



## *Pennsylvanian trilobites from the Madera Formation, Cedro Canyon, New Mexico*

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# PENNSYLVANIAN TRILOBITES FROM THE MADERA FORMATION, CEDRO CANYON NEW MEXICO

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## INTRODUCTION

Fossils have been known from Pennsylvanian strata east of Albuquerque since 1853, when Jules Marcou, a member of the Whipple Expedition, collected numerous brachiopods, corals, and nautiloids from the Sandia Mountains and Tijeras Canyon (Marcou, 1858). Studies of the Madera Formation (or Group, see Myers, 1973) in the Sandia, Manzanita, and Manzano mountains since then have revealed that marine invertebrates are abundant and diverse; plants and vertebrate remains are also present in some of the nonmarine parts of the Madera. Of the more than 300 reported species of invertebrates, most are brachiopods, corals, foraminifers, bryozoans, pelecypods, gastropods, and crinoid stems (Northrop, in Kelley and Northrop, 1975). Many of these are similar or identical to forms found elsewhere in the Pennsylvanian strata of New Mexico, and indeed, in Pennsylvanian rocks throughout the midcontinent and east-central parts of the United States.

Trilobites are uncommon elements of Pennsylvanian marine faunas of North America, and their occurrence in the Madera Formation and equivalent units in northern New Mexico is limited generally to occasional isolated pygidia, cephalon fragments, and rare complete specimens. A single locality in Cedro Canyon, however, over the years has yielded hundreds of trilobites, including many complete individuals. The purpose of this paper is to describe, discuss, and illustrate these trilobites and to examine some aspects of their paleoecology.

## PREVIOUS STUDIES AND LOCALITIES

Trilobites were first reported in the southern Sandia-Manzanita mountains area by Herrick and Johnson (1900), who illustrated but did not describe two pygidia identified as *Phillipsia* sp. n. from Pennsylvanian exposures near Coyote Spring (NW1/4 SE1/4 sec. 16, T9N, R5E). One of the pygidia (pl. 47, fig. 9 of Herrick and Johnson, 1900) came from the "Flint Ridge shales," which would be about 50 m above the base of the Madera Formation, or in the Desmoinesian Los Moyos Limestone of the Madera Group, using the terminology of Myers (1973; Northrop, in Kelley and Northrop, 1975). The other pygidium (pl. 47, fig. 11 of Herrick and Johnson, 1900) came from the "Sandia limestone," now the Sandia Formation. The "Flint Ridge shales" specimen was also noted by Herrick and Bendrat (1900, p. 242) as being "undoubtedly new" but, because only the pygidium was present, was not considered to be worthy of being formally named.

A third pygidium, identified as *Phillipsia* (now *Ameura*) *major* (pl. 47, fig. 10 of Herrick and Johnson, 1900) was stated by Herrick and Johnson to have come from the "upper layers Permo-carboniferous" but no locality was given. Herrick and Bendrat (1900, p. 236) however, mentioned the presence of *Phillipsia major* in a limestone and shale sequence containing Permian faunal elements that was at least 60 to 120 m (200-400 ft) above the "Flint Ridge shales" in the Coyote Springs area. This locality very probably was the one that produced the *Phillipsia major* specimen illustrated by Herrick and Johnson (1900).

All of the specimens mentioned above were probably lost in a 1910 fire that destroyed the Hadley Climatological Lab, in which most of the early University of New Mexico fossil collections were stored.

Szabo (1953), in an unpublished master's thesis, reported trilobites from four localities along New Mexico State Highway 14 in Cedro Canyon, south of the town of Tijeras. He described but did not illustrate two species, *Ameura sangamonensis* and *Ditomopyge olsoni*. In his study Szabo designated a "Cedro Canyon Trilobite Section," the name inspired by a black massive limestone with a basal, thin, calcareous shale unit that contained "an abundance of trilobite pygidia and cephalons and occasional complete specimens" (Szabo, 1953, p. 37), all identified as *Ditomopyge olsoni*. This trilobite-rich unit, to be considered in more detail below, is about 15 m above the base of the section, on the west side of New Mexico Highway 14, about 5 km south of Interstate 40, in the NW1/4, sec. 2, T9N, R5E. The locality has long been known to local fossil enthusiasts and was apparently discovered in the early 1940s by UNM geology students (S. A. Northrop, verbal commun., 1981). Szabo (1953) also reported *Ameura sangamonensis* (now considered synonymous with *Ameura missouriensis*) from two other localities near the "Trilobite Section."

## OCCURRENCE AND PRESERVATION

The unit containing the trilobite assemblage at Szabo's "Cedro Canyon Trilobite Section" is a massive, black, cliff-forming limestone that grades progressively into silty black limestones and black to gray-brown calcareous siltstones toward its base. Though a few trilobites are present in the middle and upper parts of the unit, the greatest concentrations are in an approximately 20-cm-thick layer in the least calcareous basal part of the unit. The lateral extent of the trilobite bed is unknown; the samples described in this paper were collected from a restricted exposure of the bed about 5 m long.

The trilobites occur with a diverse assortment of other invertebrates, especially brachiopods, bryozoans, crinoid-stem segments, and solitary rugose corals. Thin layers of shell debris are common. The calcareous skeletal parts of many fossils have been transformed into a soft, light yellow-brown, chalky material, with consequent loss of detail on some specimens. Nearly all of the trilobites were exposed by splitting their silty matrix, which generally produced part and counterpart specimens divided at varying depths through the relatively thick dorsal exoskeleton of the specimens. Though the majority of the nearly 300 trilobite specimens examined are represented by detached pygidia and cephalon elements, complete specimens are not uncommon (Table 1). Several slabs contain numerous complete or nearly complete individuals (figs. 1, 2). Most of the fossils are oriented parallel to bedding planes, but

Table 1. Number and nature of trilobite skeletal parts examined.

complete	40
cephalon only	46
cephalon + thorax	8
pygidium only	126
pygidium + thorax	40
thoracic segments only	22
<b>TOTAL</b>	<b>282</b>

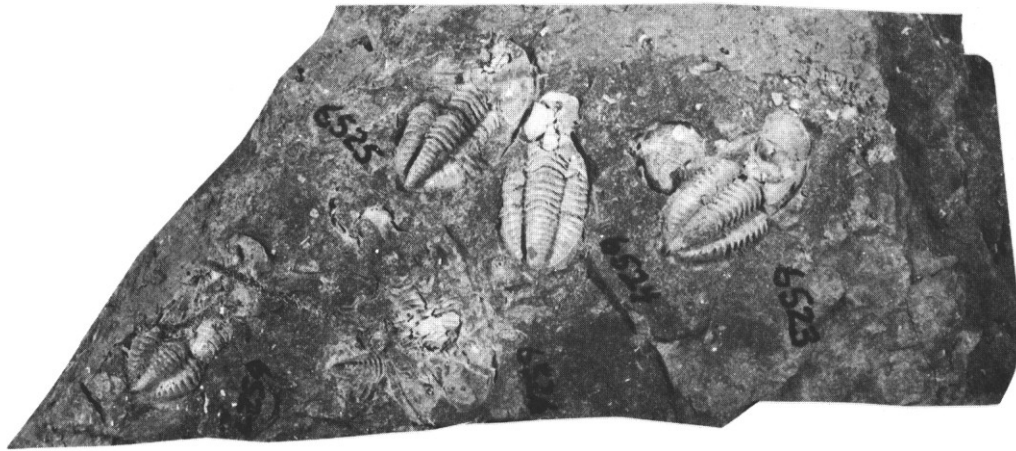


Figure 1. Slab with three complete specimens of *Ditomopyge cf. scitula*, about natural size (UNM 6523–6527).

a few pygidia are inclined at moderate angles to the bedding planes. The relatively high number of more or less complete trilobites and the high density of specimens in the trilobite bed make this locality unique in the Pennsylvanian strata of northern New Mexico.

#### THE TRILOBITES

Szabo (1953) identified these trilobites as *Ditomopyge olsoni*. For several reasons, discussed in a later part of this paper, they are here assigned to *Ditomopyge cf. scitula*. All specimens discussed and illustrated are in the University of New Mexico, Department of Geology paleontology collections.

#### Genus *Ditomopyge*

*Ditomopyge* includes several species of relatively small trilobites that range from Middle Pennsylvanian (Atokan) through Lower Permian (Wolfcampian) strata in North America (Chamberlain, 1969). The genus is characterized primarily by the presence of a rectangular median and two small subtriangular lateral preoccipital lobes on the cephalon, an anteriorly expanded glabella, and a very narrow or absent frontal cephalon border (fig. 3). Two other late Paleozoic trilobite genera found in New Mexico, *Sevillia* and *Anisopyge*, may be confused with *Dito-*

*mopyge. Sevillia*, however, frequently possesses a conspicuous frontal border, and its median preoccipital lobe is ovoid or even nearly circular, rather than rectangular. *Anisopyge*, which probably evolved from *Ditomopyge* in the Early Permian (Pabian and Fagerstrom, 1972, p. 813–814), possesses a narrow to wide frontal border and has more numerous axial segments on the pygidium than does *Ditomopyge*.

#### *Ditomopyge cf. scitula*

#### Description

Complete specimens of *Ditomopyge cf. scitula* from the "Trilobite Section" bed range in length from about 7 to 24 mm (fig. 4). Large isolated pygidia suggest a maximum length for a mature individual of about 30 mm. Typically, the cephalon is slightly longer than the py-

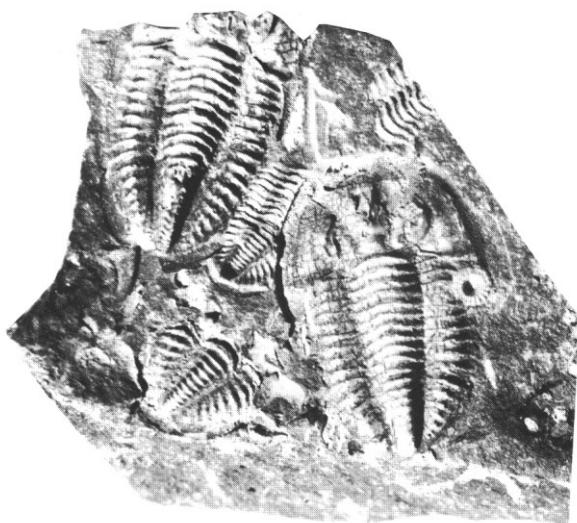


Figure 2. Several specimens of *Ditomopyge cf. scitula*,  $\times 2$  (UNM 6503–6505).

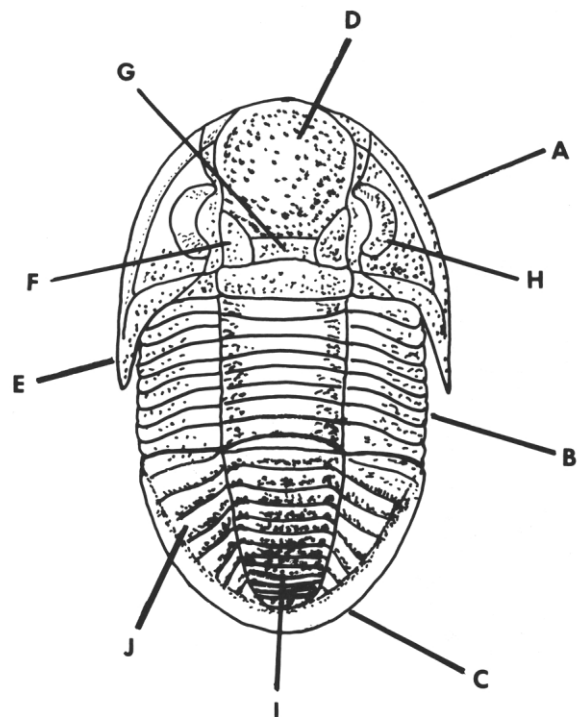


Figure 3. Diagram of *Ditomopyge*, showing main body parts. A—cephalon; B—thorax; C—pygidium; D—glabella; E—genal spine; F—lateral preoccipital lobe; G—median preoccipital lobe; H—eye; I—axial lobe of pygidium; J—pleural lobe of pygidium.

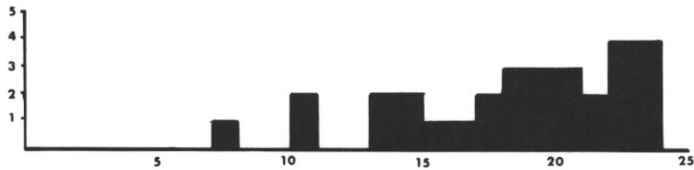


Figure 4. Size distribution of *Ditomopyge cf. scitula* complete specimens. Number of specimens on y-axis; length (in mm) on x-axis.

gidium, which in turn is slightly longer than the thoracic area (fig. 5). The cephalon is devoid of ornamentation; its anterior margin is gently convex, and the genal spines are long, narrow, and extend past the back of the cephalon to about the 6th thoracic segment. The lateral margins of the free cheeks are curved into rounded ridges (fig. 6). The mean cephalon length/width ratio is 0.66, and this proportion did not change significantly with growth. The glabella is swollen and expands anteriorly to almost twice its posterior width; it extends in almost all specimens up to the anterior cephalon margin, leaving no frontal border. The glabella is not divided into subsidiary lobes, but a few specimens have one or two obscure constrictions near the back of the glabella.

The median and lateral preoccipital lobes are prominent. The median lobe is normally rectangular and bound by moderately deep funtows, but in some specimens it is more rounded and is surrounded by relatively deep indentations (fig. 7). The lateral preoccipital lobes are relatively large, vary from subtriangular to nearly ovoid, project anteriorly past the median lobes for about a third of their length, and are inclined away from the axial line of the cephalon toward the inner central margins of the eyes. The gradational variation in the shape of these lobes appears to be related to the degree to which the dorsal cephalon exoskeleton has become exfoliated.

The eyes are large, raised, and arcuate in shape. Their length is 35 to 40 percent of the cephalon length, and they are situated toward the posterior part of the cephalon. The post-eye/pre-eye length ratio (distance from the back of an eye to the posterior margin, relative to the distance from the front of an eye to the anterior margin) is about 0.40 (a ratio of 1.00 would indicate an eye equidistant from the anterior and posterior margins). The eyes are also situated well inward from the lateral cephalon margins, to a distance equivalent to about three-fourths of the pre-eye length. A few very well-preserved specimens show the



Figure 5. Complete specimen of *Ditomopyge cf. scitula*,  $\times 2.5$ , showing proportions of main body parts (UNM 5000).

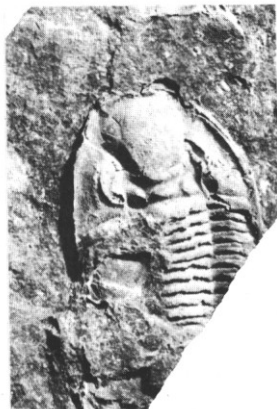


Figure 6. Cephalon of *Ditomopyge cf. scitula*,  $\times 2$ , showing anteriorly expanded glabella and raised free cheek margins (UNM 6502).



Figure 7. Several specimens of *Ditomopyge cf. scitula*,  $\times 1.5$ , showing especially the well-defined lateral and median preoccipital lobes of the cephalon (UNM 6569–6572). hundreds of facets that composed each compound eye.

There are nine thoracic segments in each trilobite. Each segment is smooth and has a sharply rounded ridge at its posterior margin; the 1st thorax has a deep, broad furrow separating the axial from each of the pleural lobes.

The pygidium consists of a central axial region separated by deep furrows from the pleural lobes on each side. Mean pygidium length/width ratio is 0.73; this did not change appreciably with growth. The number of axial segments on mature pygidia varies from 10 to 13 (10 = 15 percent; 11 = 15 percent; 12 = 70 percent; 13 = 8 percent); the number of pleural segments ranges from 6 to 9 (6 = 7 percent; 7 = 54 percent; 8 = 39 percent; 9 = 1 percent). One very small pygidium (1 mm long) has only 8 axial and 4 pleural segments and is less convex around the posterior margin than larger pygidia.

The axial lobes are elevated, strongly arched, slightly flattened on top, and have a sharp even ridge at the posterior margin of each segment which fades abruptly to obscurity on the flanks of the axis. This ridge broadens to form a small but conspicuous, laterally elongate node of the lateral dorsal parts of each axial segment, producing a double row of small nodes along the top of the axial lobe as a whole. These nodes become more conspicuous toward the posterior segments. The pleural lobes are asymmetrically convex, the surface of a lobe rising from the furrow at the axial-pleural boundary to form a broad rounded ridge and descending more abruptly into a broad, concave, striated doubleure that forms the periphery of the pygidium. Each pleural segment has a single large rounded node about at its midpoint, along the sharp ridge that marks the posterior margin of the segment. On a well-preserved pygidium this results in a row of conspicuous nodes in the center of each pleural lobe, about midway between the axial lobe and the lateral margin of the pygidium (figs. 8, 9). On a few specimens there is a hint of two or three additional low obscure nodes between the large node and the axial-pleural furrow. No granules or other fine ornamentation were observed on the surface of the pygidium.

#### Discussion

*Ditomopyge cf. scitula* is most easily recognized by its relatively small size, rather low number of axial segments in the pygidium, and row of nodes on the axial and pleural lobes of the pygidium. *Ameura mis* u, high alcn nornc in thp Madera Fnrmatinn in Cechy.) C Amin?

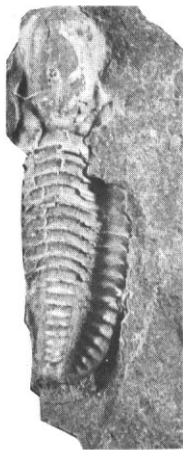


Figure 8. Partial skeleton of *Ditomopyge cf. scitula*,  $\times 2.5$ , showing glabella, and thorax and pygidium ornamentation (UNM 6511).

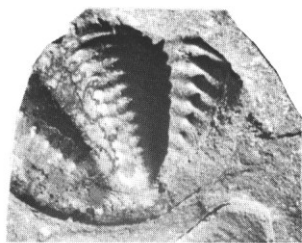


Figure 9. Large pygidium of *Ditomopyge cf. scitula*,  $\times 2.5$ , showing axial and pleural lobe ornamentation and wide marginal doublure (UNM 6580).

(though not in the main trilobite bed), is much larger (more than 50 mm long), has upward of 20 axial segments in the pygidium, and lacks nodes on the pygidium.

Several species of Pennsylvanian *Ditomopyge* are very similar and are probably synonymous. Chamberlain (1969) suggested that *D. parvula* and *D. olsoni* are synonyms of *D. scitula*, and Fabian and Fagerstrom (1972) added *D. lansingensis* to the synonymy, while questioning the status of *D. olsoni*. Meek and Worthen's (1865) original description of *D. scitula* mentioned 11-12 axial and 6 pleural pygidial segments and the presence of a "minute pustule" on each segment of the pleural lobes but made no reference to nodes or pustules on the axial lobe. Fabian and Fagerstrom (1972) examined Missourian and Virgilian examples of *D. scitula* from Nebraska and noted 11-14 axial and 7-11 pleural pygidial segments; several small granules were present on each axial and pleural pygidial segment and also on the thoracic segments and parts of the cephalon. The pygidium length/width ratio on these specimens was 0.75, very close to the 0.73 of the Cedro Canyon specimens.

Williams (1933) established *Ditomopyge olsoni* on the basis of minor differences from *D. scitula*. *Ditomopyge olsoni* was said to lack a prominent median preoccipital lobe and the single row of prominent nodes on the axis of segments of the thorax and pygidium that has been attributed by some authors to *D. scitula* (though these were apparently not present on Meek and Worthen's specimens). *Ditomopyge olsoni* has irregularly arranged granules on the axis and a line of nodes on the segments of the pleural lobes. Because the pygidial axial lobes of Williams' specimens are eroded, the absence of nodes there may not be significant. Also, the pygidia of *D. olsoni* are wider than those of *D. scitula*, having a mean length/width ratio of about 0.67.

Specimens assigned to *Ditomopyge scitula* and its synonyms from several parts of the United States show a modest variation in skeletal, especially pygidial, ornamentation. Because only two specimens of *D. olsoni* have been described, and the type specimens are apparently lost (Chamberlain, 1969), the range of variation in ornamentation, pygidium dimensions, and prominence of the median preoccipital lobe in *D. olsoni*, relative to *D. scitula*, cannot be properly assessed. At this time it is probably best to regard *D. olsoni* as a separate species which may be synonymous with *D. scitula* until more information becomes available.

Though Szabo (1953) identified the trilobites of the "Cedro Canyon Trilobite Section" assemblage as *Ditomopyge olsoni*, they are distinct

from that species in having a double row of small nodes along the axial lobe and a single row of prominent nodes along each pleural lobe of the pygidium, and in possessing a prominent median preoccipital lobe and a narrower pygidium. In most features the Cedro Canyon trilobites resemble *D. scitula*, though they lack granules over the skeleton, and particularly a row of granules on each segment of the axial and pleural lobes of the pygidium. They also possess a double row of elongate nodes on the pygidial axis, a feature not mentioned in the original description of *D. scitula* by Meek and Worthen (1865). Variation in such subtle features may easily be due to the vagaries of preservation or slight differences developed between geographically and/or temporally separated populations. More study of *D. scitula* and related species from a wider range of localities is needed before the importance of such variations at the species level can be properly assessed. The Cedro Canyon specimens are therefore referred to *Ditomopyge cf. scitula*.

The trilobite pygidium, reported as *Phillipsia* sp. n. and illustrated in plate 47, Figure 9 by Herrick and Johnson (1900) from the Desmoinesian of Coyote Springs, has 11 axial segments, a single row of pleural nodes, and a double row of axial nodes. It undoubtedly belongs to the same taxon as the Cedro Canyon specimens discussed above.

#### ASSOCIATED ORGANISMS AND PALEOECOLOGY

The trilobite bed contains a diverse assemblage of marine invertebrates, of which *Ditomopyge cf. scitula* is only one element. During collection of the trilobites, representative samples of the other organisms were also taken, sufficient to establish the major constituents of this assemblage (Table 2). The samples collected are relatively small, and work planned for the future will very likely add to the number of species present in the trilobite bed. Precise identification of many organisms was hindered by the relatively poor preservation of some groups. Brachiopods were generally dorso-ventrally compressed and distorted, and bryozoans were often represented by impressions or by zoaria with only the reverse side exposed. Nevertheless, some preliminary statements can be made about this assemblage and its paleoecology.

Together with the trilobites, brachiopods and bryozoans dominate the assemblage, in terms of number of specimens. Crinoid-stem segments, some quite long, are also abundant; solitary rugose corals are moderately common. Pelecypods are rare and no gastropods were observed. Of the brachiopods, *Desmoinesia* and *Hustedia* together account for about 40 percent of the specimens, and *Fenestella*, represented by at least two species, makes up more than half of the bryozoan specimens.

The nearly complete dominance of stenohaline groups (brachiopods, bryozoans, corals, crinoids, trilobites) suggests a normal marine environment far removed from the effects of freshwater influx, probably many kilometers offshore in moderately deep water. The very low number of molluscs supports this idea, as late Paleozoic molluscs were generally most abundant and diverse in nearshore environments. The presence of many complete fossils, including unbroken fronds of fenestrate bryozoans, delicately branching *Rhombopora* zoaria, long portions of crinoid stems, and generally complete brachiopods, some having their delicate spines still attached, indicates a quiet environment. Occasional gentle currents were responsible for thin and very limited concentrations of broken shell fragments, but there is no indication of significant transportation. The organisms in the assemblage appear to represent elements of a single paleocommunity.

Except for the trilobites, this assemblage was composed almost entirely of epifaunal filter-feeding organisms. These filter-feeders were moderately dense on the sediment surface, which suggests that the sediment was relatively firm and sedimentation rates and turbidity were low. Filter-feeding is hindered in conditions where much sediment is suspended in the water, and mature colonies of bryozoans, for example, would have had difficulty in becoming established and growing to full

Table 2. Fauna of the trilobite assemblage. Relative abundance of each taxon is indicated by A (abundant, 50 or more specimens), C (common, 10–49 specimens), U (uncommon, 3–9 specimens), and R (rare, 1–2 specimens).

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**COELENTERATA**

1 unidentified species of solitary rugose coral—C

**BRYOZOA**

*Fenestella* spp.—A  
*Penniretepora* spp.—C  
*Polypora* sp.—U  
*Septopora* sp.—U  
*Rhombopora* sp.—C  
*Tabulipora?* sp.—C  
 unidentified fenestrate—U

**BRACHIOPODA**

*Lingula carbonaria*—R  
*Orbiculoidea missouriensis*—U  
*O. cf. capuliformis*—R  
*Chonetinella cf. plebeia*—C  
*Mesolobus* sp.—C  
*Derbyia* sp.—U  
*Antiquatonia* sp.—C  
*Canclinella boonensis*—R  
*Desmoinesia cf. missouriensis*—A  
*Linoproductus* sp.—R  
*Pulchratia?* sp.—U  
*Anthracospirifer cf. curvilateralis chavezae*—C  
*Neospirifer* sp.—R  
 unidentified juvenile spiriferid—R  
*Composita subtilita*—C  
*Crurithyris* sp.—C  
*Phricodothyris perplexa*—C  
*Hustedia mormoni*—C  
*Beecheria* sp.—R

**PELECYPODA**

*Acanthopecten* sp.—R  
*Anmuliconcha cf. interlineata*—R  
*Aviculopecten* sp.—R  
*Edmondia* sp.—U

**ARTHROPODA**

*Ditomopyge cf. scitula*—A

**ECHINODERMATA**

unidentified crinoid stems and calyx plates—A

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size in conditions of high sedimentation. The unusually high concentration of trilobites, which fed on detritus and small pieces of organic matter in the sediments and perhaps on the dead remains of other organisms, has been noted earlier. In many late Paleozoic marine shelf environments, gastropods were the main motile epifaunal organisms on muddy or silty substrates, their numbers and diversity far exceeding that of trilobites. Many gastropods were herbivorous, but some probably utilized the same food sources as trilobites. The absence of gastropods in this assemblage may be related to subtle factors that favored trilobites. Perhaps these factors involved an absence of the marine algae utilized

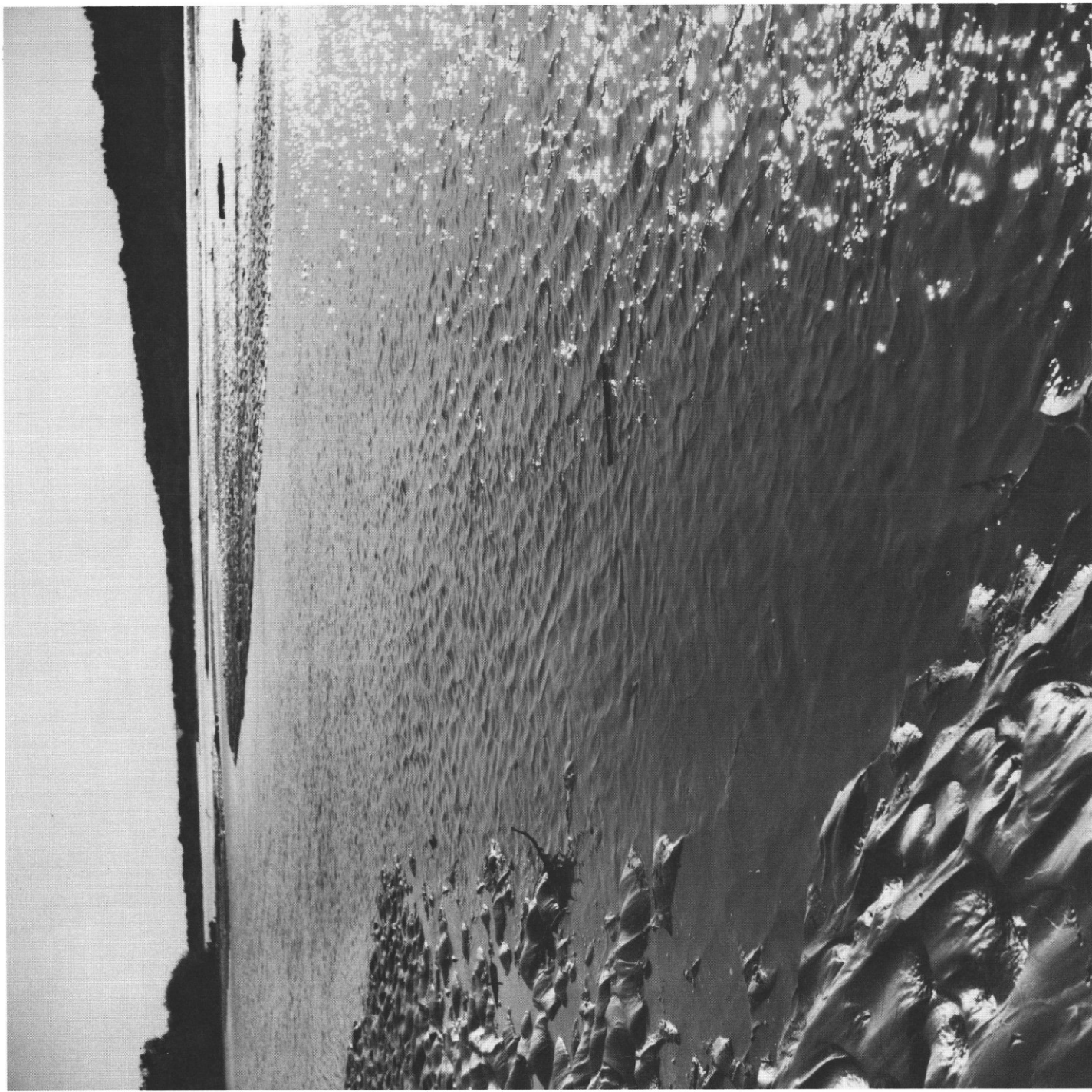
by some gastropods for food because of excessive depth and/or a location farther offshore than was preferred by many late Paleozoic gastropods.

Explaining the large number of trilobites in the assemblage is difficult at the present time. Each trilobite shed its skeleton many times during its life; most trilobite fossils are those of cast-off molts. A high concentration of trilobite skeletons could have resulted from a gradual build-up of molts on the seafloor from a small population of trilobites under conditions of low sedimentation, or from winnowing of scattered molts into a restricted area by currents. However, the good preservation of the trilobites and the relatively high number of complete or nearly complete skeletons having a wide size range argues against any significant concentration by current activity. On the other hand, the presence of numerous trilobites of approximately the same size in close proximity on some bedding planes within the trilobite-rich unit suggests that the local trilobite population was high at any given time. The best explanation for the high concentration in the assemblage may be the local presence of a microhabitat that was unusually favorable for trilobites, perhaps due to conditions that "lured" large numbers of trilobites to a restricted area. The nature of these conditions remains a subject for future study.

The age of this assemblage, as indicated by some of the brachiopods that could be precisely identified, is early to middle Desmoinesian (Middle Pennsylvanian), which accords with Szabo's (1953) observations, and with the conclusions of Myers and McKay (1976) who mapped the strata of the trilobite locality as part of the Desmoinesian Los Moyos Formation of the Madera Group.

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*Rio Grande from Corrales Bridge (J. F. Callender photo).*