



Pennsylvanian stratigraphy and paleontology of the Taos area, north-central New Mexico

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PENNSYLVANIAN STRATIGRAPHY AND PALEONTOLOGY OF THE TAOS AREA, NORTH-CENTRAL NEW MEXICO

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INTRODUCTION

The most extensively exposed sequence of Pennsylvanian strata in New Mexico occurs in the Sangre de Cristo Mountains, where it reaches a thickness of more than 2,000 m and includes sediments deposited from earliest (Morrowan) to latest (Virgilian) Pennsylvanian time. Outcrops of Pennsylvanian age extend continuously from near Pecos and Bernal in the south to near Eagle Nest and Elizabethtown in the north, a distance of about 135 km (Fig. 1). A large variety of depositional environments is present in this sequence, including basinal terrigenous mudstones, offshore marine shelf carbonates, deltaic marine and fluvial shales, sandstones and conglomerates, and arkosic continental elastic sediments, among others. Some of the marine units are highly fossiliferous, but with the notable exception of the brachiopods, these faunas have not been comprehensively studied. This paper summarizes the Pennsylvanian stratigraphy and paleontology of the Taos area, presents preliminary observations on a remarkably diverse Middle Pennsylvanian mollusc-dominated marine fauna currently under study by the author, and includes illustrations of some of the more conspicuous molluscan species present in this fauna. All specimens illustrated in this paper are in the University of New Mexico Department of Geology paleontological collections and bear UNM catalogue numbers.

STRATIGRAPHY

The Carboniferous age of strata at the southern end of the Sangre de Cristo Mountains near Pecos was established by Jules Marcou, the first geologist to examine significant collections of fossils from the area (Marcou, 1856, 1858). Marcou recorded these strata as the "Mountain Limestone" (Lower Carboniferous), but Hall (1856) and Newberry (1861) soon recognized their actual "Coal Measures" or Pennsylvanian age. Although several other early workers also contributed information concerning the Pennsylvanian of the Santa Fe—Pecos area (see Sutherland and Harlow, 1973, for a summary), the first relatively detailed examination of Pennsylvanian stratigraphy and general geology of the Taos area was made by Stevenson (1881), as part of a regional study of the Sangre de Cristos in New Mexico and southern Colorado. Stevenson reported more than 1,000 m of Pennsylvanian strata in the Coyote Creek—Mora area, made a few observations on the Pennsylvanian near Taos, and recognized striking facies changes from Taos to Pecos, including an increase in marine limestones to the south.

Subsequently, no detailed stratigraphic analysis or formational subdivision of the Pennsylvanian in the Sangre de Cristos were attempted for more than half a century. Gruner (1920) reported general features of the stratigraphy in an area southwest of Wheeler Peak, and additional brief comments on the marine Pennsylvanian (termed the Magdalena Group or Formation) near Taos were presented by Darton (1928), Ray and Smith (1941), and Wanless (1947). Stratigraphic subdivision and correlation of the Pennsylvanian in the Taos and neighboring areas has proven difficult because of marked lateral facies changes and the isolation of Pennsylvanian exposures in this area from those in other regions (Sutherland, 1963). Beginning in the 1940's, it became customary to divide the Pennsylvanian into a basal, relatively thin, elastic-dominated Sandia Formation, overlain in ascending order by the "lower gray limestone" and "upper arkosic limestone" members of the Madera Formation, and finally by the arkosic continental elastics of the Pennsylvanian—Permian Sangre de Cristo Formation (e.g., Read and Wood, 1947; Brill, 1952; Baltz and Bachman, 1956; Baltz, 1965). The Sandia and Madera Formations had originally been defined in the Sandia Mountains, some 100 km to the southwest. Young (1946b) proposed the name Cortado Formation for the thick, predominantly shaly and arkosic cyclothemic sequence of Desmoinesian age in the Taos area, and Cieneguilla Formation for similar beds to the east near Black Lake, but these terms did not find general acceptance.

Concurrently, a general picture of the regional tectonic influences on Pennsylvanian deposition in north-central New Mexico began to be developed (Read and Wood, 1947; Brill, 1952; Baltz and Bachman, 1956; Wanek and Read, 1956; Sutherland, 1963; Baltz, 1965). Briefly, the area around Taos was found to be part of a north—south trending trough (variously called the Taos trough, Rowe—Mora Basin, or part of the Colorado—northern New Mexico geosyncline) between the adjacent Uncompahgre highland to the west and the Sierra Grande uplift somewhat farther away to the east. Thick sequences of marine, deltaic, and continental sediments, primarily eroded from the Uncompahgre highland, accumulated in this trough, while to the south (Santa Fe—Pecos—Las Vegas area) a much thinner sequence of mainly marine carbonate sediments was deposited on a shallow shelf (Pecos shelf of Sutherland, 1963). Marine sedimentation ceased in late Desmoinesian time in the Taos area, as the trough was filled with arkosic elastic sediments of the Sangre de Cristo Formation, but continued until nearly the end of the Pennsylvanian on the shelf before southward prograding Sangre de Cristo sediments covered it. The Pennsylvanian tectonic setting of the Taos trough was considered in detail by Sutherland (1963) and Casey (1980).

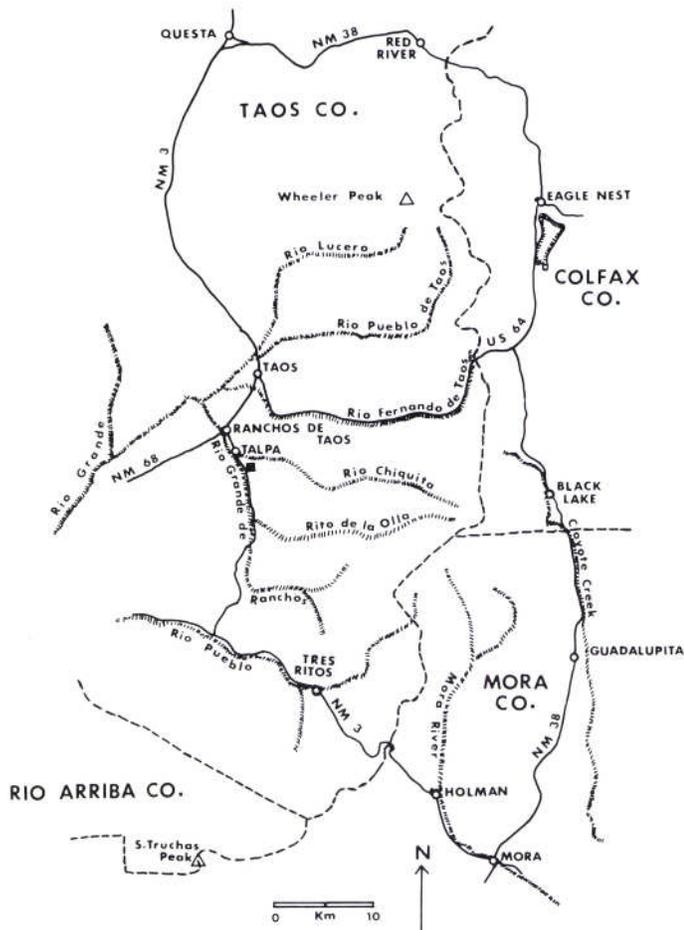


FIGURE 1. Reference map of Taos area. Black square indicates Flechado Formation locality discussed in text.

The Pennsylvanian stratigraphic nomenclature used widely today in the Sangre de Cristo Mountains (Fig. 2) was established by Sutherland (1963), following a detailed study of the area from Taos to Pecos. Sutherland rejected the use of Sandia and Madera Formations in this area and defined three new formations, the La Pasada, Flechado, and Alamitos. The La Pasada Formation, about 300 m thick, is primarily a cyclic carbonate unit of Morrowan to Desmoinesian age. It was deposited on the Pecos shelf and consists of shallow, nearshore shale, siltstone, and limestone units in its lower half and mainly neritic offshore carbonates in its upper part. The La Pasada was traced by Sutherland (1963) as far north as Jicarilla ridge, near the Truchas Peaks, about 40 km south of Taos. The Flechado Formation is the northern equivalent of the La Pasada, intertonguing with that unit near Jicarilla ridge, but thickening to about 750 m northward at its type locality along the Rio Pueblo in southern Taos County. The Flechado unconformably overlies Mississippian limestones of the Tererro Formation and consists primarily of olive, brown and dark-gray shales and siltstones, and low-feldspar sandstones and conglomerates; limestones represent only 5-10% of the formation (Sutherland, 1963).

In a study involving 85 measured sections in an area extending from the Rio Fernando (east of Taos) southward to the Rio Pueblo, Casey (1980) interpreted the Morrowan part of the Flechado as consisting of a basal fluvial—estuarine sandstone sequence overlain by a thick sequence of lignitic shales and siltstones representing shallow marine and prograding strand-plain environments. The Atokan to earliest Desmoinesian part includes distal alluvial-fan and braided-stream conglomerates, and coarsening-upward, stratigraphically complex fan-delta systems that prograded eastward and southeastward into the Taos trough as the Uncompahgre highland was uplifted. Sedimentation occurring in early to middle Desmoinesian time consisted of alluvial-fan sandstones and conglomerates dominated by braided-stream processes, low-sinuosity fluvial deposits, lobate, river-dominated delta systems, and various marine prodelta, shelf, and basinal mudstones and carbonates.

Overlying both the La Pasada and Flechado Formation is the Alamitos Formation (Sutherland, 1963). Approximately equivalent to the "upper arkosic limestone member" of the Madera, the Alamitos is composed chiefly of arkosic sandstones, with lesser amounts of shales, siltstones, and limestones. In general, the lower half of the formation has a greater abundance of elastics, whereas the upper part has a relatively high amount of limestone. In the Pecos area the Alamitos is about 400 m thick and spans Desmoinesian to Virgilian time, but to the north it thickens to 1,200 m and represents only the late Desmoinesian. The northernmost exposures of the Alamitos studied by Sutherland (1963) are along the north side of the Rio Pueblo.

Throughout the southern Sangre de Cristos, the Alamitos is overlain by the nonmarine Sangre de Cristo Formation, which consists of poorly sorted arkosic sandstones and conglomerates interbedded with red shales and siltstones. The Sangre de Cristo Formation increases in thickness northward, from about 150 m near Pecos to 725 m east of Mora, to

2,875 m just north of the New Mexico—Colorado boundary (Brill, 1952). About 1,515 m were measured in the Moreno Valley east of Taos by Wanek and Read (1956). In the Pecos area the basal Sangre de Cristo interfingers with beds of Virgilian age and is probably mainly of Early Permian age, but to the north it overlies marine units of late Desmoinesian age (Sutherland, 1963). The presence of *Callipteris conferta* and other fossil plants indicates an Early Permian age for at least part of the formation in the Moreno Valley (Wanek and Read, 1956). Lungfish burrows and other Early Permian vertebrate remains were reported from near the top of the Sangre de Cristo Formation near the village of Pueblo, 38 km south of Pecos (Vaughn, 1964).

North of Taos, in the Eagle Nest area, Pennsylvanian strata of Atokan and Desmoinesian age reach an estimated thickness of 1,500 m, but formation names used in the south have not been applied; the entire Pennsylvanian is assigned to the undivided Magdalena Group (Clark, 1966; Clark and Read, 1972). The sequence is composed of alternating coarse-grained gray to brown sandstones, thick beds of brown, gray, purple, and pale-red shales, and minor gray, locally oolitic or nodular limestones. The Sangre de Cristo Formation overlies the Magdalena Group in the Eagle Nest area and reaches a thickness of about 1,600 m.

PREVIOUS PALEONTOLOGICAL STUDIES

Geologists on several early exploring expeditions in the 1850's and 1860's observed and collected fossils from the Pennsylvanian of the southern Sangre de Cristos (Sutherland and Harlow, 1973), but their efforts concentrated in the Santa Fe and Pecos areas, near the Santa Fe Trail. The first collections of Pennsylvanian invertebrate fossils from near Taos were made, ironically, by the vertebrate paleontologist Edward D. Cope, while a member of the Wheeler Survey of 1874. Cope (1875, p. 66) followed the valley of Rancho Creek (now the Rio Grande de Ranchos) for 13 km, noting thick sandstone deposits containing plant fossils and reporting "limestone of the Carboniferous period, which is at the top thin-bedded and alternating with dark-colored shales." Cope found in these beds "great numbers of characteristic fossils, weathered out and beautifully preserved, including Echinoderms, Crinoids, small pieces of *Orthoceras*, *Goniatites*, Spirifers and other brachiopods, with Gastropods resembling *Trochus*, *Turritella*, and *Nerita*." These fossils were almost certainly collected from the Flechado Formation, at or near the highly fossiliferous shales south of Talpa.

A few years later, during the summers of 1878 and 1879, J. J. Stevenson surveyed the geology of the Sangre de Cristos and made collections of Pennsylvanian fossils from several localities in the Taos area, including Taos Peak, along the Rio Fernando de Taos, at the head of Mora Creek, and in the area of Coyote Creek and Black Lake (Stevenson, 1881). These collections, and those made by Cope, were turned over to C. A. White, who listed nearly 100 taxa and described nine new species, mainly from Cope's locality (White, 1881). One of the most distinctive gastropods was named *Murchisonia copei* after its discoverer; later Girty made it the type species of a new genus *Taosia*, now considered to be a subgenus of *Stegocoelia* (Fig. 3.33).

White (1881, p. 19) remarked that this fauna showed "the contemporaneous prevalence of a greater profusion of specific forms than has hitherto been discovered in any one Carboniferous locality so far westward and southward," and perceptively suggested that the high number of species observed was probably just a small part of the total species that actually existed in the Taos area, "as indicated by the fact that at the single locality of Taos alone, Professor Cope obtained 50 species . . . and he was not then making a special investigation in that direction." Recent work by me at or near the locality south of Talpa where Cope made his collection (discussed below) has supported White's suspicions: more than 170 invertebrate species, mainly molluscs, have so far been identified.

Subsequent paleontological information on the Taos area, with the exceptions mentioned below, consists of lists of fossils identified from various Pennsylvanian units (Table 1). The first modern study of Taos area paleontology was presented by Young (1945a), who in an unpublished doctoral dissertation reported or described nearly 150 species of

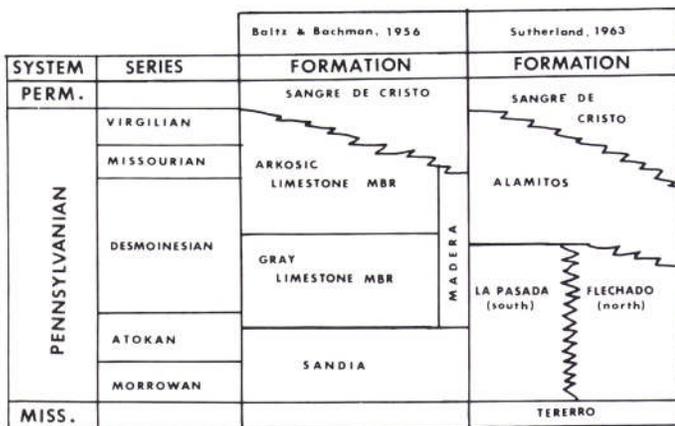


FIGURE 2. Stratigraphic nomenclature of Taos to Las Vegas area (after Casey, 1980).

PENNSYLVANIAN STRATIGRAPHY AND PALEONTOLOGY

TABLE 1. Papers reporting lists of fossils from Pennsylvanian marine units in the Taos area, after 1900.

Gruner, 1920	Five brachiopods and one coral from Wheeler Peak area.
Ray & Smith, 1941	Late Pennsylvanian plant assemblage, 3.2 km south of Agua Fria Creek, Moreno Valley.
Brill, 1952	Corals, brachiopods, molluscs, and a trilobite from south end of Moreno Valley, about 4.8 km north of Black Lake.
Wanek & Read, 1956	Fusulinids from Mora-Holman area.
Tschanz et al., 1958	Corals, brachiopods, bryozoans, and molluscs of Middle Pennsylvanian age from upper part of "Magdalena Group," and several marine invertebrate taxa and plants of Late Pennsylvanian age from lower Sangre de Cristo Formation, Coyote area.
Sutherland, 1963	Brachiopods from several localities south of Taos.
Clark & Read, 1972	About 70 taxa of invertebrates from 60 localities in Eagle Nest area.
Sutherland & Harlow, 1973	Fusulinid and conodont zones (along with descriptions of brachiopods), Sangre de Cristo Mountains.

Pennsylvanian invertebrates of which 36 were considered new. Several new nautiloids and a new genus and species of giant scaphopod, *Pro-dentalium raymondi* (Fig. 4.31), were described in publications (Young, 1942, 1945b), and the stratigraphy and brachiopod fauna were briefly discussed in abstracts (Young, 1941, I 946a, b), but the majority of the taxa described as new species in the dissertation were never published. About 35 species of gastropods alone were reported from near Talpa. Later, Sutherland and Harlow (1973) comprehensively described the Pennsylvanian brachiopods of the Sangre de Cristos, a total of 94 species. Though most of their collections were made from the Santa Fe—Nambé—Pecos area, several localities in Taos County were also reported.

Most recently, Casey (1980) summarized the Atokan and Desmoinesian faunal communities that existed in the Taos area. Casey recognized a productid community in prodeltaic facies, a productid-*Composita* community farther offshore, a molluscan—*Mesolobus* community in nearshore deltaic embayments, and transitional brachiopod-crinoid and phylloid algae communities in shallow, abandoned fan-delta platform environments where carbonates were accumulating. Basinal environments within the Taos trough were characterized by few invertebrate body fossils but numerous trace fossils of nonselective deposit feeders. Though Casey's communities were not quantitatively defined and probably represent informal associations of species rather than true paleocommunities, his work represents the first attempt to interpret the distribution and associations of the diverse Pennsylvanian marine faunas of the Taos area, and to tie them in with specific depositional environments.

**PALEONTOLOGY OF FLECHADO FORMATION
NEAR TALPA**

An excellent and characteristic example of a highly fossiliferous, nearshore-marine, dominantly dark-gray shale—siltstone facies of the Flechado Formation occurs along the east side of New Mexico State Highway 3, about 2.5 km south of the village of Talpa. The steeply dipping section exposed here is more than 150 m thick and consists of several relatively thin conglomeratic to medium-grained, locally trough crossbedded sandstone units separated by thicker intervals of dark-gray shales and siltstones. Following the interpretation given by Casey and Scott (1979) for sequences in the immediate vicinity, the sandstone beds represent delta-front and fluvial-channel sediments associated with fan-delta lobes that prograded intermittently across shallow, muddy, marine environments.

The slope-forming shales and siltstones that form the greater part of the thickness of this sequence are abundantly fossiliferous. The fossils erode readily from these relatively soft units and their preservation is

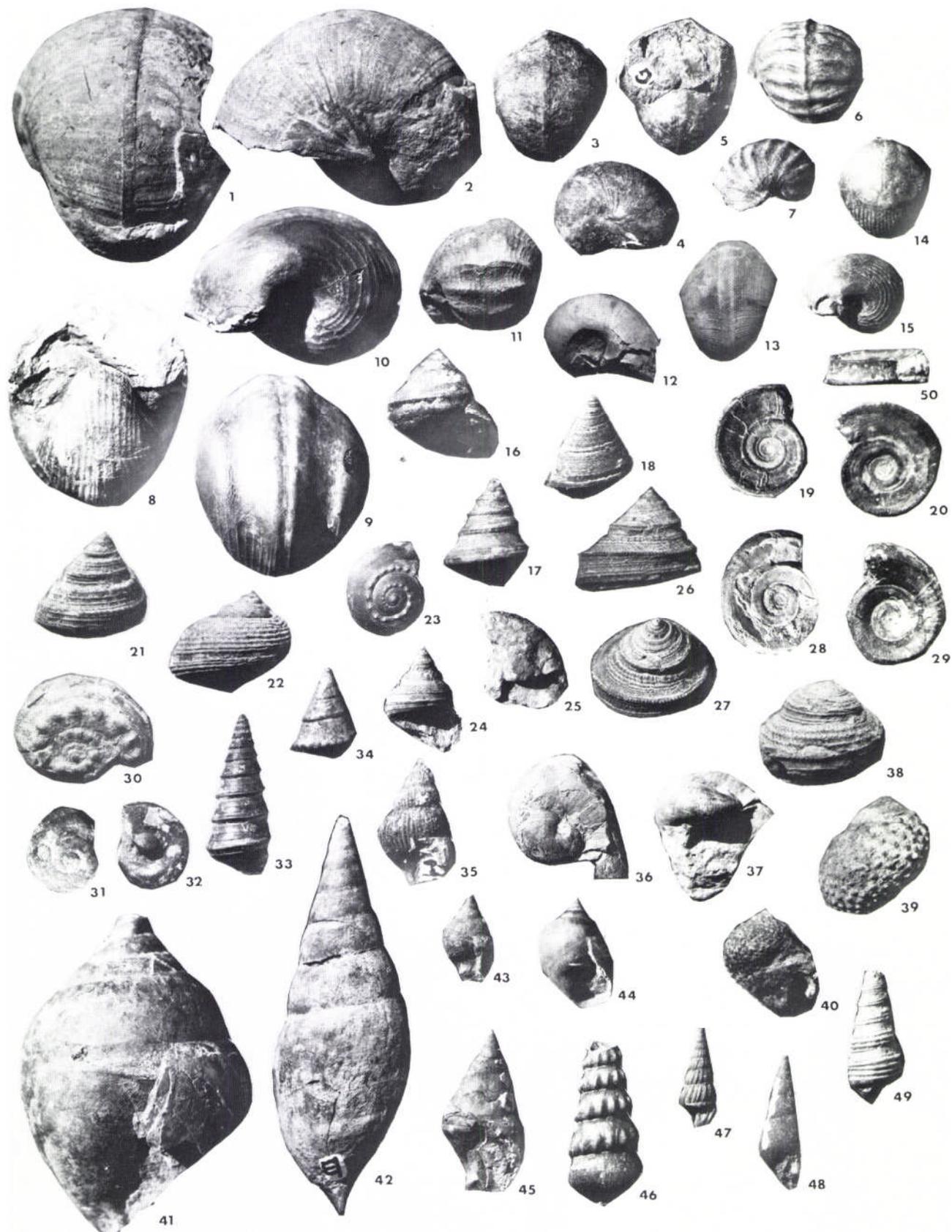
generally very good. Based on the brachiopod species present and their ranges in the Pennsylvanian of the Sangre de Cristos as determined by Sutherland and Harlow (1973), the age of this section is early Desmoinesian. My intention here is to briefly characterize this unusual fauna, illustrate some of the most common or conspicuous gastropod and bivalve species (Figs. 3, 4) (see Sutherland and Harlow, 1973, for descriptions and illustrations of most of the brachiopods), and summarize some aspects of ongoing investigations.

About 170 species of marine invertebrates have thus far been identified from this locality, in collections totaling more than 15,000 specimens. The list of species below provides a general measure of the relative diversity of major groups.

- COELENTERATA
Paraconularia crustula
Syringopora? sp.
solitary rugose corals, 2 spp.
- BRYOZOA
Fistulipora sp.
Prismopora triangulata
- BRACHIOPODA
Lingula carbonaria
Orbiculoidea capuliformis
O. missouriensis
O.? sp. (very large)
Crania sp.
Rhipidomella carbonaria
Derbyia cf. *crassa*
Plicochonetes? sp.
Mesolobus striatus
M. cf. *profundus*
Chonetinella jeffordsi
Leptalosia? sp.
Kozlowskia haydenensis
Desmoinesia "missouriensis"
D. cf. *muricata*
Sandia? sp.
Echinaria cf. *knighti*
Buxtonia sp.
Antiquatonia hermosana
Linoproductus sp.
Wellerella sp.
Hu.stedia "mormoni"
Composita subtilita
Cleiothyridina pecosii
Crurithyris cf. *planoconvexa*
Neospirifer cameratus
N. tewaensis?
Anthracospirifer curvilateralis chavezae
A. "opimus"?
Punctospirifer sp.
Phricodothyris perplexa
Beecheria cf. *bovidens*
- MOLLUSCA—BwArviA
Nuculopsis anodontoides
N. aff. *anodontoides*
N. croneisi
N. girtyi
N.? sp.
Paleyoldia glabra
Phestia arata
P. cf. *bellistriata*
Solemya (Janeia) radiata
Parallelodon carbonarius?
P. hexacostata
P. aff. *tenuistriatus*
cf. *Parallelodon*
Promytilus sp.
Myalina (M.) cf. *arbala*
Leptodesma (L.) aff. *longa*
Acanthopecten meeki
Clavicosta echinata
Limipecten cf. *morsei*
Aviculopectinidae indet.
Streblochondria tenuilineata
Chaenocardia ovata
Posidonia? n.sp.
Paleolima sp.
Schizodus amplus
S. curtus
S. aff. *ulrichi*
Astartella compacta
A. concentrica

- A. newberryi*
A. varica
Cypricardina carbonaria
Edmondia anodontoides
E. ovata?
Wilkingia terminale
W. n.sp.?
Chaenomya sp.
Sanguinolaes costata
S. aff. costata
 cf. *S.?* *elongatus* of Ciriacks, 1963
 MOLLHSCA-RosTRocoiscfFLA
Pseudoconocardium cf. obliquum
P. n.sp.?
 MOLLHSCA--GAsTRoPoon
 Bellerophonataceae
Bellerophon (B.) crassus
B. (B.) aff. planodorsatus
B. (B.) wewokanus
B. (Pharkidonotus) percarinatus
Knightites (Cymatospira) montfortianus
K. (Retispira) "tenuilineata"
Euphemites "carbonarius"
E. cf. enodis
E. nodocarinatus (= *Bellerophon inspeciosus* of White, 1881)
 Euomphalacea
Straparollus (Amphiscapha) cf.
S. (A.) cf. reedsi
S. (Euomphalus) plummeri
S. (E.) permodosus
 Pleurotomariacea
Treospira (T.) illinoisensis
Euconospira aff. turbiniformis
E. n.sp.
Spiroskala n.sp. cf.
Schwedagonia Glabrocingulum
(G.) grayvillense
G. (G.) spp.
G. (Ananias) sp.
Worthenia tabulata
Gossetina spironema
G. cf. spironema
Plah.zona n.sp.
Shansiella carbonaria
S. beckwithana
Porcellia sp.
Glyptotomaria (Dictyotomaria) quadrilineata
G. (D.) aff. scitula
G. (D.) n.sp.?
Paragoniozona multilirata
P. cf. nodolirata
Phymatopleura nodosus
 Trochonemataceae
Amaurotoma aff. humerosa
A. ? n.sp.
 Platycerataceae
Platyceras (Orthonychia) parvum
Strophostylus girtyi
 Microdomataceae
Microdoma? n.sp.
Eucochlis perminuta
 Anomphalacea
Anomphalus verruculiferus
A. sp.
 Neritacea
Naticopsis (N.) aff. judithae
N. (Jedria) meeki
N. (J.) ventrica
Trachydomia whitei
T. sp.
Oncochilus vaningeni
 Murchisoniacea
Murchisonia (M.?) sp. M.
(Donaldospira?) sp. M. (new
subgen.?) n.sp. Stegocoelia
(S.) aff. wortheni
S. (Taosia) copei
S. (T.) cf. percostata
S. (T.) spp.
Goniasma lasallensis
G.? sp.
 Loxonemataceae
Plocezyga (P.) cf. corona
P. (P.) aff. tenuilirata
P. (P.) spp.
P.? (Gamizyga) illineata
Pseudozygopleura (P.) spp.
Stephanozyga subnodosa
S. n.sp.?
 Cerithiacea
Orthonema inornatum
O. cf. salteri
O. n.spp.
Callispira quinquecostata
C.? sp.
 Subulitacea
Leptopterygia subtilistriatum
L. virgatum
L. sp.
Ceraunocochlis fulminata
Strobeus regularis
S. brevis
S. paludinaeformis
S. primigenius?
S. n.sp.
Meekospira peracuta
Girtyspira sp.
 Pyramidellacea
Donaldina stevensana
D. cf. robusta
Streptacis cerithiformis
S. aff. scalpta
 MOLLUSCA-SCAPHOPODA
"Dentalium" sublaeve
Prodentium rasmondi
 MOLLUSCA-CEPHALOPODA
Brachycycloceras sp.
Metacoceras sp.
Mooreoceras sp.
Pseudorthoceras knoxense
 TRILOBITA
Ditymopyge sp.
 ECHINODERMATA
 crinoid stem fragments and plates
Archaeocidaris triplex
 echinoid spines and plates
 VERTEBRATA
Petalodus? sp.

FIGURE 3. Gastropods from the Flechado Formation, Taos area. All specimens are from the locality south of Talpa discussed in text. **1-2**, *Bellerophon (B.) crassus*, top and side views, UNM 7223, xl; **3-5**, *Bellerophon (B.) wewokanus*, top, side, and apertural views, UNM 7224, xl; **6-7**, *Bellerophon (Pharkidonotus) percarinatus*, top and side views, UNM 7225, xl; **8-10**, *Euphemites nodocarinatus*, apertural, top, and side views, UNM 7226, xl; **11**, *Knightites (Cymatospira) mondOrtianus*, top view, UNM 7227, xl.5; **12-13**, *Knightites (Retispira) "tenuilineata"*, side and top views, UNM 7228, x2; **14-15**, *Euphemites "carbonarius"*, top and side views, UNM 7229, x2; **16**, *Glabrocingulum (G.) grayvillense*, apertural view of an eroded specimen, UNM 7230, xl.5; **17**, *Spiroskala* n.sp., apertural view, UNM 7015, x2; **18**, *Paragoniozona multilirata*, slightly oblique apertural view, UNM 7119, x3; **19-20**, **50**, *Straparollus (Amphiscapha) cf. catilloides*, top, basal, and side views, UNM 7231, xl.5; **21**, *Phymatopleura nodosus*, apertural view, UNM 7099, x3; **22**, *Shansiella carbonaria*, apertural view, UNM 7058, x2; **23**, *Treospira (T.) illinoisensis*, top view, UNM 7193, xl; **24**, *Platyzona* n.sp., apertural view, UNM 7069, x2; **25**, *Platyceras (Orthonychia) parvum*, side view, UNM 7232, xl; **26-27**, *Worthenia tabulata*, apertural and oblique top views, UNM 7233, xl.5; **28-29**, *Straparollus (Euomphalus) plummeri*, top and basal views, UNM 7234, xl.5; **30**, *Gossetina cf. spironema*, oblique top view of a laterally crushed specimen, UNM 7027, xl; **31-32**, *Anomphalus verruculiferus*, top and basal views, UNM 7235, and basal view, UNM 7236, both x2; **33**, *Stegocoelia (Taosia) copei*, apertural view, UNM 7237, xl; **34**, *Microdoma? n.sp.*, apertural view, UNM 7238, x2; **35**, *Plocezyga? (Gamizyga) illineata*, apertural view, UNM 7239, xl.5; **36-37**, *Strophostylus girtyi*, top and apertural views of a laterally compressed specimen, UNM 7240, xl; **38**, *Glyptotomaria (Dictyotomaria) quadrilineata*, slightly oblique apertural view, UNM 7079, x2; **39-40**, *Trachydomia whitei*, apertural view, UNM 7241, and apertural view, UNM 7242, both xl.5; **41**, *Strobeus primigenius?*, apertural view, UNM 7243, xl; **42**, *Strobeus regularis*, apertural view, UNM 7244, xl; **43**, *Strobeus brevis*, apertural view, UNM 7245, x 1; **44**, *Strobeus? n.sp.*, apertural view, UNM 7246, x 1; **45**, *Strobeus paludinaeformis*, apertural view, UNM 7247, xl; **46**, *Stephanozyga subnodosa*, apertural view, UNM 7248, xl; **47**, *Pseudozygopleura (P.)* sp., apertural view, UNM 7249, xl; **48**, *Meekospira peracuta*, apertural view, UNM 7250, xl.5; **49**, *Callispira quinquecostata*, apertural view, UNM 7251, xl.



This list is preliminary and is based almost entirely on specimens collected from the surface of outcrops. Some bulk sediment samples have been screen-washed, and the concentrates contain large numbers of minute fossils, particularly fusulinids and gastropods, that have yet to be studied. In addition, some gastropod taxa identified here only to the generic or subgeneric level include numerous species; for example, there are probably 10 or 12 as yet unidentified species of the small, high-spired gastropod *Pseudozygopleura* (*Pseudozygopleura*) (Fig. 3.47). Thus, the total number of species at this locality is almost certainly well over 200.

Gastropods are especially common and diverse in this fauna, to an extent found in few other Pennsylvanian localities in North America. Although many species are uncommon to rare, some, such as *Worthenia tabulata* (Fig. 3.26-27), *Glabrocingulum* (*Glabrocingulum*) *grayvillense* (Fig. 3.16), *Trachydomia whitei* (Fig. 3.39-40), *Anomphalus verruculiferus* (Fig. 3.31-32), *Microdoma?* n.sp. (Fig. 3.34), *Stegocoelia* (*Taasia*) *copei* (Fig. 3.33), and *Bellerophon* (*Pharkidonotus*) *percarinatus* (Fig. 3.6-7) are abundant. One or two of these common species may dominate numerically a particular interval of the shale sequence. Further, preliminary examination of sieved sediment samples shows that in some units the number of minute gastropods (those with shells less than 2 mm high, representing small species and juveniles of larger species) per unit volume of shale exceeds the number of larger gastropods by at least a factor of five. The majority of gastropod species in this fauna are present also in contemporaneous units in the midwestern United States, but some, such as *Anomphalus verruculiferus* (Fig. 3.31-32), *Glyptotomaria* (*Dictyotomaria*) *quadrilineata* (Fig. 3.38), *Paragoniozona multilirata* (Fig. 3.18), and *Callispira quinquecostata* (Fig. 3.49) have been reported only from New Mexico, Colorado, or west Texas. Several undescribed species are also present—not surprising in view of the fact that very few studies of New Mexico Pennsylvanian gastropods have been done.

Brachiopods are far less diverse and less abundant than gastropods in most parts of this sequence. However, some shale units contain high numbers of the small chonetid *Mesolobus striatus*, which may represent as much as 35% of all megainvertebrates present. Bivalves are generally less abundant than gastropods or brachiopods, and most bivalve species are uncommon to rare. Nuculoids, especially *Nuculopsis girtyi* (Fig. 4.1), and the several species of *Astartella* (Fig. 4.24-26) are locally very common, however, and comprise about 57% and 35%, respectively, of the bivalve specimens from this locality. Other molluscan groups are uncommon, although moderate numbers of scaphopod and orthoconic nautiloid shell fragments are present in some beds. Rostroconchs are represented by a total of 10 specimens; the single polyplacophoran valve from this locality was described by Kues (1983). Solitary rugose corals are present through most of the sections and appear to be most numerous in beds dominated by *Mesolobus*. Crinoids, echinoids, bryozoans, and trilobites are very minor elements of this mollusc-dominated fauna. Systematic descriptions and more comprehensive documentation of the gastropod, bivalve, rostroconch, and scaphopod taxa are in preparation.

Although the above observations are generally true for the locality as a whole, examination of collections made from each shale interval between a pair of sandstone units and from different levels within each interval suggests that considerable variation in the relative abundances

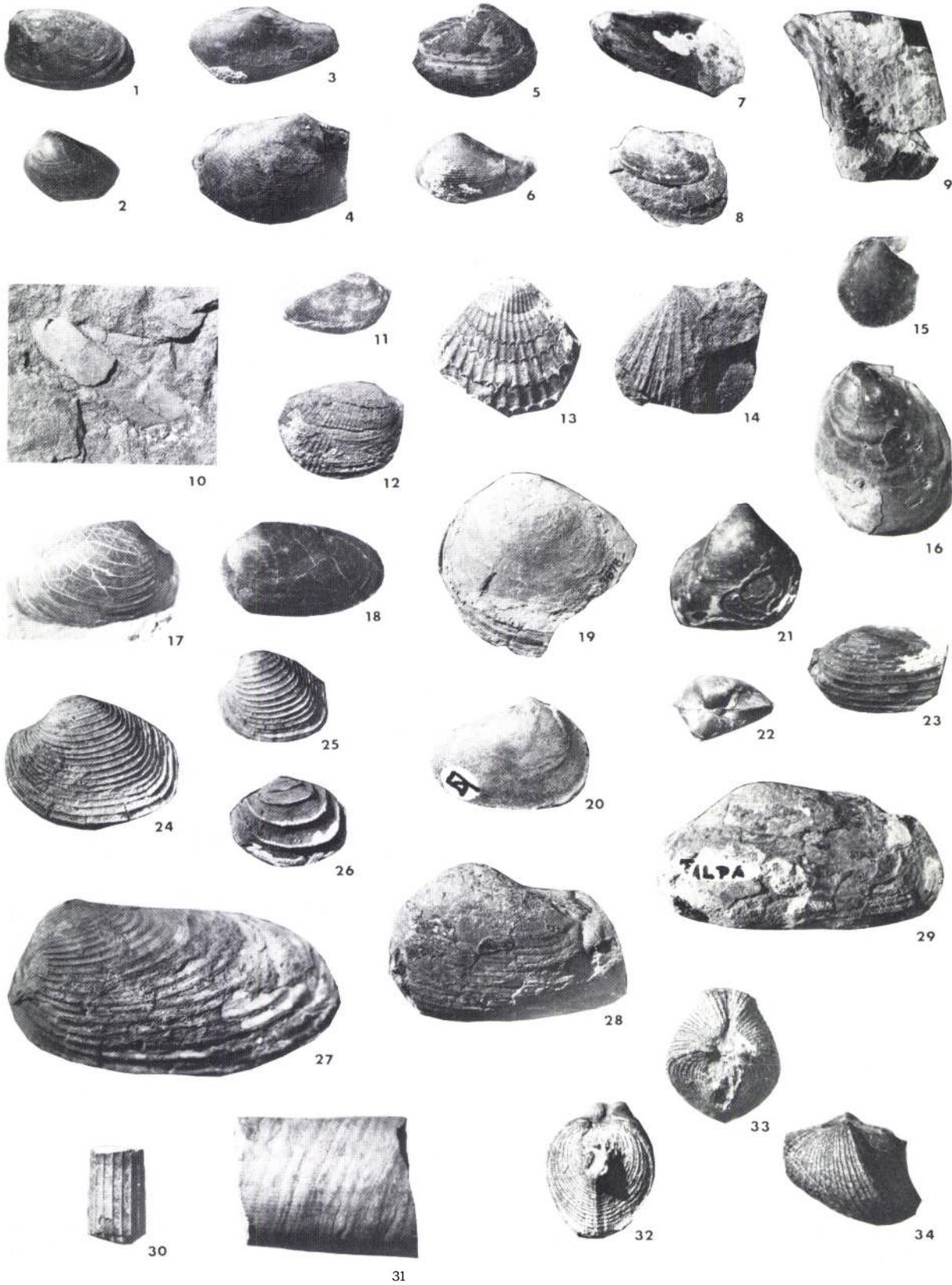
of taxa exists through the sequence. Several assemblages, each characterized by different dominant species as well as by different relative abundances of subsidiary species, appear to have occupied nearshore-marine environments during deposition of the shale at this locality. Quantitative analysis of the constituent species in each assemblage must await completion of taxonomic studies, but the assemblages observed qualitatively very likely represent subsets of some of the broad, generalized "communities" recognized by Casey (1980) through the Flechado of the Taos area. Only slight differences in color, grain size, and other lithologic features of the shales are discernible at outcrop; more detailed examination of the physical characteristics of the shale intervals is planned. At present, it appears that relatively subtle differences in the environment, related to proximity to the shifting fan-delta lobes, affected the abundance of many mollusc species, resulting in significant variations in the proportions of taxa living in various prodelta- and interdeltic-embayment environments.

While detailed consideration of the paleobiogeographic relationships of the Flechado mollusc fauna is premature, some general comments may be made. During the Pennsylvanian, a long, north-south trending line of connected positive areas (Front Range, Apishapa, and Sierra Grande uplifts) existed to the east of the present Sangre de Cristo Mountains in Colorado and northeastern New Mexico (Mallory, 1972; Chronic, 1979; Armstrong et al., 1979). This would have prevented any direct connection of Flechado faunas with contemporaneous marine faunas present to the northeast, for example in Kansas. Sutherland and Harlow (1973) noted a rather poor correlation of Desmoinesian brachiopod species in the Sangre de Cristos with Midcontinent species. A continuous band of marine Pennsylvanian carbonate and elastic facies is present in the subsurface south of the Sierra Grande uplift, from near Las Vegas through the Tucumcari Basin and into the Texas panhandle (Roberts et al., 1976). Midcontinent species present in north-central New Mexico are thus probably derived from the extensive marine environments that prevailed in north-central Texas during the Pennsylvanian. The Middle Pennsylvanian gastropod and bivalve faunas of north-central Texas are diverse; however, they have not been extensively studied, and further comparisons thus cannot be made. In view of the restriction of Pennsylvanian marine environments in the Taos area between uplifts to the east and west, and the possible partial separation of the Taos trough (or Rowe-Mora Basin) from the central Colorado seaway by a westward extension of the Sierra Grande uplift (Cimarron arch of Baltz, 1965), the presence of some endemic mollusc species restricted to north-central New Mexico is not unlikely. Several apparently endemic brachiopods were reported by Sutherland and Harlow (1973).

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I am grateful to Mr. LeGrand Smith for showing me the Talpa locality and later conveying to me his large collections of fossil invertebrates from the Taos area for study. His continued interest, along with that of fellow fossil enthusiasts Lud and Lois Gritzko, who loaned specimens from their collection, represent the ideal collaboration between amateur and professional paleontologists. I also thank Elmo Brown and Pat Dickerson for reviewing the manuscript and offering helpful suggestions on its improvement.

FIGURE 4. Bivalves, scaphopods, and rostroconchs from the Flechado Formation, Taos area. All specimens are from the locality south of Talpa discussed in text, unless otherwise indicated. 1, *Nuculopsis girtyi*, left valve, UNM 8787, x1.5; 2, *Nuculopsis anodontoides*, left valve, UNM 8788, x1.5; 3, *Paleyodia glabra*, left valve, UNM 8789, x1.5; 4, *Paleyodia glabra*, anterior part of left valve, UNM 8790, x2; 5, *Phestia bellistriata*, anterior part of right valve, UNM 8791, x1; 6, *Phestia arata*, left valve, UNM 8792, x1.5; 7, *Promytilus* sp., left valve, UNM 8793, x1.5; 8, *Posidonia?* n.sp., left valve, UNM 8794, x2; 9, *Myalina* (*M.*) cf. *arbala*, part of left valve, UNM 8795, x0.5; 10, *Leptodesma* (*L.*) cf. *longa*, left valve, UNM 4511, x 1; 11, *Parallelodon hexacostata*, right valve, UNM 8797, x1.5; 12, *Parallelodon carbonarius?*, anterior part of right valve, UNM 8798, x1; 13, *Acanthopecten meeki*, left valve, UNM 8799, x1.5; 14, *Clavicosta echinata*, left valve, UNM 8800, x1.5; 15, *Streblochondria tenuilineata*, right valve, UNM 8801, x1.5; 16, *Chaenocardia ovata*, left valve, UNM 8802, x1.5; 17, *Edmondia ovata?*, slightly oblique view of right valve having ventral periphery partially covered by matrix, UNM 8803, x1; 18, *Edmondia anodontoides*, left valve, UNM 8804, x1.5; 19, *Schizodus amplus*, left valve, UNM 3878, from Taos Canyon, x0.5; 20, *Schizodus* aff. *ulrichi*, right valve, UNM 8805, x1.5; 21, 22, *Schizodus curtus*, right valve, x3, and top view, x2, UNM 8806; 23, *Sanguinolites costata*, anterior part of left valve, UNM 8807, x1; 24, *Astartella newberryi*, left valve, UNM 8808, x2; 25, *Astartella concentrica*, left valve, UNM 8809, x2; 26, *Astartella varica*, left valve, UNM 8810, x1; 27, *Wilkingia terminalis*, left valve, UNM 8811, x1; 28, *Chaenomva* sp., left valve, UNM 8812, x1; 29, cf. *Sanguinolites?* *elongatus*, left valve, UNM 8813, x1; 30, "*Dentalium*" *sublaeve*, fragment of shell, UNM 8815, x1; 32-34, *Pseudoconocardium* cf. *obliquum*, posterior, top, and left side views, UNM 8816, x1.5.



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Note added in proof

A recent paper that deals comprehensively with the late Paleozoic stratigraphy of an area from Las Vegas to Mora, along the southeastern side of the Sangre de Cristo Mountains, deserves mention, although it was received too late to be incorporated into the main discussion. It is Baltz, E. H., and Myers, D. A., 1984, *Porvenir Formation (new name)-and other revisions of nomenclature of Mississippian, Pennsylvanian, and Lower Permian rocks, southeastern Sangre de Cristo Mountains, New Mexico*: U.S. Geological Survey, Bulletin 1537-B, 39 pp. In the area covered, the term Sandia Formation is retained for rocks of mainly Atokan age, and the Madera Formation is raised to a Group including the Desmoinesian Porvenir Formation, overlain by the Alamitos Formation, of Desmoinesian to (locally) Wolfcampian age.