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PENNSYLVANIAN TRILOBITES FROM THE SANGRE DE CRISTO AND JEMEZ MOUNTAINS, NORTH-CENTRAL NEW MEXICO

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ABSTRACT.—Trilobites are rare in marine Pennsylvanian strata of New Mexico. More than 100 specimens from Morrowan to Virgilian strata in the Sangre de Cristo and Jemez Mountains, belonging to five species, are described here. These are: aff. *Paladin* sp. (Morrowan), *Sevillia trinucleata* (Herrick) (upper Atokan-lower Desmoinesian), *Sevillia sevillensis* Weller (lower Desmoinesian), *Ditomopyge scitula* (Meek and Worthen) (Desmoinesian-middle Virgilian), and *Ameura missouriensis* (Shumard) (Atokan-middle Virgilian). These trilobites represent a depauperate but geographically widely distributed North American Pennsylvanian trilobite fauna. The taxa aff. *Paladin* sp., *Ditomopyge scitula*, and *Ameura missouriensis* appear to have preferred shallow, carbonate-shelf environments in which they occur with stenohaline groups such as brachiopods, bryozoans, and crinoids. Less commonly, the latter two species also occur in limestone assemblages dominated by bivalves and gastropods. The two species of *Sevillia*, on the other hand, are most common in dark-gray shales of the Flechado Formation, representing prodelta to interdistributary bay environments, where they occur with large numbers of gastropods and bivalves.

INTRODUCTION

Trilobites are rare constituents of Pennsylvanian marine assemblages in New Mexico, and although noted in faunal lists from many parts of the state few specimens have been described and illustrated. Collections of trilobites made by the author and others from several localities in the Sangre de Cristo and Jemez Mountains, represent stratigraphic levels from Morrowan to Virgilian, and are described here to augment the sparse existing record of Pennsylvanian trilobites in New Mexico. All specimens are in the paleontology collections of the Department of Earth and Planetary Sciences, University of New Mexico (UNM), Albuquerque.

PREVIOUS STUDIES

The record of adequately documented Pennsylvanian trilobites in New Mexico is limited to a few papers, and a summary of this record provides an appropriate background for the new specimens described below. Although not described, the first Pennsylvanian trilobites to be illustrated from the state were three pygidia from central New Mexico in a paper by Herrick and Johnson (1900). Two specimens (pl. 47, figs. 9, 11) were reported as *Phillipsia* n. sp. from the Manzanita Mountains southeast of Albuquerque, near Coyote Spring. The first specimen (pl. 47, fig. 9) was from a unit called the "Flint Ridge Shales" by Herrick and Bendrat (1900), now known to be about 50 m above the base of the Los Moyos Limestone (Madera Group) and Desmoinesian in age (see Kues, 1982). This pygidium is clearly Ditomopyge scitula (Meek and Worthen) and is very similar to pygidia in a large assemblage of trilobites from the same interval and nearby locality described by Kues (1982). The second specimen of "Phillipsia" n. sp. (pl. 47, fig. 11) is from the underlying Atokan Sandia Formation. Judging from the rudimentary hand-drawn figure, it possesses 15 axial rings and 10 pleural ribs, and was ornamented with tiny nodes. The number of rings and ribs would be unusually high for D. scitula, and the specimen may instead represent Sevillia, but must be regarded as unidentifiable. These specimens are no longer extant, having been destroyed in a fire at UNM in 1910.

The third of Herrick and Johnson's specimens (pl. 47, fig. 10) was identified as Phillipsia major (Shumard), a species now regarded as a synonym of Ameura missouriensis (Shumard) (Pabian and Fagerstrom, 1972; Brezinski, 1988). No locality was given for this specimen but the stratigraphic interval was stated to be "upper layers, Permo-Carboniferous". However, Herrick and Bendrat (1900, p. 236) reported *P. major* in a sequence in the Sandia Mountains containing Permian faunal elements, and it is likely that this is the specimen that was illustrated by Herrick and Johnson (1900). The interval yielding P. major was said by Herrick and Bendrat to be more than 400 ft above the "Flint Ridge Shales". Based on the thickness of Pennsylvanian strata in the Sandia-Manzanita Mountains area (Kelley and Northrop, 1975; Myers and McKay, 1976), and the alternating limestone and red shale lithologies just above the *P. major* horizon, this trilobite was probably collected from strata of Virgilian age.

Subsequently, Kues (1982) described a large assemblage of fragmentary to complete specimens of Ditomopyge scitula from the Desmoinesian of the Manzanita Mountains and Kues and Koubek (1991) studied fragmentary specimens of the same species in a nearby Desmoinesian assemblage. Lucas et al. (1999, fig. 4T) illustrated a pygidium of *Ditomopyge* sp. from the Virgilian at the north end of the Sandia Mountains, and Kues (1996) briefly described and figured D. scitula and Ameura missouriensis from Missourian-Virgilian strata near Jemez Springs. The latter specimens and more recent collections of trilobites from the Jemez Mountains are considered in greater detail in this paper, together with previously undescribed specimens from the Pennsylvanian of the Sangre de Cristo Mountains. The only previous record of trilobites from the Sangre de Cristos are occasional mention of "Phillipsia" sp. in old faunal lists (e.g., White, 1881; Stevenson, 1881; Gardner, 1910; Darton, 1928), and a report of Ditomopyge sp. from the Flechado Formation near Taos (Kues, 1984).

LOCATIONS AND STRATIGRAPHY

The trilobites described here were collected from several localities and intervals in the Sangre de Cristo and Jemez Moun-

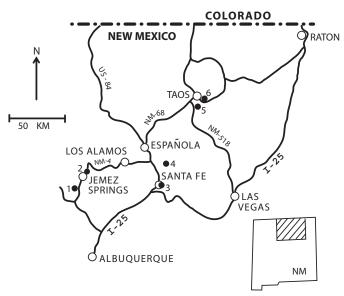


FIGURE 1. Reference map of north-central New Mexico, showing Pennsylvanian trilobite localities. 1, Guadalupe Box localities – Osha Canyon Formation (Morrowan), Sandia Formation (Atokan); lower Madera Group (Desmoinesian); 2, roadcuts on NM-4 north of Jemez Springs (upper Madera Group, Missourian-Virgilian); 3, Santa Fe quarries (La Pasada Formation, Atokan); 4, Nambe section (La Pasada Formation, Desmoinesian); 5, roadcuts on north side of NM-518 just south of village of Talpa (Flechado Formation, lower Desmoinesian); 6, roadcuts in US-64 in Taos Canyon (Flechado Formation, Atokan). See text and references for more detailed information.

tains (Figs. 1, 2). In the Sangre de Cristos, most specimens came from dark-gray shales in the upper part of the Flechado Formation (early Desmoinesian) exposed for about 1.5 km along the east side of NM-518, beginning about 1.75 km south of the village of Talpa, Taos County (see Kues and Batten, 2001, for more details). Other collections are from 1) the middle part of the La Pasada Formation (Desmoinesian) at Sutherland and Harlow's (1973) Nambe section (section 78), about 8 km southeast of Nambe Pueblo, Santa Fe County; 2) an Atokan interval of the La Pasada Formation at the Santa Fe quarries (Sutherland and Harlow's locality 62, units 17-18), about 1.6 km southeast of Santa Fe plaza, near the center of the city; and 3) late Atokan strata of the Flechado Formation in Taos Canyon, just east of Taos town, at Sutherland and Harlow's (1973) section 67, bed 13.

In the Jemez Mountains, southwest of the Sangre de Cristo range, Late Pennsylvanian strata of the upper part of the Madera Group are exposed along NM-4 from the north end of the town of Jemez Springs northward for about 9.5 km (Fig. 1). Missourian to middle Virgilian trilobites have been collected from measured sections at two localities along this interval (Kues, 1996); near the Ranger Station north of Jemez State Monument just north of Jemez Springs town, and on slopes opposite Hummingbird Camp, about 6.0 km north of the Monument. Additional specimens from this line of exposures without exact locality information but known to be of Missourian to Virgilian age are also present in the UNM collections.

Trilobites have also been collected from Guadalupe Box, in the canyon of the Rio Guadalupe northwest of Jemez Pueblo. One Morrowan trilobite from the type section of the Osha Canyon Formation (DuChene et al., 1977), and one specimen from the overlying Atokan Sandia Formation at the same locality are described here. This locality is a ridge along the east side of the Rio Guadalupe, opposite a point on NM-485 about 9.4 km north of its intersection with NM-4. One latest Atokan or early Desmoinesian trilobite from the lower part of the Madera Group at the base of Holiday Mesa, just to the north, is also present in the collections.

SYSTEMATIC PALEONTOLOGY

Five taxa are recognized in the assemblages from the Sangre de Cristo and Jemez Mountains. These are aff. *Paladin* sp. (Morrowan), *Sevillia trinucleata* (Herrick) (late Atokan-early Desmoinesian), *S. sevillensis* Weller (early Desmoinesian), *Ditomopyge scitula* (Meek and Worthen) (Desmoinesian-middle Virgilian), and *Ameura missouriensis* (Shumard) (Atokan-middle Virgilian).

Sevillia trinucleata (Herrick, 1887) Figures 3A-G, N

Material

Taos Canyon (Flechado Formation, upper Atokan), one pygidium; near Talpa (Flechado Formation, lower Desmoinesian), three complete enrolled specimens, one cranidium, 10 pygidia; Guadalupe Box (Sandia Formation, Atokan), one pygidium.

Description

The largest enrolled specimen (Figs. 3A-F) has a total length of about 40 mm; isolated pygidia and cephalon fragments are smaller than their counterparts on the enrolled specimen (Table 1).

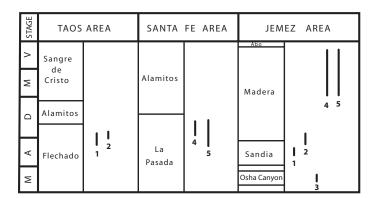


FIGURE 2. Formations and stratigraphic distribution of Pennsylvanian trilobites in the Taos, Santa Fe, and Jemez Mountains areas of north-central New Mexico. Systems (from bottom to top): M, Morrowan; A, Atokan; D, Desmoinesian; M, Missourian; V, Virgilian. Taxa: 1, Sevillia trinucleata; 2, S. sevillensis; 3, aff. Paladin sp.; 4, Ditomopyge scitula; 5, Ameura missouriensis.



FIGURE 3. Pennsylvanian trilobites from the Sangre de Cristo and Jemez Mountains, New Mexico. **A-G**, **N**, *Sevillia trinucleata* (Herrick). **A**, cephalon of enrolled specimen, UNM 13,414, Flechado Formation (lower Desmoinesian), south of Talpa, x2.2; **B**, side view, same specimen, x2.35; **C**, back view, same specimen, x2; **D**, pygidium, same specimen, x 2.5; **E**, pygidium, side view, same specimen, x2.35; **F**, side view of cephalon, showing eye facets, same specimen, x 4.75; **G**, small pygidium, UNM 13,418, same locality as A-F, x3; **N**, pygidium, UNM 13,452, Sandia Formation (Atokan), Guadalupe Box, x2.67. **H-M**, *Sevillia sevillensis* Weller. **H**, **M**, cephalon (x2) and pygidium (x2.5) of an enrolled specimen, UNM 13,415, Flechado formation (lower Desmoinesian), south of Talpa; **I**, cranidium, UNM 13,451, Flechado Formation (upper Atokan), Taos Canyon, x2.85; **J**, cranidium

The cephalon is semicircular in outline, with width/length about 1.45, having moderately long genal spines and a narrow border ornamented with fine parallel lirae. The glabella is subrectangular in outline, a little longer than wide, widens moderately anteriorly, is broadly convex around its anterior margin, inflated to form the highest portion of the cephalon, and bears two oblique, elongate, lateral-posterior glabellar lobes separated by shallow furrows on each side, with the posterior lobe of each pair elevated slightly above the anterior lobe. The lateral preoccipital lobes are large, tear-drop shaped, raised centrally into high, pointed, nearly circular nodes, and are separated from the glabella by slightly arcuate, deep lateral furrows that converge medially at about a 45-degree angle. Between the lateral lobes, the medial preoccipital lobe is narrow, relatively small, transversely suboval to subrectangular in outline, raised into a vaguely circular low central node, and is barely separated from the central posterior margin of the glabella by a shallow, straight, transverse preoccipital furrow. Posteriorly, the occipital lobe is strong, wide, elevated into a sharp flange posteriorly, and slopes steeply forward into the occipital furrow. A narrow ridge marks the postero-lateral margins of the cephalon and extends into the genal spines. The eyes are large, high, and arcuate, and opisthoparian facial sutures are well developed. Nine thoracic segments are present.

The pygidium is parabolic in outline, with an acutely rounded posterior margin, length/width ratio about 1.3, and a relatively wide border. The axial lobe is high, typically with 18 or 19 rings, broadly arched anteriorly but becomes flattened across the crest posteriorly, and its sides slope steeply downward. The posterior end of the axial lobe is bluntly squared off at the inner edge of the border, which is concave and extends a moderate distance beyond the last axial ring. Each axial ring is short, sharply rounded, and bears a transverse row of about 10 fine nodes. The pleural lobes consist typically of 11 moderately arched ribs, which bear less well-defined, irregular small nodes. The pygidia within a single collection from the Flechado Formation range in length from about 7.3 mm to 14.5 mm (Table 1), but the smallest is similar morphologically to the largest, and has approximately the same number of axial rings and pleural lobes.

Discussion

The complete enrolled specimen is unusually large, but displays all of the diagnostic features of the species, as first described by Herrick (1887) from Ohio and later by such authors as Chamberlain (1969) from north-central Utah, and Brezinski (1988) and Brezinski et al. (1989; see for synonymy) from the Appalachian basin. *Sevillia trinucleata* is known from late Morrowan to early Desmoinesian strata in the Appalachian basin, and was reported from Morrowan to early Atokan strata in Utah. The specimens from Utah are considerably smaller than most of the Flechado specimens, and the pygidia have fewer axial rings (typically 15) and pleural ribs (typically 9) than even the smallest of the Flechado specimens. The Flechado specimens are more closely comparable to late Atokan specimens from the Appalachian basin in size and pygidial characters. In both Utah and the Appalachian basin *S. trinucleata* occurs with *S. sevillensis* and this is also true in the Flechado Formation. Comparisons of the two Flechado species are summarized in the discussion of *S. sevillensis* below.

The cephalon of *S. trinucleata* is characterized, among other features, by relatively large lateral preocciptal lobes and a smaller, slightly transversely subrectangular medial preoccipital lobe that is aligned with or slightly forward of the highest points (at the posterior end) of the lateral preoccipital lobes. The deep furrow along the inner margin of the lateral preoccipital lobes is evenly and gently curved as it extends medially and posteriorly to the occipital furrow. Ornamentation appears to be lacking or obscure across the cephalon.

The eyes are rather strongly arcuate, and measure 4.7 mm long by 2.8 mm wide on the large enrolled specimen. Facets are well preserved on this specimen (Fig. 3F) and consist of upwards of 1000 circular to diamond-shaped units aligned in rows that sweep obliquely upward from the base to the top of the eye.

The pygidium of the large enrolled specimen (Figs. 3D, E) appears shortened because part of the posterior border has broken off. This makes it appear as though the blunt end of the axial lobe extends to the posterior margin, a feature said to be characteristic of *S. sevillensis*, but close examination indicates that the posterior border, concave in side view behind the axial lobe, actually extended 1 to 1.5 mm beyond the end of the lobe. A relatively wide posterior border is present on all of the isolated pygidia of *S. trinucleata*, and indeed, is also present on specimens identified as *S. sevillensis* based on cephalon characters. Thus, it may be that in the Flechado specimens, differences in the width of the border behind the axial lobe are not as significant among the two species as indicated for Appalachian basin specimens by Brezinski (1988) and Brezinski et al. (1989).

FIGURE 3. Continued.

of small specimen, UNM 13,419, Flechado Formation (lower Desmoinesian), south of Talpa, x3; **K**, pygidium, UNM 13,417, Flechado Formation (lower Desmoinesian), south of Talpa, x3.25; **L**, pygidium, UNM 13,446, lower Madera Group (Desmoinesian), Guadalupe Box, x3. **O**, aff. *Paladin* sp., cranidium, UNM 13,445, Osha Canyon Formation (Morrowan), Guadalupe Box, x2.75. **P-V**, *Ditomopyge scitula* (Meek and Worthen). **P**, **Q**, cephalon and anterior thoracic segments (x3) and pygidium and posterior thoracic segments (x3.2) of an enrolled specimen, UNM 5026, upper Madera Group (Virgilian), Ranger Station section, just north of Jemez Springs; **R**, back view of pygidium, UNM 5031, upper Madera Group (Missourian-Virgilian) north of Jemez Springs, x4.3; **S**, pygidium, UNM 5032, same locality as R, x5; **T**, partial pygidium, showing ornamentation, UNM 13,447, upper Madera Group (Virgilian), opposite Hummingbird Camp, north of Jemez Springs, x5; **U**, partial pygidium, UNM 13,449, La Pasada Formation (Desmoinesian), near Nambe Falls, x4; **V**, partial pygidium, weathered, emphasizing nodes on axial and pleural segments, UNM 13,448, same locality as U, x3. **W-Z**, *Ameura missouriensis* (Shumard). **W**, pygidium, UNM 12,683A, upper Madera Group (Missourian), Ranger Station section, just north of Jemez Springs, x3; **X**, partial cranidium, UNM 12,683B, same locality as W, x2.67; **Y**, pygidium, UNM 13,450, upper Madera Group (Virgilian), Ranger Station section, just north of Jemez Springs, x 1.85; **Z**, pygidium, UNM 6999, same locality as W, x3.

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TABLE 1. Measurements of Sevillia trinucleata_and S. sevillensis (in mm). L, length; W, width; e, estimated. All specimens f	rom
Flechado Formation (early Desmoinesian) near Talpa, except UNM 13.452 (Sandia formation, Atokan, Guadalupe Box).	

Specimen	Cephalon		Thorax	Pygidium				
	\mathbf{L}	\mathbf{W}	\mathbf{L}	L	\mathbf{W}	axial lobe	no. of	no. of
						length	axial rings	pleural ribs
S. trinucleata								
UNM 13,414	13.0	19.0	13.0	14.5e	18.5	12.8	18	11
UNM 13,416	9.5	-	-	12.7	-	11.0	18	11
UNM 13,418	-	-	-	7.3	8.5e	6.4	19	10
UNM 13,452	-	-	-	12.5	15.0e	11.0	17	10
S. sevillensis								
UNM 13,415	11.5	20.0e	11.0e	14.0	19.0e	12.1	19	11
UNM 12,417	-	-	-	9.9	-	8.9	18	10
UNM 13,446	-	-	-	6.6	9.1	5.5	15	9

Sevillia sevillensis (Weller, 1936) Figures 3H-M

Material

Near Talpa (Flechado Formation, lower Desmoinesian), one complete enrolled specimen, three cranidia, four pygidia; Guadalupe Box (lower Madera Group, late Atokan to early Desmoinesian), one pygidium.

Description

The only complete enrolled specimen has a total length of about 36 mm (Table 1). The cephalon, somewhat flattened anteriorly by postdepositional compaction, is broadly semicircular in outline, with a width/length ratio of about 1.75, relatively long, narrow genal spines, and is ornamented with small circular nodes across its surface, especially posteriorly. The border is narrow, almost completely covered by the anterior portion of the glabella, and is ornamented by fine, sharp, parallel lirae. The glabella is subquadrate in outline, widens anteriorly, with maximum width approximately equalling length, and is moderately inflated so that its highest point is about at the elevation of the top of the eyes. Two oblique lateral posterior glabellar lobes separated by a shallow furrow are present on each side. The posteriormost of these lobes is oval, larger and higher than the anterior lobe, and only slightly smaller than the lateral preoccipital lobes. The deep furrow dividing the posterior glabellar lobe from the lateral preoccipital lobe extends at a low angle medially, and bends sharply around the inner margin of the lateral preoccipital lobe before intersecting the occipital furrow. The lateral preoccipital lobes are broadly oval in outline and raised centrally into nearly circular crests. The medial preoccipital lobe is slightly transversely oval, nearly equal in size to the lateral preoccipital lobes, and its crest is situated significantly forward of the crests of the lateral lobes. A shallow, curved transverse preoccipital furrow separates the medial preoccipital lobe from the end of the glabella. Along the posterior margin of the cephalon, a strong occipital lobe is sharply elevated posteriorly and convex as it descends forward into the occipital furrow. A bold ridge borders the posterolateral margins of the cephalon and extends onto the genal spines. The eyes are large, high, and slightly arcuate, and opisthoparian facial

sutures are well developed. Nine thoracic segments are present.

The pygidium is broadly subtriangular in outline, and has an estimated length/width ratio of 1.3. The axial lobe is high and gently convex to nearly flat across its crest, consists of 19 rings, and its posterior termination is bluntly squared off. The dorsal surface of the rings is adorned with six to 10 circular to elongate small nodes, and the sides of the axial lobe descend almost vertically to the axial furrows. The pleural lobes consist of 11 sharply rounded, obscurely nodose ribs, and are rather sharply arched from the base of the axial lobe to their outer ends. The pygidial border is relatively wide and extends more than a millimeter beyond the end of the axial lobe, where it becomes concave in lateral view.

Discussion

The single complete specimen (Figs. 3H, M) has the anterior part of the glabella and the pygidium flattened, but this has not obscured the salient features of these structures. Weller (1936) originally described *Sevillia sevillensis* from the Seville Limestone of Illinois. Willman et al. (1975, p. 183-184, fig. P-2) indicated that this unit is near the base of the Spoon Formation, of early Desmoinesian age, but also suggested correlation of the Seville Limestone Member with the Lower Mercer unit of the Appalachian basin, which is now considered late Atokan (e.g., Brezinski et al., 1989; Hoare et al., 1997), and which is the only unit that has yielded specimens of *S. sevillensis* in that area. The Flechado specimens, of early Desmoinesian age, are essentially contemporaneous within present levels of resolution. Chamberlain (1969), on the other hand, reported *S. sevillensis* only from Morrowan to early Atokan strata in north-central Utah.

Weller's (1936) description of *Sevillia sevillensis* indicated several points of difference between that species and the closely related *S. trinucleata*. The former species has a larger (median) preoccipital lobe with a crest located anterior to those of the "basal" (= lateral preoccipital) lobes, has more granular ornamentation of the glabella, and possesses a subtriangular pygidium with a wider axial lobe. The type specimens of *S. sevillensis* have 17 to 18 axial rings and 10 or 11 pleural ribs on the pygidium, similar to Appalachian basin specimens, but the numbers are 16 and nine on the older Utah specimens. The type specimens dis-

play a rather narrow concave border around the end of the axial lobe, whereas the posterior border of the Utah specimens is relatively wide and not significantly different from that of *S. trinucleata* (Chamberlain, 1969), and the border of the Appalachian basin specimens is very narrow, so that the axial terminus may overhang it (Brezinski et al., 1989). The Flechado specimens of *S. sevillensis* agree closely in most respects with Weller's description of the type specimens, but have a relatively wider posterior border that resembles that of the Utah specimens assigned to the species.

The specimens of Sevillia sevillensis and S. trinucleata from the Flechado Formation near Talpa both attain relatively large sizes (total length 35 to 40 mm), but differ chiefly in characters of the cephalon. Sevillia sevillensis differs from S. trinucleata in having a lower, suboval medial preoccipital lobe that extends forward past the posterior margins of the last pair of lateral glabellar lobes, so that its crest is anterior to those of the lateral preoccipital lobes, and the shallow preoccipital furrow is curved around the anterior margin of the medial preoccipital lobe. On S. trinucleata the medial preoccipital lobe is virtually aligned in a transverse row with the two sharp-crested lateral preoccipital lobes, and the preoccipital furrow in front of it is straight. In addition, the deep furrows bordering the inner margins of the lateral preoccipital lobes are evenly and gently arcuate and extend medially and posteriorly to the occipital furrow at a relatively high angle on S. trinucleata, whereas these furrows extend medially at a lower angle and are sharply bent around the posterior inner margins of the lateral preoccipital lobes before intersecting the occipital furrow on S. sevillensis. This results in slightly different shapes for the lateral preoccipital lobes on the two species; those of S. trinucleata being more elongate and subtriangular compared to a broader, more polygonal shape for those of S. sevillensis. In both species the posterior lateral glabellar lobes are well developed although smaller than the lateral preoccipital lobes, but those of S. sevillensis are slightly shorter and broader than those of S. trinucleata. On the specimens at hand, the eyes of S. trinucleata appear to be slightly narrower and more conspicuously arcuate in shape than the eyes of S. sevillensis. Finally, the glabella of S. sevillensis was said to be distinguished from that of S. trinucleata by having more granular ornamentation (e.g., Weller, 1936; Chamberlain, 1969) and this appears also to be the case with the Flechado specimens. The apparent conspicuous anterior widening of the glabella of S. sevillensis (see Fig. 3H) is the result of localized dorsoventral compression rather than a true morphological character.

aff. *Paladin* sp., Figure 3O

Material

One partial cranidium from the Morrowan Osha Canyon Formation, Guadalupe Box, Jemez Mountains.

Description

The single cranidium is missing the left lateral preoccipital lobe but includes an elongate, pyriform glabella that is widest anteriorly and narrows evenly posteriorly to about 65 percent of its maximum anterior width. The length of the glabella is 5.0 mm and maximum width is 4.0 mm. The glabella is bordered posteriorly by a shallow transverse proccipital furrow and a transversely elongate medial preoccipital lobe, followed by a prominent occipital lobe. The right lateral preoccipital lobe is small, triangular in outline, and longer than wide, with the apex of the lobe extending anterior to the preoccipital furrow a distance approximately equal to the distance the posterior part of this lobe extends in back of it. A narrow, lirate anterior border is present in front of the glabella. Lateral glabellar lobes, if present, are extremely obscure, and it is not certain that slight undulations in this area of the glabella have not resulted from weathering. Opisthoparian sutures intersect the anterolateral margin of the cephalon not far from the margins of the glabella.

Discussion

The elongate pyriform outline of the glabella closely resembles that of Paladin, and although Paladin does not possess a preoccipital furrow or a medial preoccipital lobe (Weller, 1936; Brezinski, 2003), some species display a constricted and elevated posterior glabellar region "almost forming a medial preoccipital lobe" (Chamberlain, 1969, p. 51). For example, P. pyriformis Chamberlain (1969, p. 51), from the early Atokan of Utah, "approaches Sevillia in cranidial and pygidial characteristics, but is distinguished by the relatively long glabella with wide lateral expansion of the frontal lobe and by lack of a completely developed medial preoccipital lobe." Brezinski (2003), however, recently suggested assignment of P. pyriformis to the genus Pseudophillipsia. In any case, Paladin lacks lateral glabellar lobes, whereas species of Sevillia possess well-developed lobes; the presence of these lobes on the New Mexico Morrowan specimen is equivocal. Chamberlain (1969) believed that Sevillia evolved from Paladin in the Early Pennsylvanian, and Brezinski (1988) showed that in the Appalachian basin Sevillia appears in the Morrowan shortly after Paladin_became extinct.

Unfortunately, the single specimen of this taxon is too incomplete to allow definite assignment. Based on the cranidial features that are preserved, it can be assigned neither to <code>Paladin_nor</code> to <code>Sevillia</code> as those genera are presently understood. The elongate, pyriform glabella that apparently lacks lateral lobes and furrows is closer to <code>Paladin</code> than to <code>Sevillia</code>, which has a shorter, wider, more rectangular glabella with well-developed lateral lobes. However, the distinct medial preoccipital lobe of the Osha Canyon specimen is more characteristic of <code>Sevillia</code>, although presaged in some Late Mississippian-Early Pennsylvanian species of <code>Paladin</code>.

Ditomopyge scitula (Meek and Worthen, 1865) Figures 3P-V

Material

Nambe section (La Pasada Formation, Desmoinesian), 12 pygidia; Jemez Springs area (upper Madera Group, Missourian-Virgilian), nine cranidia, 10 free cheeks, 25 pygidia; Jemez

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TABLE 2. Measurements of Ditomopyge scitula and Ameura missouriensis (in mm). L, length; W, width; e, estimated.

Specimen	Cepl L	halon W	Thorax L	Pygidi L	um W	no. of axial rings	no. of pleural ribs
Ditomopyge scitula	(Nambe sec	tion, Desmoi	nesian)			8	•
UNM 13,462	_	-	-	2.9	3.3	12?	8
UNM 13,463	-	-	-	4.0	5.2e	12	7
UNM 13,464	-	-	-	8.2	11.0	12	7
UNM 13,448	-	-	-	7.9	-	-	-
UNM 13,449	_	-	-	-	-	-	7
Ditomopyge scitula	(Jemez Spri	ngs area, Vir	gilian)				
UNM 5026	6.5	10.2	8.0	6.3e	9.5e	11	6
UNM 13,453	-	-	-	8.1	-	12	-
UNM 13,454	-	-	-	7.5	10.0e	12	6?
UNM 13,455	-	-	-	7.0e	-	12	7
UNM 13,447	-	-	-	7.0	8.0+	12	7
UNM 13,456	-	-	-	4.3	6.5e	12	6?
UNM 13,457	-	-	-	6.6	9.0e	13	7
UNM 13,458	-	-	-	-	-	12	6
Ditomopyge scitula	(Jemez Spri	ngs area, Mis	ssourian/Virgilian)				
UNM 5031	-	-	-	5.0	6.5	12	7
UNM 5032	-	-	-	5.0	6.6	12	7
UNM 5033	-		-	3.8e	-	13	-
UNM 5038	-		-	5.0	-	11	6
UNM 13,460	-		-	4.3	5.4	12	6
Ameura missouriens	sis (Jemez S	prings area, f	irst three Missouri	an; 13,450 V	irgilian)		
UNM 12,683A	-	-	-	13.0	15.2	22	12
UNM 6999	-	-	-	11.0	13.0e	20	11
UNM 13,461	-		-	12.0		20e	11
UNM 13,450	-	-	-	14.1	15.5e	21	11

Springs area (upper Madera Group, Virgilian), one enrolled complete specimen, 12 pygidia.

Description

Ditomopyge scitula is a relatively small species (Table 2), the New Mexico specimens attaining a length of about 25 mm. The cephalon bears a slightly pyriform glabella that lacks posterior lateral glabellar lobes, a small transversely rectangular medial preoccipital lobe that is about the same height as the back of the glabella, relatively small subtriangular lateral preoccipital lobes that extend only a short distance anterior to the preoccipital furrow, a deep occipital furrow, a large occipital lobe that is highest posteriorly, and sharp, moderately long genal spines. Ornamentation is restricted to fine, obscure granules. There are nine thoracic segments. The pygidium is short, wide, and broadly convex around its posterior margin, and possesses a wide border. On the New Mexico specimens the number of axial rings ranges from 11 to 13, and the number of pleural ribs from six to seven. The axial rings are flattened across their crest and the pleural ribs are moderately to strongly geniculate about at midwidth. Ornamentation consists of small, typically longitudinally elongate nodes on the axial rings, and obscure nodes on the pleural ribs. Desmoinesian specimens tend to display a single low enlarged node about at midwidth on the pleural ribs.

Discussion

Ditomopyge scitula is the most common and widespread Pennsylvanian trilobite in North America, and it and its synonyms have been described from the Appalachian basin (Brezinski, 1988; Brezinski et al., 1989), Midcontinent and Texas region (e.g., Pabian and Fagerstrom, 1972; Bucurel and Chamberlain, 1977; Brezinski and Stitt, 1982; Pabian et al., 1993), Utah (Chamberlain, 1969), and central New Mexico (Kues, 1982). The specimens from north-central New Mexico described here range from Desmoinesian to Virgilian in age and fit well within the rather broad concept of the species.

Desmoinesian specimens differ in some minor features from Missourian-Virgilian specimens in New Mexico, especially in the presence on Desmoinesian specimens of a solitary, low, large node at about midwidth on the pleural ribs (e.g., Figs. 3U, V). These nodes are conspicuous on Desmoinesian specimens from the Manzanita Mountains of central New Mexico (Kues, 1982), and are present on Desmoinesian specimens from other regions as well (e.g., Brezinski and Stitt, 1982; Brezinski et al., 1989), but are obscure or lacking on Missourian and Virgilian specimens from New Mexico.

The cephalon of *Ditomopyge scitula* is distinguished from that of its closely related successor, *D. decurtata* Gheyselinck, in having its medial preoccipital lobe about equal in height to the

posterior part of the glabella, instead of conspicuously lower. The pygidium of *D. scitula* differs from that of *D. decurtata* in having a flattened rather than arched axial lobe crest, which produces a subtrapezoidal cross section, and in having more strongly geniculate pleural ribs (Brezinski et al., 1989). In the Appalachian basin *D. decurtata* replaces *D. scitula* in the early Virgilian, but *D. scitula* apparently ranges into the early Wolfcampian in the Midcontinent region (Pabian and Fagerstrom, 1972). The youngest (mid-Virgilian, Jemez Springs area) specimens of *Ditomopyge* in north-central New Mexico display the features characteristic of *D. scitula*. Elsewhere in the southwestern United States, *D. decurtata* has been documented from late Virgilian through Wolfcampian strata in west Texas (Brezinski, 1992), and from earliest Wolfcampian strata in south-central New Mexico (Kues, 2002).

Ameura missouriensis (Shumard, 1858) Figures 3W-Z

Material

Nambe section (La Pasada Formation; Atokan), one pygidium; Santa Fe quarries (La Pasada Formation, Desmoinesian), one pygidium; Jemez Springs area (upper Madera Group, Missourian), six pygidia and one partial cranidium; Jemez Springs area (upper Madera Group, Virgilian), four pygidia.

Discussion

Ameura missouriensis attains a larger size than any other New Mexico Pennsylvanian trilobite, and its cephalon is distinguished by lacking a medial preoccipital lobe, as is shown on the only cephalon fragment present in the UNM collections (Fig. 3X). The pygidium is subtriangular in outline, with maximum width scarcely exceeding the total length, has a wide border, and is unornamented. On the New Mexico specimens 19 to 22 high, dorsally arched, relatively narrow, unornamented axial rings are present, and 11 to 12 unornamented, broadly convex pleural ribs (Table 2). A fragmentary pygidium from the upper Missourian of the Jemez Springs area had an estimated maximum length of more than 25 mm when complete. This species has been observed in Atokan through Virgilian strata in north-central New Mexico.

DISCUSSION

Brezinski (1999) viewed trilobite evolution in the North American Pennsylvanian as divisible into two stages. At least two species of *Paladin* continued into the Morrowan from the Mississippian (ending Stage 2), but these were replaced in the Morrowan-Atokan by *Sevillia sevillensis* and *S. trinucleata*, with *Ditomopyge scitula* and *Ameura missouriensis* appearing slightly later, in Atokan time, and initiating the Stage 3 fauna. *Sevillia* became extinct in the early Desmoinesian, leaving the latter two species as the only trilobite taxa nearly to the end of the Pennsylvanian. By the end of the Virgilian *D. decurtata* replaced *D. scitula*, *Ameura missouriensis* continued on into the Wolfcampian, and several other rare genera immigrated into North America from other areas during the late Virgilian and Wolfcampian, forming the last phase of the Stage 3 fauna.

The trilobites reported here add information about the occurrence of *Ditomopyge scitula* and *Ameura missouriensis* in Desmoinesian to Virgilian strata in New Mexico, and document for the first time the occurrence of the two species of *Sevillia* in Atokan and early Desmoinesian strata in the state. The presence in New Mexico of all four of the main species of post-Morrowan trilobites recognized by Brezinski is perhaps not surprising, as each of them also occurs in nearby Utah (Chamberlain, 1969), and testifies to the widespread geographic distribution of the depauperate Stage 3 fauna.

The only New Mexico Morrowan trilobite is a single fragmentary cranidium that appears to be related to *Paladin*. Further collecting in the thick Morrowan part of the Flechado Formation in the Sangre de Cristo Mountains, and in the few other Morrowan sequences in the state, is needed to better understand trilobite distribution in the earliest Pennsylvanian of New Mexico, and to determine whether the New Mexico record accords with the general Morrowan pattern outlined by Brezinski (1999). The youngest trilobites of the Pennsylvanian of the Sangre de Cristo and Jemez Mountains are of middle Virgilian age, and apparently preceded both the appearance of *Ditomopyge decurtata* and the possible entry of exotic genera marking the last phase of Stage 3 in New Mexico.

The depositional environments, lithological context, and faunal associates of the five trilobite species discussed here varies considerably. The Morrowan specimen of aff. Paladin sp. was collected from a bioclastic limestone unit in the Osha Canyon Formation, where it occurs in an assemblage dominated by stenohaline groups such as brachiopods, solitary rugose corals, bryozoans, and crinoids (DuChene et al., 1977). In contrast, Sevillia sevillensis and S. trinucleata from the late Atokan to early Desmoinesian upper part of the Flechado Formation in the Talpa area occur in a dark-gray shale sequence with interbedded, thin, dark-gray, argillaceous limestone beds. These strata represent prodelta and interdistributary bay environments at the distil end of fan-delta systems that prograded into marine environments from the Uncompangre uplift to west (Kues and Batten, 2001). These shallow marine environments were thus subject to periods of salinity instability owing to proximity to freshwater runoff from the nearby land area. The shales are dominated by highly diverse and abundant molluscs, especially gastropods and bivalves, whereas brachiopods and corals are locally abundant in the more calcareous facies. Most, if not all of the specimens of Sevillia from the Flechado Formation occur with gastropods and bivalves in the dark-gray shale facies. Their occurrence in the Flechado Formation appears similar to their occurrence most commonly elsewhere in nearshore, molluscan biofacies (Brezinski, 1999, table 1).

Based on its presence in the Sangre de Cristo and Jemez Mountains of north-central New Mexico, *Ditomopyge scitula* had relatively broad ecological preferences. The Desmoinesian specimens from the La Pasada Formation of the Nambe section are uniformly in hard, medium-gray limestones bearing large numbers of the chonetoid *Mesolobus*, productoids and other brachiopods, together with fenestrate bryozoans, crinoid fragments, and moderate numbers of pectinid bivalves. This was a shallow,

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carbonate-shelf environment, probably above wave base but with stabile, normal-marine salinity conditions. The large Desmoine-sian assemblage of *D. scitula* reported from central New Mexico by Kues (1982) is similar, in that it is part of an assemblage composed almost exclusively of stenohaline groups, but differs in occurring in a dark-gray, silty limestone facies that was probably deposited below wave base, in quiet conditions, rather far from the shoreline.

Most of the Missourian-Virgilian specimens of *Ditomopyge scitula* in the Jemez Springs area were collected from medium gray, micritic to argillaeous limestones, in assemblages varying from brachiopod/crinoid/bryozoan dominated, to mixed molluscan-brachiopod assemblages. A few specimens are from units that are mainly tan calcareous shale, with a relatively high diversity and abundance of gastropods and bivalves. From my observations of the occurrence of *D. scitula* in the Sangre de Cristo and Jemez Mountains, it appears that this species was a relatively widespread but always minor constituent of shallow, stable, normal-marine, carbonate-shelf environments dominated by stenohaline groups, but could also tolerate nearer-shore, less stable habitats that mainly supported molluscs. This species prefers deeper offshore environments in the northern mid-continent region (Pabian, written commun., 2004).

The number of specimens of *Ameura missouriensis* is too few to draw any firm conclusions about environmental preferences, but those from the Jemez Springs area appear to mirror the distribution of *Ditomopyge scitula*, although they are much less common, and specimens of both species co-occur in some Missourian-Virgilian units.

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REFERENCES

- Brezinski, D. K., 1988, Appalachian Carboniferous trilobites: Journal of Paleontology, v. 62, p. 934-945.
- Brezinski, D. K., 1992, Permian trilobites from west Texas: Journal of Paleontology, v. 66, p. 924-943.
- Brezinski, D. K., 1999, The rise and fall of late Paleozoic trilobites of the United States: Journal of Paleontology, v. 73, p. 164-175.
- Brezinski, D. K., 2003, Evolutionary and biogeographical implications of phylogenetic analysis of the late Paleozoic trilobite *Paladin*: The Palaeontological Association, Special Papers in Paleontology, v. 70, p. 363-375.
- Brezinski, D. K., and Stitt, J. H., 1982, *Ditomopyge scitula* (Meek and Worthen) from the Lower Pennsylvanian of central Missouri and central Texas: Journal of Paleontology, v. 56, p. 1242-1250.
- Brezinski, D. K., Sturgeon, M. T., and Hoare, R. T., 1989, Pennsylvanian trilobites of Ohio: Ohio Geological Survey, Report of Investigations no. 142, 18 p.
- Bucurel, H. G., and Chamberlain, C. K., 1977, Status and redescription of the Lower Pennsylvanian trilobite *Ditomopyge ornate* (Vogdes): Journal of Paleontology, v. 51, p. 405-410.
- Chamberlain, C. K., 1969, Carboniferous trilobites: Utah species and evolution in North America: Journal of Paleontology, v. 41, p. 227-239.

Darton, N. H., 1928, "Red beds" and associated formations in New Mexico: U. S. Geological Survey, Bulletin 794, 356 p.

- DuChene, H. R., Kues, B. S., and Woodward, L. A., 1977, Osha Canyon Formation (Pennsylvanian), new Morrowan unit in north-central New Mexico: American Association of Petroleum Geologists Bulletin, v. 61, p. 1513-1524
- Gardner, J. H., 1910, Isolated coal fields in Santa Fe and San Miguel Counties, New Mexico: U. S. Geological Survey, Bulletin 381-C, p. 155-159.
- Herrick, C. L., 1887, A sketch of the geological history of Licking County, Appendices I & II, Carboniferous trilobites: Denison University Scientific Laboratories Bulletin, v. 2, part 2, p. 51-70.
- Herrick, C. L., and Bendrat, T. A., 1900, Identification of an Ohio Coal Measures horizon in New Mexico: American Geologist, v. 25, p. 234-242.
- Herrick, C. L., and Johnson, D. W., 1900, The geology of the Albuquerque sheet: Denison University Scientific Laboratories Bulletin, v. 11, art. 9, p. 175-239.
- Hoare, R. D., Sturgeon, M. T., and Anderson, J. R. Jr., 1997, Pennsylvanian marine gastropods from the Appalachian basin: Journal of Paleontology, v. 71, p. 1019-1039.
- Kelley, V. C., and Northrop, S. A., 1975, Geology of Sandia Mountains and vicinity: New Mexico Bureau of Mines and Mineral Resources, Memoir 29, 136 p.
- Kues, B. S., 1982, Pennsylvanian trilobites from the Madera Formation, Cedro Canyon, New Mexico: New Mexico Geological Society, 33rd Field Conference Guidebook, p. 239-243.
- Kues, B. S., 1984, Pennsylvanian stratigraphy and paleontology of the Taos area, north-central New Mexico: New Mexico Geological Society, 35th Field Conference Guidebook, p. 107-114.
- Kues, B. S., 1996, Guide to the Late Pennsylvanian paleontology of the upper Madera Formation, Jemez Springs area, north-central New Mexico: New Mexico Geological Society, 47th Field Conference Guidebook, p. 169-188.
- Kues, B. S., 2002, A marine invertebrate fauna from the upper part of the Panther Seep Formation (earliest Wolfcampian) near Hembrillo Pass, San Andres Mountains, south-central New Mexico: New Mexico Geological Society, 53rd Field Conference, Guidebook, p. 241-256.
- Kues, B. S., and Batten, R. L., 2001, Middle Pennsylvanian gastropods from the Flechado Formation, north-central New Mexico: The Paleontological Society, Memoir 54, Journal of Paleontology, v. 75, supplement to no. 1, 95 p.
- Kues, B. S., and Koubek, J., 1991, A marine invertebrate assemblage from the Middle Pennsylvanian Los Moyos Limestone (Madera Group), Manzanita Mountains, New Mexico: New Mexico Journal of Science, v. 31, p. 49-63.
- Lucas, S. G., Rowland, J. M., Kues, B. S., Estep, J. W., and Wilde, G. L., 1999, Uppermost Pennsylvanian and Permian stratigraphy at Placitas, New Mexico: New Mexico Geological Society, 50th Field Conference Guidebook, p. 281-292.
- Myers, D. A., and McKay, E. J., 1976, Geologic map of the north end of the Manzano Mountains, Tijeras and Sedillo quadrangles, Bernalillo County, New Mexico: U. S. Geological Survey, Miscellaneous Investigations Map I-968, scale 1:24,000.
- Pabian, R. K., and Fagerstrom, J. A., 1972, Late Paleozoic trilobites from south-eastern Nebraska: Journal of Paleontology, v. 41, p. 789-816.
- Pabian, R. K., Borovich, J., and Mapes, R. H., 1993, Growth stages of the Middle and Late Pennsylvanian trilobite *Ditomopyge scitula* from the North American Midcontinent: Journal of Paleontology, v. 67, p. 230-240.
- Stevenson, J. J., 1881, Report upon geological examinations in southern Colorado and northern New Mexico during the years 1878 and 1879: Report upon United States geographical surveys west of the 100th Meridian [Wheeler Survey], v. 3, supplement, 420 p.
- Sutherland, P. K., and Harlow, F. H., 1973, Pennsylvanian brachiopods and biostratigraphy in southern Sangre de Cristo Mountains, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Memoir 27, 173 p.
- Weller, J. M., 1936, Carboniferous trilobite genera: Journal of Paleontology, v. 10, p. 704-714.
- White, C. A., 1881, Report upon the Carboniferous invertebrate fossils of New Mexico: Report upon United States geographical surveys west of the 100th Meridian [Wheeler Survey], v. 3, supplement, appendix, p. 1-38.
- Willman, H. B., Atherton, E., Buschbach, T. C., Collinson, C., Frye, J. C., Hopkins, M. E., Lineback, J. A., and Simon, J. A., 1975, Handbook of Illinois stratigraphy: Illinois State Geological Survey, Bulletin 95, 261 p.