsylvanian contact (Armstrong, 1967).

Armstrong (1955, 1967) notes that the stratigraphic position and lithologic character of the Log Springs Formation is similar to that of the Molas Formation of Colorado.

OSHA CANYON FORMATION

The name "Osha Canyon Formation" is informally suggested by DuChene (1973) for a sequence of Morrow-age limestones and shales in the southern Nacimiento Mountains. Northrop and Wood (1945) first recognized that a unique Morrow-age fauna is present near the base of the Sandia Formation near Guadalupe Box. Wood and Northrop (1946) included the rocks containing this fauna in the lowest part of their Upper Clastic Member of the Sandia Formation. Armstrong (1955) recognized that Morrow-age rocks lie unconformably on the Log Springs Formation in Los Pinos and Penasco Canyons and at Guadalupe Box. He also recognized that the upper surface of the Morrow strata is an unconformity which is overlain by the arkosic part of the Madera Formation at Los Pinos and Penasco Canyons, and by the Sandia Formation at Guadalupe Box. The Osha Canyon also crops out at several places southwest of Guadalupe Box, and at most of these places, the unit rests nonconformably on Precambrian crystalline rocks.

The most complete section of the Osha Canyon Formation is exposed at Guadalupe Box (Fig. 2). Here the unit is 56 feet thick and is composed of two distinct parts. The basal 31 feet consists of highly fossiliferous, light-gray to white, arenaceous limestone in 4- to 12-inch beds, intercalated with fossiliferous, calcareous, grayish-white shale. Fragments of echinoids, corals, bryozoans, and brachiopods are common. The upper 25 feet of the formation consists of whitish-gray to purplish-gray shale which contains abundant nodules of gray limestone near the top (DuChene, 1973). Diagnostic fossils are the brachiopod *Schizophoria oklahomae* and the foraminifer *Millerella* sp. (Northrop and Wood, 1945; Armstrong, 1955, 1967). In most localities, only part of the basal limestone is preserved. The Osha Canyon Formation is generally a slope-forming unit although the outcrops in Los Pinos and Penasco Canyons stand out as low cliffs above the Log Springs Formation.

The Osha Canyon Formation is lithologically and temporally distinct from the units that bound it. Lateral equivalents have not been firmly established although the unit may be in part correlative with the lower parts of Sutherland's (1972) La Pasada and Flechado Formations in the Sangre de Cristo Mountains.

The Osha Canyon Formation will be formally named by DuChene and others (in preparation).

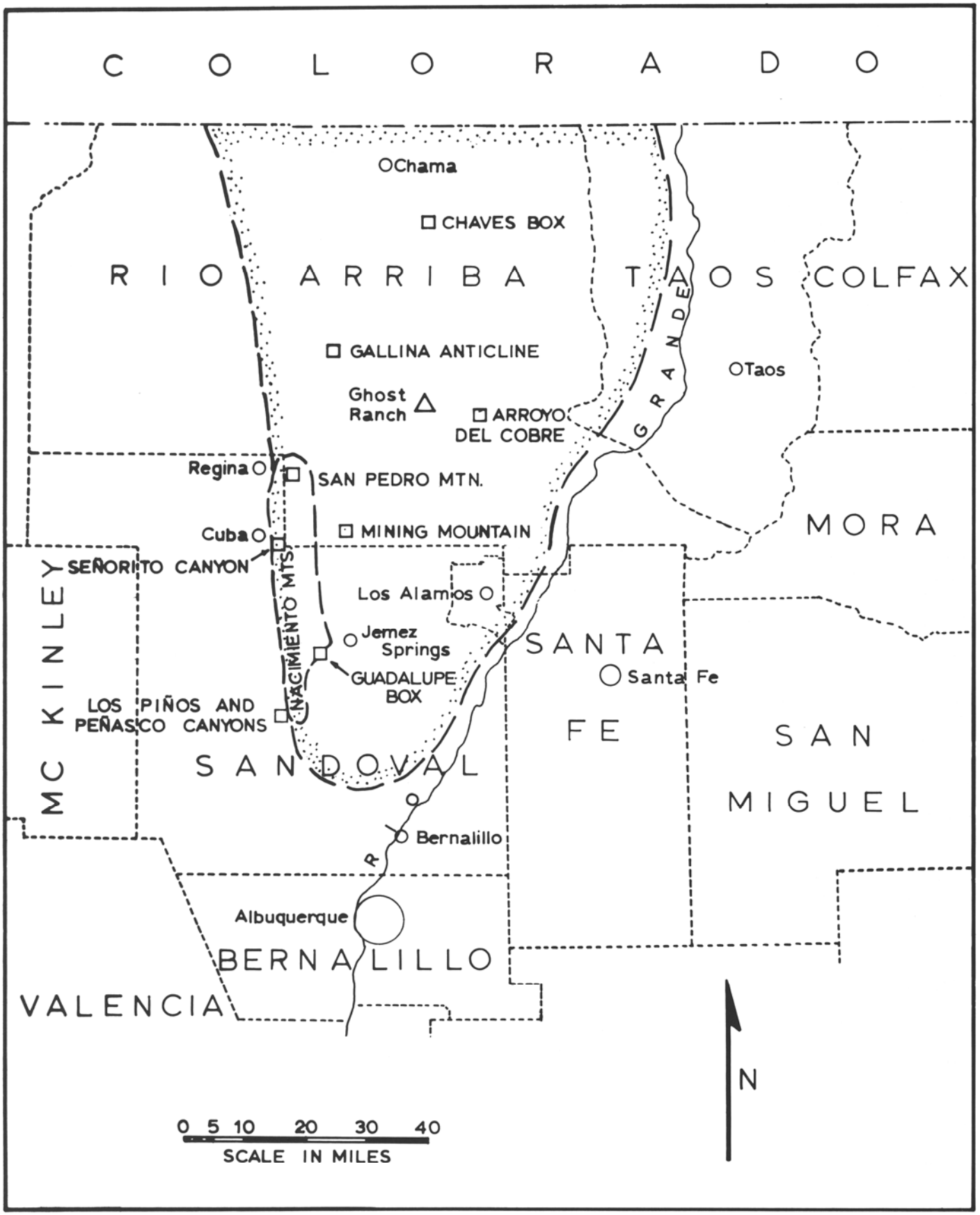

Figure 1. Map showing location of Pennsylvanian outcrops in north-central New Mexico. Stippling shows area included in this paper.

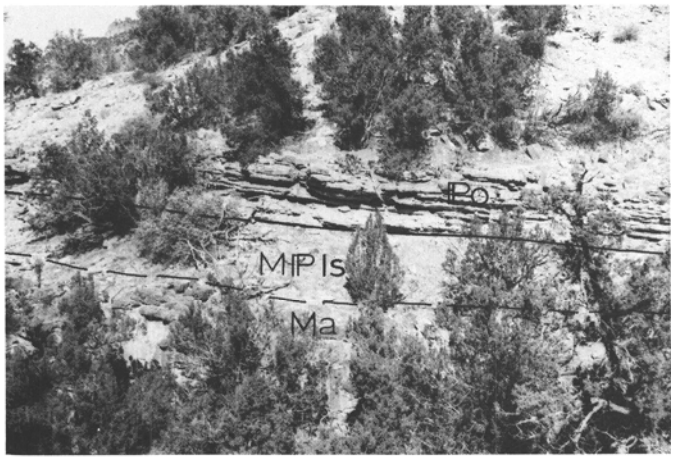

Figure 2. Part of Lower Pennsylvanian section at Guadalupe Box. Note ledge-forming limestone beds of lower part of the Osha Canyon Formation. Symbols: Ma = Arroyo Penasco Formation (Mississippian); MIPIs = Log Springs Formation (covered); IPo = Osha Canyon Formation, lower part. Photo by L. A. Woodward.

SANDIA FORMATION

The name "Sandia Series" was proposed by Herrick (1900) for the series of clastic sediments resting above "basal quartzite" in the southern Sandia Mountains. Gordon (1907) included the Sandia Formation as the lower unit of the Magdalena Group of central New Mexico. His definition of the Sandia included all of the sedimentary rocks between the Kelly Limestone and the Madera Limestone in the Magdalena Mountains. Wood and Northrop (1946) subdivided the Sandia Formation into a Lower Limestone Member and an Upper Clastic Member in the Nacimiento Mountains.

The Sandia Formation as described herein is restricted to the Upper Clastic Member of Wood and Northrop (1946) less the Morrow-age rocks of the Osha Canyon Formation. It includes the sequence of primarily clastic sedimentary rocks between the underlying Osha Canyon Formation and the lowest laterally continuous limestone of the overlying Madera Formation. Wood and Northrop's (1946) Lower Limestone Member has been divided into the Mississippian Arroyo Penasco Formation and the Log Springs Formation (Armstrong, 1955, 1967).

At Guadalupe Box the Sandia Formation consists of massive, coarse-grained, beige to light-brown, ledge-forming quartz sandstone. This sandstone is overlain by interbedded, slope-forming, green, gray, and yellow shales, yellow, fine-grained silty sandstone, and gray, thin-bedded, argillaceous, highly fossi l iferou s limestone. The yellow silty sandstone is bioturbated and contains numerous plume-like trace fossils, probably *Zoophycos* (C. T. Siemers, oral communication, 1974). Based on paleontologic evidence, the Sandia Formation is considered to be of Lampasas (Atoka) age (Wood and Northrop, 1946).

The Sandia Formation is up to 225 feet thick near Guadalupe Box, but thins to a feather edge to the north and west. Several small outcrops of Sandia are noted by Wood and Northrop (1946) about one mile north of Jemez Springs. The formation is absent at Penasco Canyon and in the central and northern parts of the Nacimiento and San Pedro Mountains.

MADERA FORMATION

The Madera Formation was named by Keyes (1903), and was included in the Magdalena Group by Gordon (1907). Wood and Northrop (1946) subdivided the Madera into a lower Gray Limestone Member and an upper Arkosic Member in the Nacimiento and San Pedro Mountains.

The Madera Formation is exposed on the flanks of the Nacimiento and San Pedro Mountains, and to a lesser extent, in the valleys that dissect the Jemez Plateau. In this area, the only complete section of the formation is found at Guadalupe Box where 760 feet of strata are exposed. At this locality, the Gray Limestone Member is in gradational contact with the under lying Sandia Formation. This member is characterized by dense, fossiliferous, dark-gray, locally cherty limestone in beds ranging in thickness from a few inches to several feet. Intercalated with the limestone are thin beds of arkosic sandstone and gray, fossiliferous shale. The Arkosic Member gradationally overlies the Gray Limestone Member and is gradationally overlain by the Abo Formation. The Arkosic Member consists of arkosic gray limestone and pink arkose intercalated with fossiliferous, calcareous shale. Feldspar fragments in the limestone and the arkose are pink and range up to one inch in diameter. The arkose becomes increasingly abundant upward in the section until it predominates near the top of the unit. The uppermost part of the Madera is intercalated with reddish-brown sandstone, mudstone, and shale typical of the Abo Formation. Carbonate becomes less abundant near the top of the formation, consisting of nodular limestone beds from 1 to 3 inches thick. Based on paleontologic evidence, Wood and Northrop (1946) determined that the Gray Limestone Member ranges in age from Lampasas (Atoka) to early Desmoines, and that the Arkosic Member ranges in age from Desmoines to Virgil.

The Madera Formation rests on the Sandia Formation at Guadalupe Box and near Jemez Springs. The Madera rests disconformably on the Osha Canyon Formation at Los Pinos and Penasco canyons; and elsewhere in that area it rests nonconformably on Precambrian crystalline rocks. Near Joaquin Mesa, the Gray Limestone Member rests nonconformably on Precambrian rocks. Farther to the north and west, this member is missing and the Arkosic Member rests on the Precambrian. On the northwest flank of the Nacimiento Mountains between the latitudes of Senorito Canyon and Regina, Pennsylvanian rocks are absent (Wood and Northrop, 1946). The Madera Formation crops out on the north flank of San Pedro Mountain and at Mining Mountain to the east. North of San Pedro Mountain, Lookingbill (1953) noted 194 feet of Pennsylvanian strata similar in fossil content and lithologic properties to the Arkosic Member of the Madera.

OTHER OUTCROPS OF PENNSYLVANIAN ROCKS

In the southeastern part of the Chama basin, Smith and others (1961) found about 35 feet of thin-bedded, carbonaceous gypsiferous, and micaceous siltstone exposed along a fault at Arroyo del Cobre. These beds are of probable Desmoines age according to paleobotanical evidence. Smith and others (1961) were unable to determine from the limited exposure whether these rocks are more closely related to the Hermosa beds of Colorado or to the Madera Formation of New Mexico.

Rocks containing fossils of Desmoines age are exposed at

the base of Chaves Box (Muehlberger, 1967). These rocks rest unconformably on Precambrian quartzite and are unconformably overlain by the Triassic Chinle Formation. The section may be as much as 400 feet thick with the lower part consisting primarily of sandstone and siltstone. The upper part of the unit rests disconformably on the sandstone and siltstone, and it consists of arkosic sandstone and fossiliferous limestone (Muehlberger, 1967).

GEOLOGIC HISTORY

The modern Nacimiento and San Pedro Mountains are superimposed on an ancient highland that began to develop in latest Mississippian or Early Pennsylvanian time. Wood and Northrop (1946, Fig. 6) show this highland as a north-trending positive feature which Read and Wood (1947) refer to as the Penasco Axis. The Penasco Axis influenced Pennsylvanian sedimentation in north-central New Mexico by providing a source area for clastic material, and because it was an island over which the Pennsylvanian sea advanced.

The uplift of the Penasco Axis probably began after the deposition of the Arroyo Penasco Formation. The unconformities on the Arroyo Penasco, Log Springs, and Osha Canyon Formations suggest pulsating uplift in Early Pennsylvanian time. These episodes of uplift established the Penasco Axis as a strong positive feature that was gradually transgressed by the Pennsylvanian sea and nearly buried by clastic and carbonate sediments. This transgression is recorded in the sequence of onlapping marine clastic and carbonate rocks that progressively cover the Penasco Axis from south to north. The large amount of arkose in the Arkosic Member of the Madera suggests that an additional period of uplift may have rejuvenated the Penasco Axis allowing a flood of detrital material to be washed into the sea in Desmoines, Missouri, and Virgil time. Martinez (1974) has noted that the Madera on the southeast side of the Nacimiento Mountains is more arkosic than it is to the east and has attributed this difference to an asymmetrical uplift. He suggests that the Penasco Axis had a steep west side and a gently sloping east side.

The end of Pennsylvanian marine sedimentation in north-central New Mexico is marked by a sequence of interfingered marine and continental sedimentary rocks. The sea alternately was pushed back by continental detrital material and then advanced over the terrestrial deposits until the area remained above sea level and subaerial conditions prevailed. This episode of regression is recorded in the gradational contact between the Madera and Abo Formations.

PENNSYLVANIAN FOSSILS

The Pennsylvanian strata of north-central New Mexico are abundantly fossiliferous at many localities, especially in places such as Guadalupe Canyon and San Diego Canyon in the J emez Plateau. Fusulinids, brachiopods, bryozoans, and crinoids are probably the most common. Sponges, conularids, nautiloid cephalopods, scaphopods, annelids, trilobites, and shark teeth are less common and are scarce at most places (Northrop, 1961).

Pennsylvanian faunas of the Jemez-Nacimiento region have been described by several investigators, notably Wood and Northrop (1946) and Sutherland and Harlow (1967). Northrop (1961) made the following comments regarding Pennsylvanian fauna and faunal zones:

> "In 1946 Northrop and Wood reported for the Jemez-Nacimiento area a total of about 185 species, based on a preliminary study of nearly 100 collections from 33 stratigraphic sections, and proposed five faunal zones—designated A, B, C, D, and E (from oldest to youngest)—`each of which is characterized either by species having short stratigraph ic ranges, by the earliest appearance of longer-ranging species which range through more than one zone, or by a combination of these.' Faunal zone A = Morrowan; B = late Morrowan, Lampasan, and early Desmoinsean; C = late Desmoinsean and earliest Missourian; D = remainder of Missourian; and E = Virgilian.
>
> In conclusion, it seems likely that the Pennsylvanian sequence in the Jemez country ranges from Morrowan to Virgilian...."

A list of Pennsylvanian fossils of the Jemez-Nacimiento region, and one for the Chaves Box in the Chama basin are included as an appendix to this paper. This list was provided by Stuart A. Northrop, and his assistance in the preparation of this paper is gratefully acknowledged.

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APPENDIX

PENNSYLVANIAN FOSSILS OF THE JEMEZ-NACIMIENTO MOUNTAINS AREA

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The following list is based on one prepared in 1961 for the Guidebook of the Albuquerque country (New Mexico Geological Society, 12th Field Conference), p. 107-109, but includes both published and unpublished work subsequent to 1961, and a number of revised generic assignments. Unless otherwise indicated, the citations are from Wood and Northrop (1946), which included microfossils by Henbest, Read, and others (1944). Other citations are indicated by key numbers in parentheses, as follows:

1. Bisbee (1932)
2. Needham (1937)
3. Moore and Dudley (1944)
4. Northrop and Wood (1945)
5. Thompson (1948)
6. Armstrong (1955)
7. Lovejoy (1958)
8. Sutherland and Harlow (1967)
9. N. Gary Lane, oral communication, June 17, 1968
10. S. A. Northrop, subsequent to 1961
11. A. K. Armstrong and B. L. Mamet, paper in this Guidebook

ALGAE

Culcisphaera sp. (11)

FORAMINIFERA

Apterrinellids (11)
Archaediscus sp. (11)
Asphaltina cordillerensis (11)
A. sp. (11)
Asteroarchaediscus sp. (11)
Beedeina of the group *B. cylindrica* [formerly *Fusulina*
Beedeina sp. aff. *B. euryteines*
B. lee i B.
sp. aff. *B. lee-*
B. tregoensis?
B. sp.
Biseriella of the group *B. parva* (11)
B. sp. (11)
Bradyina 2 sp.
B.? sp.
Climacammina sp.
Earlandia sp. (11)
Endothyra sp.
E.? sp. *Eolasiodiscus*
sp. (11)
Fusulina of the group *F. cylindric°*
Fusulinella carmani?
F. sp. aff. *F. iowensis*
F. cf. *juncea* (5)
F. stouti
F. sp.
F.? sp. *Globivalvulina* sp., sensu
stricto (11)
Millerella sp. aff. *M. marblensis* Thompson emend. (11)
M. pressa (11)
M. sp.
Neoarchaediscus sp. (11)
Planoendothrya sp. (11)
Pseudoglomospira sp. (11)
Spiroplectammina sp.
Tetrataxis sp.
Textulariidae
Triticites irregularis
T. irregularis var.
T. jemezensis [syntypes] (2)
T. kellyensis [syntypes] (2)
T. kellyensis? T. nebraskensis T. sp. aff. *T. nebraskensis*
T. sp. aff. *T. plummeri*
T. cf. *rhodesi (7)*
T. ventricosus (7)
T. ventrocosus var.
T. sp. aff. *T. whetstonensis* (8)
T. sp.
T.? sp.
Wedekindellina euthysepta
W. excentrica
W. excentrica?
W. minuta
W. sp.
Zellerina sp. (11)

PORIFERA

New genus, new species (red siliceous sponge)
Spicules (7)
Sponge(?) borings

ANTHOZOA

Aulopora cf. *prosseri*
A. sp. (4)
Carcinophyllum? sp. [formerly *Axophyllumn*
Chaetetes milleporaceus
C. sp.
Cyathaxonia distorta?
Lophophyllidium proliferum (1)
L. proliferum?
Michelinia cf. *eugeneae* (10) [formerly *Pleurodictyund*
M.? sp.
Neozaphrentis? sp.
Undetermined horn corals

BRYOZOA

Bascomella sp. (7)
Batostomellid
Condranema? sp. [formerly *Heteroneman*
Cyclotrypa pelagia [holotype and paratypes] (3)
Fenestellids
Prismopora sp.
Rhombopora cf. *lepidodendroides*
Septopora biserialis
Undet. genera of massive, encrusting, and foliate forms

BRACHIOPODA

Anthracospirifer occiduus [formerly *Spirifer occidental's]*
A. cf. *occiduus*
A. opimus
A. rockymontanus
A. cf. *rockymontanus*
A. sp. A (7)
A. spp. (6)

Antiquatonia coloradoensis [formerly *Productus, Dictyoclostus]*
A. crassicostata (7)
A. cf. *hermosana*
A. jemezensis [holotype and paratypes] (8)
A. portlockiana
A. sp.
A.? sp.
Beecheria bovidens
B. sp. (8)
Cancrinella boonensis
Chonetinella flemingi alata (7)
C.? sp.
Cleiothyridina pecosii [formerly *C. orb/colons] (7)*
Composita cf. *elongata (7)*
C. cf. *gibbosa*
C. cf. *magna (7)*
C. ovcita (7)
C. subtilita
C. trilobata (7)
C. cf. *trilobata*
C. spp.
Crania (Lissocrania) modesta [formerly *Petrocranial*
C. cf. *modesta* (8)
Crurithyris planoconvexa
Derbyia bennetti
D. cf. *bennetti*
D. crassa
D. cymbula?
D. cf. *haesitans*
D. sp. aff. *D. haesitans*
D. plattsmouthensis (7)
D. texana
D. cf. *texana*
D. sp.
Desmoinesia cf. *missouriensis*
Echinaria moorei
E. cf. *moorei (7,* 8)
E. semipunctata
E. cf. *semipunctata*
E. sp.
Hustedia cf. *miser/*
H. mormoni
H. sp. (4)
Hystriculina armata (8)
H. wabashensis
Isogramma sp. (10)
juresania nebrascensis
Kozlowskia splendens (1)
Leptalosia cf. *ova/is* (8)
Lingula sp.
Linoproductus cf. *oklahomae*
L. platyumbonus
L. sp. aff. *L. platyumbonus*
L. prattenianus
L. cf. *prattenianus*
L. sp.
"Marginifera" sp.
Meekella striatocostata
M. cf. *striatocostata Neochonetes*
granulifer [formerly *Chonetes]*
N. meekanus (7)
N. "transversalis" (8)
N. sp.
Neospirifer alatus
N. dunbari
N. cf. *dunbari*
N. gibbosus (7)
N. pattersoni [holotype and paratypes] (8)
N. sp.
Orbiculoidea sp. (8)
O.? sp. *(7)*
Phricodothyris perplexa
P. sp. (8)
Pulchratia cf. *ovalis*
P. symmetrica (7)
Punctospirifer ken kentuckyensis
P. kentuckyensis?
Schizophoria oklahomae (6, 10)
S. cf. *oklahomae*
S. sp. aff. *S. oklahomae* (4)
Schuchertella? sp. *(7)*
Wellerella immatura
W. osagensis
Genus undet. (7)

PELECYPODA

Acanthopecten carbon iferus
Astartella vera (1)
Aviculopecten occidental's (1)
A. sp.
A.? sp.
Edmondia aspinwallensis (1)
E. gibbosa
E. cf. *gibbosa*
E. nebrascensis
E. sp.
Limipecten? sp.
Myalina (Orthomyalina) cf. *s/ocomi*
M. (0.) sub
subquadrata M. (0.)
sp.
Myalinella? sp.
"Nuclana" sp.
Palaeoneilo? sp. [formerly *Anthraconeilod*
Permophorus sp. aff. *P. tropidophorus [formerly Pleurophorus]*
Pseudomonotis equistriata
P. robusta (1)
P. sp.
P.? sp.
Pteronites nebrascensis [formerly *Aviculopinna]*
P. peracutus
P. cf. *peracutus*
Schizodus cuneatus
S. subcircularis? (1)
S. wheeleri (1)
S. sp. (1)
S.? sp.
Sep Septimyalina sp.
Solemya (laneia) cf. *trapezoides* [formerly *Solenomya*
S.? O.)? sp.
Streblochondria sp.
Wilkingia terminale [formerly *Allorisma]*
W. sp.

GAST ROPODA

Bellerophon cf. *giganteus*
B. sp.
Bellerophon (Pharkidonotus) percarinatus (1)
Euphemites nodocarinatus
Ianthinopsis primogenius [formerly *Strobeus] (1)*
I. sp.
I.? sp.
Meekospira? sp. (1)
Naticopsis sp. *(7)*
Phymatopleura? sp. (1)
Platyceras (Orthonychia) parvum
Shansiella carbonaria (1)
Straparollus (A mphiscapha) catilloides
S. (A.) cf. *subrugosus*
S. (A.) sp.
Straparollus (Euomphalus) sp.
S.? (E.)? sp.
Straparollus sp.
Strophostylus remex (1)
S. sp.
Trepospira depressa (1)
T. discoidalis (7)
T. sp.
T.? sp.
Worthenia sp. (1)
Undet. large form

CEPHALOPODA
Dolorthoceras? sp.
Endolobus? sp.
Ephippioceras cf. *ferratum*
Mooreoceras? sp.
"Orthoceras" sp.
Tainoceras sp.

SCAPHOPODA
Plagioglypta? sp.

ANN ANNELIDA
Myzostomites sp. in crinoid columnals (10)
Spirorbis sp.
S.? sp.
Worm (?) borings

T RI LOBITA
Ameura sp.
Ditomopyge parvula? (1)
D. new species *(7)*
D. sp.
Sevillia trinucleata (10)
Undet. pygidium

CRINOIDEA
Delocrinus sp. (1)
Ethelocrinus sp. (10)
Hydreionocrinus sp. *(1)*
Paradelocrinus sp. (9)
Sciadiocrinus sp. (9
Ulocrinus sp. (9)
Undet. calyces, plates, and columnals

ECHINOIDEA
Archaeocidaris sp. plates and spines [formerly *Echinocrinus]*

VERTEBRATA
Undet. shark teeth and a fin spine

In a recent paper on Pennsylvanian brachiopods of the southern Sangre de Cristo Mountains, Sutherland and Harlow (1973) have described three new genera and twenty-nine new species and subspecies. Many of these new forms will doubtless be found in the Jemez-Nacimiento Mountains area.

The following list is modified from one prepared by Muehlberger and others (1960) for a collection taken from Chaves Box in the Chama basin area:

Wedekindellina euthysepta
Beedeina haworthi [formerly *Fusulina]*
Prismopora sp.
Mesolobus sp.
Derbyia sp.
Dictyoclostus sp. [probably *Antiquatonia]*
Spirifer sp. [probably *Anthracospirifer]*
Neospirifer [juvenile]
Composita sp.
Phricodothyris perplexa [formerly *Squamularia)*
Pun Punctospirifer ken kentuckyensis
Crinoid fragments

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