BUREAU OF ECONOMIC GEOLOGY
The University of Texas
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PETER T. FLAWN, *Director*

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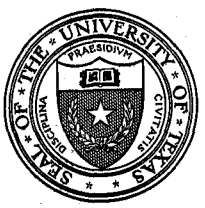

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LATE CAMBRIAN AND EARLY ORDOVICIAN FAUNAS FROM THE WILBERNS FORMATION OF CENTRAL TEXAS

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ABSTRACT—The San Saba Member of the Wilberns Formation of central Texas is mostly coarse-grained, trilobitic limestone that grades eastward to dolomite and contains sandstone intervals in its westernmost exposures. Faunas from the limestone place the middle part of the San Saba within the Trempealeauan Stage (*Saukia* zone) of the Upper Cambrian, but the uppermost part belongs to the Lower Ordovician. Three subzones within the *Saukia.* zone are described. In ascending order they are: the *Saukiella junia* subzone containing *Bayfieldia, Briscoia, Corbinia, Euptychaspis, Eurekia, Saukia, Saukiella, Stenopilus, Triarthropsis,* and *Finkelnburgia;* the *Saukiella norwalkensis* subzone containing *Bayfieldia, Bowmania, Briscoia, Calvinella, ?Dikelocephalus, Eurekia, Euptychaspis, Heterocaryon, Idiomesus, Keithiella, Leiocoryphe, Macronoda, Plethometopus, Prosaukia, Saukiella, Stenopilus, Theodenisia,* and *Finkelnburgia;* the *Corbinia apopsis* subzone containing *Acheilops, Apatokephaloides, Corbinia, Eurekia, Idiomesus, Leiobienvillia, Leiocoryphe, Plethometopus, Theodenisia Triarthropsis, Apheoorthis, Finkelnburgia, Glyptotrophia,* and *Nanorthis.* Trilobites of the *Saukiella junia* and *Saukiella norwalkensis* subzones are closely allied to those of the Trempealeauan of the upper Mississippi Valley, whereas the trilobites of the *Corbinia apopsis* subzone represent an influx of the *Hungaia magnifica* fauna.

The low Ordovician faunas are subdivided into two zones. The lower zone is named the *Missisquoia* zone and contains *Highgatella, Homagnostus, Hystricurus, Missisquoia, Paraholinella, Symphysurina, Apheoorthis, Conotreta* and *Syntrophina.* It correlates closely with a low Ordovician fauna from Vermont described by Shaw. The upper zone is the *Symphysurina* zone and contains *Clelandia, Homagnostus, Hystricurus, Jujuyaspis, Symphysurina, Apheoorthis,* and *Syntrophina.* It correlates most closely with the *Symphysurina* zone of Utah and Nevada.

New trilobite species are *Acheilops masonensis, Bayfieldia simata, Bowmania sagitta, Briscoia llanoensis, Calvinella procera, Clelandia texana, Corbinia apopsis, Corbinia implumis, Euptychaspis jugalis, Homagnostus reductus, Keithiella patula, Leiobienvillia leonensis, Leiocoryphe halei, Missisquoia inflata, Missisquoia nasuta, Saukiella planata,* and *Symphysurina bubops.*

INTRODUCTION

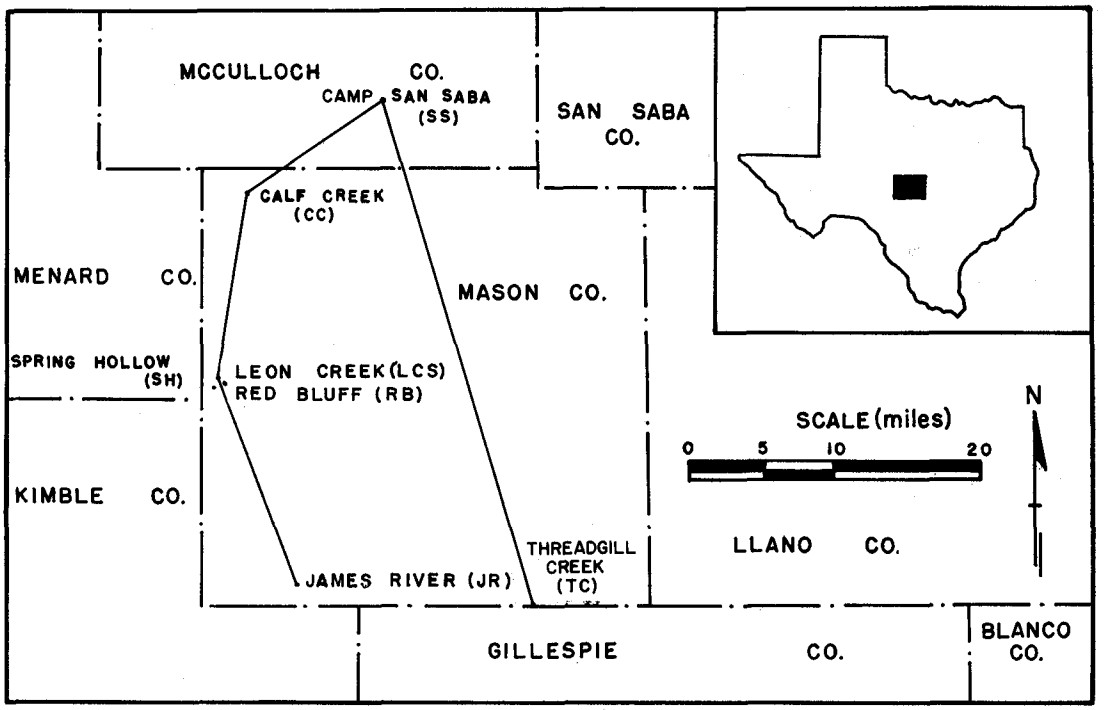
ALTHOUGH Upper Cambrian strata of North America have received much recent lithostratigraphic and biostratigraphic attention, work on Trempealeauan faunas and their relation to Ordovician faunas has lagged. Trempealeauan rocks over most of the craton are only sparsely fossiliferous, but in the Wilberns Formation of Texas (text-fig. 1) occur the rich Trempealeauan and Lower Ordovician faunas described in this paper.

PREVIOUS WORK

This investigation builds upon the studies of several people, and their contributions are here acknowledged. Bridge, Barnes, & Cloud (1947) described the lithostratigraphy of the Wilberns Formation, and from their measured and painted sections Ellinwood (1953, Unpub. Ph.D. thesis, Univ. Minnesota) collected and described fossils. Although Ellinwood's manuscript remained unpublished, the gap he recognized between the Cambrian and Ordovician faunas became the subject of two M.A. theses under the direction of W. C. Bell: one by Winston (1957, Unpub. M.A. thesis, Univ. Texas) and the other by Nicholls, unfinished. Bell subsequently reinvestigated the lower Wilberns collections and described them (Bell & Ellinwood, 1962). Winston studied all the remaining Cambrian collections and Nicholls the Ordovician collections, but both were called to other duties before their manuscript was completed. During the summers of 1963 and 1964 Winston restudied all the upper Wilberns collections but has retained some of Nicholls' taxonomic descriptions and his plates of Ordovician fossils.

ACKNOWLEDGMENTS

We thank V. E. Barnes, who guided us through several Cambrian areas early in the field work, and W. C. Bell, who supervised the theses upon which this paper is based and who criticized this manuscript. We are also grateful to R. A. Robison and J. C. Brower for reading the manuscript and offering constructive suggestions.



TEXT-FIG. 1—Index map showing location of measured sections and their arrangement in text-figure 2.

STRATIGRAPHY

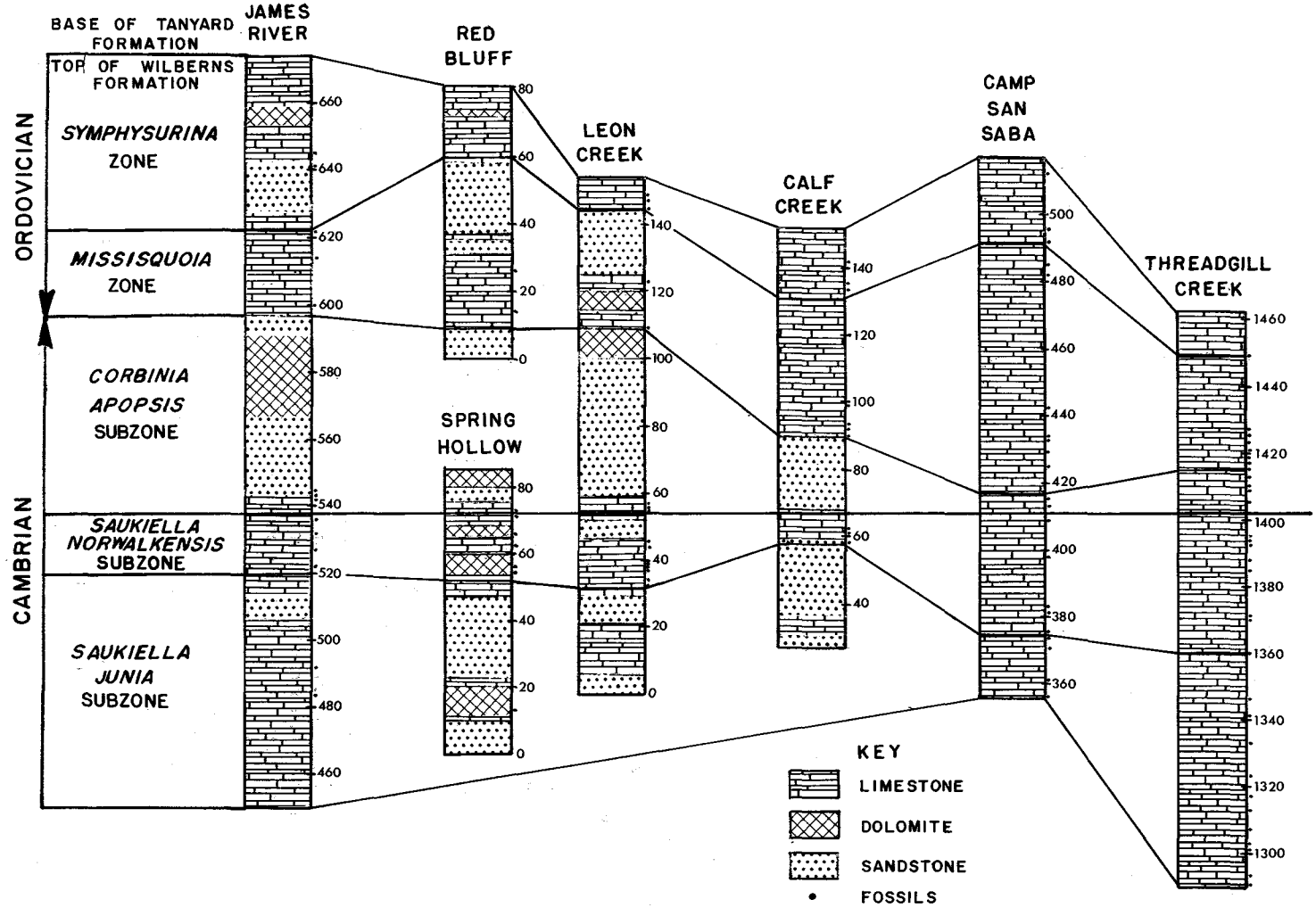
The Wilberns Formation consists of four members, in ascending order the Welge, Morgan Creek, Point Peak, and San Saba. The upper Trempealeauan and Lower Ordovician collections came wholly from the San Saba Member, which has an eastern dolomite facies and western limestone and sandstone facies. Fossils from the dolomitic facies come from chert nodules, which which occur characteristically as float-blocks. Only in the western limestone and sandstone facies can one collect successfully from outcropping sections, and for this reason our collections are limited to these (text-fig. 2). The limestone is mostly coarse-grained biosparite and becomes progressively interbedded with sandstone lentils in a westward direction. The thickest interval of sandstone separates the highest Cambrian from the lowest Ordovician collections in the westernmost sections. Rocks containing the lowest Ordovician fossils are mostly flat-pebble limestone-conglomerate. Some of the sections from which the fossils were collected were measured and painted by P. E. Cloud, Jr., and V. E. Barnes, and include the Threadgill Creek, James River, Leon Creek, San Saba, and Calf Creek sections. Winston measured and collected the Spring Hollow and Red Bluff sections.

Fossil occurrences are listed in feet above the base of each section and the sections are given the following abbreviations: Calf Creek (CC), James River (JR), Leon Creek (LCS), Red Bluff (RB), Spring Hollow (SH), San Saba (SS), and Threadgill Creek (TC). Thus, CC-27 refers to a bed 27 feet above the base of the Calf Creek section. Localities with numbers such as 159T-8-42A are not from measured sections but are spot localities plotted on aerial photographs on file at the Texas Bureau of Economic Geology. The spot localities and measured sections will be plotted on maps, and measured sections will be described in a forthcoming volume on the Cambrian of central Texas by V. E. Barnes and W. C. Bell. The collections are housed at the University of Texas.

BIOSTRATIGRAPHY

Introduction

Grant (1962) has recently discussed some of the principles upon which Cambrian trilobites have been zoned. We have defined three Cambrian assemblage subzones and two Ordovician assemblage zones, using the same empiric methods that other workers have used. In so doing, we have merely subdivided the faunas in a reconnaissance way and have laid the groundwork for more detailed studies that may discover biofacies and lithofacies interrelationships that hopefully will result in ecologic interpretations of the faunas. Distinctive faunules



TEXT-FIG. 2—Biostratigraphic correlation of measured sections.

(Fenton & Fenton, 1928) appear to form key beds that extend discontinuously for 30 or 40 miles, and these may be used for future detailed stratigraphic correlation.

We agree with Grant's (1962, p. 976) recommendation that zone boundaries be defined in a positive manner at their base by the occurrence of an identifying fauna, and that their top be extended up to the base of the next overlying zone. In this way "barren intervals" between collections are included in the underlying zone. "Barren intervals" do vertically separate most of our distinctive faunas, but future collecting from these intervals probably will show that the zone and subzone boundaries are, in fact, paleontologically gradational, with the exception, we believe, of the Cambrian-Ordovician boundary.

Cambrian Zonation

Definition.—We have subdivided our Cambrian rock interval, which represents the upper part of the Trempealeauan, or *Saukia* zone, into three subzones, in ascending order: the *Saukiella junia* subzone, the *Saukiella norwalkensis* subzone, and the *Corbinia apopsis* subzone (text-fig. 3).

The *Saukiella junia* subzone is defined on the occurrence of *Bayfieldia simata,* n. sp. var. A; *Briscoia hartti; Corbinia implumis,* n. sp.; *Euptychaspis typicalis; Saukia imperatrix; Saukia tumida; Saukiella junia; Saukiella pepinensis;* and *Triarthropsis* sp. A. Other species that occur in this zone, but are not confined to it, are *Bayfieldia binodosa; Bayfieldia simata,* n. sp.; *Euptychaspis jugalis,* n. sp.; *Euptychaspis kirki; Eurekia eos;* and *Stenopilus latus.* The base of the subzone is at JR-4SO, SS-356, and TC-1290. The top of the subzone is at the base of the *Saukiella norwalkensis* subzone.

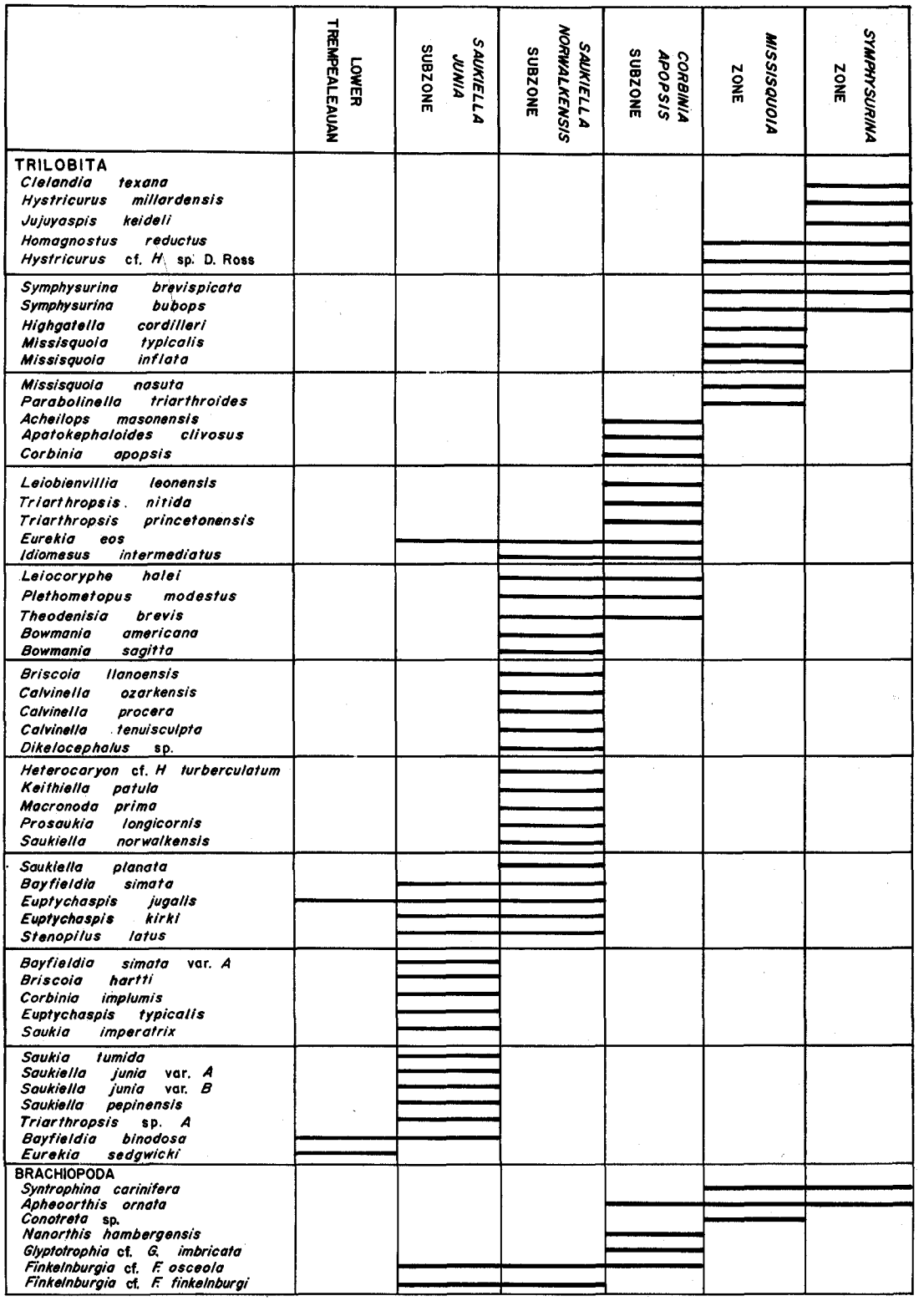
The *Saukiella norwalkensis* subzone is defined on the occurrence of *Bowmania americana; Bowmania sagitta,* n. sp.; *Briscoia ttanoensis,* n. sp.; *Calvinella ozarkensis; Calvinella procera,* n. sp.; *Calvinella tenuisculpta; ?Dikelocephalus; Heterocaryon* cf. *H. tuberculatum; Keithiella patula,* n. sp.; *Macronoda prima; Prosaukia longicornis; Saukiella norwalkensis;* and *Saukiella planata,* n. sp. Also occurring in this subzone, but not confined to it, are *Bayfieldia simata,* n. sp.; *Eurekia eos; Euptychaspis jugalis,* n. sp.; *Euptychaspis kirki; Idiomesus intermedius; Leiocoryphe halei,* n. sp.; *Plethometopus modestus; Stenopilus latus; and Theodenisia brevis.* Its base is at CC-58, JR-519, LCS-32, SH-52, SS-375, and TC-1360. Its top is at the base of the *Corbinia apopsis* subzone.

The *Corbinia apopsis* subzone is defined on the occurrence of *Acheilops masonensis,* n. sp.; *Apatokephaloides clivosus; Corbinia apopsis,* n. sp.; *Leiobienvillia leonensis,* n. sp.; *Triarthropsis nitida;* and *Triarthropsis princetonensis.* Also occurring in this subzone are *Eurekia eos; Idiomesus intermedius; Leiocoryphe halei,* n. sp.; *Plethometopus modestus;* and *Theodenisia brevis.* Its base is at CC-67, JR-538, LCS-53, SH-72, SS-411, and TC-1402. The top is at the Cambrian-Ordovician boundary.

Regional correlation.—The Dresbachian and Franconian Stages contain a sequence of faunal zones that extend broadly across the North American craton with remarkable continuity. However, similarly defined regional zones have not been recognized within the Trempealeauan, or *Saukia* zone. If the Trempealeauan does indeed contain a regional sequence of faunas, reasons for their not having been recognized may be threefold: (1) Trempealeauan faunas are sparse and have not been studied to the extent that those of the Dresbachian and Franconian have; (2) zonation of Trempealeauan rocks may depend cheifly upon the saukiids, which are presently separated into polyphyletic genera, so that natural biologic groupings may be masked; and (3) the lithologic and biostratigraphic framework of the Croixian area may not be understood well enough yet to provide a sound basis for zonation within the historically recognized type area. Text-figure 4 is presented only to emphasize the problems of correlating the Texas faunas with those of Minnesota.

Because our knowledge is still so incomplete, we choose to retain the *Saukia* zone in its present status and to propose our zonation on the subzone level. Should our subzones prove to have regional extent, they can then be raised to zone level.

The *Corbinia apopsis* subzone of Texas represents a strong influx of the *Hungaia magnifica* fauna of the intermediate faunal realm (Lochman-Balk & Wilson, 1958, p. 339). Elements of the *Hungaia magnifica* fauna are only sparsely represented in the *Saukiella junia* and *Saukiella norwalkensis* subzones of Texas by a few specimens of *Heterocaryon, Keithiella, Leiocoryphe,* and single specimens of *Theodenisia* and *Triarthropsis.* The *Corbinia apopsis* subzone is far more representative of the *Hungaia magnifica* fauna both in numbers of species and specimens. Common diagnostic genera are *Apatokephaloides, Leiocoryphe, Theodenisia,* and *Triarthropsis.* When the Texas sequence is compared with that from the Windfall Formation of Nevada (Palmer, *in* Nolan and others, 1956), where a *Hungaia* fauna lies below a dikelocephalid-eurekid—saukid fauna, the biofacies relationship between the two (Lochman-Balk & Wilson, 1958, p. 340) seems well substantiated.



TEXT-FIG. 3—Ranges of species in the upper part of the Wilberns Formation.

	Bayfieldia	*Bowmania*	*Calvinella*	*Corbinia*	*Dikelocephalus*	*Euptychaspis*	*Eurekia*	*Plethometopus*	*Prosaukia*	*Saukia*	*Saukiella*	(*Saukiella pepinensis*)	(*Saukiella norwalkensis*)	*Stenopilus*	*Triarthropsis*
MINNESOTA															
***Saukiella – Calvinella* subzone**		X	X	X	X	X	X	X		X	X	X		X	
Upper ***Dikelocephalus* subzone**			X	X	X	X	X	X		X	X			X	X
***Rasettia* subzone**				X	X		X	X						X	
***Osceolia* subzone**	X	X		X	X	X	X				X		X	X	X
***Ptychaspis – Prosaukia* subzone**									X						
TEXAS															
***Corbinia apopsis* subzone**				X			X	X							X
***Saukiella norwalkensis* subzone**	X	X	X		X	X	X	X	X		X		X	X	X
***Saukiella junia* subzone**	X			X		X	X			X	X	X		X	

TEXT-FIG. 4—Comparison of known ranges of genera in Texas with those in Minnesota.

Cambrian-Ordovician Boundary

The Cambrian-Ordovician boundary in the Wilberns Formation is marked by profound faunal discontinuity. Apparently not a single Cambrian trilobite species or family survived the migration of Ordovician trilobite stocks into the area. In the James River, Leon Creek, and Calf Creek sections the highest Cambrian collections are separated from the lowest Ordovician collections by as much as 100 feet of sandstone. But in the San Saba and Threadgill Creek sections the boundary occurs within a conformable limestone sequence, and Ordovician faunas occur 1 foot and 6 feet above Cambrian faunas, respectively. Even here we could find no Cambrian trilobites mixed with Ordovician trilobites. Coincident with the lowest Ordovician trilobites are the lowest occurrences of Paleozoic conodonts in central Texas.

The abrupt change in trilobites is characteristic of the Cambrian-Ordovician boundary wherever it has been studied on the North American craton (Frederickson, 1941; Palmer, *in* Bass & Northrup, 1953; Lochman, 1964a, 1964b). On the other hand, there is little change in the brachiopod and gastropod faunas, and they cross the systemic boundary relatively unaltered. In the extracratonic and intermediate faunal realms bordering the cratonic realm, the Cambrian-Ordovician trilobite discontinuity does not appear to be so sharp, and the following Cambrian taxa have been reported mixed with Ordovician faunas: *Bienvillia* (Rasetti, 1954; Kindle & Whittington, 1958), *Rasettia* (Wilson,

1954; Kindle & Whittington, 1958), the Leiostegiidae (Whittington, 1953; Kobayashi, 1955).

Ordovician Zonation

We have divided the Ordovician faunas of the Wilberns Formation into two zones: a lower *Missisquoia* zone and an upper *Symphysurina* zone (text-fig. 3). *Missisquoia typicalis; Missisquoia nasuta,* n. sp.; *Missisquoia expansa,* n. sp.; *Highgatella cordilleri;* and *Parabolinella triarthroides* define the *Missisquoia,* zone, and *Symphysurina bubops,* n. sp. occurs abundantly within it, but is not restricted to it. The overlying *Symphysurina* zone is defined on the occurrence of *Jujuyaspis keideli; Hystricurus millardensis;* and *Clelandia texana,* n. sp.; but is characterized by abundant specimens of *Symphysurina brevispicata,* a species not restricted to it. In addition *Homagnostus reductus*, n. sp. and *Hystricurus* cf. *H.* sp. D Ross occur sparsely in both zones. The base of the *Missisquoia* zone is at CC-90, JR-597, LCS-108.5, RB-8.6, SS-417, and TC-1415. The base of the *Symphysurina* zone is at CC-132, JR-622, LCS-144, RB-60, SS-491.5, and TC-1449.

Regional correlation.—Lower Ordovician trilobite faunas have been zoned most extensively by Ross (1951) and Hintze (1952), and their work has become a standard for correlation of North American cratonic assemblages. Lochman (1964b) has recently correlated faunas from Montana with the A, *Symphysurina* (B), and possibly *Paraplethopeltis* (C) zones of Ross and Hintze. Although we feel **that** her correlation of the *Symphysurina* (B) zone is justified, we believe her evidence for correlating the A zone is scanty indeed. On the contrary, we believe that Lochman's A zone can better be correlated with the fauna of the Highgate Formation, described by Shaw (1951), on the basis of *Highgatella.* We also correlate the *Missisquoia* zone of Texas with that of the Highgate on the basis of *Missisquoia, Highgatella, Parabolinella,* and *Symphysurina.* The overlying *Symphysurina* zone of Texas correlates most closely with the *Symphysurina* (B) zone of Ross and Hintze. *Symphysurina, Hystricurus,* and *Clelandia* are genera common to both faunas.

Both the *Missisquoia* zone and the *Symphysurina* zone contain cratonic and extracratonic elements. In the *Missisquoia* zone the genera with extracratonic affinities include *Highgatella,* which is closely related to *Euloma* (known extensively from the Scandinavian and British Tremadoc), *Parabolinella* (known from the Tremadoc of Scandinavia, North and South America), and possibly *Missisquoia,* though it is known only from Vermont. *Symphysurina* and *Hystricurus* are cratonic genera.

The *Symphysurina* zone is composed mostly of cratonic genera, including *Symphysurina, Hystricurus,* and *Clelandia.* On the other hand, *Jujuyaspis* is an extracratonic lower Tremadocian genus widely known from South America and Scandinavia.

SYSTEMATIC PALEONTOLOGY

Phylum ARTHROPODA
Class TRILOBITA
Order AGNOSTIDA Kobayashi, 1935
Family AGNOSITIDAE M'Coy, 1849
Genus HOMAGNOSTUS Howell, 1935

HOMAGNOSTUS REDUCTUS Winston & Nicholls, n. sp.

Pl. 13, figs. 20, 23

Description.—Glabella two-thirds length of cephalon, tapered, clearly bilobed with additional triangular basal glabellar lobes. First glabellar furrow deep, curved slightly forward at extremities. Second glabellar furrow impressed only as pits in the axial furrow; faint axial node situated between them. Axial furrow sharp at sides, but preglabellar segment broadens and is slightly indented on most specimens, reflecting the last vestige of a preglabellar median furrow. Border furrow broad; border wide in front, narrower in posterior corners where the cheeks nearly overhang it. Axial lobe of pygidium three-fourths pygidial length, tapered, trilobed longitudinally. Shallow anterior furrows curve forward to articulating furrow subdividing the anterior segment transversely into three subequal lobes. Second segment bears prominent axial node that meets the shallow transverse posterior furrow, but does not deflect it significantly. Posterior portion of the axis low for the genus and slopes evenly to the pleural field. Border furrow broad; border has pair of marginal spines.

Discussion.—This species is placed in *Homagnostus* on the basis of the vestigial preglabellar median furrow. It continues an upward stratigraphic trend recognized by Palmer (1955, 1960) from *Homagnostus obesus,* to *H. tumidosus,* to *H. brevis,* in which the preglabellar median furrow and the axis of the pygidium are progressively reduced. In *H. reductus* the preglabellar median furrow is barely visible, the pygidial axis is strongly tapered, and the posterior portion of the axis is low and slopes evenly to the pleural field.

This species resembles some other North American low Ordovician agnostid species. Lochman (1964b) has assigned specimens from Montana to *Geragnostus mundus* (Raymond). In as much as Raymond described as a pygidium what apparently is a cephalon, that species is inadequately defined. His figure has a parallel-sided glabella. Furthermore, Lochman mentions

a faint median preglabellar furrow, which places her specimens in *Homagnostus*. The cephalons of Lochman's specimens may be identical with those from Texas, but the pygidial axes of the Montana specimens are larger and more inflated posteriorly. Kobayashi (1955) described species having affinity to *Geragnostus mundus,* but which he states have no median preglabellar furrow. Matthew (1892) described *Agnostus bisectus* for specimens which appear to differ from the Texas specimens only in lacking a median preglabellar furrow. Shaw (1951) assigned to the same species specimens which have parallel-sided glabellas and shallow transglabellar furrows, and which, therefore, probably belong to different species.

Occurrence.—Rare in the *Missisquoia* zone at CC-120; RB-13.2; 159T-8-34A; 159T-8-42A. Rare in the *Symphysurina* zone at SS-515.

Order PTYCHOPARIIDA Swinnerton, 1915
Family PTYCHOPARIIDAE Matthew, 1887
Genus HIGHGATELLA Shaw, 1955
HIGHGATELLA CORDILLERI (Lochman)
Pl. 13, figs. 8,11,13

Euloma cordilleri LOCHMAN, 1964b, p. 464, pl. 63, figs. 27–38.

Remarks.—There is little doubt that the Texas specimens are conspecific with those described by Lochman from Montana. A problem does arise, however, in the generic assignment of the species. Although Lochman has placed it in *Euloma,* we have assigned it to the closely related genus, *Highgatella,* on the basis of the inflated preglabellar field and the elevated, small palpebral lobes of most specimens. In addition, the glabellar furrows are confluent with the dorsal furrow in *Euloma* but are not so in *Highgatella.*

The fundamental proportions of the cranidium of this genus range so widely that they cannot be used for generic identification. Instead, the combination of seemingly trivial features such as the three pairs of laterally impressed glabellar furrows, deep axial but shallow preglabellar furrows, bulging frontal area marked by genal caeca, pitted border furrow, eye ridges, and high palpebral lobes, serve to characterize the genus.

Specimens in our collections, like those of *H. gelasinata* (Shaw, 1951) range widely in form from those with low, narrow, parallel-sided glabellas set between high palpebral lobes, to those with higher, wider, more conical glabellas set between lower palpebral lobes. However, in our collections the variation appears to occur within an adult population and does not appear to be a factor of growth, as in Shaw's material from Vermont.

Occurrence.—Common in the *Missisquoia* zone at CC-93, 120; JR-597; LCS-108.5; RB-8.6, 26; SS-432, 433, 485; TC-1421; 159T-8-34A; 159T-8-42A.

Family ?SHUMARDIIDAE Lake, 1927
Genus IDIOMESUS Raymond, 1924
IDIOMESUS INTERMEDIUS Rasetti
Pl. 10, fig. 21

Idiomesus intermedius RASETTI, 1959b, p. 393, pl. 51, figs. 25, 26.
Idioniesus sp. HAMBLIN, 1958, pl. 5, fig. 14 (genus misspelled, figure of cranidium, not pygidium).

Remarks.—*Idiomesus tantittus* Raymond, 1924, *I. intermedius* Rasetti, 1958, and *I. levisensis* (Rasetti), 1944, the three described species of *Idiomesus,* have similar cranidia except that *I. tantittus* has a posterior glabellar furrow without lateral glabellar pits, *I. intermedius* has a posterior glabellar furrow and a single pair of lateral glabellar pits, and *I. levisensis* has a posterior glabellar furrow and two pair of lateral glabellar pits.

Occurrence.—Common in the *Saukiella norwalkensis* subzone at CC-61; JR-529; LCS-32.4, 39, 40, 44, 45, 45.4, 45.8; SH-54; TC-1383±, 1392, 1394, 1400. Common in the *Corbinia apopsis* subzone at CC-67; JR-539.5, 540; LCS-55.5; SS-411; and 86T-16-20B.

Family DIKELOCEPHALIDAE Miller, 1889
Genus BRISCOIA Walcott, 1925
BRISCOIA HARTTI (Walcott)
PL 10, fig. 9

Conocephalites hartti WALCOTT, 1879, p. 130.
Dikelocephalus hartti (Walcott), WALCOTT, 1914, p. 368, pl. 63, figs. 1–7,7a (synonymy to date).
Briscoia hartti (Walcott), KOBAYASHI, 1935, p. 51.

Remarks.—This species is distinguished from others in Texas by its nearly parallel-sided subtruncate and subequidimensional glabella with gently impressed broad transglabellar furrow, broad (sag.) occipital ring, faint marginal furrow, and low, wide palpebral lobes with broad furrow. It is represented in the Texas collections by three specimens.

Occurrence.—Rare in the *Saukiella junia* subzone at SS-372.5; TC-1341-1346.

BRISCOIA LLANOENSIS Winston & Nicholls, n. sp.
Pl. 10, figs. 1–3,5

Description.—Glabella moderately convex, elongate, straight sided, tapered, truncate. Posterior glabellar furrow not quite confluent with axial furrow, bowed backward and deep laterally, becoming transverse and shallow over top

of glabella. Rest of glabella smooth or with two pairs of very faint laterally impressed anterior furrows. Occipital furrow bowed slightly backward at lateral extremities, transverse or bowed slightly forward in center. Frontal area of variable length, one-fourth to one-third cranidial length, smooth, concave, slightly pointed anteriorly. Fixigenae wide for the genus, horizontal or upsloping; palpebral lobes small, three-eighths glabellar length, centered opposite posterior glabellar furrow. Posterior limb stout at base, becoming parallel-sided and attenuated laterally, crossed by straight border furrow. Anterior course of facial suture diverges strongly in front of eyes to a point of deepest concavity of frontal area, where it swings broadly to midpoint.

Pygidial length five-sevenths width, widest at midpoint. Axis one-half length of pygidium with five or six rings plus terminal axial piece that fades posteriorly into pleural region. Pleural region with elevated platform around axis; pleural furrows of anterior four pleura stronger than interpleural furrows, dividing pleura unequally. Segmentation fades laterally; margin smooth, upturned in back.

Remarks.—*Briscoia llanoensis* differs from the other species of the genus in its tapered and truncate glabella, and in its smooth, concave frontal area. It may be descended from the *Briscoia* collected from the *Ptychaspis-Prosaukia* zone of Texas and represented by fragmentary material (Bell & Ellinwood, 1962, p. 390, pl. 52, figs. 5,6). In the Franconian species the anterior border is represented by a gently upturned rim, which we believe has become obsolete in *B. llanoensis*. Although the smooth frontal area is more characteristic of *Dikelocephalus,* we place the species in *Briscoia* for two reasons: (1) the pygidium lacks spines and (2) we believe this species to be descended from species clearly assignable to *Briscoia,* not from dikelocephalid stock.

Occurrence.—Abundant in the *Saukiella norwalkensis* subzone at CC-58.2, 61; JR-521.5, 532;

EXPLANATION OF PLATE 9

FIGS. *1,2—Bayfieldia binodosa* (Hall). *1,* Cranidium, ×1.5, UT 12535, from JR-357. *2,* Pygidium, ×2, UT 12536, from TC-1286.

3—Corbinia implumis Winston and Nicholls, n. sp. Holotype cranidium, ×2, UT 12537, from TC-1290.

4–6—Saukiella pepinensis (Owen). *4,* Cranidium, ×1, UT 12538, from TC-1293, *5,* Pygidium, ×1, UT 12539, from JR-460. *6,* Cranidium, ×1, UT 12540, from TC-1293.

7,9,11—Saukia tumida Ulrich and Resser. *7,* Cranidium, ×2, UT 12541, from SS-356. *9,* Pygidium, ×1, UT 12542, from JR-481. *11,* Cranidium, ×1, UT 12543, from SS-356.

8,14,22—Saukiella junta (Walcott) var. B. *8,* Cranidium with transverse border furrow and narrow preglabellar field, ×1, UT 12544, from TC-1301. *14,* Cranidium with transverse border furrow nearly confluent with anterior dorsal furrow, ×1, UT 12545, from TC-1305-1310. *22,* Clay squeeze of pygidium, ×0.5, UT 12546, TC-1301.

10,12—Saukiella junia (Walcott) var. A. *10,* Cranidium with anteriorly bowed border furrow, ×1, UT 12547, from TC-1341–1346. *12,* Cranidium with broad border, ×1, UT 12548, from TC-1341–1346.

13—Euptychaspis jugalis Winston & Nicholls, n. sp. Holotype Cranidium, ×5, UT 12549, from TC- 1395.

15,16,21—Saukia imperatrix Ulrich and Resser. *15,* Cranidium, ×6, UT 12550, from SH-12.6. *16,* Librigena, ×1, UT 12551, from SH-12.6. *21,* Pygidium, ×1.3, UT 12552, from 159T-8-31B.

17—Euptychaspis typicalis Ulrich. Cranidium, ×4, UT 12553, from TC-1301.

18—Euptychaspis kirki Kobayashi. Cranidium, ×3, UT 12554, from SS-409.

19—Macronoda prima Lochman. Cranidium, ×2, UT 12555, from JR-521.5.

20,23,25—Bayfieldia simata Winston & Nicholls, n. sp. *20,* Paratype cranidium, ×2, UT 12556, from TC-1400. *23,* Paratype pygidium, ×2, UT 12557, from TC-1400. *25,* Holotype cranidium, ×1.25, UT 12558, from TC-1394.

24,26—Bayfieldia simata var. A. *24.* Cranidium, ×2, UT 12559, from SH-12.6. *26,* Pygidium, ×2, UT 12560, from SH-12.6.

27—Triarthropsis sp. A. Cranidium, ×5, UT 12561, from CC-27.

28—Stenopilus latus Ulrich. Pygidium, ×2, UT 12562, from LCS-45.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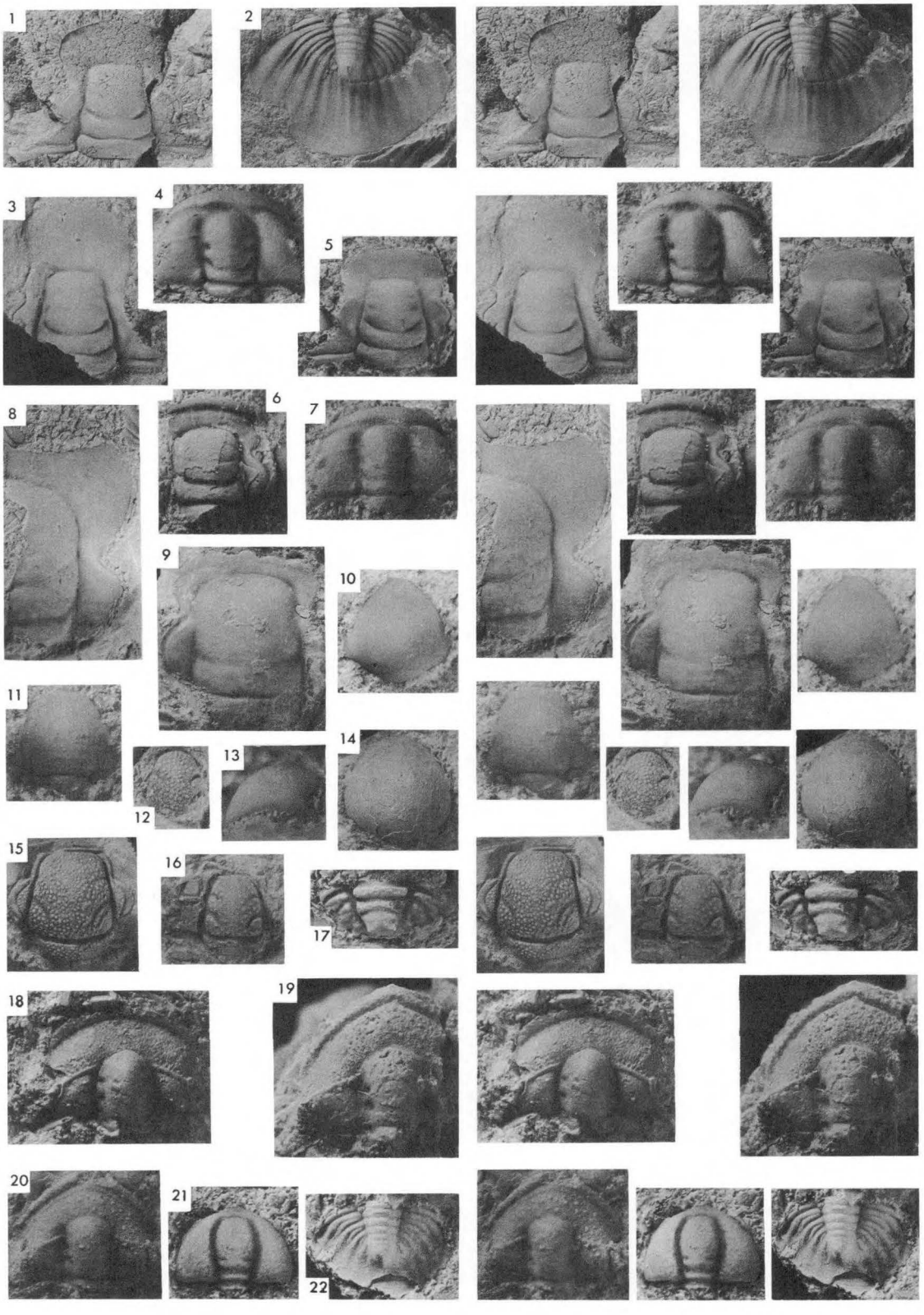
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LCS-44, 45, 45.4, 45.8, 52; SH-58.5-60, 61.5, 65.5; SS-409; TC-1383 ± , 1385, 1391.5, 1392, 1394, 1395.

Genus DIKELOCEPHALUS Owen, 1852

DIKELOCEPHALUS sp.

PL 10, fig. 8

Remarks.—This genus is tentatively recognized from a single fragmentary cranidium which resembles that of *Dikelocephalus minnesotensis* Owen, the type. However, without pygidia and better preserved cranidia even generic assignment cannot be certain.

Occurrence.—Rare in the *Saukiella norivalkensis* subzone at TC-1383± .

Family OLENIDAE Burmeister, 1843

Genus JUJUYASPIS Kobayashi, 1936

JUJUYASPIS KEIDELI Kobayashi, 1936

Pl. 12, figs. 20,23

Jujuyaspis keideli KOBAYASHI, 1936, p. 90, pl. 16, figs. 5–9; 1937, p. 176, text-fig. 6; HARRINGTON, 1938, p. 206, pl. 9, figs. 2–4,10; HARRINGTON & LEANZA, 1943, p. 352, pl. 2, figs. 2,7; 1952, p. 197, pl. 1, fig. 8; 1957, p. 99, figs. 33–34; HENNINGSMOEN, 1957, p. 262, pl. 2, fig. 7; POULSEN, 1959, p. O266, fig. 196, 2.

Remarks.—This species is easily recognized in the Texas collections and is distinguished from other species of the genus by lacking a frontal area and at the same time having the eyes placed forward. Characteristically in the genus the eyes are set even with, or behind, the midpoint (Henningsmoen, 1957, p. 261).

Occurrence.—Locally abundant in the *Symphysurina* zone at CC-135, 136; SS-491.5, 496; TC-1449.

Genus LEIOBIENVILLIA Rasetti, 1954

LEIOBIENVILLIA LEONENSIS Winston & Nicholls, n. sp.

Pl. 11, figs. 16,20,21

Description.—Cranidium low, semielliptical, wider than long, averaging 2 mm in length. Glabella about three-fourths length of cranidium, half as wide, expanded and rounded anteriorly, clearly defined by shallow axial furrow, smooth or with two pairs of faint, laterally impressed glabellar furrows. Occipital ring wide (sag.) with spine. Frontal area downsloping, undifferentiated. Fixigenae wide, downsloping, with faint ocular ridges. Palpebral lobes small, centered anterior to glabellar midpoint. Posterior border furrow strong. Anterior course of facial suture directed forward and down, then arcing to midpoint; posterior facial suture trending directly to corner of cranidium.

Associated pygidium length one-half to two-thirds width, with six or more segments. Axis extends to posterior margin; medial part of axial

EXPLANATION OF PLATE 10

FIGS. *1—3,5—Briscoia llanoensis* Winston & Nicholls, n. sp. 7, Holotype cranidium, ×1.25, UT 12563, from SH-58.5–60. *2,* Paratype pygidium, ×1, UT 12564, from SH-58.5–60. *3,* Paratype cranidium, ×1.1, UT 12565, from TC-1391.5 5, Paratype cranidium, ×1.25, UT 12566, from TC-1395.

4,7—Keithiella patula Winston & Nicholls, n. sp. *4,* Holotype cranidium, ×3, UT 12567, from TC-1400. 7, Paratype cranidium, ×3, UT 12568, from TC-1400.

6—Prosaukia longicornis Ulrich & Resser. Cranidium, ×4, UT 12569, from LCS-40.

8—?Dikelocephalus sp. Fragmentary cranidium, ×1, UT 12570, from TC-1383±.

9—Briscoia hartii (Walcott). Crandium, ×1, UT 12571, from SS-372.5.

10,13—Leiocoryphe halei Winston & Nicholls, n. sp. Holotype cranidium, dorsal and side views, ×4, UT 12572, from LCS-40.

11—Plethomotopus modestus Ulrich. Cranidium, ×4, UT 12573, from LCS-55.5.

12,16—Eurekia sedgwicki (Billings). *12,* Fragmentary cranidium, ×2, UT 12574, from JR-374.5. *16,* Cranidium, ×2, UT 12575, from JR-354.

14—Stenopilus lalus Ulrich. Cranidium, ×2, UT 12576, from SH-12.6.

15,17—Eurekia eos (Hall). *15,* Cranidium, ×2, UT 12577, from TC-1379–1385. *17,* Pygidium, ×1, UT 12578, from TC 1368–1374.

18—Bowmania americana (Walcott). Cranidium, ×4, UT 12579, from SH-54.

19,20—Bowmania sagitta Winston & Nicholls, n. sp. *19,* Paratype cranidium, ×3, UT 12580, from LCS-45. *20,* Holotype cranidium, ×3, UT 12581, from LCS-45.4.

21—Idiomesus intermedius Rasetti. Cranidium, ×4. UT 12582, from LCS-45.

22—Calvinella procera Winston & Nicholls, n. sp. Paratype pygidium, ×1.75, UT 12583, from LCS-40

furrow bowed slightly forward. Pleural lobes with both pleural and interpleural furrows, restricted laterally by border furrow and narrow border.

Remarks.—This species is included in *Leiobienvillia* rather than in *Bienvillia* because it lacks a border furrow (Henningsmoen, 1957, p. 159). It closely resembles *Leiobienvillia terranovica* (Rasetti), but differs in its anteriorly expanded glabella, fainter transverse glabellar furrows, and occipital spine. The pygidia assigned to *L. leonensis* closely resemble a pygidium figured and described by Rasetti (1945, p. 477, pl. 62, fig. 35); he left it unassigned, but suggested that it belonged to *Bienvillia corax*.

Occurrence.— Common in the *Corbinia apopsis* subzone at CC-67, JR-540, LCS-55.5, TC-1402.

Genus PARABOLINELLA Brögger, 1882

PARABOLINELLA TRIARTHROIDES Harrington, 1938

Pl. 13, fig. 14

Parabolinella triarthroides HARRINGTON, 1938, p. 194, test-fig. 9, pl. 7, figs. 10,11; SHAW, 1951, p. 102, pl. 22, figs. 1–10; HENNINGSMOEN, 1957, p. 139; HARRINGTON & LEANZA, 1957, p. 105, figs. 39, 1a–b.
Parabolinella cf. *P. triarthroides* Harrington, WILSON, 1954, p. 280, pl. 27, fig. 18.

Remarks.—This species is represented in our collections by a single specimen. The glabellar shape and frontal area resemble inflated specimens of *Highgatella gelasinata,* but the species is distinguished chiefly by the sigmoidal posterior glabellar furrows and the lateral bifurcation of the occipital furrow.

Occurrence.—Rare in the *Missisquoia* zone at SS-422.

Family SOLENOPLEURIDAE Angelin, 1854

Genus HYSTRICURUS Raymond, 1913

HYSTRICURUS MILLARDENSIS Hintze

Pl. 12, figs. 14,18

Hystricurus millardensis HINTZE, 1952, p. 168, pl. 6, figs. 17–21.

Remarks.—Specimens in the Texas collections are assigned to this species on the basis of their regularly tapered, truncate glabellas. They range from coarsely granulose to almost smooth and consequently this feature is not considered to be of specific significance. Glabellar furrows likewise range from posteriorly directed knife-like lines to pits, and on some specimens are absent. There is the tendency, as in Hintze's (1952, pl. 6, fig. 17c) photographed cranidium, for the preglabellar furrow to be deeply impressed at the anteriolateral corners of the glabella, but to become shallower across the middle.

Occurrence.—Locally common in the *Symphysurina* zone at CC-132, 133.5, 134.5, 135: TC-1449; 159T-8-34A; 159T-8-42A.

HYSTRICURUS cf. H. sp. D Ross

PL 12, figs. 12,22,25

Hystricurus sp. D Ross, 1951, p. 54, pl. 9, figs. 35, 36, 38–41.

Remarks.—This species is represented in our collection by eight fragmentary cranidia. They compare closely with *Hystricurus* sp. D Ross in having tumid, rounded glabellas outlined by deep, broad axial and preglabellar furrows. However, they lack the smooth patches on the sides of the glabella, genal caeca, and eye grooves described by Ross.

Occurrence.—Rare in the *Missisquoia* zone at TC-1421, 1425; and rare in the *Symphysurina* zone at CC-142; LCS-147.

Family DOKIMOCEPHALIDAE Kobayashi, 1935

Genus HETEROCARYON Raymond, 1937

HETEROCARYON cf. H. TUBERCULATUM Rasetti

Pl. 11, figs. 15,18

Heterocaryon tuberculatum RASETTI, 1944, p. 241, pl. 36, fig. 55.

Description.—The rather poor preservation of Rasetti's figured specimen, and the incompleteness of the three Texas specimens make conspecific assignment questionable. Length of cranidium about two-thirds width; glabella tumid, slightly expanded anteriorly, rounded in front, defined by strong axial furrows. Two pairs of glabellar furrows impressed as lateral pits, posterior pair directed backward. Frontal area poorly preserved, but about one-fourth length of cranidium, sharply downsloping, divided into preglabellar field and border by pitted border furrow. Fixigenae about three-fourths width of glabella, traversed by faint eye ridge. Palpebral lobes minute, situated posterior to glabellar midpoint. Posterior fixigenae crossed by strong border furrow. Anterior course of facial suture drops nearly vertically to border; posterior course poorly known. Cranidial surface strongly pustulose.

Remarks.—If the fixigenae of Rasetti's figured specimen are complete, then the Texas specimens differ from those of the Levis in having wider fixigenae. The eye ridges are also more pronounced on Rasetti's figured specimen.

Occurrence.—Rare in the *Saukiella norwalkensis* subzone at TC-1392, 1400.

Family CATILLICEPHALIDAE
Raymond, 1938
Genus THEODENISIA Clark, 1948
THEODENISIA BREVIS (Rasetti)
PL 11, fig. 19

Acheilus brevis RASETTI, 1944, p. 236, pl. 36, figs. 36–37.
Theodenisia brevis (Rasetti), RASETTI, 1954b, p. 609.

Remarks.—Three incomplete cranidia are assigned to this species on the basis of their equidimensional, strongly convex, slightly anteriorly expanded glabella, and the absence of a frontal area.

Occurrence.—Rare in the *Saukiella norwalkensis* subzone at LCS-45; SH-54; and *Corbinia apopsis* subzone at LCS-S4.

Genus ACHEILOPS Ulrich in Bridge

Acheilops Ulrich in BRIDGE, 1931, p. 218.

Remarks.—In describing *Acheilops,* Ulrich emphasized the absence of frontal area and anterior fixigenae, the position of the eyes far back on the cranidium close to the glabella, and the narrow (sag.), long posterior limbs. These characteristics place *masonensis,* n. sp. in *Acheilops.* On the other hand, the glabellar configuration and pygidium are strikingly similar to those of *Theodenisia* and clearly demonstrate the close relationship of *Acheilops* to *Theodenisia,* as Rasetti (1954b, p. 611) has suggested. Indeed, *Acheilops masonensis* probably is intermediate between *A. dilatus* Ulrich, the type species, and species of *Theodenisia,* such as *T. marcoui* (Raymond).

Reduction of the frontal area, anterior expansion of the glabella, posterior migration of the eyes, and progressive flattening of the anterior part of the cranidium appear to be evolutionary tendencies developed, often separately, in species of the family Catillecephalidae. Three genera of the family are recognized in Texas, *Triarthropsis, Theodenisia,* and *Acheilops. Triarthropsis* possesses a frontal area. In *Theodenisia* the frontal area is lost, but the palpebral lobes are centered at or anterior to the glabellar midpoint, and anterior fixigenae are usually present. In *Acheilops* the palpebral lobes are close to the glabella and centered behind the glabellar midpoint, so that both the frontal area and anterior fixigenae are lost and the expanded glabella forms the anterior third or more of the cranidium. Flattening of the anterior part of the cranidium and obsolescence of the glabellar furrows are also characteristic features. Ulrich described *Acheilops* as lacking palpebral furrows, a feature which his figures of *A. dilatus* clearly possess, and which *A. masonensis* possesses as well.

In constructing *Acheilops,* Ulrich included in it *Acheilops dilatus* Ulrich, 1931 (type species); *Acheilus macrops* Raymond, 1924; *Acheilus spicatus* Raymond, 1924; and five other recognized species that have remained undescribed. Rasetti (1954b, p. 609) placed *Acheilops macrops* in *Theodenisia,* and Raymond (1937, p. 1095) placed *Acheilops spicatus* in *Distazeris,* an assignment that Rasetti (1954b), in redescribing that genus, has chosen to ignore. Thus as *Acheilops* is now constituted, it consists of the type species and *A. masonensis,* plus listed but undescribed species from Missouri and Minnesota (Raasch, 1951, p. 148; Nelson, 1951, p. 768).

ACHEILOPS MASONENSIS Winston & Nicholls, n. sp.
Pl. 11, figs. 23–25

Description.—Glabella elongate, parallel sided from occipital ring to just in front of the palpebral lobes. At this point the axial furrow swings laterally and down to the margin of the cranidium forming an anteriorly expanded glabella that is rounded and depressed in front and devoid of surrounding frontal area and anterior fixigenae. Glabellar furrows weak to imperceptible on some specimens; posterior pair recurved, second pair transverse and laterally impressed, third pair transverse but medially impressed, and anterior pair transverse and laterally impressed. Fully developed glabellar configuration resembles that of *Theodenisia communis* (see Rasetti, 1954b, fig. 3b) but is fainter. Occipital ring strongly defined by transverse occipital furrow; posterior margin may be curved or with suggestion of a spine. Some specimens have a mesial tubercle. Palpebral lobes slightly less than one-third length of cranidium, lying very close to glabella and centered posterior to glabellar midpoint. Posterior area of fixigenae narrow behind palpebral lobe, passing to narrow (sag.), long posterior limb traversed by deep marginal furrow.

Pygidial length five-sevenths width; strongly convex. Axis high with four rings plus terminal axial peice that extends nearly to posterior margin. Anterior four rings narrow (sag.), with small axial spines that overlap backward. Pleural region has four pleurae that decrease in size and definition posteriorly. Anterior two have well developed pleural furrows; pleural margin spinose.

Remarks.—This species differs from *Acheilops dilatus* in that the glabella is more truncate in front and is parallel sided behind the anterior margin of the palpebral lobe. In addition the palpebral lobes are shorter and posterior limb is stouter.

Occurrence.—Common in the *Corbinia apopsis* subzone at CC-67; JR-539, 540; LCS-53, 53.5, 55.5; SH-72; SS-411; TC-1405, 1409.

Genus TRIARTHROPSIS Ulrich in Bridge, 1931

TRIARTHROPSIS NITIDA Ulrich

Pl. 11, figs. 27,28

Triarthropsis nitida Ulrich in BRIDGE, 1931, p. 214, pl. 19, figs. 3,4; SHIMER & SHROCK, 1944, p. 635, pl. 266, figs. 7,8; RASETTI, 1954b, p. 607, text-fig. 2d; 1959a, p. O285, fig. 210,8; 1959b, p. 382, pl. 55, figs. 6–13.

Remarks.—This species has been completely described by Rasetti, and the only observed difference between the Texas specimens and Rasetti's description is that the Texas specimens have only two rows of faint nodes on the axis of the pygidium instead of four.

Occurrence.—Rare in the *Corbinia apopsis* subzone at CC-67; JR-539, 540; LCS-53.3, 53.5, 55.5.

TRIARTHROPSIS PRINCETONENSIS Kobayashi

PL 11, fig. 26

Triarthropsis princetonensis KOBAYASHI, 1935, p. 56, pl. 8, fig. 1.

Theodenesia princetonensis (Kobayashi), RASETTI, 1954b, p. 609.

Remarks.—This species is distinguished by its elongate, parallel-sided glabella, diminutive frontal area, forward position of the eyes set out on wide palpebral fixigenae in front of broad posterior fixigenae. The Texas specimens appear to have a slightly longer and more rectangular glabella than that of Kobayashi's figured specimen.

Rasetti reassigned this species to *Theodenesia,* but the presence of a narrow, but clearly defined frontal area arbitrarily places it with *Triarthropsis* and thus distinguishes it from *Theodenesia microps* Rasetti, 1944 and *Theodenesia depressus* Rasetti, 1944, which it otherwise closely resembles.

Occurrence.—Rare in the *Corbinia apopsis* subzone at LCS-55.5.

TRIARTHROPSIS sp. A

Pl. 9, fig. 27

Description.—Cranidium 2 mm long, broadly rounded in front. Glabella two-thirds length of cranidium, strongly convex, parallel sided, rounded anteriorly. Two pairs of glabellar furrows laterally impressed, posterior pair strongly recurved, anterior pair slightly recurved. Frontal area broad for the genus, downsloping, undifferentiated. Fixigenae wide; palpebral lobes centered posterior to glabellar midpoint. Posterior area of fixigenae broad with deep furrow.

Remarks.—This form is represented by a single specimen. It differs from most species of the genus by its wide (sag.) frontal area and thus most closely resembles *Triarthropsis limbatus* Rasetti, 1959b, from which it differs in lacking four pairs of glabellar furrows, pointed glabella, and anterior border.

Occurrence.—Rare in the *Saukiella junia* subzone at CC-27.

Family PTYCHASPIDIDAE Raymond, 1924

Genus EUPTYCHASPIS Ulrich

Euptychaspis Ulrich in BRIDGE, 1931, p. 217.

Remarks.—In the Trempealeauan, *Euptychaspis* produced some remarkable variations involving chiefly the degree to which the anterior glabellar ring is expanded and the degree to which the eyes have migrated toward or away from the glabella. *Euptychaspis typicalis* probably represents the stem form from which the other species evolved. Indeed in the *Saukiella junia* subzone, many specimens are intermediate between *E. typicalis* and *E. jugalis,* n. sp. on the one hand, and between *E. typicalis* and *E. kirki* on the other. However, in the *Saukiella norwalkensis* subzone the species appear distinct. In *E. jugalis* the anterior glabellar ring is laterally expanded, but vertically depressed, and the eyes have moved toward the glabella, producing the yoked outline of the cranidium. In *E. kirki* the anterior glabellar ring is bulbous, and again the eyes have moved toward the glabella. *Macronoda prima,* which represents an extreme development of the stock, has a tumid anterior glabellar ring, like *E. kirki,* but the eyes have migrated toward the margin of the cranidium and have probably diminished in size. In addition to the foregoing, the glabella of some specimens tends to be notched in front.

EUPTYCHASPIS TYPICALIS Ulrich in Bridge

Pl. 9, fig. 17

Euptychaspis typicalis Ulrich in BRIDGE, 1931, p. 218, pl. 19, figs. 5–7; DAKE & BRIDGE, 1932, p. 740, pl. 12, fig. 3; SHIMER & SHROCK, 1944, p. 625, pl. 264, fig. 27; LOCHMAN-BALK, 1959, p. O322, fig. 237, 4a,b.

Remarks.—The type species is characterized by its nearly parallel sided, tunnel-shaped glabella with only slightly expanded anterior glabellar ring, comparatively long (sag.) frontal area, and wide fixigenae. Longitudinal striations on the frontal areas are preserved on a few specimens.

Occurrence.—Rare in the *Saukiella junia* subzone at CC-27; SH-12.5; TC-1301, 1305-1310.

EUPTYCHASPIS JUGALIS Winston & Nicholls, n. sp.
Pl. 9, fig. 13

Description.—Cranidium longer than wide; anterior glabellar ring laterally expanded, but raised only slightly, so that the upsloping curve of the frontal area is continuous without substantial break over the top of the glabella. Preglabellar furrow is impressed to a variable depth. Top of the middle and posterior glabellar segments is flattened, producing corners on the lateral edges of the glabellar rings. Occipital ring forms robust spine. Frontal area smooth, moderately long (sag.) with evenly curved anterior margin. Fixigenae narrow with eyes set rather close to the glabella for the genus, opposite the anterior glabellar furrow. Facial suture continues curve of anterior margin inward to the eye and then swings laterally to the posterior corners of the cranidium, giving the cranidium the outline of an inverted yoke. This outline is repeated in the combination of the anteriorly rounded, medially constricted axial furrow and the wide, deep posterior marginal furrow. Some glabellas are notched in front. Pygidium unknown.

Remarks.—This species is characterized by 1) the inverted yoke outline of the cranidium and glabella, 2) laterally expanded but low anterior glabellar ring, and 3) the corners on the flattened middle and posterior glabellar rings.

Occurrence.—Rare in the Lower Trempealeauan at JR-357, 369.5; TC-1237; common in the *Saukiella junia* subzone at CC-27; JR-481; TC-1349; common in the *Saukiella norwalkensis* subzone at JR-532, 536; SS-398; TC-1393, 1395; 86T-16-20B.

EUPTYCHASPIS KIRKI Kobayashi
Pl. 9, fig. 18

Euptychaspis kirki KOBAYASHI, 1935, p. 56, pl. 10, figs. 4, 5.
Euptychaspis sp. STAUFFER, 1940, p. 55, pl. 6, figs. 9, 10.

Remarks.—This species is characterized by its greatly expanded anterior glabellar ring that nearly overhangs the reduced frontal area. The fixigenae are narrower than those of *E. typicalis* and *Macronoda prima,* and the facial suture swings slightly inward at the eye, especially in the stratigraphically high forms.

Occurrence.—Rare in the *Saukiella junia* subzone at TC-1346; abundant in the *Saukiella norwalkensis* subzone at CC-61, 63± ; JR-521.5; LCS-32.4, 33, 35.7, 40, 44, 45, 45.4; SH-52, 54, 55, 60, 65.5, 71; SS-409; TC-1368-1374, 1380±, 1388, 1391.5, 1392, 1400.

Genus MACRONODA Lochman, 1964
MACRONODA PRIMA Lochman
Pl. 9, fig. 19

Macronoda prima LOCHMAN, 1964a, p. 53, pl. 14. figs. 12–23

Remarks.—This species is represented in the Texas collections by only five cranidia, **that** differ slightly from Lochman's typical specimens in lacking palpebral lobes. However, the palpebral lobes on Lochman's specimens are so subtle that they can not be identified from her photographs.

Occurrence.—Rare in the *Saukiella norwalkensis* subzone at JR-521.5, 529; TC-1388, 1392, 1400.

Genus KEITHIELLA Rasetti, 1944
KEITHIELLA PATULA Winston & Nicholls, n. sp.
Pl. 10, figs. 4,7

Description.—Cranidium quadrate to trapezoidal in outline, anterior broadly rounded. Glabella elongate, parallel sided, truncate, defined by broad, rather shallow axial furrow. Anterior glabellar furrows exceedingly faint, occur only as lateral pits opposite eye ridges; middle glabellar furrows deep, laterally impressed, directed backward; posterior glabellar furrow complete, strong at sides, becoming shallow and transverse over the top of glabella. Occipital furrow broad; occipital ring with node. Anterior border furrow wide, confluent with preglabellar furrow at anterior corners of glabella. Frontal area convex, downsloping. Fixigenae broad, convex to nearly horizontal in some specimens, extending slightly in front of glabella, traversed by eye ridges. Eyes small, centered opposite middle glabellar furrow; posterior border furrow broad, directed backward. Shallow depressions directed from the posterior glabellar furrow back across the posterior area of the fixigenae to the posterior border furrow restrict raised triangular knobs next to the posterior corners of the glabella. Anterior course of the facial suture is straight forward and down; posterior course is obliquely backward.

Remarks.—This species is characterized by being low, with the consequence that the axial and border furrows are less deeply impressed than in most species. The fixigenae are broad and low, scarcely rising above the axial furrows. In these respects it most closely resembles *Keithiella depressa* Rasetti, 1944, but differs from it in having a longer, narrower glabella. It differs from *Keithiella scrupulosa* Ellinwood, 1962, the other Texas species, in having more depressed fixigenae and frontal area. The anterior margin and the anterior border furrow of

K. patula are more transverse. Furthermore the entire length of the preglabellar furrow is confluent with the anterior border furrow, whereas in *K. scrupulosa* the glabella is more rounded and the preglabellar furrow is confluent with the border furrow only in the center.

Occurrence.—Common at TC-1400, but otherwise rare in the *Saukiella norwalkensis* subzone at LCS-35.6, 39, 44: SH-54. 61.5; SS-409.

Family SAUKIIDAE Ulrich
& Resser, 1933
Genus CALVINELLA Walcott, **1914**
CALVINELLA OZARKENSIS Walcott
Pl. 11, figs. 5,9

Calvinella ozarkensis WALCOTT, 1914, p. 389, pl. 70, figs. 1–6; Ulrich in BRIDGE, 1931, p. 216, pl. 19, figs. 8,9,?11; SHIMER & SHROCK, 1944, p. 621, pl. 261, figs. 15,16.

Remarks.—The Texas specimens assigned to this species have wider fixigenae than does Walcott's holotype, but in other respects are similar enough to be considered conspecific. Cranidia are proportionately shorter and wider than those of *Clavinella tenuisculpta* and *Calvinella procera;* length is 1.6 times glabellar width, and is 8 times border length (sag.). The glabella has more strongly developed glabellar furrows than those of *C. tenuisculpta* and *C. procera.* This species appears to be closely related to *Prosaukia stosei* (see Rasetti, 1959b, p. 389), but the presence of a significant preglabellar field places *stosei* in *Prosaukia,* illustrating again the artificial division of the saukids.

Occurrence.—Abundant in the upper part of the *Saukiella norwalkensis* subzone, rare below that in the zone; CC-61; JR-529, 536; LCS-44, 45, 45.4, 53; TC-1400.

CALVINELLA PROCERA Winston
& Nicholls, n. sp.
Pl. 10, fig. 22; pl. 11, figs. 1,3

Description.—Axial part of cranidium elongate and narrow for the genus, cranidial length twice glabellar width. Glabellar width four-fifths length, regularly tapered, truncate in front. Two anterior pairs of glabellar furrows form faint, broad lateral depressions; posterior glabellar furrow broad, laterally impressed, bowed backward and becoming obsolete over top of glabella. Occipital furrow directed backward at sides, bowed slightly forward in center. Occipital ring has long spine. Border sharply convex, anterior edge broadly rounded, length (sag.) two-fifths width, and one-fourth length of cranidium. Border furrow directed backward from anterolateral corners of the cranidium, confluent with the transverse preglabellar furrow.

Fixigenae wide and low, particularly on juvenile forms. Palpebral lobes gently raised or on some specimens downsloping laterally, one-third length of cranidium, centered opposite middle glabellar furrow. Posterior area stout near glabella, tapering abruptly; posterior border furrow strongly impressed.

Pygidial length one-half to two-thirds width, axis high, consisting of five axial rings plus terminal piece. Four pleurae, unequally divided by pleural furrows, can be recognized in front of flattened posterior part of pleural region; they also fade before reaching flattened marginal part of pleural region.

Remarks.—This species can be recognized by its long, tapered, truncate glabella, wide (sag.), inflated, anteriorly rounded frontal area, and wide, low fixigenae. The pygidium is short for the genus, but is otherwise characteristic and cannot be distinguished from figured specimens of some other species of *Calvinella,* such as *C. ozarkensis* Walcott, 1914.

Occurrence.—Common in the *Saukiella norwalkensis* subzone at LCS-35.7, 39, 40, 45, 45.4, 45.8; SH-52, 52.6, 54, 55; SS-383; TC-1357- 1363, 1368, 1371.

CALVINELLA TENUISCULPTA Walcott
Pl. 11, fig. 4

Calvinella tenuisculpta WALCOTT, 1914, p. 391, pl. 64, figs. 7,7a.

Remarks.—The Texas specimens agree with Walcott's brief description except that they lack the granulations and bertillion pattern mentioned by Walcott, but not evident in his figured specimen. This species differs from *Calvinella ozarkensis* in that the glabella and frontal area are proportionally longer (sag.). It differs from *C. procera* in that the glabella is more rectangular and that the frontal area is shorter (sag.) and less ovate.

Occurrence.—Rare in the lower part of *Saukiella norwalkensis* subzone at JR-519; LCS-33, 33.5, 44; SS-375.

Genus PROSAUKIA Ulrich
& Resser, 1933
PROSAUKIA LONGICORNIS Ulrich & Resser
Pl. 10, fig. 6

Prosaukia longicornis ULRICH and RESSER, 1933, p. 156, pl. 27, figs. 12–21; RAASCH, 1951, p. 143, 149; BERG, 1953, p. 567, pl. 61, figs. 7,9.

Remarks.—This species is recognized in Texas by its highly raised glabella, its prosaukid frontal area, and by its pronounced occipital spine. Cranidia of the three Texas specimens are less than seven millimeters long.

Occurrence.—Rare in *Saukiella norwalkensis* subzone at LCS-40; SH-55.

Genus SAUKIA Walcott, 1914
SAUKIA IMPERATRIX Ulrich & Resser
Pl. 9, figs. 15,16,21

Saukia imperatrix ULRICH & RESSER, 1933, p. 192, pl. 31, figs. 21–25; RAASCH, 1951, p. 144.

Description.—The overall dimensions of this species are low and wide for the genus. Glabella of Texas specimens moderately convex, slightly constricted between the eyes, expanded in front with angulated anterior corners on some specimens. Posterior glabellar furrow continuous, but is shallow across top; second and third pairs laterally impressed, second pair directed backward, anterior pair directed forward. Occipital furrow curved forward slightly in the middle. Anterior border furrow confluent with preglabellar furrow, directed forward and laterally from corners of glabella. Anterior slope of glabella and border gentle for the genus, forming an angle of 40 degrees with the horizontal. Palpebral lobes slope gently toward axial furrow; facial sutures diverge moderately in front of eyes to produce a wide (trans.) border.

Librigenae have robust spines that are directed obliquely, suggesting that the species had a wide thorax. Pygidial length three-eighths width, axis with four pleurae plus terminal axial piece. Pleural region has four pleurae that are subequally divided by pleural furrows.

Remarks.—This species is lower and wider than *Saukia tumida,* a feature that is reflected particularly in the glabella and pygidium. The glabellar furrows are less deeply impressed, the anterior third of the cranidium is more gently downsloping, the palpebral lobes are lower, and the facial sutures are more divergent in front of the eyes. Although both species occur in the *Saukiella junia* subzone, *S. tumida* occurs below *S. imperatrix.*

Occurrence.—Locally abundant in the *Saukiella junia* subzone at JR-484, 492; SH-12.6; 159T-8-31B.

SAUKIA TUMIDA Ulrich & Resser
PL 9, figs. 7,9,11

Saukia tumida ULRICH & RESSER, 1933, p. 192, pl. 30, figs. 11,12.

Description.—Cranidia of the Texas specimens are highly raised. Glabella cylindrical, nearly parallel sided with only slightly expanded posterior and anteroglabellar lobes, rounded in front. Posterior glabellar furrow deep, wide, and continuous; anterior glabellar furrow shallower and confluent in most specimens. Top of glabella horizontal from occipital ring to midpoint of the anterior glabellar lobe at which point the glabella rounds and drops steeply to preglabellar furrow. Occipital furrow broad and deeply impressed, bowed slightly forward in center. Preglabellar furrow confluent with border furrow, forming a narrow horizontal shelf in front of glabella. Border furrow directed forward and laterally from anterior corners of glabella. Border flat, steep, forms an angle of SO to 70 degrees with the horizontal. Palpebral lobes rise steeply from dorsal furrow. Anterior facial sutures diverge slightly from palpebral lobes to anterior corners of the cranidium producing anterior fixigenae and borders of variable width (trans.). Cranidial surface pustulose.

Pygidium long and narrow for the genus, similar to that of *S. rudis* (see Ulrich and Resser, 1933, pl. 30, figs. 24,25); length two-thirds width, axis high, composed of four segments plus a terminal piece that tapers to a point near the posterior margin. The four pleurae are subequally divided by pleural furrows.

Remarks.—This species is characterized by its cylindrical, anteriorly rounded glabella, deep glabellar furrows, steeply sloping front, high palpebral lobes, and narrow fixigenae.

Occurrence.—Locally abundant in the *Saukiella junia* subzone at JR-481; SS-356, 360.5; TC-1301, 1305–1310, 1320–1325; 86T-16-14B.

Genus SAUKIELLA Ulrich & Resser, 1933
SAUKIELLA JUNIA (Walcott)
PL 9, figs. 8,10,12,14,22

Saukia junia WALCOTT, 1914, p. 378, text-fig. 17.
Saukiella junia (Walcott), RESSER, 1938, p. 43.

Description.—Abundant specimens in the Texas collections permit a fuller description than that from Walcott's single specimen. Cranidium low, length two or more times glabellar width. Glabella subrectangular in outline, either expanded and truncate anteriorly, or parallel sided and rounded anteriorly. Single shallow glabellar furrow is well developed on all specimens, some have a very faint second glabellar furrow. Occipital furrow transverse or bowed slightly forward medially. Border furrow very faint, either curved back from the sides of the cranidium and confluent with the preglabellar furrow, transverse and separated from preglabellar furrow by short (sag.), low preglabellar field, or bowed forward forming a larger preglabellar field. Border long (sag.), gently convex, downsloping. Fixigenae narrow, palpebral lobes half glabellar length, centered opposite lateral extremity of glabellar furrow. Facial suture diverges in front of palpebral lobes to marginal furrow, where it swings broadly to midpoint.

Pygidium convex in comparison to cranidium, length two-thirds to three-fifths width. Axis highly arched, composed of four rings plus a

terminal axial piece. Pleural regions have four pleurae subequally divided by strong pleural furrows.

Remarks.—We have interpreted this species to include a rather broad range of characteristics and have subdivided it into two informal variants, rather than to recognize two species. Our reason for doing this is that within single collections, specimens range between the end points that characterize the two variants. Nevertheless, assignment to variety may be made by considering the dominant characteristics of the collection as a whole. Collections assigned to *S. junia* var. B occur stratigraphically below those assigned to *S. junia* var. A. Thus, varieties are established to illustrate stratigraphically reflected shifts in morphology, and do not necessarily imply genetic separation of the population.

SAUKIELLA JUNIA (Walcott) var. A
Pl. 9, figs. 10,12

Description.—This variant has an elongate cranidium, parallel sided and anteriorly rounded glabella, and anteriorly bowed border furrow that separates the frontal area into a broad border and short (sag.) preglabellar field. It most closely resembles Walcott's figured specimen, and occurs stratigraphically above *S. junia* var. B.

Occurrence.—Moderately common in the *Saukiella junia* subzone at CC-27; JR-460, 479; TC-1341–1346; 159T-7-25A.

SAUKIELLA JUNIA (Walcott) var. B
Pl. 9, figs. 8,14,22

Description.—This variant has an anteriorly expanded and truncate glabella with rather sharp corners. The frontal area is shorter (sag.) than that of *S. junia* var. A. The marginal furrow is faint, and it is either transverse and separated from the preglabellar furrow, or curved back and confluent with it.

Occurrence.—Abundant in the *Saukiella junia* subzone at SS-356, 370; TC-1301, 1303, 1305–1310, 1310–1315, 1315–1320, 1330–1335; G-16-9-G; 86T-16-14A; 86T-16-14B; 86T-16-14B2.

SAUKIELLA NORWALKENSIS Ulrich & Resser
PL 11, figs. 6–8,12

Saukiella norwalkensis ULRICH & RESSER, 1933, p. 209, pl. 36, figs. 5–27.
Saukiella pyrene (Walcott), RAASCH (pars), 1951, p. 145.
Saukiella indenta (Ulrich & Resser), RAASCH (pars), 1951, p. 145.

Remarks.—Although Raasch assigned some of Ulrich and Resser's figured specimens to *Saukiella pyrene* (Ulrich & Resser, 1933, pl. 36, figs. 5–11,15–25) and other specimens to *Saukiella indenta* (Ulrich & Resser, 1933, pl. 36, figs. 12–14, 26,27), we choose to recognize *Saukiella norwalkensis* in Texas because our specimens consistently have nearly parallel sided, or anteriorly tapering glabellas, and most have only a single glabellar furrow. Thus they coincide with the concept of *Saukiella norwalkensis,* although some of the Texas specimens have more quadrate glabellas and wider anterior fixigenae than do the Upper Mississippi Valley specimens. In this respect they more closely resemble a specimen figured by Rasetti (1946, pl. 1, fig. 19) and assigned to *Prosaukia ebracensis.* The pygidia are narrow and high and are thus more similar to those assigned to *Saukiella indenta* by Ulrich & Resser (1933, p. 208, pl. 35, figs. 28–30), although they commented that they occur with both *S. indenta* and *S. norwalkensis.* The bertillion pattern shown on the figured specimens is not commonly preserved.

Occurrence.—Abundant in the *Saukiella norwalkensis* subzone at CC-58.2, 61; JR-521.5, 529, 536; LCS-32, 33.5, 35.7, 39, 40, 44, 45, 45.4; SH-52, 52.6, 54, 55, 61.5; TC-1380±, 1387.5, 1388, 1392, 1400.

SAUKIELLA PEPINENSIS (Owen)
PL 9, figs. 4–6

Dikelocephalus pepinensis OWEN, 1852, p. 574, pl. 1, figs. 9,9a,b.
Saukia pepinensis (Owen) WALCOTT, 1914, p. **381**, pl. 67, figs. 1–13,13a (synonymy to date).
Saukiella pepinensis (Owen), ULRICH & RESSER, 1933, p. 202, pl. 33, figs. 22–24; SHIMER & SHROCK, 1944, p. 633, pl. 260, figs. 31–37; RAASCH, 1951, p. 144; LOCHMAN-BALK, 1959, p. O325, fig. 239,3.
Saukiella typicalis ULRICH & RESSER, 1933, p. 197, pl. 32, figs. 1–21; RICHTER & RICHTER, 1949, figs. 3a,b.
Saukiella typicalis convexa ULRICH & RESSER, 1933, p. 197. pl. 32, figs. 22–29.
Saukiella typicalis subrecta ULRICH & RESSER, 1933, p. 198. pl. 33, figs. 1–6.
Saukiella ampla ULRICH & RESSER, 1933, p. 199, pl. 33, figs. 28,29.
Saukiella subgracilis ULRICH & RESSER, 1933, p. 200, pl. 33, figs. 7–18.
Saukiella subgracilis hybrida ULRICH & RESSER, 1933, p. 201, pl. 33, figs. 19–21.
Saukiella subgracilis parallela ULRICH & RESSER, 1933, p. 201, pl. 33, figs. 25–27.

Remarks.—By placing *S. typicalis, S. typicalis convexa, S. typicalis subrecta, S. ampla, S. subgracilis, S. subgracilis hybrida,* and *S. subgracilis parallela* in synonymy with *S. pepinensis,* Raasch (1951) has left this species well illustrated.

Occurrence.—Locally abundant in the *Saukiella junia* subzone at JR-450, 453, 459, 460; TC-1291, 1293, 1305, 1330–1335; 86T-16-8L.

SAUKIELLA PLANATA Winston
& Nicholls, n. sp.
PL 11, figs. 2,10

Description.—Cranidium low; glabella rec-

tangular or slightly tapering, truncate, smooth or with faint glabellar furrow that is posteriorly bowed as in other species of the genus. Occipital furrow weak, medially transverse, curving forward laterally. Border furrow transverse; preglabellar field very short (sag.); border raised, flat, downsloping, producing a foreshortened *Saukiella-type* frontal area. Palpebral lobes long, about two-thirds glabellar length, narrow, and nearly horizontal. Posterior limb narrow (sag.); facial suture directed straight forward or slightly obliquely in front of eyes to marginal furrow, where it swings medially.

Remarks.—In essence *Saukiella planata* is a depressed *S. norwalkensis* with obsolete glabellar furrow, a more truncate and foreshortened frontal area, and longer, narrower palpebral lobes. Some specimens appear intermediate between the two species. *S. planata* occurs with the highest *S. norwalkensis* and higher in the *S. norwalkensis* subzone. Although *S. planata* differs considerably from most species of the genus, we prefer to include it in *Saukiella* rather than to erect a monotypic genus in the already confused saukid group.

Occurrence.—Locally common in the upper part of the *Saukiella norwalkensis* subzone at LCS-44, 45, 52; SH-61.5, 65.5; TC-1400.

Family EUREKIIDAE Hupé, 1953

Remarks.—The Eurekiidae comprise an important family in the Texas collections and are represented by the genera *Bayfieldia, Corbinia,* and *Eurekia.* Inasmuch as these genera are poorly defined and differentiated, this investigation offers an opportunity to redescribe them within a stratigraphic context.

As Lochman (1956, p. 450) pointed out, *Maladia* is the *Prosaukia* zone genus from which the rest of the family probably developed. It is characterized by a rather plain, anteriorly rounded glabella, medium sized frontal area with well developed preglabellar field and low border, low and narrow fixigenae with palpebral lobes set close to the glabella, and robust posterior area. In the development of Trempealeauan genera, the tendency appears for the carapace to have become inflated and foreshortened with the result that the preglabellar field was reduced, the border elevated, and the glabella became more truncate. The palpebral lobes rose to the level of the glabella and the axial furrow became therefore more deeply impressed. The posterior fixigenae became more strap-like and the pygidium became shorter. This trend is apparent in passing from *Maladia* to *Bayfieldia* and reached its full development in *Corbinia* and *Eurekia.*

Genus BAYFIELDIA Clark, 1924

Bayfieldia CLARK, 1924, p. 31; RASETTI, 1944, p. 239; LOCHMAN-BALK, 1959, p. 0325.

Description.—Glabella conical, rounded anteriorly, standing well above fixigenae, delineated by sharp but shallow axial furrow; glabellar furrows commonly absent, but if present are shallow and recurved. Occipital segment long (sag.), defined by broad, shallow occipital furrow **that** commonly bifurcates just before reaching axial furrow, restricting a low triangular bulge. Preglabellar field downsloping; border furrow recurved; border raised, but not greatly. Fixigenae very narrow, palpebral lobes narrow, with or without furrow. Cranidial surface smooth or granulose. Axis of pygidium high, with one or two rings plus a terminal axial piece commonly having two terminal nodes. Pleural fields spinose and commonly with pleural furrows that merge anteriorly with interpleural furrows.

Remarks.—This genus differs from *Maladia* in its shorter frontal area and narrower fixigenae. On the other hand, like *Maladia* and unlike both *Corbinia* and *Eurekia,* the preglabellar field is only partly reduced, the border is not highly raised, the palpebral lobes are low, and the occipital furrow bifurcates before reaching the axial furrow. In addition it differs from *Corbinia* in having an anteriorly rounded glabella.

Bayfieldia has four described species: *B. barabuensis* (Whitfield), 1878; *B. binodosa* (Hall), 1863; *B. tumifrons* (Clark), 1924; and *B. simata,* n. sp. In addition Rasetti (1959b, p. 389, pl. 55, figs. 20–23) has described and figured an unnamed species he assigned to *Bayfieldia.* We concur with his assignment on the basis of the frontal area, but point out that the degree of glabellar truncation, the deep occipital furrow, and short, wide pygidium also ally it to *Corbinia* and show the close relationship of the two genera.

BAYFIELDIA BINODOSA (Hall)

PL 9, figs. 1,2

Conocephalites? binodosus HALL, 1863, p. 160, pl. 7, fig. 47.
Ptyochoparia binodosa (Hall), CLARK, 1924, p. 32.
Eurekia binodosa (Hall), WALCOTT, 1925, p. 89; GRANT, 1965, p. 116, pl. 14, figs. 15,16,20.
Bayfieldia finkelnburgi CLARK, 1924, p. 32, pl. 4, fig. 7.
Eurekia finkelnburgi (Clark), RESSER, 1935, p. 28.

Description.—This species is recognized by its conical, anteriorly rounded glabella, posteriorly bowed border furrow, strongly elevated anterior border, narrow fixigenae and palpebral lobes. Glabella may be smooth or granulose. Occipital furrow broad, gently bowed forward in center, bifurcating laterally, with one segment swinging anteriorly and the other segment swinging pos-

teriorly, leaving a triangular area restricted laterally by the axial furrow. In some specimens either the anterior segment or the posterior segment may predominate. Highly raised axis of pygidium has an articulating half ring, a single strong axial ring, and a second faint axial ring that in some specimens is fused with the terminal axial piece. The two terminal nodes, which Hall emphasized in choosing the specific name, seem to be a common generic characteristic. Pleural fields have strong interpleural furrows and weaker pleural furrows that merge laterally with adjacent anterior interpleural furrows. Margin has four or five pairs of spines.

Remarks.—This species was originally described by Hall (1863) from a pygidium collected at Osceola Mills, Wisconsin and tentatively ascribed to *Conocephalites.* Hall described the pygidium as having "three rounded annulations beside the terminal one." In some of the Texas specimens the two posterior segments are fused. Clark (1924, p. 32) described the cephalon from Osceola Mills as *Bayfieldia finkelnburgi* but commented that it occurs with pygidia of *Ptychoparia binodosa* (Hall), but that they probably belong to different species. Walcott (1925, p. 89) recognized that the cephalon and pygidia belonged together, a fact apparently overlooked by Resser when he assigned *Bayfieldia finkelnburgi* to *Eurekia.*

This species differs from *B. tumifrons,* the type species, in having larger palpebral lobes and in lacking glabellar furrows. *B. binodosa* occurs in Texas, Wisconsin, and Montana (Grant, 1965) and may be important in regional correlation.

Occurrence.—Common in the lower Trempealeauan at JR-357, 394; TC-1237, 1265, 1286, 1287; and in the *Saukiettajunia* subzone at JR-459, 481; SS-356; TC-1291.

BAYFIELDIA SIMATA Winston & Nicholls, n. sp.
Pl. 9, figs. 20,23–26

Description.—Cranidium, excluding posterior fixigenae elongate, gently convex and rounded in front. Glabella smooth, gently tapered, slightly expanded medially. Axial furrow shallow; occipital furrow broad and shallow, transverse to forwardly bowed, widening at lateral extremities and in some specimens bifurcating, with the posterior segment stronger. Frontal area downsloping, gently convex, with faint, posteriorly bowed border furrow; border slightly raised. Anterior area of fixigena narrow. Palpebral lobes narrow, one-half to two-thirds glabellar length, centered posterior to glabellar midpoint, with or without palpebral furrows. Posterior area of fixigena of variable width (sag.), parallel sided, with furrow. Anterior course of facial suture either straight, slightly convergent, or more commonly divergent. Axis of pygidium with two rings plus terminal axial piece that slopes medially to pleural platform. Pleural regions raised or low; pleura with or without furrows, but separated by strong interpleural furrows that swing sharply backward near periphery, separating eleven or twelve marginal spines.

Remarks.—This species appears to be a flattened descendent of *Bayfieldia binodosa.* The flattening has changed the appearance of the species considerably, but the basic form and structure are close enough to *Bayfieldia* to retain it in the genus. Although this species is clearly unique within the genus, its cranidium is nearly identical to those of *Monocheilus* and *Stigmacephalus* of the family Parabolinoididae (Lochman, 1956). Consistent differences between *Bayfieldia simata* and *Monocheilus* cranidia are difficult to determine, but *B. simata* generally has a faint anterior border furrow, medially expanded glabella, and laterally bifurcated occipital furrow. *Stigmacephalus* differs from *B. simata* in having shorter palpebral lobes. The principal distinction between *B. simata* and both genera is that *B. simata* has a spinose pygidium.

Occurrence.—Rare in the *Saukietta junia* subzone at CC-27; JR-481; LCS-31; SS-360.5; abundant in the *Saukiella norwalkensis* subzone at CC-58.2, 61; JR-519, 532, 536; LCS-32, 33, 33.5, 34–36, 35.7, 44, 44.5, 45, 45.4; SH-52, 52.6, 65.5; SS-375, 381, 383, 398; TC-1360, 1371, 1380, 1387.5, 1391.5, 1392, 1393, 1394, 1395, 1400; 16T-5-4B;86T-16-20B.

BAYFIELDIA SIMATA var. A
Pl. 9, figs. 24,26

Description.—Cranidium not distinctive, but pygidium characterized by a higher axis and by faint nodes on posterior segment. Pleural regions are more highly raised and the pleura have furrows that merge laterally with adjacent anterior interpleural furrows as in *Bayfieldia binodosa.* Five pairs of stout marginal spines with or without small terminal spine.

Remarks.—This informal variant is recognized because it provides an evolutionary link between *Bayfieldia binodosa* and *B. simata,* and because it occurs stratigraphically below *B. simata.*

Occurrence.—Locally common in the *Saukiella junia* subzone at SH-12.6; SS-356.

Genus EUREKIA Walcott, 1924

Eurekia WALCOTT, 1924, p. 56; 1925, p. 89; RESSER, 1935, p. 28; LOCHMAN-BALK, 1959, p. O325.

Description.—Glabella highly convex, anteriorly rounded or truncate; axial furrow deep; two pairs of glabellar furrows, commonly deep and recurved. Occipital furrow deep, swinging forward laterally. Preglabellar field very narrow or absent, anterior border furrow transverse or only slightly recurved, border sharply upturned. Fixigenae very narrow; palpebral lobes close to glabella, with palpebral furrows. Posterior limb long (trans.) and slender, with deep furrow. Cranidial surface commonly granulose. Pygidium with highly raised axis and two terminal nodes. All furrows deep and wide, producing rugged appearance. Margins spinose; spines commonly cropped.

Remarks.—This genus, like *Corbinia* and unlike *Maladia* and *Bayfieldia,* has deep axial furrows and high palpebral lobes. The preglabellar field is reduced, and the border is sharply upturned. The glabella is more equidimensional than that of *Corbinia,* and has deeper furrows. *Eurekia* has six species: *E. granulosa* Walcott, 1924; *E. angustifrons* (Walcott), 1884; *E. dissimilis* (Walcott), 1884; *E. eos* (Hall), 1863; *E. sedgwicki* (Billings), 1860; and *E. denticulata* (Meek), 1877.

EUREKIA EOS (Hall)
PL 10, figs. 15,17

Conocephalites eos HALL, 1863, p. 151, pl. 7, figs. 24,25; pl. 8, figs. 8,9.
Eurekia eos (Hall), WALCOTT, 1924, p. 89 (list); RESSER, 1935, p. 28 (list); SHIMER & SHROCK, 1944, p. 625, pl. 265, figs. 4-6.

Remarks.—The Texas specimens differ from Hall's figures in being granulose, but we believe this is probably a result of preservation. The Wisconsin specimens are preserved as internal molds in sandstone, and consequently granulations might be lost or overlooked. *Eurekia eos* differs from *Eurekia granulosa,* the type species, chiefly in the fact that the facial sutures pass straight forward or converge slightly in front of the eyes, but do not diverge, and that the border furrow is nearly transverse and not significantly recurved. It differs from *Eurekia sedgwicki* in having a more truncate glabella, although there appears to be a gradation of specimens from those with conical glabellas assigned to *E. sedgwicki,* stratigraphically upward to those with more truncate glabellas assigned to *E. eos.*

The illustrated specimens of *E. angustifrons* and *E. dissimilis,* two other somewhat similar forms, are too fragmentary for adequate comparison [the pygidium assigned by Walcott (1884, pl. 10, fig. 1b) to *E. angustifrons* probably belongs to *Briscoia*].

Occurrence.—Rare in the Lower Trempealeauan at TC-1244, 1287; rare in the *Saukiella junia* subzone at TC-1346; abundant in the *Saukiella norwalkensis* subzone at JR-529, 532; LCS-32, 35.7, 40, 44; SH-52, 52.6, 53.5, 54, 55, 65.5; SS-375, 398, 409; TC-1360, 1371, 1380±, 1391.5, 1392, 1393, 1395; rare in the *Corbinia apopsis* subzone at LCS-54; and at 86T-16-20B.

EUREKIA SEDGWICKI (Billings)
Pl. 10, figs. 12,16

Menocephalus sedgwicki BILLINGS, 1860, p. 316, fig. 19; 1863, p. 237, fig. 266; 1865, p. 407, fig. 387.
"Menocephalus" sedgwicki Billings, RASETTI, 1944, p. 258, pl. 36, fig. 56.

Remarks.—This species is represented in the Texas collection by three poorly preserved specimens that illustrate features of the glabella and part of the frontal area. The convex, granulose glabella with deep recurved glabellar furrows is characteristic of *Eurekia.* It differs from other species of the genus in its strongly conical, anteriorly rounded glabella, but grades stratigraphically upward to *Eurekia eos.*

Occurrence.—Rare in the Lower Trempealeauan at JR-354, 374.5.

Genus CORBINIA Walcott, 1924

Corbinia WALCOTT, 1924, p. 55; 1925, p. 81; LOCHMAN-BALK, 1959, p. O325.

Description.—Glabella elongate, tapered, truncate, delineated by deep axial furrow. Glabellar furrows absent or present as fine, recurved grooves or wide, shallow pits. Occipital furrow deep and turned forward laterally. Preglabellar field absent, or narrow and downsloping; anterior border furrow transverse or gently recurved; anterior border sharply elevated. Anterior area of fixigena very narrow; palpebral lobes close to glabella, with or without furrows. Posterior area narrow (sag.) and long, with deep furrow. Pygidium is short and wide, with highly arched axis that extends almost to posterior margin. Pleurae spinose.

Remarks.—This genus differs from *Eurekia* in its longer, tapered and more truncate glabella with only faint glabellar furrows. The glabella of *Eurekia* is more quadrate and is either truncate or anteriorly rounded, with deep glabellar furrows. The surface of *Corbinia* cranidia is only finely granulose. The pygidium of *Corbinia* is wider and shorter, with finer furrows and sharper spines than that of *Eurekia. Corbinia* has five species: *C. horatio* Walcott, 1925; *C. valida* Walcott, 1925; *C. apopsis,* n. sp.; *C. implumis,* n. sp., and *Bayfieldia ulrichi* Rasetti, 1945, here placed with *Corbinia* on the basis of its elongate, truncate, faintly furrowed glabella and sharply raised anterior border.

CORBINIA APOPSIS Winston & Nicholls, n. sp.
Pl. 11, figs. 13,14,17,22

Bayfieldia sp. RASETTI, 1959b, p. 388, pl. 55, figs. 20–23.

Description.—Cranidium elongate; glabella tapered and truncate anteriorly. Glabellar furrows may be absent or present as fine posteriorly directed grooves, or shallow broad depressions. Occipital furrow deep and broad, bowed forward in center and again swinging anteriorly at lateral extremities. Anterior border furrow tangent to preglabellar furrow, may be transverse to lateral extremities, or may arc slightly forward. Anterior border gently or sharply upraised, bent down at corners, extremely narrow. Palpebral lobes elevated, close to glabella, up to one-half length of cranidium, complete with furrow. Some cranidia are granulose. Librigena with granulose field, sharply defined border furrow, and broad border that extends medially in front of the facial suture and bears fine, irregular, horizontal striations. Genal angle sharp; no spines.

Pygidium wide and short; axis highly arched, extending nearly to posterior margin. Pleura high, sharply downsloping near margin. Two anterior pairs of pleural furrows are strong across pleurae, fade laterally where interpleural furrows become impressed, and separate the five pairs of marginal spines.

Remarks.—*Corbinia apopsis* differs from *C. horatio* Walcott, 1925 and from *C. valida* Walcott, 1925 in having larger palpebral lobes, narrower border, and more parallel sided posterior limbs. It differs from *C. ulrichi* (Rasetti), 1945 in its more elongate, less convex glabella and its broader border. Furthermore, the pygidium is wider, flatter and has a smaller axis than that of *C. ulrichi.*

Rasetti (1959b, p. 388, pl. 55, figs. 20–23) described and figured specimens he referred to as *Bayfieldia* sp. We believe they are conspecific with *C. apopsis* and differ from ours only in having slightly more recurved anterior border furrows and less sharp furrows on the pleurae of the pygidium. We consider his figured specimens to lie within the range of variation of our collection.

Occurrence.—Abundant in the *Corbinia apopsis* subzone at CC-67; JR-538, 539, 540, 542, 543, 545; LCS-53.3, 53.8, 55, 55.5, 56; SH-72; SS-411, 413, 416; TC-1402, 1409.

CORBINIA IMPLUMIS Winston & Nicholls, n. sp.

Description.—Glabella strongly convex, slightly tapered, truncate and delineated by deep axial furrows; two pairs of faint, posteriorly directed glabellar furrows. Occipital furrow wide and deep, bifurcating laterally. Border furrow deep and broad, recurved, tangent to preglabellar furrow at midpoint; anterior margin sharply elevated. Fixigenae narrow; palpebral lobes centered on midline of glabella, set close to glabella, with palpebral furrow. Posterior limb narrow (sag.), long, downsloping, with deep, broad furrow. Entire cranidium except furrows is coarsely granulose.

Remarks.—This species is represented by specimens from a single collection. Some specimens are gradational with *Bayfieldia binodosa* and demonstrate the relationship between the two genera. Its bifurcating occipital furrow and recurved border furrow show its affinity to *Bayfieldia,* but its tapered and truncate glabella, deep axial furrow, and elevated palpebral lobes place the species in *Corbinia.*

Occurrence.—Rare in the *Saukiella junia* subzone at TC-1290.

Family REMOPLEURIDIDAE Hawle and Corda, 1847
Genus APATOKEPHALOIDES Raymond, 1924
APATOKEPHALOIDES CLIVOSUS Raymond
Pl. 11, fig. 11

Apatokephaloides clivosus RAYMOND, 1924, p. 425, pl. 13, fig. 13 (not fig. 17, referred to *Bayfieldia ulrichi* by Rasetti, 1945, p. 462); RASETTI, 1963, p. 1010, pl. 130, figs. 19,20.

Description.—This, the type species, is characterized by its elongate, tapering glabella with two pairs of posteriorly directed glabellar furrows, which range from well defined furrows to pits. Occipital furrow is straight, behind medial third of glabella, but marginal segments pass convexly forward to axial furrow. In most specimens a second very faint pair of furrows diverge from the extremities of the straight medial segment, and pass backward to posterior margin of occipital ring short of the axial furrow. This configuration is similar to that found in many olenids. Preglabellar field is depressed, and has genal caeca on one exfoliated specimen. Border is narrow (sag.), nearly straight and elevated, but not upturned. Palpebral lobes are wide and short, and do not extend behind the limits of the posterior glabellar furrows. Anterior course of the facial suture diverges only slightly from the very narrow fixigenae. Although abundant cranidia were found in some beds, no pygidia could be identified for this species.

Remarks.—Texas specimens of this species differ from *Apatokephaloides pauper* (Billings), 1865 and *A. rotundatus* Rasetti, 1945, by having a longer, narrower glabella, wider (trans.) palpebral lobes, wider (sag.) frontal area, and lower border. They differ from *A. minor* Rasetti, 1959

in having more parallel anterior facial sutures, in configuration of the occipital furrow, and by lacking pits along the marginal furrow. *A. clivosus* most nearly resembles *A. macrops* Rasetti, 1959, but has shorter (sag.) palpebral lobes and consequently wider (sag.) posterior limbs.

Occurrence.—Common in the *Corbinia apopsis* subzone at CC-67; LCS-53, 53.3; SH-72; SS-411.

Family ASAPHIDAE Burmeister, 1843
Genus SYMPHYSURINA Ulrich
in Walcott, 1924
SYMPHYSURINA BREVISPICATA Hintze
Pl. 12, figs. 7–10,15

Symphysurina brevispicata HINTZE, 1952, p. 236, pl. 3, figs. 9–17; LOCHMAN, 1964b, p. 464, pl. 63, figs. 1–16.

Remarks.—This species has been characterized well by Hintze and by Lochman. Specimens assigned to it range from those with evenly convex, quadrate glabellas (pl. 12, figs. 8,9), like those described by Hintze, to those with glabellas that have become anteriorly elongate and flattened, so that the convexity is restricted to the posterior part of the cranidium (pl. 12, fig. 7). Similarly, the pygidia range from those that are more evenly convex, like those described by Hintze, to those which are nearly flat on top and slope down sharply at the sides (pl. 12, fig. 10). Because these variations appear to be continuous within single collections, we recognize only a single species.

Occurrence.—Rare in the *Missisquoia* zone at SS-427, 428, 429, 482.5, 485, 490.5, 491; common in the *Symphysurina* zone at CC-135, 136, 142; JR-622, 641, 645, 646, 647, 673; LCS-144, 147, 148, 153; RB-60; SS-491.5, 496, 512; TC-1449.

SYMPHYSURINA BUBOPS Winston
& Nicholls, n. sp.
Pl. 12, figs. 13,16,17,19

Nileus cf. *N. armadillo* (Dalman), Ross, 1965, p. 19, pl. 8, figs. 21,22,25,29,34.

Description.—Cranidium subquadrate. Glabella smooth and moderately raised; sharply downsloping in anterior one-fourth. Median node visible on most specimens, centered between the eyes. Faint occipital furrow on some specimens transverse, restricts posteriorly rounded occipital ring. Axial furrow shallow and broad, convergent between the eyes, broadly curving at anterior corners of cranidium and fading medially. Anterior margin bowed up slightly, marked by wire-like rim composed of two longitudinal striations. Palpebral lobes large, one-fourth to one-third length of cranidium, centered on or anterior to glabellar midpoint, elevated above axial furrow and sloping laterally. Librigenae wide (trans.). Marginal furrow forms broad, semi-elliptical depression from which the ocular platform domes upward around the eye. Pygidium broadly elliptical in outline, axis flattened, but entirely defined, extending almost to posterior margin, and crossed by three or four broad, flat furrows. Pleural regions smooth or slightly furrowed, gently sloping to margin, which is marked by very narrow, depressed border.

Remarks.—The only other species in which the cranidium is so strongly convex in front and in which the eyes are set anterior to the glabellar midpoint is *Symphysurina globosa* Raymond, 1937. *Symphysurina bubops* differs from *S. globosa* in that the axial furrow extends in front of the eyes and the palpebral lobes are larger. The shallow axial furrow, pinched medially between the eyes is suggestive of *Bellefontia,* but nevertheless the pitted doublure of the librigena (pl. 12, fig. 17) is convincing evidence for its belonging to *Symphysurina.*

Occurrence.—Common in the *Missisquoia* zone at CC-99.5, 120; JR-614; LCS-108.5, 123; RB-8.6, 13.2; 159T-8-34A; 159T-8-42A; rare in the *Symphysurina* zone at JR-647, TC-1449.

Family PLETHOPELTIDAE Raymond, 1925
Genus LEIOCORYPHE Clark, 1924
LEIOCORYPHE HALEI Winston &
Nicholls, n. sp.
Pl. 10, figs. 10,13

Description.—Cranidium completely smooth, equidimensional, tapering anteriorly, highly convex. Sagittal convexity nearly regular. Palpebral lobes absent; posterior limb blunt, directed laterally and down, not extending in back of bulge representing the occipital ring. Facial suture rises along anterior margin of posterior limb, then arcs regularly forward to midpoint.

Remarks.—Facial sutures arc high on the cephalon and produce a uniquely elongate, subtriangular cranidium of this genus that closely resembles the outline of *Stenopilus.* However, lack of palpebral lobes places the species in *Leiocoryphe.* It lacks the occipital furrow characteristic of *Leiocoryphe occipitalis* Rasetti from the lower Trempealeauan of Texas (Bell and Ellinwood, 1962, p. 403, pl. 59, fig. 4).

Occurrence.—Common in the *Saukiella norwalkensis* subzone at JR-529; LCS-33, 35, 40, 45, 45.4; TC-1400; 16T-2-57C; 27T-7-62A; 86T-2-12G; rare in the *Corbinia apopsis* subzone at LCS-53.

Genus PLETHOMETOPUS Ulrich, 1931
PLETHOMETOPUS MODESTUS Ulrich
Pl. 10, fig. 11

Plethometopus modestus Ulrich *in* BRIDGE, 1931, p. 222, pl. 19, figs. 34–37 (not pl. 18, fig. 7).

Remarks.—Texas specimens of this species are more convex than the one profile figured by Ulrich (1931, pl. 19, fig. 37), but the marked occipital furrow and narrow posterior limbs are in our opinion more important characteristics. Although Ulrich does not mention it, his figured cranidia of *P. modestus* are relatively shorter than the complete cranidium of *P. convexus* figured by him (1931, pl. 19, fig. 30). Bell (in Bell and Ellinwood, 1962, p. 403, pl. 59, figs. 5,6) has assigned lower Trempealeauan specimens to *P. convexus,* but the cranidial proportions of the upper Trempealeauan specimens are closer to those of *P. modestus.*

Occurrence.—Common in the *Saukiella norwalkensis* subzone at LCS-39, 40; SH-54; and in the *Corbinia apopsis* subzone at JR-539, 540; LCS-53.3, 55.5; SS-411.

Genus STENOPILUS Raymond, 1924
STENOPILUS LATUS Ulrich
PL 9, fig. 28; pl. 10, fig. 14

Stenopilus latus Ulrich *in* BRIDGE, 1931, p. 222, pl. 19, figs. 27,28,32,33; SHIMER & SHROCK, 1944, p. 633, pl. 260, figs. 8,9.

Remarks.—This species is characterized by its smooth, nearly equidimensional, tapering, posteriorly convex cranidium. *Stenopilus pronus* Raymond, recognized in the lower Trempealeauan of central Texas (Bell & Ellinwood, 1962, p. 403, pl. 59, figs. 7–9), differs in being more elongate. The pygidium appears identical with that assigned by Rasetti (1959) to *S. pronus* Raymond.

Occurrence.—Common in the *Saukiella junia* subzone at JR-460, 481; SH-12.6; SS-356, 370; TC-1323, 1332, 1346. Abundant in the *Saukiella norwalkensis* subzone at CC-58.2, LCS-33.5, 40, 45, 45.4; TC-1380±, 1385; 16B-5-4B; 16T-6-25A; 86T-2-12G.

Family MISSISQUOIIDAE Hupé, 1953
Genus MISSISQUOIA Shaw, 1951

Missisquoia SHAW, 1951, p. 108; LOCHMAN-BALK, 1959, p. O510.

The many well preserved specimens in our collection and the recognition of two new species make possible a more complete generic description.

Description.—Cranidium small, width greater than length; glabella elongate, rectangular, tapered or expanded, strongly convex transversely, three pairs of short glabellar furrows present on lateral slopes, anterior notch present on all but smallest specimens; frontal area short, bluntly pointed or evenly rounded; border furrow absent in front of glabella; fixigenae convex, upsloping; palpebral lobes small, centrally located; palpebral furrow absent; ocular ridges faint and slightly oblique; axial furrow deep and broad along posterior two-thirds of glabella, depth anteriorly varies specifically; occipital ring widest at its center, tapered laterally; occipital furrow well defined. Facial sutures parallel or convergent in front of palpebral lobes; surface of cranidium with or without granules.

Librigenae gently convex, length and width (excluding spine) subequal; border broad, flat, tapered forward, projected rearward into a narrow, curved spine; marginal furrow well developed.

Pygidium broadly triangular, width greater than length, strongly convex transversely. Axis distinct, well elevated, tapered, terminal end steeply downsloping, length twice greatest width, number of axial rings ranges from 6 to 12. Pleural platforms convex, steeply downturned on small specimens, less so on larger ones; pleural furrows faint at axis, broad and distinct along lateral margins; interpleural furrows just the opposite, well defined axially, indistinct at the lateral margins; lateral margins bear blunt spines; surface may be granulose.

MISSISQUOIA TYPICALIS Shaw
Pl. 13, figs. 2,5,6,10,12,15,18

Missisquoia typicalis SHAW, 1951, p. 108, pl. 23, figs. 1–10; LOCHMAN-BALK, 1959, p. O510, fig. 403a,b.

The variability of *M. typicalis* in central Texas necessitates certain emendments to Shaw's (1951, p. 108) original description.

Description.—Glabella parallel sided, tapered forward, or expanded; axial furrow deep and broad along posterior three-fourths of glabella, narrow, but distinct along anterior fourth; frontal area downsloping, of constant width or tapered laterally, may have a small longitudinal ridge immediately in front of the glabellar notch; fixigenae elevated, width one-third to two-thirds width of glabella; slightly oblique eye ridges visible on larger specimens; facial sutures parallel or convergent in front of the small palpebral lobes; surface of cranidium with or without granules.

Description of the pygidium is given in the generic description. The pleural platforms slope almost vertically on small pygidia, but on mature specimens they tend to slope less, giving the larger pygidia a wider appearance. The presence of a terminal spike, contrary to Shaw (1951, p. 109), is not a function of size, and several of the large pygidia possess granules.

Remarks.—Specimens of *M. typicalis* in our collections exhibit the same ontogenetic changes noted by Shaw (1951, p. 108) in specimens from Vermont, as well as noticeable individual variation which is not related to size.

Occurrence.—Abundant in the *Missisquoia* zone at CC-90, 93; JR-597; SS-417, 420, 429, 432, 442; TC-1415, 1416, 1417, 1421, 1423; 159T-8-34A; 1S9T-8-42A.

MISSISQUOIA INFLATA Winston & Nicholls, n. sp.
Pl. 13, figs. 4,7

Description.—In addition to the generic characteristics, this species is distinguished by its unusually large, strongly arched glabella and very narrow, low fixigenae. The anterior half of the glabella is steeply downsloping and the width of fixigenae is slightly less than one-fourth that of the glabella. Like *M. typicalis* the frontal area is very narrow and evenly rounded, and the axial furrow is distinct the entire length of the glabella.

M. inflata differs from *M. typicalis* and *M. nasuta* in having a relatively larger glabella that is steeply depressed in its anterior half and strongly accentuated because of the narrow, almost horizontal fixigenae.

Occurrence.—Rare in the *Missisquoia* zone at CC-93 associated with *M. typicalis* and *M. nasuta.*

MISSISQUOIA NASUTA Winston & Nicholls, n. sp.
Pl. 13, figs. 1,3,9

Description.—This species possesses the characteristics of the type, *M. typicalis,* but differs in the following respects: the axial furrow is very shallow along the anterior one-fourth of the glabella and on many specimens appears to fade out before reaching the border furrow. The border furrow and the anterior border are bluntly pointed, so that the cranidium is roughly spear-shaped. The width of the fixigenae averages two-thirds that of the glabella.

Very small specimens of this species are often difficult to distinguish from *M. typicalis* because they may not have the well developed nasute frontal area. However, the persistency in larger specimens of the features that characterize *M. nasuta* supports its reocgnition.

Occurrence.—Common in the *Missisquoia* zone at CC-90.5, 93; SS-425, 432, 433; TC-1418, 1421, 1426.

Family uncertain
Genus BOWMANIA Walcott, 1928
BOWMANIA AMERICANA (Walcott)
Pl. 10, fig. 18

Arethusnia americana WALCOTT, 1884, p. 62, pl. 9, fig. 27.
Bowmania americana (Walcott), WALCOTT, 1925, p. 73, pl. 15, figs. 15,16.

Remarks.—This, the type species, is characterized by its semicircular cranidium; strongly convex, slightly tapered glabella; slightly convex, horizontal fixigenae with posteriorly directed eye ridges, and forward trace of the facial suture in front of the eyes.

The Texas specimens agree more closely with Walcott's (1925, pl. 15, figs. 15,16) photograph than with the sketch (Walcott, 1884, pl. 9. fig. 27) included with the original description. Nevertheless, it resembles the original description closely enough to be considered conspecific.

Occurrence.—Rare in the *Saukiella norwalkensis* subzone at CC-58.2; LCS-40; SH-52, 54, 61.5.

BOWMANIA SAGITTA Winston & Nicholls, n. sp.
PL 10, figs. 19,20

Description.—Cranidium bluntly triangular. Glabella about one-half length of cranidium, strongly convex, slightly expanded anteriorly. Two short pairs of glabellar furrows are laterally impressed on sharply sloping sides of glabella. Occipital ring narrow (sag.), sharply defined. Preglabellar field wide, convexly downsloping to a well defined, narrow, convex border. Slope of anterior area of fixigena becomes steeper laterally until it is vertical below the eyes. Palpebral area of fixigenae flat, upsloping from dorsal furrow to eyes, with eye ridge. Palpebral lobes small, situated opposite center glabellar lobe. Posterior area of fixigena narrow, sharply downsloping, with furrow. Facial suture in front of eye drops vertically or slightly posteriorly to margin. Posterior segment of facial suture sweeps downward and backward to extremity of posterior limb. Cranidium sparsely granulose. No librigenae or pygidium are assigned to this species.

Remarks.—Bowmania sagitta differs from *B. americana* in its triangular cranidium, anteriorly expanded glabella, convex border, elevated eyes, and the course of the anterior segment of the facial suture. This species probably is intermediate between *B. americana* and *Entomaspis radiatus* Ulrich, 1931.

Occurrence.—Common in *Saukiella norivalkensis* subzone at CC-61; LCS-40, 45, 45.4, 45.8, 52; SH-61.5, 65.5.

Genus CLELANDIA Cossmann, 1902
CLELANDIA TEXANA Winston & Nicholls, n. sp.
PL 12, figs. 11,26

Description.—Cranidium small, trapezoidal in outline. Glabella conical, raised high above downsloping fixigenae, with two pairs of laterally impressed, posteriorly directed, glabellar fur-

rows. Occipital furrow broad and deep, bowed forward in center, and bending anteriorly again at lateral extremities. Posterior margin of occipital ring bowed backward, so that the ring is thickest in the center. Axial furrow very shallow. Frontal area horizontal, one-third to one-fifth glabellar length (sag.). Anterior area of fixigena narrow, gently downsloping, crossed by faint eye ridge from the anterior part of the glabella back to the eye region; no palpebral lobe. Posterior area of fixigena stout and downsloping, with broad posterior border furrow. Anterior facial sutures either parallel or slightly convergent in front of the eyes to the anterior corners of the cranidium, where they cut sharply up and over the frontal area of the cephalon to the midpoint. Some cranidia granulose.

Remarks.—This species is distinguished from the other two species of the genus by having two pairs of glabellar furrows. *C. parabola* (Cleland), 1900 has a single pair, and *C. utahensis* Ross, 1951 lacks glabellar furrows. It most closely resembles *C. parabola* in having narrow anterior fixigenae and frontal area.

Occurrence.—Rare in the *Symphysurina* zone at CC-132, 135.

Genus and species undetermined
PL 13, figs. 16,19

Description.—Cranidium low, broadly convex. Glabella bullet-shaped, smooth, defined by shallow axial furrow. Occipital furrow transverse, posterior margin of occipital ring bowed backward. Preglabellar field broad, gently downsloping to border furrow. A raised ridge passes from the pointed anterior of the glabella down to the flat border, where on one specimen (pl. 13, fig. 16) it joins a raised line that runs transversely the distance of the border. Palpebral lobes set distally on wide, gently downsloping fixigenae. Anterior course of facial suture slightly convergent; posterior course strongly divergent producing stout posterior areas. Strong posterior border furrow curves forward from the axial furrow and out.

Remarks.—We know of no described genus into which this unique species with the pointed glabella and anterior ridge belongs. It has some

EXPLANATION OF PLATE 11

FIGS. *1,3—Calvinella procera* Winston and Nicholls, n. sp. *1,* Holotype cranidium, ×2, UT 12584, from LCS-40. *3,* Paratype cranidium, ×1.4, UT 12585, from SH-52.

2,10—Saukiella planata Winston and Nicholls, n. sp. *2,* Holotype cranidium, ×4, UT 12586, from LCS-44. *10,* Paratype cranidium showing faint glabellar furrow, ×2, UT 12587, from LCS-52.

4—Calvinella tenuisculpta Walcott. Cranidium, ×2, UT 12588, from LCS-33.5.

5,9—Calvinella ozarkensis Walcott. *5,* Cranidium, ×1.25, UT 12589, from TC-1400. *9,* Cranidium, ×3, UT 12590, from LCS-45.4.

6–8,12—Saukiella norwalkensis Ulrich and Resser. *6,* Cranidium, ×2.5, UT 12591, from SH-54. *7,* Librigena, ×1.4, UT 12592, from LCS-45. *8,* Cranidium, ×2.25, UT 12593, from TC-1400. *12,* Pygidium, ×2, UT 12594, from LCS-40.

11—Apatokephaloides clivosus Raymond. Cranidium, ×3.25. UT 12595, from LCS-53.

13,14,17,22—Corbinia apopsis Winston and Nicholls, n. sp. *13,* Paratype cranidium, ×2, UT 12596, from LCS-55.5. *14,* Holotype cranidium, ×2, UT 12597, from SS-411. *17,* Paratype pygidium, ×1.2, UT 12598, from SS-411. *22,* Paratype librigena, ×1.25, UT 12599, from SS-411.

15,18—Helerocaryon cf. *H. tuberculatum* Rasetti. *15,* Cranidium, ×3, UT 12600, from TC-1392. *18,* Cranidium, ×4, UT 12601, from TC-1400.

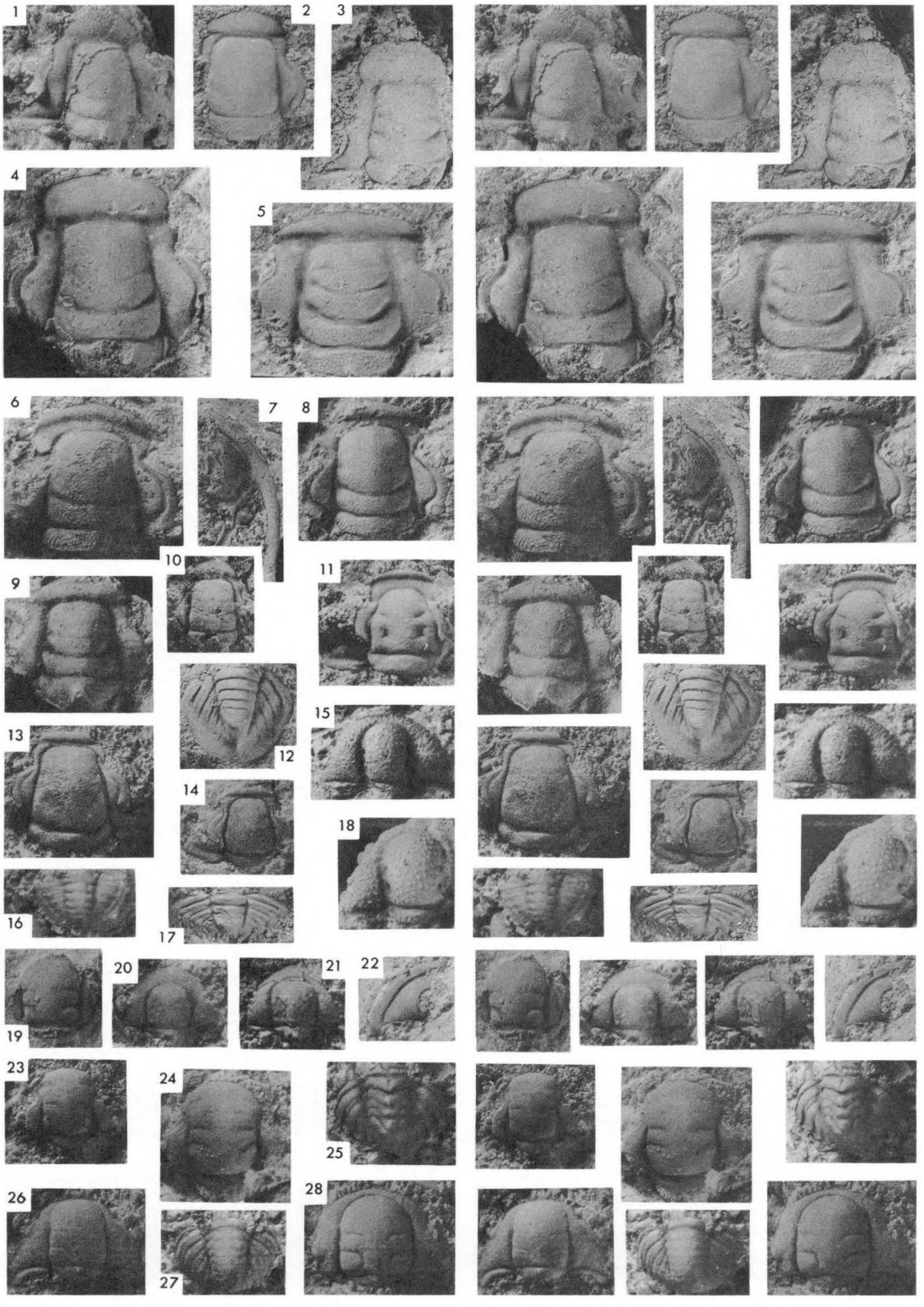
16,20,21—Leiobienvillia leonensis Winston and Nicholls, n. sp. *16,* Paratype pygidium, ×5, UT 12602, from LCS-55.5. *20,* Holotype cranidium, ×5, UT 12603, from LCS-55.5. *21,* Paratype cranidium ×5, UT 12604, from LCS-55.5.

19—Theodenisia brevis (Rasetti). Cranidium, ×4, UT 12605, from SH-54.

23–25—Acheilops masonensis Winston and Nicholls, n. sp. *23,* Holotype cranidium, ×3, UT 12606, from LCS-55.5. *24,* Paratype cranidium, ×4, UT 12607, from LCS-55.5. *25,* Paratype pygidium, ×5, UT 12608, from LCS-55.5.

26—Triarthropsis princelonensis Kobayashi. Cranidium, ×3, UT 12609, from LCS-55.5.

27,28—Triarthropsis nilida Ulrich. *27,* Pygidium, ×5, UT 12610, from LCS-55.5. *28,* Cranidium, ×4, UT 12611, from LCS-55.5.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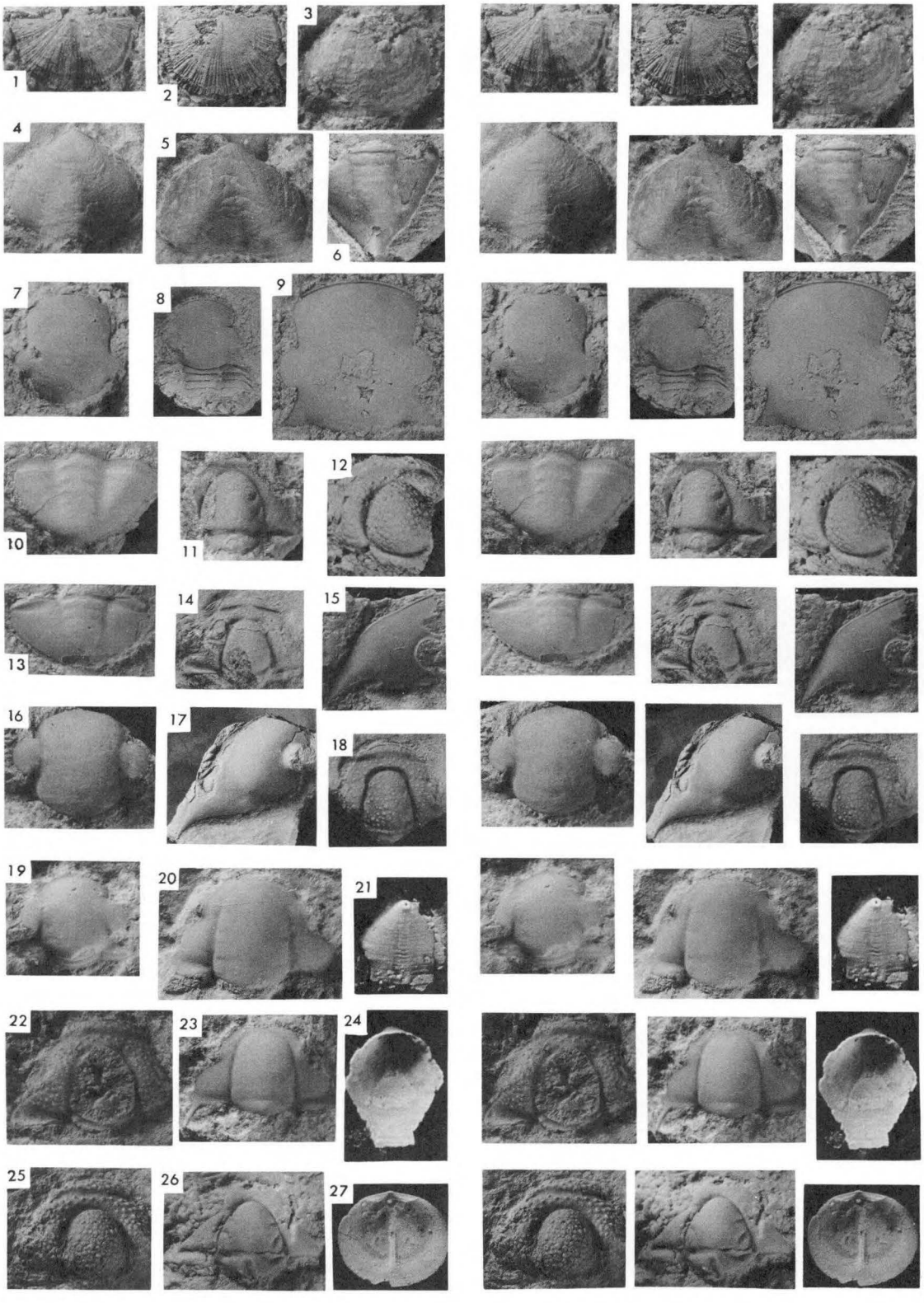
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of the characteristics suggesting *Bathyurellus* (see *Bathyurellus pogonipensis* Hintze, 1952, p. 138, pl. 10, figs. 14,15). It is represented in our collections by only two specimens.

Occurrence.—Rare in the *Missisquoia* zone at CC-93.

Undetermined pygidium I
Pl. 12, fig. 6

Description.—Pygidium triangular in outline, tapering to terminal spine; strongly raised. Axis broad, defined by faint axial furrows that fade posteriorly. Articulating half-ring restricted by broad furrow, but remaining three axial rings and terminal axial piece faintly defined. Pleural regions smooth, slope steeply down to margin.

Remarks.—Although many Lower Ordovician genera have smooth, spined pygidia, this single specimen appears unique in its degree of convexity.

Occurrence.—Rare in the *Missisquoia* zone at RB-8.6.

Undetermined pygidium II
Pl. 13, fig. 17

Description.—Pygidium low and plain; length three-fifths width; axis seven-tenths length. Shallow axial furrow restricts a smooth axis crossed only by the furrow limiting the articulating half-ring. Pleural regions also smooth except for anterior pleural furrows; slope posteriorly, and level out before reaching margin, producing a horizontal posterior shelf. Pygidium complete with articulating facets that extend slightly forward at anterolateral corners.

Remarks.—This type of pygidium is known only from a single specimen. The axis and pleural fields strongly suggest *Bellefontia,* and it even has a faint notch in the posterior margin as does *Bellefontia ibexensis* Hintze, 1952. On the other

EXPLANATION OF PLATE 12

FIGS. *1*—*Finkelnburgia* cf. *F. finkelnburgi* (Walcott). Brachial valve, ×3, UT 12612, from LCS-35.7.

2—*Finkelnburgia* cf. *F. osceola* (Walcott). Brachial valve, ×3, UT 12613, from LCS-35.6.

3—*Glyptotrophia* cf. *G. imbricata* Ulrich and Cooper. Brachial valve, ×2.5, UT 12614, from TC-1411.

4,5—*Syntrophina carinifera* Ulrich and Cooper. *4,* Brachial valve, ×2, UT 12615, from JR-622. *5,* Pedicle valve, ×1.5, UT 12616, from JR-614.

6—Undetermined pygidium I, ×1, UT 12617, from RB-8.6.

7–10,15—*Symphysurina brevispicata* Hintze. *7,* Cranidium with median tubercle, ×2, UT 12618, from CC-142. *8,* Cranidium and four thoracic segments of a nearly complete carapace, ×1.5, UT 12619, from SS-512. *9,* Cranidium, ×1.6, UT 12620, from LCS-148. *10,* Pygidium, ×2, UT 12621, from JR-647. *15,* Librigena, ×2, UT 12622, from LCS-148.

11,26—*Clelandia texana* Winston & Nicholls, n. sp. *11,* Paratype cranidium, ×4, UT 12623, from CC-132. *26,* Holotype cranidium, ×4, UT 12624, from CC-132.

12,22,25—*Hystricurus* cf. *H.* sp. D Ross. *12,* Cranidium, ×3, UT 12625, from CC-142. *22,* Fragmentary cranidium, ×1.7, UT 12626, from CC-142. 25, Fragmentary cranidium, ×2.5, UT 12626, from CC-142.

13,16,17,19—*Symphysurina bubops* Winston & Nicholls, n. sp. *13,* Paratype pygidium, ×1.25, UT 12628, from CC-120. *16,* Holotype cranidium, ×2, UT 12629, from 159T-8-34A. *17,* Paratype librigena with pitted doublure, ×1, UT 12630, from CC-120. *19,* Paratype cranidium and two thoracic segments, ×3, UT 12631, from CC-99.

14,18—*Hystricurus millardensis* Hintze. *14,* Cranidium, ×2, UT 12632, from TC-1449. *18,* Cranidium, ×1.5, UT 12633, from CC-132.

20,23—*Jujuyaspis keideli* Kobayashi. *20,* Cranidium, ×2.5, UT 12634, from SS-496. *23,* Immature cranidium with metafixigenal spine, ×4, UT 12635, from SS-496.

21,24,27—*Conotreta* sp. *21,* Pedicle deltoid pseudointerarea. *24,* Pedicle interior. *27,* Brachial interior. All specimens ×10 and from CC-99.5.

hand, the *pygidium* is longer than the characteristically transverse pygidium of *Beliefontia,* so that generic assignment remains in doubt.

Occurrence.—Rare in the *Missisquoia* zone at SS-429.

Phylum BRACHIOPODA
Class INARTICULATA Huxley, 1869
Order NEOTREMATA Beecher, 1891
Superfamily ACROTRETACEA Schuchert, 1896
Family ACROTRETIDAE Schuchert, 1913
Subfamily ACROTRETINAE Matthew, 1903
Genus CONOTRETA Walcott, 1889

CONOTRETA Sp.
Pl. 12, figs. 21,24,27

Remarks.—This cataconical acrotretoid, having a width in the adult approximating 2 mm and a height of 1.25 mm, agrees in several respects with Cooper's (1956, p. 247) description of *Conotreta.* The foramen is small, essentially apical, but directed somewhat posteriorly (pl. 12, fig. 21). The deltoid pseudointerarea is virtually flat, not otherwise differentiated from the posterior pedicle slope, and the intertrough is in fact slightly convex, parallel sided, and bordered by faint grooves (pl. 12, fig. 21). The pedicle valve internally has a narrow, low, parallel sided apical process that is restricted to the anterior slope, and from which diverge a pair of pallial trunks (pl. 12, fig. 24). The brachial valve has a small but deep median groove that is bordered by small propareas and from which extends anteriorly a narrow median septum (pl. 12, fig. 27).

The obvious differences between this early Ordovician central Texas species and the middle Ordovician species of *Conotreta* illustrated by Cooper (1956, pls. 16 and 17) can in large part be accounted for by differences in thickness of the shell. The pedicle valve of the Texas species is exceptionally thin, so delicate in fact that from the prolific faunule at Calf Creek only rarely do substantially intact valves survive etching and decanting. Because the shell is thin, internal structures are virtually non-existent; there is no vesicular deposit in the apex, no rugged apical process on the anterior slope, no deep muscle scars, and no deeply incised pallial trunks that in large part justify the generic status of *Conotreta* (Cooper, 1956, p. 247).

Until more and better material is obtained, we prefer not to name a new species that may be an important link between *Angulotreta* and *Conotreta,* and that deserves comprehensive treatment.

Occurrence.—Abundant in the *Missisquoia* zone at CC-99.5.

Class ARTICULATA Huxley, 1869
Superfamily ORTHACEA Walcott & Schuchert, 1908
Family BILLINGSELLIDAE Walcott & Schuchert, 1908
Genus APHEOORTHIS Ulrich & Cooper, 1936
APHEOORTHIS ORNATA Ulrich & Cooper
Pl. 13, figs. 21,22,24

Apheoorthis ornata ULRICH & COOPER, 1936, p. 620; 1938, p. 86, pl. 11E, figs. 16–24.

This species is characterized by its broad plications, each with a strong costella on its crest, and by abundant radial fine costellae.

Occurrence.—Rare in the *Corbinia apopsis* subzone at TC-1412.5; abundant in the *Missisquoia* zone at CC-90.5, 93, 120; SS-429, 432, 433; TC-1418, 1421, 1423, 1425, 1426, 1427; rare in the *Symphysurina* zone at JR-622.

Genus NANORTHIS Ulrich & Cooper, 1936
NANORTHIS HAMBURGENSIS (Walcott)
Pl. 13, figs. 25–27

Orthis hamburgensis WALCOTT, 1884, p. 73, pl. 11, fig. 5.
Nanorthis hamburgensis (Walcott), ULRICH & COOPER, 1938, p. 89, pl. 12F, figs. 19–26.

This species is distinguished by its small size (average length about 3 mm), fascicostellate surface, and especially by the fasciculation of the costellae toward the frontal margin. Both valves are convex, the pedicle more so, wider than long, and have their greatest width anterior to the hinge line.

Occurrence.—Common in the *Corbinia apopsis* subzone at CC-67, JR-540, LCS-55.5; SS-413; TC-1412.

Family FINKELNBURGIIDAE Schuchert and Cooper, 1932
Genus FINKELNBURGIA Walcott, 1905

FINKELNBURGIA cf. F. FINKELNBURGI (Walcott)
Pl. 12, fig. 1

Orthis (Finkelnburgia) finkelnburgi WALCOTT, 1905, p. 278.
Finkelnburgia finkelnburgi (Walcott), WALCOTT, 1912, p. 794, pl. 93, figs. 2–2e; ULRICH & COOPER, 1938, p. 137, pl. 24A, figs. 1–5.

Remarks.—Tentative identification has been made from exteriors only, mostly on the basis of their acute cardinal extremities and the deep sulcus on the brachial valve. Walcott mentions that there is considerable variation in the shell dimensions; this is true of the Texas specimens as well. The Texas specimens are more finely costellate than those described by Walcott, and have four or more costellae per mm at the shell margin.

Occurrence.—Rare in the *Saukiella junia* sub-

zone at SH-12.6; TC-1342-1352; common in the *Saukiella norwalkensis* subzone at LCS-35.6, 35.7, 39, 40; SS-383.

FINKELNBURGIA cf. F. OSCEOLA (Walcott)
PL 12, fig. 2

Orthis (Finkelnburgia) osceola WALCOTT, 1905, p. 279. *Finkelnburgia osceola* (Walcott), WALCOTT, 1912, p. 795, pl. 93, figs. 1–1h; ULRICH & COOPER, 1938, p. 140.

Remarks.—This species, like *Finkelnburgia finkelnburgi* is tentatively identified from exteriors only. It differs from *F. finkelnburgi* in having rounded cardinal extremities and a flatter brachial valve. The costellae are finer than those figured by Walcott, and range from three to six per mm at the shell margin.

Occurrence.—Rare in the *Saukiella junia* subzone at CC-27; SS-360.5; common in the *Saukiella norwalkensis* subzone at JR-519; LCS-32, 32.5, 35.6, 52.6; SH-61.5; rare in the *Corbinia apopsis* subzone at CC-69.5; SS-413; TC-1412.

Superfamily SYNTROPHIACEA Schuchert & Cooper, 1931
Family HUENELLIDAE Schuchert & Cooper, 1932
Genus GLYPTOTROPHIA Ulrich & Cooper, 1936
GLYPTOTROPHIA cf. G. IMBRICATA Ulrich & Cooper
Pl. 12, fig. 3

Glyptotrophia imbricata ULRICH & COOPER, 1936, p. 627; 1938, p. 202, pl. 41C, figs. 16–19, 23.

Remarks.—Several fragmentary brachial valves exhibit the strong concentric lamellae, widely spaced and faint radial costellae, and the broad fold characteristic of *G. imbricata*. Specific assignment cannot be made with certainty because of the poor condition of the specimens.

Occurrence.—Rare in the *Corbinia apopsis* subzone at TC-1411.

Genus SYNTROPHINA Ulrich, 1928
SYNTROPHINA CARINIFERA Ulrich & Cooper
PL 12, figs. 4,5

Syntrophina carinifera ULRICH & COOPER, 1938, p. 218, pl. 47F, figs. 16–22; SHAW, 1951, p. 99, pl. 23, figs. 19,20.

Several well preserved ventral valves possess the deep, long sulcus and smooth surface characteristic of this species. There is some doubt concerning the identification of the brachial valve that we have illustrated (pl. 12, fig. 4). Its fold is broadly convex rather than sharply crested and the valve may belong to another species, or genus. The specimen is tentatively assigned to *S. carinifera* until more material, including interiors, are available for comparison.

Occurrence.—Rare in the *Missisquoia* zone at JR-614; LCS-123; SS-485; rare in the *Symphysurina* zone at JR-622.

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(Explanation of Plate 13 appears on the following page)

EXPLANATION OF PLATE 13

FIGS. *1,3,9*—*Missisguoia nasuta* Winston & Nicholls, n. sp. *1,* Paratype cranidium, ×3.5, UT 12639, from TC-1421. *3,* Holotype cranidium, ×4.5, UT 12640, from CC-93. *9,* Paratype cranidium, ×3, UT 12641, from SS-432.

2,5,6,10,12,15,18—*Missisquoia typicalis* Shaw. *2,* Librigena, ×4, UT 12642, from CC-93. 5, Cranidium, ×3, UT 12643, from CC-90. *6,* Cranidium, ×3, UT 12644, from SS-432. *10,* Cranidium, ×3, UT 12645, from CC-93. *12,* Pygidium, ×3, UT 12646, from CC-93. *15,* Pygidium, ×3, UT 12647, from CC-93. *18,* Pygidium, ×3, UT 12648, from CC-93.

4,7—*Missisguoia inflata* Winston & Nicholls, n. sp. *4,* Holotype cranidium, ×4, UT 12649, from CC-93. *7,* Paratype cranidium, ×4, UT 12650, from CC-93.

8,11,13—*Highgatella cordilleri* (Lochman). *8,* Librigena, ×3, UT 12651, from CC-120.*11,* Cranidium, ×2, UT 12652, from JR-597. *13,* Cranidium, ×3, UT 12653, from SS-485.

14—*Parabolinella triarthroides* Harrington. Cranidium, ×2, UT 12654, from SS-422.

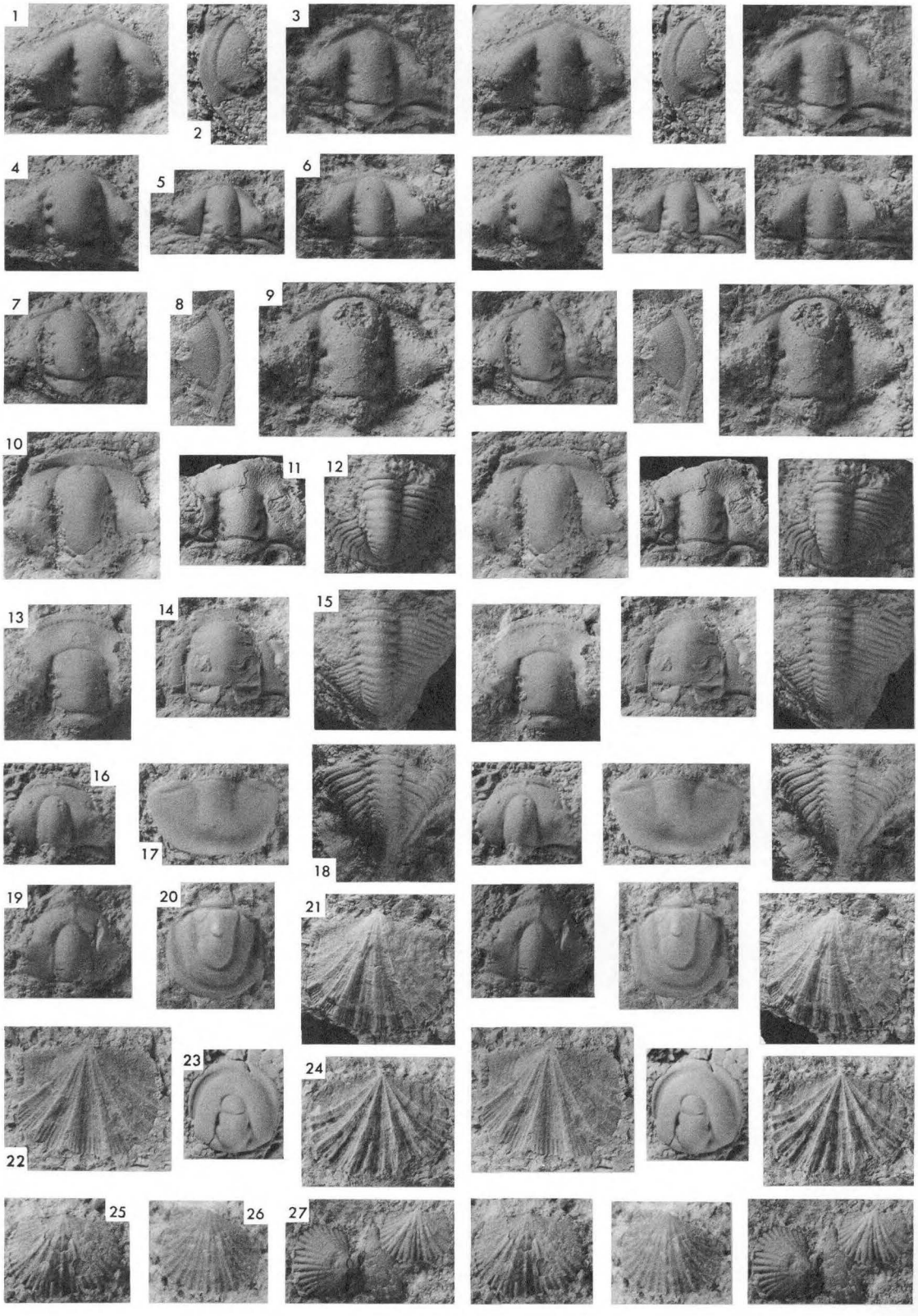
16,19—Genus and species undetermined. *16,* Cranidium, ×3, UT 12655, from CC-93. *19,* Cranidium, ×2.5, UT 12656, from CC-93.

17—Undetermined pygidium II, ×2, UT 12657, from SS-429.

20,23—*Homagnostus reductus* Winston & Nicholls, n. sp. *20,* Paratype pygidium, ×4, UT 12658, from 159T-8-34A. *23,* Holotype cranidium, ×4, UT 12659, from 159T-8-42A.

21,22,24—*Apheoorthis ornata* Ulrich & Cooper. *21,* Pedicle valve, ×2, UT 12660, from TC-1425. *22,* Brachial valve, ×2.75, UT 12661, from TC-1425. *24,* Brachial valve, ×2, UT 12662, from TC-1421.

25–27—*Nanorthis hambergensis* (Walcott). *25,* Brachial valve, ×3, UT 12663, from TC-1412. *26,* Pedicle valve ×3, UT 12664, from TC-1412. *27,* Pedicle (left) and brachial (right) valves, ×3, UT 12665, from TC-1412.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