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LATE PENNSYLVANIAN INVERTEBRATE PALEONTOLOGY OF BRUTON CANYON, NORTHERN SIERRA OSCURA, SOCORRO COUNTY, NEW MEXICO

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ABSTRACT—The excellently exposed Upper Pennsylvanian sequence in Bruton Canyon, first studied by Thompson (1942), consists of several members of the Missourian-Virgilian Atrasado Formation (named as formations by Thompson) and the overlying Bursum Formation (Madera Group). The Burrego, Story, Del Cuerto, and Moya Members of the Atrasado Formation yielded marine invertebrate collections dominated by brachiopods; crinoid fragments, rugose corals, bryozoans, and fusulinids are subsidiary elements of these assemblages, with molluscs being rare. The Burrego assemblage is unusual in its abundance of the large productide *Echinaria*, generally an uncommon genus in New Mexico Pennsylvanian strata. By far the largest collection (>1400 specimens), from the middle part of the Del Cuerto Member, is dominated by brachiopods (19 species), with solitary rugose corals and crinoid debris next in abundance. This Del Cuerto assemblage is dominated numerically by the brachiopod genera *Composita* and *Enteletes* (73% of all brachiopod specimens), with moderate numbers of *Phricodothyris* and the small productide *Hystriaculina*, but only small numbers of the other brachiopod species. This is the only assemblage known in the Pennsylvanian of New Mexico in which *Enteletes*, which is absent from most Late Pennsylvanian strata, is a dominant element. Its association with locally dense concentrations of solitary rugose corals in the Del Cuerto Member is similar to a few assemblages in the Late Pennsylvanian of the Midcontinent region, and suggests that the genus flourishes only in a restricted and specific set of ecological conditions. All of the Atrasado assemblages are strongly dominated by stenohaline groups, and lived in well-oxygenated, offshore, shallow-marine environments that experienced no salinity fluctuations and little turbidity.

INTRODUCTION

One of the best exposed sequences of Upper Pennsylvanian strata in central New Mexico crops out along the slopes of Bruton Canyon, in the northern Sierra Oscura. The stratigraphy and age of this sequence, based on fusulinids, was studied initially by Thompson (1942), in a paper covering the Pennsylvanian stratigraphy of much of New Mexico. Thompson proposed numerous group- and formation-rank units of Late Pennsylvanian (Missourian and Virgilian) age based on type sections in the Bruton Canyon area, but these units were generally not recognized by later workers. In the more than 60 years since Thompson's studies, little additional information about this sequence has been published. Thompson noted some beds in his stratigraphic sections that are rich in invertebrate fossils but reported no taxa identified to the generic level. The purpose of this paper is to review the Upper Pennsylvanian stratigraphy of Bruton Canyon and to discuss the invertebrate faunas in several of Thompson's units.

LOCATION AND ABBREVIATIONS

Bruton Canyon extends along the northeastern side of the Sierra Oscura, about 18 km west of the western edge of Chupadera Mesa, and south-southeast of the village of Bingham, in eastern Socorro County (Fig. 1). The fossils described here were collected from the eastern slopes of the canyon, about 0.8 km west of Borrego Spring, in NE1/4NE1/4 sec. 31, T5S, R6E (Fig. 2). This is the general location of Thompson's (1942) type section of his Keller Group, and includes underlying strata down to his Council Springs Limestone. Fossil collections were made from six intervals in Thompson's Missourian-Virgilian section here (see below). Localities and figured specimens in this paper bear New Mexico Museum of Natural History and Science (NMMNH) numbers.

STRATIGRAPHY

Thompson (1942) established type sections for numerous Missourian and Virgilian units in the Bruton Canyon area. These include the Veredas Group (lower Missourian), consisting in ascending order of the Coane, Adobe, and Council Spring Formations, totaling 38 m in thickness; the Hansonburg Group (upper Missourian), consisting of the Burrego and Story Formations, totaling 34 m in thickness; and the Keller Group (lower Virgil-

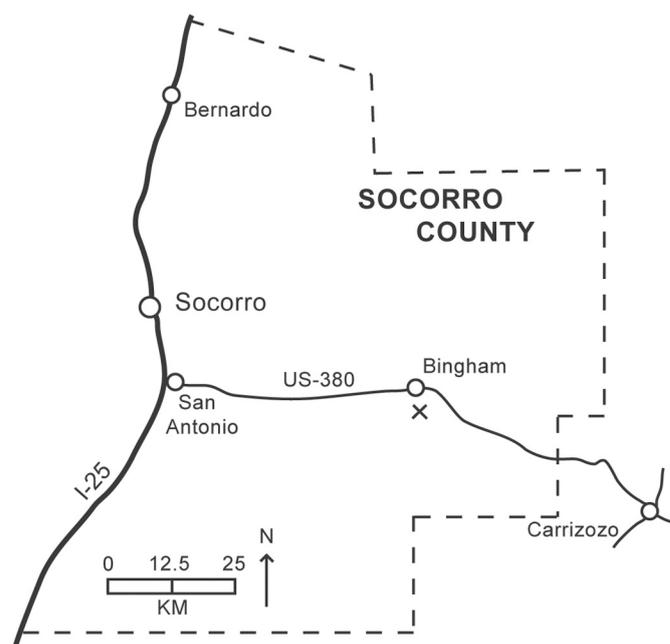


FIGURE 1. Map showing location of Bruton Canyon (X) in Socorro County, NM.

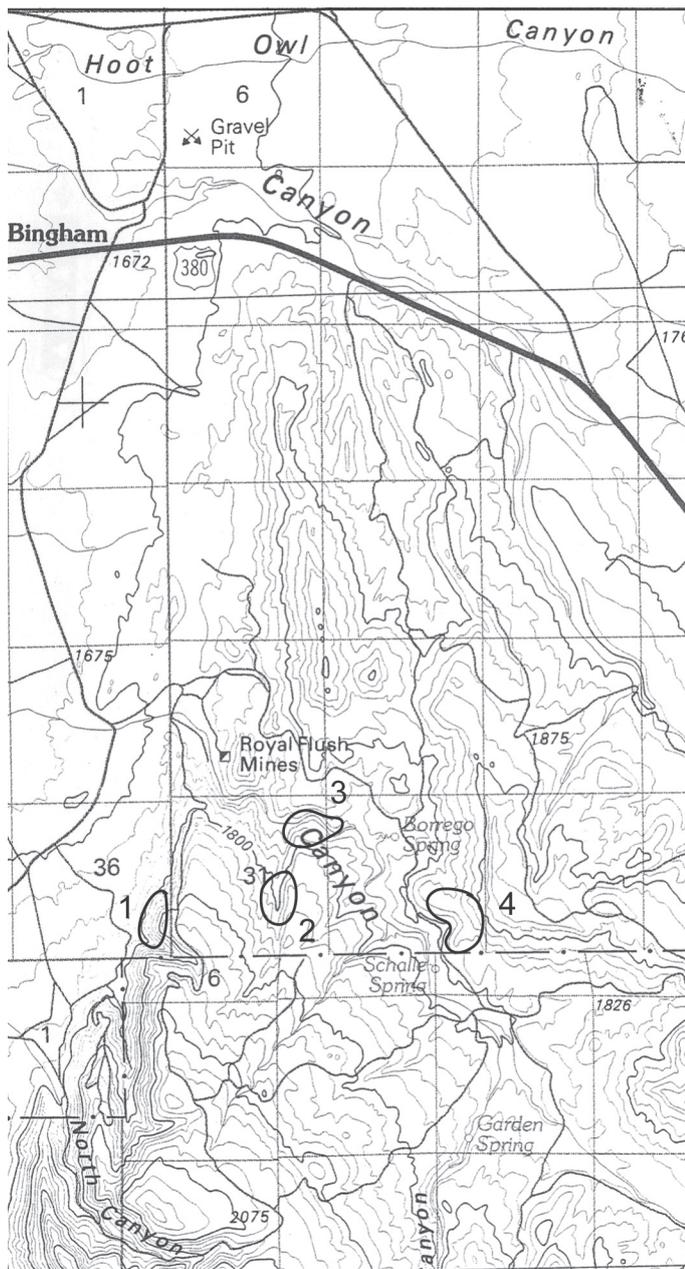


FIGURE 2. Map of Bruton Canyon, showing Thompson's (1942) Upper Pennsylvanian stratotype locations for his formations (herein members) in Veredas Group (1), Hansonburg Group (2), Keller Group (3), and Bruton Formation (4). Collections described here are from the Burrego through Moya Members of the Atrasado Formation (Thompson's Hansonburg and Keller Groups) exposed in area 3. Base map is USGS 1:100,000 Oscura Mountains quadrangle.

ian), consisting of the Del Cuerto and Moya Formations, totaling 40 m in thickness (Fig. 3). He also named the Bruton Formation (33.5 m thick) for upper Virgilian strata of the Fresnal Group overlying the Keller Group.

The type section for the Veredas Group is along the west side of the northern Sierra Oscura (SE1/4 sec. 36, T5S, R5E), about 1.5 km west of Bruton Canyon. The Hansonburg type section is

just south of Bruton Canyon (SE1/4 sec. 31, T5S, R6E), and the type section for the Keller Group is along the slopes of Bruton Canyon, mainly in NE1/4 sec. 31, T5S, R6E but extending into the west-central part of sec. 32. The type section of the Bruton Formation is a little to the east, in SE1/4 sec. 32, T5S, R6E (see Fig. 2 for these locations). The Veredas Group was not examined in this study, which focuses on the Hansonburg and Keller Groups and the Bruton Formation.

Although Thompson's Groups and Formations were carefully defined on the basis of their lithological characters, and are quite recognizable in the Sierra Oscura, they were not adopted by the U. S. Geological Survey. In geologic mapping of eastern Socorro County, Wilpolt et al. (1946) and Wilpolt and Wanek (1951) ignored Thompson's names and subsumed most of these strata within what they called "the upper arkosic limestone member" of the Madera Formation. A new name, Bursum Formation (Wilpolt et al., 1946), was substituted for Thompson's Bruton Formation and overlying unnamed limestones considered Lower Permian by Thompson (1942), based on a type section only 15 km west of the Bruton type section. Based on the fusulinid biostratigraphy then current, the Bursum/Bruton interval was considered earliest Wolfcampian in age by most subsequent workers, and incorporated a sequence of alternating reddish nonmarine clastics and thin marine limestone beds below the red beds of the Abo Formation. The Madera-Bursum nomenclature has generally prevailed to the present, although a few workers (e.g., Kottlowski, 1953; Hambleton, 1962; Kottlowski and Steensma, 1979) utilized Thompson's names in the Sierra Oscura, or have noted (e.g., Kottlowski, 1960) that these units are recognizable as far west as the Socorro area.

Recent work has added considerably to knowledge of the Late Pennsylvanian to earliest Permian stratigraphy of central New Mexico, and the relevance of Thompson's stratigraphic concepts to modern stratigraphic nomenclature. The Madera Formation has been raised to Group status, first by Myers (1973) in the Manzanita and Manzano Mountains and then regionally by Kues (2001), with the Bursum as the uppermost formation within the Madera Group. The underlying Atrasado Formation, a name first applied to the Missourian-Virgilian part of the Pennsylvanian section in the Lucero Mesa area (Kelley and Wood, 1946), has been applied to the lithologically similar and stratigraphically equivalent unit formerly termed the "upper arkosic limestone member" of the Madera (Kues, 2001). Thompson's formations in the Bruton Canyon area cannot generally be mapped at standard map scales, but Kues (2001) and Kues and Lucas (2001), followed by Lucas (2002), suggested that they are appropriate as members of the Atrasado Formation. Thompson's Veredas, Hansonburg, and Keller Groups lack a convincing stratigraphic justification, and appear to have been utilized mainly for fusulinid-based age segments of the Upper Pennsylvanian section, and so are not utilized here. Thus, in this paper, the formations recognized by Thompson (1942) in the northern Sierra Oscura (Coane through Moya Formations of Fig. 3) are regarded as members of the Atrasado Formation of the Madera Group.

Recent studies of the Bruton and Bursum Formations have added to our understanding of this part of the Upper Pennsyl-

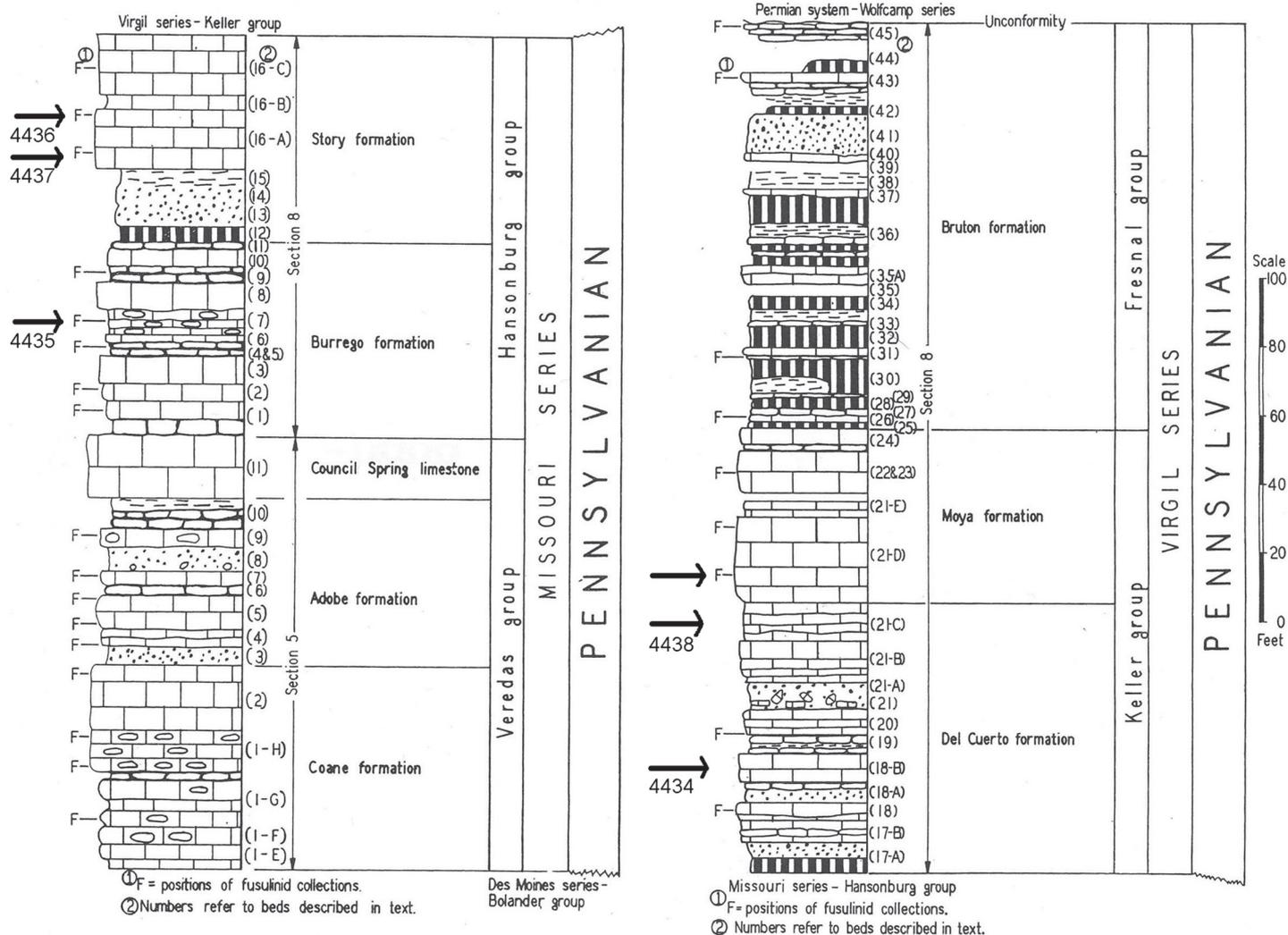


FIGURE 3. Thompson's (1942) stratigraphic section of Upper Pennsylvanian units in Bruton Canyon. Coane through Moya Formations are here considered members of the Atrasado Formation, and his Bruton Formation represents the lower part of what is now considered the Bursum Formation. Arrows indicate units from which collections were made; numbers are NMMNH locality numbers.

vanian section in the Sierra Oscura area. Lucas et al. (2000, 2002) studied the stratigraphy and fusulinid biostratigraphy, and Kues (2002) the macropaleontology, of the Bursum type section, and discussed its relationship to Thompson's Bruton Formation. Although the latter name has priority, the wider usage of Bursum Formation in the past 60 years makes it advisable to continue using that name regionally. At the Bruton type section, the Bursum includes all of the strata above the Moya Member that Thompson assigned to the Bruton Formation, plus about 20 m of overlying limestone and intercalated marine and nonmarine clastic beds below the Abo Formation that Thompson had not assigned to a formation (see Lucas et al., 2002, for further discussion), for a total thickness of about 55 m.

Lucas and Krainer (2004) sought to retain Bruton as a stratigraphic name by making it a member of the expanded Bursum Formation, the only member of the Bursum present at the Bruton and Bursum type localities. They also expanded the concept of Bursum Formation beyond its traditional use by including

(as members) equivalent formations far from its type section, such as the Laborcita Formation of the Sacramento Mountains to the south and the Red Tanks Formation of the Lucero uplift in west-central New Mexico. There are several problems with this approach. First, as Lucas and Krainer (2004, p. 43) admitted, these units are mappable at formation rank; thus considering them as the sole members of the Bursum where they crop out is inconsistent with their justifiably formation-rank status. The Bursum, Laborcita, and Red Tanks units meet all of the lithologic and mappability criteria for formations as explained in the most recent North American Stratigraphic Code (NACOSN, 2005).

A second problem is that the Bruton "Member" of the Bursum was distinguished (Lucas and Krainer, 2004, p. 44) by being "dominantly (more than 50%) marine shale and limestone with only minor interbeds of nonmarine siliciclastics." However, at the Bruton type section, as Thompson (1942; Fig. 3) clearly showed and field examination verified, the Bruton and overlying beds now included with the Bruton in the Bursum Formation

consist predominantly of reddish, pinkish, and purplish shales and sandstones displaying no evidence of a marine origin. These nonmarine beds are interbedded with thinner limestones bearing marine biotas, including fusulinids, algae and invertebrates. These marine beds comprise about 17% of Thompson's original Bruton Formation, and represent a similar proportion of the overlying strata between the Bruton and the Abo that Thompson did not assign to a formation, but which are now included in the Bursum Formation. A stratigraphic section of the Bursum at Thompson's Bruton Formation type locality (Lucas et al., 2002, fig. 3) likewise exhibits only a few thin fossiliferous limestone beds of marine origin. Further, the detailed study of the microfacies and sedimentary environments of the Bursum type section reported by Lucas et al. (2002) revealed evidence for marine environments in only a small proportion (about 20%) of the total thickness of the formation. Therefore, no justification exists for recognizing a "Bruton Member" of the Bursum; strata so recognized by Lucas and Krainer (2004) are best considered typical sections of the Bursum Formation. Moreover, as Kues (2004b) discussed in detail, other "members" (Laborcita and Red Tanks) included in the Bursum Formation by Lucas and Krainer (2004) differ significantly in their lithology and depositional environments from the Bursum and are best considered separate formations. Accordingly, in the northern Sierra Oscura, the Atrasado Formation and its members (the Missourian and lower Virgilian formations of Thompson, 1942), and the overlying Bursum Formation (including Thompson's Bruton Formation) are considered here to be the upper two formations of the Madera Group, in conceptual accord with most other workers who have studied this part of the section in central New Mexico.

Although the Bruton Formation was considered to be late Virgilian in age by Thompson (1942), and overlain by Wolfcampian (earliest Permian) strata now considered the upper part of the Bursum, the entire Bursum was traditionally assigned a Wolfcampian age based on fusulinid evidence. The fusulinids of the Bursum and correlative units (zone PW-1 of Wilde, 1990; and "Newwellian" substage of Wilde, 2006) are transitional between Virgilian and Wolfcampian faunas. Recent re-evaluation of the Virgilian-Wolfcampian (Pennsylvanian-Permian) boundary in the Midcontinent region (see Sanderson et al., 2001; Wahlman and King, 2002) has led nearly all workers to accept its placement stratigraphically higher, at a position that would place strata containing typical Bursum fusulinids as late Virgilian (latest Pennsylvanian) in age. As noted by Kues (2002), few significant changes in marine invertebrate faunas occur from the Atrasado to the Bursum and equivalent formations in New Mexico, and the data of Mudge and Yochelson (1962) suggest the same conclusion for equivalent strata of the Midcontinent region. Thus the revised Pennsylvanian-Permian boundary is accepted here, and the Bursum Formation is considered to be of late Virgilian age.

In the following discussion of the Late Pennsylvanian paleontology of Bruton Canyon, fossil occurrences are related to the stratigraphic units reported by Thompson (1942; Fig. 3). His stratigraphic column for the Council Spring through Moya Members was checked in the field in February 2000, when Spencer Lucas, Sally Johnson, and I measured a stratigraphic section in

the NE1/4NE1/4 sec. 31, T5S R6E, the approximate location of Thompson's type sections for his Keller Group (Fig. 2). The section we measured was drafted by Lucas (written commun., 2000), and is nearly identical to Thompson's stratigraphy. Thompson's Council Spring through Moya section is 260.5 ft (79 m) thick and includes 34 separate beds, whereas the 2000 section for this interval is 78 m thick and includes 33 beds. The lower part of the Atrasado Formation (Coane and Adobe Members) was not examined for this study.

FOSSIL ASSEMBLAGES

Introduction

Collections were made from six intervals within the Atrasado Formation along the east side of Bruton Canyon, and these assemblages are discussed below. The stratigraphically lowest assemblage occurs near the middle of the Burrego Member (bed 7 of Thomson, 1942; Fig. 3; NMMNH locality 4435). Two collections (from NMMNH localities 4437 and 4436), were made from the lower and upper parts, respectively, of a thick cliff-forming limestone unit in the middle of the Story Member (bed 16A of Thompson, 1942; Fig. 3). The largest and most species-rich assemblage in the Bruton Canyon section occurs in Thompson's bed 18B (Fig. 3), a 2.5 m-thick ledge-forming limestone near the middle of the Del Cuerto Member. A collection of loose specimens was made from this limestone where it had eroded to a rubbly slope (NMMNH locality 4434). The argillaceous gray limestone near the top of the Del Cuerto Member (bed 21C of Thompson, 1942; Fig. 3; NMMNH locality 4438) yielded a small collection. A few specimens were also collected from massive limestones near the base of the Moya Member (bed 21D of Thompson; Fig. 3). Finally, sparse fossils were observed in the overlying Bursum Formation at Thompson's Bruton Formation type section.

Preservation of the fossils from all of these intervals is generally poor. Most shells have been heavily recrystallized and severely weathered, and some have been dissolved away, leaving molds and steinkerns. Except for the middle Del Cuerto assemblage, collections are neither well enough preserved nor extensive enough to provide an accurate indication of species composition or relative abundance, and only a general discussion of these assemblages is provided here. All taxa observed in these assemblages, together with relative abundances of brachiopods in the middle Del Cuerto assemblage are given in Table 1, and all of the brachiopod taxa observed in this assemblage are described and illustrated (Figs. 4, 5).

Burrego Member

The specimens from the middle part of the Burrego Member were collected from a relatively thin, hard, medium gray limestone that locally is moderately bioclastic and cherty; Thompson (1942, p. 64) also reported an "abundance of brachiopods" from this unit (bed 7). The Burrego Member contains several fusulinid horizons (species of *Triticites*) that date this member as early late Missourian. Bed 7 is indeed rich in brachiopods; the assemblage



FIGURE 4. Invertebrates from the Atrasado Formation, Bruton Canyon. Unless otherwise indicated, taxa are from the middle part of the Del Cuerto Member (bed 18A of Thompson, 1942; NMMNH locality 4434). All bed numbers are from Thompson's (1942) section. Except for A and B, all taxa are brachiopods. **A**, *Girtyocoelia* sp. (sponge), NMMNH 57,890, lower Del Cuerto Member, bed 18, x 0.8. **B**, Syringoporid tabulate coral, NMMNH 57,891, Del Cuerto Member, bed 21, x 0.45. **C-F**, *Enteleles hemiplicata*, pedicle, brachial, front, and side views, NMMNH 57,892, x 1.5. **G**, *E. hemiplicata*, brachial valve of a less plicate specimen, NMMNH 57,893, x 1.5. **H, I**, *E. hemiplicata*, pedicle valve (NMMNH 57,894, x 1.75) and brachial valve (NMMNH 57,895, x 2.25) of juvenile specimens, before development of plications. **J, K**, *Enteleles* n. sp., brachial valve and front view of an incomplete and poorly preserved specimen, NMMNH 57,896, lower Moya Member, bed 21D, x 1.5. **L-N**, *Hystriculina wabashensis*, front (x 2), back and top (x 1.5) views of a pedicle valve, NMMNH 57,897. **O**, *Hystriculina "fragilis"*, front view of pedicle valve, NMMNH 57,898, x 1.5. **P, Q**, *Kutorginella* cf. *K. lasallensis*, top and back views of exfoliated pedicle valve, NMMNH 57,899, x 1. **R**, *Antiquatonia* sp., oblique view of side and anterior trail of a large specimen, NMMNH 57,900, Story Member (locality 4436), x 0.9. **S**, *Antiquatonia* sp., oblique side view of back of pedicle valve, NMMNH 57,901, Story Member (locality 4436), x 0.9. **T**, *Reticulatia americana*, top posterior view of an incomplete pedicle valve, NMMNH 57,902, Story Member (locality 4437), x 0.9. **U, V**, *Calliprotonia* cf. *C. renfrarum*, side and top views of pedicle valve, NMMNH 57,903, x 1.5.

is dominated by specimens of the large productide *Echinaria semipunctata*, with smaller numbers of other productides (*Antiquatonia*, *Linoproductus*), *Composita subtilita*, and *Neospirifer alatus* (Table 1). Isolated fusulinids and fragments of fenestrate

bryozoans and crinoids are the only other invertebrates observed in this assemblage. The high concentration of *Echinaria* in this assemblage is unusual in the Pennsylvanian of New Mexico, but the specific ecological conditions responsible for this con-

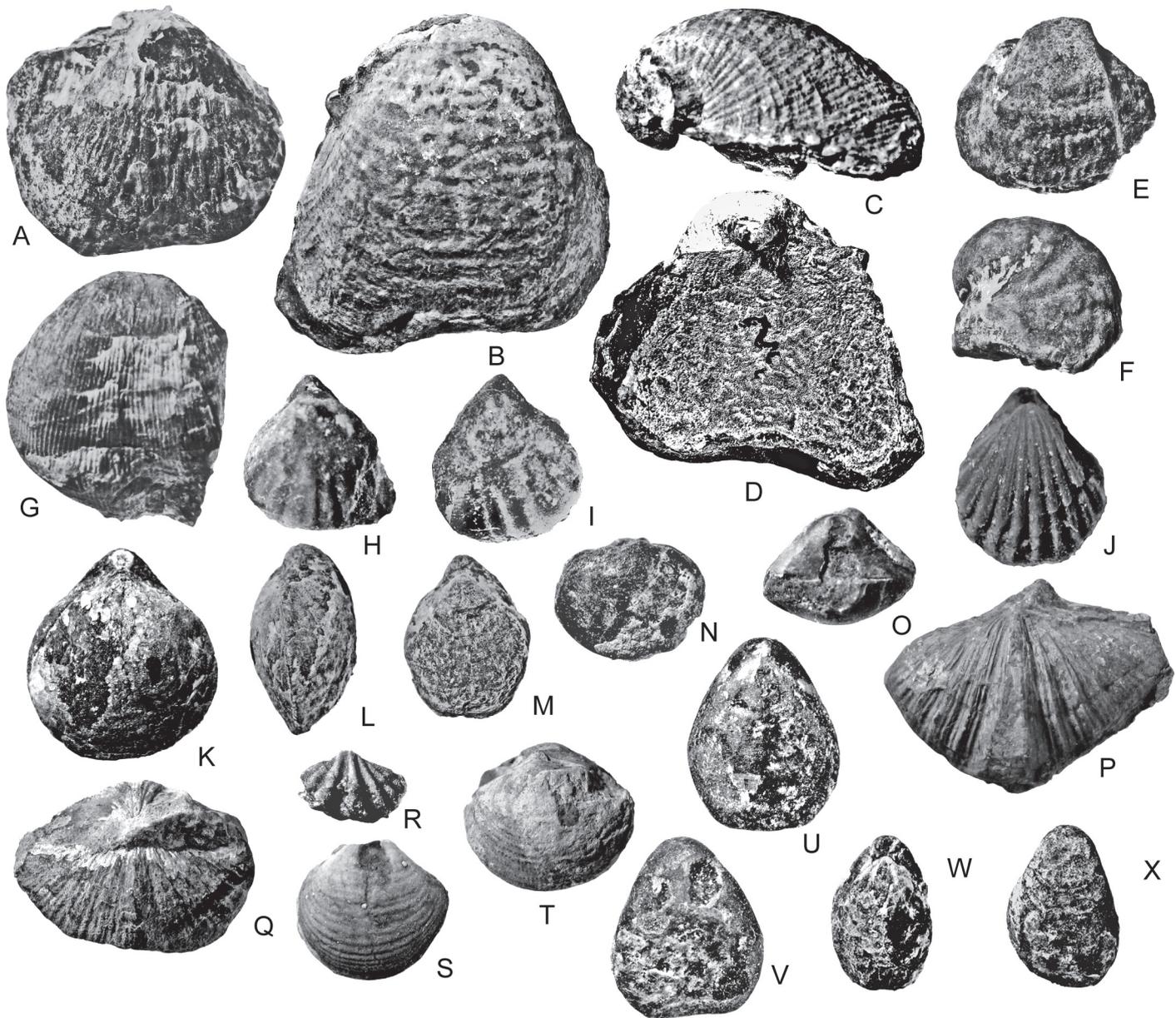


FIGURE 5. Brachiopods from the Atrasado Formation, Bruton Canyon; same notations as Fig. 4. **A**, *Buxtonia*? sp., pedicle valve, NMMNH 57,904, x 1.5. **B-D**, *Echinaria semipunctata*, top and side views of pedicle valve, and brachial valve view, of an incomplete, severely weathered specimen, NMMNH 57,905, Burrego Member (locality 4435), x 0.67. **E, F**, *Parajuresania nebrascensis*, top and side views of severely weathered pedicle valve, NMMNH 57,906, Story Member (locality 4436), x 1.7. **G**, *Linoproductus* cf. *L. platyumbonus*, incomplete pedicle valve, NMMNH 57,907, Story Member (locality 4436), x 1.25. **H, I**, *Wellerella* cf. *W. immatura*, brachial and pedicle valves, NMMNH 57,908, x 4. **J**, *Hustedia mormoni*, brachial valve, NMMNH 57,909, x 3. **K, L**, *Composita subtilita* (*C. "ovata"* morph), brachial and side views, NMMNH 57,910, x 1.5. **M**, *C. subtilita* (typical morph), severely weathered brachial valve, NMMNH 57,911, x 1.5. **N, O**, *Crurithyris* n. sp.?, brachial valve (overhanging pedicle beak is missing) and hinge view showing high interarea and pedicle foramen, NMMNH 57,912, x 2.67. **P**, *Neospirifer alatus*, brachial valve, NMMNH 57,913, Burrego Member (locality 4435), x 0.9. **Q**, *Neospirifer* cf. *N. dunbari*, posterior parts of brachial and pedicle valves, NMMNH 57,914, x 0.9. **R**, *Punctospirifer kentuckyensis*, pedicle valve of incomplete specimen, NMMNH 57,915, x 1.75. **S, T**, *Phricodothyris perplexa*, pedicle valve (missing beak), NMMNH 57,916, and brachial valve, NMMNH 57,917, x 1.5. **U, V**, *Beecheria bovidens*, pedicle and brachial valves, NMMNH 57,918, x 2. **W, X**, *Beecheria* cf. *B. millepunctatus*, pedicle valve, NMMNH 57,919, and brachial valve, NMMNH 57,920, x 2.

Story Member

centration are unclear. Specimens of *Echinaria* occur in many Late Pennsylvanian marine assemblages, but typically only a few isolated individuals are present in a given assemblage. The brachiopods in this Burrego unit tend to have exfoliated shells and are strongly weathered when found loose on the outcrop.

The thick, cliff-forming unit (bed 16A) in the middle of the Story Member is a light gray to white, coarsely crystalline, micritic, bioclastic limestone containing a high density of fossils, predominantly brachiopods, many with recrystallized and/

TABLE 1. Invertebrate taxa from members of the Atrasado Formation in Bruton Canyon. Numbers of specimens are given only for brachiopods and molluscs; abundance of other groups is indicated by subjective terms: A, abundant; C, common; MC, moderately common; UC, uncommon; R, rare. Percent of total specimens is given only for brachiopod taxa in Del Cuerto collection 4434.

Taxon	Burrego 4435	Story 4437	Story 4436	Del Cuerto 4434	%	Del Cuerto 4438	Moya
Fusulinids	C	UC					
Corals							
Solitary rugose corals				C		R	
Syringoporid tabulate corals						R	
Bryozoa							
Fenestrate	UC			R			
Rhabdomesine				UC			
Other, encrusting forms				UC			
Brachiopods							
<i>Eteletes hemiplicata</i>		7		387	31.8	9	
<i>Eteletes</i> n.sp.							2
<i>Neochonetes</i> sp.				1	0.1	3	
<i>Hystriculina wabashensis</i>		32		68	5.6	15	5
<i>H.</i> "fragilis"		13		18	1.5	3	2
<i>Kutorginella</i> cf. <i>K. lasallensis</i>				12	1.0	2	
<i>Antiquatonia</i> sp.	8	17	22	14	1.1		1
<i>Reticulatia americana</i>		1					
<i>Buxtonia?</i> sp.				4	0.3	1	
<i>Calliprotonia</i> cf. <i>C. renfrarum</i>				20	1.6		
<i>Echinaria semipunctata</i>	23	1	3	2	0.2		
<i>Parajuresania nebraskensis</i>			1				
<i>Linoproductus</i> cf. <i>L. platyumbonus</i>	1	3	16	5	0.4	2	
<i>Linoproductus</i> sp.							1
<i>Wellerella</i> cf. <i>W. immatura</i>				3	0.2		
<i>Hustedia mormoni</i>				4	0.3		
<i>Composita subtilita</i>	8	42	3	497	40.8	8	5
<i>Crurithyris</i> n. sp.?		2		4	0.3	3	
<i>Neospirifer alatus</i>	5	1	2				
<i>N.</i> cf. <i>N. dunbari</i>				3	0.2	1	
<i>N.</i> sp.		1					
<i>Punctospirifer kentuckyensis</i>				9	0.7		
<i>Phricodothyris perplexa</i>		3		125	10.3	1	
<i>Beecheria bovidens</i>		3		25	2.1		
<i>B.</i> cf. <i>B. millepunctata</i>				12	1.0		
Unidentified productides			7	6	0.5	1	
Bivalves							
<i>Permophorus?</i> sp.							
<i>Schizodus</i> sp.		1		1			
Unidentified pectinid				1			
Unidentified myalinid				1			
Unidentified				5			
Gastropods							
<i>Euomphalus</i> sp.			1				
Unidentified				4		1	1
Cephalopods							
<i>Pseudorthoceras</i> sp.						1	
" <i>Mooreoceras</i> " <i>normale</i>						1	
Crinoids (unidentifiable fragments)	MC	MC	MC	MC		MC	MC

or exfoliated shells. Local concentrations of crinoid skeletal debris are also present, as are occasional specimens of fusulinids. Thompson (1942, p. 66) cited late (but not latest) Missourian *Triticites* from bed 16A. In the lower part of this bed (locality 4437), *Composita subtilita* (attaining a maximum length of about 21 mm and including the wide, relatively thin “*C. ovata*” morph), and the small productides *Hystriculina wabashensis* and *H. “fragilis”* dominate the fauna (totaling 69% of the 126 brachiopods collected), although specimens of larger productides (especially *Antiquatonia*, 13%) are also moderately common. Other brachiopod taxa, notably *Enteletes hemiplicata*, *Linoproductus* cf. *L. platyumbonus*, *Phricodothyris perplexa*, and *Beecheria bovidens* (totaling 10% of brachiopod specimens) are represented by only a few specimens. *Reticulatia americana*, *Crurithyris*, *Neospirifer alatus*, and *Echinaria semipunctata* are each rare in this assemblage. Crinoid debris, isolated fusulinids, and single specimens of the bivalves *Schizodus* and *Permophorus* complete the list of invertebrates observed (Table 1).

The lithology of the upper part of Thompson’s bed 16A in the Story Member (locality 4436) is essentially the same as the lower part but only six species of brachiopods were collected (Table 1), and their relative abundance is quite different from that of locality 4437. In the upper fauna, larger productides are by far the most abundant brachiopods, especially *Antiquatonia* sp. and *Linoproductus* cf. *platyumbonus*, with a few large valves of *Echinaria semipunctata* also present. *Composita subtilita*, *Neospirifer alatus*, and *Parajuresania nebrascensis* are rare and no specimens of *Hystriculina* were collected. One specimen of the gastropod *Euomphalus* represents the only mollusc observed.

Del Cuerto Member

The Del Cuerto Member consists mainly of thin to irregularly bedded and concretionary limestones, with thin shale and sandstone beds near the base and top, respectively (Fig. 3). A 2.5 m-thick, dark gray, ledge-forming limestone (Thompson’s bed 18B) occurs near the middle of the member and is highly fossiliferous, including a dense accumulation of solitary rugose corals (noted by Thompson, p. 71) in its lower part. Thompson (1942) also reported early Virgilian species of *Triticites* from units just above and just below bed 18B. The assemblage collected from this bed (locality 4434) is by far the largest and most species rich in the Late Pennsylvanian of Bruton Canyon, and is the only one for which the sample is large and well preserved enough for relative abundances of taxa (see Table 1) to be accurate indicators of the original community from which the assemblage was derived. Kues and Lucas (2001) provided a brief preliminary report on this unusual assemblage.

Of the more than 1400 specimens collected, brachiopods are by far the dominant element, with only moderate numbers of corals and crinoid stem fragments. Bryozoans are sparse and include small rhabdomesine branches, encrusting forms, and rare fenestrates. Molluscs (gastropods and bivalves) are limited to a few specimens, mostly steinkerns, and comprise less than 1% of the total brachiopod specimens.

The taxonomic composition and relative abundances of the various brachiopod species make this assemblage unique in the Pennsylvanian of New Mexico and possibly in the United States. The 19 brachiopod species include some taxa, such as *Enteletes hemiplicata*, *Calliprotonia* sp., *Kutorginella* cf. *K. lasallensis*, and *Buxtonia?* sp. that are rarely encountered in other Late Pennsylvanian assemblages in New Mexico, whereas other species that are typical constituents (such as *Neochonetes* and *Parajuresania*) of Late Pennsylvanian shallow marine carbonate assemblages are rare to absent. Molluscs are generally subsidiary elements of offshore marine environments dominated by brachiopods, crinoids, corals, and bryozoans, and this assemblage has unusually low numbers of bivalves and gastropods.

Further, this assemblage is distinguished by its dominance by two species of brachiopods, *Composita subtilita* and *Enteletes hemiplicata*, which comprise about 73% of all of the brachiopod specimens. *Phricodothyris perplexa* (about 10% of total brachiopods) and several species of productides (12%; mostly two species of the small productide *Hystriculina*) comprise most of the remainder of brachiopod specimens. Of the 19 brachiopod species identified, the relative abundance of 11 of them is each 1% or less of the total brachiopod specimens in this assemblage. Clearly, an unusual combination of ecological factors affected the marine community from which this assemblage was derived.

Pennsylvanian assemblages with large numbers of *Composita* and *Phricodothyris* are not uncommon in New Mexico but this is the first report of an assemblage in which *Enteletes* is abundant. This genus is rare in New Mexico, with only a few reports, and it is absent from the diverse Pennsylvanian brachiopod faunas studied by Sutherland and Harlow (1973) and Kues (1996). Additional discussion of the middle Del Cuerto assemblage is presented below, in the section on paleogeography and environments.

A small collection from the argillaceous gray limestones near the top of the Del Cuerto Member (bed 21C of Thompson, 1942; locality 4438) contains 12 of the 19 brachiopod taxa present in the far larger assemblage about 10 m below it (Table 1). *Hystriculina*, *Enteletes hemiplicata*, and *Composita subtilita* comprise about two thirds of the brachiopods. Two orthocerid nautiloid shell fragments and a syringoporid tabulate coral colony represent groups not observed in the middle Del Cuerto assemblage. However, the upper Del Cuerto sample is too small to allow detailed meaningful comparisons with the middle Del Cuerto assemblage.

Moya Member

The Moya Member, the uppermost member of the Atrasado Formation in Bruton Canyon, consists almost entirely of massive, dense, gray limestone beds, from which few fossils could be collected. Thompson (1942) reported early Virgilian species of *Triticites* from the Moya. Horizons of mostly crinoidal bioclastic debris are common in the member, and *Hystriculina* and *Composita* appear to be the most abundant brachiopods (Table 1). A possible new species of *Enteletes* (two specimens) appears in the Moya, apparently replacing *E. hemiplicata* from the Del Cuerto Member.

Bursum Formation

As noted above, the Bursum Formation in Bruton Canyon (including Thompson's type section of the Bruton Formation) consists mainly of nonmarine, slope-forming, reddish to maroon shales between the top of the Moya Member of the Atrasado Formation and the base of the red, nonmarine, siliciclastic Abo Formation. The Bursum here includes several thin gray marine limestone beds and a 5 m-thick cliff-forming limestone about 35 m above its base (see Lucas et al., 2002, fig. 3). Fusulinids (large *Triticites*, *Schwagerina*) are by far the most conspicuous fossils in the limestones (Thompson, 1954, fig. 6). Most of the limestone beds also contain fragmented shell debris and algae, but identifiable invertebrates are rare. *Composita*, productide shell fragments, and crinoid skeletal debris are present in bed 5, near the base of the Bursum. Bed 18, in the upper part of the formation, above the limestone cliff, contains abundant shell fragments, but also *Composita*, crinoid stem fragments, and isolated echinoid plates and spines. A single large valve of the bivalve *Myalina* (*Orthomyalina*) *subquadrata*, associated with fenestrate bryozoa and crinoid debris, was collected in a piece of limestone float below the limestone cliff.

Additional collecting would probably increase the number of identifiable invertebrates from the Bursum in Bruton Canyon. However, this section appears to be considerably less fossiliferous than the Bursum Formation at its type section to the west, which contains relatively diverse assemblages of brachiopods and molluscs (Kues, 2002; Lucas et al., 2002).

PALEOGEOGRAPHY AND PALEOENVIRONMENTS

The Upper Pennsylvanian strata in Bruton Canyon were deposited on a shallow marine shelf west of the Pederal uplift, a long, north-south trending land mass that extended from the latitude of Albuquerque south to the Texas border (Kues and Giles, 2004). Southward, Upper Pennsylvanian strata thicken considerably into the rapidly subsiding Orogrande basin but in the area of the northern Sierra Oscura little tectonic activity is evident in the Atrasado stratigraphic sequence, and the Upper Pennsylvanian section, totaling about 160 m in thickness (including the Bursum Formation), is relatively thin compared with other Upper Pennsylvanian sequences in central New Mexico.

The Atrasado section in Bruton Canyon is chiefly composed of thin- to thick-bedded gray limestones, with only a small percentage (about 14%) of siliciclastic (shale and sandstone) units (Thompson, 1942; Fig. 3). Deposition of the predominantly siliciclastic and mainly nonmarine strata of the overlying Bursum Formation reflects renewed uplift of local land masses, especially the Pederal and Uncompahgre uplifts, which shed large volumes of reddish fluvial, floodplain, deltaic, and coastal plain sediments into southward receding shallow marine environments across much of northern and central New Mexico during latest Pennsylvanian and Early Permian time.

Although the species richness, taxonomic composition, and relative abundances of particular taxa varies from member to member through the Atrasado Formation, all of the assemblages

occur in limestones and all are dominated by stenohaline marine groups, including articulate brachiopods, crinoids, fusulinids, bryozoans, and rugose corals. Molluscs are either not present or are extremely rare (< 1% of identifiable specimens) in each of the assemblages discussed here. The composition of these assemblages in a broad way resembles the "brachiopod-crinoid" assemblages of the gray "core" shale portions of Kansas cyclothems (e.g., Malinky and Heckel, 1998), although lithologically the Atrasado units more closely resemble the marine limestones above and below the gray "core" shales, which have similar faunas (Malinky and Heckel, 1998, p. 316). Likewise, the Bruton Canyon strata contain many of the same brachiopod genera of the brachiopod-dominated "biofacies 3" of Lebold and Kammer (2006) in the transgressive, fully marine limestones and shales of the Virgilian Ames Member in the Appalachian basin. These and other assemblages of the same age and similar taxonomic composition have been generally interpreted as having lived in offshore marine environments that were well oxygenated, free from fluctuations in salinity, and with low turbidity (e.g., Malinky and Heckel, 1998; Lebold and Kammer, 2006, and references therein).

Although detailed analysis of the paleoecology of the Bruton Canyon assemblages is beyond the scope of this paper, some additional observations relevant to the diverse middle Del Cuerto Member assemblage are pertinent. As noted above, assemblages in which *Enteleles* is a dominant element have not been reported previously from New Mexico. A few Late Pennsylvanian faunas in which *Enteleles* is stated to be common have been reported in the Midcontinent region, although exactly what "common" means in terms of relative taxonomic abundance is unknown. Moore (1964, p. 335) described an *Enteleles* assemblage in a thin upper Missourian limestone in Kansas, where this genus commonly occurs with the small productide *Hystriaculina*. He also noted other assemblages (p. 316-318), of late Virgilian age, that are dominated by *Pulchratia* (a medium-sized productide similar to *Calliprotonia* in the Del Cuerto assemblage) and by rugose corals that include *Enteleles* as a significant component. Haglund (1967) reviewed occurrences of *Enteleles* in the Missourian and Virgilian of Kansas and reported that the genus typically is restricted to thin-bedded gray limestones with shale partings. He noted that the genus is most abundant in shallow, carbonate seafloor environments around the periphery of small coral/algal reefs, banks, and biostromes. The high concentration of *Enteleles* in a coral-rich limestone in the Del Cuerto Member is another example of this genus's apparent ecological preference.

Haglund (1967, p. 3) also noted that in the "brachiopod fauna of a unit where *Enteleles* is present, *Composita* is usually the dominant brachiopod, with *Enteleles* and *Hystriaculina* occurring in minor numbers. Where *Enteleles* occurs abundantly, *Hystriaculina* is usually moderately abundant and *Composita* less abundant and in many places absent." In the Del Cuerto assemblage *Hystriaculina* is likewise moderately abundant but *Composita*, in contrast, is extremely abundant together with *Enteleles*. Haglund's observations suggest a reciprocal ecological relationship such as competitive exclusion between *Enteleles* and *Composita*, with

one or the other genus predominating. This supposition seems reasonable; both taxa are of approximately the same size, and both lived on or slightly above the sediment surface, anchored to it by their pedicles. *Composita*, with its spiral, brachidia-supported lophophores, has been interpreted as an efficient filter feeder in relatively shallow water with high levels of primary productivity, whereas other brachiopods, such as productides (and presumably *Enteletes*) that lack skeletal lophophore support could have been able to extend the lophophores farther from and around the valves, which would be advantageous in deeper water with more dispersed nourishment (see Perez-Huerta and Sheldon, 2005, for discussion). The high abundance of both genera in the middle Del Cuerto limestone bed in Bruton Canyon suggests an unusual and specific set of ecological conditions that allowed both genera to thrive. That this was not the result of erosional blending of taxa from two stratigraphically closely-spaced but separate assemblages is indicated by the presence of mature specimens of both genera in slabs of limestone collected from the locality.

The rarity of *Neochonetes* and *Crurithyris* in the middle Del Cuerto assemblage is also noteworthy, as these genera are common in other marine assemblages, including in limestones, elsewhere in the Late Pennsylvanian of New Mexico. Both genera have been reported from a variety of lithologies and environments in North America, especially those representing the initial phase of transgressions, and have been interpreted as eurytopic, opportunistic taxa (e.g., Malinky and Heckel, 1998; Lebold and Kammer, 2006). The relative stability of the Atrasado offshore marine shelf environments in the Bruton Canyon area appears to have favored other brachiopods at the expense of these genera.

Parajuresania, also a relatively common constituent of many Late Pennsylvanian marine faunas in New Mexico, is absent in the Del Cuerto Member and represented only by a single specimen from the Story Member, whereas other productides of similar size, such as *Buxtonia*?, *Calliprotonia*, and *Kutorginella*, are present in the Del Cuerto. Insufficient information is available concerning detailed environments, faunal associations, and paleogeography of various productide genera in the Pennsylvanian of New Mexico (or for that matter of other regions) to offer an explanation, but such studies would be worthwhile.

SYSTEMATIC PALEONTOLOGY

The taxa identified from each of the six Atrasado assemblages sampled for this study are listed in Table 1, together with the number of specimens of each taxon. The abundance of highly fragmented or colonial groups (bryozoans and crinoids) is indicated by qualitative estimates: A, abundant; C, common; MC, moderately common; UC, uncommon; R, rare. As brachiopods are the dominant fossils in the Del Cuerto and other members of the Atrasado Formation in Bruton Canyon, they are described and illustrated below. Other invertebrate groups are summarized after discussion of the brachiopod species.

Brachiopods

Enteletes hemiplicata (Hall)

The orthide *Enteletes hemiplicata* (Figs. 4C-I) is one of the two dominant brachiopods in the Del Cuerto Member and is a minor element of Story Member faunas. Its shell is of medium size (up to about 20 mm long), strongly biconvex, rather globose, and bears prominent plications, producing a conspicuous zig-zag commissure. Shell width typically exceeds length on mature specimens (length more than 15 mm; mean W/L = 1.13; range = 1.02-1.19; N = 18) and shell thickness averages 0.88 of length (range = 0.74-1.07; N = 18). The convexity of the brachial valve exceeds that of the pedicle valve, which is lower and tends to be slightly flattened. Maximum brachial valve convexity is anterior to midlength, where the valve develops a strong geniculation that produces a high, truncated anterior margin on mature specimens. The beaks of both valves are incurved, but the brachial valve beak is somewhat larger and wider. The pedicle valve displays a relatively narrow cardinal area and a narrowly triangular pedicle opening.

The surface of the valves is covered by fine (5/mm), closely-spaced, somewhat flattened radial lirae, which do not increase significantly in size with growth. The brachial valve bears a strong, high, sharp-crested medial plication, or fold, that is flanked typically by three lateral plications on each side, the outermost of which may be weak to obscure on some specimens. The pedicle valve bears a strong, angular medial sulcus and three lateral plications of decreasing size on each side. The plications on both valves develop gradually, beginning on average about 10-11 mm distance along the valve surface from the tip of the beak. The plications increase rapidly in size and height with further growth.

Because the plications develop relatively late in growth, and the valves turn inward anteriorly towards the plane of the commissure rather than growing forward, the external morphology of juvenile specimens (Figs. 3H, I) is quite different from that of adults. The Del Cuerto collections include a few specimens ranging from about 5 mm to 15 mm in length, allowing changes with growth to be observed. Juvenile specimens have low, gently convex to flattened, nearly equivalved shells, which closely resemble adult shells of smaller genera such as *Rhipidomella*.

Most of the nearly 400 Del Cuerto specimens are severely weathered, in many specimens to the point of dissolution or corrosion of most of the valves, and some are distorted, preventing accurate measurement of most of the specimens.

The taxonomy of North American Pennsylvanian *Enteletes* is unsettled, and most available information is from Midcontinent specimens. *Enteletes hemiplicata*, the most widely recognized species, is reported from late Missourian to late Virgilian strata (e.g., Dunbar and Condra, 1932; Mudge and Yochelson, 1962). Several other species (e.g., *E. pugnoides*, *E. plattsmouthensis*, *E. hemiplicata plattsburgensis*, *E. transversus*) were described by Newell (1931).

Haglund (1967) studied the genus in the Kansas Pennsylvanian, redefined some species, and erected three new species

for Virgilian specimens that had previously been considered *E. hemiplicata*. These species (*E. beilensis*, *E. churchensis*, *E. brownsvillensis*), and a very restricted concept of *E. hemiplicata* were differentiated mainly by minor differences in the distance from the beak to the onset of the plications and in the “fold angle” reflecting the width of the medial plication. In Haglund’s taxonomy, the name *E. pugnoides*, originally defined as having a biplcate fold, was extended to include uniplcate forms similar to *E. hemiplicata*, including *E. h. plattsburgensis*, and *E. hemiplicata* was restricted to unusually globose specimens having thickness greater than length. Haglund reported *E. pugnoides*, *E. hemiplicata*, and *E. beilensis* from lower Virgilian strata in Kansas.

Allowing for the effects of weathering and distortion of some specimens in the Del Cuerto assemblage, wide but gradational variability in such features as valve proportions, point of initiation of plications, and fold angle appear to characterize these specimens. Individual specimens could be selected that could be assigned to each of Haglund’s three Lower Virgilian species mentioned above. Only a few specimens, however, even approach the unusually thick, globose, strongly geniculate form of specimens Haglund designated as *E. hemiplicata*. Based on the minor differences that Haglund utilized to separate the species he recognized, and evidence of significant variability in the Del Cuerto collections, a broader species concept for lower Virgilian *Enteleles* seems more reasonable and practical. Accordingly the Del Cuerto specimens are referred to *E. hemiplicata sensu lato*.

Cooper and Grant (1976) described numerous Lower Permian species of *Enteleles* from the west Texas region. The earliest of these, *E. bowsheri*, was said to be from the Bursum Formation at a locality designated “Bowsher 3361” (Cooper and Grant, 1976, p. 2629). This locality is in the Sacramento Mountains, in strata now regarded as the Laborcita Formation, and is locality M-3 of Otte (1959), about 250 ft above the base of the Laborcita. Although originally believed to be of early Wolfcampian (earliest Permian) age, recent adjustment of the Midcontinent Pennsylvanian-Permian boundary places the fusulinids of the Laborcita Formation in the latest Virgilian (latest Pennsylvanian). *Enteleles bowsheri* resembles the Del Cuerto specimens in some features, such as the relatively low, flattened pedicle valve, but differs in being much larger (adult specimens range up to 38 mm wide), having a greater width/length ratio (1.26-1.32, compared to a mean of 1.13 and a maximum of 1.19 for the Del Cuerto specimens), and in having four, rather than three lateral plications on both valves, which are lower and more subdued than those of the Del Cuerto specimens.

Enteleles n. sp.

Two specimens of *Enteleles* from the Moya Member (Figs. 4J, K) appear to fall outside the range of variation of *E. hemiplicata* from the underlying Del Cuerto Member. The most complete of these specimens is narrower than the latter specimens, with more steeply sloping valve flanks and length and width subequal. In addition, the fold, sulcus-bordering, and lateral plications are lower and more broadly rounded, and only two lateral plications on each side of the fold and one plication on each side of the

sulcus are present. The Moya specimens belong to the same taxon identified as *E. n. sp.* from the late Virgilian La Casa Member of the Wild Cow Formation (=Atrasado Formation) west of Abo Pass (Kues, 2009).

Neochonetes sp.

A few fragments of *Neochonetes* valves in the Del Cuerto Member are the only record of this common and widespread Virgilian genus in the Bruton Canyon section.

***Hystriculina wabashensis* (Norwood and Pratten)**

Small productide assigned to *Hystriculina wabashensis* (Figs. 4L-N) are common in both the Story and Del Cuerto Members. Preservation is generally poor; most specimens are incomplete, with exfoliated to severely weathered shells. They are of small to medium size, most specimens ranging from about 12 to 17 mm in width with the largest about 20 mm wide. The width of these specimens slightly exceeds their length. The pedicle valve is strongly convex (maximum convexity is a little posterior of midlength), with a wide, shallow median sulcus that develops within 5 mm of the beak and extends to the anterior margin. The lateral portions of the valve are inflated, and the umbonal slopes are relatively steep. Ornamentation consists of well-developed, rounded, closely-spaced radial costellae, about 7-8/5 mm at midlength, and a few small spine bases scattered across the valve surface. Accurate counts of spines could not be made because of the weathered valve surfaces.

These specimens agree in all observable features with *Hystriculina wabashensis*, which is common in Missourian and Virgilian strata in the Midcontinent (e.g., Dunbar and Condra, 1932) and extend into basal (revised) Wolfcampian (e.g., Mudge and Yochelson, 1962). *Hystriculina wabashensis* is known from numerous Virgilian localities in New Mexico, including the Wild Cow Formation in the northern Sandia Mountains (Lucas et al., 1999), the Holder Formation in the Sacramento Mountains (Kues, 2004a), the Red Tanks Formation of the Lucero uplift area (Kues, 2004b), and the Bursum Formation at its type section west of Bruton Canyon (Kues, 2002).

***Hystriculina “fragilis”* (Dunbar and Condra)**

Occurring with typical specimens of *Hystriculina wabashensis* in the Story and Del Cuerto collections are small productides of about the same size and ornamentation but which have a more inflated pedicle valve (Fig. 4O). These valves are narrower, have more steeply sloping flanks, and completely lack or display only an obscure median sulcus. Specimens of this type, with the additional features of unusually thin shells and many small spines, from the Virgilian of the Midcontinent region, were assigned to a new species, *Marginifera fragilis*, by Dunbar and Condra (1932). Mudge and Yochelson (1962, p. 83) noted that the thin lustrous shells of *M. fragilis* were probably a consequence of preservation in dark gray to black shales, and suggested that *M. fragilis* is a synonym of *Marginifera* [now *Hystriculina*] *wabashensis*.

In the Story and Del Cuerto Members, specimens with the morphology of *Hystriculina fragilis* but with shells that are of normal thickness are less common than *H. wabashensis* and, insofar as can be determined from their relatively poor preservation, appear to intergrade with the latter species. However, typical representatives of the two forms are quite distinctive and easily recognized. Thus, while these specimens may represent a single highly variable species, I am using the name *H. "fragilis"* to refer to the inflated specimens that lack or have an obsolete median sulcus.

***Kutorginella* cf. *K. lasallensis* (Worthen)**

Specimens of a distinctive, medium-sized productide are incomplete and exfoliated, but comparison with well-preserved examples of *Kutorginella* cf. *K. lasallensis* from the Virgilian Holder Formation of the Sacramento Mountains (Kues, 2004a) indicates that the Bruton Canyon specimens from the Del Cuerto Member (Figs. 4P, Q) belong to that taxon. The pedicle valve is strongly geniculate posteriorly, with maximum convexity attained not far in front of the hingeline, followed by a gently convex but steeply sloping anterior trail. A pronounced median sulcus begins at the beak and extends to the anterior valve margin. The central portions of the valve on either side of the sulcus are somewhat inflated, and the valve flanks slope steeply to the commissure. Ornamentation is poorly preserved, but appears to consist of fairly even radial costellae, numbering about 9/5 mm at midlength, with scattered spine bases across the valve surface. The pedicle valve hingeline is wide, with flaring ears, and marks the widest part of the valve. The strong geniculation reduces valve length, so that maximum valve width considerably exceeds length. The largest and best preserved specimen is approximately 32 mm wide and 22 mm long.

***Antiquatonia* sp.**

Fragments of a relatively large productide with a strongly convex pedicle valve displaying a nodose reticulated ornamentation pattern posteriorly (Figs. 4R, S) are present throughout the Bruton Canyon Upper Pennsylvanian section. The largest and best preserved specimens were collected from the upper part of the Story Member, but even these were incomplete and many specimens were exfoliated and weathered. The strongly reticulated part of the pedicle valves extends forward about 25 to 30 mm from the beak, and a shallow median sulcus begins on the umbo and extends to the anterior margin. The long anterior trail is ornamented by closely-spaced, rounded, very regular radial costae that average 7 to 8/10 mm near midlength and bear sparse spine bases. The pedicle valve is strongly but evenly convex in lateral view, with steeply sloping flanks that flare outward near the ears. The ears are large and well extended laterally, making the hinge line the widest part of the valve. Specimens on which one or both ears are preserved also display an arcuate ridge near the base of the umbonal slopes, immediately above the ears, a feature that distinguishes the genus *Antiquatonia* from other similar genera such as *Reticulatia*. Although accurate measurements could not be obtained, mature specimens average an estimated 45

to 50 mm wide. An unusually large specimen was an estimated 60 mm wide when complete.

This large *Antiquatonia* may be an undescribed species, but more complete and better-preserved specimens are required to fully understand its morphology. It is considerably larger and has coarser costae than the Virgilian *A. jemezensis*, described by Sutherland and Harlow (1967) from north-central New Mexico. An unnamed Missourian species (*A. n. sp. A* of Sutherland and Harlow, 1973) from the Sangre de Cristo Mountains approaches the Bruton Canyon specimens in size and coarseness of the costae, but the costae are more irregular and bifurcated and the ears much smaller than in the specimens at hand. *Antiquatonia inflativentra* (Cooper and Grant, 1975), from Virgilian strata in west Texas, is similar in most respects to the Bruton Canyon specimens, including shell size, size and regularity of the costae, and widely flaring ears, but the pedicle valve is more strongly and sharply convex. *Antiquatonia portlockiana* and *A. crassicosata*, common Late Pennsylvanian species of the Midcontinent (e.g., Dunbar and Condra, 1932) and Appalachian Basin (e.g., Sturgeon and Hoare, 1968), are smaller, and in the case of the latter has coarser, very irregular costae.

Fragmented valves of *Antiquatonia* may not be distinguishable from *Reticulatia* unless much of the pedicle valve is preserved. Here, most valve fragments are referred to *Antiquatonia* unless diagnostic features of *Reticulatia* (very large size, absence of a lower umbonal ridge, internal characters) were preserved. Perez-Huerta (2006) discussed the taxonomic complexities of these two genera, implying that North American species traditionally referred to *Antiquatonia* might be better placed in *Reticulatia*.

***Reticulatia americana* (Dunbar and Condra)**

The only Bruton Canyon specimen that can be assigned definitely to *Reticulatia* is a large, incomplete brachial valve with its interior surface exposed, from the Story Member (Fig. 4T). This valve is large (53 mm, estimated total restored width = 60+ mm), with its posterior surface nearly flat and displaying a nodose, strongly reticulate ornamentation before curving abruptly anteriorly with radial costae that break up into short, spinose ridges. Part of the median septum is preserved, together with the adjacent subtriangular adductor muscle scars. The posterior scars are large and display dendritic ornamentation, whereas the adjacent anterior scars are small and smooth. These scars and other features of the brachial valve interior closely resemble that of specimens of *R. americana* described (as *R. huecoensis*) by Muir-Wood and Cooper (1960, pl. 105, figs. 5, 6, 8). *Reticulatia americana* is characteristic of Missourian through early Wolfcampian strata in the Midcontinent (e.g., Dunbar and Condra, 1932; Mudge and Yochelson, 1962) and has been described previously from the Late Pennsylvanian of central New Mexico (e.g., Kues, 1996; 2004b).

***Buxtonia?* sp.**

The few Del Cuerto specimens assigned questionably to *Buxtonia* (Fig. 5A) are incomplete and exfoliated, rendering detailed

understanding of their ornamentation difficult. The largest specimen was an estimated 30 mm wide when complete, with a moderately and evenly convex pedicle valve with relatively gently sloping flanks and a very shallow median sulcus. Ornamentation consists of sharp radial costae with swollen spine bases along their length that typically mark either the termination or bifurcation of a costa. Concentric rugae are present posteriorly on the sides of the umbo but appear to fade across the center of the valve. Because these rugae are larger than the radial costae they cross, a finely reticulated, nodose pattern, such as characterizes the posterior part of *Antiquatonia* and *Reticulatia* pedicle valves, is not developed on *Buxtonia*?. Lamellate concentric bands with transversely aligned suites of spines, such as characterize *Echinaria*, *Calliprotonia*, and *Parajuresania*, likewise are not present on these specimens.

Valve proportions and residual exfoliated ornamentation suggest that these specimens may be *Buxtonia*, a genus that is uncommon in the Pennsylvanian of New Mexico (e.g., Sutherland and Harlow, 1973). However, the radial ornamentation of these Del Cuerto specimens appears to be coarser than is typical of this genus.

***Calliprotonia* cf. *C. renfrarum* Muir-Wood and Cooper**

Specimens assigned to the productide *Calliprotonia* (Figs. 4U, V) are relatively small (typically 14 to 18 mm wide), with a strongly convex pedicle valve displaying a shallow median sulcus, moderately steep lateral slopes, and a relatively wide beak and umbo that project significantly beyond the hingeline. All of the specimens are severely weathered, but the pedicle valve surface displays evidence of regular, concentric, spinose bands. Small areas of unweathered valve surfaces on two specimens reveal that the bands are wide imbricating lamellae bearing two to three irregular transverse rows of small prostrate spines, which increase in size anteriorly.

Based on the features that can be observed on these weathered specimens, they are very similar in external morphology to, and possibly conspecific with, *Calliprotonia renfrarum*, described by Muir-Wood and Cooper (1960) from the Virgilian Finis Shale (Graham Formation) of northern Texas. *Calliprotonia* is rare in North America and appears to be limited to Middle Pennsylvanian to earliest Permian strata. An unidentified Desmoinesian species of *Calliprotonia* was reported from northern New Mexico by Sutherland and Harlow (1973). The Del Cuerto specimens, as well as *C. renfrarum*, differ mainly in having a wider pedicle valve beak and umbo that extends farther behind the hingeline.

***Echinaria semipunctata* (Shepard)**

Although all available specimens are incomplete and weathered, the large size, proportions, and ornamentation of the valves allow certain identification of the largest productide in the Atrasado section in Bruton Canyon as *Echinaria semipunctata* (Figs. 5B-D). The pedicle valve is broadly triangular in surface view, with a relatively narrow umbo but expanding anteriorly so that maximum width nearly equals valve length, which is esti-

mated at 80-85 mm for the largest specimens. The pedicle valve is evenly and moderately convex longitudinally, with the greatest convexity about at midlength, and bears a shallow median sulcus that is deepest posteriorly but continues to the anterior margin. The umbo extends significantly beyond the hingeline, and terminates in a small, strongly curved beak. The hingeline is relatively narrow, about two thirds of the maximum width of the valve. The surface of both valves bear many narrow concentric bands, ornamented with fine spine bases aligned in two or three irregular rows across each band.

Echinaria semipunctata ranges from the base of the Missourian into the early Virgilian in the Midcontinent region (Dunbar and Condra, 1932). Other *Echinaria* species of Desmoinesian and Virgilian age are considerably smaller and differ in details of pedicle valve proportions and ornamentation. Sutherland and Harlow (1973) reported *E. cf. E. semipunctata* only from Missourian strata in north-central New Mexico, but the species is known to range into the middle Virgilian in Texas (Muir-Wood and Cooper, 1960) and central New Mexico (Lucas et al., 1999). The species is unusually abundant in the Burrego Member in Bruton Canyon, where it is the most abundant brachiopod species.

***Parajuresania nebrascensis* (Owen)**

One incomplete, exfoliated, weathered specimen from the Story Formation can be identified as *Parajuresania nebrascensis* (Figs. 5E, F). The pedicle valve had an estimated width of 23 mm when complete, is moderately and evenly convex in lateral view, with relatively steep lateral slopes, and a beak that significantly overhangs the hinge line. Its surface displays slightly raised remnants of concentric bands that become apparent about 10 mm anterior of the beak. Coarse, short spine ridges are aligned transversely across each band but are not continuous from one band to the next. All spines and discrete spine bases have been weathered away, but the general pattern of surficial features is consistent with that of *P. nebrascensis*, a common Late Pennsylvanian species in New Mexico.

This specimen differs from those assigned to *Calliprotonia* from the Del Cuerto Member in being larger, having much wider and fewer bands, and much coarser ornamentation that clearly supported relatively few large spines, rather than the large number of minute spines that covered the bands of *Calliprotonia*. Exfoliated pedicle valves of *Buxtonia*? from the Del Cuerto Member differ in being larger, less convex, in lacking discrete bands, and in possessing sharp spinose costellae that may extend without interruption across much of the surface length of the valve.

***Linoproductus* cf. *L. platyumbonus* Dunbar and Condra**

Fragments of the productide *Linoproductus* are present in the Burrego, Story, and Del Cuerto Members, but are most common in the upper part of the Story Member. The best preserved pedicle valves from the upper Story (Fig. 5G) are of medium size for the genus, attaining a length of nearly 40 mm. Complete description of their morphology is not possible because of their fragmentary nature, but they display a flattened to slightly sulcate median area,

virtual absence of spines, and fine regular radial costellae that average 9/5 mm on the anterior trail. These features characterize *Linoproductus platyumbonus*, described initially by Dunbar and Condra (1932) from the Missourian of the Midcontinent, and later reported tentatively from the Missourian of the Sangre de Cristo Mountains by Sutherland and Harlow (1973). Fully grown specimens of *L. platyumbonus* attain a considerably larger size than any of the Bruton Canyon specimens, and are distinguished by a median fold that appears near the anterior margin of mature specimens (not observed on any of the Bruton Canyon specimens).

***Wellerella* aff. *W. immatura* Dunbar and Condra**

Wellerella, a small rhynchonellide, is rare in the Atrasado Formation in Bruton Canyon. The two available specimens (Figs. 5H, I) are small (maximum length 6.4 mm), with a mean width/length ratio of 0.91 and a thickness/length ratio of 0.67. Three strong plications are present on the relatively low brachial valve fold, two within the pedicle valve sulcus, and four or five smaller plications occur on each lateral valve surface. The plications begin about one half of the distance from the posterior to anterior margin of the valves. The brachial valve ascends anteriorly to attain its maximum convexity just before the anterior margin, a point that represents the maximum thickness of the shell. The valves are abruptly truncated at the anterior margin and the plications produce a conspicuous zig-zag commissure. The pedicle valve is gently convex and terminates posteriorly in a sharp triangular beak that is only slightly curved and extends beyond the hingeline.

These specimens are closely similar in most features to *Wellerella immatura*, initially described by Dunbar and Condra (1932) from upper Missourian strata of the Midcontinent, and documented by Sutherland and Harlow (1973) from the Alamitos Formation (Virgilian) near Pecos. The Del Cuerto specimens were compared with a collection of more than 60 specimens from one of Sutherland and Harlow's localities. They are slightly thicker and a bit narrower relative to valve length than the mean for the Pecos assemblage, but are well within the range of variation. The number of fold and sulcus plications, their relatively late initiation with growth, and the small size of the Del Cuerto specimens are also typical of *W. immatura* in the Alamitos assemblage. About one third of the Alamitos specimens display four plications on the fold and three in the sulcus, but very few Alamitos specimens have as many as the five lateral plications observed on one of the Del Cuerto specimens.

Because so few specimens are available from the Del Cuerto, knowledge of intraspecific variation in this population is lacking. These specimens appear to be transitional between typical early Virgilian examples of *Wellerella immatura* and smaller specimens bearing five or six lateral plications observed in younger Virgilian strata (La Casa Member, Wild Cow Formation, near Abo Pass) reported as *W. n. sp.* by Kues (2009).

***Hustedia mormoni* (Marcou)**

Hustedia mormoni (Fig. 5J) is a small athyridide that is rare in the Bruton Canyon section. It is immediately recognized by its

biconvex shell, oval outline, and strong, sharp radial costellae on each valve. The pedicle valve surface is evenly and moderately convex along its length, with a prominent sharp beak that extends well past the hingeline and bears a circular pedicle foramen. The brachial valve surface is a little more strongly convex, especially along the posterior half of the valve. The pedicle valve bears 16 and the brachial valve 15 bold, sharp-crested, unbranched costellae that extend the entire length of each valve, and are separated by interspaces slightly less wide than the costellae. The largest specimen is 9.4 mm long, and the mean (N = 2) width/length and thickness/length ratios are 0.84 and 0.65, respectively.

The Del Cuerto specimens are a little narrower and slightly less thick relative to shell length than in most assemblages of *Hustedia mormoni* for which measurements are available, but are well within the range of variability documented for this species, and the number of costellae is entirely typical. *Hustedia mormoni* ranges from the Desmoinesian to early Wolfcampian in the Midcontinent (Dunbar and Condra, 1932; Mudge and Yochelson, 1962). This species has seldom been reported from the Late Pennsylvanian of New Mexico, and is most common in Desmoinesian strata (Sutherland and Harlow, 1973).

***Composita subtilita* (Hall)**

Composita subtilita (Figs. 5K-M), an athyridide, is the most abundant species in the Del Cuerto assemblage, and is common in the Story Formation as well. Most specimens are weathered and/or incomplete, allowing accurate measurements of only a small percentage of the total specimens. The species is characterized generally by its unornamented biconvex shell, with the pedicle valve slightly more convex lengthwise than the brachial valve and possessing a moderately inflated umbo that extends significantly beyond the hingeline and terminates in a curved beak that bears a circular pedicle foramen. The valves have no fold or sulcus, but the median part of the anterior commissure is deflected upwards to form a narrow to rather broad, fold-like undulation. The species attains a maximum length of about 27 mm in the Del Cuerto Member.

Most Middle and Late Pennsylvanian *Composita* belong to a single species, *C. subtilita*, which displays considerable intraspecific variability, to the extent that some morphotypes have been given separate specific names (Grinnell and Andrews, 1964). The majority of mature (length greater than 15 mm) Del Cuerto specimens can be identified visually as typical examples of *C. subtilita*. These shells are elongate-oval in outline (mean width/length = 0.82; N = 14), moderately inflated (mean thickness/length = 0.62), and have a relatively narrow, shallow to moderately deep anterior commissure deflection. About one third of the specimens represent a morph, "*C. ovata*", that has a more circular outline (mean width/length = 0.92; N = 7), less inflated valves (mean thickness/length = 0.57), and typically a lower, wider anterior deflection than typical specimens of *C. subtilita*. The two morphotypes intergrade through a series of specimens intermediate in the characters mentioned above, but their differences are less pronounced in smaller specimens.

***Crurithyris* n. sp.?**

Specimens of this small spiriferide genus (Figs. 5N, O) are characterized by their biconvex shell, subequal length and width, large, strongly convex pedicle beak and umbo, high triangular interarea, and large triangular pedicle foramen. The largest of the few available Del Cuerto specimens is about 13 mm long. Weathered valve surfaces appear smooth but traces of concentric rows of fine spine bases are preserved on some specimens. The brachial valve surface is evenly convex lengthwise but much less so than the pedicle valve.

The Del Cuerto specimens differ from the most widely reported species, *Crurithyris planoconvexa* (Shumard), in having an evenly convex rather than flat brachial valve, and in their larger size and more pronounced pedicle umbo. In the Midcontinent region, *C. planoconvexa* is replaced in the late Virgilian by the larger species *C. expansa*, which differs also in having a more transverse outline, a posteriorly convex brachial valve with a broad, shallow median sinus anteriorly, and a smaller pedicle umbo and beak.

The combination of valve features observed on the Del Cuerto specimens do not permit assignment to either of these species. These specimens attain a relatively large size and have a convex brachial valve, like *C. expansa* and unlike *C. planoconvexa*, but they differ from the former species in that their umbo, beak and interarea characters are more pronounced, they lack a median sinus on the brachial valve, and length and width are subequal rather than width significantly exceeding length. Specimens from the Bruton Canyon section are few and are incomplete or distorted, however, preventing a more rigorous analysis of valve characters that might justify the naming of a new species.

***Neospirifer alatus* Dunbar and Condra**

Specimens of *Neospirifer alatus* (Fig. 5P) in the Burrego Member of Bruton Canyon are closely similar to specimens described as *N. latus* by Dunbar and Condra (1932) and *N. latus latus* by Spencer (1967) in the Midcontinent region, where they range from lower Missourian into Virgilian strata. Sutherland and Harlow (1973) considered *N. latus* a synonym of *N. alatus* Dunbar and Condra, and used the latter name for robust forms ranging from moderately to strongly alate in shape. The Burrego specimens are of relatively large size (width up to 50-55 mm), and are not exceptionally alate (width/length = about 1.5). They are characterized by a high, relatively narrow fold, and strongly fasciculate (bundled) costae, resulting from branching of individual costae as the valve grew. In the *N. alatus* specimens at hand, the fascicules form high, prominent radial ribs, particularly near the fold, and typically each fasciculate rib consists of five costae near the anterior valve margin. Because of weathering and incomplete preservation, details of plica branching could not be observed in detail on the fold and sulcus, but typical specimens display about 28 costae on each lateral surface.

***Neospirifer* cf. *N. dunbari* King**

The few incomplete specimens of *Neospirifer* from the Del Cuerto Member (Fig. 5Q) are smaller than those from the Burrego Member, having a maximum estimated width of about 42 mm, and possess a wider fold and sulcus. Because only portions of the available valves are preserved and these are weathered, details of valve ornamentation could not be studied completely. However it is clear from the best-preserved specimens that the first two or three major costae on each side of the sulcus branches twice a short distance in front of the beaks, to form fascicles consisting of three costae throughout the remainder of growth. The costae are typically lower and the fascicles consist of fewer costae than is the case with the Burrego Member specimens assigned to *N. alatus*.

The characters of the Del Cuerto specimens that could be observed accord well with *N. triplicatus* of Dunbar and Condra (1932), which was renamed *N. dunbari* by King (1933), and with *N. d. dunbari* of Spencer (1967). Sutherland and Harlow (1973) reported *N. dunbari*? from Virgilian strata near Pecos, NM. The Del Cuerto specimens were compared with specimens from the Pecos locality in the UNM collections and they appear to be conspecific.

***Punctospirifer kentuckyensis* (Shumard)**

Specimens of *Punctospirifer* (Fig. 5R) are uncommon in the Del Cuerto Member and all are small and incomplete, precluding accurate measurements. Maximum length is about 6 mm, and the shells appear to have been of a compact, semicircular outline, without significant transverse extension of the cardinal extremities. Strong, angular plicae are present on both valves. The pedicle valve has a pronounced deep sulcus bordered on each side by a large plica, with three or four progressively smaller plicae on each lateral surface. The brachial valve has a single wide plica marking the fold. The valve surface is covered by distinctive sharp, fine, closely spaced concentric lamellae.

These specimens are smaller than is typical of *Punctospirifer kentuckyensis*, a long-ranging and widespread species in the Late Pennsylvanian of North America, including New Mexico. They agree especially well with smaller specimens of a taxon described by Sturgeon and Hoare (1968) as *P. kentuckyensis* var. *amesi*, from early Virgilian strata of the Appalachian Basin. This variety was characterized by fewer plicae and the lack of an incipient costella within the sulcus and a median groove on the fold. However, Sutherland and Harlow (1967) noted that the latter features were absent on about half of the specimens in a middle Virgilian assemblage of *P. kentuckyensis* from the Jemez Springs area, and the number of lateral plicae is also variable, in part correlated with the degree of extension of the cardinal extremities. Thus, a varietal designation for this morph of the species is not needed.

***Phricodothyris perplexa* (McChesney)**

The spiriferide *Phricodothyris perplexa* (Figs. 5S, T) is common in the Del Cuerto assemblage but the specimens are

weathered and the posterior end of the pedicle valve umbo has broken off of most of them. The shell is strongly biconvex (mean thickness/length = 0.65; N = 9), with the pedicle valve having an inflated, strongly curved umbo that extends posteriorly well past the hingeline, and a moderately high interarea bearing a triangular pedicle foramen. Maximum shell length and width are about 19 mm (mean width/length = 1.01). Ornamentation is obscured by weathering, but the raised concentric bands characteristic of the species are visible on most specimens and traces of the short spines that extend from the bands are preserved on a few specimens.

Phricodothyris perplexa ranges through much of the Pennsylvanian (Morrowan to Virgilian) in New Mexico (e.g., Sutherland and Harlow, 1973), and is a common species at some localities.

***Beecheria bovidens* (Morton)**

Specimens of the terebratulide *Beecheria bovidens* (Figs. 5U, V) from the Story and Del Cuerto Members in Bruton Canyon range up to about 18 mm long, with a mean (N = 9) width/length ratio of 0.70 and a thickness/length ratio of 0.44. The shells are oval to subtrigonal in outline, with maximum width about two thirds of the distance from the posterior to anterior margins. Along its length, the pedicle valve surface is evenly and moderately convex, and the pedicle valve bears a wide, shallow median sulcus that begins within about one third of the distance from the posterior to anterior end. The surface of the brachial valve in side view is flat, and moderately arched in cross section, which produces a conspicuous, relatively wide upward bend in the anterior commissure where it meets the depressed sulcus of the pedicle valve. The pedicle valve beak is strongly incurved behind the hingeline and bears a small circular pedicle foramen.

In all valve features these specimens closely agree with *Beecheria bovidens* (e.g., Dunbar and Condra, 1932), a widespread, although not abundant, and long-ranging (Desmoinesian-Virgilian) species in the Midcontinent and Southwest. Most specimens are from the middle Del Cuerto Member, where the species is somewhat more abundant than is typical of late Pennsylvanian faunas in New Mexico.

***Beecheria* cf. *B. millepunctatus* (Hall)**

A second species of *Beecheria* in the middle Del Cuerto fauna (Figs. 5W, X) differs from *B. bovidens* in being relatively narrower (width/length = 0.67; N = 4), in having a conspicuously convex rather than flat brachial valve in lateral profile, and therefore a significantly greater thickness/length ratio (0.58), and in displaying a narrower, less conspicuous to obscure median sulcus on the pedicle valve. In front view, the brachial valve is more strongly arched, with steeply sloping flanks, and the fold in the anterior commissure is narrower than in *B. bovidens*. Also, surface ornamentation tends to be coarser, consisting of raised growth lines, than is typical of *B. bovidens*.

These Del Cuerto specimens may be conspecific with *Beecheria millepunctatus*, a poorly known species first described by Hall

(1856) from near Pecos, New Mexico. Sutherland and Harlow (1973) described and illustrated several poorly preserved, incomplete specimens from at or near the type locality. Comparison of the Del Cuerto specimens with about 15 specimens of *B. millepunctatus* collected from just north of Pecos (probable topotypes) revealed general similarities in the relatively narrow outline of the valves, longitudinally convex and strongly arched brachial valve, and obscure narrow median sulcus, that suggest that these two Virgilian taxa are closely related or conspecific. Another Virgilian species, described as *Beecheria* sp. from the Jemez Springs area by Sutherland and Harlow (1967), also differs from *B. bovidens* in several of the same features that distinguish *B. cf. millepunctatus*, although it has a more pronounced pedicle sulcus.

Other invertebrates

Sponges

The only fossil sponge observed in the Bruton Canyon section was collected in a hard medium-gray nodular limestone from the lower part of the Del Cuerto Member (Thompson's bed 18). It is exposed in cross-sectional view (Fig. 4A), which indicates an elongate, chambered, calcareous, sphinctozoan sponge about 50 mm long. The 10 chambers are linearly sequential, subcircular to upwardly convex, apparently overlapping, with a reniform outline and a maximum diameter of 12 mm. The walls of the chambers are thin, about 1 mm thick, and composed of coarsely recrystallized calcite. The cross section suggests a sponge similar to *Girtyocoelia typica* King, recently described by Rigby et al. (2008), from the Missourian Graford Formation of Texas.

Corals

Solitary rugose corals are abundant in the middle limestone bed of the Del Cuerto Member (Thompson's bed 18B), occurring in dense concentrations locally, and with some individuals attaining a length of 8 cm or more. No collections of these corals were made. Some specimens were collected from the eroded exposures of this unit that yielded the *Composita-Enteletes* brachiopod assemblage; these were typically incomplete and weathered. At least two taxa are present, based on corallite shape, but no attempt was made to identify them. Rugose corals were not observed in the other members of the Atrasado Formation in Bruton Canyon.

One large colony of a syringoporida coral (Fig. 4B) was collected from the upper limestone conglomerate bed of Thompson's bed 21 in the Del Cuerto Member. This colony, preserved in a weathered, dense, medium-gray limestone, consists of hundreds of recumbent to nearly erect corallites covering a surface area of 125 by 90 mm and is about 35 mm thick. The colony had grown around several angular limestone clasts, the largest with a maximum diameter of 17 mm. The corallites of this colony range from about 1.5 to 2.0 mm in diameter and have been completely replaced with coarse calcite crystals.

Bryozoans

Bryozoans are sparse to rare in the Bruton Canyon Upper Pennsylvanian sequence, and were only minor components of the benthic communities that were sampled in the collections from each member. Several zoarial forms, including thick branches, thin rhabdomesine branch fragments, and rare fenestrates were observed. Only two of the more than 1200 brachiopod specimens from the middle Del Cuerto assemblage (both specimens of *Composita*) had small encrusting bryozoan colonies on their shells.

Crinoids

Crinoid skeletal debris, mostly small stem fragments and isolated stem elements, are a persistent component of most of the Bruton Canyon assemblages, and in some beds are moderately abundant. They were clearly an important, although not dominant element of the faunal communities of each member, but no identifiable remains were observed.

Molluscs

Molluscs are very rare in the Story and Del Cuerto Members and none were collected from the Burrego Member. Nearly all are preserved as steinkerns or molds that lack shell material, preventing even generic identification in most cases. Gastropods and bivalves were most abundant in the main Del Cuerto assemblage, yet specimens of each group comprise less than 1% of the number of brachiopods. Among the identifiable bivalves *Permophorus?* and *Schizodus* are present in the Story Member and *Schizodus*, a pectinid, and a myalinid were recovered from the Del Cuerto. Of gastropods, only a small *Euomphalus* (Story Member) could be identified; a few other low-spined steinkerns were collected from the Del Cuerto Member.

Two orthocerid (straight-coned) nautiloid fragments from the upper Del Cuerto assemblage are the only cephalopods collected. One is a small (maximum diameter 9 mm) steinkern. The other consists of three chambers of a moderately large shell measuring 19.5 mm long with a maximum diameter of 23.5 mm. The septa, which are well preserved, are moderately concave with the siphuncle situated a short distance below the center of each septum. Traditionally shells like this have been assigned to *Mooreoceras normale* Miller, Dunbar and Condra or a related species, but Kroger and Mapes (2005) demonstrated that *M. normale* is a synonym of *Pseudorthoceras knoxense* (McChesney) and that *Mooreoceras* is an invalid genus.

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