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The Faunas of the Riley Formation in Central Texas

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THE FAUNAS OF THE RILEY FORMATION IN CENTRAL TEXAS[1]

ALLISON R. PALMER
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ABSTRACT—Sixty-eight species of trilobites, 10 species of inarticulate brachiopods, two species of articulate brachiopods, one ostracode and fragments of sponges, pelmatozoan echinoderms and unidentifiable organisms constitute the faunas of the Riley formation. The fossils were collected from eight measured sections around the periphery of the outcrop area in Mason, Gillespie, Blanco, Burnet, Llano and San Saba counties, Texas. All of the fossils are described and illustrated by stereophotographs. Two families, four genera and 16 species of trilobites, and three genera and five species of brachiopods are described as new. These are: Coosellidae, Tricrepicephalidae, *Crepicephalus australis, C.? perplexus, Cedaria eurycheilos, Arcuolimbus convexus* (genotype), *Bolaspidella prooculis, Aphelaspis constricta, A. longifrons, A. spinosus, Blandicephalus texanus* (genotype), *Dytremacepkalus granulosus* (genotype), *D. laevis, Labiostria conveximarginata* (genotype), *L. platifrons, L. sigmoidalis, Cheilocephalus minutus, Dunderbergia variagranula, Angulotreta triangularis* (genotype), *A. postapicalis, Apsotreta expansa* (genotype), *A. orifera, Opisthotreta depressa* (genotype). Most of the fossils are early Late Cambrian in age although some from the lower part of the formation may be latest Middle Cambrian in age. Six trilobite zones are recognized. These are, from oldest to youngest: *Bolaspidella, Cedarina-Cedaria, Coosella, Maryvillia, Aphelaspis and* post-*Aphelaspis.* Inarticulate brachiopods, sponge spicules and problematica obtained from residues of limestone digested in acetic or formic acid characterize zones whose boundaries are to some extent independent of those of the trilobite zones. The boundaries of the zones and the boundaries of the members and sub-members of the Riley formation do not coincide.

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[1] Publication authorized by the Director, U. S. Geological Survey, and Director, Bureau of Economic Geology, The University of Texas.

LIST OF ILLUSTRATIONS, TEXT FIGURES, AND TABLES

INTRODUCTION

THE Riley formation is the oldest sedimentary formation of Paleozoic age in central Texas. It contains the remains of at least 68 species of trilobites, 10 species of inarticulate brachiopods, 2 species of articulate brachiopods, 1 ostracode species, and fragments of sponges, pelmatozoan echinoderms, and unidentifiable organisms. The bulk of the fossil material is Dresbachian* (early Late Cambrian) in age, but some of the fossils in collections from the lower part of the formation may be late Middle Cambrian in age.

Previous work on the fauna of the Riley

* The terms Dresbachian and Franconian have not been approved by the Geologic Names Committee, U. S. Geological Survey.

formation has been meager and mostly of a reconnaissance nature. Shumard (1861), Walcott (1890), and Bridge (1934, 1937) described some Upper Cambrian fossils from Texas, including a few from the Riley formation. Lochman (1938) made a preliminary study of the fossils from the Riley formation, recognized the presence of the *Cedaria, Crepicephalus,* and *Aphelaspis* faunas, noted that the faunas cut across lithologic boundaries, and described some of the trilobites.

Most of the fossils described in this paper were collected from eight measured sections located around the periphery of the outcrop area of the Riley formation (fig. 1). Collections from the James River (JR), Little Llano (LL), Morgan Creek (MC), Pontotoc (P), Streeter (S), Threadgill Creek (TC), and White Creek (WC) were made by the writer in 1947 and 1948. Those from the Lion Mountain (LM) section were made by Josiah Bridge and C. L. Dake in the 1930's. Other material studied came from collections by V. E. Barnes, W. C. Bell, and J. L. Wilson made since 1940. The U. S. Geological Survey collections of Bridge and Dake are housed in the U. S. National Museum.

ACKNOWLEDGMENTS

Field work for this project was carried out while the writer was a member of the staff of the Bureau of Economic Geology, The University of Texas. Dr. Virgil E. Barnes, geologist at the Bureau, supervised the project and located and measured the sections from which the fossils were collected. A doctoral dissertation by the writer, discussing the faunas of the Riley formation, was prepared under the guidance of Prof. W. Charles Bell, of the Department of Geology at the University of Minnesota, during 1948–1950. The Shell Oil Fellowship in Geology supplied living and laboratory expenses for that period. Revision of the dissertation to its present form was made under the auspices of the U. S. Geological Survey in Washington, D. C. The photographic illustrations are by N. W. Shupe of the U. S. Geological Survey.

STRATIGRAPHY

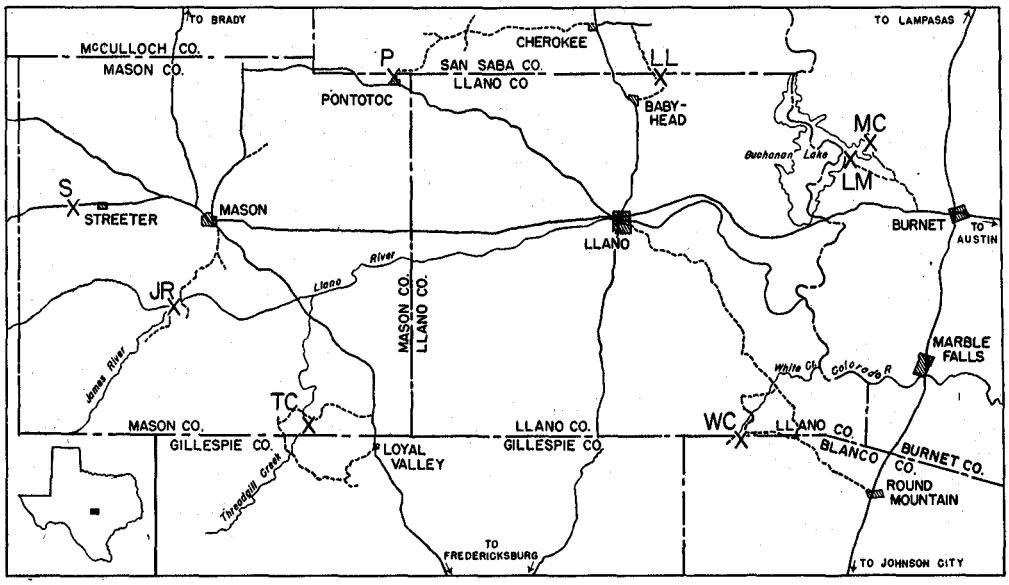
The Riley formation has been defined by Bridge, Barnes, and Cloud (1947, p. 112) as "all of the Cambrian strata in central Texas beneath the Wilberns formation. It includes, from base to top, rocks formerly known as the Hickory sandstone, the Cap Mountain formation, and the Lion Mountain sandstone member of the Cap Mountain formation. The contacts of these three units intergrade laterally, crossing faunal zones. For this reason they are here considered to be members of a single formation and are designated the Hickory sandstone, the Cap Mountain limestone, and the Lion Mountain sandstone members of the Riley formation. ..." The boundaries of all of the divisions of the formation are subject to interpretation, and "would not be picked at the same place by different people ... or by the same person on different days" (Barnes, personal communication, 1950).

Figure 1 shows the location of measured sections of the Riley formation in central Texas from which the fossils here described were principally obtained.

The Hickory sandstone member is a noncalcareous, nonglauconitic sandstone unit consisting of buff coarse sand at the base grading upward into buff to maroon fine sand at the top. The average thickness is 360 feet. The thickness of the member is variable because of the irregular surface on which the basal sands were deposited and because of the lateral gradation with the Cap Mountain limestone member at the top. The maroon color of the upper part of the Hickory sandstone member in many areas continues into the lower portion of the Cap Mountain limestone member, so that a "red zone" often straddles the Hickory sandstone member and Cap Mountain limestone member boundary.

The Cap Mountain limestone member consists of brown to gray, fine to medium granular, glauconitic and occasionally oolitic sandy or silty limestone aggregating about 280 feet in thickness. In the Morgan Creek (MC), White Creek (WC), James River (JR), and Threadgill Creek (TC) sections, shown in figure 1, it can be subdivided into a lower limestone unit, a middle siltstone and silty limestone unit, and an upper limestone unit. This subdivision becomes less distinct to the north and west; in the Streeter (S), Pontotoc (P), and Little Llano (LL) sections the whole member is quite silty, particularly in the lower portion (fig. 3).

The Lion Mountain sandstone member, which has a maximum thickness of 50 feet,



MAP OF CENTRAL TEXAS SHOWING LOCATION OF MEASURED SECTIONS OF THE RILEY FORMATION
JR-JAMES RIVER LL-LITTLE LLANO LM-LION MOUNTAIN MC-MORGAN CREEK P-PONTOTOC
S-STREETER TC-THREADGILL CREEK WC-WHITE CREEK

FIG. *1*

is a highly glauconitic sandstone containing in the lower part numerous tangential lenses of limestone composed essentially of trilobite remains. The size of the sand grains increases upward, but at the top this unit usually has a zone of glauconite or glauconitic shale several feet thick. In the west the contact with the overlying nonglauconitic Welge sandstone member of the Wilberns formation is abrupt. In the White Creek and Morgan Creek sections, however, the contact appears to be gradational.

FAUNAL ZONATION

The Dresbachian faunal sequence in the United States has been divided classically into three zones designated in ascending order the *Cedaria, Crepicephalus,* and *Aphelaspis* zones. At the type area in Minnesota and Wisconsin these zones are clearly defined. In central Texas the *Cedaria* and *Crepicephalus* faunas merge into each other. According to Lochman and Duncan (1944, pp. 33, 34) this is true also in central Montana. In Texas, the *Aphelaspis* fauna merges with the superjacent *Elvinia* fauna of the Franconian stage. The only distinct zone boundary still recognizable in all areas studied to date is at the base of the *Aphelaspis* zone.

Lochman and Duncan (1944) used the *Cedaria-Crepicephalus* zonal names in Montana even though many of their collections lacked definitive zonal guides and were arbitrarily assigned to one zone or the other on the basis of "faunal affinity." The *Cedaria, Crepicephalus,* and *Aphelaspis* zones are recognized here as "stratigraphic generalizations" that lack definition in most areas outside of the Upper Mississippi Valley. The writer believes that, as generalizations, they are useful for regional stratigraphic correlation. For detailed stratigraphic paleontology in a small geographic area, however, a sequence of distinctive local faunal assemblages that aid correlation within the area is considered a necessity. The name applied to each of these faunal assemblages should be, wherever possible, the name of a common and characteristic genus of the assemblage.

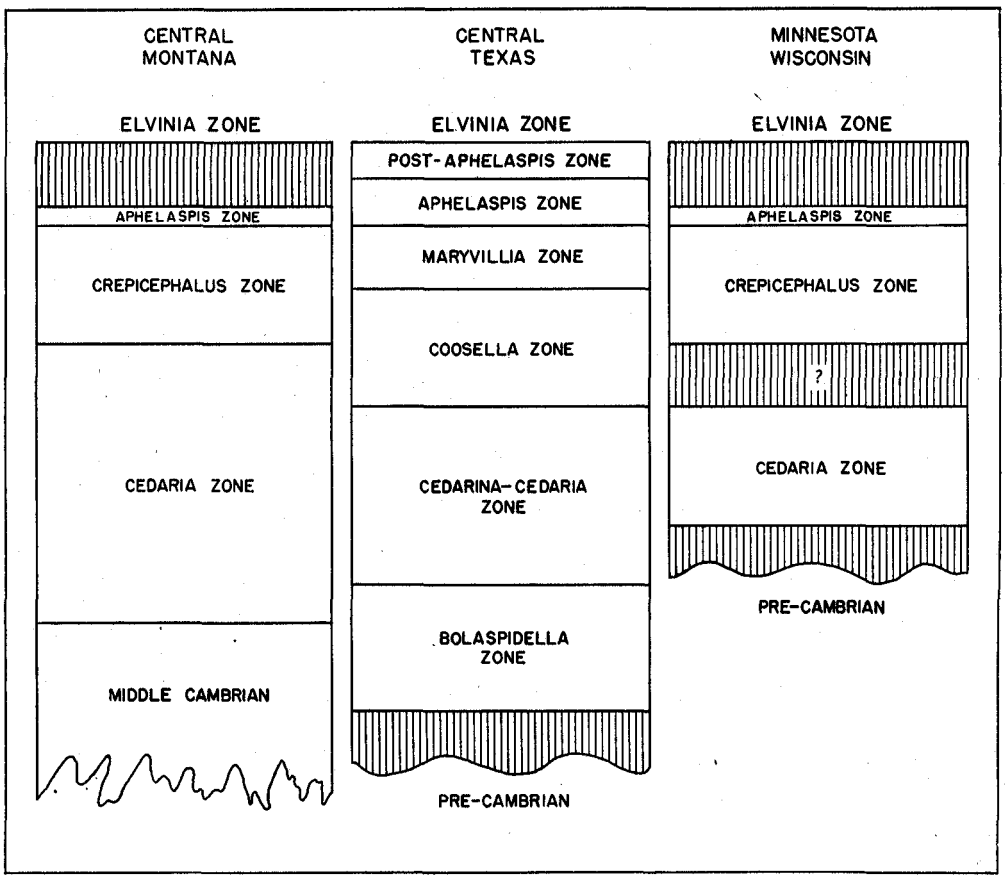


FIG. 2—Correlation of the trilobite zones of the Riley formation with those recognized in the type Dresbachian section in Minnesota and Wisconsin, and in central Montana.

In central Texas, the pre-*Aphelaspis* faunas can be conveniently divided into four zonal assemblages designated in ascending order the *Bolaspidella, Cedarina-Cedaria, Coosella,* and *Maryvillia* assemblages. All but three of the 31 identifiable trilobite genera from this part of the sequence are found also in the Pilgrim limestone in Montana, but the stratigraphic ranges of the genera in Texas are not the same as those in Montana. Therefore, although fairly accurate correlations can be made (fig. 2), the faunal divisions recognized by Lochman and Duncan cannot be applied for practical purposes to the faunal sequence in the Riley formation.

Evidence for the hiatus and consequent disconformity between the *Cedaria* and *Crepicephalus* zones in the upper Mississippi Valley (fig. 2) is shown in Wisconsin, particularly at Colfax and Eau Claire, where the uppermost bed containing a *Cedaria* assemblage is immediately overlain by a bed containing a *Crepicephalus* assemblage without the faunal gradation apparent in Texas and Montana. Indication of a temporary change in conditions of sedimentation at that time in some other parts of the continent is shown in central Texas and southeastern Arizona. The "silty zone" of the Cap Mountain limestone member of the Riley formation (fig. 3) and a sandy unit in the Abrigo limestone in southeastern Arizona are at the approximate horizon of the inferred disconformity.

The Dresbachian fauna above the base of the *Aphelaspis* zone in central Texas has a

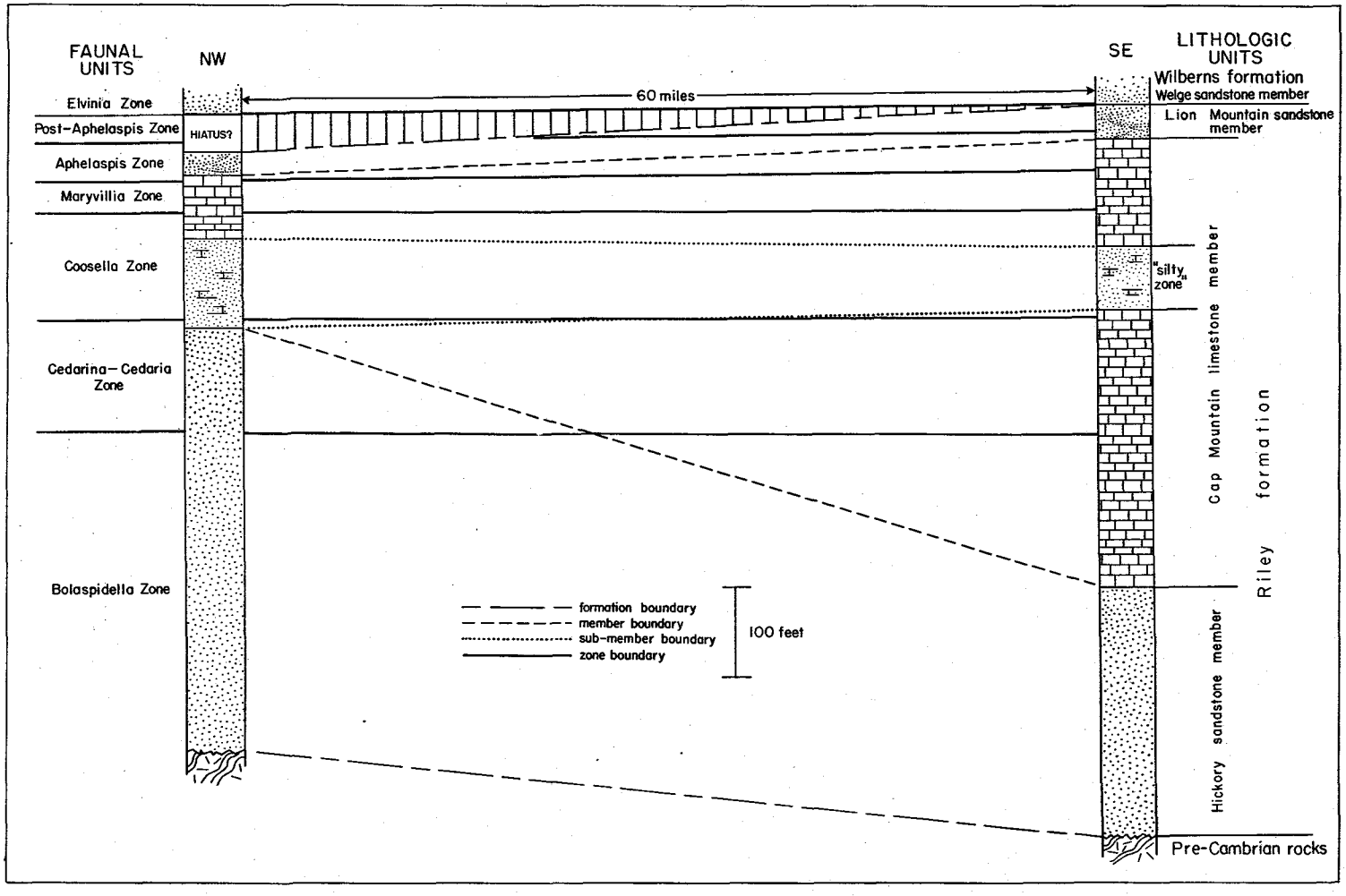


FIG. 3—Faunal and lithic relationships within the Riley formation.

greater development than that reported anywhere else in the United States. Two trilobite assemblages can be recognized in this part of the sequence. The lower, the *Aphelaspis* assemblage, is a well known continent-wide guide to rocks of late Dresbachian age. The upper, here designated the post-*Aphelaspis* assemblage, has not previously been recognized. It contains some genera that range up from the *Aphelaspis* zone and others that appear first at this horizon and continue upward into the *Elvinia* zone. No one genus is characteristic of the assemblage.

DISCUSSION OF THE FAUNAS

The stratigraphic relationships between the faunal zones and the lithic members of the Riley formation are shown on figure 3.

Representatives of the *Bolaspidella* zone have been found in the Hickory sandstone member in the Little Llano (LL), Morgan Creek (MC), Pontotoc (P), Streeter (S), White Creek (WC), and Threadgill Creek (TC) sections (fig. 1). In the White Creek section, they have been found also in the basal portion of the Cap Mountain limestone member. Although seven species from five genera made up the assemblage, species of *Bolaspidella* are the dominant elements both in numbers and in geographic distribution. Some or all of the fauna of this zone may be late Middle Cambrian in age. Until more information concerning the faunal associations at the top of the Middle Cambrian is available, accurate determination of the boundary between Middle and Upper Cambrian series in central Texas cannot be made. This zone correlates in part with the lower *Cedaria* subzone of Lochman and Duncan.

Representatives of the *Cedarina-Cedaria* zone have been found in the upper part of the Hickory sandstone member or the lower limy portion of the Cap Mountain limestone member in all of the measured sections. The zone is characterized throughout most of its extent by *Cedarina cordillerae* (Howell and Duncan). The upper portion is marked by the presence of *Cedaria eurycheilos* Palmer, n. sp., *Syspacheilus* cf. *S. camurus* Lochman, and *Meteoraspis* cf. *M. robusta* Lochman. This zone corresponds approximately to the middle *Cedaria* subzone of Lochman and Duncan. *Arapahoia,* a common diagnostic genus for this part of the faunal sequence in western United States has not been found in central Texas.

Representatives of the *Coosella* zone have been found principally in the silty and upper limy portions of the Cap Mountain limestone member in all of the measured sections. This zone is marked by the abundance of several species of *Coosella,* and *Meteoraspis metra* (Walcott). *Coosia connata* (Walcott), *Tricrepicephalus texanus* (Shumard), and *Arcuolimbus convexus* Palmer, n. gen., n. sp., are distinctive forms in the lower part of the zone. *Crepicephalus australis* Palmer, n. sp., and *Llanoaspis modesta* Lochman are distinctive of the upper part of the zone. This zone corresponds approximately to the upper *Cedaria* subzone and the lower part of the *Crepicephalus* zone of Lochman and Duncan.

Representatives of the *Maryvillia* zone have been found in the upper limy portion of the Cap Mountain limestone member in all of the measured sections. The zone is characterized by *Maryvillia* cf. *M. ariston* Walcott, and *Coosia* cf. *C. albertensis* Resser. *Llanoaspis undulata* Lochman is distinctive of the lower part of the zone, and *Llanoaspis peculiaris* (Resser) is distinctive of the upper part of the zone. It corresponds to the upper part of the *Crepicephalus* zone of Lochman and Duncan.

Representatives of the *Aphelaspis* zone have been found in the upper limy portions of the Cap Mountain limestone member and/or calcareous lenses in the Lion Mountain sandstone member in all of the measured sections. This zone is characterized by abundant individuals of several species of *Aphelaspis*—particularly *A. walcotti* Resser. *Raaschella ornata* Lochman is distinctive of the lower portion of the zone. This fossiliferous zone appears suddenly and succeeds the relatively unfossiliferous beds of the *Maryvillia* zone. It is not accompanied by a marked lithologic change.

Representatives of the post-*Aphelaspis* trilobite assemblage have been found in the upper portions of the Lion Mountain sandstone member in the James River, Lion Mountain, Morgan Creek, Threadgill Creek, and White Creek sections. This assemblage is characterized particularly by *Dytremace-*

phalus granulosus Palmer, n. gen., n. sp., and the lack of specimens of any species of *Aphelaspis*. The geographic distribution of the sections in which this assemblage is present suggests either that the contact of the Riley and Wilberns formations represents a sharp lithofacies change that is older in the west than in the east, or that a disconformity whose faunal hiatus decreases in magnitude in a southeasterly direction exists between the two formations.

Inarticulate brachiopods of several types are found in insoluble residues from limestones in the Riley formation obtained by etching with acetic or formic acid. They are not found in residues of these same limestones prepared using hydrochloric acid. *Opisthotreta depressa* Palmer, n. gen., n. sp., is characteristic of residues from limestones in the *Coosella* and *Maryvillia* zones. Beginning at the base of the *Aphelaspis* zone, the inarticulate brachiopods can be divided roughly into three zonal assemblages designated here as the *Dictyonina perforata, Angulotreta triangularis,* and *Apostreta expansa* assemblages.

The *Dictyonina perforata* assemblage is unique in that its constituents are commonly fragmental. Very few complete or even nearly complete specimens are present in insoluble residues of rocks from the base of the *Aphelaspis* zone in southeastern Arizona, Wyoming, Montana, Tennessee, and Texas. The upper few feet of its range in the Riley formation corresponds to the lower part of the range of *Angulotreta triangularis* Palmer, n. gen., n. sp., but in the lower seven feet of beds in the *Aphelaspis* zone it is the principal diagnostic inarticulate brachiopod.

The *Angulotreta triangularis* zone contains great numbers of individuals of this species. Distinctive minor constituents are fragments of a species of *Micromitra* and *Angulotreta triangularis digitalis* Palmer, n. var.

The *Apsotreta expansa* zone is marked by an abundance of *A. expansa* Palmer, n. gen., n. sp., to the exclusion of nearly everything else except linguloids.

Primitive orthoid brachiopods questionably assigned to *Diraphora* are rare constituents of the *Coosella* and *Maryvillia* faunas.

Spicules of several types are moderately common in acetic and formic acid residues from many parts of the formation. Spicule type B, called *Chancelloria* by Walcott (1920), often accompanied by the simple symmetrical hexactinellid spicules, anchor-shaped spicules, and asymmetrical hexactinellid spicules of spicule type A, is distinctive of the *pre-Aphelaspis* part of the section. Small symmetrical hexactinellid spicules, spicule type C, are characteristic of the *Dictyonina perforata* assemblage.

Small organic objects called *Kinsabia* by Lochman (1940a) are common in acetic and formic acid residues of limestone collections in and adjacent to the silty portion of the Cap Mountain limestone member. They are found principally in the upper portion of the *Cedarina-Cedaria* zone and the *Coosella* zone.

Fragments of pelmatozoan echinoderms are found in nearly all acetic and formic acid residues of limestone of the Riley formation. They do not provide any useful stratigraphic information at this time.

Ostracode? fragments were recovered

EXPLANATION OF PLATE 76

AGNOSTIDAE

FIGS. *1–3—Pseudagnostus communis* (Hall and Whitfield), ×4. *1,* exfoliated cephalon, UT-32205, TC-807; *2,* exfoliated pygidium, USNM 123309, USGS coll. 10 (CO); *3,* pygidium, UT-32169, TC-821; *Aphelaspis* zone. (p. 720)

4, 6—Geragnostus cf. *G. tumidosus* (Hall and Whitfield), ×6. *4,* cephalon, UT-32130, LL-599; *6,* pygidium, UT-32131, TC-807; *Aphelaspis* zone. (p. 719)

5, *7—Pseudagnostus? nordicus* (Lochman). 5, cephalon ×8, UT-32085, TC-656; *7,* pygidium ×5, UT-32086, WC-628; *Coosella* zone. (p. 721)

8–12—Kormagnostus simplex Resser, ×5. *8,* cephalon, UT-32137, MC-446; *9, 10, 12,* pygidia showing variation within species, UT-32138, MC-419; UT-32140, TC-656; UT-32139, MC-419; *Coosella* zone. *11,* internal mold of cephalon, UT-32136, TC-362; *Cedarina-Cedaria* zone. (p. 718)

13–14—Baltagnostus cf. *B. centerensis* (Resser), ×6. *13,* internal mold of cephalon, UT-32087, 16T-6-20A; *14,* internal mold of pygidium, UT-32088, 16T-6-20A; *Bolaspidella* zone. (p. 718)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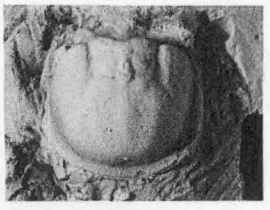
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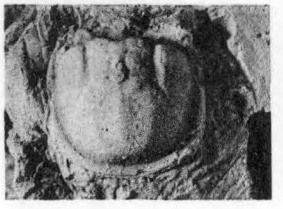


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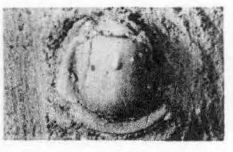


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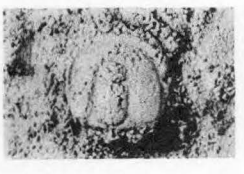
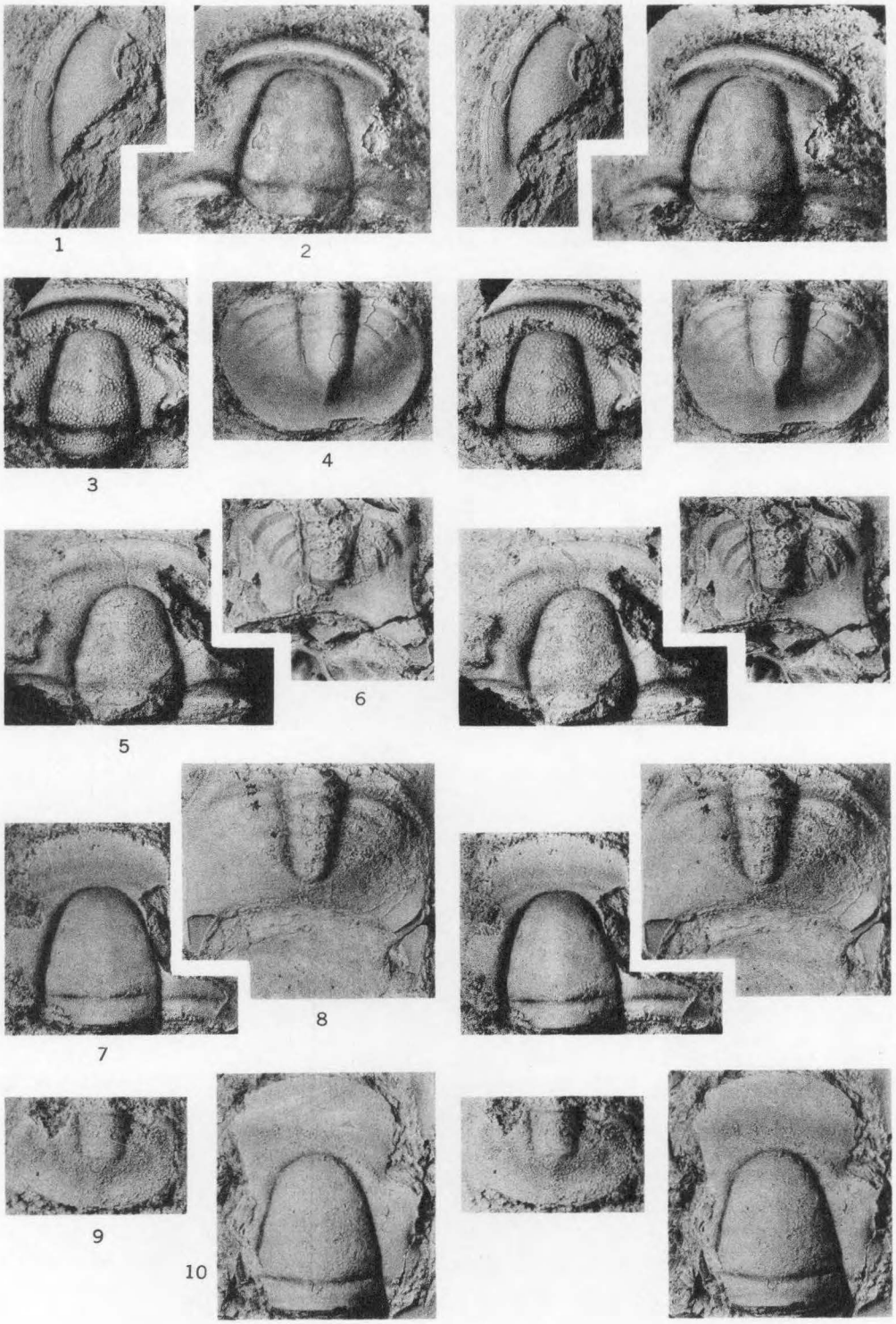


Palmer, Cambrian faunas from Texas



Palmer, Cambrian faunas from Texas

from several acetic acid residues of collections from the *Aphelaspis* zone. They are principally of academic interest and have little stratigraphic value.

PALEOECOLOGY

Marine paleoecology of the early part of the Late Cambrian has been discussed in considerable detail by Lochman (1949, pp. 31-71). The study of the faunas of the Riley formation has not produced any additional information.

SYSTEMATIC PALEONTOLOGY

Specimens with museum numbers preceded by UT are in the collections of the University of Texas. Those with museum numbers preceded by USNM are in the collections of the United States National Museum. The letters JR, LL, MC, P, S, TC, or WC are abbreviations referring to the James River, Little Llano, Morgan Creek, Pontotoc, Streeter, Threadgill Creek, and White Creek measured sections, respectively. They are followed by a number giving the distance in feet of the collection above the base of the section.

U. S. Geological Survey collection numbers followed by (OS) refer to an old series of numbers. U. S. Geological Survey collection numbers followed by (CO) refer to collections of early Paleozoic age catalogued under a later system of numbering. These numbers are marked on the specimens.

The stratigraphic ranges of all of the fossils of the Riley formation described in this report are given in Table III (Appendix). Measurements, unless otherwise indicated, are to the nearest 0.5 mm.

I. TRILOBITA

Remains of at least 68 species of trilobites representing 42 genera have been found in the Riley formation. Sixteen of the species and four of the genera are new. Formal descriptions are given only for new genera and new species and for inadequately defined or incompletely understood genera and species that are represented in Texas by better or more complete material.

Wherever possible, genera are assigned to established families and subfamilies. The descriptions are arranged alphabetically by family, and alphabetically by genus within a family. Descriptions of the collecting localities are given in the appendix.

The known geographic distribution of the genera reported from the Riley formation is given in Table I (Appendix).

The terminology proposed by Howell et al. (1947) is used here with one exception: Axial lobe is substituted for axis to denote the median longitudinal division of the trilobite on the thorax and pygidium. Frontal area (Nelson, 1951, p. 771) refers to that portion of the cranidium between the front of the glabella and the anterior margin.

Possible examples of sexual dimorphism are suggested for *Aphelaspis spinosus* Palmer, n. sp., *Cedarina cordillerae* (Howell and Duncan), *Cedaria eurycheilos* Palmer, n. sp., *Protillaenus* spp., and members of the Coosellidae Palmer, n. fam. The implications of dimorphism are important in the taxonomy of these trilobites. Although there is no way of proving the existence of dimorphic forms, such a consideration is entirely possible. Evidence concerning this phenomenon should be looked for by other workers.

EXPLANATION OF PLATE 77

COOSELLIDAE

FIGS. *1, 2, 4—Crepicephalus? perplexus* Palmer, n. sp. *1,* free cheek ×4, UT-32121, MC-529; *2,* holotype cranidium ×4, UT-32119, MC-529; *4,* pygidium ×3, UT-32120, MG-529; basal bed of *Aphelaspis* zone. (p. 733)

3, 6—Crepicephalus cf. *C. iowensis* (Owen). *3,* cranidium ×4, UT-32117, MC-516; *6,* exfoliated pygidium ×2, UT-32118, MC-516; *Maryvillia* zone. (p. 732)

5, 8—Crepicephalus australis Palmer, n. sp., ×2. *5,* holotype exfoliated cranidium, UT-32115, JR-201; *8,* exfoliated pygidium, UT-32116, JR-201; *Maryvillia* zone. (p. 732)

7, 9, 10—Coosia cf *C. albertensis* Resser. *7,* exfoliated cranidium ×4, UT-32112, JR-201; *9,* exfoliated pygidium ×4, UT-32113, P-602; *10,* cranidium ×2, USNM 123310, USGS coll. 6 (CO); *Maryvillia zone.* (p. 731)

Family AGNOSTIDAE M'Coy, 1849
Subfamily PERONOPSINAE Westergard, 1936
Genus BALTAGNOSTUS Lochman, 1944

Baltagnostus LOCHMAN, 1944, p. 138.

Genotype.—Proagnostus? centerensis Resser, 1938a, p. 48.

Diagnosis.—Cephalon with bilobed glabella and no median longitudinal preglabellar furrow; basal glabellar lobes present. Pygidium with axial lobe well defined, long, broad, nearly parallel sided, rounded posteriorly reaching to or nearly to the marginal furrow. The border of the pygidium bears a pair of small marginal spines approximately opposite the posterior end of the axial lobe. Between the spines, the border is marked by a straight transverse ridge behind which the margin is distinctly downsloping.

Discussion.—Lochman (1944, p. 138) established this genus for the late Middle Cambrian species *Proagnostus? centerensis* Resser from the Conasauga shale in Alabama. She included in it another Middle Cambrian species, *Proagnostus maryvillensis* Resser from shales correlated by Resser with the Maryville limestone in Tennessee, and a new species, *Baltagnostus beltensis* Lochman, from the Upper Cambrian *Cedaria* zone in the Pilgrim limestone in Montana.

The writer has examined the types of all of these species.

The flattened shale specimens of *B. centerensis* (Resser) and *B. maryvillensis* (Resser) are poorly preserved and inadequate for the determination of valid specific characteristics. Better material may show that they are conspecific.

B. beltensis Lochman is represented by fragmentary material. The small figured cephalon could be an immature kormagnostid. The holotype pygidium does not have the characteristic border features of this genus and is certainly congeneric if not conspecific with *Kormagnostus simplex* Resser.

The occurrence in the Riley formation of a species assignable to *Baltagnostus* suggests that the horizon from which it was obtained may be late Middle Cambrian in age.

BALTAGNOSTUS cf. B. CENTERENSIS (Resser)
Plate 76, figures 13, 14

Proagnostus? centerensis RESSER, 1938a, p. 48, pl. 10, fig. 18.

Baltagnostus centerensis (Resser) LOCHMAN and DUNCAN, 1944, p. 138.

The specimens from the Riley formation have all of the characteristic features of this genus. They do not appear to differ significantly from *B. centerensis* (Resser). However, they are not well enough preserved for adequate comparison with that species.

Figured specimens.—

	Length
Cephalon, UT-32087, from 16T-6-20A	2 mm.
Pygidium, UT-32088, from 16T-6-20A	2 mm.

Occurrence.—Moderately common, *Bolaspidella* zone. Specimens were collected at locality 16T-6-20A.

Genus KORMAGNOSTUS Resser, 1938

Kormagnostus RESSER, 1938a, p. 49; LOCHMAN, 1940a, p. 24; SHIMER and SHROCK, 1944, p. 600.

Genotype.—Kormagnostus simplex Resser, 1938a, p. 49.

Diagnosis.—Cephalon with anterior lobe of glabella completely or nearly completely effaced; basal glabellar lobes present. Pygidium with broad, elongate, well defined axial lobe that is bluntly rounded posteriorly and extends to or nearly to the marginal furrow. Posterolateral marginal spines are usually present.

KORMAGNOSTUS SIMPLEX Resser
Plate 76, figures 8-12

Kormagnostus simplex RESSER, 1938a, p. 49, pl. 9, figs. 11–13; SHIMER and SHROCK, 1944, pl. 251, figs. 25–27; RASETTI, 1946, p. 444, pl. 69; figs. 32-34.

Kormagnostus harlanensis RESSER, 1938a, p. 49, pl. 10, figs. 11, 12.

Kormagnostus esterius LOCHMAN, 1940a, p. 24, pl. 2, figs. 32–35; LOCHMAN and DUNCAN, 1944, p. 77, pl. 5, figs. 14–16; LOCHMAN, 1950, p. 348, pl. 51, figs. 6–9.

Kormagnostus splendens LOCHMAN, 1940a, p. 25, pl. 2, figs. 23–31.

Diagnosis.—Cephalon moderately to strongly arched transversely and longitudinally, slightly expanded anteriorly. Posterior lobe of glabella prominent, well defined, and truncated anteriorly; anterior lobe not outlined by dorsal furrow but may be represented by low, poorly defined elevation. Border expands slightly forward, is separated from cheeks by broad, shallow marginal furrow.

Pygidium moderately to strongly arched

transversely and longitudinally, bears a pair of small marginal spines approximately opposite the posterior end of the axial lobe. Axial lobe broad, well defined, parallel-sided, or slightly expanded backward and rounded posteriorly, reaching to or nearly to marginal furrow, two anterior segments poorly defined, second segment bears low median node. Border separated from pleural platforms and end of axial lobe by broad, shallow marginal furrow.

Discussion.—The writer's collections contain many specimens of this species from horizons in the lower half of the Riley formation. Although the number of individuals at any one horizon is small, enough specimens are available to indicate that there is complete intergradation between the features used by Resser and by Lochman for the definition of several of their species. The hypodigm of *K. simplex* Resser, as characterized by specimens from the Riley formation, includes *K. esterius* Lochman, *K. splendens* Lochman, and *K. harlanensis* Resser.

Figured specimens.—

	Length
Cephalon, UT-32136, from TC-362	3 mm.
Cephalon, UT-32137, from MC-446	2.5 mm.
Pygidium, UT-32138, from TC-656	3 mm.
Pygidium, UT-32139, from MC-419	3.5 mm.
Pygidium, UT-32140, from MC-419	2 mm.

Occurrence.—Moderately common, *Bolaspidella, Cedarina-Cedaria,* and *Coosella* zones. Specimens have been obtained from measured sections at: JR-42, 120, 132; LL-450; MC-299, 419, 446, 453, 464, 485; P-395, 425; S-105; TC-323, 330, 345, 348, 362, 429 505, 515, 656, 660; WC-460, 655; U.S.G.S. coll. 4 (CO).

Subfamily GERAGNOSTINAE Howell, 1935

Genus GERAGNOSTUS Howell, 1935

Geragnostus HOWELL, 1935, p. 231; SHAW, 1951, pp. 110, 111.

Genotype.—*Agnostus sidenbladhi* Linnarsson, 1868, p. 82, pl. 2, figs. 60, 61.

Diagnosis.—Cephalon with bilobed glabella and no median longitudinal preglabellar furrow; basal glabellar lobes present. Pygidium with short, prominent, distinctly defined, nearly parallel-sided axial lobe that is rounded posteriorly and does not reach to the marginal furrow. Posterolateral marginal spines are usually present.

GERAGNOSTUS cf. G. TUMIDOSUS (Hall and Whitfield)

Plate 76, figures 4, 6

Agnostus tumidosus HALL and WHITFIELD, 1877, p. 231, pl. 1, fig. 32.

Two cephala and a pygidium seem referable to this species. The cephala have a distinct frontal lobe on the glabella and a faint suggestion of a median depression for a short distance in front of the glabella.

The pygidium has a short axial lobe that does not reach to the marginal furrow, two pairs of deep furrows present only on the sides of the axial lobe, a median axial node, and short posterolateral spines.

Kobayashi (1939, p. 162) referred *Agnostus tumidosus* H & W, from the Dunderberg formation at Eureka, Nevada, to *Homagnostus.* The type specimen, a cephalon, does not have the shallow median longitudinal furrow given as a characteristic of *Homagnostus.* It agrees in all features with cephala assigned to *Geragnostus.* Associated pygidia differ from others assigned to the genus only in having a relatively longer axial lobe.

The Texas specimens are nearly identical to those from Nevada. The only differences are the slightly longer glabella relative to the total cephalic length, and slightly larger marginal spines on the pygidium.

Figured specimens.—

	Length
Cephalon, UT-32130, from LL-559	2 mm.
Pygidium, UT-32131, from TC-807	2 mm.

Occurrence.—Rare, lower part of the *Aphelaspis* zone. Specimens have been obtained from measured sections at: LL-559; TC-807.

Subfamily PSEUDAGNOSTINAE Whitehouse, 1936

Genus PSEUDAGNOSTUS Jaekel, 1909

Pseudagnostus JAEKEL, 1909, p. 400; KOBAYASHI, 1935, p. 107; 1937, p. 451; 1939, p. 157; SHIMER and SHROCK, 1944, p. 601; SHAW, 1951, p. 112.
Plethagnostus CLARK, 1923, p. 124; 1924, p. 16.
Rhapatagnostus WHITEHOUSE, 1936, p. 97.

Genotype.—*Agnostus cyclopyge* Tullberg, 1880, p. 26.

Diagnosis.—Cephalon with bilobed glabella and median longitudinal preglabellar furrow; basal glabellar lobes present. Pygidium with anterior third of axial lobe defined

by dorsal furrows; posterior portion expanded and partially or completely merged with pleural lobes. Posterolateral marginal spines usually present.

Discussion.—Kobayashi (1935, p. 108) has used the term "diagonal accessory furrow" for the furrow that outlines the posterior portion of the axial lobe of the pygidium of this genus. He believes that the true outline of the posterior portion of the axial lobe is marked by two convergent rows of pits present behind the anterior portion of the axial lobe of some specimens and that the diagonal accessory furrow is not homologous to the dorsal furrow of other agnostids. He interprets the pits as muscular attachments.

Troedsson (1937, p. 24) has disagreed with Kobayashi. He believes that the expansion of the posterior portion of the axial lobe is a primary feature and that "there is no doubt that these furrows [the diagonal accessory furrows] are homologous to the rudimentary dorsal furrows. The rows of muscle scars have a more median position."

The writer has evidence to support the views of Troedsson.

An internal mold of a pygidium of *Pseudagnostus communis* (Hall and Whitfield) from the *Aphelaspis* zone (pl. 76, fig. 3) has two convergent rows of pits identical to those that are stated by Kobayashi to mark the outline of the posterior portion of the axial lobe. A rubber impression of the mold, simulating the appearance of the under surface of the pygidium, shows two posteriorly convergent rows of small, circular knobs on the posterior portion of the axial lobe. Two pairs of knobs identical to those mentioned above are present on the anterior portion of the axial lobe. They are adjacent to the impression of the median node at the inner ends of the low ridges representing the transverse furrows, and they appear to mark places of muscle attachment homologous to those on the posterior portion of the axial lobe.

This evidence suggests that the points of muscular attachment are not in, the dorsal furrow and therefore do not mark the outline of the posterior portion of the axial lobe as claimed by Kobayashi. The writer agrees with Troedsson and believes that the expansion of the posterior portion of the axial lobe is a primary feature. The furows partially outlining it are considered homologous to the dorsal furrows of more typical agtiostids.

Whitehouse (1936, p. 97) proposed *Rhapatagnostus* for pseudagnostids showing the posteriorly convergent rows of muscle attachments. Kobayashi (1939, p. 157) has considered *Rhapatagnostus* a synonym of *Pseudagnostus.* The specimen from the Riley formation mentioned above is associated with *Pseudagnostus* pygidia that do not show clear muscular attachments. Kobayashi appears to have been correct in placing *Rhapatagnostus* in synonymy with *Pseudagnostus.* The presence of discernible points of muscle atttachment on the axial lobe of pseudagnostids is considered to be a function of quality of preservation of material studied and not a fundamental character for taxonomic differentiation.

PSEUDAGNOSTUS COMMUNIS
(Hall and Whitfield)
Plate 76, figures 1–3

Agnostus communis HALL and WHITFIELD, 1877, p. 228, pl. 1, figs. 28, 29.
Pseudagnostus communis (Hall and Whitfield) KOBAYASHI, 1939, p. 157.

Diagnosis.—Cephalon with glabella outlined by moderately well developed dorsal furrow. Depth of preglabellar median furrow approximately equal to that of dorsal furrow.

Pygidium with axial lobe outlined for most of its length by moderately well developed dorsal furrows. Posterolateral marginal spines present.

Discussion.—The characteristic preglabellar median furrow on the cephalon and the expanded posterior lobe on the pygidium distinguish this species from *Geragnostus* cf. *G. tumidosus* (Hall and Whitfield), the only other agnostid described from the *Aphelaspis* zone.

Paired points of muscle attachment found on a specimen of this species from the *Aphelaspis* zone have been described under the genus. If each pair corresponds to a fundamental body segment, as in other trilobites, then at least eight body segments were covered by the pygidium of this species.

In addition to the points of muscle attach-

ment mentioned above, the pygidium has three pairs of shallow depressions on the under surface of the test that appear as elevations on the internal mold (pl. 76, fig. 3). Each pair is situated near the anterior margin of one of the first three segments of the axial lobe. The posterior margins of the elevations are clearly outlined, but the anterior portions are not differentiated from the surface of the axial lobe. The elevations on the first segment appear to be transversely bilobed, those on the following two segments are approximately circular in outline.

Similarly situated and possibly homologous markings have been illustrated by Westergård (1946, pl. 16, fig. 2) for *Phalacroma glandiforme* (Angelin) from the Middle Cambrian of Sweden. He suggested that perhaps they corresponded to the pits sometimes seen on other agnostids and interpreted as muscle attachments. The specimen from the *Aphelaspis* zone indicates that the muscle attachments and the paired markings illustrated by Westergård are separate phenomena. The relationship of these markings to the anatomy of the agnostid is not known.

Figured specimens.—

	Length
Cephalon, UT-32205, from TC-807	3 mm.
Pygidium, UT-32169, from TC-821	5 mm.
Pygidium, USNM 123309, from USGS coll. 10 (CO)	4 mm.

Occurrence.—Moderately rare, *Aphelaspis* zone. Specimens have been obtained from measured sections at: MC-561; TC-815, 821 ;U.S.G.S. coll. 8, 10 CO.

PSEUDAGNOSTUS? NORDICUS (Lochman)
Plate 76, figures *5, 1*

"Agnostus" nordicus LOCHMAN, 1940a, p. 23, pl. 2, figs. 20–22.
"Agnostus" valentinus LOCHMAN, 1944, p. 78, pl. 5, fig. 14.

Diagnosis.—Cephalon with anterior lobe of glabella triangular in outline, depressed, poorly defined posteriorly by transverse glabellar furrow; median longitudinal preglabellar furrow deep. Pygidium with only anterior third of axial lobe defined by straight dorsal furrow; no transverse furrows; median node present.

Discussion.—This species differs from all others assigned to *Pseudagnostus* by the triangular outline and depressed character of the anterior glabellar lobe, and the straight dorsal furrow and wide unfurrowed axial lobe of the pygidium. The relatively wide border on the pygidium further distinguishes it from *P. communis* (Hall and Whitfield). These differences are so much greater than the differences between *P. communis* (Hall and Whitfield) and other species of *Pseudagnostus* that this species may represent a new genus of the Pseudagnostinae.

Several specimens each of the cephalon and pygidium have been found in the Riley formation. Although they are associated at only one locality, they have the same stratigraphic ranges and probably represent the two shields of the same species. The cephalon was first described as *"Agnostus" valentinus* Lochman from the *Crepicephalus* zone in Montana. The pygidium, *"Agnostus" nordicus* Lochman, was first described from the *Cedaria* zone in Missouri.

Figured specimens.—

	Length
Cephalon, UT-32085, from TC-656	2 mm.
Pygidium, UT-32086, from WC-628	3 mm.

Occurrence.—Moderately rare, *Coosella* and *Maryvillia* zones. Specimens have been obtained from measured sections at: JR-223; LL-450; S-369; TC-656, 787; WC-628; U.S.G.S. coll. 4 (CO).

Family ASAPHISCIDAE Raymond, 1924

The writer uses the classification of this family proposed by Shaw (1952, p. 470).

Subfamily ASAPHISCINAE Kobayashi, 1935
Genus BLOUNTIA Walcott, 1916

Blountia WALCOTT, 1916b, p. 396; SHIMER and SHROCK, 1944, p. 619.

Genotype.—*Blountia mimula* Walcott, 1916b, p. 399, pl. 61 figs. 4–4c.

The writer follows the diagnosis of this genus given by Walcott. Cranidia are distinguished from those of *Maryvillia* by having sharply pointed rather than bluntly rounded posterior limbs. Pygidia are characterized by having an elongate multisegmented axial lobe, gentle transverse arching, and a distinct border that is continuous with the surface of the pleural platform on internal molds.

BLOUNTIA NIXONENSIS Lochman
Plate 79, figure 4

Maryvillia hybrida RESSER (part), 1942b, p. 71, pl. 13, figs. 14, 15.
Blountia nixonensis LOCHMAN, 1944, p. 43, pl. 4, figs. 7–12.

The sharply pointed posterior limb of the cranidium of this species is the most significant feature that distinguishes it from the cranidia of *Maryvillia* cf. *M. ariston* Walcott.

The cranidium, figured as *Maryvillia hybrida* by Resser, is identical in every respect with *B. nixonensis* Lochman. The pygidium, designated by Resser, as the holotype of *M. hybrida,* represents an unidentifiable species of *Coosella.* This confusion is the result of a mixed collection. The material from U. S. Geological Survey locality 14d (OS), the type locality for Resser's species, contains two different types of limestone that appear similar on their weathered surfaces. The cranidia are found on blocks with numerous specimens of *Aphelaspis.* The pygidium is associated with fragments of *Tricrepicephalus.* Acetic acid residues from the rock specimens containing the figured cranidium and pygidium show that the parts definitely could not belong to the same species. The residue of the block containing the cranidium has abundant specimens of *Dictyonina perforata* Palmer, n. sp., associated with *Angulotreta triangularis* Palmer, n. sp., and fragmentary silicified specimens of *Raaschella ornata* Lochman. The known stratigraphic range of these species would place the horizon of the occurrence of the cranidium 7 to 10 feet above the base of the *Aphelaspis* zone. The residue of the block containing the pygidium has many specimens of *Kinsabia,* which is characteristic of the upper *Cedarina-Cedaria* and lower *Coosella* zones and has not been found in abundance within 100 feet stratigraphically of the horizon from which the cranidium was probably obtained.

Figured specimen.—

	Length
Cranidium, USNM 108765, from USGS loc. 14d (OS)	13 mm.

Occurrence.—Rare, lower *Aphelaspis* zone. The only specimens from central Texas are in U.S.G.S. coll. 14d (OS).

BLOUNTIA sp.
Plate 79, figure 12

Pygidia most nearly resembling *Blountia* aff. *B. janei* Lochman (1944, p. 85) in general outline have been found in five collections. They differ principally in the somewhat greater relative width of the pygidial border.

Figured specimen.—

	Length
Pygidium, UT-32089, from S-183	11 mm.

Occurrence.—Moderately rare, upper part of the *Cedarina-Cedaria* zone, and *Coosella* zone. Specimens have been obtained from measured sections at: MC-419, 446, 453; S-183; U.S.G.S. coll. 4 (CO).

Genus MARYVILLIA Walcott, 1916

Maryvillia WALCOTT, 1916b, p. 400; RESSER, 1942a, p. 31; SHIMER and SHROCK, 1944, p. 627.

Genotype.—*Maryvillia arion* Walcott (part), 1916b, p. 400, pl. 64 figs. 4, 4b.

Diagnosis.—Cranidium subtrapezoidal in outline, gently to moderately arched transversely and longitudinally, gently to moderately rounded anteriorly. Glabella low, broad, tapered forward, broadly rounded anteriorly, poorly defined by shallow dorsal furrow. Width of fixed cheeks about one-half that of glabella; palpebral lobes situated anterior to transverse median line of glabella. Posterior limbs short, blunt.

Pygidium subsemicircular in outline, moderately to strongly arched transversely and longitudinally. All furrows on outer surface of test are shallow. On internal molds, axial lobe low, broad, bluntly terminated posteriorly, faintly segmented. Most specimens have a narrow median post-axial ridge.

Discussion.—The character of the pygidium of this genus was correctly interpreted by Resser (1942a, p. 32). Many pygidia actually belonging to *Coosella* have been referred to *Maryvillia* and have given an erroneous impression of the stratigraphic range of this genus. Where there is adequate information the writer has found true representatives of *Maryvillia* to characterize a zone immediately below the *Aphelaspis* zone, and to be reliable, common, and geographically widespread guides to this horizon.

MARYVILLIA cf. M. ARISTON Walcott
Plate 79, figures 6–9

Maryvillia ariston WALCOTT, 1916b, part, p. 401, pl. 64, fig. 5.

Many cranidia from 18 collections are characterized by smooth transverse and longitudinal profiles hardly broken by sharp furrows or abrupt changes in slope from the glabella to the fixed cheeks and frontal area, and from the brim to the border. They are nearly identical with the types of *M. ariston* Walcott. Associated pygidia have a low, broad axial lobe with five segments and a small terminal portion visible on internal molds, and a steeply depressed margin. A poorly defined border, also visible only on internal molds, is wider than the faintly furrowed triangular pleural platform. The pygidia differ from those associated with the types of *M. ariston* Walcott by having the margin more steeply depressed, more axial segments, and shallower furrows on the axial and pleural lobes of internal molds.

The cranidia of many species assigned to *Maryvillia* from other areas of fossiliferous Upper Cambrian rocks are nearly identical to those of *M. ariston* Walcott. Pygidia of these species often designated as holotypes, are commonly exfoliated. They vary in the amount of transverse and longitudinal arching, in the relative width of the poorly defined, smooth border, and in the number of visible segments on the axial and pleural lobes. Lack of abundant material in most collections makes comparisons of little actual value. The observed differences between the available samples of described species are small and qualitative and could be attributed to local and/or geographic intraspecific variation.

Figured specimens.—

	Length
Cranidium, UT-32155, from MC-516	13 mm.
Cranidium, UT-32156, from WC-706	15 mm.
Pygidium, UT-32157, from JR-218	10 mm.
Pygidium, UT-32158, from LL-557	6 mm.

Occurrence.—Common, *Maryvillia* zone. Specimens have been obtained from measured sections at the following horizons: JR-210, 218, 223; LL-537, 548, 557; MC-504, 516, 529; P-618, 622; S-369; TC-732, 774, 776; WC-706; U.S.G.S. coll. 5, 6 (CO).

Genus PROTILLAENUS Raymond, 1937

Protillaenus RAYMOND, 1937, p. 1118; SHAW, 1952, p. 474.
Blountina LOCHMAN, in LOCHMAN and DUNCAN, 1944, p. 55.

Genotype.—*Protillaenus marginatus* Raymond, 1937, p. 1118, pl. 3, fig. 10.

The characterization of this genus by Lochman (as *Blountina)* adequately describes the generic features of the pygidia found in central Texas. The narrow vertical margin and distinct dorsal and marginal furrows on exfoliated specimens distinguish them from *Blountia.*

PROTILLAENUS spp.
Plate 79, figures 2, 3, 5

Pygidia from two collections, characterized either by the effacement of nearly all furrows on the outer surface of the test, or, if exfoliated, by a well defined border and axial lobe, are definitely referable to *Protillaenus.* They may represent more than one species of the genus, but not enough material is available to establish adequate specific groupings.

The pygidia from LL-468 are all exfoliated, and two distinct kinds are recognizable: one with eleven axial segments and a narrow border, and one with seven axial segments and a border that is relatively broad on the axial line. It is interesting that the pygidia of *P. eleanora* (Lochman) and P. *triangularis* (Lochman) (1944, pp. 56, 57), described from one horizon in the Pilgrim limestone in Montana, although having more triangular outlines than the Texas specimens, have seven and eleven axial segments respectively. Possibly this is an example of sexual dimorphism.

Pygidia from MC-483 show only the outer surface of the test and cannot be compared adequately with the exfoliated specimens.

Figured specimens.—

	Length
Pygidium, UT-32166, from LL-468	3.5 mm.
Pygidium, UT-32167, from LL-468	4.0 mm.
Cranidium, UT-32168, from MC-483	4.0 mm.

Occurrence.—Rare, *Coosella* zone. Specimens have been obtained from measured sections at: LL-468; MC-483.

Subfamily KINGSTONIINAE Kobayashi, 1933

Genus ANKOURA Resser, 1938

Ankoura RESSER, 1938, p. 58; LOCHMAN, 1940a, p. 31.

Genotype.—*Ankoura triangularis* Resser, 1938, p. 58, pl. 9, fig. 33.

Lochman (1940a, p. 31) gives a full description of this genus and cites the horizontal position of the border of the cranidium and the relatively high posterior end of the axial lobe of the pygidium as distinctive characteristics.

ANKOURA cf. A. APICALIS Duncan

Plate 79, figures 10, 11

Ankoura apicalis DUNCAN, in LOCHMAN and DUNCAN, 1944, p. 109, pl. 14, figs. 29–31.

Diagnosis.—Cranidium subtrapezoidal in outline, strongly arched transversely and longitudinally. Glabella faintly outlined all around by dorsal furrow; occipital ring short, not extended into spine. Frontal area short, with brim steeply depressed from front of glabella and about twice width of nearly horizontal border. Palpebral lobes small, situated opposite anterior third of glabella. Posterior limbs short, broad, bluntly pointed distally; shallow marginal furrow extends outward and forward in broad curve from dorsal furrow.

Facial sutures extend straight forward or slightly inward from palpebral lobes; behind palpebral lobe they extend outward and backward in a broad curve to cut posterior margin at or near genal angle.

Pygidium subtriangular in outline. Axial lobe consisting of seven segments visible only on exfoliated specimens. Border moderately wide, nearly vertical behind end of axial lobe.

Discussion.—The pygidium of this species does not seem to differ significantly from that of *A. apicalis* Duncan. The cranidium is characterized by the anteriorly curved course of the marginal furrow on the posterior limbs, the unspined occipital ring, and the narrow, horizontal border. Because of the nondescript nature of trilobites in the Kingstoniinae, relationships determined solely on comparison of pygidia might be misleading. Until the cranidium of *A. typicalis* Duncan is described, it will be impossible to determine whether the suggested relationship of the Texas species is correct.

Figured specimens.—

	Length
Cranidium, UT-32076, from S-183	4.5 mm.
Pygidium, UT-32077, from S-183	3.5 mm.

Occurrence.—Rare, upper part of the *Cedarina-Cedaria* zone. Specimens have been obtained only from the Streeter section at: S-162?, 183.

Genus KINGSTONIA Walcott, 1924

Kingstonia WALCOTT, 1924, p. 58; 1925, p. 103; RESSER, 1936, p. 24; SHAW, 1952, p. 471; SHIMER and SHROCK, 1944, p. 627; TASCH, 1952b, p. 859.

Ucebia WALCOTT, 1924, p. 60; 1925, p. 118.

Genotype.—*Kingstonia apion* Walcott, 1924, p. 58, pl. 14, fig. 2.

The generic diagnosis given by Shimer and Shrock (1944, p. 627) is about as succinct as possible for this nondescript genus. A more detailed description is given by

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EXPLANATION OF PLATE 78

COOSELLIDAE

FIG. *1*—*Coosella* cf. *C. widnerensis* (Resser) ×3, exfoliated cranidium, UT-32110, JR-163; *Coosella* zone. (p. 730)

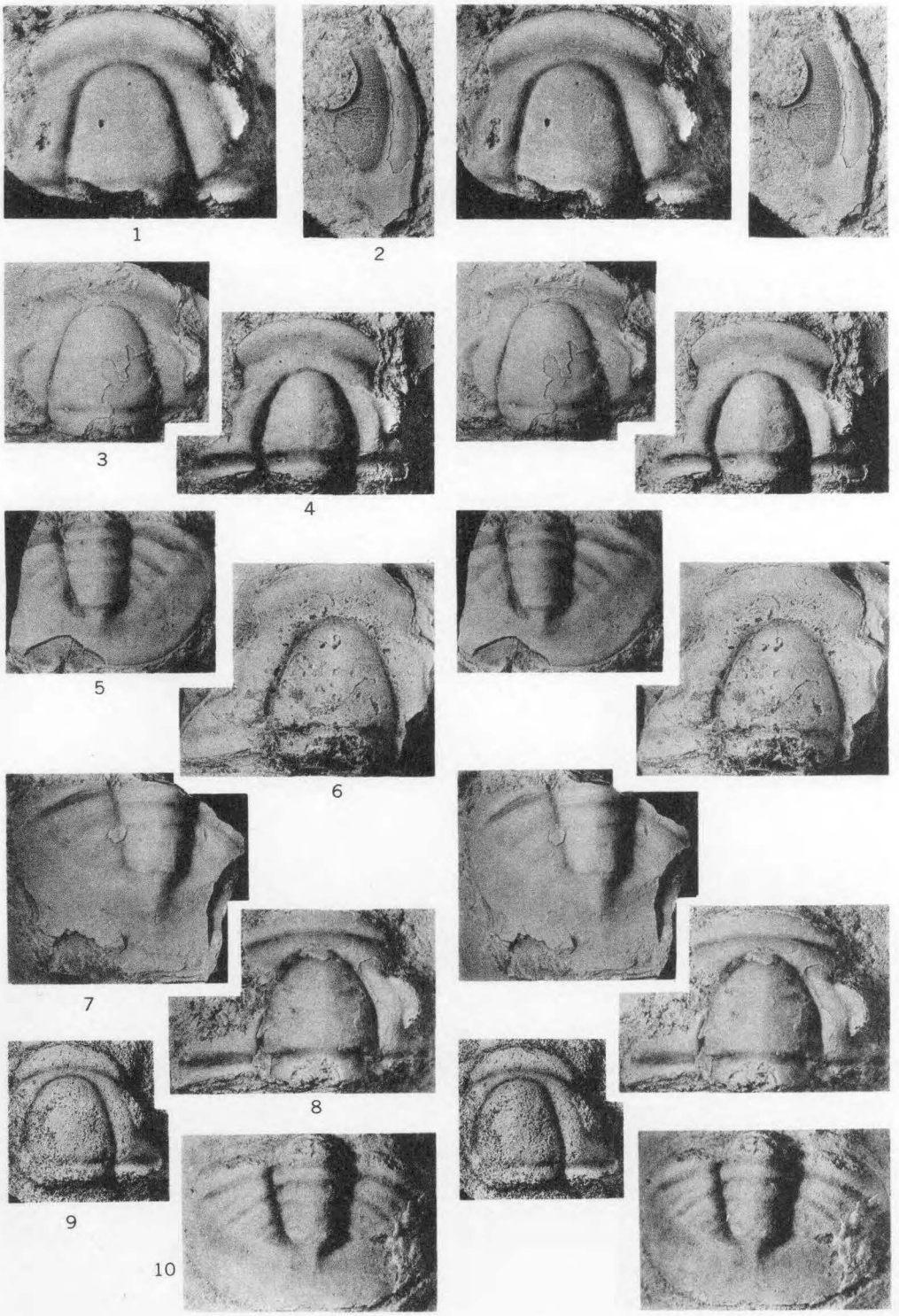
2, 3—*Coosella* cf. *C. granulosa* Rasetti, ×2. *2,* free cheek, UT-32109, JR-163; *3,* cranidium, UT-32108, MC-419; *Coosella* zone. (p. 730)

4, 5—*Coosella beltensis* Lochman, ×2. *4,* exfoliated cranidium, USNM 123312, USGS coll. 4 (CO); 5, pygidium, USNM 123311, USGS coll. 3 (CO); *Coosella* zone. (p. 728)

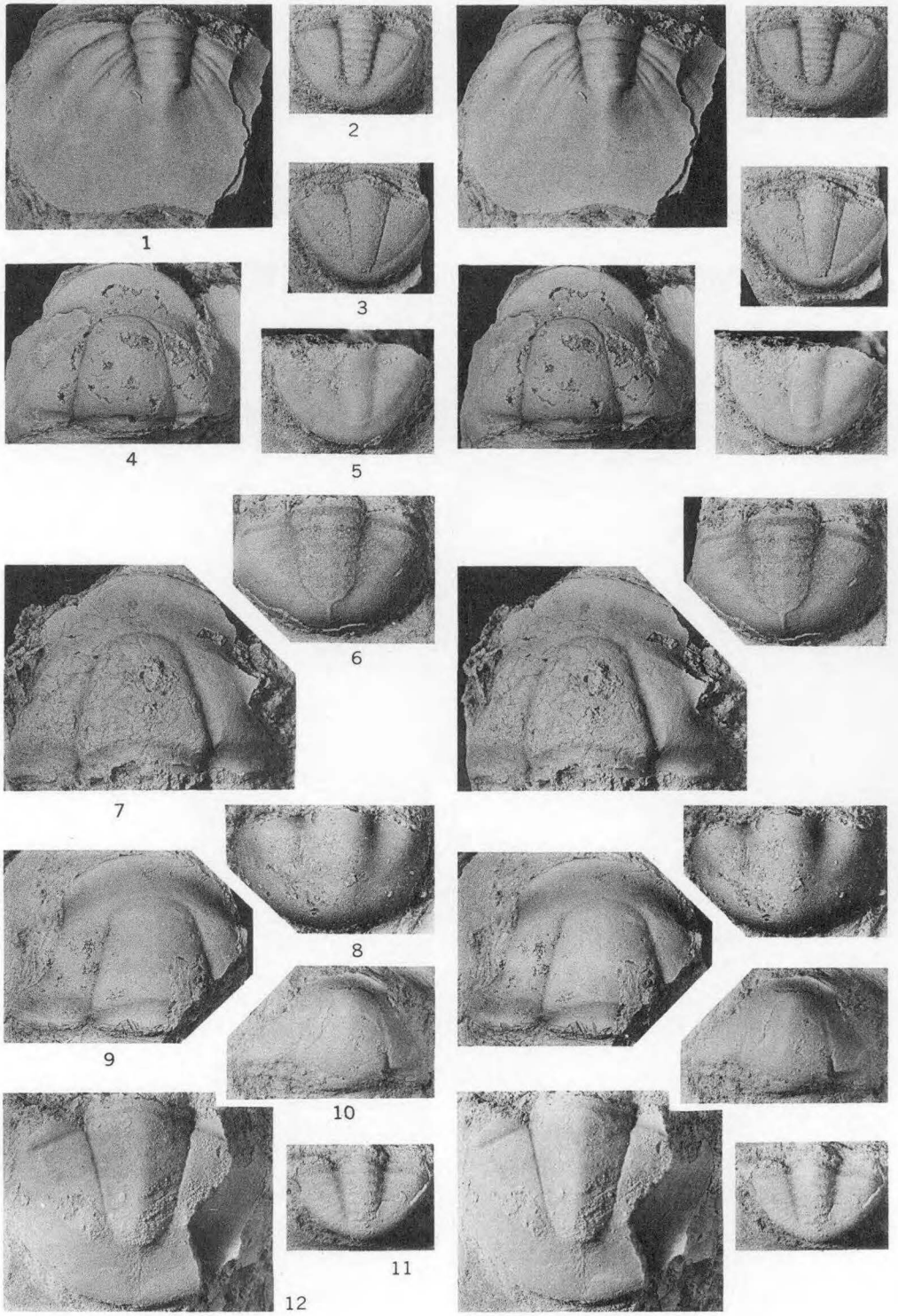
6, 7—*Coosia connata* (Walcott). *6,* exfoliated cranidium, ×1.5, USNM 108773a, USGS loc. 67a (OS); *7,* exfoliated pygidium, ×2, UT-32114, MC-419; *Coosella* zone. (p. 731)

8, 10—*Syspacheilus* cf. *S. camurus* Lochman, ×3, *8,* cranidium, UT-32176, S-183; *10,* exfoliated pygidium, UT-32177, S-162; *Cedarina-Cedaria* zone. (p. 734)

9—*Syspacheilus dunoirensis* (Miller), ×2, internal mold of cranidium, UT-32178, TC-345; *Cedarina-Cedaria* zone. (p. 734)



Palmer, Cambrian faunas from Texas



Palmer, Cambrian faunas from Texas

Tasch (1952b, p. 859). The subtrapezoidal to subhemispherical, nearly furrowless cranidium and the triangular, furrowless pygidium are characteristic. The outline of the glabella on the cranidium and the character of the axial lobe on the pygidium are better defined on exfoliated specimens.

Subgenus UCEBIA Walcott, 1924

Ucebia WALCOTT, 1924, p. 60; 1925, p. 118.

Subgenotype.—Ucebia ara Walcott, 1924, p. 60, pl. 14 fig. 4.

Diagnosis.—Cranidium with short, blunt posterior limbs.

Discussion.—The recognition of two subgenera of *Kingstonia* by Shaw (1952, p. 471) based upon the shape of the posterior limbs of the cranidium has been challenged by Tasch (1952b, p. 859), who believes Shaw's criteria are more likely specific than subgeneric. Tasch (1951, pp. 295–298), however, has used such features as convexity for the discrimination of species of *Kingstonia,* while Shaw (op. cit.) states that the shape of the glabella and most other features (exclusive of the shape of the posterior limbs) seem to be somewhat intergrading. The writer prefers to consider the two kinds of posterior limbs as subgeneric features. They appear to be the most objective taxonomic characteristics recognized for differentiation of kingstoniid trilobites, and they may have some real biologic significance.

KINGSTONIA (UCEBIA) PONTOTOCENSIS Lochman

Plate 80, figures 1–4

Kingstonia pontotocensis LOCHMAN, 1938a, p. 77, pl. 18, figs. 14–16.
Kingstonia texana LOCHMAN, 1938a, p. 77, pl. 18, figs. 20–24.

Diagnosis.—Cranidium with short, blunt posterior limbs and a moderately to strongly arched longitudinal profile.

Pygidium with short, nearly vertical border that is accentuated on internal molds.

Discussion.—K. texana Lochman is essentially the same as *K. (U.) pontotocensis* Lochman except for a slight difference in longitudinal profile. The variation in longitudinal profile of other specimens of *Kingstonia* from Texas suggests that this is not a valid criterion for specific differentiation.

Figured specimens.—Holotype: cranidium, U.S.N.M. 95512, S. fork of Morgan Creek, Burnet Co., Texas. Length, 2.5 mm.

	Length
Cranidium, UT-32133, from MC-464	3.0 mm.
Pygidium, UT-32134, from TC-732	2.5 mm.
Pygidium, UT-32135, from MC-453	2.0 mm.

Occurrence.—Moderately common, *Coosella* and *Maryvillia* zones. Specimens have been obtained from measured sections at: JR-201, 218, 223; LL-468; MC-453, 464, 475; TC-732, 776; WC-628, 706; U.S.G.S. coll. 4 (CO).

Family CEDARIIDAE Raymond, 1937

Genus BONNETERRINA Lochman, 1936

Bonneterrina LOCHMAN, 1936, p. 41.
Piedmontia RESSER, 1938, p. 94.

Genotype,—Bonneterrina prima Lochman, 1936, p. 42

Diagnosis.—Cranidium with glabella elongate, tapered anteriorly, straight sided, strongly rounded at front, essentially unfurrowed, well defined by dorsal furrow; occipital furrow shallow; occipital ring produced into spine. Frontal area subequally divided by narrow marginal furrow; border

EXPLANATION OF PLATE 79

COOSELLIDAE, ASAPHISCIDAE

FIG. *1—Coosella* sp., ×3, pygidium, UT-32111, MC-472; *Coosella* zone. (p. 730)
2, 3, 5—Protillaenus spp., ×4. *2,* exfoliated pygidium, UT-32166, LL-468; *3,* exfoliated pygidium, UT-32167, LL-468; *5,* pygidium, UT-32168, MC-483; *Coosella* zone. (p. 723)
4—Blountia nixonensis Lochman, ×2, USNM 108765b, USGS loc. 14d (OS); *Aphelaspis* zone. (p. 722)
6–9—Maryvillia cf. *M. ariston* Walcott. *6,* exfoliated pygidium ×2, UT-32157, JR-218; *7, 9,* exfoliated cranidia showing extreme in variation of frontal area, ×2, UT-32156, WC-706; UT-32155, MC-516; *8,* pygidium, ×3, UT-32158, LL-557; *Maryvillia* zone. (p. 723)
10–11—Ankoura cf. *A. apicalis* Duncan, ×4. *10,* cranidium, UT-32076, S-183; *11,* exfoliated pygidium, UT-32077, S-183; *Cedarina-Cedaria* zone. (p. 724)
12—Blountia sp., ×3, pygidium, UT-32089, S-183; *Cedarina-Cedaria* zone. (p. 722)

gently convex. Fixed cheeks downsloping from dorsal furrow; width about one-third that of glabella; palpebral lobes situated on or slightly posterior to transverse median line of glabella. Posterior limbs short, bluntly pointed; marginal furrow narrow.

Discussion.—The shape of the glabella, presence of a well differentiated brim and border, and character of the posterior limbs of this genus suggest a relationship to the Cedariidae. However, if the free cheek described by Lochman (1936, p. 42) is correctly assigned, this relationship may be only superficial.

B. aspinosa Tasch (1951, p. 288) lacks the narrow marginal furrow and elongate, tapered, straight-sided glabella characteristic of *Bonneterrina* and has a deep occipital furrow. The writer questions its assignment to this genus. *Piedmontia* Resser 1938 has been considered a synonym of *Bonneterrina* by Lochman and Duncan (1944, p. 90).

BONNETERRINA APPALACHIA (Walcott)
Plate 80, figure 9

Lonchocephalus appalachia, WALCOTT, 1916, part, p. 190, pl. 35, figs. 6, 6a, 6c; RESSER, 1938a, p. 86, pl. 10, fig. 30.

Diagnosis.—Cranidium with marginal furrow on frontal area deep, border downsloping. Palpebral lobes about on transverse median line of glabella. Marginal furrow on posterior limb deep, narrow, curved sharply forward to cut the anterior margin of the limb near its distal extremity. Occipital spine nearly horizontal.

Discussion.—This species differs from *B. prima* Lochman, the genotype, in all features mentioned above. It is much too large for *Lonchocephalus,* and its lacks the distinct glabellar furrows and wire-like border characteristic of that genus. It appears to be a distinct species of *Bonneterrina* that is considerably older than *B. prima* Lochman.

Figured specimen.—

	Length (to occipital furrow)
Cranidium, UT-32098, from TC-330	13 mm.

Occurrence.—Rare, *Bolaspidella* zone. Specimens have been obtained only from the Threadgill Creek section at TC-323, TC-330.

Genus CEDARIA Walcott, 1924

Cedaria WALCOTT, 1924, p. 55; 1925, p. 78; SHIMER and SHROCK, 1944, p. 621.

Genotype.—*Cedaria prolifica* Walcott, 1924, p. 55, pl. 10, fig. 6.

Diagnosis.—Cranidium with glabella elongate, anteriorly tapered, unfurrowed, strongly rounded at front. Frontal area moderately long, divided by distinct marginal furrow into brim and border. Posterior course of facial suture directed straight laterally or somewhat forward until reaching the marginal furrow. Pygidium subsemicircular in outline. Axial lobe distinctly segmented. Pleural lobes gently arched, bearing well defined furrows that reach to or across distinct flat border.

CEDARIA EURYCHEILOS Palmer, n. sp.
Plate 80, figures 5–7

Diagnosis.—Cranidium with axial length of border equal to or greater than that of the brim. Posterior limbs long, moderately expanded distally. Pygidium with axial length slightly greater than one-half greatest width. Width of the border nearly one-half width of pleural lobe.

Discussion.—This species is distinguished from other species of *Cedaria* by the broad border on the cranidium and pygidium.

A similar form has been collected by the writer from the *Cedaria* zone of Wisconsin, in strata just below those containing *C. woosteri* (Whitfield).

A collection in the U. S. National Museum from an unknown horizon in the vicinity of the basal segment of the Morgan Creek section of this paper contains remains of a trilobite that, except for the presence of an occipital spine, is conspecific with *C. eurycheilos* Palmer. The taxonomic importance of an occipital spine in two otherwise identical groups is open to question. Until more information about the stratigraphic and geographic distribution of the spined forms is available, the writer hesitates to describe them as representatives of a new species.

Figured specimens.—

	Length
Holotype Cranidium, UT-32100, from S-105	14 mm.
Cranidium, UT-32099, from MC-373	7 mm.
Pygidium, UT-32101, from S-105	7 mm.

Occurrences.—Moderately common, upper *Cedarina-Cedaria* zone. Specimens have been obtained from measured sections at MC-322?, 373; S-105, 130; TC-429, 432, 499, 515; WC-460.

Genus CEDARINA Lochman, 1940

Cedarina LOCHMAN, 1940, p. 36.

Genotype.—Cedarina vale Lochman, 1940a, p. 37, pl. 2, figs. 50–53.

This genus is adequately defined by Lochman. The nearly straight forward course of the facial suture in front of the palpebral lobe on the cranidium and the relatively long axial lobe and distinctly transverse outline of the pygidium distinguish the genus from *Cedaria.*

CEDARINA CORDILLERAE (Howell and Duncan)
Plate 80, figures 8, 10

Piedmontia cordillerae HOWELL and DUNCAN, 1939, p. 9, pl. 1, fig.4.
Cedarina cordillerae (Howell and Duncan) LOCHMAN and DUNCAN, 1944, p. 89, pl. 17; figs. 1–10; LOCHMAN, 1950, p. 347, pl. 50, figs. 20, 21.

Diagnosis.—Cranidium with axial length of border slightly less than that of brim. Occipital ring commonly bearing backward directed spine. Posterior limbs tapered, bluntly pointed distally.

Width of pygidium about twice length; border narrow. Axial lobe consists of four or five segments and a small terminal portion, reaches to inner margin of border.

Discussion.—Some cranidia associated with typical examples of this species in the writer's collections lack the characteristic occipital spine. This may be an example of sexual dimorphism as suggested by Lochman (1940a, p. 90).

Figured specimens.—

	Length
Cranidium, UT-32102, from LL-327	6 mm. (to occipital furrow)
Pygidium, UT-32103, from LL-327	4 mm.

Occurrence.—Common, lower two-thirds of the *Cedarina-Cedaria* zone. Specimens have been obtained from measured sections at: LL-324, 325, 327; MC-283, 299; P-350, 385, 395, 425; S-0; TC-348, 362, 378.

Family COOSELLIDAE Palmer, n. fam.

Type genus.—Coosella Lochman, 1936, p. 39.

The family Coosellidae as used in this report includes the following Dresbachian trilobite genera: *Coosella, Coosia, Crepicephalus,* and *Syspacheilus.* The writer believes that these four genera form a related group (fig. 4).

The cranidia are characterized by a well defined, faintly furrowed, broad, low, anteriorly tapered glabella; a distinct occipital ring; a frontal area with both brim and border present but often not clearly differentiated; fixed cheeks between one-third and two-thirds the width of the glabella; moderate sized palpebral lobes situated opposite the middle third of the glabella; and posterior limbs with a distinct marginal furrow.

The pygidia are characterized by an axial lobe bearing three or more segments and a small terminal portion. The width of the axial lobe is less than one-third the width of the pygidium, and it barely reaches to the inner margin of a moderately broad, concave border. There is no distinct furrow between the border and the triangular pleural platform. Faint to moderately well impressed pleural furrows and interpleural grooves are present on the pleural platform and may extend a short distance onto the border.

The character of the furrows and grooves on the pleural platforms of the pygidia is considered to be strong evidence supporting the assignment of *Syspacheilus, Coosella, Coosia,* and *Crepicephalus* to the same family.

Two pleural platform "furrow-groove patterns" are illustrated for specimens assigned to the Coosellidae: (1) three deep pleural furrows and two or three shallow interpleural grooves about equally spaced (pl. 78, fig. 5); and (2) deep anterior pleural furrow and one or two pairs of interpleural grooves and adjacent pleural furrows of about equal strength (pl. 79, fig. 1).

Both patterns are present on specimens referable to *Coosella, Coosia,* and *Crepicephalus* in collections of the writer or collections at the U. S. National Museum. The pygidium assigned to *Syspacheilus* as used here has pattern type 1. Approximately equal numbers of pygidia with patterns of each type are present in a collection of about 30 articulated specimens of *Coosella curticei* Resser from the Conasauga formation at U.S.G.S. locality 91 (OS), Cedar Bluff, Alabama. Whether or not the "furrow-groove pattern" indicates sex differences is not known at this time.

Coosella and *Coosia* have been considered as members of the Anomocaridae by Lochman and Duncan (1944) and others.

Crepicephalus has been placed previously

with *Tricrepicephalus* and *Meteoraspis* in the Crepicephalidae by Kobayashi (1935), Lochman (1936, 1938), Lochman and Duncan (1944), and Kindle (1948). That family, as conceived by Kobayashi (1935, p. 275), is considered by the writer to be an unnatural association of several unrelated trilobite genera. The stratigraphic range of *Crepicephalus* and its similarity to *Coosia, Coosella,* and *Syspacheilus* in many major features of the carapace suggests that it is more closely related to those genera. The marginal spines of the pygidium, which are distinctive of the genus, are considered here as a late development in the *Syspacheilus-Coosella-Crepicephalus* lineage. The writer does not believe that they have the suprageneric taxonomic importance given them by Kobayashi and others.

Syspacheilus is grouped with *Coosella, Coosia,* and *Crepicephalus* on the basis of the cranidium and pygidium assigned to *Syspacheilus* cf. *S. camurus* Lochman in this paper.

The ancestry of the Coosellidae of this paper is uncertain at the present time. The writer believes future studies will show that there is no real relationship to the Anomocaridae as used by Poulsen (1927) and Kobayashi (1935).

Cranidia of some of the ptychopariid genera in the late Middle Cambrian are indistinguishable at the family level from those assigned to the Coosellidae. The family characteristics seem to be mainly in the pygidia of those genera which are relatively small and have a prominent, broad axial lobe and no distinct border (see *Modocia* cf. *M. oweni* [Walcott], pl. 87, figs. 3, 4, 6).

Genus COOSELLA Lochman, 1936

Coosella LOCHMAN, 1936, p. 39; SHIMER and SHROCK, 1944, p. 621.

Genotype.—*Coosella prolifica* Lochman, 1936, p. 39, pl. 9, figs. 4–11.

Diagnosis.—Marginal furrow of cranidium with concave rounded profile. Occipital furrow on outer surface of carapace deep distally, shallow mesially; broad, shallow, slightly bowed forward on exfoliated specimens.

Genal angle of free cheek produced into a short, posteriorly directed spine, or rounded.

Thorax of 11 or 12 segments. Pleural lobes of each segment subequally divided by deep pleural furrows that are pointed distally.

Axial lobe of pygidium well defined laterally by dorsal furrows, merges posteriorly with border; consist of three or four segments and a short terminal portion that usually has a shallow median depression. Pleural platforms triangular in outline, usually marked by three pairs of pleural furrows, less frequently marked by only two. Interpleural grooves are shallow and located equidistant from adjacent deep pleural furrows, or they are nearly the same strength as the pleural furrows and situated closest to the furrow of the next posterior pygidial segment. Where the interpleural grooves are shallow neither the grooves nor the furrows extend onto the border; where the interpleural grooves are deep, the pleural furrows sometimes extend onto the border as broad, shallow depressions. The border is narrowest at the anterolateral corners of the pygidium and widens posteriorly. There is no furrow between it and the pleural platform. The border is longest on specimens with deep interpleural grooves.

Discussion.—This genus is intermediate in age and morphology between *Syspacheilus* from the *Cedarina-Cedaria* zone and *Crepicephalus* from the upper *Coosella* and *Maryvillia* zones. The round profile of the marginal furrow on the cranidium distinguishes it from *Syspacheilus.* It is distinguished from *Crepicephalus* principally by lacking marginal spines on the pygidium.

COOSELLA BELTENSIS Lochman
Plate 78, figures 4, 5

Coosella beltensis LOCHMAN, 1944, p. 81, pl. 12, figs. 28–30.
Coosella occidens LOCHMAN, 1944, p. 82, pl. 12, figs. 31–34.

Diagnosis.—Cranidium with broad, shallow marginal furrow. Border poorly defined. Length of frontal area about one-third length of cranidium.

Axial lobe of pygidium has four poorly defined segments. Pleural platform marked by three deep pleural furrows; interpleural grooves shallow or absent. Border about same width as widest portion of pleural platform.

Discussion.—Many cranidia and a few pygidia are referable to this species. It

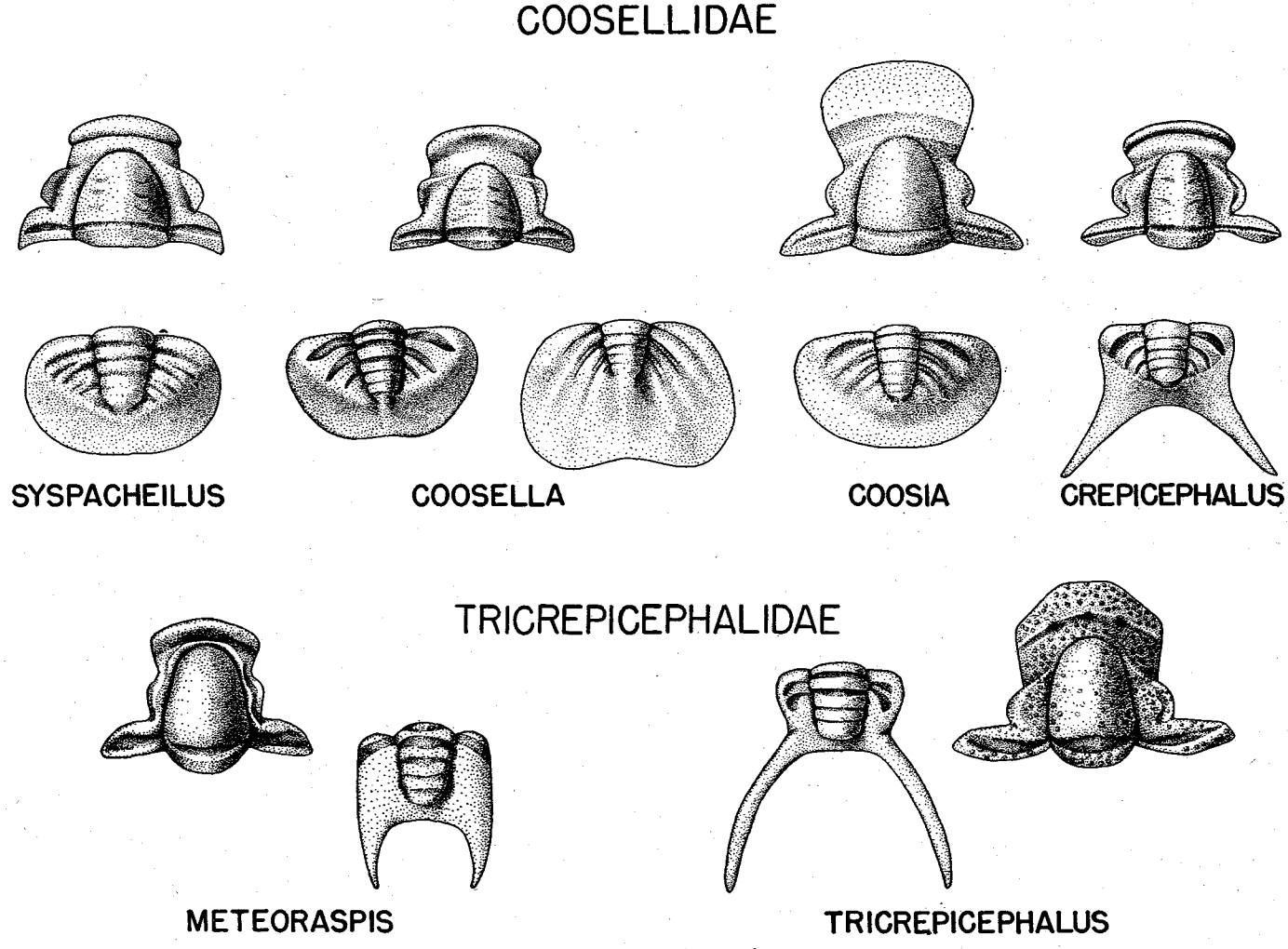

COOSELLIDAE
SYSPACHEILUS
COOSELLA
COOSIA
CREPICEPHALUS
TRICREPICEPHALIDAE
METEORASPIS
TRICREPICEPHALUS

FIG. 4

differs from other species of *Coosella* by the broad, shallow marginal furrow and relatively long frontal area of the cranidium. The writer considers the differences between *C. beltensis* Lochman and *C. occidens* Lochman in the Pilgrim limestone in Montana well within the expected limits of variation of individuals from one population.

Figured specimens.—

	Length
Cranidium, USNM 123312, from USGS coll. (4) (CO)	12 mm.
Pygidium, USNM 123311, from USGS coll. 3 (CO)	12 mm.

Occurrence.—Common, *Coosella* zone. Specimens have been obtained from measured sections at: JR-120, 132; LL-450, 468; MC-419, 446, 453; P-451; S-295; WC-628, U.S.G.S. colls. 3, 4 (CO).

COOSELLA cf. C. GRANULOSA Rasetti
Plate 78, figures 2, 3

Coosella granulosa RASETTI, 1946, p. 451, pl. 68, fig. 31.

Several cranidia characterized by a distinct border, broad shallow marginal furrow, and granular surface resemble *C. granulosa* Rasetti in most features, but differ in having more pronounced ocular ridges, more distinct palpebral lobes, and finer surface granulation. The cited differences are minor and qualitative and may be the result of intraspecific and/or geographic variation. The writer believes that the information available is insufficient for considering the Texas specimens as representatives of a new species.

A free cheek with a distinct granular surface and a well defined border that widens somewhat posteriorly is tentatively assigned to this species.

Figured specimens.—

	Length
Cranidium, UT-32108, from MC-419	13 mm.
	Width
Free cheek, UT, 32109, from JR-163	7 mm.

Occurrence.—Moderately rare, *Coosella* zone. Specimens have been obtained from measured sections at: JR-120, 132, 163?; MC-419, 446.

COOSELLA cf. C. WIDNERENSIS (Resser)
Plate 78, figure 1

Maryvillia widnerensis RESSER, 1938a, p. 88, pl. 13, fig. 1.

Several cranidia characterized by a short frontal area and relatively wide fixed cheeks resemble *Maryvillia widnerensis* Resser. They differ principally in having a relatively longer border, but the brim-border ratio is one of the most variable features on trilobite cranidia and not enough specimens are available to test the significance of the observed difference.

Maryvilla widnerensis Resser is similar to species of *Maryvilla* in the width of the fixed cheeks, but the broad, shallow marginal furrow and distinctly defined, slightly elevated glabella are more distinctive of *Coosella.* The writer prefers to consider it a representative of that genus.

Figured specimen.—

	Length
Cranidium, UT-32110, from JR-163	10 mm.

Occurrence.—Moderately common, *Coosella* zone. Specimens have been obtained from measured sections at: JR-163; MC-464, 469, 472; P-594?; S-325; TC-702.

COOSELLA sp.
Plate 79, figure 1

Several pygidia are characterized by a short axial lobe and a wide border with a slight posterior median indentation. They resemble the pygidium of *C. prolifica* Lochman, the genotype of *Coosella,* but have a less strongly developed indentation of the posterior margin and one more furrow and groove on the pleural platform.

Figured specimen.—

	Length
Pygidium, UT-32111, from MC-472	10 mm.

Occurrence.—Rare, *Coosella* zone. Specimens have been obtained from measured sections at: MC-419, 446, 472; TC-655.

Genus COOSIA Walcott, 1911

Coosia WALCOTT, 1911, p. 94; 1913, p. 210; SHIMER and SHROCK, 1944, p. 623.

Genotype.—*Coosia superba* Walcott, 1911, pl. 94, pl. 16, figs. 1, 1a.

Diagnosis.—Marginal furrow of cranidium broad, shallow. Border of most species distinctly longer than brim. Occipital furrow narrow, shallow, straight. Occipital ring flat.

Genal angle of free cheek produced into *a* posteriorly directed genal spine.

Thorax of 12 segments. Pleural furrows of each segment narrow, situated at the anterior margin and extended half the width of the pleural lobe.

Pygidium subsemicircular in outline. Axial lobe well defined laterally by dorsal furrow, merges posteriorly with border; consists of three poorly defined segments and a short terminal portion that has a shallow median depression on exfoliated specimens; length about one-half or less the length of the pygidium. Pleural platforms on exfoliated specimens show furrow-groove patterns of the same types as *Coosella.*

Discussion.—The straight narrow occipital furrow and flat occipital ring distinguish cranidia of this genus from those of *Coosella, Crepicephalus,* and *Syspacheilus,* Pygidia are characterized by their smooth outer surface. They are distinguished from those of *Syspacheilus* and *Coosella* by the relatively shorter axial lobe and from *Crepicephalus* by the absence of posterolateral marginal spines.

COOSIA cf. C. ALBERTENSIS Resser
Plate 77, figures 7, 9, 10

Coosia albertensis RESSER, 1942, p. 73, pl. 13, figs. 25–28; LOCHMAN, 1950, p. 335, pl. 49, figs. 13–21.

Several cranidia characterized by a short frontal area with a broad, shallow marginal furrow and with the axial length of the border slightly greater than that of the brim may be conspecific with *C. albertensis* Resser. The associated pygidia are small and differ from those assigned to Resser's species by having the axial lobe somewhat longer relative to the total pygidial length.

The subequal division of the frontal area into a brim and border is the most distinctive character of this species.

Figured specimens.—

	Length
Cranidium, UT-32112, from JR-201	7 mm.
Pygidium, UT-32113, from P-602	4 mm.
Cranidium, USNM 123310, from USGS coll. 6 (CO)	18 mm.

Occurrence.—Moderately rare, *Maryvillia* zone. Specimens have been obtained from measured sections at: JR-201, 218, 223; LL-557; MC-516; P-602, 618; S-369; TC-787; U.S.G.S. coll. 6 (CO).

COOSIA CONNATA (Walcott)
Plate 78, figures 6, 7

Ptychoparia connata WALCOTT, 1890, p. 272, pl. 21, fig. 2.
Coosia connata (Walcott) RESSER, 1937, p. 7: SHIMER and SHROCK, 1944, pl. 264, figs. 23, 24.
Coosia magna LOCHMAN, 1940a, p. 35, pl. 3, figs. 6–9.
Coosella texana RESSER, 1942b, p. 75, pl. 13, figs. 21–24; pl. 14, figs. 2–5.
not *Coosia connata* (Walcott) LOCHMAN and DUNCAN, 1944, p. 46, pl. 6, figs. 7, 8.

Diagnosis.—Cranidium subtrapezoidal in outline. Glabella large, anteriorly tapered, strongly rounded in front. Palpebral lobes moderately large, parallel to the dorsal furrow and situated slightly anterior to the transverse median line of the glabella. Posterior limbs broad.

Pygidium subsemicircular in outline with the length slightly more than one-half the width. The length of the axial lobe is slightly more than one-half, and the width is about one-fourth that of the pygidium. The border is wide, smooth, or faintly roughened, gently downsloping behind the axis, and strongly downsloping to depressed at the anterolateral corners of the pygidium.

Discussion.—*Coosia magna* Lochman and *Coosella texana* Resser are identical in every respect with *C. connata* (Walcott). The cranidium identified as *Coosia connata* (Walcott) by Lochman and Duncan has a shallow marginal furrow and gently arched border and an occipital furrow of variable depth. These are features of cranidia assignable to *Coosella* or *Crepicephalus* and definitely exclude the specimen from *Coosia.* Associated pygidia of *Coosella* type that were identified as *Maryvillia* sp. undet. 2 suggest that the cranidium and pygidia may be parts of an undetermined species of *Coosella.*

Figured specimens and measurements.—

	Length
Cranidium, USNM 108773a, from USGS coll. 67a (OS)	22 mm.
Pygidium, UT-32114, from MC-419	15 mm.

Occurrence.—Moderately common, lower portion of the *Coosella* zone. Specimens have been obtained from measured sections at the following horizons: MC-419; TC-655; WC-582. The illustrated cranidium, from U.S.G.S. collection 67a (OS), Potatotop, Burnet County, Texas, probably was col-

lected from the same bed as collection MC-419 of this paper.

Genus CREPICEPHALUS Owen, 1852

Crepicephalus OWEN, 1852, p. 576; WALCOTT, 1916, p. 199 (see this for complete synonymy prior to 1916); SHIMER and SHROCK, 1944, p. 623.

Genotype.—*Dikelocephalus? iowensis* Owen, 1852, p. 575, pl. 1, fig. 4; pl. 1A, fig. 13.

Diagnosis.—Glabella well defined by dorsal furrow, tapering forward, moderately arched above the general surface of the cranidium. Border of most species rimlike. Fixed cheeks moderately broad, slightly upsloping. Palpebral lobes arcuate, situated about opposite the transverse median line of the glabella. Posterior limbs long, slender.

Pygidium broad, subquadrate in outline. Axial lobe narrow, distinctly segmented. Pleural platforms with furrow-groove patterns of both types described for *Coosella* (p. 727). A pair of posterolateral spines is developed from the edges of the border.

CREPICEPHALUS AUSTRALIS Palmer, n. sp.
Plate 77, figures 5, 8

Diagnosis.—Width of cranidium between palpebral lobes nearly equal to axial length of cranidium; anterior margin gently rounded. Anterior end of glabella strongly and evenly rounded. Axial length of the border about equal to axial length of the brim. The brim on many specimens has a median broad depressed area that extends from the front of the glabella to the marginal furrow.

Pygidium nearly twice as wide as it is long. Axial lobe narrow, reaching nearly to posterior margin. Marginal spines directed nearly straight posteriorly; length about two-thirds that of axial lobe.

Discussion.—The nearly straight anterior margin of the cranidium, strongly rounded anterior end of the glabella, and shallow median depression on the brim are particularly distinctive of cranidia of this species. The relatively long, narrow axial lobe and short marginal spines characterize the pygidia.

Trilobites possibly belonging to this species have been observed by the writer in collections from the Abrigo limestone in southeastern Arizona.

Figured specimens.—

	Length
Holotype, cranidium, UT-32115, from JR-201	14 mm.
Pygidium, UT-32116, from JR-201	10 mm. (exclusive of spines)

Occurrence.—Moderately common, upper portion of the *Coosella* zone. Specimens have been obtained from measured sections at the following horizons: JR-201; LL-507; MC-469, 478, 483; P-602, 604, 609.

CREPICEPHALUS cf. C. IOWENSIS (Owen)
Plate 77, figures 3, 6

Dikelocephalus? iowensis OWEN, 1852, p. 575, pl. 1, fig. 4; pl. 1A, fig. 13.
Crepicephalus iowensis (Owen) WALCOTT, 1916, p. 207, pl. 29, figs. 1, 2, 2a–f (see this for complete synonymy prior to 1916); SHIMER and SHROCK, 1944, pl. 262, figs. 7, 8.

Two cranidia are characterized by an elongate, subquadrate outline; gently rounded anterior margin; and bluntly rounded anterior end to the glabella. The axial length of the border is distinctly less than that of the brim. The surface is strongly granulated. These specimens differ from *C. iowensis* (Owen) in the less truncate anterior margins of the cranidium and glabella.

An associated pygidium is not quite twice as wide as long and has marginal spines longer than the axial lobe and diverging at a

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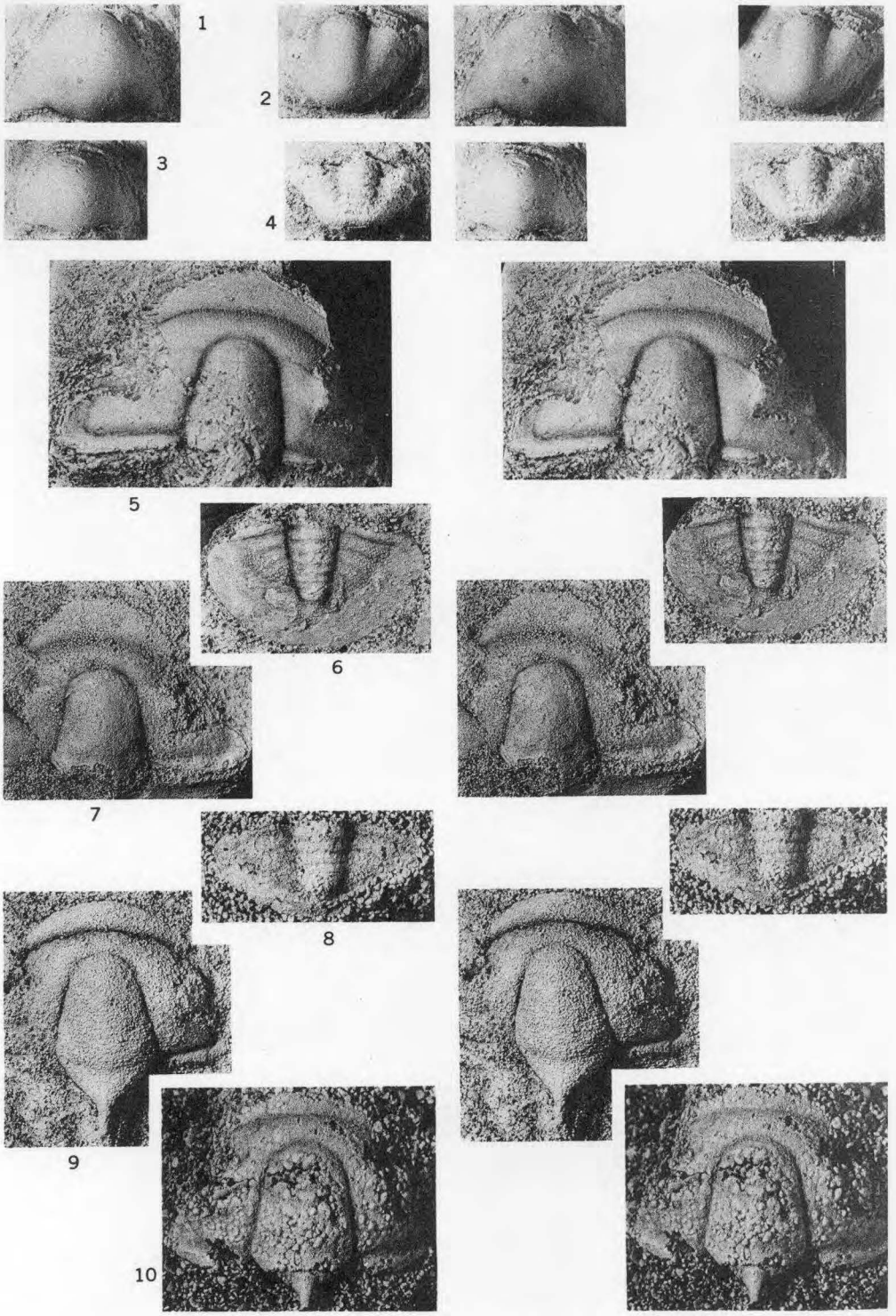
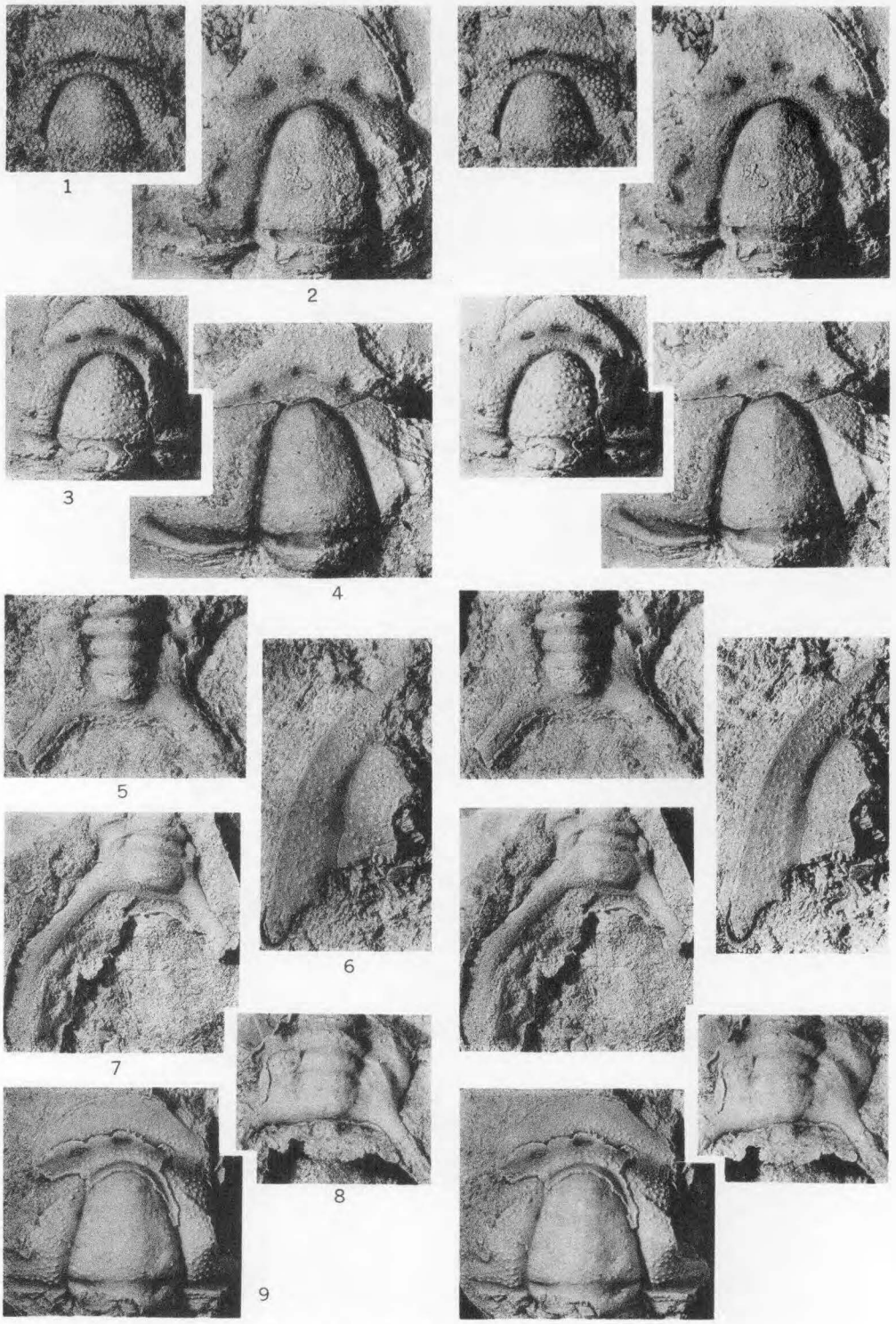
EXPLANATION OF PLATE 80
ASAPHISCIDAE, CEDARIIDAE

FIGS. *1–4—Kingstonia (Ucebia) pontotocensis* Lochman, ×5. *1,* cranidium, UT-32133, MC-464; *3,* holotype cranidium, USNM 95512, S. fork Morgan Creek; *4,* exfoliated pygidium, UT-32135, MC-453; *Coosella* zone. *2,* pygidium, UT-32134, TC-732; *Maryvilliazone.* (p. 725)
5–7—Cedaria eurycheilos Palmer, n. sp. *5,* cranidium, ×4, UT-32099, MC-373; *6,* pygidium, ×3, UT-32101, S-105; 7, holotype cranidium, ×2, UT-32100, S-105; *Cedarina-Cedaria* zone. (p. 726)
8, 10—Cedarina cordillerae (Howell and Duncan), ×4. *8,* pygidium, UT-32103, LL-327; *10,* cranidium, UT-32102, LL-327; *Cedarina-Cedaria* zone, (p. 727)
9—Bonneterrina appalachia (Walcott), ×2, cranidium, UT-32098, TC-330; *Bolaspidella* zone. (P-726)



Palmer, Cambrian faunas from Texas



Palmer, Cambrian faunas from Texas

moderate angle from the axial line. It is not significantly different from that of Owen's species.

Because of the small number of specimens, it is impossible to determine whether the observed differences constitute a valid basis for specific differentiation.

C. auratus Lochman (1938, p. 75) and this species may be the same, but Lochman's type lot consists entirely of small, poorly preserved individuals that cannot be compared adequately with the specimens collected by the writer. The granular surface of the writer's specimens seems to be the principal distinctive feature, but lack of this ornament on Lochman's specimens may be a function of their small size and/or poor preservation.

Figured specimens.—

	Length
Cranidium, UT-32117, from MC-516	7 mm.
Pygidium, UT-32118, from MC-516 (exclusive of marginal spines)	8 mm.

Occurrence.—Rare, *Maryvillia* zone. Specimens have been obtained from MC-516.

CREPICEPHALUS? PERPLEXUS Palmer, n. sp.

Plate 77, figures 1, 2, 4

Diagnosis.—Cranidium with short frontal area subequally divided into depressed brim, and strongly developed, raised border. Glabella elongate, bluntly rounded anteriorly, slightly constricted opposite palpebral lobes. Posterior limbs pointed distally, somewhat shorter than width of glabella at occipital furrow. The surface of the Cranidium is roughened by low, broad, closely spaced granules.

Free cheek with moderately narrow, broadly curved, distinctly defined border and short, pointed genal spine.

Pygidium moderately arched in transverse profile; length about two-thirds width. Axial lobe prominent, slightly more than one-fourth width of pygidium, consists of three segments and terminal portion that ends on border in low, downsloping, pointed ridge. Pleural platforms triangular with three pairs of distinct pleural furrows and shallow interpleural grooves reaching to inner margin of border. Border moderately broad, concave, lateral margins nearly horizontal; posterior margin with slight median indentation.

Discussion.—Cranidia and pygidia assigned to this species are abundant and occur in about equal numbers in two collections, 30 miles apart, from the basal bed of the *Aphelaspis* zone. The species may represent a new genus of crepicephalid trilobites. The cranidium differs from that of typical *Crepicephalus* species by having shorter posterior limbs and a very slightly different shape of the glabella, and the pygidium lacks the characteristic posterolateral spines. The combined characters of the known parts of the carapace do not fit well into any described genus.

As far as is known, this species is the youngest in a lineage including *Syspacheilus, Coosella,* and *Crepicephalus.* In many respects it has similarities to members of this lineage from the *Cedarina-Cedaria* and *Coosella* zones. The rounded anterior margin of the cranidium and the rounded anterior end of the glabella are characteristic of the older species of *Crepicephalus* (see *C. oweni* Raasch, 1943, p. 231 = *C. edwardsi* Raasch, 1945, p. 77). The pygidium is nearly identical to that figured as *Syspacheilus* cf. *S. camurus* Lochman (pl. 78, fig. 10) from the upper portion of the *Cedaria-Cedarina* zone. It is possible that *C.? perplexus* Palmer is an aberrant species having ancestral character-

EXPLANATION OF PLATE 81

TRICREPICEPHALIDAE

FIGS. *1–4, 6—Tricrepicephalus coria* (Walcott). *1,* cranidium, ×4, UT-32182, MC-529; basal bed of *Aphelaspis* zone. *2, 4,* exfoliated cranidia showing variation in character of frontal area, ×2, UT-32179, MG-453; UT-32180, MC-464; *6,* free cheek, X2, USNM 123313, USGS coll. 4 (CO); *3,* exfoliated cranidium, ×4, UT-32181, MC-419; *Coosella* zone. (p. 755)

5, 7, 8—Tricrepicephalus spp., ×2. 5, pygidium, USNM 123314, USGS coll. 3 (CO); *8,* rubber cast of pygidium, UT-32184, MC-419; *Coosella* zone. *7,* rubber cast of pygidium, UT-32185, S-183; *Cedarina-Cedaria* zone. (p. 756)

9—Tricrepicephalus texanus (Shumard), ×1.5, cranidium, UT-32183, MC-419; *Coosella* zone. (p. 755)

istics caused by the conditions associated with the sudden faunal change at the base of the *Aphelaspis* zone. Until more information is available concerning the faunal relationships near the boundary, the writer does not feel that the proposal of a new genus for this interesting species is warranted.

Figured specimens.—

	Length
Holotype cranidium, UT-32119, from MC-529	7 mm.
Pygidium, UT-32120, from MC-529	7 mm.
	Width
Free cheek, UT-32121, from MC-529	4.5 mm.

Occurrence.—Moderately common, basal bed of the *Aphelaspis* zone. Specimens have been obtained from measured sections at the following horizons: LL-557; MC-529.

Genus SYSPACHEILUS Resser, 1938

Syspacheilus RESSER, 1938a, p. 99; LOCHMAN, 1940a, p. 42.

Genotype.—Syspacheilus typicalis Resser, 1938a, p. 100, pl. 10, figs. 35, 36.

Diagnosis.—Cranidium resembles *Coosella* in all linear proportions but differs in the possession of a broad, convex border defined by a narrow marginal furrow. Pygidium indistinguishable from that of *Coosella* with furrow-groove pattern type 1 (see p. 727).

Discussion.—Lochman (1940a, p. 42) noted the similarity of the cranidium to that of *Coosella* and stated that the genera were undoubtedly closely related. The writer agrees with Lochman and has assigned them to the Coosellidae, but in his opinion the pygidia described by Resser (1938, p. 100) and Lochman (1950, p. 343) for species of *Syspacheilus* do not belong to coosellid trilobites.

Three kinds of pygidia, including the specimen figured here, have been referred to this genus. Resser assigned a small six-spined specimen to *S. typicalis* Resser, the genotype. Lochman referred specimens with a distinct broad flat border to *S. occidens* Lochman, stating, however, that the assignment was no more convincing for the Montana material than Resser's was for the material from the southern Appalachians. Resser's specimen cannot be assigned to any family at this time. Lochman's specimens belong to the Cedariidae.

Pygidia of the kind illustrated here have been found associated with cranidia assigned to *Syspacheilus* at horizons stratigraphically below the lowest known range of *Coosella* in central Texas. Although they are indistinguishable from *Coosella* pygidia, their stratigraphic position and association with *Syspacheilus* cranidia support their assignment to that genus.

SYSPACHEILUS cf. S. CAMURUS Lochman
Plate 78, figures 8, 10

Syspacheilus camurus LOCHMAN, 1940a, p. 42, pl. 3, figs. 21–25.

Diagnosis.—Cranidium with nearly straight or gently curved marginal furrow. Axial length of border less than twice that of brim. Fixed cheeks approximately horizontal. Pygidium indistinguishable from that of *Coosella beltensis* Lochman.

Discussion.—The cranidium of this species is distinguished from that of *S. dunoirensis* (Miller) by having a relatively wider brim, a more gently curved anterior margin and marginal furrow, and more nearly horizontal fixed cheeks. It differs from the holotype of *S. camurus* Lochman, a small and perhaps immature specimen, by having the dorsal and occipital furrows less deeply impressed. It is nearly identical to one of Lochman's figured paratypes (Lochman, 1940a, pl. 3, fig. 24).

Figured specimens.—

	Length
Cranidium, UT-32176, from S-183	9 mm.
Pygidium, UT-32177, from S-162	8 mm.

Occurrence.—Moderately rare, upper portion of the *Cedarina-Cedaria* zone. Specimens have been obtained from measured sections at: JR-42; MC-373; S-162, 183; TC-580.

SYSPACHEILUS DUNOIRENSIS (Miller)
Plate 78, figure 9

Blountia dunoirensis MILLER, 1936, part, p. 27, pl. 8, figs. 25, 26.
Syspacheilus dunoirensis (Miller) LOCHMAN and DUNCAN, 1944, p. 131, pl. 11, figs. 44, 45.

Diagnosis.—Cranidium with moderately to strongly curved anterior margin and marginal furrow. Axial length of border about twice that of brim. Fixed cheeks downsloping.

Thorax of thirteen segments. Axial lobe

nearly as wide as pleural lobes. Pleural furrows deep, extended nearly to tips of thoracic segments.

Pygidium unknown.

Discussion.—The cranidium of this species differs from *Syspacheilus* cf. *S. camurus* Lochman by having the anterior margin and marginal furrow more strongly rounded, the border relatively wider, and the fixed cheeks downsloping. Several specimens identical to cranidia figured by Miller and by Lochman and Duncan extend the known geographic range of this species from Wyoming and Montana into central Texas.

Figured specimen.—

	Length
Cranidium, UT-32187, from TC-345	10 mm.

Occurrence.—Rare, lower portion of the *Cedarina-Cedaria* zone. Specimens have been obtained only from the Threadgill Creek section at: TC-340, 345, 348.

Family LLANOASPIDAE Lochman

ARCUOLIMBUS Palmer, n. gen.

Genotype.—*Arcuolimbus convexus* Palmer, n. sp.

Diagnosis.—Cranidium, exclusive of the posterior limbs, subquadrate in outline, slightly longer than wide, moderately arched transversely and longitudinally, and distinctly rounded at anterior margin. Glabella elongate, nearly parallel sided, moderately arched transversely and longitudinally, well defined by shallow dorsal furrow, bluntly rounded anteriorly; length about two-thirds and width about one-half that of the cranidium. There are three pairs of faint, straight, posteriorly directed glabellar furrows. Occipital furrow moderately wide and deep, curving slightly forward medially. Occipital ring moderately arched, longest on median longitudinal line. Border flat, its axial length equal to or slightly greater than that of downsloping brim; separated from brim by narrow, well defined marginal furrow. The furrow has a sinuous course caused by being curved more strongly forward in front of the glabella than in front of the fixed cheeks. Fixed cheeks about one-fourth width of glabella, rising steeply from dorsal furrow. Palpebral lobes situated on highest point of cheeks, slightly posterior to transverse median line of glabella; weak ocular ridges present. Posterior limbs slender, slightly longer than occipital ring, very slightly backswept. Marginal furrow moderately deep, parallels posterior margin. Anterior course of facial suture moderately divergent from longitudinal axis. Posterior course at nearly ninety degrees to longitudinal axis just behind the palpebral lobes, turns abruptly back distally to cut posterior margin within genal angle.

Free cheek not known.

Pygidium subtriangular in outline, slightly wider than long, strongly arched transversely. Longitudinal profile flat along axial lobe abruptly depressed behind. Axial lobe moderately arched transversely well defined by dorsal furrow, tapers slightly backward and reaches nearly to posterior margin; divided into six segments, and a pointed, slightly upturned terminal portion; width slightly less than one-third that of pygidium. Pleural lobes strongly arched, nearly vertical along lateral margins; bearing four or five shallow furrows, which do not extend onto the narrow, poorly defined border. Margin rises in broad curve from front to back so that lower edge of pygidium when viewed from rear resembles broad, overturned V.

Surface of all known parts of carapace smooth.

Derivation of name.—*Arcus,* L. bow; *limbus,* L. edge, margin; referring to the distinctive marginal furrow outlining the anterior margin of the brim.

Discussion.—The presence of a distinct brim and border and broadly curved marginal furrow in association with the elevated fixed cheeks, and the posterior position of the palpebral lobes serve to distinguish the cranidia of this genus from known Dresbachian forms. The strong transverse arching of the pygidia and characteristic posterior view are unlike any described genus.

The shape of the glabella, character of the fixed cheeks, position of the palpebral lobes, and long posterior limbs suggest a possible relationship to llanoaspid trilobites.

ARCUOLIMBUS CONVEXUS Palmer, n. sp.

Plate 83, figures 1, 2, 4

As this is the only known species of the genus, the distinctive specific characteristics cannot be ascertained. The generic description is also a description of the species. Nine cranidia and three associated pygidia

of this species are present in the collections.

Figured specimens.—

	Length
Holotype, cranidium, UT-32082, from TC-655	6 mm.
Cranidium, UT-32083, from TC-655	5 mm.
Pygidium, UT-32084, from TC-655	2.5 mm.

Occurrences.—Moderately rare, *Coosella* zone. Specimens have been obtained from measured sections at: JR-120, 132; MC-453; TC-655; U.S.G.S. coll. 4 (CO).

Genus GENEVIEVELLA Lochman, 1936

Genevievella LOCHMAN, 1936, p. 40; SHIMER and SHROCK, 1944, p. 625.

Genotype.—*Genevievella neunia* Lochman 1936, p. 41, pl. 9, figs. 12–21.

Diagnosis.—Glabella prominent, well defined by dorsal furrow; occipital furrow deep, straight; occipital ring with or without median spine. Border relatively short compared to that of *Llanoaspis,* tangent to front of glabella or separated from it by short brim. Marginal furrow straight, shallow. Fixed cheeks about one-third width of glabella; palpebral lobes situated on or slightly posterior to transverse median line of glabella. Posterior limbs longer than occipital ring, tapered distally.

Pygidium subsemicircular in outline. Axial lobe prominent, extended nearly entire length of pygidium, indistinctly segmented. Pleural lobes marked by distinct, narrow pleural furrows that continue onto concave border.

Discussion.—Resser (1938b, p. 33) suppressed *Llanoaspis* Lochman 1938 in favor of *Genevievella* Lochman 1936 without stating any reasons. The cranidium of *Llanoaspis* has a wide border and a slightly pointed or moderately rounded anterior margin. The posterior limbs are long, expand distally, and the marginal furrow curves forward to cut the anterolateral margin of the limb. The cranidium of *Genevievella* has a narrow border and gently rounded anterior margin. The posterior limbs are long, do not expand distally, and the marginal furrow cuts the lateral margin of the limb.

The pygidium of *Llanoaspis* has six or more segments on the axial lobe and on the pleural lobes, delineated by distinct narrow furrows. The pygidium of *Genevievella* has five or less indistinctly defined axial segments and an equivalent number of moderately well defined pleural segments. In addition, species of *Genevievella* are small trilobites characteristic of the *Cedarina-Cedaria* and lower *Coosella* zone equivalents, whereas species of *Llanoaspis* are at least twice as large in the adult condition and are characteristic of the upper *Coosella* zone and *Maryvillia* zone equivalents.

All of the "species" described by Resser (1938a) and assigned to *Genevievella* are considered here to belong to *Llanoaspis.*

GENEVIEVELLA cf. G. SPINOSA Lochman
Plate 83, figures 3, 5, 6

Genevievella spinosa LOCHMAN, 1944, p. 104, pl. 13, figs. 35–41.

Diagnosis.—Cranidium with glabella tapered forward, bluntly rounded anteriorly; brim narrow; occipital ring with distinct spine. An exfoliated pygidium associated with the illustrated cranidium has the anterior ridge of each segment of the pleural lobe continued backward across the border. An isolated pygidium questionably assigned to this species has narrow, posteriorly curved pleural furrows on the pleural platform, a sinuous, undulating posterior margin, and a granular surface.

Discussion.—The cranidia from Texas differ from the types of *G. spinosa* Lochman in Montana by having a somewhat wider brim and less tapered glabella. Because of the small number of specimens in the collections from both areas, the amount of variation within the species is not known. The differences that do exist might well be attributed to geographic variation inasmuch as both groups come from about the same stratigraphic horizon.

Figured specimens.—

	Length
Cranidium, UT-32127, from MC-419	2.5 mm. (to occipital furrow)
Pygidium, UT-32128, from MC-419	2.0 mm.
Pygidium, UT-32129, from TC-580	2.5 mm.

Occurrence.—Rare, *Coosella* zone. Specimens have been obtained from measured sections at: MC-419; TC-580; U.S.G.S. coll. 4(CO).

Genus LLANOASPIS Lochman, 1938

Llanoaspis LOCHMAN, 1938a, p. 80.

Genotype.—*Llanoaspis modesta* Lochman 1938a, p. 81, pl. 17, figs. 9–14.

Diagnosis.—Cranidium, exclusive of posterior limbs, subquadrate in outline, moderately to strongly rounded or bluntly acuminate anteriorly. Glabella prominent, nearly parallel sided, bluntly rounded anteriorly, reaching to border and marked by three pairs of shallow arcuate glabellar furrows. Border moderately wide, flat, or with undulating lateral profile. Marginal furrow narrow, tangent to anterior end of glabella, straight or directed somewhat posteriorly towards axial line. Fixed cheeks narrow, upsloping; palpebral lobes situated slightly posterior to transverse median line of glabella; ocular ridges usually visible, intersecting dorsal furrow well behind anterior end of glabella. Posterior limbs long, expanded distally; marginal furrow deep, narrow, curved forward to cut anterior margin of limb. Anterior course of facial suture nearly straight forward in front of palpebral lobe; posterior course curves forward from palpebral lobe and then outward to cut lateral margin of cranidium.

Pygidium with axial lobe reaching nearly to posterior margin, consisting of six or more segments poorly defined along axial line. Pleural lobes with deep, narrow pleural furrows that extend onto border. Border wide anteriorly, tapered rapidly to a thin band behind fifth or sixth pleural segment.

Discussion. The difference between this genus and *Genevievella,* with which it has been confused by Resser (1938a, b), are discussed under *Genevievella* (p. 736).

The types of all described species referable to *Llanoaspis* have been studied by the writer. In his opinion, there has been unnecessary discrimination of new species. Complete synonymies of each species recognized in central Texas are given with the species descriptions.

LLANOASPIS MODESTA Lochman
Plate 82, figures 10, 11

Llanoaspis modesta LOCHMAN, 1938a, p. 81, pl. 17, figs. 9–14.
Genevievella campbelli RESSER. 1938a, p. 77, pl. 15, figs. 1, 2.
Genevievella walcotti RESSER, 1938a, p. 77, pl. 15. figs. 3–5.
Genevievella blandensis RESSER, 1938a, p. 78, pl. 15, fig. 11.
Genevievella marionensis RESSER, 1938a, p. 78, pl. 15, figs. 14, 15.
Genevievella wallacensis RESSER, 1938a, p. 79, pl. 15, figs. 12, 13.
Genevievella buttsi RESSER, 1938a, p. 79, pl. 15, figs. 19, 20.

Diagnosis.—Cranidium gently arched longitudinally, Glabella moderately arched in transverse profile. Longitudinal profile of border flat or slightly convex upward. Marginal furrow straight and tangent to anterior end of glabella or curved forward slightly around it.

Pygidia have no apparent distinctive specific characteristics.

Discussion.—The longitudinal profile of the border and the course of the marginal furrow distinguish this species from all other members of *Llanoaspis.* In central Texas, the pygidia have a greater relative length, one or two more segments, and larger anterolateral "flaps" than those associated with *L. undulata* Lochman. The six species described by Resser and cited in the synonymy conform to the concept of *Llanoaspis modesta* Lochman in all observable characteristics.

Figured specimens.—

	Length
Holotype, cranidium, USNM 95509, from near Fredonia, San Saba County, Texas	4.5 mm.
Pygidium, UT-32148, from MC-472	6.0 mm.

Occurrence.—Moderately common, upper portion of the *Coosella* zone. Specimens have been obtained from measured sections at: JR-144, 163; MC-472, 475, 483; TC-702; WC-695.

LLANOASPIS PECULIARIS (Resser)
Plate 82, figure 5

Genevievella peculiaris RESSER, 1938a, p. 78, pl. 15, figs. 6, 7.

Diagnosis.—Cranidium strongly arched longitudinally. Glabella moderately to strongly arched in transverse profile. Longitudinal profile of border flat or concave with inner portion downsloping from front of glabella. Marginal furrow straight, tangent to anterior end of glabella.

Pygidium has no distinctive specific characteristics.

Discussion.—Only cranidia of this species have been found in central Texas. *L. peculiaris* (Resser) differs from other species of the genus by having a strongly arched longitudinal cranidial profile and a somewhat shorter and broader glabella. The posterior limbs are not expanded distally to the degree commonly present in the other species.

A specimen possibly conspecific with *L. peculiaris* (Resser) is present in U.S.G.S. collection 6a (OS) from the Sawatch quartzite near Taylor Peak in the Sawatch Range in central Colorado.

Figured specimen.—

	Length
Cranidium, UT-32149, from MC-516	5.5 mm.

Occurrence.—Moderately common in the upper portion of the *Maryvillia* zone. Specimens have been obtained from measured sections at: JR-218; LL-557; MC-516; S-369.

LLANOASPIS UNDULATA Lochman
Plate 82, figures 6, 7

Llanoaspis undulata LOCHMAN, 1938a, p. 81, pl. 17, figs. 24–26.
Genevievella rogersvillensis RESSER, 1938a, p. 78, pl. 15, figs. 16–18.
Llanoaspis montanensis LOCHMAN, 1944, p. 67, pl. 7; figs. 14, 15.

Cranidium gently arched longitudinally. Glabella moderately arched in transverse profile. Longitudinal profile of border sigmoid, being concave upward directly in front of marginal furrow and convex upward near anterior margin. Marginal furrow either straight and tangent to anterior end of glabella or curves very slightly forward around it.

Pygidium has no distinctive specific characteristics.

Discussion.—The undulating margin and straight marginal furrow are distinctive characteristics of *L. undulata* Lochman. It is the commonest and most widespread species of *Llanoaspis*. *Genevievella rogersvillensis* Resser from the Nolichucky shale in Tennessee and *Llanoaspis montanensis* Lochman from the Pilgrim limestone in Montana conform to the concept of this species in all observable characteristics. In addition to described specimens from Montana, Texas, and Tennessee, specimens of this species are present in U.S.G.S. collection 738 (CO) from the Little Dragoon Mountains in southeastern Arizona, and in U.S.G.S. collection 39e (OS) from the Highland Range in Nevada. In central Texas the pygidia are relatively shorter and have smaller anterolateral "flaps" than those of *L. modesta* Lochman.

Figured specimens.—

	Length
Cranidium, UT-32150, from WC-706	5.0 mm.
Pygidium, UT-32151, from MC-504	2.5 mm.

Occurrence.—Moderately common, lower portion of the *Maryvillia* zone. Specimens have been obtained from measured sections at: JR-201; LL-507, 537; MC-504; P-602?; TC-732; WC-706.

LLANOASPIS UNDULATA Lochman var. GRANULATA Palmer, n. var.
Plate 82, figure 9

Two cranidia assigned to *L. undulata* Lochman have strongly granulated borders. The borders of all other known cranidia of this species are smooth. Scattered granules are present, however, on some pygidia in the collections. Granulation is such a variable feature in many trilobites that it is considered only a varietal characteristic in this instance inasmuch as all other distinguishing criteria are lacking.

Figured specimen.—

	Length
Holotype, cranidium, UT-32152, from LL-537	6 mm.

Occurrence.—Rare, *Maryvillia* zone. Specimens have been obtained from measured sections at: LL-537; MC-504.

LLANOASPIS VIRGINICA (Resser)
Plate 82, figure 8

Genevievella virginica RESSER, 1938a, p. 79, pl. 15, fig. 8.

Diagnosis.—Cranidium gently arched longitudinally. Glabella moderately arched in transverse profile. Border has sigmoid longitudinal profile, being concave directly in front of marginal furrow and convex near anterior margin. Marginal furrow curves slightly backward and intersects dorsal furrow between anterolateral corners of glabella.

Pygidium has no distinctive specific characteristics.

Discussion.—This species is similar to *L. clinchensis* (Resser, 1938a, p. 78) (jr. syn. *L. dorothea* Lochman, 1944, p. 66). It differs from that species by having the marginal furrow gently instead of sharply curved backward near the glabella, and the border sigmoid instead of convex upward in longi-

tudinal profile. Lochman (1944, p. 67) considered *L. virginica* (Resser) a synonym of *L. rogersvillensis* (Resser). The writer has examined the types of both species and is of the opinion that the gentle backward curvature of the marginal furrow on the cranidium of *L. virginica* (Resser) is a distinctive specific characteristic, and **that** *L. rogersvillensis* (Resser) is a synonym of *L. undulata* Lochman.

Figured specimen.—

	Length
Cranidium, UT-32153, from WC-628	9 mm.

Occurrence.—Rare, *Coosella* zone. A single specimen has been obtained from WC-628.

Family MENOMONIIDAE Walcott, 1916
(emend. Shaw, 1952)
Genus BOLASPIDELLA Resser, 1937

Bolaspidella RESSER, 1937, p. 3; SHAW, 1952, p. 477.
Hysteropleura RAYMOND, 1937, p. 1094.
Deltophthalamits RESSER, 1938, p. 74.
Deissella HOWELL and DUNCAN, 1939, p. 7; SHIMER and SHROCK, 1944, p. 609.
Howellaspis LOCHMAN and DENSON, in Lochman and Duncan, 1944, p. 125.

Genotype.—Ptychoparia housensis Walcott, 1886, p. 201, pl. 25, fig. 5.

Diagnosis.—Cranidium distinctly subtrapezoidal in outline, gently to moderately arched transversely and longitudinally, gently to moderately rounded at anterior margin; axial length between one-half and three-fourths width at posterior margin. Glabella small, prominent, tapered gently forward, truncated anteriorly, moderately well defined by dorsal furrow; width at occipital ring about one-fourth width of cranidium at posterior margin; axial length, including occipital ring, about two-thirds cranidial length. Two pairs of faint glabellar furrows often represented by depressions in glabellar sides; occipital furrow shallow; occipital ring widest on median line, may bear a spine. Frontal area concave in most species, moderately to strongly arched transversely; margin upturned to form distinct border poorly defined by shallow marginal furrow. Fixed cheeks broad, upsloping, as wide, or slightly wider than glabella; palpebral lobes prominent, situated slightly anterior to transverse median line of glabella; indistinct ocular ridges extend nearly straight out from anterolateral corners of glabella to anterior ends of palpebral lobes. Posterior limbs broad, triangular, steeply depressed distally; marginal furrow broad, shallow; anterior course of facial suture nearly straight forward from palpebral lobe until reaching border where it turns sharply inward and is intra-marginal for short distance before cutting anterior margin. Posterior course of facial suture makes angle of about 60 degrees with longitudinal axis of cranidium, continues in this manner for short distance and then curves strongly backward to cut posterior margin well within genal angle.

Outer surface of many specimens bears scattered granules.

Free cheek gently to moderately arched, transversely elongate; outline resembles one-fourth of an ellipse with its short radius parallel to axis of cranidium and slightly greater than one-half its long radius in length. Eye at inner angle. Border well defined by shallow marginal furrow; width slightly less than one-third length of short radius. Marginal furrow curves inward distally leaving broad, short, pointed genal spine.

Pygidium small, about two-thirds as long as wide. Axial lobe well defined, segmented, tapered slightly posteriorly, terminated just before reaching posterior margin. Pleural lobes gently arched, downsloping to broad, slightly concave border. Faint furrows bend backward paralleling anterior margin and extend slightly onto border.

Discussion.—Lochman and Duncan (1949, p. 439) and Shaw (1952, p. 477) have considered *Howellaspis* and *Hysteropleura* respectively to be synonyms of *Bolaspidella*. The writer is of the opinion that *Deissella* (Howell and Duncan, 1939, p. 7) and *Deltophthalamus* (Resser, 1938, p. 74) are additional synonyms of that genus. Each of these four genera agrees in all observable characteristics with the diagnosis of *Bolaspidella* given above.

This genus is a rather common constituent of the faunas of upper Middle Cambrian and lower Upper Cambrian rocks in the United States.

The small, prominent glabella; wide, concave, transversely arched frontal area; distinct, upturned border; moderately wide fixed cheeks; and anterior position of the

palpebral lobes are characteristic of cranidia of this genus. The single pygidium known has no observable distinctive generic characteristics.

BOLASPIDELLA BURNETENSIS (Walcott)
Plate 83, figures 10, 12, 13

Piychoparia burnetensis WALCOTT, 1890, p. 272, pl. 21, fig. 1.
Cedaria burnetensis (Walcott) RESSER, 1936, p. 12; LOCHMAN, 1938a, p. 78, pl. 17, fig. 29.

Diagnosis.—Cranidium with anterior margin moderately to strongly rounded. Length of frontal area about one-third that of cranidium; profile gently concave upward. Border gently upsloping, axial length about equal to that of brim. Palpebral lobes situated opposite anterior third of glabella. Occipital ring without spine.

Free cheek and pygidium without distinctive observable specific characteristics.

Discussion.—The principal distinguishing characteristic of this species is the longitudinal profile of the frontal area. The border is not distinctly upturned, and therefore the frontal area is gently concave instead of moderately to strongly concave as in all other known species of *Bolaspidella.*

Resser (1936, p. 12) referred the types of this species to *Cedaria,* and Lochman (1938a, p. 78) illustrated Walcott's holotype, also referring it to *Cedaria.* The writer has examined the types and has collected additional material from approximately the type locality (MC-222). The glabella and free cheek of this species are characteristic of trilobites of the Menomoniidae. The pygidium, although poorly preserved, lacks the flat border and well defined pleural furrows of species of *Cedaria.* The writer believes that the assignment of this species to *Cedaria* resulted from imperfect knowledge of the poorly preserved type material. He considers *Ptychoparia burnetensis* Walcott to be a distinct species of *Bolaspidella.*

Figured specimens.—

	Length
Cranidium, UT-32091, from P-326	4.0 mm.
Pygidium, UT-32092, from P-326	1.5 mm.
	Width
Free cheek, UT-32095, from P-326	3.0 mm.

Occurrence.—Moderately common, *Bolaspidella* zone. Specimens have been obtained from measured sections at: LL-252; MC-222; P-320, 326; TC-323, 330.

BOLASPIDELLA PROOCULIS Palmer, n. sp.
Plate 83, figures 14, 15

Diagnosis.—Cranidium with anterior margin moderately rounded. Length of frontal area about one-third that of cranidium; border strongly upturned. Palpebral lobes situated opposite anterior end of glabella; ocular ridges extend slightly forward from anterolateral corners of glabella so that a line tangent to anterior ends of palpebral lobes passes just anterior to front of glabella. Occipital ring without spine.

Free cheek without distinct observable specific characteristics. Pygidium unknown.

Discussion.—This species differs from *B. wellsvillensis* (Lochman and Denson) principally in the position of the palpebral lobes and the forward extension of the ocular

EXPLANATION OF PLATE 82
TRICREPICEPHALIDAE, LLANOASPIDAE

FIG. *1*—*Meleoraspis* cf. *M. loisi* Lochman, ×3, pygidium, UT-32161, P-618; *Maryvillia* zone. (p. 753)

2, 4—*Meteoraspis melra* (Walcott), ×2. *2,* rubber cast of pygidium, UT-32163, MC-453; *4,* exfoliated cranidium, UT-32162, MC-453; *Coosella* zone. (p. 753)

3—*Meteoraspis* cf. *M. robusta* Lochman, ×2, exfoliated cranidium, UT-32164, MC-373; *Cedarina-Cedaria* zone. (p. 754)

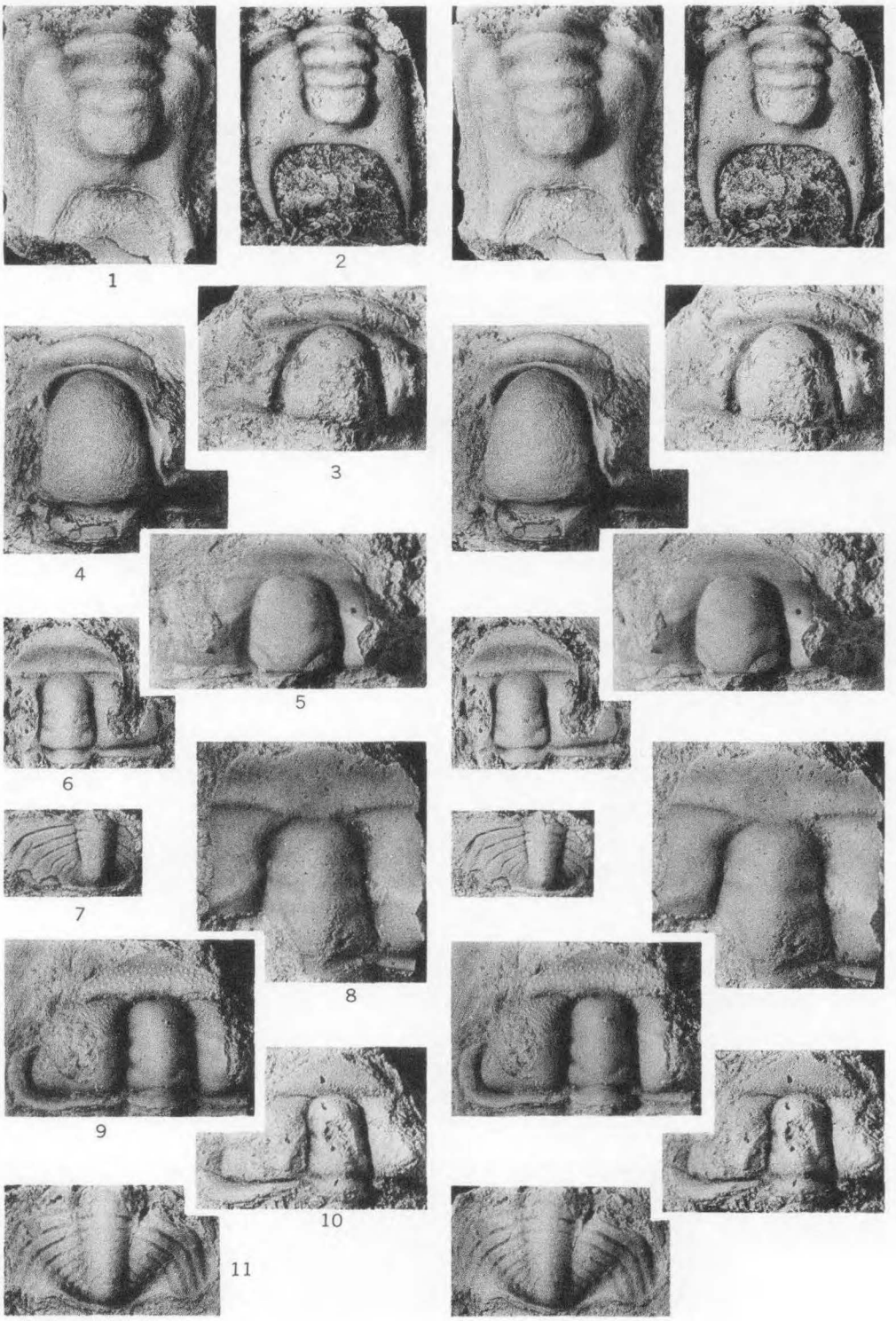
5—*Llanoaspis peculiaris* (Resser), ×4, cranidium, UT-32149, MC-516; *Maryvillia* zone. (p. 737)

6, 7—*Llanoaspis undulata* Lochman, ×4. *6,* exfoliated cranidium, UT-32150, WC-706; *7,* pygidium, UT-32151, MC-504; *Maryvillia* zone. (p. 738)

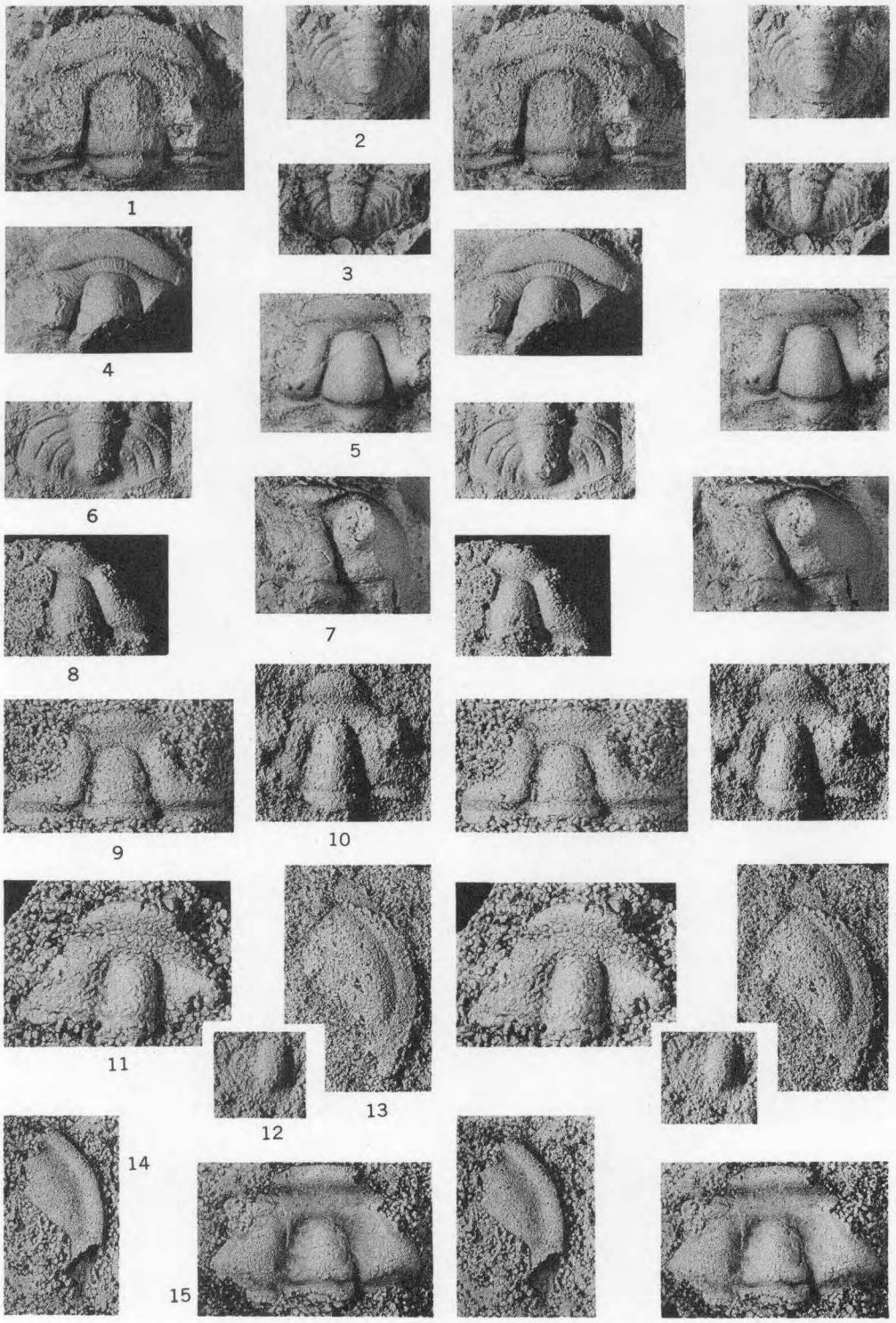
8—*Llanoaspis virginica* (Resser), ×4, exfoliated cranidium, UT-32153, WC-628; *Coosella* zone. (p. 738)

9—*Llanoaspis undulata granulata* Palmer, n. var., ×4, cranidium, UT-32152, LL-537; *Maryvillia* zone. (p. 738)

10, 11—*Llanoaspis modesta* Lochman. *10,* holotype cranidium, ×5, USNM 95520, near Fredonia, San Saba Co., Texas; *11,* pygidium, ×3, UT-32148, MC-472; *Coosella* zone. (p. 737)



Palmer, Cambrian faunas from Texas



Palmer, Cambrian faunas from Texas

ridges. These features are consistent for at least 20 specimens from two localities.

Figured specimens.—

	Length
Holotype: Cranidium, UT-32095, from 16T-6-9A	5 mm.
	Width
Free cheek, UT-32094, from 16T-6-9A	3 mm.

Occurrence.—Moderately common, *Bolaspidella* zone. Specimens have been obtained from the lower part of the Hickory sandstone member at two localities: 16T-6-9A and 16T-6-20A.

BOLASPIDELLA WELLSVILLENSIS
(Lochman and Denson)
Plate 83, figure 11

Howellaspis wellsvillensis LOCHMAN and DENSON, 1944, in Lochman and Duncan, p. 124, pl. 15, figs. 18–20.
Bolaspidella wellsvillensis (Lochman and Denson) LOCHMAN and DUNCAN, 1949, p. 439.
Howellaspis snowyensis DUNCAN, 1944, in Lochman and Duncan, p. 126, pl. 15, figs. 14–17.
Bolaspidella snowyensis (Duncan) LOCHMAN and DUNCAN, 1949, p. 439.

Diagnosis.—Cranidium with anterior margin moderately rounded. Length of frontal area about one-third that of cranidium; border strongly upturned. Palpebral lobes extend nearly straight laterally or very slightly backward from anterolateral corners of glabella. Occipital ring without spine.

Free cheek and pygidium not known.

Discussion.—This is the most widespread species of *Bolaspidella*. Specimens referable to it have been seen by the writer in collections from southeastern Arizona, central Nevada, Utah, Montana, and Texas.

Bolaspidella snowyensis (Duncan) does not differ significantly in any feature except preservation from *B. wellsvillensis* (Lochman and Denson).

Figured specimen.—

	Length
Cranidium, UT-32096, from TC-288	5 mm.

Occurrence.—Moderately common, *Bolaspidella* zone. Specimens have been obtained from measured sections at: P-279; TC-288, 296; WC-252?, 270, 341.

BOLASPIDELLA sp.
Plate 83, figure 9

A cranidium with a nearly straight border and anterior margin, elevated fixed cheeks, anteriorly situated palpebral lobes, and relatively narrow posterior limbs may represent another species of *Bolaspidella*. The anterior margin is less curved, the border is less strongly upturned, and the free cheeks and posterior limbs are narrower than *B. prooculis* Palmer. The character of the frontal area and the more anterior position of the palpebral lobes distinguish it from *B. wellsvillensis* (Lochman and Denson) and *B. burnetensis* (Walcott). Fragmentary poorly preserved cranidia associated with the figured specimen, and from approximately the same stratigraphic horizon in another section suggest that the differences cited may be significant.

Figured specimen.—

EXPLANATION OF PLATE 83
LLANOASPIDAE, MENOMONIIDAE

FIGS. *1, 2, 4—Arcuolimbus convexus* Palmer, n. gen., n. sp. *1,* partly weathered holotype cranidium, X4, UT-32082, TC-655; *2,* pygidium, ×5, UT-32084, TC-655; *4,* cranidium, ×4, UT-UT-32083, TC-655; *Coosella* zone. (p. 735)
3, 5, 6—Genevievella cf. *G. spinosa* Lochman. *3,* rubber cast of pygidium, X6,UT-32128,MC-419; *5,* cranidium, ×6, UT-32127, MC-419; *Coosella* zone. *6,* rubber cast of pygidium questionably assigned to this species, ×5, UT-32129,TC-580; *Cedarina-Cedaria* zone. (p. 736)
7—Densonella sp., ×5, fragmentary cephalon, UT-32159, MC-453; *Coosella* zone. (p. 742)
8—Menomonia sp., ×5, cranidium, UT-32160, TC-432; *Cedarina-Cedaria* zone. (p. 742)
9—Bolaspidella sp., ×4, cranidium, UT-32097, MC-283: *Cedarina-Cedaria* zone. (p. 741)
10, 12, 13—Bolaspidella burnetensis (Walcott), ×5. *10,* rubber cast of cranidium, UT-32091, P-326; *12,* rubber cast of pygidium, UT-32092, P-326; *13,* free cheek, UT-32093, P-326; *Bolaspidella* zone. (p. 740)
11—Bolaspidella wellsvillensis (Lochman and Denson), ×4, cranidium, UT-32096, TC-288; *Bolaspidella* zone. (p. 741)
14, 15—Bolaspidella prooculis Palmer, n. sp., ×4. *14,* free cheek, UT-32094, 16T-6-9A; 75, holotype cranidium, UT-32095, 16T-6-9A; *Bolaspidella* zone. (p. 740)

Length
Cranidium, UT-32097, from MC-283 4 mm.

Occurrence.—Rare, lower portion of the *Cedarina-Cedaria* zone. Specimens have been obtained from measured sections at the following horizons: MC-283; P-354.

Genus DENSONELLA Shaw, 1952

Millardia WALCOTT, 1916 (not *Millardia* Thomas, 1911), p. 163; LOCHMAN, 1940a, p. 9.
Densonella SHAW, 1952, p. 477.

Genotype.—Millardia semele Walcott, 1916, p. 166.

The writer follows the diagnosis of this genus given by Lochman (1940, p. 9, as *Millardia).*

DENSONELLA sp.
Plate 83, figure 7

Three fragmentary specimens have the small, prominent tapered glabella, the stalked eyes, and the tight facial suture characteristic of this genus. None are well enough preserved for accurate comparison with D. *magnagranulata* (Lochman) and *D. avitas* (Walcott) described from the Riley formation by Lochman (1938a, p. 84).

Figured specimen.—

Length
Cephalon, UT-32159, from MC-453 3.5 mm.

Occurrence.—Rare, *Coosella* zone. Specimens have been obtained from measured sections at: LL-468; MC-453; U.S.G.S. coll. 4 (CO).

Genus MENOMONIA Walcott, 1916

Menomonia WALCOTT, 1916, p. 161; RESSER, 1938b, p. 34; LOCHMAN, 1940a, p. 9; SHIMER and SHROCK, 1944, p. 627.

Genotype.—Conocephalites calymenoides Whitfield, 1878, p. 52.

The writer follows the diagnosis of this genus given by Lochman (1940, p. 9).

MENOMONIA sp.
Plate 83, figure 8

Six fragmentary cranidia have the small, prominent, tapered glabella and the anteriorly placed, unstalked eyes characteristic of *Menomonia.* None are well enough preserved for specific determination.

Figured specimen.—

Length
Cranidium, UT-32160, from TC-432 3 mm.

Occurrence.—Rare, *Cedarina-Cedaria* zone. Specimens have been obtained from measured sections at: TC-348, 362, 429, 432, 515; WC-460.

Family NORWOODIIDAE Walcott, 1916
Genus HOLCACEPHALUS Resser, 1938

Holcacephalus RESSER, 1938, p. 81; LOCHMAN, 1940a, p. 515.
Norwoodina LOCHMAN, 1940a, p. 11.

Genotype.—Holcacephalus granulatus Resser, 1938, p. 81, pl. 9, figs. 15–17.

The writer follows the diagnosis for this genus given by Lochman (1940a, p. 11, as *Norwoodina).*

HOLCACEPHALUS cf. H. TENERUS (Walcott)
Plate 84, figure 3

Norwoodia tenera WALCOTT, 1916, p. 172, pl. 28, figs. 2–2g; LOCHMAN, 1938, p. 83, pl. 18, figs. 11–13.
Norwoodina tenera (Walcott) LOCHMAN, 1940a, pp. 11, 50, pl. 5, figs. 12–14.
Holcacephalus tenerus (Walcott) LOCHMAN and DUNCAN, 1944, p. 137, pl. 13, figs. 15–17.
Holcacephalus granulatus RESSER, 1938, p. 81, pl. 9, figs. 15–17.

Seven incomplete cranidia have the elongate subrectangujar glabella and short, subequally divided frontal area characteristic of this species. They differ from the types by having a pair of low nodes on the fixed cheeks opposite the posterior end of the glabella and adjacent to the dorsal furrow.This feature also seems to be present on the specimen figured by Rasetti (1946, pl. 69, fig. 16) as *Holcacephalus* cf. *H. tenera* (Walcott). The significance of these nodes cannot be determined with the material available. More and better specimens may show that they are a distinctive specific characteristic.

Figured specimen.—

Length
Cranidium, UT-32132, from JR-42 1.5 mm.

Occurrence.—Moderately rare, upper portion of the *Cedarina-Cedaria* zone and lower portion of the *Coosella* zone. Specimens have been obtained from measured sections at: JR-42; MC-419, 446; U.S.G.S. coll. 4 (CO).

Genus NORWOODIA Walcott, 1916

Norwoodia WALCOTT, 1916, p. 168; RESSER, 1938b, p. 36; LOCHMAN, 1940a, p. 10; SHIMER and SHROCK, 1944, p. 629.

Whitfieldina RESSER, 1937, p. 27.

The writer follows the diagnosis for this genus given by Lochman (1940a, p. 10).

NORWOODIA QUADRANGULARIS (Whitfield)
Plate 84, figure 1

Conocephalites quadratus WHITFIELD, 1880 (not Hartt, 1868), p. 47; 1882, p. 180, pl. 1, figs. 15, 16.
Ptychoparia? quadrata (Whitfield) MILLER, 1889, p. 565.
Ptychoparia quadrangularis WHITFIELD in Vogdes, 1890, p. 144; 1893, p. 353.
Whitfieldina quadrata (Whitfield) RESSER, 1937, p. 27.
Norwoodia quadrata (Whitfield) RESSER, 1938b, p. 36; LOCHMAN, 1940a, p. 46, pl. 5, figs. 22,

A single specimen has the long, strongly depressed brim and short border characteristic of this species. It shows for the first time the character of the posterior limb. This structure is broken from all of the cranidia obtained from the type area in Wisconsin. The limb is long, expanded slightly outward, and bears a moderately long, slightly curved genal spine.

Figured specimen.—

	Length
Cranidium, UT-32165, from MC-419	2 mm.

Occurrence.—Rare, lower portion of the *Coosella* zone. The single specimen came from MC-419.

Family PTYCHOPARIIDAE Matthew, 1888
Genus APHELASPIS Resser, 1935

Aphelaspis RESSER, 1935, p. 11; SHIMER and SHROCK, 1944, p. 619.

Genotype.—Aphelaspis walcotti Resser, 1938, p. 59, pl. 13, fig. 14 (see Palmer, 1953, p. 157, for discussion).

Diagnosis.—Cranidium with glabella straight-sided, usually truncate anteriorly; frontal area consisting of distinct brim and border but lacking well defined marginal furrow.

Free cheek with distinct border and genal spine but without well defined marginal furrow along lateral margin.

Pygidium with short axial lobe consisting of three or four segments. Border broad, poorly defined.

Description.—The abundant material of this genus present in the collections from central Texas, supplemented by material in the collections of the United States National Museum, allows for a clearer generic concept than has hitherto been given.

The carapace is ovate in outline with the greatest width on line with the posterior margin of the cephalon. The cephalon is subsemicircular in outline with posteriorly directed genal spines.

The cranidium, exclusive of the posterior limbs, tends to be elongate rectangular in outline, moderately arched transversely and longitudinally, and moderately to strongly rounded at the anterior margin. The glabella is distinct, well defined, straight sided, tapers slightly forward, and is bluntly rounded or truncate anteriorly. It is commonly featureless, although traces of three pairs of slightly arcuate glabellar furrows can sometimes be seen on weathered specimens. There is a tendency for the dorsal furrow around the front of the glabella to be deepest at the anterolateral corners and quite shallow on the axial line. The occipital ring may or may not bear a median spine. A shallow occipital furrow is always present on the axial line but may disappear before reaching the dorsal furrow. Both a brim and border are present. They are separated by a distinct, usually sharp break in slope. There is no marginal furrow. The brim is gently to moderately arched, usually continuing the curvature of the longitudinal profile of the cranidium. The border is approximately horizontal and very gently arched transversely and longitudinally. The fixed cheeks are approximately horizontal, very gently arched, and narrow, usually about one-third the greatest width of the glabella. The palpebral lobes are subsemicircular in outline and rather poorly defined by a shallow, arcuate palpebral furrow. Weakly developed ocular ridges are present. The posterior limbs are narrow and sharply pointed. Their length is variable but averages nearly equal to the greatest width of the glabella. The marginal furrow on the posterior limb is broad and shallow.

The facial sutures are divergent in front of the palpebral lobes but turn sharply inward upon reaching the border and cut the anterior margin about opposite the anterolateral corners of the glabella. The posterior course of the facial sutures diverges widely behind the palpebral lobes and continues in a

straight line until across the marginal furrow, where it curves backward to cut the posterior margin well within the genal angle.

The hypostome is elongate subovate in outline and strongly arched transversely and longitudinally. The anterolateral corners are extended into short, depressed, pointed alae. A narrow, distinct border is always present along the lateral margins and may be present around the posterior margin. Two shallow posteriorly curved furrows divide the posterior portion of the hypostome into a pair of faintly defined lobes.

The free cheek has a long slender sharply pointed anterior projection as a result of the partly intramarginal course of the anterior branch of the facial suture. The border on the anterior part of the cheek is separated from the ocular platform by an abrupt change of slope. This relation may continue nearly the length of the lateral margin. A broad shallow marginal furrow usually appears near the genal angle. The continuation of the marginal furrow from the posterior limb of the cranidium is broad and shallow, but conspicuously deeper than the marginal furrow along the outside portion of the cephalon. The two furrows join and continue a short distance on the genal spine as a shallow pointed depression. The genal spine is usually long, slender, curved, and sharply pointed. An infra-ocular ring is present between the eye surface and the surface of the ocular platform.

Several complete carapaces from the southern Appalachians indicate that the thorax probably consisted of 13 segments. The axial lobe is distinct and elevated above the pleural lobes. The pleural furrows are broad and shallow and extend nearly to the sharply pointed tips of the pleural segments. The furrows maintain a position nearly equidistant from the front and back margins of the segments throughout their course.

The pygidium is wide and short and much smaller than the cephalon. The axial lobe is well defined, distinctly elevated above the pleural lobes, and bluntly terminated before reaching the posterior margin. It usually bears three distinct transverse furrows. The pleural lobes may be flat or distinctly arched. The pleural furrows are very shallow. Usually only one or two pairs are visible. A broad, poorly defined border that tapers rapidly towards the axial line is usually present. The posterior margin frequently shows a slight median indentation.

The surface of the carapace in all known species is smooth or finely punctate.

Discussion.—The genus as here described is considered in a more restricted sense than that employed by Resser (1935, 1938a). *A. camiro* (Walcott) (1916, p. 205) and *A. quadrata* Resser (1938a, p. 59) (synonym *A. laxa* Resser, 1938a, p. 60), forms with a distinct marginal furrow separating the brim and border on the cranidium, are excluded from *Aphelaspis*. *A. quadrata* is considered a member of *Labiostria* Palmer, n. gen. *"A." camiro* (Walcott) possibly represents a new genus.

A. hamblenensis Resser (1938a, p. 60) is considered to be a synonym of *A. walcotti* Resser (1938a, p. 59). *A. tumifrons* Resser (1938a, p. 60) and *A. simulans* Resser (1938a, p. 59) appear to be distinct species. *A. wyomingensis* (Miller) (1936, p. 29) is a Middle Cambrian trilobite that has been erroneously placed in *Aphelaspis* by Resser. *"A." depressus* (Shumard) (1861, p. 219) is an indeterminate trilobite, and specimens formerly assigned to this species are considered to be representatives of *A. walcotti* Resser (Palmer, 1953, p. 157).

Cranidia of *A. spinosus* Palmer, from U.S.G.S. collection 7 (CO), and *A. walcotti* Resser, from U.S.G.S. collection 34 (CO), are sufficiently abundant so that a statistical analysis of selected linear ratios has been made (Table I). The mean, the standard deviation of the mean, and the standard errors of each have been calculated for 10 linear ratios derived from measurements of 33 cranidia of *A. spinosus* Palmer, n. sp., and 34 cranidia of *A. walcotti* Resser. The same ratios for the holotypes of *A. longifrons* Palmer, n. sp., and *A. constricta* Palmer, n. sp., are presented for comparison. Figure 5 shows scatter diagrams for the ratios that appeared to be significant for the differentiation of the two populations on the basis of the statistical data.

The cranidia that were studied are preserved in limestone and do not appear to have been distorted. They range in length from 4 to 12 millimeters (av. 8 mm.) and

have at least one fixed cheek, one posterior limb, and the border, brim, glabella, and occipital ring preserved. Measurements were made with a micrometer eyepiece (1 div. equal to .05 mm.) in a binocular microscope as follows:

Longitudinal: (1) length of border: from midpoint of anterior margin to midpoint of marginal furrow; (2) length of brim: from midpoint of marginal furrow to midpoint of dorsal furrow at anterior end of glabella; (3) length of glabella: from midpoint of dorsal furrow at anterior end of glabella to midpoint of posterior margin of occipital ring; (4) length of palpebral lobe on a line parallel to the axial line of the cranidium; (5) from the midpoint of the palpebral furrow to the posterior margin on a line parallel to the axial line of the cranidium.

Transverse: (1) one-half maximum width of cranidium anterior to palpebral lobes; (2) one-half width of cranidium between anterior ends of palpebral lobes; (3) width of glabella between points where ocular ridges touch dorsal furrows; (4) width of fixed cheek; from midpoint of palpebral furrow to midpoint of dorsal furrow on line through midpoints of palpebral furrows; (5) width of cranidium between midpoints of palpebral furrows; (6) width of glabella between midpoints of dorsal furrows at occipital ring; (7) width of posterior limb.

The information presented in Table I and figure 5 shows that minor significant statistical differences between superficially similar fossil populations can be determined by the comparison of selected linear ratios of sufficient numbers of individuals. The taxonomic interpretation of the information, no matter how detailed that information might be, however, remains subjective.

The writer considers *A. spinosus* Palmer, n. sp., a distinct species of *Aphelaspis* that differs from the genotype, *A. walcotti* Resser, and all other described species of *Aphelaspis* by possessing an occipital spine.

The calculated statistical differences cited also may be characteristics of the species or they may be due either to ecological or to temporal factors that have nothing to do with the fundamental characteristics of the species. A study of other populations of *A. spinosus* Palmer and *A. walcotti* Resser from other horizons or localities within the *Aphelaspis* zone will be necessary to determine the real statistically significant characters of the species.

APHELASPIS CONSTRICTA Palmer, n. sp.
Plate 84, figure 11

Diagnosis.—Cranidium with anterior margin gently rounded. Border flat or slightly convex, usually makes angle of less than 90 degrees with brim; axial length averages slightly less than one-half that of brim. Total length of the frontal area averages less than one-third that of the cranidium.

Width of border of free cheek averages less than one-half width of ocular platform at anterior margin.

Pygidium not known.

Discussion.—This is a small species usually associated with *A. longifrons* Palmer, n. sp.

The narrow border of the cephalon and the short frontal area of the cranidium distinguish it from other described species of *Aphelaspis.*

Figured specimen.—

	Length
Holotype: cranidium, USNM 123340, from USGS coll. 8 (CO)	3.5 mm.

Occurrence.—Moderately rare, middle portion of *Aphelaspis* zone. Specimens have been obtained from measured sections at: MC-547; TC-815; U.S.G.S. coll. 8 (CO).

APHELASPIS LONGIFRONS Palmer, n. sp.
Plate 84, figures 9, 12;
plate 85, figures 2, 3

Diagnosis.—Cranidium with anterior margin strongly rounded. Border flat or slightly convex, usually makes angle of less than 90 degrees with brim; axial length averages nearly equal to that of brim. Total length of frontal area averages nearly one-half that of cranidium.

Border of free cheek nearly equal in width to ocular platform at anterior margin of cheek.

Pygidium moderately arched transversely and longitudinally. Axial lobe short, elevated above pleural lobes, tapers to blunt point about one-third its length from posterior margin. Border flat, faintly distinguished from pleural platform, distinctly downsloping.

Discussion.—This is a relatively large

species usually associated with *A. constricta* Palmer.

The wide border, relatively long frontal area, and strongly curved anterior margin are distinctive of the cranidium. The wide border also distinguishes the free cheek. The downsloping border characterizes the pygidium. Comparisons of selected linear ratios on the cranidium with those of the other species of *Aphelaspis* from the Riley formation are shown in Table I and figure 5.

Figured specimens.—

	Length
Holotype cranidium, UT-32078, from TC-815	12.5 mm.
Cranidium, USNM 123316, from USGS coll. 8 (CO)	8.0 mm.
Pygidium, UT-32079, from TC-815	4.0 mm.
	Width
Free cheek, USNM 123316, from USGS coll. 8 (CO)	4.0 mm.

Occurrence,—Moderately rare, middle portion of *Aphelaspis* zone. Specimens have been obtained from measured sections at: MC-547; TC-815; U.S.G.S. coll. 8 (CO).

APHELASPIS SPINOSA Palmer, n. sp.
Plate 84, figure 10

Diagnosis.—Cranidium with anterior margin gently to moderately rounded. Border flat or slightly convex, usually makes angle of less than 90 degrees with brim; axial length averages about two-thirds that of brim. Total length of frontal area averages about one-third that of cranidium. Occipital ring bears strong median spine.

Free cheek and pygidium identical in all respects to those of *A. walcotti* Resser.

Discussion.—This species is distinguished from other species of *Aphelaspis* by the prominent occipital spine on the cranidium. It is similar in all other respects to *A. walcotti* Resser. A comparison of cranidia of a population of *A. spinosa* Palmer with one of *A. walcotti* Resser (Table I, fig. 5) indicates that the average length of the border and of the palpebral lobe of *A. walcotti* Resser is shorter and the glabella is narrower and longer than that of *A. spinosa* Palmer. However, the parameters overlap sufficiently so that single specimens of either population cannot be distinguished with any degree of assurance from each other except by the presence or absence of an occipital spine. Perhaps this is an example of sexual dimorphism.

Figured specimen.—

	Length
Holotype: cranidium, UT-32080, from TC-807	9 mm.

Occurrence.—Common, lower portion of *Aphelaspis* zone. Specimens have been obtained from measured sections at MC-532; P-638; TC-807; U.S.G.S. coll. 7 (CO).

APHELASPIS WALCOTTI Resser
Plate 84, figures 2, 4–8

Not *Conocephalites depressus* SHUMARD, 1861, p. 219.

Aphelaspis depressa (Shumard) BRIDGE, in Bridge and Girty, 1937, p. 255, pl. 69, figs. 23–26; SHIMER and SHROCK, 1944, pl. 263, figs. 35, 36; NELSON, 1951, p. 774, pl. 106, fig. 14.

Aphelaspis walcotti RESSER, 1938a, p. 59, pl. 13, fig. 14; SHIMER and SHROCK, 1944, pl. 263, figs. 19, 20.

Aphelaspis hamblenensis RESSER, 1938a, p. 60, pl. 13, fig. 28; SHIMER and SHROCK, 1944, pl. 263, fig. 37.

Diagnosis.—Cranidium with anterior margin gently to moderately rounded. Border flat or slightly convex, usually makes angle of less than 90 degrees with brim; axial length about two-thirds that of brim. Total length of frontal area averages about one-third that of cranidium. Occipital ring smooth or bears low median node.

Border of free cheek about two-thirds width of ocular platform of anterior margin of cheek.

Pygidium wider than long, gently arched transversely and longitudinally. Axial lobe short, elevated above pleural lobes, tapers to blunt point about one-third its length from posterior margin. Pleural lobes flat or gently arched upward. Border not distinctly differentiated from pleural platform, usually concave.

Discussion.—This is the most common and widespread species of *Aphelaspis*. It has been reported (as *A. depressus* [Shumard], see discussion in Palmer [1953, p. 157]) from Texas (Resser, 1935, p. 11; Bridge, 1937, p. 255), and the Dresbach sandstone in the St. Croix Valley in Minnesota (Nelson, 1951, p. 774), and was originally described from the Nolichucky shale in the southern Appalachians. In addition, the writer has collected specimens of the species

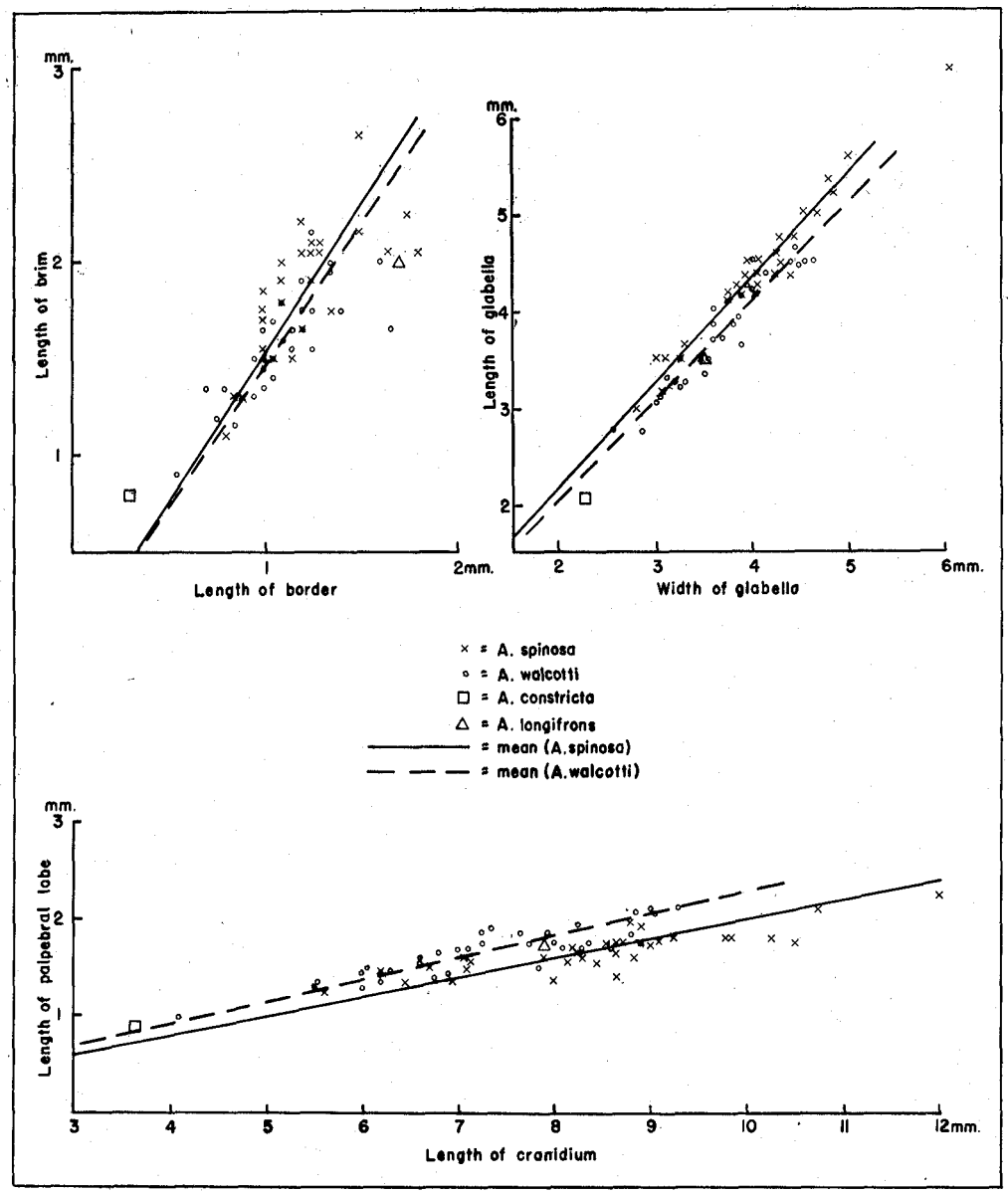


FIG. 5—Graphic comparison of significant linear ratios for the species of *Aphelaspis* described from the Riley formation.

from the Gallatin formation in Wyoming, the Pilgrim limestone in Montana and the Abrigo limestone in Arizona.

A. hamblenensis Resser agrees with the concept of this species in all observable characteristics.

Table I (p. 778) and figure 5 (p. 747) show statistical and graphic comparisons of selected linear ratios of this species with the other species of *Aphelaspis* described from the Riley formation.

Figured specimens.—

	Length
Cranidium, UT-32081 LL-589	6 mm.
Cranidium, USNM 90172, from USGS coll. 67 (OS)	15 mm.
Cranidium, USNM 123315, from USGS coll. 184 (CO)	11.5 mm.
Pygidium, USNM 90172, from USGS coll. 67 (OS)	5 mm.
Hypostome, USNM 90172, from USGS coll. 67 (OS)	4.5 mm.
	Width
Free cheek, USNM 90172, from USGS coll. 67 (OS)	5 mm.

Occurrence.—Common, *Aphelaspis* zone. Specimens have been obtained from measured sections at: JR-248, 250, 260, 265; LL-557, 558, 559, 560, 565, 578, 589; MC-530, 547, 561; P-636, 639, 647, 650, 652, 655; S-387, 393, 412; TC-800, 802, 805, 811, 821, 825; WC-744, 750, 751; U.S.G.S. coll. 7, 8, 9, 10 (CO).

Additional specimens used for illustration are from U.S.G.S. collection 184 (CO) and U.S.G.S. collection 67 (OS).

Genus BLANDICEPHALUS Palmer, n. gen.

Genotype.—*Blandicephalus texanus* Palmer, n. sp.

Diagnosis.—Cranidium, exclusive of posterior limbs, distinctly elongate, gently arched transversely and longitudinally, strongly rounded at anterior margin. Glabella faintly outlined by narrow, shallow dorsal furrow; straight sided, tapered forward, strongly rounded anteriorly; on exfoliated specimens there is a narrow, low, median longitudinal glabellar ridge; three pairs of weakly developed glabellar furrows may sometimes be seen on exfoliated specimens. Shallow occipital furrow and narrow occipital ring may be seen on exfoliated forms only; occipital ring bears small, low median node. Frontal area broad, concave. Border wide, nearly flat. Brim with axial length somewhat more than one-half that of border; gently downsloping from front of glabella and separated from border by a slight break in slope. Fixed cheeks gently downsloping from dorsal furrow; width including palpebral lobes about one-half greatest width of glabella; shallow palpebral furrows delineate narrow palpebral lobes on exfoliated specimens only.

Posterior limbs narrow, sharply pointed; length usually distinctly less than greatest width of glabella; marginal furrow shallow.

Facial sutures divergent in front of palpebral lobes but turn sharply and extend in a broad curve inward after reaching border and cut anterior margin near axial line of Cranidium. Posterior course of facial sutures diverges widely behind palpebral lobes and continues in straight line until across marginal furrow, where it curves backward to cut posterior margin well within genal angle.

Free cheek has long, slender, sharply pointed anterior projection resulting from partly intramarginal course of facial suture; marginal furrow absent; border separated from ocular platform by gradual change in slope; genal spine long, tapered gradually from broad base to narrow tip.

No articulated specimens have been

EXPLANATION OF PLATE 84

NORWOODIIDAE, PTYCHOPARIIDAB

FIG. *1*—*Norwoodia quadrangularis* (Whitfield), ×8, cranidium, UT-32165, MC-419; *Coosella* zone. (p. 743)

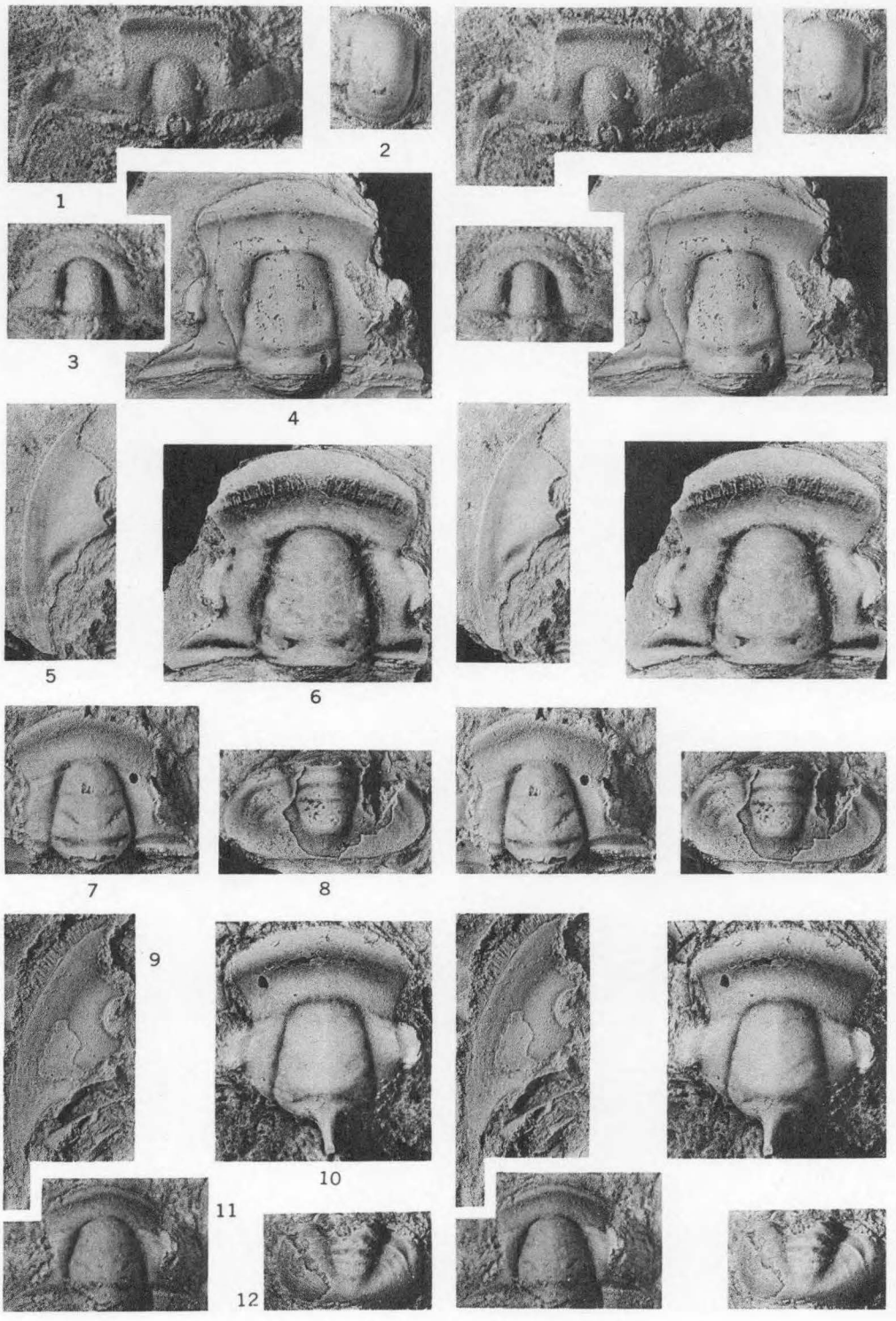
2, 4–8—*Aphelaspis walcotti* Resser. *2,* hypostome, ×4, USNM 90172, USGS loc. 67 (OS); *4,* cranidium used by Resser for characterization of *Aphelaspis,* ×2, USNM 90172, USGS loc. 67 (OS); *5,* free cheek, ×3, USNM 90172, USGS loc. 67 (OS); *6,* common type of cranidium, ×3, USNM 123315, USGS coll. 184 (CO); *7,* cranidium showing variation approaching *Dytremacephalus laevis* Palmer, n. sp., ×4, UT-32081, LL-589; *8,* pygidium, ×3, USNM 90172, USGS loc. 67 (OS); *Aphelaspis* zone. (p. 746)

3—*Holcacephalus* cf. *H. tenerus* (Walcott), ×10, cranidium, UT-32132, JR-42; *Cedarina-Cedaria* zone. (p. 742)

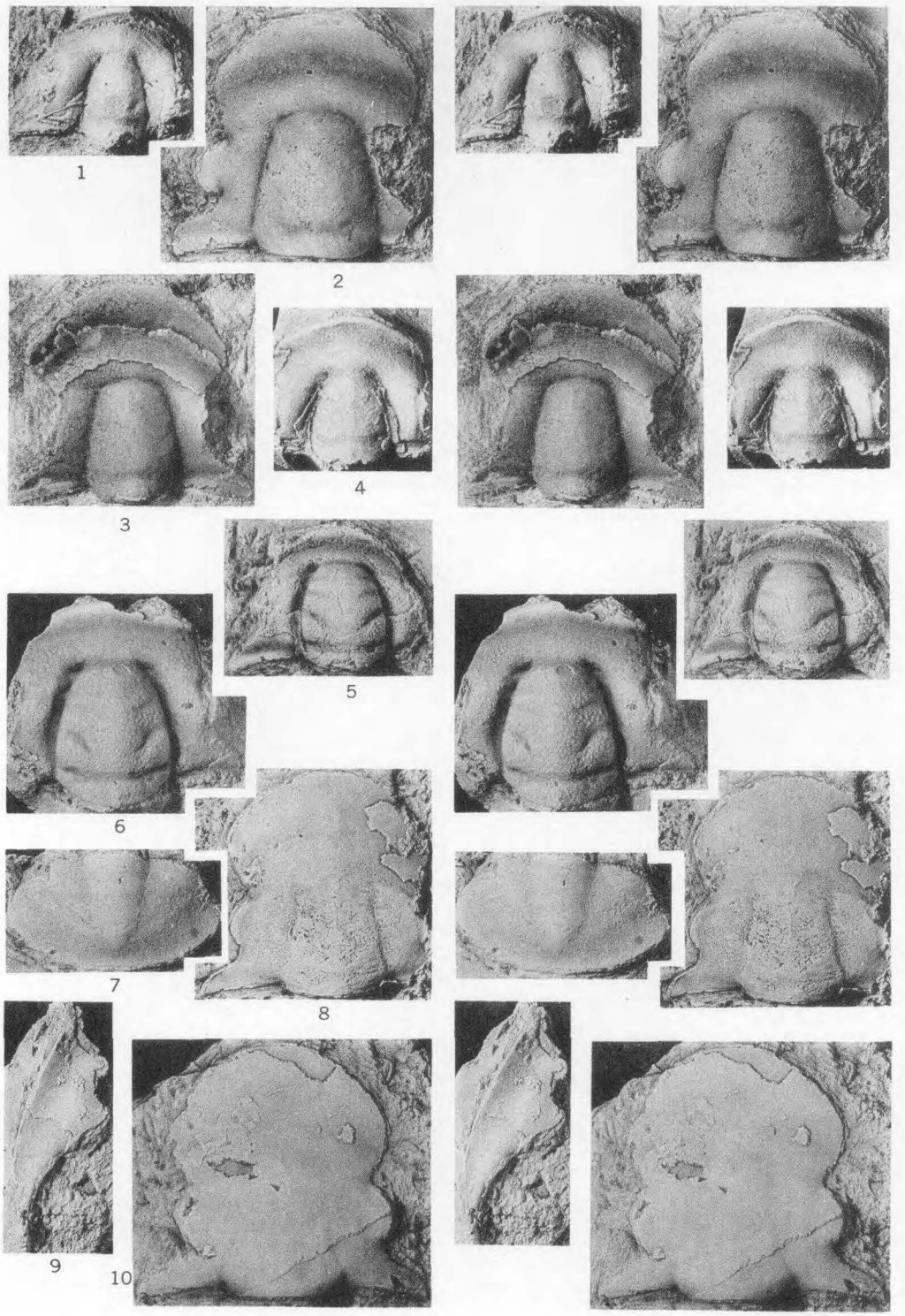
9, 12—*Aphelaspis longifrons* Palmer, n, sp. *9,* free cheek, ×4, USNM 123316, USGS coll. 8 (CO); *12,* pygidium, ×3, UT-32079, TC-815; *Aphelaspis* zone. (p. 745)

10—*Aphelaspis spinosa* Palmer, n. sp., ×3, holotype cranidium, UT-32080, TC-807; *Aphelaspis* zone. (p. 746)

11—*Aphelaspis constricta* Palmer, n. sp., ×5, holotype cranidium, USNM 123334, USGS coll. 8 (CO); *Aphelaspis* zone. (p. 745)



Palmer, Cambrian faunas from Texas



Palmer, Cambrian faunas from Texas

found, and the character of the thorax is unknown.

Pygidium subsemicircular in outline. Axial lobe somewhat elevated above pleural lobes, tapered gently to inner margin of border. Border concave, separated from pleural platform by shallow marginal furrow; no distinct transverse furrows on either axial or pleural lobes.

Derivation of name.—*Blandus,* L., mild; *Kephale,* Gr., head; referring to the relatively featureless cranidium of the genotype.

Discussion.—This genus is distinguished from all associated and stratigraphically adjacent genera by the nearly featureless character of the carapace and the long flat border on the cranidium. It is represented by more than a dozen cranidia and several pygidia from one locality.

BLANDICEPHALUS TEXANUS Palmer, n. sp.
Plate 85, figures 7–10

As this is the only known species of *Blandicephalus,* its characters are those described for the genus. The largest cranidium in the collection is 18 mm. long.

Discussion.—*B. texanus* Palmer shows some resemblance to *Aphelaspis longifrons* Palmer. The shallow furrows on the external surface of the carapace and the wide, gently arched pygidium distinguish it from that species.

Figured specimens.—

	Length
Hypotype cranidium, USNM 123320, from USGS coll. 33 (CO)	13 mm.
Cranidium, USNM, 123321, from USGS coll. 33 (CO)	16 mm.
Pygidium, USNM 123321, from USGS coll. 33 (CO)	6 mm.
	Width
Free cheek, USNM 123321, from USGS coll. 33 (CO)	10 mm.

Occurrence.—Rare, post-*Aphelaspis* zone. The only known specimens occur in moderate abundance in USGS coll. 33 (CO).

Genus DYTREMACEPHALUS Palmer, n. gen.

Genotype.—*Dytremacephalus granulosus* Palmer, n. sp.

Cranidium, exclusive of posterior limbs, somewhat elongate subquadrate in outline, moderately arched transversely and longitudinally, moderately rounded at anterior margin. Glabella distinct, well defined, tapered forward, usually truncate anteriorly; three pairs of glabellar furrows visible on large specimens. Dorsal furrow deep at sides of glabella, bears distinct pits at anterolateral corners of glabella; furrow between the pits distinctly shallower than that along glabellar sides. Occipital ring moderately arched, nearly constant in width, may bear median node. Brim and border present, separated by a distinct, usually sharp break in slope; no marginal furrow; brim gently to moderately arched, steeply downsloping, usually continuing curvature of longitudinal profile of cranidium; border flat or slightly concave, usually at a sharp angle to brim. Fixed cheeks gently to moderately arched, horizontal, or slightly upsloping, width between one-third and one-half that of glabella; palpebral lobes small, subsemicircular in outline, distinctly defined by shallow, arcuate palpebral furrow; poorly defined ocular ridges commonly present. Posterior limbs narrow, pointed length averages about equal to that of occipital ring; marginal furrow broad, deep

EXPLANATION OF PLATE 85
PTYCHOPARIIDAE

FIGS. *1, 4*—*Dytremacephalus laevis* Palmer, n. gen., n. sp. *1,* cranidium, ×5, USNM 123318, USGS coll. 10 (CO); *4,* holotype cranidium, ×5, USNM 123317, USGS coll. 10 (CO); *Aphelaspis* zone. (p. 750)

2, 3—*Aphelaspis longifrons* Palmer, n. sp., ×3. *2,* holotype cranidium, UT-32078, TC-815; *3,* cranidium, USNM 123316, USGS coll. 8 (CO), *Aphelaspis* zone. (p. 745)

5, 6—*Dytremacephalus granulosus* Palmer, n. sp., ×4. *5,* holotype cranidium, USNM 123319, USGS coll. 11 (CO); *6,* cranidium, UT-32123, WC-795; post-*Aphelaspis* zone. (p. 750)

7–10—*Blandicephalus texanus* Palmer, n. gen., n. sp. 7, pygidium, ×3, USNM 123321, USGS coll. 33 (CO); *8,* exfoliated cranidium, ×2, USNM 123321, USGS coll. 33 (CO); *9,* free cheek, ×1.5, USNM 123321, USGS coll. 33 (CO); *10,* holotype cranidium, ×3, USNM 123320, USGS coll. 33 (CO); *Aphelaspis* zone. (p. 749)

Facial sutures slightly divergent in front of palpebral lobes, turned sharply upon reaching border and extended short distance inward before cutting anterior margin.

Free cheeks, thorax, and pygidium not known.

Surface of carapace may be either smooth or granulose.

Derivation of name.—*Dy,* Gr., double; *trema,* Gr., hole; *Kephale.* Gr., head. Literally, "two holes in the head," referring to the pits at the anterolateral corners of the glabellas of species of this genus.

Discussion.—Species of this genus are distinguished from associated and stratigraphically adjacent forms by the presence of distinct pits at the anterolateral corners of the glabella. This genus appears to be a direct derivative of *Aphelaspis* and forms that appear to be gradational between the two genera are present.

In addition to the specimens collected from Texas, the writer has collected specimens referable to the genus from limestones below the Dunderberg shale horizon in eastern Nevada.

DYTREMACEPHALUS GRANULOSUS Palmer, n. sp.
Plate 85, figures 5, 6

Diagnosis.—Surface of cranidium granulose. Glabella prominent, elevated above the fixed cheeks, bears three pairs of distinct, moderately deep, nearly straight glabellar furrows. Frontal area usually one-third or less total length of cranidium; border commonly less than one-half width of brim. Fixed cheeks about one-third width of glabella, moderately arched, horizontal or gently upsloping.

Discussion.—This species most nearly resembles *Aphelaspis constricta* Palmer, from which it differs by the presence of a granular surface, distinct anterolateral glabellar pits, and distinct moderately deep glabellar furrows.

Figured specimens.—

	Length
Holotype cranidium, USNM 123319, from USGS coll. 11 (CO)	8 mm.
Cranidium, UT-32123, from WC-795	6 mm.

Occurrence.—Moderately common, post-*Aphelaspis* zone. Specimens have been obtained from measured sections at: JR-275; TC-841; WC-795; U.S.G.S. coll. 10, 11 (CO).

DYTREMACEPHALUS LAEVIS Palmer, n. sp.
Plate 85, figures 1, 4

Surface of cranidium smooth. Glabella depressed so that top is frequently not much above level of palpebral lobes; glabellar furrows shallow, short; frontal area averages slightly more than one-third total length of cranidium. Border commonly one-half or more width of brim. Fixed cheeks slightly less than one-half width of glabella, moderately arched, usually distinctly upsloping.

Discussion.—This species can be distinguished from *D. granulosus* Palmer by the smooth surface of the cranidium, depressed glabella, and shallow glabellar furrows. The frontal area tends to be somewhat longer and the fixed cheeks slightly wider and more consistently upsloping than in *D. granulosus* Palmer.

Figured specimens.—

	Length
Holotype cranidium, USNM 123317, from USGS coll. 10 (CO)	4.5 mm.
Cranidium, USNM 123318, from USGS coll. 10 (CO)	4.0 mm.

Occurrence.—Moderately common, middle and upper portion of the *Aphelaspis* zone. Specimens have been obtained from measured sections at: MC-561; USGS coll. 8, 9, 10 (CO).

Genus LABIOSTRIA Palmer, n. gen.

Genotype.—*Labiostria convexima rginata* Palmer, n. sp.

Diagnosis.—Cranidium with glabella straight sided, usually truncate anteriorly. Frontal area consists of distinct brim and border separated by narrow marginal furrow. Occipital furrow usually extends full width of glabella.

Free cheeks with marginal furrow along lateral and posterior margins.

Pygidium with axial lobe consisting of five to six segments.

All other features of carapace essentially those of *Aphelaspis.*

Discussion.—This genus is widespread in North America in the *Aphelaspis* and post-*Aphelaspis* zones. In addition to the Texas species, *L. quadrata* (Resser) (1938a, p. 59) represents the genus in the Maynardville

limestone member of the Nolichucky shale in the southern Appalachians, and undescribed species are present in the lower portion of the Dunderberg shale and in pre-Dunderberg limestones in central, southern, and eastern Nevada.

Derivation of name.—Labium, L., lip; *stria,* L., furrow; referring to the narrow marginal furrow on the frontal area of the cranidium that distinguishes this genus from *Aphelaspis.*

LABIOSTRIA CONVEXIMARGINATA Palmer, n. sp.
Plate 86, figures 1–4

Diagnosis.—Border of cranidium distinctly convex upward; length averages about three-fourths that of brim. Marginal furrow on most specimens has slight posterior median bend.

Free cheek with distinct, well-defined convex border.

Pygidium with no distinctive observable specific characteristics.

Discussion.—This species is distinguished from other species assigned to *Labiostria* by the convex border on the cranidium and free cheeks and the posterior median inbend of the marginal furrow.

Figured specimens.—

	Length
Holotype cranidium, UT-32141, from WC-775	12 mm.
Pygidium, UT-32142, from WC-775	7 mm.
Cranidium, USNM 123322, from USGS coll. 10 (CO)	10 mm.
	Width
Free cheek, UT-32143, from WC-775	8 mm.

Occurence.—Moderately rare, middle and upper portions of the *Aphelaspis* zone and in the post-*Aphelaspis* zone. Specimens have been obtained from measured sections at: JR-248, 265; MC-538, 570; P-650; TC-835; WC-775; USGS coll. 8, 9, 10 11 (CO).

LABIOSTRIA PLATIFRONS Palmer, n. sp.
Plate 86, figures 6–8

Diagnosis.—Border of cranidium flat; axial length equal to or slightly greater than that of brim.

Free cheek has distinct, well defined, flat or slightly concave border.

Pygidium known only from poorly preserved fragmentary specimens, has no distinctive observable specific characteristics.

Discussion.—This species is distinguished from other species assigned to *Labiostria* by the flat border on the cranidium and free cheek. There is a tendency for the base of the genal spine in this species to be relatively wider than that of *L. conveximarginata* Palmer. Not enough free cheeks have been found to determine whether this is a significant feature.

Figured specimens.—

	Length
Holotype cranidium, UT-32144, from WC-771	9.5 mm.
Pygidium, UT-32145, from WC-771	3.5 mm.
	Width
Free cheek, UT-32146, from WC-771	7.0 mm.

Occurrence.—Rare, *Aphelaspis* zone. Specimens have been obtained in one collection in the White Creek section, at WC-771, where many individuals are present.

LABIOSTRIA SIGMOIDALIS Palmer, n. sp.
Plate 86, figure 5

Diagnosis.—Border of cranidium convex upward adjacent to marginal furrow, concave upward near anterior margin so that its profile is sigmoid in appearance. Glabellar furrows deeper than on other species of *Labiostria;* posterior pair distinctly forked.

Free cheek and pygidium not known.

Discussion.—This species is distinguished from other species assigned to *Labiostria* by the flexure of the border of the cranidium and the presence of distinct glabellar furrows.

Figured specimen.—

	Length
Holotype cranidium, UT-32147, from WC-795	11 mm.

Occurrence.—Rare, post-*Aphelaspis* zone. Specimens have been obtained from collections in measured sections at: WC-795; PTC-848.

Genus PTEROCEPHALIA Roemer, 1849

Pterocephatia ROEMER, 1849, p. 421; 1852, p. 92; BRIDGE, in Bridge and Girty, 1937, p. 247; SHIMER and SHROCK, 1944, p. 631.

Genotype.—Pterocephalia sanctisabae Roemer, 1849, p. 421.

Diagnosis.—Cranidium, exclusive of

posterior limbs, elongate subquadrate in outline, gently arched transversely and longitudinally, broadly rounded anteriorly; three pairs of glabellar furrows usually visible. Occipital furrow narrow, deepest at sides of glabella. Dorsal furrow deep at sides of glabella, shallow across front. Frontal area concave, axial length as long or longer than glabella. Border and brim separated by gradual change in slope. Fixed cheeks one-third or more width of glabella, usually upsloping; ocular ridges distinct; palpebral lobes situated opposite posterior pair of glabellar furrows. Posterior limbs long, narrow; marginal furrow shallow.

Anterior course of facial sutures slightly divergent from palpebral lobes; posterior course at nearly right angles to longitudinal axis of cranidium.

Free cheek with broad concave border separated from narrow ocular platform by shallow marginal furrow and tapered gradually backward to long, pointed genal spine.

Pygidium subovate in outline, moderately arched transversely and longitudinally. Axial lobe consists of seven or more segments. Pleural furrows extend from axial lobe onto broad, concave border. Pleural platform separated from border by gradual change in slope.

Discussion.—The long concave frontal area of the cranidium and the broad concave furrowed border of the pygidium are the most distinctive features of this genus. This is the first recorded occurrence of the genus below the *Elvinia* zone.

PTEROCEPHALIA cf. P. OCCIDENS Walcott

Plate 86, figures 9, 10;
plate 87, figures 1, 2

Ptychoparia (Pterocephalus) occidens WALCOTT, 1884, pl. 9, fig. 2f.
Pterocephalia occidens Walcott, BRIDGE, in Bridge and Girty, 1937, p. 250.

Diagnosis.—Length of frontal area about one-half length of cranidium. Surface of carapace with low scattered granules, particularly on exfoliated specimens.

Free cheeks same as for *P. sanctisabae* Roemer.

Pygidium with seven or eight axial segments.

Discussion.—This species is not as large as *P. sanctisabae* Roemer. Most cranidia are less than 20 mm. in length, as compared to 25 mm. or more for many cranidia of Roemer's species.

The Texas specimens differ from those in Nevada chiefly by having the fixed cheeks somewhat less upsloping, a more gently concave frontal area, and a somewhat more transverse pygidium. These differences could be attributable to geographic variation. Specimens from both areas are from approximately the same stratigraphic horizon.

Figured specimens.—

	Length
Cranidium, UT-32170, from WC-795	13 mm.
Cranidium, UT-32171, from 16T-6-12A	21 mm.
Pygidium, UT-32172, from 16T-6-12A	11.5 mm.
	Width
Free cheek, UT-32173, from 16T-6-12A	13 mm.

Occurrence.—Rare, post-*Aphelaspis* zone. Specimens have been obtained from measured sections at: TC-848; WC-795; USGS coll. 11 (CO). Additional specimens used in illustration are from 16T-6-12A.

Family TRICREPICEPHALIDAE Palmer, n. fam.

Type genus.—*Tricrepicephalus* Kobayashi, 1935, p. 278.

This family is proposed for the Dresbachian genera *Tricrepicephalus* and *Meteoraspis. Tricrepicephalus* has been placed in the Crepicephalidae by Kobayashi (1935, p. 278), and both genera have been placed in that family by Lochman and Duncan (1944), Kindle (1948), and others. One of the principal diagnostic characters of the Crepicephalidae is a pair of pygidial spines. The writer has shown (p. 728) that *Crepicephalus,* the type genus of the family, probably developed from trilobites that lacked a pair of pygidial spines. He believes that paired pygidial spines have been developed in several trilobite stocks and considers the Crepicephalidae to be an unnatural association of unrelated trilobites.

Most species of the Tricrepicephalidae are characterized by cranidia with the general outline and proportions of those assigned to the Coosellidae Palmer, n. fam. (fig. 4), but with much deeper dorsal, marginal, and occipital furrows, two or three pits in the marginal furrow, and greater

overall relief. *Meteoraspis metra* (Walcott) seems to be a specialized form that developed narrower fixed cheeks and a more elongate glabella than most of the other species in the family.

The pygidia have a broad axial lobe, one-third or more the width of the pygidium, that bears three or fewer segments and reaches nearly to the posterior margin. There is no distinct border. Spines are developed from the margin in *Meteoraspis* and from the surface of the pleural lobes in *Tricrepicephalus*.

The Tricrepicephalidae and the Cooseliidae may have had a common ancestor among the upper Middle Cambrian ptychoparid trilobites, but determination of suprageneric relationships of pre-Dresbachian trilobites awaits studies comparable in scope to those that have been made for the Dresbachian trilobites of North America.

Genus METEORASPIS Resser, 1935

Meteoraspis RESSER, 1935, p. 40; 1938, p. 472; LOCHMAN, 1938, p. 472; SHAW, 1952, p. 475.
Coelopachys RAYMOND, 1937, part, p. 1120.
Greylockia RAYMOND, 1937, p. 1108.

Genotype.—*Ptychoparia metra* Walcott, 1890, p. 273, pl. 21, fig. 7.

Diagnosis.—Cranidium with dorsal, marginal, and occipital furrows well developed. Border strongly arched in longitudinal profile, often also in transverse profile. Marginal furrow bears two or three shallow to moderately deep pits.

Pygidium with pair of marginal spines extending nearly straight back from posterolateral margin. Width of axial lobe nearly one-third width of pygidium; axial furrows deep; those on pleural lobes very shallow. Surface of carapace smooth.

Discussion.—The prominent glabella and strongly arched longitudinal profile of the border of the cranidium, and the paired marginal spines that are developed from the margin of the pygidium distinguish this genus from *Tricrepicephalus*.

Coelopachys and *Greylockia* are considered to be synonyms of *Meteoraspis* by Shaw (1952, p. 475).

METEORASPIS cf. M. LOISI Lochman
Plate 82, figure 1

Meteoraspis loisi LOCHMAN, in Lochman and Duncan, 1944. p. 64, pl. 5, figs. 24–26.

A single pygidium with an elongate quadrangular outline and narrow posterolateral spines resembles that of *M. loisi* Lochman and comes from a comparable stratigraphic horizon. It differs from Lochman's specimens by having the lateral margins slightly concave inward and the posterolateral spines slightly divergent. Both Lochman's and the writer's samples are small and come from widely separated geographic areas. The recognized differences may be the result of infraspecific variation.

Figured specimen.—

	Length (not including spines)
Pygidium, UT-32161, from P-618	9 mm.

Occurrence.—Rare, *Maryvillia* zone. The only specimen in the collections was obtained from P-618.

METEORASPIS METRA (Walcott)
Plate 82, figures 2, 4

Ptychoparia? metra WALCOTT, 1890, p. 273, pl. 21, fig. 7.
Meteoraspis metra (Walcott) RESSER, 1935, p. 41; SHIMER and SHROCK, 1944, pl. 265, fig. 42.
Meteoraspis bipunctata LOCHMAN, 1938a, p. 83, pl. 17, figs. 4–8.

Diagnosis.—Cranidium with border strongly arched transversely. Fixed cheeks narrow, upsloping. Spines on pygidium directed straight backward or slightly inward.

Discussion.—This species differs from *Meteoraspis* cf. *M. robusta* Lochman by its more elongate cranidium as well as the characteristics mentioned above. Variation in shape of the glabella and in the position of the fixed cheeks on cranidia in the writer's collections suggest that *M. bipunctata* Lochman is not specifically distinct from *M. metra* (Walcott).

Cranidia of the "*metra*" type have been described from Missouri, Montana, and Newfoundland.

Figured specimens.—

	Length
Cranidium, UT-32162, from MC-453	16.5 mm.
Pygidium, UT-32163, from MC-453	10.0 mm. (not including spines)

Occurrence.—Moderately common, *Coosella* zone. Specimens have been obtained from measured sections at: LL-507; MC-446, 453, 469, 475, 478, 485; S-295; TC-702; WC-628, 655, 677; USGS coll. 4 (CO).

METEORASPIS cf. M. ROBUSTA Lochman
Plate 82, figure 3

Meteoraspis robusta LOCHMAN, 1944, p. 100, pl. 9, figs. 11–17.

Eight fragmentary cranidia are characterized by a relatively wide, subquadrate outline, moderately arched transverse profile of the frontal area, strongly tapered, well defined glabella, and moderately wide fixed cheeks. They represent a group of meteoraspids typified by *M. robusta* Lochman and distinguished from the "*metra*" group by the relatively wider fixed cheeks and moderately arched transverse profile of the frontal area. They differ from the types of *M. robusta* Lochman principally by having the width of the cranidium at the palpebral lobes nearly equal to the axial length of the cranidium.

Cranidia of the "*robusta*" group have been described from Montana and Newfoundland. In Texas and Montana they are found stratigraphically below cranidia of the "*metra*" group.

Figured specimen.—

	Length
Cranidium, UT-32164, from MC-373	12 mm

Occurrence.—Moderately rare, upper portion of *Cedarina-Cedaria* zone. Specimens have been obtained from measured sections at: JR-42; MC-373; S-162, 183.

Genus TRICREPICEPHALUS Kobayashi, 1935

Tricrepicephalus KOBAYASHI, 1935, p. 278; SHIMER and SHROCK, 1944, p. 635.
Paracrepicephalus LOCHMAN, 1936, p. 36.

Genotype.—*Arionellus* (*Bathyurus*) *texanus* Shumard, 1861, p. 218.

Diagnosis.—Cranidium with three pits in marginal furrow and moderately long, gently arched border. Free cheek with broad, flat, well defined, posteriorly widening border. Width of axial lobe of pygidium about one-third total pygidial width. A pair of marginal spines extends back from posterolateral surface of pleural lobes.

Discussion.—*Tricrepicephalus* was proposed by Kobayashi (1935) for some trilobites of his newly established family Crepicephalidae for which "the most distinguishing character is found in the three strong pits usually found upon the frontal groove." Lochman (1936), unaware of Kobayashi's publication, proposed *Paracrepicephalus* for the same trilobites and cited the same species, *T. texanus* (Walcott), as genotype. The genus differs from *Meteoraspis* by having a gently arched border on the cranidium and by having the paired pygidial spines developed from the surface of the pleural lobes instead of from the pygidial margin.

The writer considers *Tricrepicephalus comus* (Walcott), *T. comus occidentalis* Lochman, *T. nuperus* Resser, *T. paracomus* (Lochman), and *T. unicornis* Kindle to belong to *Meteoraspis* rather than to *Tricrepicephalus*. Each of these species has a strongly arched, relatively short border and three pits in the marginal furrow, and agrees in all characteristics with the present concept of *Meteoraspis*. All stages of gradation exist between two and three distinct pits in the marginal furrow of cranidia of *Meteoraspis* examined by the writer. He does not, therefore, consider that feature, used alone, as a good criterion for generic differentiation.

Twenty-nine described "species" conform to the diagnosis given above. Many are based on single specimens or small samples, and few have adequate stratigraphic information regarding their type localities. All of the types except those of Kindle (1948, pp. 445, 446) and all available specimens in the U. S. National Museum and U. S. Geological Survey collections, as well as those from the Riley formation, have been studied in an attempt to devise a practical taxonomy for *Tricrepicephalus*.

Five collections containing *Tricrepicephalus* from Arizona, nine from Montana, and eighteen from Texas are from measured sections and provided the information on the regional stratigraphic value of the species of that genus discussed here.

In the present revision, the writer recognizes three species. The character of the surface granulation of the cranidium is considered the most important taxonomic feature. Internal molds tend to have the granulation subdued, but the distribution of the granules is the same on the mold as on the outer surface of the test, with one exception: internal molds may show a row of small granules within the pits in the marginal furrow, whereas this feature is not present in the pits on the outer surface of the test.

Isolated pygidia cannot be assigned with certainty to any given species. Observable differences between pygidia are seen principally on the posterolaterally directed spines, which have either spatulate or pointed tips. Both kinds have been found throughout the range of the genus.

The writer believes that the present taxonomic arrangement within *Tricrepicephalus* is of greater aid to stratigraphic paleontology than the recognition of distinctive individuals or small samples as "species" that have doubtful biologic or stratigraphic value.

One of the three species recognized here, *T. tripunctatus* (Whitfield) (syn. *T. magnispinus* [Walcott]), is not present in the Texas collections. It is characterized by having the surfaces of all parts of the cranidium granulated and by having a strong occipital spine.

TRICREPICEPHALUS CORIA (Walcott)
Plate 81, figures 1–4, 6

Crepicephalus coria WALCOTT, 1916a, p. 206, pl. 33, figs. 3, 3a–g.
Crepicephalus thoosa WALCOTT, 1916a, p. 214, pl. 31, figs. 1, 1a–k.
Tricreptcephalus thoosa (Walcott) RESSER, 1938a, p. 101, pl. 14, fig. 8.
Crepicephalus tumidus WALCOTT, 1916a, p. 217, pl. 31, fig. 2.
Paracrepicephalus tumidus (Walcott) LOCHMAN, 1936, p. 36.
Tricrepicephalus tumidus (Walcott) RESSER, 1938a, p. 102, pl. 11, fig. 58.
Crepicephalus texanus (Shumard) WALCOTT, 1916a, part, p. 209, pl. 29, fig. 7.
Paracrepicephalus walcotti LOCHMAN, 1936, p. 39, pl. 9, figs. 29, 31, 33.
Tricrepicephalus walcotti (Lochman) RESSER, 1938a, p. 102, pl. 11, fig. 54.
Tricrepicephalus beltensis RESSER, 1937, p. 27; LOCHMAN and DUNCAN, 1944, p. 61, p. 5, figs. 27–30.
Tricrepicephalus davidi LOCHMAN, 1940a, p. 27, pl. 3, figs. 26–34.
Tricrepicephalus nasutus DUNCAN, 1944, in Lochman and Duncan, p. 63, pl. 5, figs. 1–6.
Tricrepicephalus rusticus KINDLE, 1948, p. 447, pl. 1, figs. 4, 5.

Diagnosis.—Entire surface of cranidium evenly and usually thickly granulated; occipital ring unspined.

Discussion.—This species differs from the much rarer *T. tripunctatus* (Whitfield) principally by the lack of a prominent occipital spine.

The eight described "species" cited in the synonymy share the characteristics stated in the diagnosis. *T. coria* (Walcott) is less homogeneous than *T. texanus* (Shumard) and probably represents a "species group" rather than a single species in a strict biological sense. The greatest number of cranidia obtained from a single horizon in the Texas collections is 13. The variation in character of the pits in the marginal furrow, the surface granulation, the longitudinal profile, and the relative width of the border as compared to the brim among these specimens almost completely overlaps the observed differences in the features cited for all specimens assigned to *T. coria* (Walcott). If population studies were possible, finer discrimination of species within *T. coria* (Walcott) might be made. Specimens from the lower part of the stratigraphic range of the species characteristically have the brim one-sixth or more the length of the glabella and the border less than twice the width of the brim. Specimens from the upper part of the stratigraphic range characteristically have the brim one-seventh or less the length of the glabella and the border twice or more the width of the brim.

Figured specimens.—

	Length
Cranidium, UT-32178, from MC-529	5 mm.
Cranidium, UT-32179, from MC-453	20 mm.
Cranidium, UT-32180, from MC-464	19 mm.
Cranidium, UT-32181, from MC-419	6.5 mm.
	Width
Free cheek, USNM 123313, from USGS coll. 4 (CO)	9 mm.

Occurrence.—Common, *Coosella* and *Maryvillia* zones. Specimens have been obtained from measured sections at the following horizons: JR-120, 132, 163, 201, 218, 223; LL-468, 486, 507, 537, 557; MC-419, 446, 453, 464, 475, 485, 516, 529; P-622; S-369; TC-656, 660, 702; WC-628, 706; USGS coll. 4, 6 (CO).

TRICREPICEPHALUS TEXANUS (Shumard)
Plate 81, figure 9

Arionellus (Bathyurus) texanus SHUMARD, 1861, p. 218.
Agraulos texanus (Shumard) MILLER, 1889, p. 527.
Crepicephalus texanus (Shumard) WALCOTT, 1899, p. 460, pl. 65, fig. 5; WALCOTT, 1916a, part, p. 209, pl. 30, figs. 1, 1b, 2, 2a–b, 3, 3a, 4; BUTTS, 1926, p. 74, pl. 8, figs. 10, 11.

Paracrepicephalus texanus (Shumard) LOCHMAN, 1936, p. 27, pl. 9, figs. 27, 28, 30, 32.
Tricrepicephalus texanus (Shumard) SHIMER and SHROCK, 1944, p. 635, pl. 262, figs. 25–28.
Crepicephalus texanus danace WALCOTT, 1916a, p. 214, pl. 29, figs. 3, 3a.
Paracrepicephalus danace (Walcott) LOCHMAN, 1936, p. 36.
Crepicephalus texanus elongatus WALCOTT, 1916a, p. 214, pl. 29, figs. 4, 4a.
Paracrepicephalus elongatus (Walcott) LOCHMAN, 1936, p. 36,
Tricrepicephalus yellowstonensis RESSER, 1937, p. 27.
Tricrepicephalus cedarensis RESSER, 1938a, p. 102, pl. 14, fig. 11; SHIMER and SHROCK, 1944, p. 635, pl. 262, fig. 24.
Tricrepicephalus curticei RESSER, 1938a, p. 103, pl, 11, figs. 41, 42.
Tricrepicephalus laxus RESSER, 1938a, p. 103, pl. 14, figs. 1, 2.,
Tricrepicephalus alabamensis RESSER, 1938a, p. 103, pl. 14, fig. 10.
Tricrepicephalus simulans RESSER, 1938a, p. 104, pl. 11, fig. 59.
Tricrepicephalus aff. *T. simulans* Resser, LOCHMAN, 1950, p. 343, pl. 50, fig. 23.
Tricrepicephalus simplex RESSER, 1938a, p. 104, pl. 11, fig. 55.
Tricrepicephalus blountensis RESSER, 1938a, p. 104, pl. 14, fig. 3.
Tricrepicephalus natalia LOCHMAN, 1940a, p. 28, pl. 3, figs. 35, 36.
Tricrepicephalus rex LOCHMAN, 1940a, p. 29, pl. 3, figs. 45–51; LOCHMAN and DUNCAN, 1944, pl. 14, figs. 45–50.
Tricrepicephalus auxiliaris DUNCAN, 1944, in Lochman and Duncan, p. 95, pl. 14, figs. 42–44, pl. 9, fig. 29.
Tricrepicephalus johnsoni KINDLE, 1948, p. 449, pl. 2, figs. 5, 6.
Tricrepicephalus murphyi KINDLE, 1948, p. 448, pl. 1, figs. 1, 2, 3.
Tricrepicephalus arcuatus TASCH, 1951, p. 302, pl. 45, figs. 9–12.
Coosia? pustulata TASCH, 1951, p. 291, pl. 47, fig. 10.

Diagnosis.—Surface of cranidium unevenly granulated. Glabella smooth, or bearing indistinct granules at rear only; brim and fixed cheeks always bear granules, those on the brim being particularly well developed; border smooth or granulated.

Discussion.—The 18 described "species" cited in the synonymy share the diagnostic features stated above. The writer believes that the differences between the type specimens of those "species" are no more than might be expected to result from infraspecific and/or geographic variation of a single species.

T. texanus (Shumard) is a common constituent of the *Coosella* zone and its equivalents wherever they have been found on the North American continent.

The smooth or nearly smooth glabelia readily distinguishes this species from *T. coria* (Walcott).

Figured specimen.—

	Length
Cranidium, UT-32183, from MC-419	22 mm.

Occurrence.—Moderately common, lower portion of the *Coosella* zone. Specimens have been obtained from measured sections at: JR-120; MC-419; TC-656; WC-586, 628, 655.

TRICREPICEPHALUS spp.
Plate 81, figures 5, 7, 8

Pygidia of species of *Tricrepicephalus* are not common in the collections. Specimens preserving the long posterolateral spines are rare. Except for the instances where complete specimens of *Tricrepicephalus* have been found, pygidia have not been assigned with certainty to any described species. Several examples of pygidia from Texas are illustrated, showing some of the variation

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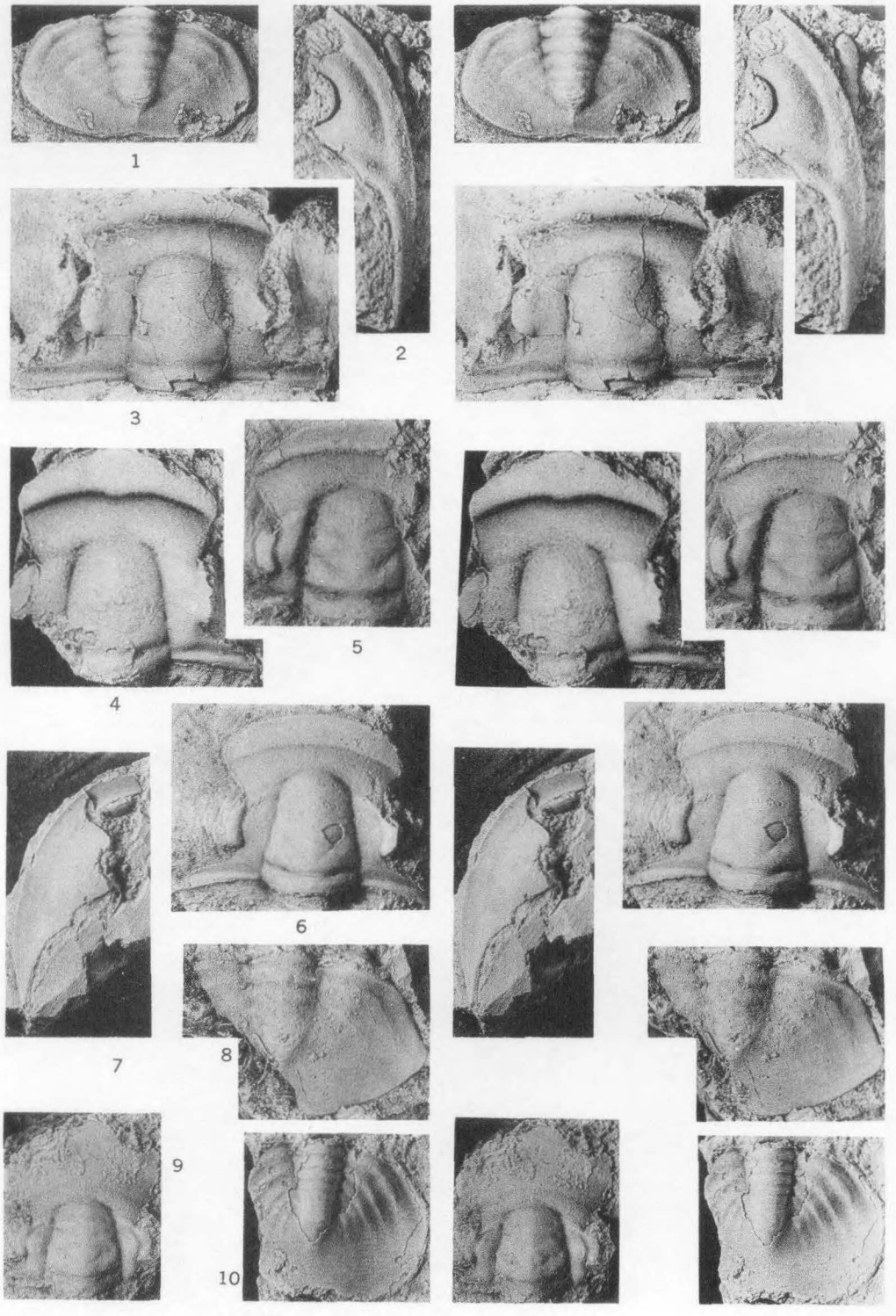
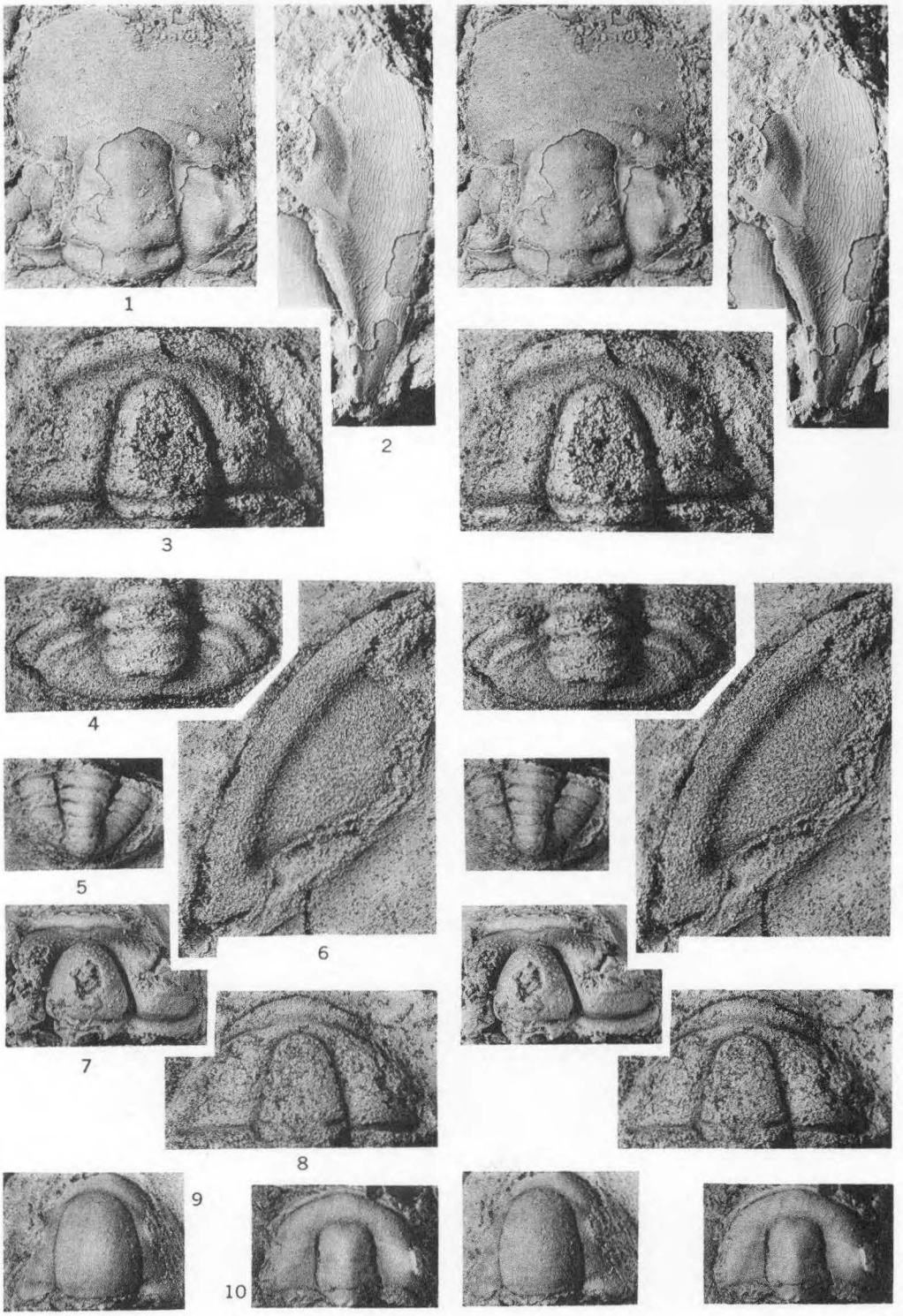
EXPLANATION OF PLATE 86
PTYCHOPARIIDAE

FIGS. *1–4*—*Labiostria conveximarginata* Palmer, n. gen., n. sp., ×3. *1,* pygidium, UT-32142; WC-775; *2,* free cheek, UT-32143, WC-775; *3,* cranidium showing variation approaching *Aphelaspis walcotti* Resser, USNM 123322, USGS coll. 10 (CO); *4,* holotype, cranidium, UT-32141, WC-775; *Aphelaspis* zone. (p. 751)
5—*Labiostria sigmoidalis* Palmer, n. gen., n. sp., ×3, holotype, cranidium, UT-32147, WC-795; post-*Aphelaspis* zone. (p. 751)
6–8—*Labiostria platifrons* Palmer, n. gen., n. sp., ×3. *6,* holotype, cranidium, UT-32144, WC-771; *7,* free cheek, UT-32146, WC-771; *8,* pygidium, UT-32145, WC-771; *Aphelaspis* zone. (p. 751)
9, 10—*Pterocephalia* cf. *P. occidens* Walcott, ×2. *9,* cranidium, UT-32170, WC-795; *10,* pygidium, UT-32172, 16T-6-12A; post-*Aphelaspis* zone. (p. 752)



Palmer, Cambrian faunas from Texas



Palmer, Cambrian faunas from Texas

in form that is present. Not enough specimens have been collected to determine the presence of any morphologic character of useful stratigraphic value.

Figured specimens.—

	Length (not including spines)
Pygidium, UT-32184, from MC-419	7.5 mm.
Pygidium, UT-32185, from S-183	6 mm.
Pygidium, USNM 123314, from USGS coll. 3 (CO)	9 mm.

Occurrence.—Moderately rare, *Cedarina-Cedaria, Coosella,* and *Maryvillia* zones. Specimens have been obtained from measured sections at the following horizons: JR-201, 218; LL-507; MC-419, 446, 453, 472, 475; P-602, 609; S-369,; TC-656, 660, 787; WC-582, 586; USGS coll. 4, 6 (CO).

FAMILY UNKNOWN

Genus BRASSICICEPHALUS Lochman, 1940

Brassicicephalus LOCHMAN, 1940a, p. 39; SHIMER and SHROCK, 1944, p. 261.

The writer follows the diagnosis of this genus given by Lochman (1940, p. 39).

BRASSICICEPHALUS cf. B. PULCHELLUS Lochman

Plate 89, figure 3

Brassicicephalus pulchellus LOCHMAN, 1940, p. 39, pl. 3, figs. 1–5; SHIMER and SHROCK, 1944, pl. 263, figs. 21–23.

Two cranidia in the collections differ from cranidia of *B. pulchellus* Lochman solely by having the frontal area undivided. The marginal furrow that subequally divides the frontal area of the type of *B. pulchellus* into a brim and border is shallow and could be obscured in the Texas specimens by the coarse type of limestone preservation.

Figured specimen.—

	Length
Cranidium, USNM 123329, from 86-T-13-17	3.5 mm.

Occurrence.—Rare, *Cedarina-Cedaria* zone. The only known specimens are in collection 86T-13-17. They are associated with *Meteoraspis* cf. *M. robusta* Lochman and *Kormagnostus* sp.

Genus CHEILOCEPHALUS Berkey, 1898

Cheilocephalus BERKEY, 1898, p. 290.
Pseudolisania KOBAYASHI, 1935, p. 162; SHIMER and SHROCK, 1944, p. 621.

Genotype.—*Cheilocephalus storoixensis* Berkey, 1898, p. 290, pl. 17, figs. 7, 8; pl. 21, fig. 19.

Diagnosis.—Cranidium with glabella large, tapering forward, bluntly terminated anteriorly, reaching to border. Palpebral lobes small, situated anterior to transverse median line of glabella. Posterior limbs large, proparian-like; marginal furrow narrow, curved forward distally.

Pygidium with semicircular outline, distinctly annulated axial lobe, and well developed articulating segment on pleural lobes. Interpleural grooves except first one, and all pleural furrows shallow; grooves extend onto concave border of exfoliated specimens.

Description.—Cephalic and caudal shields are large. There are no complete specimens known. A Cranidium with nine segments attached (USNM 62852), the type of *C. breviloba* (Walcott), is from the Nolichucky shale in the southern Appalachians. The taper of the thoracic axis and the width of axial lobes on pygidia associated with cranidia of comparable size to that of the genotype suggests that the thorax consists of more

EXPLANATION OF PLATE 87

PTYCHOPARIIDAE, POSITION UNKNOWN

FIGS. *1, 2*—*Pterocephalia* cf. *P. occidens* Walcott, ×2. *1*, cranidium, UT-32171, 16T-6-12A; *2*, free cheek, UT-32173; 16T-6-12A; post-*Aphelaspis* zone. (p. 752)
3, 4, 6—*Modocia* cf. *M. oweni* (Meek and Hayden), ×4. *3*, cranidium, UT-32124, 16T-6-20A; *4*, pygidium, UT-32125, 16T-6-20A; *6*, free cheek, UT-32126, 16T-6-20A; *Bolaspidella* zone. (p. 763)
5—*Lonchocephalus?* sp., ×4, pygidium, UT-32154, JR-201; *Maryvillia* zone. (p. 762)
7—Genus and species undet. 3, ×4, cranidium, UT-32188, MC-446; *Coosella* zone. (p. 765)
8—*Modocia* cf. *M. centralis* (Whitfield), ×2, UT-32175, TC-378; *Cedarina-Cedaria* zone. (p. 763)
9—Genus and species undet. 1, ×4, cranidium, UT-32086, MC-453; *Coosella,* zone. (p. 765)
10—Genus and species undet. 2, ×5, cranidium, UT-32187, MC-419; *Coosella* zone. (p. 765)

than nine segments. The carapace as a whole is probably elongate oval in outline. Some specimens may have reached a length of 70 to 80 mm.

The cranidium is subtrapezoidal in outline and dominated by a large, elongate, tapering, bluntly terminated glabella that is set off from the fixed cheeks by a distinct, narrow, shallow dorsal furrow. In transverse outline the glabella is evenly arched and slightly to moderately elevated above the fixed cheeks. The longitudinal arching is greatest in the anterior portion where the glabella curves down steeply to the border. No distinct glabellar furrows are visible. The occipital furrow is bowed forward medially and in most specimens it is deepest about midway between the dorsal furrow and the top of the glabella. The occipital ring is flat, moderately narrow, but widest medially. The frontal area is short and not divided into a brim and border. The fixed cheeks are gently to moderately downsloping and vary in width between one-third and one-fourth the width of the glabella at the occipital furrow. Indistinct ocular ridges, originating distinctly posterior to the front of the glabella, extend obliquely outward to small palpebral lobes. These are situated well forward on the cranidium. Palpebral furrows, if present, are broad and shallow. The posterior limbs are broad, distinctly shorter than the width of the glabella at the occipital furrow, and bluntly terminated. All specimens so far examined have a distinct "elbow" along the posterior margin of the limb between one-third and two-thirds the total length of the limb from the dorsal furrow. The marginal furrow on the limb is broad and shallow and parallels the posterior margin for most of its length. Although the furrow is very shallow distally, it can be seen to curve forward giving the whole limb a distinctly proparian aspect. Until a free cheek can be found, it will be impossible to demonstrate whether *Cheilocephalus* is a true proparian trilobite.

The hypostome is subquadrate in outline. The central lobe is evenly rounded anteriorly and bluntly rounded posteriorly. A pair of posteriorly directed furrows notch the sides of the posterior half of the lobe. The border is narrow along the sides of the anterior portion of the lobe and expanded opposite the posterior portion. A pair of deep broad depressions are present in the border opposite the posterior portion of the lobe. Opposite the anterior end, the border is depressed into short, bluntly pointed alae.

The thoracic segments on the specimen from the Nolichucky shale are broken so that little of their character can be ascertained. The pleural furrows, however, seem to be short, broad, shallow, and close to the posterior margin of the segments.

The pygidium is semicircular in outline and gently to moderately arched transversely and longitudinally. The axial lobe is long, gently tapered, and distinctly annulated, reaching to the inner margin of the border. Five to seven axial rings are visible. Each successive ring is slightly narrower than the preceding one. The pleural platforms are gently arched. The articulating segment is strongly developed on the pleural lobes. The interpleural groove is deep, wide, and flexed forward as it crosses the border to meet the margin at the anterolateral corners of the pygidium. The pleural furrow on the articulating segment is also strongly impressed, but it does not extend the entire length of the segment. An "elbow" in the same relative position as that on the cranidium is present on the anterior margin pf the pygidium. The remainder of the pleural platform is crossed by five or six pairs of shallow pleural furrows and interpleural grooves. The interpleural grooves are continued as broad, shallow depressions across the moderately broad pygidial border.

Discussion.—Cheilocephalus was described by Berkey (1898, p. 290) for a well preserved cranidium from the St. Croix Dalles in Minnesota. Kobayashi (1935, p. 162) proposed the genus *Pseudolisania* (genotype: *Lisania? breviloba* Walcott) for forms that are certainly congeneric with it. The writer considers *Pseudolisania* a subjective synonym of *Cheilocephalus.*

This genus is a distinctive and widespread member of the *Aphelaspis,* post-*Aphelaspis,* and *Elvinia* faunas over most of North America. Species from the *Aphelaspis* and post-*Aphelaspis* zones have smooth carapaces. Some species from the *Elvinia* zone have the surface of the carapace finely granular.

Cheilocephalus texana Resser (1942, p. 35), from the Hickory sandstone member, is a kingstoniid as noted by Wilson (1949, p. 34). Of the two species described from the *Aphelaspis* zone in Texas by Lochman (1938), the cranidium of *Pseudolisania texana* Lochman is too fragmentary for specific identification. The pygidium of that species and all parts of *Pseudolisania raaschi* Lochman appear identical in all characters with *C. breviloba* (Walcott).

CHEILOCEPHALUS BREVILOBA (Walcott)
Plate 88, figures 1–4

Lisania? breviloba WALCOTT, 1916, p. 404, pl. 66, figs. 3, 3c
Pseudolisania breviloba (Walcott) KOBAYASHI, 1935, p. 162; RESSER, 1938a, p. 96, pl. 16, fig. 17.
Pseudolisania raaschi LOCHMAN, 1938a, p. 77, pl. 18, figs. 25–34.
Pseudolisania texana LOCHMAN, 1938a, Idem., p. 80, pl. 18, figs. 35–38.

Diagnosis.—Glabella distinctly elevated above fixed cheeks. Palpebral lobes horizontal or slightly upturned, "elbow" on the posterior margin of cranidium less than half length of posterior limb from dorsal furrow. Pygidium with broad, concave border and nearly horizontal margin. Axial lobe usually bears seven segments, although some specimens have only six. "Elbow" along anterior edge less than half distance from dorsal furrow to lateral margin.

Surface of carapace smooth.

Discussion.—This species is characterized by the prominent glabella, the elevated axial lobe of the pygidium, the position of the "elbow" on the cranidium and pygidium, and the smooth surface of the carapace. The position of the "elbow" on the cranidium, the horizontal margin of the concave border of the pygidium, and the large size of adult portions of the carapace distinguish it from *C. minutus* Palmer, n. sp.

Figured specimens.—

	Length
Cranidium, USNM 123323, from USGS coll. 7 (CO)	15 mm.
Cranidium, UT-32104, from MC-530	6 mm.
Pygidium, UT-32105, from MC-530	5 mm.
Pygidium, UT-32106, from TC-802	9.5 mm.

Occurrence.—Common, lower portion of the *Aphelaspis* zone; moderately rare, middle and upper portions of the *Aphelaspis* zone and the post-*Aphelaspis* zone. Specimens have been obtained from measured sections at: LL-558; MC-529, 530, 547, 570; P-639; TC-800, 802; USGS coll. 7, 8, 9, 10, 11 (CO).

CHEILOCEPHALUS MINUTUS Palmer, n. sp.
Plate 88, figures 5, 6, 8

Diagnosis.—Glabella distinctly elevated above fixed cheeks. Palpebral lobes horizontal or slightly upturned. "Elbow" on posterior margin of cranidium more than one-half length of posterior limb from dorsal furrow.

Pygidium with narrow, concave, poorly defined border downsloping at margin. Axial lobe bears five distinct segments. "Elbow" along anterior edge more than half width of pleural lobe from dorsal furrow.

Surface of carapace smooth.

Discussion.—This species is distinguished from other described species of *Cheilocephalus* by the downsloping border of the pygidium and the position of the "elbow" on the cranidium and pygidium. All of the specimens of this species are small.

Figured specimens.—

	Length
Holotype cranidium, USNM 123324, from USGS coll. 476 (CO)	4.0 mm.
Pygidium, USNM 123324, from USGS coll. 476 (CO)	6.5 mm.
Pygidium, UT-32107, from LL-559	7.5 mm.

Occurrence.—Rare, lower portion of *Aphelaspis* zone. Specimens have been obtained from the Little Llano River section at LL-559. Additional material used in illustration is from USGS coll. 476 (CO).

Genus DEIRACEPHALUS Resser, 1935

Deiracephalus RESSER, 1935, p. 21.
Asteraspis KOBAYASHI, 1935, p. 224.

Genotype.—Acrocephalites? aster Walcott, 1916, p. 178, pl. 26, figs. 9, 9 a–c. The writer follows the diagnosis of this genus given by Resser (1935, p. 21).

DEIRACEPHALUS ASTER (Walcott)
Plate 89, figure 5

Acrocephalites? aster WALCOTT (part), 1916, p. 178, pl. 26, figs. 9b, 9c.
Deiracephalus aster RESSER, 1935, p. 21.
Asteraspis aster KOBAYASHI, 1935, p. 224.
Deiracephalus aster RESSER, 1938a, p. 73, pl. 16, figs. 10, 11.

Four cranidia with the distinctive me-

dian boss on the frontal area, upturned occipital spine, and scattered surface granules characteristic of this species are present in two collections.

Figured specimen.—

	Length
Cranidium, UT-32122, from MC-453	5.5 mm.

Occurrence.—Rare, *Coosella* zone. Specimens have been obtained from measured sections at the following horizons: MC-446, 453.

Genus DUNDERBERGIA Walcott, 1924

Dunderbergia WALCOTT, 1924, p. 56; 1925, p. 84; RESSER, 1935, p. 23; RAYMOND, 1937, p. 1112; KOBAYASHI, 1938, p. 181; SHIMER and SHROCK, 1944, p. 625.

Genotype.—Crepicephalus (Loganellus) nitidus Hall and Whitfield, 1877, p. 212, pl. 2, fig. 8.

Diagnosis.—Cranidium with glabella bluntly rounded or truncate anteriorly; border relatively narrow; marginal furrow and anterior margin bluntly pointed on axial line; fixed cheeks narrow; posterior limbs slender, pointed.

Pygidium with length about one-half width, axial lobe reaches nearly to posterior margin, consists of three segments and a terminal portion. A post-axial median ridge extends to the pygidial border.

Description.—The cranidium, exclusive of the posterior limbs, is subquadrate in outline, moderately to strongly arched longitudinally and moderately arched transversely. The anterior margin is commonly bluntly pointed. The glabella is distinct, well defined by a moderately deep dorsal furrow, tapers very slightly forward, and is bluntly rounded or truncate anteriorly. Three pairs of shallow glabellar furrows may be present. A moderately deep, distinct occipital furrow is always present. The occipital ring is smooth or granular depending upon the character of the surface of the rest of the carapace, and may bear a distinct median node or, rarely, a pair of spines. A brim and border are present, separated by a broad, moderately deep marginal furrow. The furrow, like the anterior margin, usually comes to a blunt point on the axial line. The border is moderately to strongly arched, and the axial length is about one-half that of the brim. The brim is gently to moderately arched and continues, in general, the longitudinal convexity of the cranidium. The fixed cheeks are gently to moderately arched, horizontal, or somewhat upsloping, and narrow, usually about one-third the greatest width of the glabella. The palpebral lobes are semicircular in outline and weakly to moderately well defined by a broad, shallow, arcuate palpebral furrow. Low ocular ridges are commonly visible. The posterior limbs are narrow and sharply pointed. Their length is variable but averages slightly greater than the greatest width of the glabella. The marginal furrow on the posterior limb is broad and deep. The anterior course of the facial suture is divergent in front of the palpebral lobe but turns sharply inward upon reaching the border and cuts the anterior margin near the anterolateral corner of the cranidium. The posterior course of the facial suture diverges widely behind the palpebral lobe and curves gently backward to cut the posterior margin near the genal angle.

The free cheek has a short, pointed anterior projection. The border is narrow and separated from the ocular platform by a distinct marginal furrow. A narrow, relatively short genal spine diverges from the general curvature of the lateral margin.

Individual thoracic segments appear to be the same as those of *Aphelaspis.*

The pygidium is wide and short. The axial lobe is well defined, distinctly elevated above the pleural lobes, and bluntly terminated before reaching the posterior margin. It usually bears two or three distinct transverse furrows. All known pygidia have a narrow, post-axial median ridge extending to the border. The pleural lobes are usually very gently arched, and the pleural furrows are less well developed than those on the axial lobe. A very narrow, distinct border of nearly constant width is present along the entire periphery of the pygidium. The posterior margin may have a slight median indentation.

The surface of the carapace may be smooth or partly or wholly granular. There is considerable variation in the amount and type of granulation within a species.

Discussion.—The description of the genus is based mainly on the study of topotype material of the genotype from the Dunder-

berg shale in the Eureka mining district of Nevada. The pygidium illustrated by Hall and Whitfield and by subsequent authors for *Dunderbergia nitida* (Hall & Whitfield), the genotype, belongs to a species of *Housia,* a very common associate of *Dunderbergia* in the Dunderberg shale. The correct pygidium is described above.

Kobayashi (1939) proposed *Megadunderbergia* as a subgenus of *Dunderbergia* for forms with a pustulose surface. In *Dunderbergia* the pustulose character of the surface of the test is highly variable. Smooth and partly pustulose specimens are present within populations of *D. nitida* (Hall and Whitfield), and every gradation between the two types exists. For that reason *Megadunderbergia* is not considered a distinctive subgenus and is not used here.

DUNDERBERGIA VARIAGRANULA Palmer, n. sp.

Plate 88, figures 7, 9, 10; plate 89, figure 1

Diagnosis.—Surface of cranidium commonly completely covered with granules; granules may be distinct and scattered, or indistinct, low, and so numerous as to give the surface a roughened appearance; some specimens may have a smooth surface. Axial length of border of cranidium usually one-half or slightly more that of brim. Front of glabella commonly bluntly rounded rather than distinctly truncate as in *D. nitida* (Hall and Whitfield); basal glabellar width averages distinctly less than glabellar length.

Pygidium not specifically distinguishable from that of *D. nitida* (Hall and Whitfield).

Discussion.—This species resembles *D. nitida* (Hall and Whitfield) in overall proportions. The relatively longer border and manner of surface ornament are the distinguishing characteristics. Most specimens of *D. variagranula* Palmer have a completely granular surface, whereas *D. nitida* (Hall and Whitfield), although it may have all of the cranidium but the glabella granulated, is more commonly smooth.

Specimens resembling typical members of the species are associated with *D. nitida* (Hall and Whitfield) in the lower part of the Dunderberg shale in the Eureka mining district in Nevada.

Figured specimens.—

	Length
Holotype cranidium, USNM 123326, USGS coll. 10 (CO)	8 mm.
Cranidium, USNM 123327, from USGS coll. 10 (CO)	12 mm.
Cranidium, USNM 123328, from USGS coll. 33 (CO)	11 mm.
Pygidium, USNM 123328, from USGS coll. 33 (CO)	5.5 mm.

Occurrence.—Moderately rare, middle and upper portions of the *Aphelaspis* zone and in the post-*Aphelaspis* zone. Specimens have been obtained from measured sections at: MC-547, 561, 570; WC-795; USGS coll. 8, 9, 10, 11 (CO),

Additional specimens used in illustration are from USGS collection 33 (CO).

Genus LONCHOCEPHALUS Owen, 1852

Lonchocephalus OWEN, 1852, p. 575; HALL, 1863, pp. 147, 160; 1867, p. 129; SHUMARD, 1863, p. 104; MILLER, 1889, p. 555; WALCOTT, 1916, p. 188; SHIMER and SHROCK, 1944, p. 627.

Genotype.—Lonchocephalus chippewaensis Owen, 1952, p. 576, table 1, figs. 6, 14; table 1A, fig. 9.

Diagnosis.—Cranidium subquadrate in outline, moderately to strongly convex transversely and longitudinally. Glabella prominent, well defined by dorsal furrow, moderately to strongly convex transversely and longitudinally; sides gently rounded, front truncate or strongly rounded; length four-fifths or more, and width one-half or more that of cranidium; three pairs of glabellar furrows present, anterior pair shallow, remaining pairs moderately to deeply impressed, posterior pair arcuate. Occipital furrow deep, narrow. Occipital ring moderately wide, always bearing slender median spine. Frontal area short, usually downsloping in front of glabella, depressed laterally. Border narrow, width equal to or less than that of brim. Brim commonly with shallow median sulcus. Fixed cheeks one-third or less width of glabella, downsloping; palpebral lobes small, narrow, on transverse median line of glabella; ocular ridges present. Posterior limbs short, pointed; marginal furrows deep.

Anterior branch of facial suture extended straight forward or slightly divergent from palpebral lobe. Posterior branch diverges at angle of about 45 degrees from longitudinal axis of cranidium, cuts posterior margin within genal angle.

Free cheek moderately broad, margin regularly curved, border broader than that of cranidium. Genal spine divergent from curvature of margin.

Thorax of six to eight segments, each bearing one median, posteriorly directed spine. Axial lobe prominent, pleural lobes nearly flat.

Pygidium subtriangular in outline, gently to moderately convex transversely and longitudinally. Axial lobe prominent, tapered gently and bluntly rounded posteriorly; consists of six to eight distinct segments; extends to narrow border. Pleural lobes with distinct pleural furrows, lateral margins often downsloping.

Surface of carapace granular,

Discussion.—This genus is characteristic of the sand facies of the Dresbachian stage, exposed in the Upper Mississippi Valley and New York State, but it is rare in the carbonate facies. The diagnosis was made from a study of many specimens of this genus in University of Minnesota collections from Minnesota and Wisconsin.

LONCHOCEPHALUS? sp.
Plate 87, figure 5

Diagnosis.—Pygidium with outline subtriangular. Axial lobe prominent, slightly tapered, distinctly segmented, reaching to posterior margin. Pleural platforms moderately arched, distinctly segmented. Border narrow, unfurrowed.

Discussion.—Seven pygidia associated with *Pemphigaspis inexpectans* Lochman resemble those of an undescribed species of *Lonchocephalus* that is present in the *Crepicephalus* zone of Minnesota associated with *Pemphigaspis bullata* Hall. The generic reference is questioned because no cranidia referable to *Lonchocephalus* are associated with the Texas specimens. The writer does not want to extend the geographic range of this genus to Texas without more adequate information.

Figured specimen.—

	Length
Pygidium, UT-32154, from JR-201	3.5 mm.

Occurrence.—Rare, *Maryvillia* zone. The only known specimens are from the James River section at JR-201.

Genus MODOCIA Walcott, 1924

Modocia WALCOTT, 1924, p. 59; 1925, p. 105; SHIMER and SHROCK, 1944, p. 629.
Metisia RESSER, 1937, p. 19.
Semnocephalus RESSER, 1942, p. 50.

Genotype.—Arionellus (Crepicephalus) oweni Meek and Hayden, 1862, p. 436.

Diagnosis. — Cranidium moderately arched transversely and longitudinally, moderately rounded anteriorly. Glabella prominent, tapered forward, strongly and evenly rounded anteriorly; sides straight or slightly bowed outward; dorsal furrow well impressed at sides and front. Glabellar furrows shallow or absent. Occipital furrow deep at sides, shallow on midline; occipital ring rounded, unspined. Frontal area with distinct brim and border; border strongly arched upward; marginal furrow deep. Width of fixed cheeks one-half or less that of glabella; ocular ridges faint or absent. Palpebral lobes situated opposite middle third of glabella; depressed below margin of cheeks. Length of posterior limbs about equal to width of glabella at occipital furrow. Anterior course of facial suture nearly straight forward until onto border, then turned inward to cut margin about midway between anterolateral corners of cranidium and axial line; posterior course divergent behind palpebral lobe, cuts margin before reaching genal angle.

Free cheek with evenly curved margin. Border narrower than ocular platform, well defined by moderately deep marginal furrow. Genal spine present, length variable.

Thorax unknown.

Pygidium with axial length one-half or less width. Axial lobe prominent, consisting of three or four segments, tapered posteriorly, bluntly terminated, or merged with posterior margin, often with median indentation in terminal segment. Pleural lobes with deep pleural furrows and shallow to moderately deep interpleural grooves. Narrow, poorly defined border may be present.

Surface of carapace on well preserved specimens covered with closely spaced granules.

Discussion.—The original diagnosis of this genus stressed the width of the fixed cheeks as an important generic characteris-

tic. This feature is subject to considerable variation in trilobites of this type and, used alone, is not considered adequate for recognition of a genus. *M. oweni* (Meek & Hayden), the genotype, represents a group of trilobites characteristic of rocks of late Middle Cambrian and early Late Cambrian age. The deep dorsal and marginal furrows of the cranidium, and the narrow border and small number of segments of the pygidium are the principal diagnostic features.

Metisia Resser (1937, p. 19), proposed for a species from a boulder in the Levis conglomerate in Quebec, is identical in all respects with the concept of *Modocia* as used here and is considered by the writer to be a synonym of that genus.

Semnocephalus Resser, 1942, is also considered a synonym of *Modocia.* The genus was indirectly suppressed by Lochman and Duncan (1944, p. 128) when they placed the genotype, *Solenopleura? weedi* Walcott (1899, p. 464), in *Modocia* without apparent knowledge of Resser's earlier publication. Cranidia, pygidia, and free cheeks of a species nearly identical to *S.? weedi* Walcott have been collected by the writer from the *Cedaria* zone in the Abrigo limestone of southeastern Arizona. They agree in all observable characteristics with the concept of *Modocia* as used here and support the conclusion that *Semnocephalus* is a synonym of *Modocia.*

MODOCIA cf. M. CENTRALIS (Whitfield)
Plate 87, figure 8

Crepicephalus (Loganellus) centralis WHITFIELD, 1877, p. 10; 1880b, p. 341, pl. 2, figs. 21–24.
Modocia centralis (Whitfield) RESSER, 1935, p. 41; LOCHMAN and DUNCAN, 1944, p. 127.

Four poorly preserved cranidia are identical in all observable characteristics with *M. centralis* (Whitfield). The outer surface of the carapace is not preserved, and the presence of the granular surface of this species cannot be determined. The relatively wide fixed cheeks and the fact that the width of the cranidium between the palpebral lobes is greater than the length of the cranidium serve to distinguish this species from *Modocia oweni* (Meek and Hayden).

Figured specimen—

	Length
Cranidium, UT-32175, from TC-378	11 mm.

Occurrence.—Rare, lower portion of *Cedarina-Cedaria* zone. Specimens have been obtained from measured sections at: P-354; TC-378.

MODOCIA cf. M. OWENI (Meek and Hayden)
Plate 87, figures 3, 4, 6

Arionellus (*Crepicephalus*) *oweni* MEEK and HAYDEN, 1862, p. 436.
Modocia oweni (Meek & Hayden WALCOTT) 1925, p. 106, pl. 16, figs. 1–3.

Twenty cranidia and a few associated free cheeks and pygidia are nearly identical to specimens in the type lot of *M. oweni* (Walcott). The shape of the glabella, the outline of the cranidium, the size and position of the palpebral lobes, the general course of the facial sutures, the broad, moderately deep, evenly curved marginal furrow, the moderate to strong arching of the border along the longitudinal axis, and the pointed posterior limbs that are slightly shorter than the width of the glabella at the occipital ring are common characteristics. The only consistent observable difference is that the axial length of the border of the Texas specimens averages about equal to that of the brim, whereas that of the genotype is narrower than that of the brim.

The outline of the pygidium, especially in the character of the posterior margin which has a slight median indentation and, when viewed from the rear, resembles, a broad, shallow inverted V; the median indentation of the posterior end of the axial lobe; and the lack of a distinct border distinguish this species from *M. oweni* (Meek & Hayden). The axial lobe of the Texas specimens does not seem to have as great a taper and appears more bluntly terminated than that of the genotype. The specimens from South Dakota and Texas do not have the character of the outer surface preserved.

The cited differences are certainly of no more than specific value and, because of the long distance between the areas of occurrence, may be the result of geographic variation.

Figured specimens.—

	Length
Cranidium, UT-32124, from 16T-6-20A	7.5 mm.
Pygidium, UT-32125, from 16T-6-20A	5.0 mm.

	Width
Free cheek, UT-32126, from 16T-6-20A	7.0 mm.

Occurrence.—Moderately common, *Bolaspidella* zone. Specimens have been obtained from the lower portion of the Hickory sandstone member at 16T-6-9A and 16T-6-20A, and from the White Creek section at WC-247, 252.

Genus PEMPHIGASPIS Hall, 1863

Pemphigaspis HALL, 1863, p. 221; PALMER, 1951, p. 763; TASCH, 1952, p. 529.
Hallaspis RAASCH and LOCHMAN, 1943, p. 230.

The writer has given a full diagnosis of this genus in an earlier paper (Palmer, 1951, p. 763).

PEMPHIGASPIS INEXPECTANS Lochman
Plate 89, figures 2, 4, 6

Pemphigaspis inexpectans LOCHMAN, 1938a, p. 84, pl. 17, figs. 27, 28; PALMER, 1951, p. 764, pl. 105, figs. 7–9.

Diagnosis.—Cranidium with glabella expanded forward, reaching to margin, posterior glabellar furrows deep, narrow, forked. Frontal area absent. Palpebral lobes long, narrow.

Pygidium with axial lobe tapering strongly posteriorly; consisting of six segments that narrow rapidly towards rear. Terminal portion not curved downward.

Discussion.—The cranidium of this species seems to be nearly identical to that of *P. bullata* Hall (1863, p. 221). The pygidium differs by having the axial lobe more strongly tapered posteriorly.

Figured specimens.—

	Length
Cranidium, UT-31921, from JR-201	4.5 mm.
Pygidium, UT-31922, from JR-201	3.5 mm.

	Width
Free cheek, UT-31923, from JR-201	1.5 mm.

Occurrence.—Rare, *Maryvillia* zone. The only specimens in the writer's collections are from the James River section at JR-201. The type specimen is from the vicinity of the Morgan Creek section.

Genus RAASCHELLA Lochman, 1938

Raaschella LOCHMAN, 1938a, p. 81.

Genotype.—*Raaschella ornata* Lochman, 1938a, p. 82, pl. 18, figs. 6–10.

The writer follows the diagnosis of this genus given by Lochman (1938a, p. 81). *Terranovella bristolensis* Resser (1938a, p. 101) from the Nolichucky shale in Virginia is a specifically indeterminate representative of *Raaschella*. This occurrence, however, extends the geographic range of the genus throughout continental United States. It is considered to be an excellent regional index fossil for the base of the *Aphelaspis* zone.

RAASCHELLA ORNATA Lochman
Plate 89, figures 7–9

Raaschella ornata LOCHMAN, 1938a, p. 82, pl. 18, figs. 6–10.

Diagnosis.—Cranidium with short frontal area subequally divided into brim and border. Free cheek with strongly rounded genal angle and convex, well defined border. Pygidium with strong node-like ribs along margins of pleural lobes.

Discussion.—This species is represented in the collections by numerous cranidia and pygidia and a few free cheeks. It is a distinctive, stratigraphically restricted member of the *Aphelaspis* fauna.

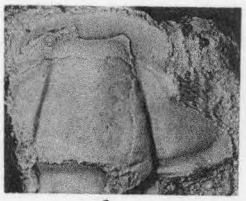
Figured specimens.—

EXPLANATION OF PLATE 88
POSITION UNKNOWN

FIGS. *1–4—Cheilocephalus breviloba* (Walcott). *1,* cranidium, ×1.5, USNM 123323, USGS coll. 7 (CO); *2,* rubber mold of exfoliated pygidium, ×2, UT-32106, TC-802; *3,* small cranidium for comparison with *C. minutus* Palmer, n. sp., ×3, UT-32104, MC-530; *4,* small pygidium for comparison with *C. minutus* Palmer, n. sp., ×4, UT-32105, MC-530; *Aphelaspis* zone. (p. 759)

5, 6, 8—Cheilocephalus minutus Palmer, n. sp. *5,* holotype, cranidium, ×4, USNM 123324, USGS coll. 476 (CO); *6,* pygidium, ×3, UT-32107, LL-559; *8,* exfoliated pygidium, ×3, USNM 123325, USGS coll. 476 (CO); *Aphelaspis* zone. (p. 759)

7, 9, 10—Dunderbergia variagranula Palmer, n. sp., ×3. *7,* holotype, cranidium showing one extreme of variation, USNM 123326, USGS coll. 10 (CO); *9,* cranidium showing other extreme of variation, USNM 123327, USGS coll. 10 (CO), *Aphelaspis* zone; *10,* pygidium, USNM 123328, USGS coll. 33 (CO); post-*Aphelaspis* zone. (p. 761)



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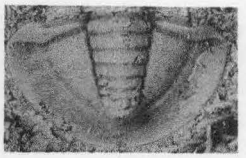

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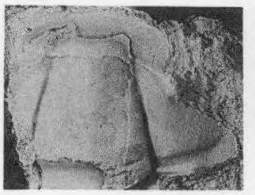

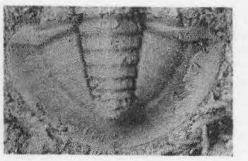

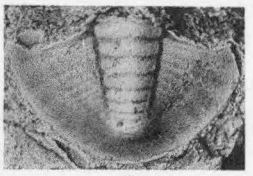

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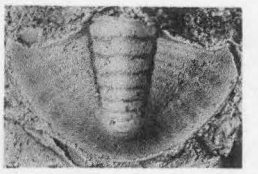

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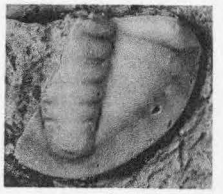

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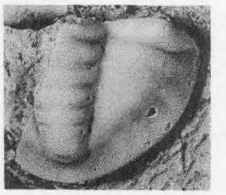

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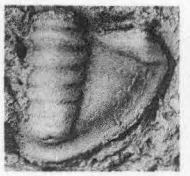

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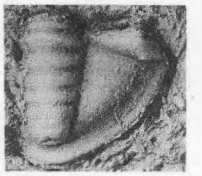

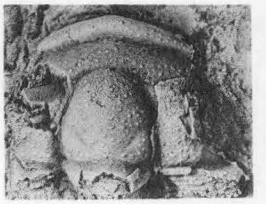

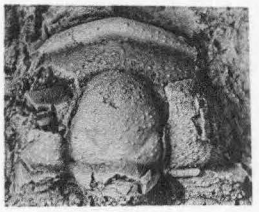

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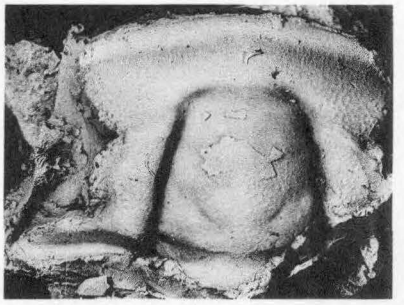

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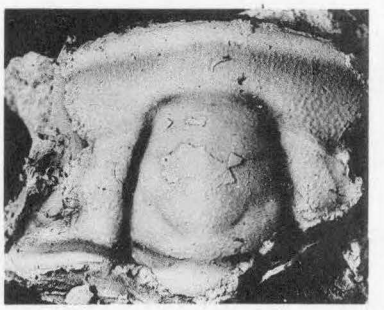
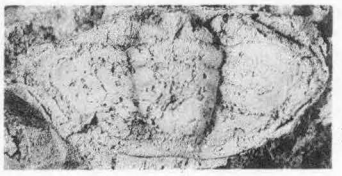
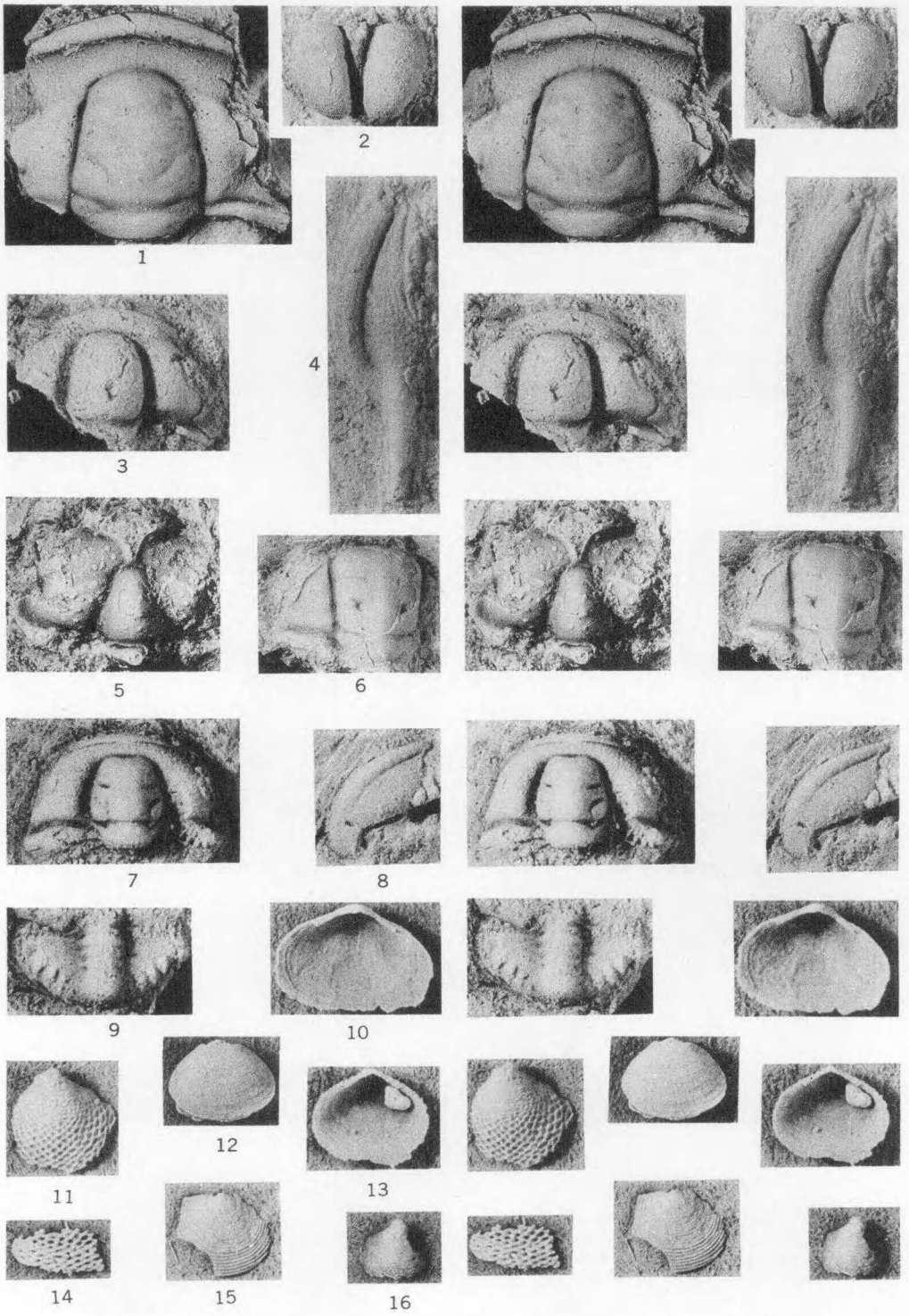




10

Palmer, Cambrian faunas from Texas



Palmer, Cambrian faunas from Texas

	Length
Cranidium, USNM 123330, from USGS coll. 7 (CO)	2 mm.
Pygidium, USNM 123331, from USGS coll. 476 (CO)	1.5 mm.
Free cheek, UT-32174, from LL-559	2 mm.

Occurrence.—Common, lower portion of *Aphelaspis* zone. Specimens have been obtained from measured sections at: LL-558, 559; MC-529, 532; P-647; S-387, 393; TC-805, 807; WC-750, 751; USGS coll. 7 (CO). The illustrated pygidium is from USGS coll. 476 (CO).

Genus and species undet. 1
Plate 87, figure 9

Two specimens of a trilobite species with a smooth, faintly furrowed cranidium, moderately to strongly arched transversely and longitudinally; a broad border moderately arched longitudinally; no brim; narrow fixed cheeks; small palpebral lobes situated slightly anterior to the transverse median line of the glabella; and short, wide, triangular, backswept posterior limbs are present in the collections. They do not seem to be referable to any described genus, although they show some affinities to *Bynumia metisensis* Rasetti and may represent a modified form of that species.

Figured specimens.—

	Length
Cranidium, UT-32186, from MC-483	4.5 mm.

Occurrence.—Rare, upper portion of the *Cedarina-Cedaria* zone and in the *Coosella* zone. Specimens have been obtained from measured sections at: MC-453; S-162.

Genus and species undet. 2
Plate 87, figure 10

A single imperfect cranidium with a subquadrate, faintly furrowed glabella, long brim, very short border, wide fixed cheeks, and small palpebral lobes situated slightly posterior to the transverse median line of the glabella may represent a new genus.

The nearest affinities of the specimen are to *Holcacephalus,* but the position of the palpebral lobes is distinctly different.

Figured specimen.—

	Length
Cranidium, UT-32187, from MC-419	3.5 mm.

Occurrence.—Rare, *Coosella* zone. The specimen is from MC-419.

Genus and species undet. 3
Plate 87, figure 7

Diagnosis.—Cranidium moderately to strongly arched transversely and longitudinally. Glabella prominent, tapered forward, bears two or three pairs of shallow glabellar furrows. Frontal area divided into distinct concave brim, and border that is thickened on axial line. Fixed cheeks moderately arched, upsloping from dorsal furrow; palpebral lobes situated just posterior to transverse median line of the glabella. Posterior limbs distinctly longer than width of glabella at occipital furrow. Surface is strongly granular.

EXPLANATION OF PLATE 89
POSITION UNKNOWN, PATERINACEA

FIG. *1*—*Dunderbergia variagranula* Palmer, n. sp., ×3, cranidium, USNM 123328, USGS coll. 33 (CO); post-*Aphelaspis* zone. (p. 761)

2, 4, 6—*Pemphigaspis inexpectans* Lochman. *2,* pygidium, ×4, UT-31922, JR-201; *4,* free cheek, ×10, UT-31923, JR-201; *6,* cranidium, ×4, UT-32191, JR-201; *Maryvillia* zone. (p. 764)

3—*Brassicicephalus* cf. *B. pulchellus* Lochman, ×6, cranidium, USNM 123329, 86T-13-17; *Cedarina-Cedaria* zone. (p. 757)

5—*Deiracephalus aster* (Walcott), ×4, cranidium, UT-32122, MC-453; *Coosella* zone. (p. 759)

7–9—*Raaschella ornata* Lochman. *7,* cranidium, ×8, USNM 123330, USGS coll. 7 (CO); *8,* free cheek, ×6, UT-32174, LL-559; *9,* pygidium, ×8, USNM 123331, USGS coll. 476 (CO); *Aphelaspis* zone. (p. 764)

10,12,13—*Dysoristus lochmanae* Bell, ×10. *10,* brachial interior, UT-32198b, MC-570; *12,* pedicle exterior, UT-32198c, MC-570; *13,* brachial interior, UT-32198a, MC-570; post-*Aphelaspis* zone. (p. 766)

11, 14—*Dictyonina perforata* Palmer, n. sp., ×10. *11,* holotype, pedicle exterior, UT-32197a, MC-529; *14,* shell fragment, UT-32197b, LL-559; *Aphelaspis* zone. (p. 766)

15, 16—*Paterina* sp., ×10. *15,* brachial exterior, UT-32201a, JR-42; *16,* pedicle exterior, UT-32201b, JR-42; *Cedarina-Cedaria* zone. (p. 767)

Discussion.—This species is represented by seven fragmentary cranidia that cannot be placed in any described genus. It shows some affinities to *Weeksina rara* Lochman (1944, p. 73).

Figured specimen.—

	Length
Cranidium, UT-32188, from MC-446	5 mm.

Occurrence.—Moderately rare, lower portion of the *Coosella* zone. Specimens have been obtained from measured sections at: JR-120; MC-419, 446.

II. BRACHIOPODA

Remains of at least 12 brachiopod species representing four atremate, three neotremate, and two protremate genera are present in collections from the Riley formation. The neotremate genera and species and one atremate species are new.

Abundant, excellently preserved examples of most of the atremate and neotremate species were obtained from acetic acid residues of limestone collections from all parts of the Riley formation. Unfortunately, there are no published studies based on comparable material so that adequate comparisons with many described forms are not possible.

The protremate species, represented by internal molds and occasional fragments of replaced shell material, were collected from the upper limy portion of the Cap Mountain limestone member and from limestone lenses in the overlying Lion Mountain sandstone member.

Order ATREMATA Beecher

Genus DICTYONINA Cooper, 1942

Iphidella WALCOTT, 1912, p. 359.
Dictyonina COOPER, 1942, p. 228; SHIMER and SHROCK, 1944, p. 287; COOPER, in Cooper et **al.**, 1952, p. 40.

Genotype.—*Trematis pannula* White, 1874, p. 6.

The writer follows the diagnosis of this genus given by Cooper (1952, p. 40).

DICTYONINA PERFORATA Palmer, n. sp.

Plate 89, figures 11, 14

Diagnosis.—The entire surface of the shell has a quincunxial pattern of sharp, raised ridges. The margin and the beak area are composed of solid shell material. In the portion of the shell between the margin and the beak the areas between the raised ridges of the surface ornament are angular perforations, and the shell resembles a screen.

Discussion.—Knowledge of the characteristics of this species is based almost entirely on broken fragments. Only one nearly complete specimen—a pedicle valve—has been obtained from the Riley formation. It is possible that the perforation of the shell results from slight solution by the acetic acid, but other species of *Dictyonina* from older rocks have been treated by the same process, and none of them had perforated shells. The wide geographic and narrow stratigraphic range of this species further suggest that the perforation is a persistent characteristic worthy of specific recognition.

Figured specimens.—

	Length
Holotype, pedicle valve, UT-32197a, from MC-529	1.5 mm.
Fragment, UT-32197b, from LL-559	0.5 mm.

Occurrence.—Moderately rare, basal portion of the *Aphelaspis zone.* Specimens have been obtained from measured sections at the following horizons: JR-247; LL-559, 560; MC-529, 538; S-387; TC-807; WC-750.

This species also occurs in the basal portion of the *Aphelaspis* zone in the Abrigo limestone in Arizona, the Gallatin formation in Wyoming, the Pilgrim limestone in Montana, and the Nolichucky shale in Tennessee.

Genus DYSORISTUS Bell, 1944

Dysoristus BELL, 1944, p. 146.

Genotype.—*Dysoristus lochmanae* Bell, 1944, p. **147.**

The writer follows the diagnosis of this genus given by Bell.

DYSORISTUS LOCHMANAE Bell

Plate 89, figures 10, 12, 13

Linnarssonella transversa LOCHMAN (not Walcott), 1940, p. 21, pl. 1, figs. 31–37.
Dysoristus lochmanae BELL, 1944, p. 147, pl. 18, figs. 32–37.

Many brachial valves and one complete shell have the characteristic transverse ovate outline, biconvex profile, and internal features of *Dysoristus lochmanae* Bell. The Texas specimens, despite their excellent preservation, do not add any new information concerning the morphology of this species. The known geographic and strati-

graphic ranges are extended greatly, however, as the previously reported occurrences of *D. lochmanae* Bell have been from the *Cedaria* zone in central Montana and Missouri.

Figured specimens.—

	Length
Brachial valve, UT-32198a, from MC-570	1.5 mm.
Brachial valve, UT-32198b, from MC-570	1.5 mm.
Complete specimen, UT-32198c, from MC-570	1.0 mm.

Occurrence.—Rare, post-*Aphelaspis* zone. Specimens have been obtained from MC-570.

Genus PATERINA Beecher, 1891

Paterina BEECHER, 1891, p. 345; WALCOTT, 1912, p. 343 (see this for synonymy pre-1912); SHIMER and SHROCK, 1944, p. 287; COOPER in Cooper et al., 1952, p. 38.

Genotype.—*Obolus labradoricus* Billings, 1861, p. 6, fig. 6.

The writer follows the diagnosis of this genus by Cooper.

PATERINA sp.
Plate 89, figures 15, 16

Many brachial valves with smooth umbonal regions and concentric ornament outside of the smooth area have the characteristics of *Paterina*. A few fragmental pedicle valves with smooth umbonal areas and concentric ornament outside of these areas also have the characteristics of this genus. There is not enough material for adequate specific differentiation.

On the basis of findings in central Texas, the stratigraphic range of the genus can be extended at least through the lower third of the Upper Cambrian.

Figured specimens.—

	Length
Brachial valve, UT-32201a, from JR-42	1 mm.
Pedicle valve, UT-32201b, from JR-42	1 mm.

Occurrence.—Moderately rare, *Cedarina-Cedaria, Coosella,* and *Aphelaspis* zones. Well preserved specimens have been obtained from measured sections at: JR-42, 144, 248; LL-450; MC-373, 419, 446, 453, 464, 469, 475, 483, 570; P-541, 544, 594, 647; S-162, 183, 287, 295, 412; TC-583, 599, 655, 656, 673, 693; WC-565, 582, 586.

Linguloid brachiopods

Fragments of linguloid brachiopods have been found in most of the insoluble residues of the Riley formation. At least two kinds are present.

Linguloid type A
Plate 90, figures 1, 3

Beak regions of a sharply acuminate "*Lingulepis*"-type linguloid brachiopod are moderately common in the *Aphelaspis* and post-*Aphelaspis* zones. The anterior portion has been broken from each of the hundreds of specimens collected so that the outline and most of the internal characters cannot be determined.

Figured specimens.—

	Length
Pedicle valve, UT-32199a, from WC-756	2.5 mm.
Pedicle valve, USNM 123372, from USGS coll. 33 (EP)	5.0 mm.

Occurrence.—Moderately common, *Aphelaspis* and post-*Aphelaspis* zones. The illustrated specimens are from WC-756 and USGS coll. 33 (CO).

Linguloid type B
Plate 90, figures 2, 4, 5

Moderately large, thick-shelled "*Lingulella*" type linguloids with acuminate pedicle valves and elongate subovate brachial valves are present in residues of limestone collections throughout the Riley formation. The insides of the shells are much like those illustrated by Walcott (1912, p. 17) for *Lingulella acutangula* (Roemer). Variations in internal characteristics of the brachial valves are illustrated for two specimens from approximately the same stratigraphic horizon.

Figured specimens.—

	Length
Brachial valve, UT-32200a, from WC-764	7.0 mm.
Pedicle valve, UT-32200b, from WC-764	8.0 mm.
Brachial valve, USNM 123332, from USGS coll. 10 (CO)	7.5 mm.

Occurrence.—Moderately common in the Riley formation. The illustrated specimens are from WC-764 and USGS coll. 10 (CO).

Order NEOTREMATA Beecher

Prior to 1946 knowledge of the internal

morphology of the neotremate brachiopods was limited to that obtained by mechanical cleaning with a needle, peeling of shell material to disclose internal characters, fortuitous interiors or internal molds of valves, and serial sections of specimens accompanied by camera lucida sketches. Most of the published work was by Waleott (1912) or Bell (1941, 1944). The advent of acetic acid etching (Bell, 1946, 1948) to obtain well-preserved complete shells has brought about the necessity for clarifying the descriptive terminology of this group. The terminology for external morphology is that applied by Bell (1941), with one addition discussed below. The internal characteristics are redescribed, and in several instances new terms are applied.

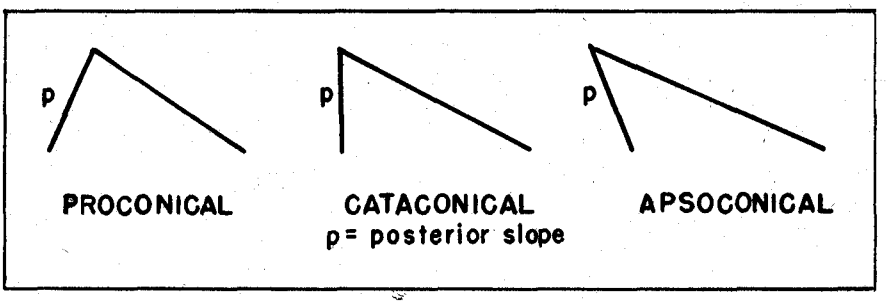


FIG. 6—Terminology for profile description of acrotretid pedicle valves.

All of the Neotremata in the Riley formation belong to the superfamily Acrotretacea and are characterized by conical pedicle valves with a small foramen at or just posterior to the apex. The posterior slope of these valves bears a furrow extending from the foramen to the commissure—the *intertrough* (Bell, 1941, p. 197)—or a weakly defined triangular feature—the *deltoid pseudointerarea*—expanding adapically and also reaching from the foramen to the commissure. This feature may be either concave or convex. Its commissure margin is often bowed adapically to fit into the median groove of the brachial valve. The shape of the pedicle valve can best be described by the terms *proconical, cataconical,* and *apsoconical* (fig. 6). These terms are adapted from procline, catacline, and apsacline, proposed by Schuchert and Cooper (1932, p. 20) to describe the position of the interarea in relation to the commissure in the Orthoidea and Pentameroidea.

The most striking feature of the interior of the pedicle valve is the *apical process.* This process is located at the apex of the shell and usually extends forward along the anterior slope. It is believed to house the pedicle tube, which has its internal opening at various places within the structure. The position of the *internal pedicle opening* is of some value in classification. The shape of the apical process ranges from triangular to spatulate. In some forms with a triangular process, a distinct cone-in-cone lamination of shell material is present (see Bell, 1941, fig. 7). Two pairs of muscle scars are visible —the *cardinal scars* (Walcott, 1912, p. 312), a pair of large subovate scars close to the commissure of the shell near the posterolateral margin, and the *apical pits,* two round, commonly deep pits adjacent to the apical process in the region of the apex. Two pallial trunks that diverge anteriorly from near the apex are sometimes visible.

The brachial valves are shallow, subcircular in outline, and have a distinct median septum. The *propareas* (Bell, 1941, p. 196), on the posterior margin, are separated by a concave, subtriangular, smooth trough—the *median groove.* At the anterior end of the groove, on the base of the median septum, is a single *postero-median scar.* Adjacent to the inner edges of the propareas are a pair of large scars—the *cardinal scars*—corresponding to those in the pedicle valve. The inner corners of the propareas frequently have low elevations that seem to have acted as stops to prevent the pedicle valve from sliding too far forward. In the center of the

shell, distant from each other by about one-third the width of the valve, are faint *centrobrachial scars.* The anterior end of the median septum may be simple or digitate. The digitation appears to be at most a specific character rather than a generic character as postulated by Bell (1941, p. 222) for *Prototreta.*

ANGULOTRETA Palmer, n. gen.

Genotype.—Angulotreta triangularis Palmer n. sp.

Diagnosis.—Pedicle valve with moderately high proconical or cataconical profile; foramen situated just posterior to the apex; deltoid pseudointerarea long, narrow. Apical process small, triangular, with cone-in-cone structure. Apical pits located near apex on lateral or posterior slopes of shell.

Brachial valve subcirdular in outline. Propareas distinct, smooth. Median septum with apex anterior to middle of shell.

Outer surface of both valves marked by fine growth lines. In addition, the brachial valve has a shallow median longitudinal sulcus and two nodes on the marginal beak.

Most specimens are three millimeters or less in diameter.

Derivation of name.—Angulus, L., angle; *treta,* Gr., bored through; referring to the angular profile and the apical foramen of the pedicle valve of this genus.

Discussion.—Angulotreta resembles *Homotreta* Bell (1941, p. 230) and *Prototreta* Bell (1941, p. 221) in details of the external surface, in the profile of the pedicle valve, and in the possession of a triangular apical process. It differs by having a deltoid pseudointerarea instead of an intertrough. Brachial valves of *Angulotreta* are generically indistinguishable from those of *Homotreta.*

Angulotreta is distinguished from *Apsotreta* and *Opisthotreta* by the proconical or cataconical profile of the pedicle valve and by the presence of an anteriorly tapered rather than anteriorly expanded apical process.

ANGULOTRETA POSTAPICALIS Palmer, n. sp.
Plate 91, figures 8–10

Diagnosis.—Pedicle valve: Internal pedicle opening distinct, often shown as ring in apical process. Apical pits located on posterior slope of shell. Deltoid pseudointerarea flat or concave.

Brachial valve specifically indistinguishable from that of the nondigitate specimens of *A. triangularis* Palmer.

Discussion.—This species is much like *Homotreta interrupta* Bell (1941, p. 230). The principal distinguishing difference is the possession of a deltoid pseudointerarea.

Figured specimens.—

Holotype, brachial valve, UT-32207a, from 16T-6-10A (LL)	2 mm.
Pedicle valve, UT-32207b, from 16T-6-10A (LL)	1.5 mm.
Pedicle valve, UT-32207c, from 16T-6-10A (LL)	2.5 mm.

Occurrence—Rare, *Cedarina-Cedaria* zone. Abundant specimens of this species have been obtained from the lower limey portion of the Cap Mountain limestone member near Sandy P.O., Blanco County, at locality 16T-6-10A (LL). Poor specimens possibly representing *A. postapicalis* Palmer are also present in WC-365.

ANGULOTRETA TRIANGULARIS Palmer, n. sp.
Plate 91, figures 1–6

Diagnosis.—Pedicle valve: Internal pedicle opening within apical process, but its position is not marked by a ring as in *A. postapicalis* Palmer. Apical pits at or near apex of shell. Deltoid pseudointerarea flat or slightly convex outward.

Brachial valve, except for var. *digitalis,* is not distinguishable from that of *A. postapicalis* Palmer.

Discussion.—This species differs from *A. postapicalis* Palmer in having the apical pits located slightly anterior to the position of those in that species, and in lacking a distinct marker for the position of the internal pedicle opening.

Figured specimens.—

	Length
Holotype, pedicle valve, UT-32196f, from WC-751	1.5 mm.
Pedicle valve, UT-32196b, from WC-751	1.5 mm.
Pedicle valve, UT-32196g, from WC-751	1.5 mm.
Brachial valve, UT-32196a, from WC-751	1.5 mm.
Brachial valve, UT-32196e, from WC-751	1.5 mm.

	Depth
Pedicle valve, UT-32196c, from WC-751	1.0 mm.

Occurrence.—Common, *Aphelaspis* zone. Specimens have been obtained from measured sections at the following horizons: JR-248, 250, 260, 265; LL-565; MC-538, 547, 561, 570; P-647, 652, 655; S-396; TC-811, 815, 821, 825, 829; WC-750, 751, 756, 764, 779; USGS coll. 8, 9, 10 (CO).

ANGULOTRETA TRIANGULARIS Palmer, **var.** DIGITALIS, n. var.
Plate 91, figure 7

Many specimens of *A. triangularis* Palmer with a digitate median septum represent a distinctive variety having a relatively limited range in the lower part of the range of the species.

Figured specimen.—

	Length
Brachiat valve, UT-32196d, from WC-751	1.5 mm.

Occurrence.—Moderately rare, *Aphelaspis* zone. Specimens have been obtained from measured sections at the following horizons: JR-248; MC-538; P-647; TC-811, 815; WC-751.

APSOTRETA Palmer, n. gen.

Genotype.—*Apsotreta expansa* Palmer, n. sp.

Diagnosis.—Adult pedicle valves have low, moderately to strongly apsoconical profile—immature forms have a proconical or cataconical profile; foramen situated just posterior to apex; deltoid pseudointerarea short, wide; posterior slope thickened. Apical process parallel sided or expanded anteriorly, with or without a distinct internal pedical opening. Apical pits situated distinctly in front of apex on anterior slope of shell.

Brachial valve subcircular to subovate in outline. Propareas distinct, smooth. Median septum with apex anterior to middle of shell.

Outer surface of both valves marked by fine growth lines. In addition, the brachial valve has a shallow median longitudinal sulcus and two nodes on the marginal beak.

Most specimens are two millimeters or less in diameter.

Derivation of name.—*Aps,* Gr., backward; *treta,* Gr., bored through; referring to the apsoconical profile of the pedicle valve of this genus.

Discussion.—*Apsotreta* has its closest affinities to the Franconian genus *Linnarssonella.* It differs from *Linnarssonella* by having a relatively longer posterior slope, a more strongly developed apical process in the pedicle valve, and by having a median septum and lacking grooves in the propareas of the brachial valve.

APSOTRETA EXPANSA Palmer, n. sp.
Plate 90, figures 6–14

Diagnosis.—Internal pedicle opening small, or absent; when present, located near apex. Sides of apical process moderately to strongly divergent anteriorly. Deltoid pseudointerarea moderately to strongly convex outward. Brachial valve subcircular to subovate in outline, moderately to strongly convex.

Discussion.—This species differs from *A. orifera* Palmer by the small size or absence of a discrete internal pedicle opening, more divergent sides to the apical process, and more anterior placement of the apical pits. Specimens from the lower portion of the stratigraphic range of the species have a small internal pedicle opening and very slightly divergent sides on a strongly developed apical process. Stratigraphically higher specimens show a gradual progressive degeneration of the apical process, increased divergence of the sides of this process, and loss of the independent internal pedicle opening. The shape of the brachial valve becomes more subovate and increases slightly in convexity in higher horizons. These changes are gradual, and all manner of intermediate forms exist. Rather than make separate species with indefinite limits, the writer considers these forms to be part of a microevolutionary series within the life span of a single species.

Figured specimens.—

	Length
Holotype, pedicle valve, UT-32193e, from TC-844	1.5 mm.
Pedicle valve, UT-32193b, from TC-844	1.5 mm.
Pedicle valve, UT-32193f, from TC-844	1.5 mm.
Brachial valve, UT-32193a, from TC-844	1.5 mm.
Brachial valve, UT-32193d, from TC-844	1.5 mm.

	Width
Pedicle valve, UT-32193c, from TC-844	1.0 mm.
	Length
Pedicle valve, UT-32194b, from TC-850	1.5 mm.
Pedicle valve, UT-32194c, from TC-850	1.5 mm.
Brachial valve, UT-32194a, from TC-850	1.5 mm.

Occurrence.—Common, post-*Aphelaspis* zone. Specimens have been obtained from measured sections at the following horizons: MC-574: TC-841, 844, 848, 850; WC-784, 795, 805, 808; USGS coll. 11 (CO).

APSOTRETA ORIFERA Palmer, n. sp.
Plate 90, figures 15, 16, 18

Diagnosis.—Internal pedicle opening distinct, located within the strongly developed apical process; sides of apical process nearly parallel. Deltoid pseudointerarea concave, flat, or convex outward.

Brachial valve subcircular in outline, specifically indistinguishable from that of *Angulotreta postapicalis* Palmer.

Discussion.—This species is distinguished from *A. expansa* Palmer by the large, distinct internal pedicle opening, the more nearly parallel-sided apical process, and by having the apical pits relatively closer to the apex. The normally parallel-sided apical process of this species appears to be subtriangular in corroded pedicle interiors of some specimens.

Figured specimens.—

	Length
Holotype, pedicle Valve, UT-32192b, from JR-42	1.5 mm.
Pedicle valve, UT-32192c, from JR-42	2.0 mm.
Brachial valve, UT-32192a, from JR-42	1.5mm.

Occurrence.—Rare, upper portion of the *Cedarina-Cedaria* zone, and the *Coosella* zone. Specimens have been obtained from measured sections at JR-42; MC-419; and TC-599.

OPISTHOTRETA Palmer, n. gen.

Genotype.—*Opisthotreta depressa* Palmer, n. sp.

Diagnosis.—Pedicle valve with strongly apsoconical profile; foramen at apex, pseudointerarea concave and variable in width. Apical process expressed as low, anteriorly expanded elevation directly in front of internal pedicle opening on anterior slope of shell. On many specimens this feature is not visible because of the vagaries of preservation. Except for shallow cardinal scars, the muscle pattern is not developed.

Brachial valve subcircular in outline, gently convex, propareas distinct, narrow, elongate; median groove somewhat pitlike, depressed below the apex of valve. Median septum absent, although a low median ridge is present. Cardinal muscle scars wide-set, just below and anterior to lateral ends of propareas.

Outer surface of both valves marked by fine growth lines.

Most specimens are one millimeter or less in diameter.

Derivation of name.—*Opisthen,* Gr., behind; *treta,* Gr., bored through; referring to the position of the apex behind the posterior margin of the pedicle valve.

Discussion.—*Opisthotreta* is distinguished from *Angulotreta* and *Apsotreta* by the strongly apsoconical profile and poorly developed apical process of the pedicle valve, and by the lack of nodes on the beak and absence of a median septum in the brachial valve. It resembles *Pegmatreta* (Bell, 1941) to some extent, differing principally in lacking the characteristic peglike thickening near the apex of the pedicle valve.

The apical process and cardinal muscle scars were observed on only a few fragmentary specimens. The unbroken specimens figured do not have these features preserved.

OPISTHOTRETA DEPRESSA Palmer, n. sp.
Plate 90, figures 17, 19–22

As this is the only known species of the genus, distinctive specific characteristics cannot be determined. The generic description is a description also of the species.

Discussion.—Specimens of this species are small and fragile, and well-preserved unbroken valves are the exception rather than the rule. Fragments of the pedicle valve are recognizable by the strongly apsaconical pedicle valve apex. Brachial valve fragments are recognizable by the depressed median groove and by the lack of a distinct median septum.

Figured specimens.—

	Length
Holotype, pedicle valve, UT-32202d, from TC-660	1 mm.
Pedicle valve, UT-32202b, from TC-660	1 mm.
Brachial valve, UT-32202a, from TC-660	1 mm.
Brachial valve, UT-32202c, from TC-660	1 mm.
Complete specimen, UT-32202e, from TC-660	1 mm.

Occurrence.—Moderately common, *Coosella* and *Maryvillia* zones. Specimens have been obtained from measured sections at the following horizons: JR-120, 132, 144, 163, 201, 218, 221; LL-468, 507, 548; MC-419, 446, 453, 464, 469, 475, 494; P-602; S-287. 295, 369; TC-655, 656, 660, 673, 693, 702, 732, 736; WC-852, 586, 628, 706, 725; U.S.G.S. coll. 3 (CO).

Order PROTREMATA Beecher
Genus BILLINGSELLA Hall, 1892

Billingsella HALL, 1892, p. 230; WALCOTT, 1912, p. 749; SCHUCHERT and COOPER, 1932, p. 48; ULRICH and COOPER, 1938, p. 72; BELL, 1941, p. 245.

The writer follows the characterization of this genus presented by Ulrich and Cooper.

Genotype.—Orthis pepina Hall, 1863, p. 134, pl. 6, figs, 23–27.

BILLINGSELLA sp.
Plate 91, figure 16

Fragmentary pedicle valves of an orthoid brachiopod with the subpentagonal outline and broad pedicle valve interarea of *Billingsella* have been obtained from the *Aphelaspis* zone. The specimens are poorly preserved and, aside from showing faint costellae and growth lines, exhibit no characteristics with sufficient clarity for adequate comparisons with other species.

Bell (1944, p. 153) mentioned the presence of *Billingsella* in the Pilgrim limestone, but the illustration here is the first for a species of *Billingsella* from pre-Franconian rocks.

Figured specimen.—

	Length
Pedicle valve, USNM 123333, from USGS coll. 8 (CO)	8 mm.

Occurrence.—Rare, *Aphelaspis* zone. The specimen was obtained from U.S.G.S. coll. 8 (CO).

Genus DIRAPHORA Bell, 1941

Dirapkora BELL, 1941, p. 243.

Genotype.—Eoorthis bellicostata Walcott, 1924, p. 505, pl. 113, figs. 8–14.

The writer follows the diagnosis of this genus given by Bell.

DIRAPHORA? sp.
Plate 91, figures 11–13

This species is known from internal molds of pedicle and brachial valves and a fragment of a pedicle valve showing external ornament. The characters of the interareas of the valves are not known.

The floor of the broad triangular delthyrial cavity in the pedicle valve is marked by

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EXPLANATION OF PLATE 90
OBOLACEA, ACROTRETACEA

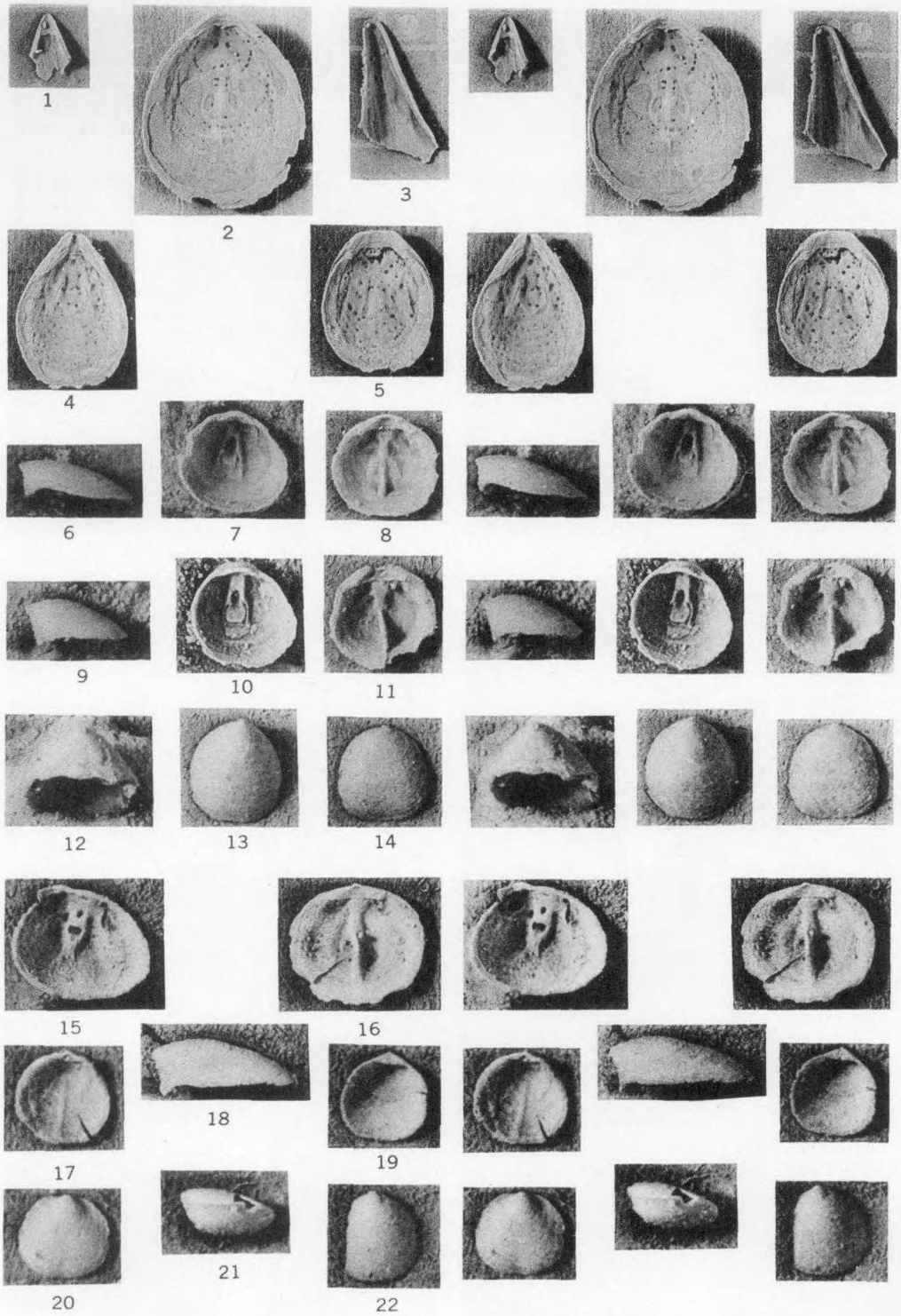
FIGS, *1, 3*—Linguloid type A, ×4, fragmentary pedicle interiors. *1,* UT-32199a, WC-754, *Aphelaspis* zone; *3,* USNM 123372, USGS coll. 33 (CO); post-*Aphelaspis* zone. (p. 767)

2, 4, 5—Linguloid type B. *2,* brachial interior, ×4, USNM 123332, USGS coll. 10 (CO); *4,* pedicle interior, ×3, UT-32200b, WC-764; *5,* brachial interior, ×3, UT-32200a, WC-764; *Aphelaspis* zone. (p. 767)

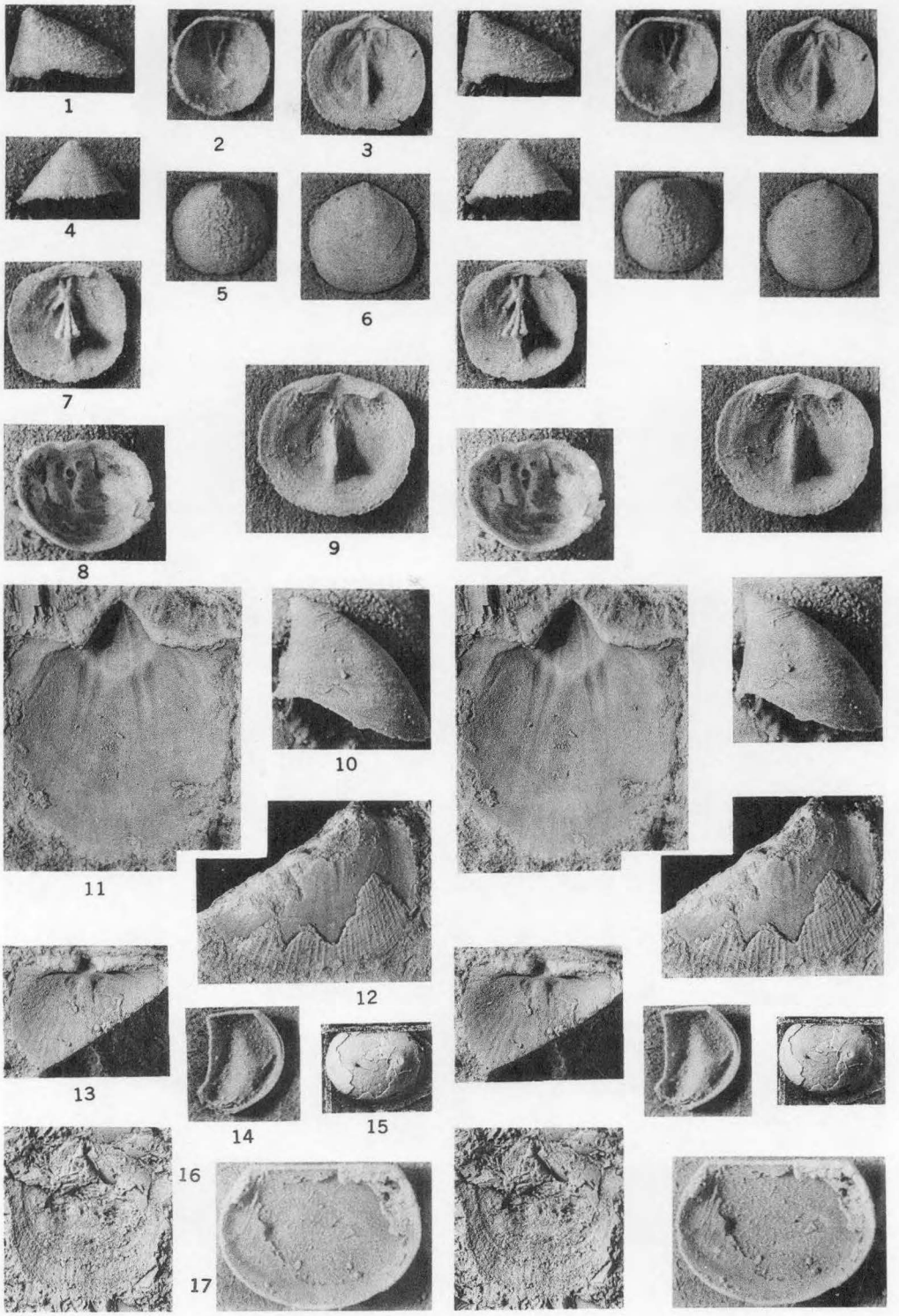
6–14—Apsotreta expansa Palmer, n. gen., n. sp., ×10. *6,* pedicle profile, UT-32194c, TC-850; *7,* pedicle interior, UT-32194b, TC-850; *8,* brachial interior, UT-32194a, TC-850; *9,* pedicle profile, UT-32193f, TC-844; *10,* holotype, pedicle interior showing minute internal pedicle opening, UT-32193e, TC-844; *11,* brachial interior, UT-32193d, WC-784; *12,* pedicle posterior, UT-31913c, TC-844; *13,* pedicle exterior, UT-32193b, TC-844; *14,* brachial exterior, UT-32193a, WC-784; post-*Aphelaspis* zone. (p. 770)

15, 16, 18—Apsotreta orifera Palmer, n. gen., n. sp., ×10. *15,* holotype, pedicle interior, UT-32192b, JR-42; *16,* brachial interior, UT-32192a, JR-42; *18,* pedicle profile, UT-32192c, JR-42; *Cedarina-Cedaria* zone. (p. 771)

17, 19–22—Opisthotreta depressa Palmer, n. gen., n. sp., ×15. *17,* brachial interior, UT-32202c, TC-660; *19,* holotype, pedicle interior, UT-32202d, TC-660; *20,* brachial exterior, UT-32202a, TC-660; *21,* profile of complete specimen, UT-32202e, TC-660; *22,* pedicle exterior, UT-32202b, TC-660; *Coosella* zone. (p. 771)



Palmer, Cambrian faunas from Texas



Palmer, Cambrian faunas from Texas

faint growth lines and a pair of centrally located, anteriorly expanded adductor tracks that are separated by a low, narrow longitudinal ridge. Poorly defined diductor tracks diverge anteriorly from the apex of the delthyrial cavity along the outer margins of the adductor scars. Two pairs of pallial trunks are present. One pair is straight and diverges from the anterior margin of the delthyrial cavity at the front end of the diductor track. The other pair extends outward and forward in a broad curve from the anterolateral margins of the delthyrial cavity. Each trunk is composed of two narrow furrows separated by a broad rounded ridge. The floor of the valve near the anterior margin is marked by faint fine costellae and a few low, indistinct growth lines.

The brachial valve has a deep triangular notothyrial cavity. There is no indication of a cardinal process. A broad, low ridge extends forward from the anterior edge of the notothyrial cavity for a short distance before merging with the floor of the valve. It is flanked by two distinct pairs of adjoining adductor scars. The larger, posterior, pair is located just in front of the notothyrial cavity. The smaller pair is located immediately anterior to the large pair. The anterior floor of the shell is marked by many low costellae and a few concentric growth lines.

The outer surface of the shell bears closely spaced costellae and growth lines of about equal strength.

The pedicle valve of this species is similar to the specimen figured by Bell (1941, pl. 33, fig. 12) as *Diraphora*? sp. It differs in having two pairs of pallial trunks, a less strongly developed adductor scar, and fewer and less prominent costellae on the internal mold. The interior of the brachial valve of *Diraphora* has not been described.

The pedicle valve differs from that of *Wimanella* (see Bell, 1941, p. 239) by having two pairs of pallial trunks, the inner pair of which consists of two furrows and an intermediate ridge. The brachial valve differs in lacking a low broad ridge in the notothyrial cavity.

The internal features, particularly the pattern of the pallial trunks, are similar to those of *Billingsella*, and it is possible that this species should be referred to that genus. A certain generic designation cannot be made until the interareas are known.

Figured specimens.—

	Length
Pedicle valve, UT-32203, from MC-419	8.0mm.
Pedicle valve, UT-32204, from WC-653	12.5 mm.
Brachial valve, UT-32206, from JR-144	6.0 mm.

Occurrence.—Moderately rare, *Coosella* and *Maryvillia* zones. Specimens have been obtained from measured sections at the following horizons: JR-144, 218; MC-419, 472, 475; S-287, 295, 325; TC-656, 673, 683; WC-565, 628, 653, 655.

EXPLANATION OF PLATE 91
ACROTRETACEA, ORTHACEA, LEPERDITIIDAE?

FIGS. *1–6—Angulotreta triangularis* Palmer, n. gen., n. sp., ×10. *1,* pedicle profile, UT-32196g, WC-751; *2,* holotype, pedicle interior, UT—32196f, WC-751; *3,* brachial interior, UT-32196e, LL-565; *4,* pedicle posterior, UT-32196c, WC-751; *5,* pedicle exterior, UT-32196b, WC-751; *6,* brachial exterior, UT-32196a, LL-565; *Aphelaspis* zone. (p. 769)

7—Angulotreta triangularis var. *digitalis* Palmer, n. var., ×10, holotype, brachial interior, UT-32196d, *WC-751; Aphelaspis zone.* (p. 770)

8–10—Angulotreta postapicalis Palmer, n. gen., n. sp., ×10. *8,* holotype, pedicle interior, UT-32207b, 16T-6-10A; *9,* brachial interior, UT-32207a, 16T-6-10A; *10,* pedicle profile, UT-32207c, 16T-6-10A; *Cedarina-Cedaria* zone. (p. 769)

11–13—Diraphora? sp. *11,* rubber mold of pedicle interior, ×4, UT-32204, WC-653; *12,* fragment of pedicle valve showing external ornament, ×3, UT-32203, MC-419; *13,* rubber mold of brachial interior, ×3, UT-32206, JR-144; *Coosella* zone. (p. 772)

14, 15, 17—Leperditiid ostracode? *14,* portion of margin showing detail of commissure, ×10, UT-32189a, MC-538; *Aphelaspis* zone; *15,* exterior of complete valve, ×5, UT-31189b, MC-570; *17,* interior of specimen in fig. *15,* ×5, UT-32189b, MC-570; post-*Aphelaspis* zone. (p. 774)

16—Billingsella sp.. ×3, pedicle interior, USNM 123333, USGS coll. 8 (CO); *Aphelaspis* zone. (p. 772)

III. MISCELLANEOUS ANIMAL REMAINS

Order OSTRACODA? Latreille, 1862
Family LEPERDITHDAE? Jones, 1856
Genus and species undetermined
Plate 91, figures 14, 15, 17

One nearly complete uncrushed valve, several crushed valves, and a few fragments of possible Ostracoda questionably assignable to the Leperditiidae have been obtained from acetic acid residues of collections in the upper part of the Riley formation.

The shell material of the single uncrushed valve is arranged in two complete layers and at the free margins, one incomplete layer that appears analogous to the duplicature of recent ostracodes. The specimen has a smooth shallowly pitted surface, a straight hinge margin, a broadly rounded ventral margin, and subequally rounded terminal margins. A prominent tubercle is located slightly above the middle of the shell near one end. There is a corresponding broad, shallow pit on the inner surface of the valve. Muscle scars have not been observed.

The width of the valve is greatest at the antituberculate end. It decreases slowly to the tubercle and then rapidly to the margin.

The hinge is non-denticulate. One of the fragmentary crushed specimens has a suggestion of a groove along the hinge margin, but this feature might be a result of crushing. The free margins of two of the fragmentary valves are definitely rabbeted.

The valves from the Riley formation resemble the Middle Ordovician genus *Eoleperditia* Swartz (1949) in having a non-denticulate hinge, but differ in having a laminated rather than fibrous shell structure.

The only other alleged North American leperditiid of (Cambrian age is *Leperditia harrisi* Frederickson (1946), described from the *Elvinia* zone (basal Franconian) of Oklahoma. It differs in having a rounded dorsal margin and in the absence of a tubercle.

The combined characteristics of a laminated shell structure, non-denticulate hinge, rabbeted margin, and apparent lack of distinct muscular markings do not fit any described leperditiid genus.

Measurements.—Height: 2.1 mm; length: 3.0 mm; width: 0.8 mm.

Figured specimens.—

Valve, UT-32198b, from MC-570
Fragment, UT-32198a, from MC-538

Occurrence.—Rare, *Aphelaspis* zone. Specimens have been obtained only from the Morgan Creek section at the following horizons: MC-529, 530, 538, 570.

Phylum PORIFERA
Spicules

Several spicule types apparently representing sponges are found in acetic acid residues of limestone collections in the Riley formation. Eight specimens illustrating three general spicule types are illustrated. Type A has been found in residues from the *Coosella* zone; type B in residues from the *Coosella* and *Maryvillia* zones; and type C in residues from the lower part of the *Aphelaspis* zone.

Spicule Type A
Plate 92, figures 5–7

Spicules of this type are characterized by cylindrical or nearly cylindrical rays in varying radial arrangements about a central ray. Each ray is a thick-walled tube with an outside diameter of about a third of a millimeter. Three specimens are illustrated—one consisting of six equally spaced rays in a plane perpendicular to the central ray; one consisting of four mutually perpendicular rays curved upward from the base of the central ray; and one consisting of a relatively large tapered central ray with four small, short, mutually perpendicular rays near the narrow end.

	Length
Figured specimens— USNM 123373a, from USGS coll. 3 (CO)	1 mm.
	1 mm.
	1 mm.

Occurrence.—Moderately rare, *Coosella* zone. Specimens have been obtained from measured sections at the following horizons: MC-419, 446, 453, 475; TC-693, 702.

Spicule Type B
Plate 92, figures 8, 10, 12

Spicules of this type were given the name *Chancelloria by* Walcott (1920). They have

a median portion as much as three-fourths of a millimeter in diameter. The spicule tapers in both directions from this portion, and one end is usually faceted. These spicules occur in clusters of four to six rays joined at the faceted surfaces and surrounding a central ray. In one sample, the rays are hollow and have an internal longitudinal rodlike axis resembling an everted umbrella. Single rods have been found in some residues.

Figured specimens.—

	Length
Central ray, UT-32191d, from MC-504	2 mm.
Lateral ray, UT-32191e, from MC-504	2 mm.
Axial rod, UT-32191c, from MC-419	0.5 mm.

Occurrence.—Moderately rare, *Coosella* and *Maryvillia* zones. Specimens have been obtained from measured sections at the following horizons: JR-144, 163, 218, 223; LL-450, 507, 537; MC-419, 464, 472, 475, 478, 494, 504; S-287, 295, 325; TC-583, 656, 660, 683, 732; WC-561, 565, 653, 655, 677, 695, 704, 725.

Spicule Type C
Plate 92, figures 9, 11

Spicules of this type are small, simple hexactinellid forms with straight cylindrical rays one-tenth millimeter in diameter.

Figured specimens.—

	Length
UT-32191a, from TC-802	0.5 mm.
UT-32191b, from TC-802	1.0 mm.

Occurrence.—Moderately rare, lower portion of the *Aphelaspis* zone. Specimens have been obtained from measured sections at the following horizons: LL-558, 559; P-430; TC-802; WC-744; U.S.G.S. coll. 7 (CO).

Position unknown
Genus KINSABIA Lochman, 1940

Kinsabia LOCHMAN, 1940a, p. 51.

Genotype.—Kinsabia variegata Lochman, 1940a, p. 51, pl. 2, figs. 10, 11. The writer follows the diagnosis of this genus given by Lochman.

KINSABIA VARIEGATA Lochman
Plate 92, figures 1–4

Kinsabia variegata LOCHMAN, 1940, p. 51, pl. 2, figs. 10, 11; LOCHMAN and DUNCAN, 1944, p. 79, pl. 8, fig. 49; LOCHMAN, 1950, p. 342.

Many hundreds of specimens representing this peculiar species have been found in residues of limestone collections from the *Cedarina-Cedaria* and *Coosella* zones. The majority of the specimens are solid or hollow asymmetrical conical plates with granular surfaces. Most of the plates are one millimeter or less in diameter. Several examples are illustrated.

Figured specimens.—

	Length
Plate cluster, UT-32190a, from TC-599	0.5 mm.
Plate cluster, UT-32190b, from TC-599	1.0 mm.
Plate cluster, UT-32190c, from TC-599	1.0 mm.
Individual plate, UT-32190d, from TC-599	0.5 mm.

Occurrence.—Moderately common, *Cedarina-Cedaria* and *Coosella* zones. Specimens have been obtained from measured sections at the following horizons: JR-42, 120, 132; LL-450, 486, MC-373, 419, 446; P-541, 594; S-183, 287; TC-599, 655, 656, 660, 673; WC-561, 565, 582, 586, 653.

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EXPLANATION OF PLATE 92

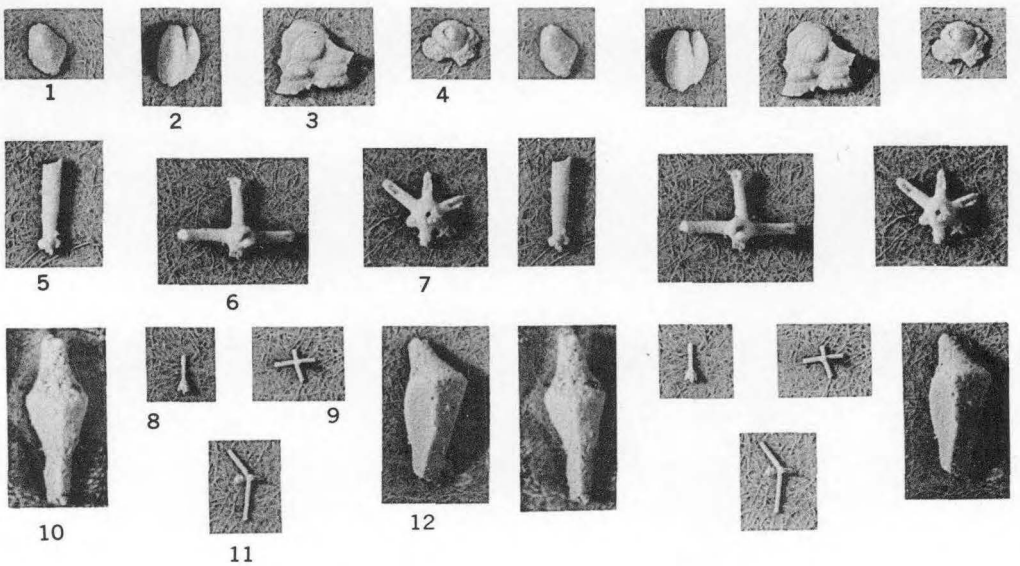
PHYLUM PORIFERA, POSITION UNKNOWN

FIGS. *1–4*—*Kinsabia variegata* Lochman, ×10, several specimens illustrating the variety of forms of this peculiar type of animal fragment, UT-32190a–d, TC-599; *Cedarina-Cedaria* zone (?). (p. 775)

5–7—Spicule type A, ×10, several specimens illustrating different associated forms and classed in this type, USNM 123373a–c, USGS coll. 3 (CO); *Coosella* zone. (p. 774)

8, 10, 12—Spicule type B, ×10. *8,* small example of internal rod of this type of spicule, UT-32191c, MC-419; *Coosella* zone; *10,* central ray, UT-32191d, MC-504; *12,* lateral ray, UT-32191e, MC-504; *Maryvillia* zone. (p. 774)

9, 11—Spicule type C, ×10, two forms of this smaller hexactinellid type, UT-32191a, b, TC-802; *Aphelaspis* zone. (p. 775)



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APPENDIX

TABLE I.—A COMPARISON OF LINEAR RATIOS AND STATISTICAL DATA FOR THE SPECIES OF *Aphelaspis* DESCRIBED FROM THE RILEY FORMATION

Class Interval 0.05	*A. spinosus* Palmer (7) −33 spms		*A. walcotti* Resser (34) −34 spms		*A. longifrons* Holotype	*A. constricta* Holotype
	M	σ	M	σ		
1. border/brim	0.646±0.012	0.070±0.009	0.681±0.010	0.061±0.007	0.85	0.37
2. frontal area/length cranidium	0.360±0.004	0.021±0.003	0.361±0.005	0.028±0.003	0.44	0.30
3. length palpebral lobe/length cranidium	0.197±0.004	0.021±0.003	0.226±0.004	0.021±0.003	0.21	0.25
4. midpt. palpebral lobe to post. margin/length cranidium (position of the palpebral lobe)	0.343±0.003	0.017±0.002	0.354±0.004	0.022±0.003	0.33	0.38
5. Basal glabellar width/width cranidium bet. eyes	0.609±0.006	0.036±0.004	0.634±0.004	0.022±0.003	0.63	0.69
6. width cheek/basal glabellar width	0.371±0.008	0.045±0.006	0.353±0.004	0.025±0.003	0.35	0.31
7. width glabella bet. eye lines/basal glabellar width	0.758±0.006	0.037±0.005	0.740±0.005	0.031±0.004	0.75	0.67
8. width cranidium/length cranidium	0.772±0.007	0.043±0.005	0.794±0.008	0.045±0.005	0.69	0.89
9. basal glabellar width/length glabella	0.928±0.007	0.038±0.005	0.974±0.006	0.033±0.004	0.99	1.10
10. ⅓ width cranidium at palp. lobe/⅓ max. width cranidium ant. to palpebral lobe (divergence of the facial sutures)	0.864±0.008	0.048±0.006	0.851±0.009	0.051±0.006	0.68	0.89

TABLE II.—THE KNOWN GEOGRAPHIC DISTRIBUTION OF THE TRILOBITE GENERA OF THE RILEY FORMATION[1]

	Dunderberg shale Nevada	Hamburg limestone Nevada	Secret Canyon shale Nevada	Abrigo limestone Arizona	Pilgrim limestone Montana	Park shale Montana	Dresbach sandstone Minn.-Wisc.	Riley formation Texas	Bonneterre dolomite Missouri	Nolichucky shale S. Appalachians	Conasauga shale S. Appalachians	Warrior limestone Pennsylvania	Rockledge formation Vermont	Petit Jordan formation Newfoundland	Cow Head breccia Newfoundland
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ankoura				X	X		X	X	X	X		X			
Aphelaspis				X	X		X	X		X					
Arcuolimbus								X							
Baltagnostus								X			X				
Blandicephalus								X							
Blountia					X		X	X	X	X		X	X	X	X
Bolaspidella		X	X	X	X	X		X			X				
Bonneterrina								X	X	X					
Brassicicephalus				X	X			X	X						
Cedaria				X	X		X	X		X					
Cedarina				X	X		X	X	X						
Cheilocephalus	X			X				X		X					
Coosella				X	X			X	X	X		X		X	X
Coosia				X	X		X	X	X	X					
Crepicephalus				X	X		X	X		X		X			X
Deiracephalus								X		X					
Densonella				X			X	X	X	X		X		X	
Dunderbergia	X							X		X					
Dytremacephalus								X							
Genevievella				X	X			X	X						
Geragnostus	X							X							
Holcacephalus				X	X			X	X	X		X			X
Kingstonia				X	X			X	X	X		X	X		X
Kormagnostus				X	X			X	X	X					
Labiostria	?							X		X					
Llanoaspis				X	X			X		X					
Lonchocephalus					X		X	X				X			
Maryvillia				X	X		X	X		X					
Menomonia					X		X	X	X						
Meteoraspis				X	X			X	X				X		X
Modocia		X	X	X	X			X							
Norwoodia					X		X	X	X	X					
Pemphigaspis					X		X	X		X		X			
Protillaenus				X	X			X		X					
Pseudagnostus	X			X	X		X	X	X	X					
Pterocephalia	X							X							
Raaschella				X	X		X	X		X					
Syspacheilus				X	X			X	X	X					
Tricrepicephalus				X	X		X	X	X	X		X			X

[1] The identifications in columns 1–4, 7, 8 are the writer's.
The information in columns 5, 6, 9–15 is modified from the following publications:
5, 6—Lochman and Duncan, 1944; 9—Lochman, 1936, 1938a;
10, 11—Resser, 1938a; 12—Tasch, 1951; 13—Shaw, 1952;
14, 15—Lochman, 1938b.

TABLE III.—THE KNOWN STRATIGRAPHIC RANGES OF THE IDENTIFIED FOSSILS OF THE RILEY FORMATION IN CENTRAL TEXAS

	ZONES											
	Bolaspidella		Cedarina-Cedaria		Coosella		Maryvillia		Aphelaspis		Post-Aphelaspis	
	L	U	L	U	L	U	L	U	L	U	L	U
I. Trilobita												
AGNOSTIDAE McCoy												
Peronopsinae Westergård												
Baltagnostus cf. B. centerensis (Resser)	x											
Kormagnostus simplex Resser		x	x	x	x	x						
Geragnostinae Howell												
Geragnostus cf. G. tumidosus (Hall and Whitfield)									x			
Pseudagnostinae Whitehouse												
Pseudagnostus communis (Hall and Whitfield)										x		
Pseudagnostus? nordicus (Lochman)					x	x		x				
ASAPHISCIDAE Raymond												
Asaphiscinae Kobayashi												
Blountia nixonensis Lochman									x			
Blountia sp.				x	x							
Maryvillia? cf. M. ariston Walcott							x	x				
Protillaenus spp					x	x						
Kingstoniinae Kobayashi												
Ankoura cf. A. apicalis Duncan				x								
Kingstonia (Ucebia) pontotocensis Lochman					x	x	x	x				
COOSELLIDAE Palmer, n fam.												
Coosella beltensis Lochman					x							
Coosella cf. C. granulosa Rasetti					x	x						
Coosella cf. C. widnerensis (Resser)						x						
Coosella sp.					x	x						
Coosia cf. C. albertensis Resser							x	x				
Coosia connata (Walcott)					x							
Crepicephalus australis, n sp						x	x					
Crepicephalus cf. C. iowensis (Owen)								x				
Crepicephalus ? perplexus, n. sp									x			
Syspacheilus cf. S. camurus Lochman				x								
Syspacheilus dunoirensis (Miller)			x									
CEDARIIDAE Raymond												
Bonneterrina appalachia (Walcott)		x										
Cedaria eurycheilos, n. sp.				x								
Cedarina cordillerae (Howell and Duncan)			x									
LLANOASPIDAE Lochman												
Arcuolimbus convexus, n. gen., n sp					x							
Genevievella cf. G. spinosa Lochman				x	x							
Llanoaspis modesta Lochman						x						
Llanoaspis peculiaris (Resser)								x				
Llanoaspis undulata Lochman							x					
Llanoaspis virginica (Resser)					x							
MENOMONIIDAE Walcott (emend. Shaw)												
Bolaspidella burnetensis (Walcott)		x										
Bolaspidella prooculis, n. sp.	x											
Bolaspidella wellsvillensis (Lochman and Denson)	x											
Bolaspidella sp.			x									
Densonella sp.					x	x						
Menomonia sp.			x	x								
NORWOODIIDAE Walcott												
Holcacephalus cf. H. tenerus (Walcott)				x	x							
Norwoodia quadrangularis (Whitfield)					x							
PTYCHOPARIIDAE Matthew												
Aphelaspis constricta, n sp.										x		
Aphelaspis longifrons, n. sp										x		
Aphelaspis spinosus, n. sp.									x			
Aphelaspis walcotti Resser									x	x		
Blandicephalus texanus, n gen., n. sp.											?	
Dytremacephalus granulosus, n gen., n. sp.										x	x	x
Dytremacephalus laevis, n gen., n. sp.										x		
Labiostria convexmarginata, n gen., n. sp.									x	x	x	
Labiostria platifrons, n. gen., n. sp										x		
Labiostria sigmoidalis, n. gen., n. sp.												x
Pterocephalia cf. P. occidens Walcott												x

	ZONES											
	Bolaspidella		Cedarina-Cedaria		Coosella		Maryvillia		Aphelaspis		Post-Aphelaspis	
	L	U	L	U	L	U	L	U	L	U	L	U
TRICREPICEPHALIDAE Palmer, n. fam.												
Meteoraspis cf. M. loisi Lochman							x					
Meteoraspis metra (Walcott)					x	x						
Meteoraspis cf. M. robusta Lochman				x								
Tricrepicephalus coria (Walcott)					x	x	x	x				
Tricrepicephalus texanus (Shumard)					x							
Position Unknown												
Brassicicephalus cf. B. pulchellus Lochman				x								
Chellocephalus breviloba (Walcott)									x	x	x	
Chellocephalus minutus, n. sp.									x			
Deiracephalus aster (Walcott)					x							
Dunderbergia variagranula, n. sp.										x	x	x
Lonchocephalus? sp.							x					
Modocia cf. M. centralis (Whitfield)			x									
Modocia cf. M. oweni (Meek and Hayden)	x											
Pemphigaspis inexpectans Lochman							x					
Raaschella ornata Lochman									x			
Genus and species undetermined 1				x	x							
Genus and species undetermined 2					x							
Genus and species undetermined 3					x							
II. Brachiopoda												
ATREMATA Beecher												
Paterinacea Schuchert												
Dictyonina perforata, n. sp.									x			
Dysoristus lochmanae Bell											x	
Paterina sp.				x	x	x			x			
Obolacea Schuchert												
Linguloid type A									x	x	x	x
Linguloid type B				x	x	x	x	x	x	x	x	x
NEOTREMATA Beecher												
Acrotretacea Schuchert												
Angulotreta postapicalis, n. gen., n. sp.			x									
Angulotreta triangularis, n. gen., n. sp.									x	x	x	
Angulotreta triangularis digitalis, n. gen., n. var.									x	x		
Apsotreta expansa, n. gen., n. sp.											x	x
Apsotreta orifera, n. gen., n. sp.				x	x							
Opisthotreta depressa, n. gen., n. sp.					x	x	x	x				
PROTREMATA Beecher												
Orthacea Walcott and Schuchert												
Billingsella sp.										x		
Diraphora sp.					x	x	x	x				
III. Miscellaneous Animal Remains												
OSTRACODA Latrielle												
Leperditiidae Jones												
Genus and species undetermined									x	x		
PORIFERA Hogg												
Spicule type A					x	x						
Spicule type B					x	x	x	x				
Spicule type C									x			
Position Unknown												
Kinsabia variegata Lochman				x	x	x						

MEASURED SECTIONS

The exact line of each measured section is marked on aerial photographs on file in the offices of the Bureau of Economic Geology at The University of Texas at Austin, Texas.

JR—James River section. About 1 mile up James River from junction with Llano River, Mason County, Texas. U. S. Department of Agriculture photographs CJC-60-12 and 13; bearing Bureau of Economic Geology index numbers 159T-5-39 and 40.

LL—Little Llano River section. Three miles east, then 2 miles south of Cherokee, Llano County, Texas. U. S. Department of Agriculture photographs CJC-6-135 and 136; bearing Bureau of Economic Geology index number 149T-4-1.

MC—Morgan Creek section. This section is in three parts. MC-0 to MC-419 are near and on Potatotop (Tatur Hill) about 5 miles northeast of Burnet; MC-419 to MC-529 are on the northwest flank of Baldy Mountain on the south side of the south fork of Morgan Creek; and MC-529 to 591 are on the north bank of the south fork of Morgan Creek. The latter two localities are about 9 miles northeast of Burnet, and all are in Burnet County, Texas. U. S. Department of Agriculture photographs CJC-11-139 (Potatotop); CJC-19-103 (Baldy Mountain); and QJC-19404 (north *bank);* bearing Bureau of Economic Geology index numbers 27T-8-28, 36, and 37, respectively.

P—Pontotoc section. About 1 mile northeast of Pontotoc along road over hill in extreme northeast corner of Mason County, Texas. U. S. Department of Agriculture photographs CJC-3-30 and 31; bearing Bureau of Economic Geology index numbers 159T-1-1 and 2.

S—Streeter section. Along highway about 2 miles west of Streeter, Mason County, Texas.

TC—Threadgill Creek section. Along Squaw and Threadgill creeks, just north of the Mason-Gillespie line in Mason County, Texas. U. S. Department of Agriculture photographs CJC-24-10, 11, and 12; bearing Bureau of Economic Geology index numbers 159T-3-42, 43, and 44.

WC—White Creek section. Along White and Ziczac Creeks on the south end of the Crown-over Ranch, 6 miles west of the Llano-Round Mountain lane in extreme northern Blanco County, Texas. U. S. Department of Agriculture photographs CJC-9-129 and 130; bearing Bureau of Economic Geology index numbers 16T-5-42 and 43.

Lion Mountain section (USGS coll. 3-11 [CO], collected by Dake, Bridge, Ulrich, and others 1930–1934). On southwest slope of Lion Mountain, along old (pre-Lake Buchanan) state highway 29, northwest of Burnet, Burnet County, Texas.

MISCELLANEOUS COLLECTIONS

U. S. Geological Survey (Cambrian-Ordovician)

33 (CO). Packsaddle mountain, on first peak east of road crossing through the gap, in wedge between two unmapped faults. Llano County, Texas (collected by Bridge and Lochman, 1934).

184 (CO). Packsaddle mountain, near summit of west face of west peak, east of saddle with road in wedge dropped between two faults. Llano County, Texas (collected by Bridge, 1934).

476 (CO). On Keltus Carter ranch, 3.8 mi. north and 0.6 mi. west of Lone Grove P. O. Collected from section measured to top of bluff; section begins at dam of tank 0.25 mi. north of east-west road and follows ravine taking left-hand fork just above head of tank. About 90 feet above forks in ravine. Collected by W. H. Hass, 1938.

U. S. Geological Survey collections (old series)

14d (OS). two miles southeast of the mouth of Fall Creek, 17 miles northwest of Burnet, Burnet County, Texas. Collection made by Ulrich, Willis, and Taff, no date.

67 (OS). Potatotop, 6 miles northwest of Burnet, Burnet County, Texas. Collection made by Walcott, 1884. Some fossils cited from this locality could not possibly have been found here as the top of Potatotop reaches barely into the lower part of the *Coosella* zone.

BUREAU OF ECONOMIC GEOLOGY LOCALITIES

These localities are given as photograph numbers in the Bureau of Economic Geology photograph files. The letter is placed on the photograph at the site of the collecting locality.

16T-6-9A. From low ridge in Hickory sandstone member along road just south of Sandy P. (X, Blanco Co., Texas.

16T-6-10A (LL). Just below crest of hill, in lower limy portion of the Cap Mountain limestone member, along road south of Sandy P. O., Blanco County, Texas.

16T-6-20A. From Hickory sandstone member along side road just west of Sandy P. O., Blanco County, Texas.

16T-6-12A. From Lion Mountain sandstone member, 10½ feet below base of Welge sandstone member of Wilberns formation, near mouth of Buffalo Run, 4 miles west of Johnson City, Blanco County, Texas. Collection made by J. L. Wilson, 1951.

16T-13-17. From Cap Mountain limestone member on Squaw Creek 250 feet southeast of Squaw Creek school and 2900 feet south of Doss-Hilltop road, Gillespie County, Texas. Collection made by Barnes, 1940.

FAUNAL LISTS

The numbers of the collections from all measured sections except the Lion Mountain section are the stratigraphic distance in feet of the collecting horizon above the base of the section.

* = Brachiopods
† = Miscellaneous animal remains

James River Section

Top of Lion Mountain sandstone member about JR-280.
Post-*Aphelaspis* zone
JR-275
Dytremacephalus granulosus
***Aphelaspis* zone**
JR-265
Aphelaspis walcotti ***Angulotreta triangularis**
Labiostria conveximarginata
JR-260
Aphelaspis walcotti ***Angulotreta triangularis**
JR-250
Aphelaspis walcotti ***Angulotreta triangularis**
JR-248
Aphelaspis walcotti ***Angulotreta triangularis digitalis**
Labiostria conveximarginata
JR-247
Aphelaspis walcotti ***Dictyonina perforata**
***Angulotreta triangularis**
Top of Cap Mountain limestone member about JR-230.
***Maryvillia* zone**
JR-223
Coosia cf. C. albertensis **Pseudagnostus? nordicus**
Kingstonia pontotocensis **Tricrepicephalus cf. T. coria**
Maryvillia cf. M. ariston **†Spicule type B**
JR-221
***Opisthotreta depressa**
JR-218
Coosia cf. C. albertensis **Tricrepicephalus coria**
Kingstonia pontotocensis ***Diraphora sp.**

Llanoaspis peculiaris — *Opisthotreta depressa
Maryvillia cf. M. ariston — †Spicule type B
JR-201
Coosia cf. C. albertensis — Maryvillia cf. M. ariston
Crepicephalus australis — Pemphigaspis inexpectans
Kingstonia pontotocensis — Tricrepicephalus coria
Llanoaspis undulata — *Opisthotreta depressa
Lonchocephalus? sp.
Coosella zone
JR-163
?Coosella granulosa — Tricrepicephalus coria
Coosella cf. C. widnerensis — *Opisthotreta depressa
Llanoaspis modesta — †Spicule type B
JR-144
Llanoaspis modesta — *Opisthotreta depressa
*Diraphora sp. — †Spicule type B
JR-132
Arcuolimbus convexus — Tricrepicephalus coria
Coosella beltensis — *Opisthotreta depressa
Coosella granulosa — †Kinsabia variegata
Kormagnostus simplex
Top of "silty zone" about JR-125
JR-120
Arcuolimbus convexus — Tricrepicephalus coria
Coosella beltensis — Genus and species undet. 3
Coosella granulosa — *Opisthotreta depressa
Kormagnostus simplex — †Kinsabia variegata
Tricrepicephalus texanus
Top of lower limy portion of the Cap Mountain limestone member about JR-63
Cedarina-Cedaria zone
JR-42
Holcacephalus cf. H. tenerus — *Apsotreta orifera
Kormagnostus simplex — *Paterina sp.
Meteoraspis cf. M. robusta — †Kinsabia variegata
Syspacheilus cf. S. camurus
Tricrepicephalus sp.

Little Llano River Section

Top of Lion Mountain sandstone member about LL-598
Aphelaspis zone
LL-592
Aphelaspis walcotti
LL-589
Aphelaspis walcotti — Dunderbergia variagranula
LL-578
Aphelaspis walcotti
LL-565
Aphelaspis walcotti — *Angulotreta triangularis
Top of Cap Mountain limestone member about LL-560
LL-560
Aphelaspis walcotti — *Dictyonina perforata
LL-559
Aphelaspis walcotti — Raaschella ornata
Cheilocephalus minutus — *Dictyonina perforata
Geragnostus cf. G. tumidosus — †Spicule type C
LL-558
Aphelaspis walcotti — Raaschella ornata
Cheilocephalus breviloba — †Spicule type C
LL-557
Aphelaspis walcotti — Maryvillia cf. M. ariston
Coosia cf. C. albertensis — Tricrepicephalus coria
Crepicephalus? perplexus
Llanoaspis peculiaris
Maryvillia zone
LL-548
Maryvillia cf. M. ariston — *Opisthotreta depressa
LL-537
Llanoaspis undulata — Tricrepicephalus coria
Llanoaspis undulata granulata — †Spicule type B
Maryvillia cf. M. ariston
Coosella zone
LL-507
Crepicephalus australis — *Opisthotreta depressa
Meteoraspis metra — †Spicule type B
Tricrepicephalus coria
LL-486
Tricrepicephalus coria — †Kinsabia variegata
LL-468
Proteillaenus sp. — Tricrepicephalus coria
Coosella beltensis — *Opisthotreta depressa
Densonella sp.
Kingstonia pototocensis
Top of "silty zone" about LL-465
LL-450
Coosella beltensis — †Kinsabia variegata
Kormagnostus simplex — †Spicule type B
Pseudagnostus? nordicus
Top of Hickory sandstone member and base of "silty zone" about LL-363. Lower limy portion of the Cap Mountain limestone member not developed.
Cedarina-Cedaria zone
LL-327
Cedarina cordillerae
LL-325
Cedarina cordillerae
LL-324
Cedarina cordillerae
Bolaspidella zone
LL-252
Bolaspidella burnetensis

Morgan Creek Section

Top of Lion Mountain sandstone member about MC-591
Post-*Aphelaspis* zone
MC-574
*Apsotreta expansa — *Dysoristus lochmanae
MC-570
Cheilocephalus breviloba — *Angulotreta triangularis
Dunderbergia variagranula — †Leperditiid? ostracode
Labiostria convexima rginata
Aphelaspis zone
MC-561
Aphelaspis walcotti — Pseudagnostus communis
Dunderbergia variagranula — *Angulotreta triangularis
MC-547
Aphelaspis constricta — Cheilocephalus breviloba
Aphelaspis longifrons — Dunderbergia variagranula
Aphelaspis walcotti — *Angulotreta triangularis
Top of Cap Mountain limestone member about MC-544
MC-538
Aphelaspis walcotti — *Dictyonina perforata
Labiostria convexima rginata — †Leperditiid? ostracode
*Angulotreta triangularis
MC-532
Aphelaspis spinosus — Raaschella ornata
MC-530
Aphelaspis walcotti — †Leperditiid? ostracode
Cheilocephalus breviloba
MC-529
Cheilocephalus breviloba — Tricrepicephalus coria
Crepicephalus? perplexus — *Dictyonina perforata
Maryvillia cf. M. ariston — †Leperditiid? ostracode
Raaschella ornata
Maryvillia zone
MC-516
Coosia cf. C. albertensis — Maryvillia cf. M. ariston
Crepicephalus cf. C. iowensis — Tricrepicephalus coria
Llanoaspis peculiaris
MC-504
Llanoaspis undulata — Maryvillia cf. M. ariston
Llanoaspis undulata granulata — †Spicule type B
MC-494
*Opisthotreta depressa — †Spicule type B
Coosella zone
MC-485
Kormagnostus simplex — Tricrepicephalus coria
Meteoraspis metra — †Spicule type B
MC-483
Protillaenus sp. — *Opisthotreta depressa
Crepicephalus australis — †Spicule type B
Llanoaspis modesta
MC-478
Crepicephalus australis — †Spicule type B
Meteoraspis metra
MC-475
Kingstonia pontotocensis — *Diraphora sp.
Llanoaspis modesta — *Opisthotreta depressa
Meteoraspis metra — †Spicule type A
Tricrepicephalus coria — †Spicule type B
Top of "silty zone" about MC-473
MC-472
Coosella cf. C. widnerensis — *Diraphora sp.
Coosella sp. — †Spicule type B
Llanoaspis modesta
MC-469

Coosella cf. C. widnerensis — Tricrepicephalus coria
Crepicephalus australis — *Opisthotreta depressa
Meteoraspis metra
MC-464
Coosella cf. C. widnerensis — *Opisthotreta depressa
Kingstonia pontotocensis — †Kinsabia variegata
Kormagnostus simplex — †Spicule type B
Tricrepicephalus coria
MC-453
Arcuolimbus convexus — Meteoraspis metra
Blountia sp. — Tricrepicephalus coria
Coosella beltensis — Genus and species undet. 1
Densonella sp. — *Opisthotreta depressa
Deiracephalus aster — †Spicule type A
Kingstonia pontotocensis
Kormagnostus simplex
MC-446
Blountia sp. — Meteoraspis metra
Coosella beltensis — Tricrepicephalus coria
Coosella granulosa — Genus and species undet. 3
Coosella sp. — *Opisthotreta depressa
Deiracephalus aster — *Paterina sp.
Holcacephalus cf. H. tenerus — †Kinsabia variegata
Kormagnostus simplex — †Spicule type A

Top of lower limy portion of Cap Mountain limestone member about MC-419
MC-419
Blountia sp. — Tricrepicephalus texanus
Coosella beltensis — Genus and species undet. 2
Coosella granulosa — Genus and species undet. 3
?Coosella sp. — *Apsotreta orifera
Coosia connata — *Diraphora sp.
Genevievella cf. G. spinosa — *Opisthotreta depressa
Holcacephalus cf. H. tenerus — †Kinsabia variegata
Kormagnostus simplex — †Spicule type A
Norwoodia quadrangularis — †Spicule type B
Tricrepicephalus coria
Cedarina-Cedaria zone
MC-373
Cedaria eurycheilos — *Paterin sp.
Meteoraspis cf. M. robusta — †Kinsabia variegata
Syspacheilus cf. S. camurus

Top of Hickory sandstone member about MC-340
MC-322
?Cedaria eurycheilos
MC-299
Cedarina cordillerae — Kormagnostus simplex
MC-283
Bolaspidella sp. — Cedarina cordillerae
Bolaspidella zone
MC-222
Bolaspidella burnetensis

Pontotoc Section

Top of Lion Mountain sandstone member about P-667
Aphelaspis zone
P-655
Aphelaspis walcotti — *Angulotreta triangularis
P-652
Aphelaspis walcotti — *Angulotreta triangularis
P-650
Aphelaspis walcotti — Pseudagnostus josephus
Labiostria conveximarginata
P-647
Aphelaspis walcotti — *Angulotreta triangularis digitalis
Raaschella ornata — *Spicule type C

Top of Cap Mountain limestone member about P-640
P-639
Aphelaspis walcotti — Cheilocephalus breviloba
P-638
Aphelaspis spinosus
P636
Aphelaspis walcotti
Maryvillia zone
P-622
Maryvillia cf. M. ariston — Tricrepicephalus coria
P-618
Coosia cf. C. albertensis — Meteoraspis cf. M. loisi
Maryvillia cf. M. ariston
P-609
Crepicephalus australis — Tricrepicephalus sp.
P-604
Crepicephalus australis
P-602
Coosia cf. C. albertensis — ?Llanoaspis undulata
Crepicephalus australis — *Opisthotreta depressa
Coosella zone
P-594
?Coosella cf. C. widnerensis — †Kinsabia variegata

Top of "silty zone" about P-570
P-544
*Paterina sp.
P-541
Coosella beltensis — †Kinsabia variegata

Top of Hickory sandstone member and base of "silty zone" about P-470. Lower limy portion of the Cap Mountain limestone member not developed.
Cedarina-Cedaria zone
P-425
Cedarina cordillerae — Kormagnostus simplex
P-395
Cedarina cordillerae — Kormagnostus simplex
P-385
Cedarina cordillerae
P-354
Bolaspidella sp. — Modocia cf. M. centralis
P-350
Cedarina cordillerae
Bolaspidella zone
P-326
Bolaspidella burnetensis
P-320
Bolaspidella burnetensis
P-279
Bolaspidella wellsvillensis

Streeter Section

Top of Lion Mountain sandstone member about S-418
Aphelaspis zone
S-412
Aphelaspis walcotti
S-396
*Angulotreta triangularis
S-393
Aphelaspis walcotti — Raaschella ornata

Top of Cap Mountain limestone member about S-389
S-387
Aphelaspis walcotti — *Dictyonina perforata
Raaschella ornata
Maryvillia zone
S-369
Coosia cf. C. albertensis — Pseudagnostus? nordicus
Llanoaspis peculiaris — Tricrepicephalus coria
Maryvillia cf. M. ariston — *Opisthotreta depressa
Coosella zone
S-325
Coosella cf. C. widnerensis — †Spicule type B
*Diraphora sp.
S-295
Coosella beltensis — *Opisthotreta depressa
Meteoraspis metra — †Spicule type B
*Diraphora sp.
S-287
*Diraphora sp. — †Kinsabia variegata
*Opisthotreta depressa — †Spicule type B

Top of "silty zone" about S-275
Cedarina-Cedaria zone
S-183
Ankoura cf. A. apicalis — Tricrepicephalus sp.
Blountia sp. — *Paterina sp.
Meteoraspis cf. M. robusta — †Kinsabia variegata
Syspacheilus cf. S. camurus
S-162
?Ankoura cf. A. apicalis — Syspacheilus cf. S. camurus
Meteoraspis cf. M. robusta — Genus and species undet. 1
S-130
Cedaria eurycheilos

Top of Hickory sandstone member and base of "silty zone" about S-116. Lower limy portion of the Cap Mountain limestone member not developed.
S-105
Cedaria eurycheilos — Kormagnostus simplex
S-0
Cedarina cordillerae

Threadgill Creek Section

Top of Lion Mountain sandstone member about TC-860
Post-*Aphelaspis* zone
TC-850
*Apsotreta expansa
TC-848
?Labiostria sigmoidalis — *Apsotreta expansa
Pterocephalia cf. P. occidens
TC-844
*Apsotreta expansa
TC-841
Dytremacephalus granulosus — *Apsotreta expansa
TC-835
Labiostria conveximargina-ta
Aphelaspis zone
TC-829
*Angulotreta triangularis
TC-825
Aphelaspis walcotti — *Angulotreta triangularis
TC-821
Aphelaspis walcotti — *Angulotreta triangularis
Pseudagnostus communis
TC-815
Aphelaspis constricta — Pseudagnostus communis
Aphelaspis longifrons — *Angulotreta triangularis
TC-811
Aphelaspis walcotti — *Angulotreta triangularis digitalis
TC-807
Aphelaspis spinosa — Raaschella ornata
Geragnostus cf. G. tumidosus — *Dictyonina perforata
TC-805
Aphelaspis walcotti — Raaschella ornata
TC-802
Aphelaspis walcotti — †Spicule type C
Cheilocephalus breviloba
TC-800
Aphelaspis walcotti — Cheilocephalus breviloba
Top of upper Cap Mountain limestone member about TC-792. Fault at this point repeats about ten feet of section.
Maryvillia zone
TC-787
Coosia cf. C. albertensis — Pseudagnostus? nordicus
TC-776
Kingstonia pontotocensis — Maryvillia cf. M. ariston
TC-774
Maryvillia cf. M. ariston
TC-736
*Opisthotreta depressa
TC-732
Kingstonia pontotocensis — *Opisthotreta depressa
Llanoaspis undulata — †Spicule type B
Maryvillia cf. M. ariston
Coosella zone
TC-702
Llanoaspis modesta — *Opisthotreta depressa
Meteoraspis metra — †Spicule type A
Tricrepicephalus coria
TC-693
*Opisthotreta depressa — †Spicule type A
*Paterina sp.
TC-683
*Diraphora sp. — †Spicule type B
TC-673
*Diraphora sp. — †Kinsabia variegata
*Opisthotreta depressa
Top of "Silty zone" about TC-667
TC-660
Kormagnostus simplex — †Kinsabia variegata
Tricrepicephalus coria — †Spicule type B
*Opisthotreta depressa
TC-656
Kormagnostus simplex — *Paterina sp.
Pseudagnostus? nordicus — *Opisthotreta depressa
Tricrepicephalus coria — †Kinsabia variegata
Tricrepicephalus texanus — †Spicule type B
*Diraphora sp.
TC-655
Arcuolimbus convexus — *Opisthotreta depressa
Coosella sp. — †Kinsabia variegata
Coosia connata
Top of lower limy portion of Cap Mountain limestone member about TC-600. Fault of unknown displacement here.
TC-599
*Apsotreta orifera — †Kinsabia variegata
TC-583
†Spicule type B
Cedarina-Cedaria zone
TC-580
?Genevievella cf. G. spinosa — Syspacheilus cf. S. camurus
TC-515
Cedaria eurycheilos — Menomonia sp.
Kormagnostus simplex
TC-505
Kormagnostus simplex
TC-499
Cedaria eurycheilos
TC-432
Cedaria eurycheilos — Menomonia sp.
TC-429
Cedaria eurycheilos — Menomonia sp.
Kormagnostus simplex
TC-378
Cedarina cordillerae — Modocia cf. M. centralis
Top of Hickory sandstone member about TC-364
TC-362
Cedarina cordillerae — Menomonia sp.
Kormagnostus simplex
TC-348
Cedarina cordillerae — Menomonia sp.
Kormagnostus simplex — Syspacheilus dunoirensis
TC-345
Kormagnostus simplex — Syspacheilus dunoirensis
TC-340
Syspacheilus dunoirensis
Bolaspidella zone
TC-330
Bolaspidella burnetensis — Kormagnostus simplex
Bonneterrina appalachia
TC-323
Bolaspidella burnetensis — Kormagnostus simplex
Bonneterrina appalachia
TC-296
Bolaspidella wellsvillensis
TC-288
Bolaspidella wellsvillensis

White Creek Section

Top of Lion Mountain sandstone member about WC-814
Post-*Aphelaspis* zone
WC-808
*Apsotreta expansa
WC-805
*Apsotreta expansa
WC-795
Dunderbergia variagranula — Pterocephalia cf. P. occidens
Dytremacephalus granulosus — *Apsotreta expansa
Labiostria sigmoidalis
WC-784
*Apsotreta expansa
WC-779
*Angulotreta tri ngularis
Aphelaspis zone
WC-775
Labiostria conveximargina-ta
Top of Cap Mountain limestone member about WC-773
WC-771
Aphelaspis walcotti — Labiostria platifrons
WC-764
*Angulotreta triangularis
WC-756
*Angulotreta triangularis
WC-751
Aphelaspis walcotti — *Angulotreta triangularis digitalis
Raaschella ornata
WC-750
Aphelaspis walcotti — *Angulotreta triangularis digitalis
Raaschella ornata — *Dictyonina perforata
WC-744
Aphelaspis walcotti — †Spicule type C
Maryvillia zone
WC-725
*Opisthotreta depressa — †Spicule type B
WC-706
Kingstonia pontotocensis — Tricrepicephalus coria
Llanoaspis undulata — *Opisthotreta depressa
Maryvillia cf. M. ariston
WC-704
†Spicule type B

Coosella zone
WC-695
Llanoaspis modesta †Spicule type B
WC-677
Meteoraspis metra †Spicule type B
WC-655
Kormagnostus simplex *Diraphora sp.
Meteoraspis metra †Spicule type B
Tricrepicephalus texanus
WC-653
*Diraphora sp. †Kinsabia variegata
*Opisthotreta depressa †Spicule type B
Top of "silty zone" about WC-652
WC-628
Coosella beltensis Tricrepicephalus coria
Kingstonia pontotocensis Tricrepicephalus texanus
Llanoaspis virginica *Diraphora sp.
Meteoraspis metra *Opisthotreta depressa
Pseudagnostus? nordicus
Top of lower limy portion of the Cap Mountain limestone member about WC-586
WC-586
Tricrepicephalus texanus †Kinsabia variegata
*Opisthotreta depressa
WC-582
Coosia connata †Kinsabia variegata
*Opisthotreta depressa
WC-565
*Diraphora sp. †Spicule type B
†Kinsabia variegata
WC-561
†Kinsabia variegata †Spicule type B
Cedarina-Cedaria zone
WC-460
Cedaria eurycheilos Menomonia sp.
Kormagnostus simplex
WC-365
?Angulotreta postapicalis
Bolaspidella zone
WC-341
Bolaspidella wellsvillensis
Top of Hickory sandstone member about WC-276
WC-270
Bolaspidella wellsvillensis
WC-252
Bolaspidella wellsvillensis Modocia cf. M. oweni
WC-247
Modocia cf. M. oweni

Lion Mountain Section

Number in brackets is footage above base of section

Post-*Aphelaspis* zone
USGS Coll. 11 (230)
Cheilocephalus breviloba Pterocephalia cf. P. occidens
Dunderbergia variagranula *Apsotreta expansa
Dytremacephalus granulosus
Aphelaspis zone
USGS Coll. 10 (215)
Aphelaspis walcotti Dytremacephalus laevis
Cheilocephalus breviloba Labiostria conveximarginata
Dunderbergeria variagranula Pseudagnostus communis
Dytremacephalus granulosus *Angulotreta triangularis
USGS Coll. 9 (210)
Aphelaspis walcotti Labiostria conveximarginata
Dunderbergia variagranula *Angulotreta triangularis
Dytremacephalus laevis
USGS Coll. 8 (200–205)
Aphelaspis constricta Dytremacephalus laevis
Aphelaspis longifrons Labiostria conveximarginata
Aphelaspis walcotti Pseudagnostus communis
Cheilocephalus breviloba *Angulotreta triangularis
Dunderbergia variagranula *Billingsella sp.
USGS Coll. 7 (190)
Aphelaspis walcotti Cheilocephalus breviloba
Aphelaspis spinosus Raaschella ornata
Maryvillia zone
USGS Coll. 6 (180)
Coosia cf. C. albertensis Tricrepicephalus coria
Maryvillia cf. M. ariston Tricrepicephalus sp.
USGS Coll. 5 (155)
Maryvillia cf. M. ariston
Coosella zone
USGS Coll. 4 (125)
Arcuolimbus convexus Kingstonia pontotocensis
Blountia sp. Kormagnostus simplex
Coosella beltensis Meteoraspis metra
Densonella sp. Pseudagnostus? nordicus
Genevievella cf. G. spinosa Tricrepicephalus coria
Holcacephalus cf. H. tenerus Tricrepicephalus sp.
USGS Coll. 3 (85)
Coosella beltensis Tricrepicephalus coria
Coosella granulosa Tricrepicephalus texanus
Holcacephalus tenerus Tricrepicephalus sp.
*Opisthotreta depressa
†Spicula type C

MISCELLANEOUS COLLECTIONS CITED

USGS Coll. 33 (post-*Aphelaspis* zone)
Blandicephalus texanus *Apsotreta expansa
Dunderbergia variagranula
USGS Coll. 184 (*Aphelaspis* zone)
Aphelaspis walcotti *Angulotreta triangularis
USGS Coll. 476 (*Aphelaspis* zone)
Cheilocephalus minutus Raaschella ornata
USNM Coll. 14d—part (*Aphelaspis* zone)
Aphelaspis walcotti *Dictyonina perforata
Blountia nixonensis †Spicule type C
*Angulotreta triangularis
USNM Coll. 67—part (*Aphelaspis* zone)
Aphelaspis walcotti *Dictyonina perforata
*Angulotreta triangularis digitalis
Bur. Econ. Geol. Loc. 16T-6-9A (*Bolaspidella* zone)
Bolaspidella prooculis Modocia cf. M. oweni
Bur. Econ. Geol. Loc. 16T-6-10A (*?Cedarina-Cedaria* zone) (LL)
*Angulotreta postapicalis
Bur. Econ. Geol. Loc. 16T-6-20A (*Bolaspidella* zone)
Baltagnostus cf. B. centerensis Modocia cf. M. oweni
Bolaspidella prooculis
Bur. Econ. Geol. Loc. 16T-6-12A (Post-*Aphelaspis* zone)
Dytremacephalus granulosus *Apsotreta expansa
Pterocephalia cf. P. occidens
Bur. Econ. Geol. Loc. 86T-13-17A (*Cedarina-Cedaria* zone)
Brassicicephalus cf. B. pulchellus
Kormagnostus simplex
Meteoraspis cf. M. robusta