Glyptagnostus and Associated Trilobites in the United States

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By ALLISON R. PALMER

SHORTER CONTRIBUTIONS TO GENERAL GEOLOGY

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The systematics, faunal associations, and stratigraphic significance of American species of Glyptagnostus *are discussed, and associated trilobites representing 21 genera and 31 species are described and figured*

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SHORTER CONTRIBUTIONS TO GENERAL GEOLOGY

GLYPTAGNOSTUS AND ASSOCIATED TRILOBITES IN THE UNITED STATES

By Allison R. Palmer

ABSTRACT

Glyptagnostus is represented in the United States by two species, *G. reticulatus* (Angelin) and *G. stolidotus* Öpik. The former is further represented by two subspecies, *G. reticulatus reticulatus* (Angelin) and *G. reticulatus angelini* (Resser). The oldest species, *G. stolidotus*, has been found only in association with species of *Cedaria*. The youngest subspecies, *G. reticulatus reticulatus*, is known only in association with *Aphelaspis* and the acrotretid brachiopod *Angulotreta*. *G. reticulatus angelini* occupies an intermediate stratigraphic position in association with aphelaspinid trilobites and the acrotretid brachiopod *Opisthotreta*.

Comparison of faunal successions in the Snake Range and at McGill, Nev., provides strong evidence to show that the beds with *G. reticulatus angelini* and aphelaspinid trilobites are contemporaneous with beds assigned to the *Crepicephalus* zone in central United States. Two biofacies, designated as the Crepicephalid and Pterocephaliid biofacies, are recognized. The contact between beds with trilobites of the Crepicephalid biofacies and younger beds with trilobites of the Pterocephaliid biofacies, previously thought to be the same age over all of the United States, is shown to be measureably older in parts of Nevada and Alabama than it is in central United States. Transgressive replacement of the Crepicephalid biofacies by the Pterocephaliid biofacies is thus indicated during the early Late Cambrian.

Accurate placement of *Glyptagnostus* in the American Cambrian section provides new evidence for correlating these beds, at least down through the *Crepicephalus* zone, with beds no older than the *Olenus* zone of the standard Upper Cambrian section of Sweden.

Trilobites representing 21 genera and 31 species found in association with *Glyptagnostus,* principally in eastern Nevada and central Alabama, are described. New taxa include: *Homagnostus comptus* n. sp., *Aspidagnostus laevis* n. sp., *Aspidagnostus rugosus* n. sp., *Pseudagnostina contracta* n. gen. n. sp., *Carinamala longispina* n. gen. n. sp., *Cedaria brevifrons* n. sp., *Coosia longocula* n. sp., *Komaspidella occidentalis* n. sp., *Deiracephalus unicornis* n. sp., *Aphelaspis brachyphasis* n. sp., *Aphelaspis subditus* n. sp., *Olenaspella regularis* n. sp., *Olenaspella separata* n. sp., *Listroa toxoura* n. gen., n. sp.

INTRODUCTION

Glyptagnostus is a bizarre genus of Upper Cambrian agnostid trilobites with a striking radial and generally also reticulate ornament on the cephalic cheeks and the pleural regions of the pygidium (pl. 2, fig. 1–8, 11). It has been recorded from North America at the following places (fig. 1): British Columbia (Kobayashi, 1938), southwest Texas (Wilson, 1954), western Tennessee (Grohskopf, 1955), central Alabama (Butts, 1926; Resser, 1938), and Newfoundland (Kindle and Whittington, 1959). During the past decade, and particularly during the field seasons of 1958 and 1959, *Glyptagnostus* was collected from the following areas in Nevada (fig. 2): (a) Hot Springs Range; (b) Tybo; (c) Hamilton district; (d) Cherry Creek; (e) McGill. Near McGill and Cherry Creek, fossiliferous sequences including *Glyptagnostus,* from the lower part of the Dunderberg formation, were intensively collected. Data obtained from these collections and from recollection of previously known localities in the Conasauga formation at Woodstock and Cedar Bluff, Ala. (fig. 3) form the principal basis for the conclusions reached in this paper.

Outside North America, *Glyptagnostus* has been reported from the northeastern Siberian platform (Savizky and Lazarenko, 1959) northwestern Siberian platform (Miroshbikov and others, 1959); south Korea (Kobayashi, 1949); southeastern China (Lu, 1956); northeastern Australia (Whitehouse, 1939; Öpik, 1956, 1958, 1961); Tasmania (Banks, 1956); southern Sweden (Angelin, 1854; Westergård, 1922, 1947); southeastern Norway (Brögger, 1882; Strand, 1929; Henningsmoen, 1958); Bornholm (Poulsen, 1923); and Great Britain (Belt, 1867; Lake, 1906). Kobayashi (1949) was impressed by the wide distribution of *Glyptagnostus* and considered all the forms then known to him to represent a single species, *G. reticulatus* (Angelin). He conceived of a "*Glyptagnostus* hemera, the oldest world instant," believing that "because morphic complexity (of *G. reticulatus*) suggests high specialization, homotaxial difference of time may be expected to be slight * * *," and that all occurrences of *Glyptagnostus reticulatus* could therefore be considered contemporaneous.

Recently, Öpik, working with the *Glyptagnostus* faunas of Australia, and the writer, working with American material, have found evidence that seems to require modification of Kobayashi's thesis. Öpik (1958, 1961) has already published some of his observations

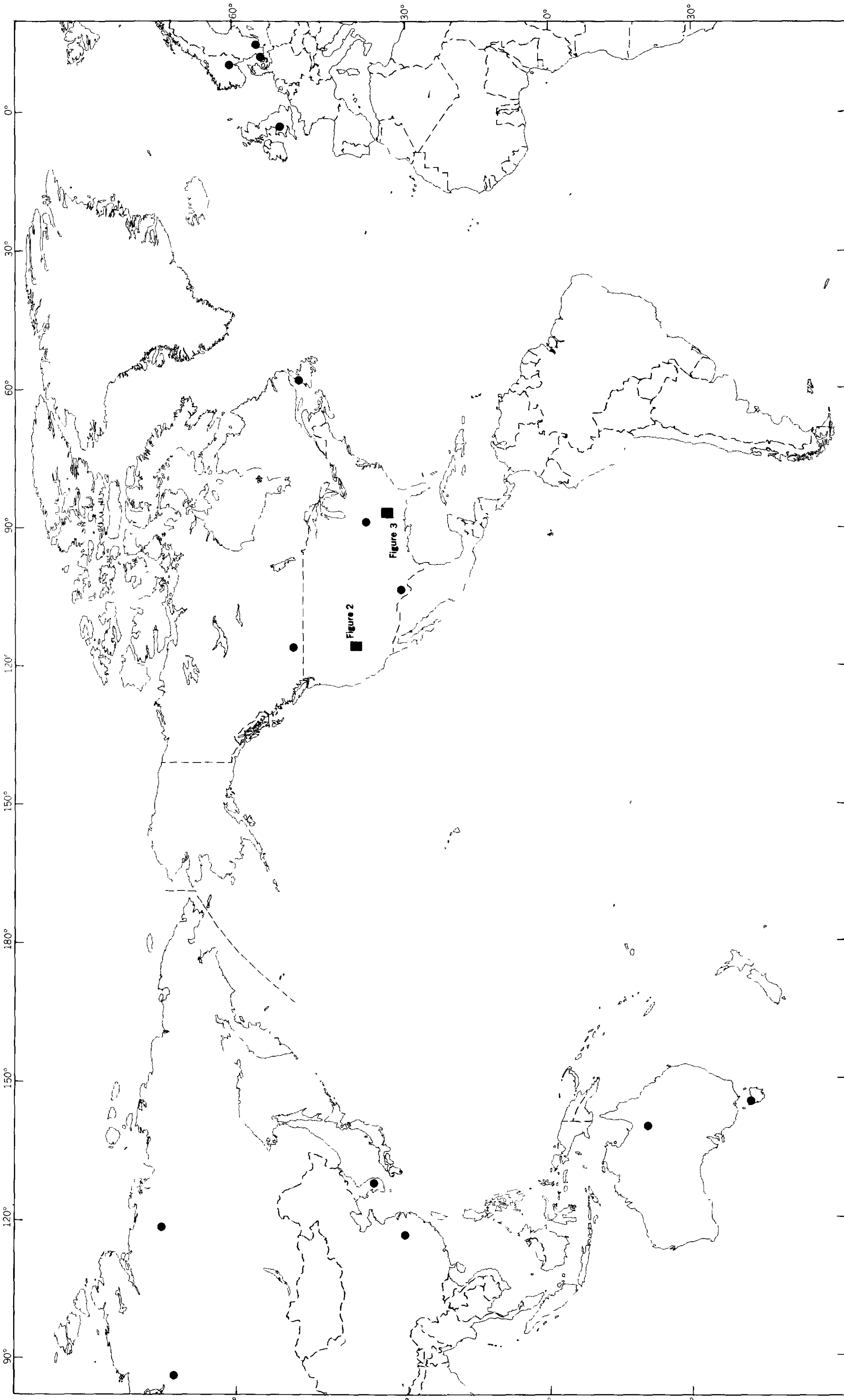

FIGURE 1.—Global occurrences of species of *Glyptagnostus*.

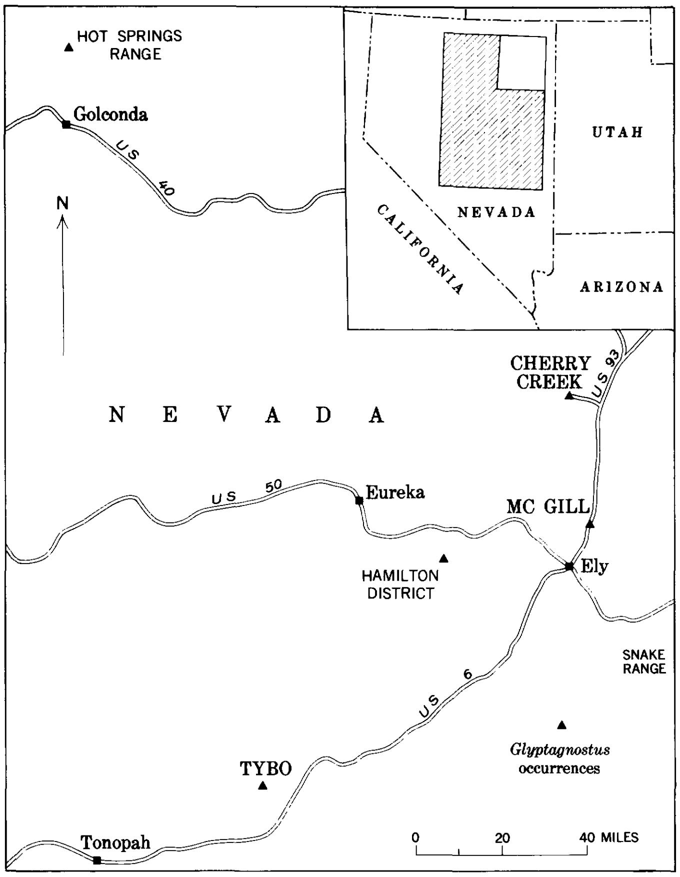

FIGURE 2.—Occurrences of species of *Glyptagnostus* in Nevada.

on the range of *Glyptagnostus*. The purpose of this paper is to examine the systematics and stratigraphic significance of *Glyptagnostus* as developed from all known occurrences of the genus in the United States.

ACKNOWLEDGMENTS

This study includes all collections with *Glyptagnostus* belonging to the U.S. Geological Survey and U.S. National Museum. In addition, Dr. W. C. Bell, University of Texas, loaned all the material of the *Glyptagnostus*-bearing exotic boulder BM–4 (Wilson, 1954) from the Woods Hollow shale, Marathon region, Texas. Dr. Hans Frebold, Geological Survey of Canada, loaned collections of *Glyptagnostus* and associated trilobites described by Kobayashi (1938) from the Brisco-Dogtooth area, British Columbia. Guidance to the *Glyptagnostus*-bearing beds near Cherry Creek and McGill, Nev., was provided in 1958 by J. C. Young, then a graduate student at Princeton University. Correspondence with Dr. A. A. Öpik, Bureau of Mineral Resources, Canberra, Australia, who is working on the *Glyptagnostus*-bearing strata of Australia, has been extremely helpful in the development of some of the systematic and stratigraphic ideas presented in this paper. Most of the photographs on the accompanying plates were prepared by N.W. Shupe and R. H. McKinney, of the U.S. Geological Survey, and photographs of the unusual *Deiracephalus unicornis* n. sp. were made by Jack Scott, of the U.S. National Museum.

TRILOBITES ASSOCIATED WITH *GLYPTAGNOSTUS*

The test of the validity of Kobayashi's thesis of a *Glyptagnostus* hemera lies in the determination of the stratigraphic range and species content of *Glyptagnostus*. All published records indicated to Kobayashi that *Glyptagnostus* was a rare trilobite found in only one fauna in each major area of occurrence (that is, northwestern Europe). All the described specimens, in the absence of large enough assemblages to permit biometric analysis, seemed to represent the same bizarre species. Thus he concluded that *Glyptagnostus* was a monotypic genus with a negligible stratigraphic range—a reasonable conclusion from the available evidence.

Glyptagnostus is found associated with three different nonagnostid trilobite faunas in the United States. Generally, it is associated with only one of these faunas at any particular locality. Two or more *Glyptagnostus*-bearing nonagnostid trilobite faunas are known to occur

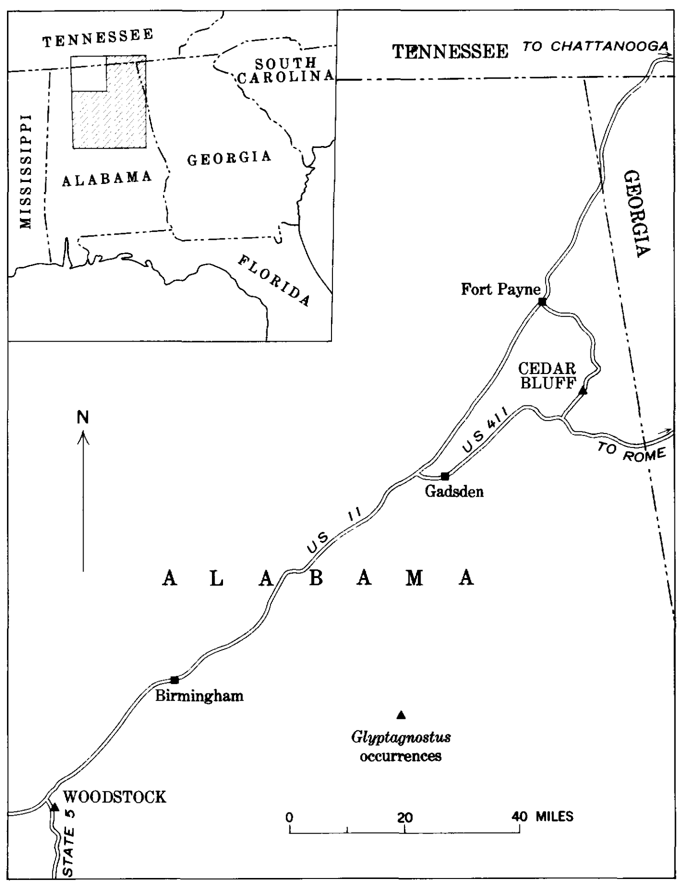

FIGURE 3.—Occurrences of species of *Glyptagnostus* in Alabama.

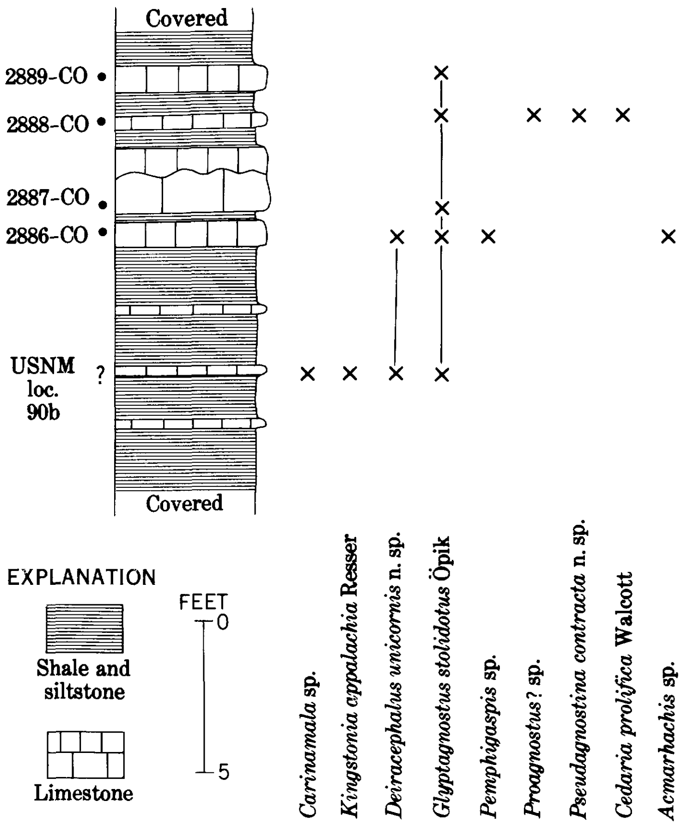

FIGURE 4.—Ranges of identified species of trilobites in *Glyptagnostus*-bearing beds at Woodstock, Ala.

in stratigraphic succession only at McGill, Nev. Successions of fossiliferous beds including part or all of the range of *Glyptagnostus*, however, are known only at Woodstock and Cedar Bluff, Ala., and McGill and Cherry Creek, Nev. The trilobite assemblages and the *Glyptagnostus* population morphology at each of these localities are in the following discussion.

Woodstock, Ala. (fig. 4).—Thirteen feet of dark-brown weathered shale and siltstone of the Conasauga formation, including several thin beds of gray silty fine-grained laminated limestone are exposed in an old railroad cut at the southeast edge of Woodstock. *Glyptagnostus* has been observed in most of the limestone beds although it is common only in colln. 2886–CO, where it is associated with rare specimens of *Deiracephalus unicornis* n. sp. and *Pemphigaspis* sp. The only identifiable trilobites in colln. 2887–CO are specimens of *Glyptagnostus*. Colln. 2888–CO is from a limestone bed about 2 inches thick. The lower, light-colored part contains moderately common specimens of *Cedaria prolifica* (Walcott) and *Pseudagnostina contracta* n. sp. and rare specimens of *Glyptagnostus*. The upper, dark-colored part contains moderately common specimens of *Glyptagnostus* and *Proagnostus* sp. associated with rare specimens of *C. prolifica* and *P. contracta*. A small collection by Charles Butts in 1904 from this railroad cut contains *D. unicornis* and *Glyptagnostus* associated with *Kingstonia appalachia* Resser and anunidentifiable species of *Carinamala* n. gen.

In all the collections, *Glyptagnostus* is represented by cephala and pygidia having a prominent radial ornament but no significant reticulation of the cheeks or pleural fields. The pygidia, in addition, have a broad longitudinally undivided penultimate segment of the posterior part of the axis that is about three times longer than the small triangular terminal segment (fig. 11).

Cedar Bluff, Ala. (fig. 5).—About 40 feet of brown weathered shale of the Conasauga formation containing rare limestone beds 1 inch or less in thickness are exposed in a drainage ditch along the west edge of the

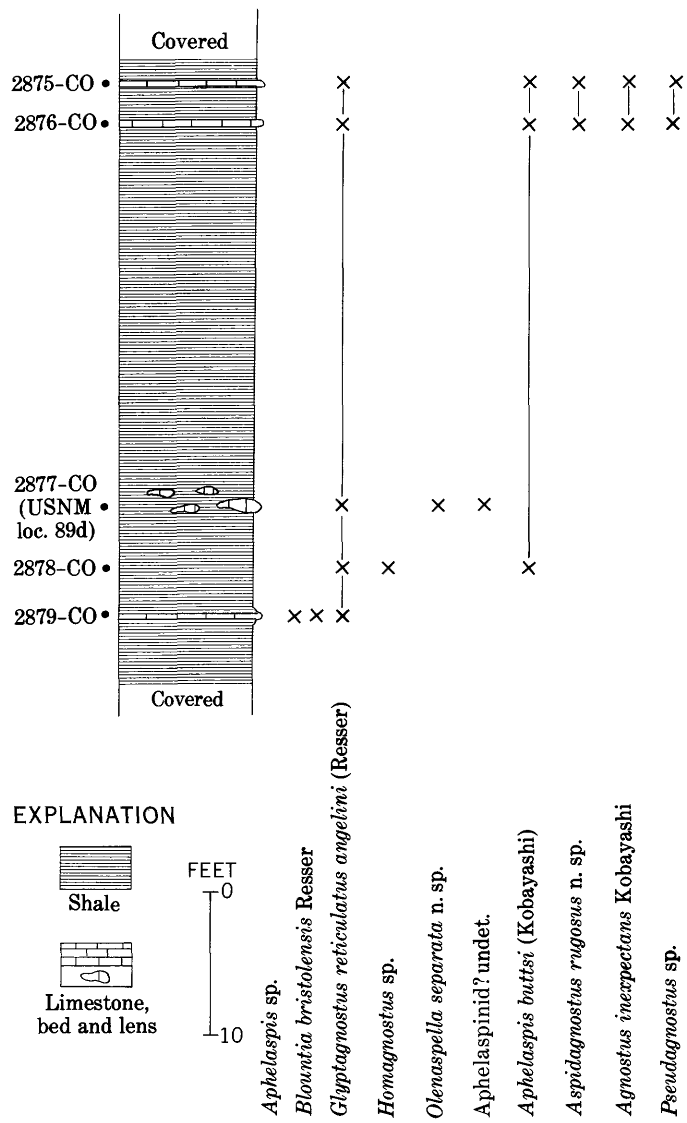

FIGURE 5.—Ranges of identified species of trilobites in *Glyptagnostus*-bearing beds at Cedar Bluff, Ala.

high-school playground 3 blocks east of the old town square in Cedar Bluff. Fossils were recovered from the shale and from layers of silt and clay between layers of calcite fibers perpendicular to the bedding in the rare limestone beds. An extremely fossiliferous lens of medium-crystalline gray limestone was present in the vicinity of colln. 2877–CO. Only one small scrap of this lens was found on the visit to this locality in 1959, but Charles Butts and E. O. Ulrich made a large collection from a lens at this spot in 1920. The specimens of *Glyptagnostus* in their collection were used in the biometric study summarized on figure 11.

In most of the collections from Cedar Bluff, *Glyptagnostus* is associated with *Aphelaspis buttsi* (Kobayashi). In colln. 2879–CO, *Blountia bristolensis* (Resser) and an indeterminate species of *Aphelaspis* are present. The collection made by Butts and Ulrich in the vicinity of 2877–CO contains many specimens of *Olenaspella separata* n. sp., in addition to common specimens of *Glyptagnostus*. *Aspidagnostus rugosus* n. sp., *Agnostus inexpectans* Kobayashi, and *Pseudagnostus communis*? (Hall and Whitfield) are present in collns. 2875–CO and 2876–CO.

Glyptagnostus is represented in all the collections at Cedar Bluff by cephala and pygidia having a prominent reticulate ornament of the cheeks and pleural fields and having the terminal segment of the pygidial axis relatively longer than that of the pygidia at Woodstock, Ala. (fig. 11).

Cherry Creek, Nev. (fig. 6).—About 250 feet of siltstone with interbeds and lenses of gray fine-grained silty generally laminated limestone, mostly less than 3 inches thick characterizes the lower part of the Dunderberg formation along the east side of the Cherry Creek Range about 4 miles north of the town of Cherry Creek. Most of the limestone beds are unfossiliferous. Three limestone beds in the lower 12 feet of the Dunderberg formation contain *Glyptagnostus* and associated trilobites. The trilobite assemblages of all 3 beds are virtually the same and include 8 species of trilobites besides the species of *Glyptagnostus*: *Aspidagnostus rugosus* n. sp., *Agnostus inexpectans* Kobayashi, *Acmarhachis acutus* (Kobayashi), *Aphelaspis subditus* n. sp., *Cheilocephalus* sp., *Listroa toxoura* n. gen., n. sp., *Olenaspella regularis* n. sp., and an undetermined aphelaspinid species. The specimens of *Glyptagnostus* in these three collections are essentially identical in ornament with the specimens at Cedar Bluff, Ala., but have a relatively longer terminal segment on the posterior part of the pygidial axis (fig. 11).

Two collections in the upper 2 feet of a massive limestone unit beneath the Dunderberg formation, here assigned to the Hamburg limestone, contain a totally different trilobite assemblage: *Carinamala longispina* n. sp., *Cedaria brevifrons* n. sp., *Coosia longocula* n. sp., *Komaspidella occidentalis* n. sp. and *Pseudagnostina contracta* n. sp.

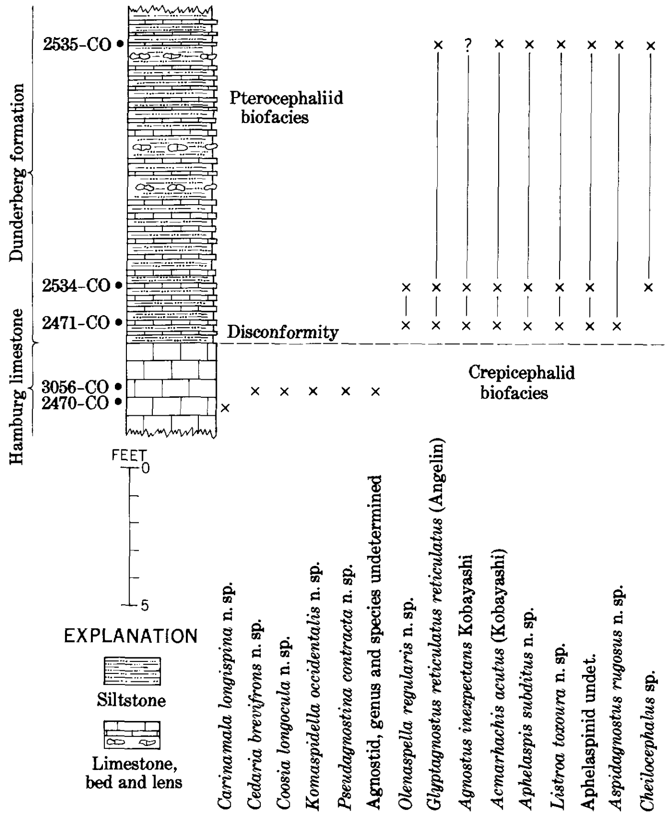

FIGURE 6.—Ranges of identified species of trilobites in *Glyptagnostus*-bearing beds at Cherry Creek, Nev.

McGill, Nev. (fig. 7).—More than 200 feet of siltstone with interbeds and lenses of gray fine-grained silty generally laminated limestone, units of nodular limestone, and a few beds of crinkly limestone characterize the lower part of the Dunderberg formation in a small canyon on the west side of the Duck Creek Range about 1 mile north of McGill. *Glyptagnostus* and associated trilobites have been collected from 19 beds or lenses of the gray fine-grained limestone in the lower 40 feet of the Dunderberg formation at this locality. Most of the collections come from the interval of rock between 27 and 40 feet above the base of the formation. Except for colln. 2476–CO, from 6 inches above the base of the formation, the trilobite assemblages are characterized by *Aphelaspis brachyphasis* n. sp., *Olenaspella separata* n. sp., *Agnostus inexpectans* Kobayashi, and *Homagnostus comptus* n. sp. Colln. 2476–CO contains *Aphelaspis buttsi* (Kobayashi) and the long-ranging species *Agnostus inexpectans* Kobayashi. In two collns. (3049–CO, 3051–CO) a rare additional species, *Aspidagnostus rugosus* n. sp. is present.

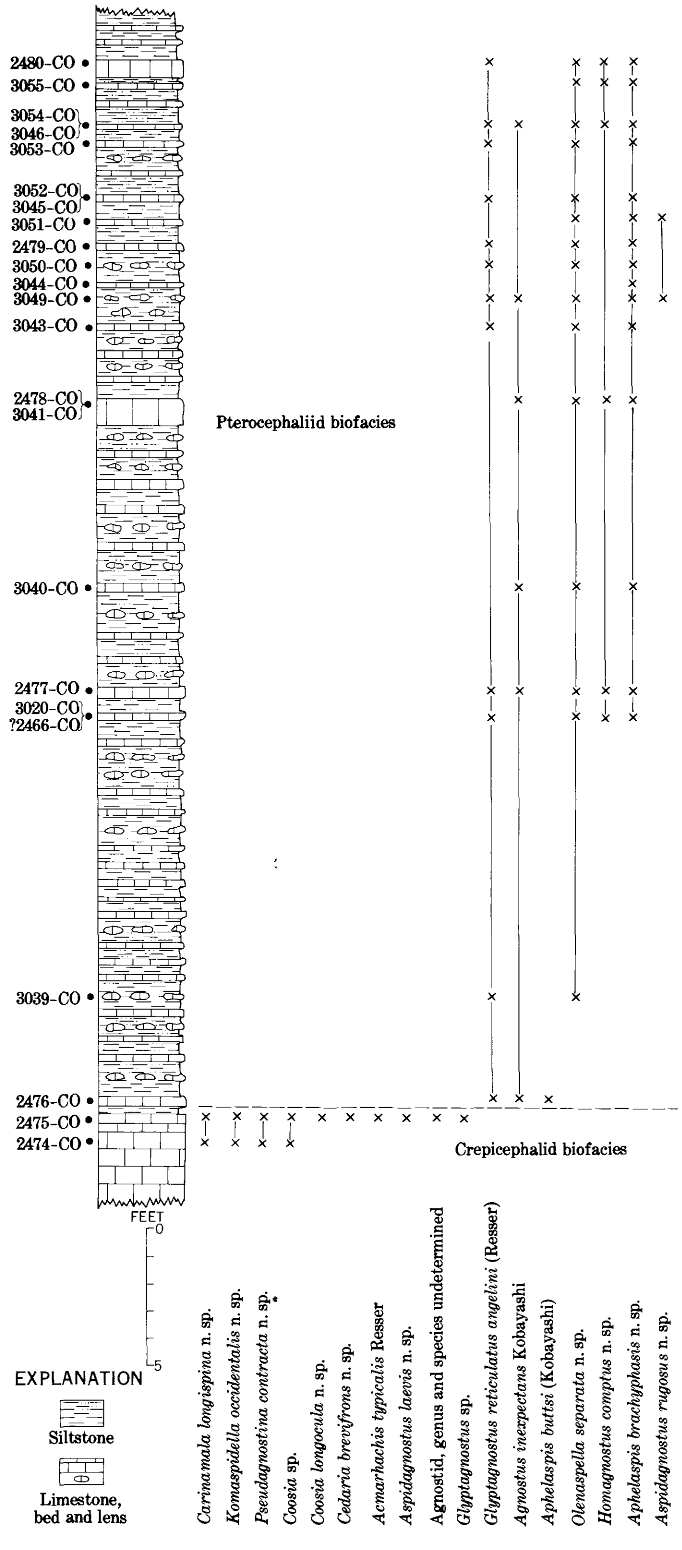

FIGURE 7.—Ranges of identified species of trilobites in *Glyptagnostus*-bearing beds at McGill, Nev.

The specimens of *Glyptagnostus* in all the collections are principally like those at Cedar Bluff, Ala.

The uppermost foot of the massive limestone unit beneath the Dunderberg formation, here assigned to the Hamburg limestone as at Cherry Creek, has yielded two collections containing an assemblage of nonagnostid trilobites totally unrelated to the assemblage in the lower part of the Dunderberg formation, but virtually the same as that in the uppermost beds of the massive limestone unit below the Dunderberg formation at Cherry Creek. These collections yielded: *Carinamala longispina* n. sp., *Coosia longocula* n. sp., *Cedaria brevifrons* n. sp., and *Komaspidella occidentalis* n. sp. The associated agnostid trilobites are: *Acmarhachis typicalis* Resser, *Pseudagnostina contracta* n. sp., *Aspidagnostus laevis* n. sp., and *Glyptagnostus* sp. Only *Aspidagnostus*, represented by a different species, and *Glyptagnostus*, represented only by a scrap of part of one shield, are related to trilobites in the immediately overlying beds of the Dunderberg formation.

Limestones 3 feet above the highest collection with *Glyptagnostus* at McGill have mainly the same trilobite assemblages as the underlying beds, but are apparently without specimens of *Glyptagnostus* and have, in addition, numerous specimens of *Glaphyraspis*.

STRATIGRAPHIC SIGNIFICANCE OF *GLYPTAGNOSTUS*

The classic early Late Cambrian trilobite zonation in the United States begins with the *Cedaria* zone, which is followed successively upward by the *Crepicephalus* and *Aphelaspis* zones. These three zones, in a general way, are recognizable from the central Appalachians westward to the eastern Great Basin. Throughout this region, except for the upper Mississippi Valley where a small hiatus seems to be present (Palmer, 1954, p. 713), the *Cedaria* fauna evolves upward into the *Crepicephalus* fauna. The *Crepicephalus* and *Aphelaspis* faunas are almost completely unrelated, however, even though in many areas a bed bearing an *Aphelaspis* fauna can be found in contact with a subjacent bed bearing a *Crepicephalus* fauna. At two places in central Texas there is a mixing of the two faunas in the basal foot of the *Aphelaspis* zone (Palmer 1954, p. 733), but this is not an evolutionary gradation. Thoughout most of the interior of the United States, the contact between the two faunas has appeared to be nearly a plane of contemporaneity and has been used for precise regional correlation. In order to evaluate the stratigraphic significance of *Glyptagnostus*, the stratigraphic paleontology of the sections containing this genus must be reviewed.

The summary in the preceding section has shown that *Glyptagnostus* is associated with several different trilobite assemblages, and furthermore that several different popualtions of *Glyptagnostus* are recognizable. The section at McGill, Nev., provides evidence to show that the different trilobite assemblages with *Glyptagnostus* are most likely also of different ages and that the population differences within *Glyptagnostus* can thus be resolved into a progressive evolutionary change in ornament and in structure of the axis of the pygidium.

Collections from the limestones immediately below the Dunderberg formation at McGill have five genera, *Glyptagnostus, Cedaria, Carinamala, Deiracephalus,* and *Pseudagnostina,* in common with *Glyptagnostus*-bearing collections from Woodstock, Ala. *Cedaria brevifrons* n. sp. at McGill belongs to the same species group as *C. prolifica* Walcott from Woodstock; the *Carinamala* specimen from Woodstock and the *Glyptagnostus* specimen from McGill are not well enough preserved for specific identification or comparison; the specimens of *Deiracephalus* at both localities, although differing slightly, have a remarkable axial spine on the back of the glabella—a unique feature among Cambrian trilobites; the specimens of *Pseudagnostina* are indistinguishable between the two localities. Insoluble residues of limestones at both localities yield representatives of the acrotretid brachiopod *Opisthotreta* (Palmer, 1954, p. 771).

Collections from the lower 40 feet of the Dunderberg formation at McGill have five genera, *Glyptagnostus, Aphelaspis, Olenaspella, Agnostus,* and *Aspidagnostus* in common with *Glyptagnostus*-bearing collections from Cedar Bluff, Ala. The agnostid genera and *Aphelaspis* are represented at both localities by indistinguishable specimens. Specimens from McGill assigned to *Olenaspella* have only 1 or 2 pairs of marginal pygidial spines while those from Cedar Bluff have 1, 2, or 3 pairs of marginal pygidial spines. Although much more variation is shown in development of the marginal pygidial spines on specimens of the same size at Cedar Bluff than is shown by specimens at McGill, the 1- and 2-spined forms at the 2 localities are not distinguishable and the populations are considered here to represent the same variable species. Insoluble residues of limestones from the two localities contain representatives of the acrotretid brachiopod *Opisthotreta.*

About 40 feet above the highest *Glyptagnostus*-bearing collection at McGill, several collections contain *Olenaspella regularis* n. sp., *Listroa toxoura* n. sp., and abundant representatives of the acrotretid brachiopod *Angulotreta* (Palmer, 1954, p. 769). This association is also present, with *Glyptagnostus,* in the lowest beds of the Dunderberg formation at Cherry Creek, Nev.

There is no doubt that the sequence of faunas at McGill represents a succession in time. According to present methods of correlation, trilobite assemblages from other areas that have species in common with those in parts of the McGill section are most likely comtemporaneous with those parts of the McGill section. Therefore, a succession of *Glyptagnostus* populations of differing age can be determined.

On the basis of the information just presented, the oldest American population of *Glyptagnostus* presently known is from Woodstock, Ala. Colln. 2886–CO contains enough specimens to allow statistical comparison of the length of segments b_2 and b_3 on the axis of the pygidium by means of a regression. Similar regressions for these characters were calculated for specimens from USNM loc. 89d at Cedar Bluff, Ala. and colln. 2476–CO from McGill, Nev., representing

TABLE 1.—*Summary of morphology, faunal associations, stratigraphic range, and correlation of* Glyptagnostus *species in the United States*

Species, morphology, and biofacies occurrence	Subspecies	Regional distribution				Standard Upper Cambrian trilobite zones
		Nevada	Texas	Tennessee	Alabama	
G. reticulatus, reticulate; length $b_3 > \frac{1}{2}$ length b_2— pterocephalid.	*reticulatus* with *Olenaspella regularis* or *Angulotreta* sp.	Cherry Creek, Tybo, Hamilton district, Hot Springs Range.	Marathon region.	Henderson Markham No.1 well, Lake County.		*Aphelaspis* zone.
	angelini with *Olenaspella separata* or *Opisthotreta* sp.	McGill			Cedar Bluff	*Crepicephalus* zone.
G. stolidotus, primarily radial; length $b_3 < \frac{1}{2}$ length b_2—crephicephalid with *Cedaria* spp.		McGill?			Woodstock	*Cedaria* zone.

populations from about the middle of the American range of the genus, and collns. 2471–CO and 2534–CO from Cherry Creek, Nev., representing the youngest populations of the genus. The results are shown on figure 11. They indicate a progressive lengthening of b_3 from the oldest to the youngest populations. The oldest populations are ornamented almost entirely by radial furrows (pl. 2, figs. 2, 5); populations of intermediate age have considerable intrapopulation variation in development of a reticulate ornament (pl. 2, fig. 4); specimens in the youngest populations are always strongly reticulated (pl. 2, figs. 1, 3). The systematic significance of these observations is discussed on page F–18.

One species and two subspecies of *Glyptagnostus* are recognized here: the oldest populations are assigned to *G. stolidotus* Öpik; the intermediate and youngest populations are assigned to *G. reticulatus angelini* (Resser) and *G. reticulatus reticulatus* (Angelin), respectively. By using the ratio of b_2 to b_3 and the degree of development of the ornament on specimens of *Glyptagnostus* from stratigraphically unplaced collections, together with the composition of the associated trilobite and brachiopod faunas, each of the *Glyptagnostus* samples from the United States has been assigned a position within the range of the genus on table 1.

An important development of the study of *Glyptagnostus* has been evidence for a much more complex biofacies problem in the Cambrian than was previously thought to exist. This has a direct bearing on the stratigraphic range of *Glyptagnostus* and on general concepts of faunal zonation within the Cambrian.

At first glance, the range of the genus would appear to be from the *Cedaria* zone to the *Aphelaspis* zone of the standard early Upper Cambrian faunal succession (Howell and others, 1944) because the oldest population of *Glyptagnostus* is associated with the type species of *Cedaria* at Woodstock, Ala., and the youngest population is associated with *Aphelaspis* and *Angulotreta* at Cherry Creek, Nev. However, the section at McGill, Nev., provides evidence to indicate that such appearances might be misleading.

A major faunal break involving nearly complete change of trilobites at the family level has been recognized for years between the early Upper Cambrian *Crepicephalus* zone and the overlying *Aphelaspis* zone (Lochman and Wilson, 1958, p. 332). In contrast, the work of Lochman and Duncan (1944) and the writer (Palmer, 1954) has shown that there is only a gradual evolutionary change from the faunas generally assigned to the older *Cedaria* zone to those generally assigned to the overlying *Crepicephalus* zone.

At McGill, Nev., a bed with *Cedaria* and *Carinamala* is present immediately below a bed with *Aphelaspis* and

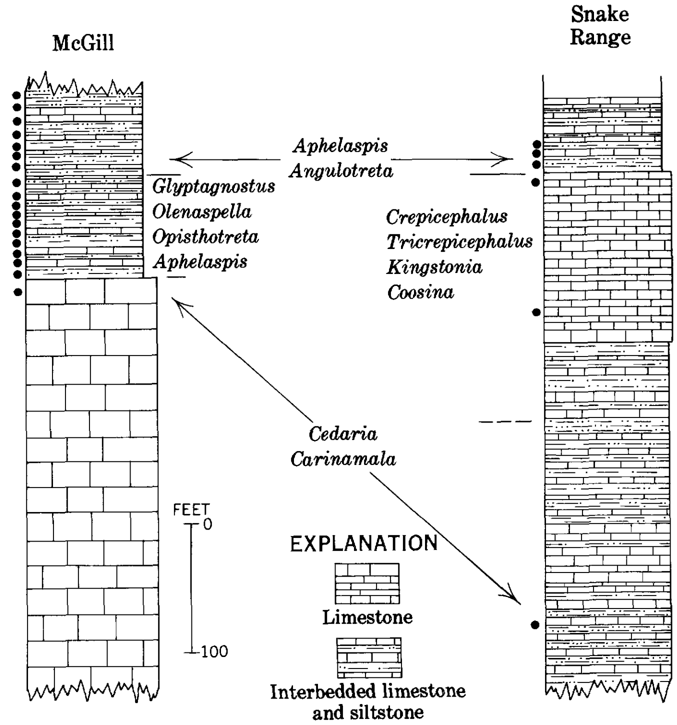

FIGURE 8.—Correlation of faunal sequences in parts of early Upper Cambrian sections at McGill and the Snake Range, Nev.

Glyptagnostus (fig. 8). The first reaction to this relation would be to suspect the presence of a disconformity because there is no interval for trilobites assignable to the *Crepicephalus* zone. This reaction would be strengthened by a casual examination of the section in the Snake Range, Nev., 50 miles to the southeast (fig. 2), where collections made in 1959 show that *Cedaria* and *Carinamala* are found in beds about 350 feet below the contact between the *Crepicephalus* and *Aphelaspis* zone faunas. This contact is approximately at the top of unit 16 of the Lincoln Peak formation (Drewes and Palmer, 1957, p. 118). The upper beds of unit 16 contain a fauna consisting of *Crepicephalus* sp., *Tricrepicephalus*, and *Crepicephalus*? *perplexus* Palmer. In the immediately overlying beds, the fauna is completely changed and includes *Aphelaspis haguei* (Hall and Whitfield), *Cheilocephalus* sp., *Glaphyraspis* sp., and *Angulotreta* sp.

Comparison of the basal *Aphelaspis* zone assemblage from the Snake Range with the section at McGill, however, shows that this assemblage correlates not with the lowest *Aphelaspis*-bearing beds but with an assemblage in beds above those with *Aphelaspis brachyphasis* n. sp., *Aphelaspis buttsi* (Kobayashi), *Glyptagnostus reticulatus angelini* Resser, *Olenaspella separata* n. sp., and *Opisthotreta*. Thus, the older *Aphelaspis*-bearing beds at McGill must correlate in part with beds bearing a totally different trilobite fauna assignable to the *Crepicephalus* zone (s. l.) in the Snake Range. The only alternative would be to require disconformities at McGill and in the Snake Range, for which there is no positive faunal or physical evidence. With regard to the Snake Range, faunal relationships between the *Aphelaspis* and *Crepicephalus* zones are essentially identical to those in central Texas (Palmer, 1954, p. 715), where this abrupt change in faunas is clearly unrelated to significant changes in sedimentation.

The indicated correlation between McGill and the Snake Range is supported by the brachiopod sequence at McGill. The contact between beds with *Opisthotreta* and overlying beds with *Angulotreta* in the midcontinent region corresponds approximately to the contact between the *Crepicephalus* and *Aphelaspis* zones (Palmer, 1954), whereas at McGill the contact between the *Opisthotreta* and *Angulotreta*-bearing beds lies between the *Aphelaspis*-*Glyptagnostus* sequence and younger beds with aphelaspinid trilobites.

The necessary conclusion is that the major trilobite faunal break present in all known early Upper Cambrian sections below the lowest *Aphelaspis*-bearing beds is not everywhere of the same age and represents in most areas a biofacies change in response to still unknown changes in ecology. Because the beds below the change in biofacies generally have representatives of the Crepicephalidae and because all the beds immediately above the biofacies change have representatives of the Pterocephaliidae, these two primary biofacies are here designated as the Crepicephalid and Pterocephaliid biofacies.

The oldest presently known beds containing the Pterocephaliid biofacies are found at McGill, Nev., and Cedar Bluff, Ala., in early Late Cambrian deposits far from the continental core. The youngest beds containing the Crepicephalid biofacies are found in the interior region. This fact indicates that the change from Crepicephalid to Pterocephaliid biofacies began near the continental margins and moved shoreward. Older beds containing trilobites of the Pterocephaliid biofacies may thus be found when early Late Cambrian beds still farther from the continental core are examined.

The age of the youngest assemblage of the Crepicephalid biofacies at McGill, Nev., presents another problem. Besides species of *Cedaria* and *Carinamala*, it contains *Coosia longocula* n. sp. and *Komaspidella occidentalis* n. sp.—species closely related to *Coosia connata* (Walcott) and *Komaspidella thea* (Walcott) from the lower beds of the *Crepicephalus* zone at its type area in Wisconsin. At Woodstock, Ala., *Cedaria* and *Carinamala* are associated with *Pemphigaspis*, a genus generally found only in beds correlative with the *Crepicephalus* zone (s. l.) in the upper Mississippi Valley and Texas (Palmer, 1951, 1954). A *Cedaria* species was reported from Murphy Creek, Quebec, on the same bedding surface as a *Crepicephalus* species by Kindle (1948, p. 449). Through the kindness of Dr. Kindle, the writer had the opportunity to examine collections from boulders in the Cow Head conglomerate of Newfoundland containing *Cedaria gaspensis* Rasetti in association with a species of *Crepicephalus*. Because *Cedaria gaspensis* is closely related to *C. prolifica* Walcott from Woodstock, Ala., and to *C. brevifrons* n. sp. from the highest beds of the Crepicephalid biofacies at McGill and Cherry Creek, Nev., evidence is accumulating which indicates that members of the *C. prolifica* species group (p. F–26) occur in beds that correlate with the *Crepicephalus* zone rather than the *Cedaria* zone as these zones are recognized in the midcontinent region of the United States. Thus, the unit occupied by *Glyptagnostus* in the American Cambrian section would seem to correspond principally to the *Crepicephalus* zone (s. l.) of the standard early Upper Cambrian faunal succession, with possible extension upward into beds that correlate with the lower part of the *Aphelaspis* zone (table 1).

The range of *Glyptagnostus* shown on figure 12 of Lochman and Wilson (1958) is based on a misidentification by the writer (Palmer) of a fragment of a wrinkled agnostid in the *Elvinia* zone of the Eureka district, Nevada, and the writer's belief, in 1957, that the structurally and stratigraphically isolated *Glyptagnostus*-bearing beds in the Hot Springs Range, Nev.—the only western *Glyptagnostus* locality then known—were younger than the *Aphelaspis* zone.

Determination of the proper position of *Glyptagnostus* in the American early Upper Cambrian now provides a more precise correlation of beds of this age with beds in the standard section of Sweden (fig. 9). *Glyptagnostus reticulatus reticulatus*, the youngest subspecies of the genus in the American section, occurs in beds equivalent in age to the *Aphelaspis* zone. In Sweden (Westergård, 1947, p. 22), *G. reticulatus reticulatus* occurs in the lowest two subzones of the *Olenus* zone, indicating that the base of the *Olenus* zone corresponds approximately to the *Aphelaspis* zone. The older American subspecies, *G. reticulatus angelini* is associated with *Agnostus inexpectans* and *Homagnostus comptus* in beds equivalent in age to the *Crepicephalus* zone. This assemblage of agnostid genera is certainly of Late Cambrian age in terms of the standard section, and it is probable that American beds with these trilobites correlate approximately with the *Agnostus pisiformis* zone in Sweden.

The precise correlation of American beds equivalent to the *Cedaria* zone with beds in the Swedish section cannot yet be satisfactorily determined. *Clavagnostus*, found in the late Middle Cambrian of Sweden, has been

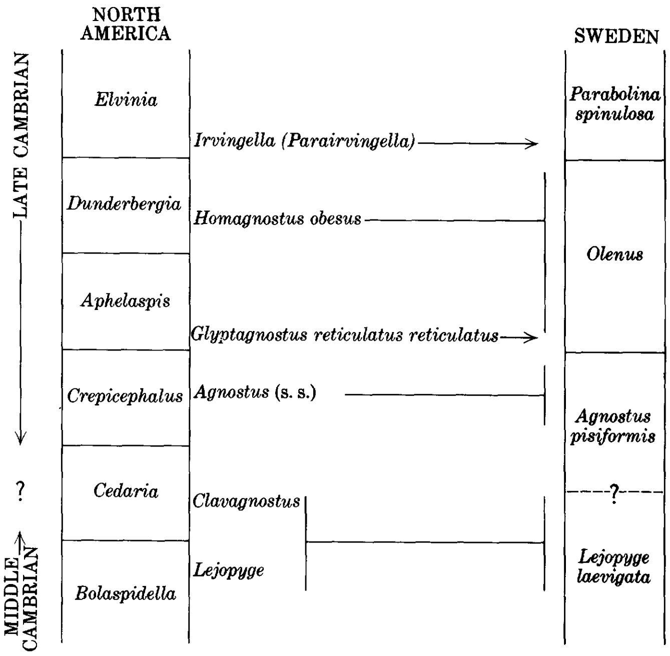

FIGURE 9.—Correlation of lower parts of Upper Cambrian faunal successions between North America and Sweden.

observed in association with *Cedaria* in both Eastern and Western United States. However, recent discovery of *Lejopyge* in quantity in association with American late Middle Cambrian species of *Bolaspidella* and *Modocia* indicates that perhaps the generally accepted Middle-Upper Cambrian boundaries of Sweden and North America are approximately equivalent.

Lochman (1956, p. 447) placed the entire American sequence of beds of Dresbach age in the Middle Cambrian and correlated it with beds older than *Agnostus pisiformis* in the Scandinavian section. No direct evidence was given to support this correlation, and it is now apparent that it was in error. Lochman and Wilson (1958) placed all beds of Dresbach age in the Upper Cambrian, and no mention was made of the earlier correlation.

Lochman and Wilson (1958, p. 333) also lowered the top of the Dresbachian stage and placed it at the "pronounced faunal break at the base of the *Aphelaspis* faunizone * * *" Because this pronounced faunal break has been shown here to be of measurably different ages at different places, it is not suitable for a boundary between temporally defined units, and revision of the Dresbach stage from its generally accepted usage on this basis does not seem to be warranted.

ECOLOGIC OBSERVATIONS

Comparison of the McGill and Cherry Creek sections (fig. 10) indicates the definite presence of an unconformity between the Dunderberg and Hamburg formations in the Cherry Creek section. In both areas the contact between beds bearing trilobites of the Crepicephalid and Pterocephaliid biofacies is also the contact between the relatively thickbedded clean limestone of the Hamburg limestone, and the silty limestone and siltstone of the overlying Dunderberg formation. Pterocephaliid trilobite species and acrotretid brachiopods like those found in the basal beds of the Dunderberg formation at Cherry Creek, however, occur about 80 feet above the base of the Dunderberg formation at McGill, and the Pterocephaliid trilobite species found in the lower part of the Dunderberg formation at McGill are missing at Cherry Creek. There is no clear evidence for a significant unconformity at the base of the Dunderberg formation at McGill, although its absence cannot be entirely ruled out.

The faunal characteristics of the upper beds of the Hamburg limestone at McGill and Cherry Creek indicate that the unconformity at Cherry Creek may have resulted from local nondeposition rather than from any significant pre-*Aphelaspis* erosion. The topmost beds in both areas contain *Cedaria brevifrons, Carinamala longispina, Coosia longocula, Komaspidella occidentalis,* and *Pseudagnostina convergens*. A few feet below these beds is another fauna characterized by a species closely related to *Kingstonia spicata* Lochman. If there had been any significant erosion prior to the deposition of the *Aphelaspis*-bearing beds, the identity of the species assemblages in the uppermost beds of the Hamburg limestone would seem to be a remarkable coincidence. Regional stratigraphic evidence indicates that a belt of relatively clean carbonate sedimentation represented

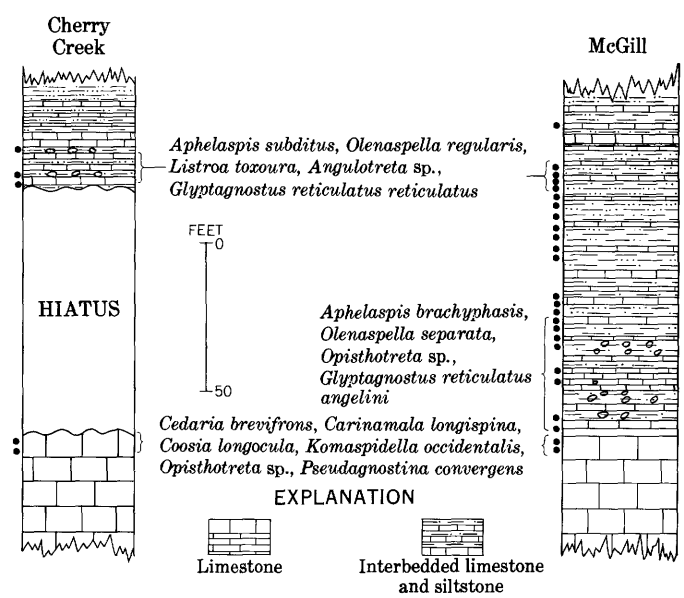

FIGURE 10.—Stratigraphic relations of the Dunderberg and Hamburg formations between McGill and Cherry Creek, Nev.

by the Hamburg was replaced by a belt of predominantly silty sedimentation which moved generally eastward across the carbonate belt for a brief period during the early Upper Cambrian (Palmer, 1960b, p. 53). If cessation of carbonate sedimentation resulted from external changes in a continuing marine enviroment, then subsequent significant erosion of the upper surface of the carbonate deposits would not be expected. The differences in age of the initial deposits of the succeeding environment of silt sedimentation could thus be related to difference in time of burial of topographic irregularities on the upper surface of the carbonate sediments.

The fact that *Glyptagnostus reticulatus*, represented by different subspecies, is abundant only in the lowermost silty limestone beds of the Dunderberg at both McGill and Cherry Creek indicates that its habitat may have been controlled by some ecologic factor related to the silty substrate adjacent to the seaward edge of the belt of clean carbonate sedimentation.

CONCLUSION

Glyptagnostus has been shown on the preceding pages to be represented in the United States by two species, *G. stolidotus* Öpik and *G. reticulatus* (Angelin), with the latter species divided into two subspecies, *G. reticulatus angelini* Resser and *G. reticulatus reticulatus* (Angelin). *G. stolidotus* is the oldest, known only in association with trilobites of the Crepicephalid biofacies. *G. reticulatus angelini* is the next younger, occurring in association with trilobites of the Pterocephaliid biofacies and the acrotretid brachiopod *Opisthotreta* in beds that are contemporaneous with those bearing the *Crepicephalus* fauna of the interior United States. *G. reticulatus reticulatus* is the youngest, occurring in association with different pterocephalid trilobites than *G. reticulatus angelini* and with the acrotretid brachiopod *Angulotreta* in beds that are correlated with the *Aphelaspis* zone of the standard early Upper Cambrian faunal succession. *Glyptagnostus* seems to have required a more restricted environment, or a different environment for optimum development than the associated nonagnostid trilobites because it occurs in silty sediments bearing other trilobites of either the Crepicephalid or Pterocephaliid biofacies and is most common in silty rocks near their contact with relatively clean carbonate rocks. The same two species of *Glyptagnostus* appear in the same stratigraphic order associated with trilobites of the Crepicephalid and Pterocephaliid biofacies in Australia (Öpik, written communication, 1959) and perhaps also in northern Siberia (Savizky and Lazarenko, 1959, p. 189–192).

Although the "*Glyptagnostus*-hemera" of Kobayashi may have been an oversimplification, as *Glyptagnostus* is now shown to have a significant stratigraphic range and is no longer monotypic, the genus and its species still constitute the most precise tools presently available for intercontinental correlation of early Upper Cambrian deposits.

SYSTEMATIC PALEONTOLOGY

The descriptive terms used here are defined or illustrated on pages 42, 44, 46, and 47 of Part O "Arthropoda 1" in Treatiseon Invertebrate Paleontology, (Harrington and others, 1959) or in the glossary on pages 117 to 126 of the same volume.

Diagnoses and descriptions are given here for all taxa that are revised or described as new, or for which only incomplete published information is available. Assignments to family or subfamily without comment indicate acceptance of the assignments given in the Treatise.

Order AGNOSTIDA McCoy
Suborder AGNOSTINA McCoy

Family AGNOSTIDAE McCoy

Diagnosis.—Agnostid trilobites with cephalon having glabella tapered forward, frontal lobe generally differentiated; median node present, generally poorly defined. Basal lobes simple. Preglabellar median furrow present or absent. Border generally well defined.

Pygidium with axis subparallel sided, strongly rounded posteriorly, generally greater than one-half length of pygidium; divided into two generally well defined anterior segments and an unsegmented posterior part. Postaxial median furrow absent. Median axial node continuous across first and second axial segments on many species. One pair of marginal spines generally present.

Discussion.—Two distinct types of agnostids are commonly found in assemblages of Upper Cambrian trilobites. One type, with axis of the pygidium bearing an expanded pseudolobe represents the Pseudagnostidæ (p. F–18). The second type, with the axis of the pygidium subparallel sided, rounded at the rear, and generally not reaching the border furrow is considered here to represent the Agnostidæ. Three genera of this family, *Agnostus*, *Homagnostus*, and *Proagnostus* are associated with *Glyptagnostus*.

Homagnostus was at one time considered by the writer as a synonym of *Geragnostus* (Palmer, 1954, 1955), but it was later reinstated and included in a subfamily Geragnostinæ (Palmer, 1960a). Although *Geragnostus* seems to be the Ordovician descendant of *Homagnostus*, it is also apparent from examination of species of *Homagnostus* and *Agnostus* that these genera are closely related. Both stratigraphic and morphologic factors favor a closer relationship of *Homagnostus* to *Agnostus* than to *Geragnostus*, and such a classification is followed here.

There is a great need for critical reevaluat on of the constitution of the families of agnostid trilobites as can be shown by comparison of the family groupings used in this paper and those presented in the most recent classification of agnostids (Howell, 1959).

The Agnostidæ as defined by Howell (1959, p. 172), although including *Agnostus* and *Homagnostus*, includes at least two genera, *Acmarhachis* and *Aspidagnostus*, that are shown here to be morphologically dissimilar and probably unrelated to *Agnostus*.

Genus AGNOSTUS Brongniart

Agnostus Brongniart, 1822, p. 38. Kobayashi, 1939, p. 159. Westergård, 1946, p. 68, 84.

Type species.—*Entomolithus paradoxus pisiformis* Linneaus, 1757 (p. 122).

Diagnosis.—Agnostidae with frontal lobe of glabella bluntly rounded anteriorly. Preglabellar median furrow complete. Axis of pygidium slightly tapered to slightly expanded posteriorly; posterior end always sharply rounded. Pleural fields confluent behind axis.

Discussion.—This genus is restricted to agnostids conforming to the diagnosis given above, which is principally the meaning given to it by Kobayashi (1939). Westergård (1947, p. 4) included *Homagnostus* as a subgenus in *Agnostus*. However, species of *Homagnostus* consistently have an incomplete preglabellar median furrow on the cephalon, and a more bluntly rounded and generally broader axis on the pygidium. These differences are considered to be of generic value (Palmer, 1960a, p. 62).

Agnostus inexpectans Kobayashi

Plate 1, figures 1-11

Agnostus inexpectans Kobayashi, 1938, p. 172, pl. 16, figs. 30—33.

Diagnosis.—Members of *Agnostus* with cephalon having anterior third of posterior glabellar lobe bearing deep notches in sides. Pygidium with first two axial segments well defined. Axis constricted at second segment. First axial segment trilobed. Second axial segment crossed lengthwise by axial node that continues posteriorly onto posterior part of axis.

Discussion.—The Nevada specimens of *A. inexpectans* have been compared with Kobayashi's illustrated specimens from British Columbia and are identical in all observable features. This species is most similar to *Agnostus neglectus* Westergård (1946, p. 85, pl. 13, figs. 7-9) from the late Middle Cambrianof Sweden in having a constricted second segment on the axis of the pygidium, and relatively strong development of the lateral furrows on the posterior lobe of the glabella. It differs from *A. neglectus* by the notched character of the lateral furrows of the posterior glabellar lobe, and by the more strongly defined axial node on the axis of the pygidium.

Occasional specimens with a particularly bluntly rounded anterior glabellar lobe have a suggestion of a median notch in the front margin of this lobe.

Occurrence: Conasauga formation: USGS collns. 2875-CO (5 cephala), 2876-CO (4 cephala, 4 pygidia), Cedar Bluff, Ala. Lower part of Dunderberg formation: USGS collns. 2466-CO (12 cephala, 16 pygidia), 2476-CO (1 cephalon, 3 pygidia), 2477-CO (1 cephalon, 1 pygidium), 3040-CO (1 cephalon, 1 pygidium), 3041-CO (2 cephala, 6 pygidia), 3046-CO (2 pygidia), 3049-CO (1 cephalon, 1 pygidium), McGill, Nev.; USGS collns. 2471-CO (3 cephala, 3 pygidia), 2534-CO (4 cephala, 5 pygidia), 2535-CO (?1 cephalon), Cherry Creek, Nev. Unnamed formation, USGS colln. 1370-CO (2 cephala, 1 pygidium), Hot Springs Range, Nev. Woods Hollow shale: Boulder BM-4 (2 cephala), Marathon region, Texas.

Figured specimens:

USNM no.	*USGS colln.*	*Part*
143122a	2534-CO	Cephalon.
143122b	2534-CO	Pygidium.
143123	2875-CO	Cephalon.
143124	2876-CO	Pygidium.
143125a, b	2466-CO	Cephala.
143125c-e	2466-CO	Pygidia.

Genus HOMAGNOSTUS Howell

Homagnostus Howell, 1935, p. 15. Kobayashi, 1939, p. 162. Whitehouse, 1939, p. 261. Shimer and Shrock, 1944, p. 600. Lochman and Duncan, 1944, p. 139. Shaw, 1951, p. 110. Palmer, 1960a, p. 62.

Oncagnostus Whitehouse, 1936, p. 84.

Geragnostus Palmer, 1954, p. 719; 1955, p. 88 (*G. tumidosus* only).

Type species.—*Agnostus pisiformis obesus* Belt, 1867 (p. 295, pl. 12, fig. 4).

Diagnosis.—Cephalon with well-defined bilobed glabella and distinct border. Preglabellar median furrow, if present, incomplete, generally deepest near glabella and fading out before reaching border furrow.

Pygidium with prominent well-defined axis generally broader than pleural regions. Posterior part of axis generally parallel sided or expanded slightly, well defined posteriorly, reaches nearly to border furrow.

Discussion.—Relations of tnis genus to *Agnostus* and *Geragnostus* are discussed in the recent papei on the Dunderberg fauna (Palmer, 1960a, p. 62).

Homagnostus comptus n. sp.

Plate 1, figures 12-15

Diagnosis.—Members of *Homagnostus* with preglabellar median furrow short, present only adjacent to frontal lobe of glabella. Pygidium with first pair of lateral furrows straight, not connected across axis; first segment not trilobate. Axial node prominent, extended from second axial segment onto anterior part of posterior part of axis. Combined length of first two axial segments less than length of posterior part of axis. Surfaces of all parts of exoskeleton covered with fine granules or roughened.

Discussion.—The distinctive fine granular ornament, which can only be observed after coating specimens lightly with magnesium oxide or ammonium chloride, and a somewhat better developed preglabellar median furrow are the only features that distinguish this species from *H. tumidosus* (Hall and Whitfield). The lack of a trilobate first axial segment on the pygidium and the distinctive ornament distinguish this species from all known foreign species.

Occurrence: Lower part of Dunderberg formation: USGS collns. 2466–CO (>20 cephala and pygidia), 2477–CO (3 cephala), 2478–CO (1 pygidium), 2480–CO (1 pygidium), 3020–CO (1 cephalon, 2 pygidia), 3054–CO (1 cephalon, 1 pygidium); 3055–CO (2 cephala), McGill, Nev.

Figured specimens:

USNM	*USGS colln.*	*Part*
143126	2466–CO	Holotype cephalon.
143127a, c	2466–CO	Pygidia.
143127b	2466–CO	Cephalon.

Homagnostus sp.

Plate 1, figure 16

Discussion.—Rare specimens of a species of *Homagnostus* are associated with abundant specimens of *Glyptagnostus reticulatus* and *Aphelaspis buttsi* in shale in USGS colln. 2878–CO, Cedar Bluff, Ala. The cephalon has the preglabellar median furrow developed for about half the distance from the front of the glabella to the border furrow. The pygidium has the distance from the end of the axis to the border furrow only slightly less than the breadth of the border. Because of the small size of the specimens and imperfect shale preservation, accurate specific identification of these specimens cannot be made.

Occurrence: Conasauga formation, USGS colln. 2878–CO (1 complete individual, 1 cephalon), Cedar Bluff, Ala.

Figured specimen: USNM 143128, USGS colln. 2878–CO, complete individual.

Genus PROAGNOSTUS Butts

Proagnostus, Shimer and Shrock, 1944, p. 601.

Type species.—*Proagnostus bulbus* Butts, 1926, pl. 9, fig. 12.

Diagnosis.—Agnostidae with glabella bilobed, preglabellar median furrow present, median glabellar node on anterior part of posterior glabellar lobe.

Pygidium with axis subparallel sided, broadly rounded at rear, reaches to or nearly to border furrow. Median axial node present on second axial segment. Pair of marginal spines present.

Description.—Agnostidae with cephalon moderately convex transversely, gently to moderately convex longitudinally; border well defined by broad moderately deep border furrow. Glabella well defined by axial furrows, bilobed; anterior lobe strongly rounded at front; first glabellar furrow complete; posterior lobe with low elongate median node on anterior part. Basal glabellar lobes well defined, triangular, undivided. Cheeks divided in front of glabella by complete moderately deep preglabellar median furrow.

Pygidium moderately convex transversely, gently to moderately convex longitudinally, border well defined by broad moderately deep border furrow; posterolateral marginal spines present. Axis well defined by axial furrows, subparallel sided, broadly rounded posteriorly, reaches to or nearly to marginal furrow. Median axial node elongate, located on second axial segment, extended slightly posteriorly onto posterior part of axis. Transverse furrow between first and second axial segments generally complete. If present, transverse furrow between second axial segment and posterior part of axial lobe interrupted by axial node.

Discussion.—Although the name *Proagnostus* was first used in a plate description by Butts (1926, pl. 9), the only published description of the genus is in Shimer and Shrock (1944, p. 601). This genus differs from *Homagnostus*, with which it has been considered a synonym by Kobayashi (1939, p. 163) and Howell (1959, p. 173), by having a complete preglabellar median furrow on the cephalon, the median glabellar node on the anterior rather than posterior part of the posterior glabellar lobe, and the axial node on the pygidium not extended forward onto the first axial segment.

Of the five species assigned to *Proagnostus* by Resser (1938, p. 48) only the type species, *P. bulbus* Butts is here retained. Lochman and Duncan (1944, p. 138) placed *P. centerensis* Resser and *P. maryvillensis* Resser, which lack a preglabellar median furrow, in the new genus *Baltagnostus*. *P. romensis* Resser is represented only by a pygidium that lacks transverse furrows on the axis and is probably a species of *Kormagnostus*. *P. major* Resser is represented by badly worn internal molds of cephala and pygidia that cannot be satisfactorily identified, and the name should be restricted to the types. The cephala seem to lack a preglabellar median furrow, and the species is thus not properly referable to *Proagnostus*. Lochman (1940, p. 24) noted correctly that *Kormagnostus speciosus* Resser, which has cephala with a well-defined frontal glabellar lobe and complete preglabellar median furrow associated with the figured pygidium, is a species of *Proagnostus* and not of *Kormagnostus*. *Proagnostus modestus* described by Lochman (1944, p. 77) may belong to this genus, but the pygidia, which have the critical generic features, are all meraspid forms, so that confirmation of the generic assignment must await description of holaspid pygidia.

Proagnostus? sp.

Plate 1, figure 17–19, 23

Numerous cephala and pygidia associated with *Glyptagnostus reticulatus* at Woodstock, Ala., represent a species that may belong to *Proagnostus*. For some undetermined reason the matrix adheres to the cheek areas of both cephala and pygidia, so that presence of a complete preglabellar median furrow, and for most specimens, length of the axis, cannot be certainly determined. Several specimens show a furrow beginning to extend forward from the axial furrow in front of the glabella. One specimen (pl. 1, fig. 19) shows that the axis of the pygidium does not quite reach to the border furrow; however, on most specimens the posterior end of the axis is not defined by the axial furrow. The prominent elongate axial nodes on the cephalon and pygidium and the fact that the axis does not reach the border furrow on the pygidium distinguish these specimens from *Proagnostus bulbus* Butts. The latter feature also distinguishes the specimens from *P. speciosus* (Resser). Until better specimens showing presence or absence of a complete preglabellar median furrow are obtained, the generic assignment must remain tentative.

Occurrence: Conasauga formation, USGS colln. 2888–CO (8 cephala, 23 pygidia), Woodstock, Ala.

Figure specimens:

USNM	*USGS colln.*	*Part*
143129a, b	2888–CO	Cephala.
143129c, d	2888–CO	Pygidia.

Agnostid, genus and species undetermined

Plate 1, figures 31–33

Pygidia possibly related to those identified here as *Proagnostus*? sp. are present in USGS collns. 2475–CO and 3056–CO in Nevada. They have the axis defined only at the sides and have a long, slender median axial node. The poor definition of the first two segments of the axis serves to distinguish these pygidia from the Alabama specimens. Except for the presence of posterolateral marginal spines, the Nevada pygidia are similar to those of *Ciceragnostus cicer* (Tullberg) illustrated by Westergard (1946, pl. 14, figs. 4, 6, 8, 9). Cephala possibly belonging with the Nevada pygidia in USGS colln 3056–CO have a well-defined glabella that lacks a transverse furrow outlining the anterior glabellar lobe. The cheeks are confluent in front of the glabella. If the cephalon-pygidium association in Nevada is correct, then these agnostids do not have the characteristics presently considered diagnostic of either *Proagnostus* or *Ciceragnostus*, and they probably should be placed in a new genus. Inadequacy of the present samples and uncertainty about association of parts do not warrant doing so at this time.

Occurrence: Upper beds of Hamburg limestone: USGS collns. 2475–CO (2 pygidia), McGill, Nev.; 3056–CO (3 cephala, 1 pygidium), Cherry Creek, Nev.

Figured specimens:

USNM	*USGS colln.*	*Part*
143137a	3056–CO	Cephalon.
143137b	3056–CO	Pygidium.
143138	2475–CO	Pygidium.

Family CLAVAGNOSTIDAE Howell

Diagnosis.—Agnostid trilobites with cephalon having glabella well defined by axial furrows, pointed anteriorly, reaching about two-thirds length of cephalon. Anterior glabellar lobe not outlined by transverse glabellar furrow. Basal glabellar lobes present, simple. Preglabellar median furrow present, complete. Border narrow, well defined by border furrow.

Pygidium with axis long, slender; sides of anterior part subparallel; posterior part tapered to sharp point at border furrow. Posterior third of axis distinctly depressed below anterior part of axis. Pair of pits usually present immediately adjacent to anterior end of depressed part of axis. Border well defined by border furrow, bears pair of posterolateral marginal spines. Median marginal spine present or absent.

Discussion.—Howell (1959, p. 173) considered the Clavagnostidae to be a monotypic family. Öpik (written communication, July 1959), however, noted the association of the cephalon of *Aspidagnostus parmatus* Whitehouse, type species of *Aspidagnostus*, which is like that of *Clavagnostus*, with a pygidium having an axis also like that of *Clavagnostus* but bearing a median spine unlike any *Clavagnostus* species. Similar cephalon-pygidium relationships have been found in both Alabama and Nevada. It now appears probable that these are the correct cephalon and pygidium for *Aspidagnostus* rather than the association illustrated by Whitehouse (1936, pl. 9, figs. 5, 6) and that the genus belongs in the same family as *Clavagnostus*, rather than in the Agnostidae where it has been placed previously (Howell, 1959, p. 173).

Genus ASPIDAGNOSTUS Whitehouse

Aspidagnostus Whitehouse, 1936, p. 104. Howell, 1959, p. 173. (Cephalon only.)

Type species.—*Aspidagnostus parmatus* Whitehouse, 1936, p. 105, pl. 9, fig. 5 only.

Diagnosis.—Clavagnostidae with cephalon having slight median point on anterior margin. Pygidium with border interrupted by deep groove extending from end of axis onto prominent median marginal spine. Low knobs on border adjacent to groove.

Discussion.—This striking agnostid genus with its posteriorly tapered pygidial axis and median marginal spine is unlike any other known agnostid genus. Because of its occurrence only in beds of middle Dresbach age and its distribution from Australia to North America, this genus, in association with *Glyptagnostus*, is particularly critical for accurate intercontinental correlation. Species are discriminated principally on ornament. Two species are recognized in the American collections: *A. laevis* n. sp., associated with *Cedaria*; and a younger species, *A. rugosus* n. sp., associated with aphelaspinid trilobites.

Aspidagnostus laevis n. sp.

Plate 1, figures 20–22

Diagnosis.—Members of *Aspidagnostus* with cheeks of cephalon and pleural fields of pygidium smooth. Glabella with large basal lobes that nearly touch behind posterior glabellar lobe. Pygidium with median node on axis poorly defined; transverse furrows behind first axial segment curved forward to isolate anterolateral axial lobes.

Discussion.—This species differs from *A. rugosus* n. sp. and *A. parmatus* Whitehouse by lacking either furrows or pits on the cheeks of the cephalon and the pleural fields of the pygidium. It differs further from *A. rugosus* by having distinct anterolateral axial lobes and a less well defined median axial node on the pygidium.

Occurrence: Upper beds of the Hamburg limestone, USGS coll. 2475–CO (3 cephala, 1 pygidium), McGill, Nevada.

Figured specimens:

USNM	*USGS colln.*	*Part*
143130	2475–CO	Holotype cephalon.
143131a	2475–CO	Pygidium.
143131b	2475–CO	Cephalon.

Aspidagnostus rugosus n. sp.

Plate 1, figures 24–30

Diagnosis.—Members of *Aspidagnostus* with cheeks of cephalon having several broad, shallow radially directed furrows. Pygidium with median axial node elongate, moderately well defined; pleural fields with several shallow depressions.

Discussion.—This species differs from *A. parmatus* Whitehouse by having furrows rather than pits on the cheeks of the cephalon and by having a somewhat shorter and broader glabella. It differs from both *A. parmatus* and *A. laevis* n. sp. by lacking distinct anterolateral lobes on the axis of the pygidium. The median axial node on the pygidium is better defined for a greater distance than the median axial node of *A. laevis*.

Two immature silicified pygidia with slightly irregular pleural fields are present in USGS coll. 2466–CO, McGill, Nev. Although they have a median marginal spine, they lack the groove across the border characteristic of other *Aspidagnostus* species (pl. 1, fig. 24). This may be an immature feature, however, and the specimens are tentatively included in *A. rugosus*.

Occurrence: Conasauga formation: USGS coll. 2875–CO (1 cephalon), 2876–CO (7 cephala, 16 pygidia), Cedar Bluff, Ala. Lower 12 ft. of Dunderberg formation: USGS coll. 2471–CO (1 cephalon, 3 pygidia), 2535–CO (1 pygidium), Cherry Creek, Nev. Lower part of Dunderberg formation: USGS coll. 2466–CO (2 pygidia), 3049–CO (1 pygidium), 3051–CO (1 cephalon), McGill, Nev.

Figured specimens:

USNM	*USGS colln.*	*Part*
143132	2466–CO	Pygidium.
143133	3049–CO	Holotype pygidium.
143134a	2471–CO	Cephalon.
143134b	2471–CO	Pygidium.
143135	2535–CO	Pygidium.
143136a	2875–CO	Cephalon.
143136b	2875–CO	Pygidium.

Family GLYPTAGNOSTIDAE Kobayashi

Genus GLYPTAGNOSTUS Whitehouse

Glyptagnostus Whitehouse, 1936, p. 101. Kobayashi, 1939, p. 155. Shimer and Shrock, 1944, p. 600. Kobayashi, 1949, p. 1–6. Öpik, 1961, p. 428.

Type species.—*Glyptagnostus toreuma* Whitehouse, (1936, p. 102, pl. 9, figs. 17–20) =*Agnostus reticulatus* Angelin, 1851 (p. 8, pl. 6, fig. 10).

Diagnosis.—Agnostid trilobites with cephalon having bilobed glabella; frontal lobe subquadrate in outline. Basal lobes elongate, divided. Narrow border present. Pygidium with posteriorly tapered axis connected to border furrow by postaxial median furrow. Posterior part of axis divided into three parts. Narrow border with pair of short marginal spines present. Cheeks and pleural fields of cephalon and pygidium with prominent ornament of radial furrows of several ranks, often connected by cross furrows to form reticulate pattern.

Description.—Cephalon with glabella bilobed; anterior lobe well defined, subquadrate; posterior lobe generally higher than anterior lobe, without distinct median node. Preglabellar median furrow present, complete, but with irregular course. Basal glabellar lobes elongate, divided by transverse furrow into slender anterior part and triangular posterior part. Border narrow, well defined by border furrow.

Pygidium with axis long, tapered to point posteriorly, connected to border furrow by postaxial median furrow. Axial node prominent, elongate, extends entire length of first two axial segments and continues onto anterior part of posterior part of axis. Furrows defining first two axial segments deep, extended inward from axial furrows to axial node. Furrows between first and second segment directed slightly forward from axial furrow. Posterior part of axis divided into three parts (b_1, b_2, b_3, fig. 11); b_2 outlined anteriorly by shallow furrows extending posterolaterally from near tip of axial node to axial furrows, and posteriorly by deep transverse furrow; generally longer (sagittal) than either b_1 or b_3. Sides of posterior part of axis marked by longitudinal row of four or more pits adjacent to axial furrows. Border well defined by border furrow, bears pair of short marginal spines.

Cheeks of cephalon and pygidium highly ornamented with furrows. Cephalon with kidney-shaped lobes always present adjacent to anterior glabellar lobe. Other furrows on cheek radiate inward from border furrow. Radiating furrows of several lengths in definite pattern; longest furrows extend inward nearly to axial furrows; generally between each pair of long furrows is shorter furrow extending inward about half breadth of cheek; between this furrow and each long furrow is still shorter furrow; margin of cheek between each of these furrows may be notched.

Pygidium ornamented with similar pattern of radiating furrows of several ranks extending inward from border furrow.

Younger species of genus with cross furrows connecting basic pattern of radial furrows thus producing reticulate ornament. Details of ornament not perfectly symmetrical on individuals and variable within populations.

Discussion.—This genus appears to be most closely related to the Middle Cambrian genus *Ptychagnostus*. Species of both genera have a preglabellar and postaxial median furrow, divided basal glabellar lobes, and a posteriorly tapered pygidial axis. A similar radial ornament is developed on the cephalon of many species in the subgenus *Ptychagnostus* (*Ptychagnostus*). (See Westergård, 1946, pl. 11, 12.) The principal distinguishing features at the genus level are that species of *Ptychagnostus* nearly always have a subtriangular anterior glabellar lobe, the radial ornament is not developed on the pygidium, the kidney-shaped areas adjacent to the anterior glabellar lobe are not developed, and the posterior part of the axis of the pygidium is not subdivided.

Glyptagnostus has been placed most recently in the Hastagnostidae (Howell, 1959, p. 178). However, the posteriorly tapered pygidial axis of *Glyptagnostus* and the postaxial median furrow are gross differences from *Hastagnostus* and a close relationship between the genera seems unlikely. Westergård, using Agnostidae in a more expanded sense than it is used here, placed *Glyptagnostus* in this family (Westergård, 1947, p. 5). The posteriorly tapered sharp-pointed pygidial axis of *Glyptagnostus* is structurally distinct from the posteriorly rounded axis of typical members of the Agnostidae (s. s.) and *Glyptagnostus* should probably be excluded from this family also.

A reclassification of the agnostid trilobites is badly needed. Until such a reclassification is forthcoming, there is no satisfactory family to include *Glyptagnostus* although a monotypic suprageneric taxon, Glyptagnostinae, was proposed by Kobayashi (1939, p. 154). The genus should probably ultimately be grouped with *Ptychagnostus*, *Triplagnostus*, *Goniagnostus*, and perhaps *Doryagnostus*, all of which have a structurally similar pygidial axis.

Species are recognized within the genus principally on details of development of the axis of the pygidium and on major variations in ornament.

Glyptagnostus stolidotus Öpik

Plate 2, figures 2, 5

Glyptagnostus stolidotus Öpik, 1961, p. 432, pl. 70, figs. 1–8, text fig. 16.

Diagnosis.—Member of *Glyptagnostus* with cephalon and pygidium having primarily radial ornament. Pygidium with length of b_3 less than one-half length of b_2 (fig. 11).

Discussion.—The ornament of this species illustrates the basic radial pattern of the ornament of the genus that is often obscured by cross furrows in *G. reticulatus* (Angelin). *G. stolidotus* differs consistently from all specimens of *G. reticulatus* by the characters given in the diagnosis. Although there is variation between individuals in details of ornament, there are no characters yet observed that would permit consistent distinction between the American and Australian forms of this species.

Occurrence: Conasauga formation: USGS collns. 2886–CO (20 cephala and pygidia), 2887–CO (1 pygidium), 2888–CO (2 cephala, 8 pygidia), 2889–CO (1 cephalon, 1 pygidium); USNM loc. 90b (2 cephala, 2 pygidia), Woodstock, Ala.

Figured specimens:

USNM	*USGS colln.*	*Part*
143140a	2886–CO	Cephalon.
143140b	2886–CO	Pygidium.

Glyptagnostus reticulatus (Angelin)

Agnostus reticulatus Angelin, 1851, p. 8, pl. 6, fig. 10. Tullberg, 1880, p. 23, pl. 1, figs. 12 a, b. Brögger, 1882, p. 57, pl. 1, figs. 11a, b. Lake, 1906, p. 8, pl. 1, fig. 11. Westergård, 1922, p. 117, 193, pl. 1, figs. 11, 12. Poulsen, 1923, p. 23, pl. 1, fig. 3.

Ptychagnostus reticulatus (Angelin) Jaekel, 1909, p. 400, fig. 19.

Pseudagnostus reticulatus (Angelin) Butts, 1926, pl. 9, fig. 5.

Glyptagnostus reticulatus (Angelin) Kobayashi, 1938, p. 170, pl. 16, fig. 34. Westergård, 1947, p. 5, pl. 1, figs, 1–9. Kobayashi, 1949, p. 1–6, pl. 1, figs. 1–15. Henningsmoen, 1958, p. 184, pl. 5, fig. 17. Öpik, 1961, p. 430, pl. 70, figs. 9–11, text fig. 15.

Agnostus nodosus Belt, 1867, p. 295, pl. 12, figs. 3a, b.

Glyptagnostus toreuma Whitehouse 1936, p. 102, pl. 9, figs. 17–20.

Glyptagnostus angelini Resser, 1938, p. 49 pl. 10, fig. 23.

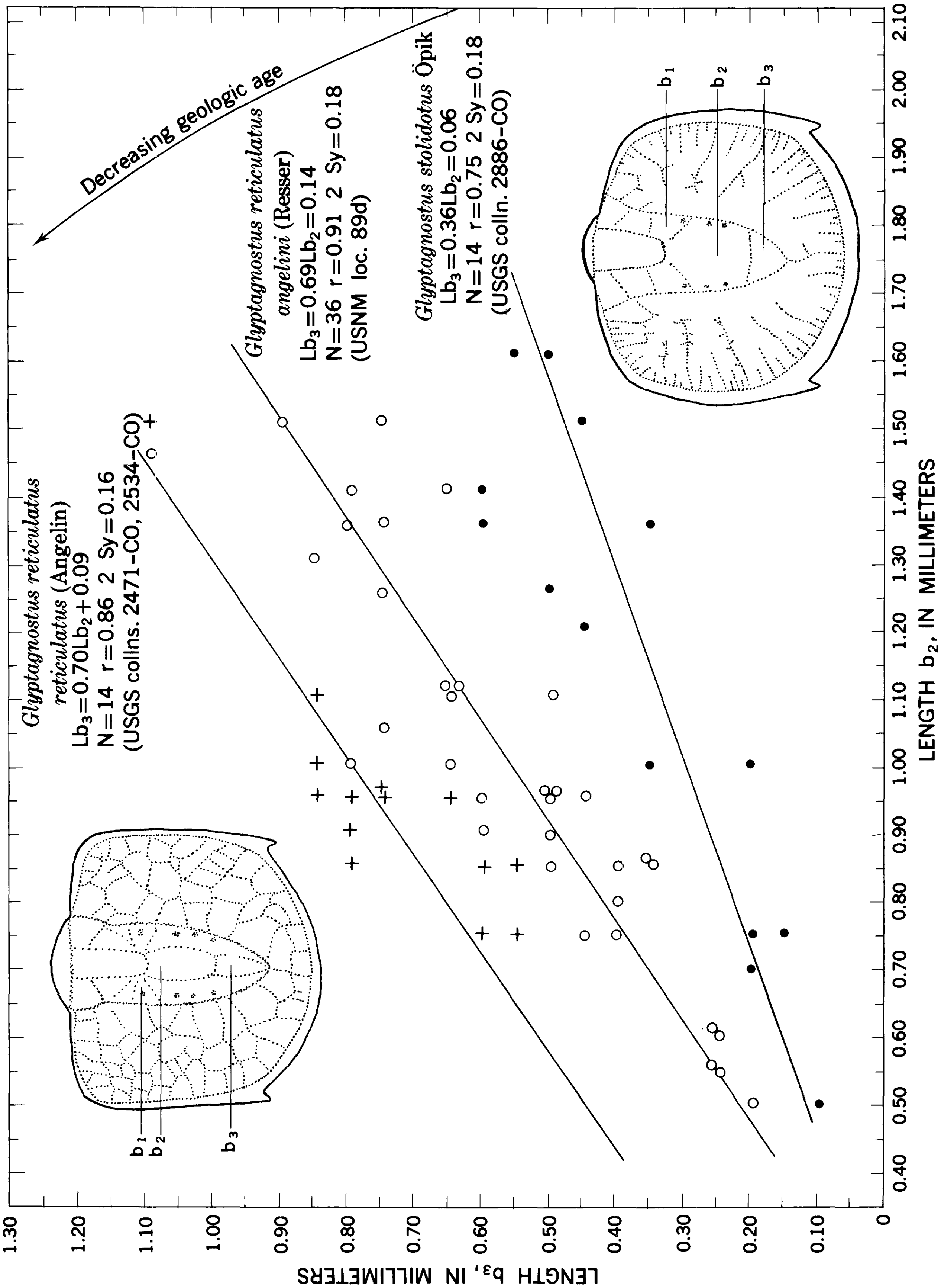

FIGURE 11.—Evolutionary development of the pygidium of *Glyptagnostus*.

Diagnosis.—Members of *Glyptagnostus* with basic pattern of radial furrows connected by irregular pattern of cross furrows, producing reticulate ornament on cephalic cheeks and pleural fields of pygidium. Pygidium with length of b_3 greater than one-half length of b_2. Lateral parts of b_2, and also b_1 and b_3 on stratigraphically younger specimens, marked off as side lobes by shallow longitudinal furrows. These furrows extend forward on some specimens to outline narrow lateral lobes on second axial segment.

Glyptagnostus reticulatus reticulatus (Angelin)

Plate 2, figures 1, 3, 8

Diagnosis.—Members of *Glyptagnostus reticulatus* with length of b_3 on axis of pygidium averaging more than 0.7 length of b_2. Posterior part of axis generally with well-developed longitudinal furrows outlining lateral lobes. Ornament of cephalon and pygidium generally strongly reticulate, but not nodose.

Glyptagnostus reticulatus angelini (Resser)

Plate 2, figures 4, 6, 7, 11

Diagnosis.—Members of *Glyptagnostus reticulatus* with length of b_3 on axis of pygidium averaging less than 0.7 length of b_2. Longitudinal furrows outlining lateral lobes on axis of pygidium poorly developed. Degree of reticulation on cephalon and pygidium variable.

Discussion.—Specimens are included in *G. reticulatus* that show an apparent progressive phylogenetic change with time. Older forms have pygidia with a relatively short b_3, poorly developed longitudinal furrows outlining lateral lobes on the posterior part of the axis, and variable development of the reticulate ornament on both cephalon and pygidum. Younger forms have pygidia with a relatively long b_3 (fig. 11), well-developed longitudinal furrows outlining lateral lobes on each division of the posterior part of the axis, and strongly developed reticulate ornament on all specimens in a population. On specimens with the longest b_3, the furrows outlining the lateral lobes converge slightly forward and give it an elongate pentagonal outline. On specimens with shorter b_3, the furrows outlining lateral lobes are subparallel. Because of complete stratigraphic gradation between the morphologic extremes, these extremes are considered here to represent only subspecies of *G. reticulatus.* Resser (1938, p. 49) proposed the name *G. angelini* for specimens now included in the older subspecies herein designated as *G. reticulatus angelini.* The younger subspecies, which agrees most nearly in details of morphology with the Scandinavian types of *G. reticulatus,* is *G. reticulatus reticulatus.* A third subspecies, *G. reticulatus nodulosus* Westergård, has been recognized only in Sweden and the island of Bornholm (Westergård, 1947, p. 7).

Specimens in the United States referable to *G. reticulatus angelini* are found principally in association with species of the acrotretid brachiopod *Opisthotreta* Palmer in beds that are correlated (table 1) with the *Crepicephalus* zone. Specimens referable to *G. reticulatus reticulatus* are found principally in association with species of the acrotretid brachiopod *Angulotreta* Palmer, in beds correlated with the *Aphelaspis* zone.

Occurrence: Lower part of the Dunderberg formation: USGS collns. 2466–CO (2 cephala, 3 pygidia), 2476–CO (6 cephala, 6 pygidia), 2477–CO (2 cephala, 10 pygidia), 2479–CO (1 cephalon), 2480–CO (1 cephalon), 3020–CO (1 cephalon), 3039–CO (1 cephalon), 3043–CO (1 cephalon), 3045–CO (1 cephalon), 3046–CO (1 cephalon), 3049–CO (1 pygidium), 3050–CO (2 cephala, 1 pygidium), 3053–CO (1 cephalon), McGill, Nev.; 2471–CO (11 cephala, 10 pygidia), 2534–CO (9 cephala, 6 pygidia), 2535–CO (1 cephalon, 3 pygidia), Cherry Creek, Nev. Uppermost beds of Swarbrick formation: USGS collns. 3057–CO (1 cephalon), 3058–CO (2 pygidia), 3059–CO (10 cephala, 6 pygidia), Tybo, Nev. Unnamed formations: USGS collns. 3106–CO (1 cephalon), Hamilton district, Nevada; 1370–CO (2 cephala), Hot Springs Range, Nev.; Henderson-Markham No. 1 well, depth 2,858 ft (1 cephalon), 2,860 ft (1 pygidium), Lake County, Tenn. Woods Hollow shale: Boulder BM–4 (3 cephala, 1 pygidium), Marathon region, Texas. Conasauga formation: USGS colln. 2875–CO (4 cephala, 2 pygidia), 2876–CO (2 cephala, 2 pygidia), 2878–CO=USNM localities 89d, 91 (>20 cephala and pygidia), 2879–CO (1 cephalon), Cedar Bluff, Ala.

Figured specimens:

USNM	*USGS colln.*	*Part*
143139a	2471–CO	Cephalon.
143139b	2471–CO	Pygidium.
143141	2476–CO	Association slab.
143142a	2466–CO	Cephalon.
143142b	2466–CO	Pygidium.
143143	Wilson boulder BM–4.	Cephalon.

Family PSEUDAGNOSTIDAE Whitehouse

Diagnosis.—Agnostid trilobites with cephalon having glabella slightly tapered forward, frontal lobe generally differentiated from remainder of glabella. Basal lobes simple. Preglabellar median furrow either present or absent.

Pygidium with posterior part of axis expanded to form pseudolobe reaching to posterior border furrow. Border always present, with or without marginal spines. Median axial node developed on second segment, may be extended onto pseudolobe. Terminal node present adjacent to border furrow on axial line.

Discussion.—Trilobites with these characters are known only from beds of Late Cambrian and possibly earliest Ordovician age. At least four genera can be assigned to the family: *Pseudagnostus* Jaekel (synonyms *Rhaptagnostus* Whitehouse and possibly *Pseudorhap-*

tagnostus Lermontova), *Pseudagnostina* n. gen., *Machairagnostus* Harrington and Leanza, and *Acmarhachis* Resser (synonyms *Oedorhachis* Resser, *Cyclagnostus* Lermontova). The principal distinguishing characters of the genera are in the development of the pseudolobe on the pygidium and the preglabellar median furrow on the cephalon. All species of *Pseudagnostus* have a complete preglabellar median furrow and have only the anterior part of the pseudolobe defined by accessory furrows. Species of *Pseudagnostina* lack a preglabellar median furrow and have the pseudolobe undefined. In *Acmarhachis* the preglabellar median furrow is present, absent, or only partly developed in front of the glabella, and in all species the pseudolobe is fully defined. These three genera are represented by many species at various stratigraphic levels in Upper Cambrian rocks of all continents. A monographic study of this family is needed to evaluate the species. It is quite possible that such study will show that some species are of particular importance for intercontinental correlation of Upper Cambrian rocks.

Machairagnostus is a monotypic genus that is reported to have the anterior part of the axis of the pygidium trisegmented rather than bisegmented as in all other genera of the family (Harrington and Leanza, 1957, p. 63). It is possible that the third pair of axial muscle scars which in some specimens are moderately well developed on the anterior part of the pseudolobe (Palmer, 1955, pl. 20, figs. 11, 14) has been interpreted as an extra segment. If this can be confirmed, then there is little difference between *Machairagnostus* and *Pseudagnostus*, and they might be considered synonymous.

Genus ACMARHACHIS Resser

Acmarhachis Resser, 1938, p. 47. Howell, 1959, p. 173.
Oedorhachis Resser, 1938, p. 49. Shimer and Shrock, 1944, p. 601. Howell, 1959, p. 185.
Cyclagnostus Lermontova, 1940, p. 126. Howell, 1959. p. 182.

Type species.—*Acmarhachis typicalis* Resser, 1938, p. 47, pl. 10, figs. 4, 5.

Diagnosis.—Pseudagnostidae with cephalon having well-defined bilobed glabella. Preglabellar median furrow present or absent; generally absent; if present, shallower than axial furrows. Border well defined. Basal glabellar lobes simple.

Pygidium with axis well defined, constricted at second segment; pseudolobe well defined, expanded and extended to border furrow at axial line. Median axial node on second segment only. Border well defined, with pair of short posterolateral marginal spines.

Discussion.—This distinctive genus differs from other pseudagnostid genera by having a well-defined bilobed glabella and by generally lacking a preglabellar median furrow on the cephalon. The pygidium is structurally like *Pseudagnostis* but has the pseudolobe fully defined and touching the border furrow only near the axial line.

Four species, *Acmarhachis typicalis* Resser, *Oedorhachis ulrichi* Resser (=*O. typicalis* Resser), *Cyclagnostus elegans* Lermontova, and *Homagnostus acutus* Kobayashi, are here assigned to this genus. The first three are the type species of their respective genera; *Acmarhachis* is retained as the oldest name for the taxon. In the most recent classification of the agnostid trilobites (Howell, 1959), these genera are placed in three families, Agnostidae, Pseudagnostidae, and Spinagnostidae. However, except for details of the pygidial border, development of some furrows, and ornament, the species are structurally alike. Each has an expanded pseudolobe reaching to the border furrow of the pygidium and bearing a terminal node, features here considered characteristic of the Pseudagnostidae.

Species of *Acmarhachis* in common with those of other genera of the Pseudagnostidae can only be certainly identified if pygidia are present. Most cephala are not distinguishable from those of agnostids such as *Peronopsis* and some species of *Homagnostus.*

Acmarhachis, as here recognized, occurs in beds of early Late Cambrian age in Eastern and Western United States and in Siberia.

Oedorhachis ulrichi Resser differs from *A. typicalis* principally by lacking any trace of a preglabellar median furrow and by having the median part of the pygidial border thickened and slightly raised. It does not differ in any significant respect from *Oedorhachis typicalis* Resser. Although *O. typicalis* is described in the paragraph preceding the description of *O. ulrichi* (Resser, 1938, p. 50), *ulrichi* is chosen as the name of the species to avoid the problem of homonomy resulting from *A. typicalis* and *O. typicalis* being considered congeneric. The other four species of *Oedorhachis* described by Resser (1938, p. 50, 51) differ in pygidial and cephalic features from *Acmarhachis* and are assigned as follows: *O. tennesseensis* and *O. greendalensis* belong to *Pseudagnostus; O. mesleri* is tentatively assigned to *Proagnostus;* and *O. boltonensis* belongs to *Pseudagnostina.* (See p. F-21.)

Cyclagnostus elegans Lermontova differs from *A. typicalis* principally by having a complete, although shallow, preglabellar median furrow and apparently by having a smooth rather than a granular or roughened surface on the pygidium.

Homagnostus acutus Kobayashi, recently assigned questionably to *Pseudagnostus* (Palmer, 1960a, p. 62), is more properly assignable to *Acmarhachis* in light of review of the Appalachian agnostids. It differs from *A. typicalis* principally because the axial segments of the pygidium are less well defined and because the furrow between the first and second axial segments are incomplete.

Acmarhachis acutus (Kobayashi)

Plate 2, figures 14, 15

Homagnostus acutus Kobayashi, 1938, p. 172, pl. 16, figs. 18–22.
Pseudagnostus? *acutus* (Kobayashi) Palmer, 160a, p. 62, pl. 4, figs. 10–12.

Diagnosis.—Members of *Acmarhachis* with cephalon having preglabellar median furrow present, absent, or only partly developed; if present, generally shallow.

Pygidium with first segment of axis poorly defined on outer surface of exoskeleton, somewhat better defined on exfoliated specimens. Furrow between first and second axial segments not crossing axis.

Discussion.—This species differs from *A. elegans* (Lermontova) and *A. typicalis* Resser by not having the furrow between the first and second axial segments cross the axial lobe. It differs from *A. ulrichi* (Resser) by lacking the thickened upturned median part of the pygidial border.

Occurrence: Lower part of Dunderberg formation: USGS collns. 2471–CO (3 cephala, 4 pygidia), 2534–CO (6 cephala, 2 pygidia), 2535–CO (1 pygidium), Cherry Creek, Nev.

Figured specimens:

USNM No.	*USGS colln.*	*Part*
143146a	2471–CO	Cephalon.
143146b	2471–CO	Pygidium.

Acmarhachis typicalis Resser

Plate 2, figures 12, 13, 17

Acmarhachis typicalis Resser, 1938, p. 47, pl. 10, figs 4, 5.

Diagnosis.—Members of *Acmarhachis* with cephalon having preglabellar median furrow developed only as short projection forward from anterior end of glabella. Pygidium with first two segments of axis well defined by complete transverse furrows; axis markedly constricted at second segment; pseudolobe pointed posteriorly. Surface of exoskeleton faintly roughened.

Discussion.—The species differs from *A. acutus* (Kobayashi) by having the first two segments of the axis well defined. It differs from *A. ulrichi* Resser and *A. elegans* (Lermontova) by having the pseudolobe distinctly pointed posteriorly. The median part of the border of the pygidium is also not thickened and upturned as in *A. ulrichi*.

One pygidium is USGS colln. 2475–CO has a prominent pair of longitudinal curved furrows within the pseudolobe (pl. 2, fig. 17). These are considered here to represent an exaggerated development of the muscle scar areas seen on many species of the Pseudagnostidae.

Occurrence: Upper part of Hamburg limestone, USGS colln. 2475–CO (2 cephala, 4 pygidia), McGill, Nev.

Figured specimens:

USNM No.	*USGS colln.*	*Part*
143145a	2475–CO	Cephalon.
143145b	2475–CO	Pygidia.

Acmarhachis? sp.

Plate 2, figures 9, 10

An agnostid possibly assignable to *Acmarhachis* occurs with *Glyptagnostus stolidotus* Öpik at Woodstock, Ala. It has a slender parallel-sided glabella with a well-defined subquadrate frontal lobe and no preglabellar median furrow. The pygidium has a long well-defined axis, narrowest at the second axial segment and with an expanded pseudolobe(?). A prominent median node is present on the second axial segment. Unfortunately, the median part of the border of both pygidia in the collection is damaged, so that the relation of the end of the axis to the border furrow cannot certainly be determined. On the illustrated specimen there seems to be a shallow depression between the end of the axis and the border furrow. If they are in contact this species is referable without question to *Acmarhachis*. If they are not in contact the generic placement is not clear, although the species would have most in common with species of *Homagnostus*. The glabellar shape and long, expanded posterior part of the axis distinguish this species from other described American agnostids.

Occurrence: Conasauga formation, USGS colln. 2886–CO (5 cephala, 2 pygidia), Woodstock, Ala.

Figured specimens:

USNM No.	*USGS colln.*	*Part*
143144a	2886–CO	Cephalon.
143144b	2886–CO	Pygidium.

Genus PSEUDAGNOSTINA n. gen.

Type species.—*Pseudagnostina contracta* n. sp.

Diagnosis.—Pseudagnostidae with cephalon having well-defined border. Glabella bilobed; frontal lobe well defined. Median axial node situated at about midlength of posterior glabellar lobe. Preglabellar median furrow absent.

Pygidium with only anterior third of axis defined by straight axial furrows. Pseudolobe undefined. Transverse furrows lacking. Median axial node and median terminal node present. Border well defined, with pair of posterolateral marginal spines.

Description.—Cephalon moderately to strongly convex transversely, moderately convex longitudinally. Outline subsemicircular; sides straight, expanded slightly forward from straight posterior margin; anterior margin broadly rounded. Border well defined by broad shallow border furrow. Glabella moderately narrow, tapered forward, distinctly bilobed; anterior lobe smaller than posterior lobe, strongly rounded anteriorly; posterior lobe without trace of lateral furrows; median node low, elongate, at about midlength of posterior lobe. Basal lobes well defined, subtriangular, undivided. Cheeks confluent in front of glabella, without trace of preglabellar median furrow.

Pygidium moderately to strongly convex transversely and longitudinally. Outline subsemicircular; sides straight, subparallel; posterior margin broadly rounded; short posterolateral marginal spines present. Border well defined by shallow marginal furrow. Axis defined by straight axial furrows only adjacent to first two segments. Pseudolobe not defined. Transverse furrows not apparent. Median node low, round, located at position of second axial segment. Terminal node present adjacent to border.

Discussion.—The combination of a *Peronopsis*-like cephalon and *Pseudagnostus*-like pygidium is a new combination for the Pseudagnostidae. Isolated cephala cannot be distinguished from cephala of *Peronopsis* or some species of *Homagnostus* and *Geragnostus*. Pygidia may be recognized by lack of transverse furrows and lack of definition of the pseudolobe, combined with the well-defined short dorsal furrows adjacent to the anterior axial segments.

The pygidium described as "*Agnostus*" *nordicus* Lochman (1940, p. 23) may represent another species of *Pseudagnostina*. This has been combined, as *Pseudagnostus*? *nordicus* (Lochman) (Palmer, 1954, p. 721), with a cephalon originally described as "*Agnostus*" *valentinus* Lochman, which has an unusually small anterior glabellar lobe and a deep preglabellar median furrow. The association of cephalon and pygidium as parts of the same trilobite is based on rather weak circumstantial evidence and the possibility that it might be erroneous should be kept in mind.

Oedorhachis boltonensis Resser from the *Cedaria* zone in northwestern Virginia is represented by cephala and pygidia that conform in all respects to Pseudagnostina.

Pseudagnostina contracta n. sp.

Plate 2, figures 18–20, 22–25

Diagnosis.—Members of *Pseudagnostina* with axial furrows on pygidium slightly convergent.

Discussion.—The only described agnostids that are referable to *Pseudagnostina* are *Oedorhachis boltonensis* Resser and possibly *Pseudagnostus*? *nordicus* (Lochman) discussed under genus *Pseudagnostina* n. gen. Pygidia of both species differ from *P. contracta* by having the dorsal furrows parallel or slightly divergent posteriorly.

One pygidium (pl. 2, fig. 18) of *P. contracta* has a row of paired pits converging posteriorly on the pseudolobe. This feature has been observed on specimens of several pseudagnostid species, and its value as a criterion for taxonomic differentiation (as in *Rhaptagnostus* Whitehouse, 1936, and *Pseudorhaptagnostus* Lermontova, 1940) is suspect.

Occurrence: Conasauga formation: USGS coll. 2888–CO (4 cephala, 9 pygidia), Woodstock, Ala. Upper part of Hamburg limestone: USGS collns. 2474–CO (1 cephalon, 2 pygidia), 2475–CO (5 cephala, 2 pygidia), McGill, Nev.; USGS colln. 3056–CO (3 cephala, 2 pygidia), Cherry Creek Nev.

Figured specimens:

USNM	*USGS colln.*	*Part*
143149a	2888–CO	Pygidium.
143149b	2888–CO	Cephalon.
143150	2888–CO	holotype pygidium.
143151	2475–CO	Cephalon.
143152	2474–CO	Pygidium.
143153a	3056–CO	Cephalon.
143153b	3056–CO	Pygidium.

Genus PSEUDAGNOSTUS Jaekel

Pseudagnostus Jaekel, 1909, p. 400. Kobayashi, 1935, p. 107; 1937, p. 451; 1939, p. 157. Shimer and Shrock, 1944, p. 601. Shaw, 1951, p. 112. Palmer, 1954, p. 719; 1955, p. 93; 1960a p. 61.

Plethagnostus Clark, 1923, p. 124; 1924, p. 16.

Rhaptagnostus Whitehouse, 1936, p. 97.

Type species.—*Agnostus cyclopyqe* Tullberg, 1880 (p. 26).

Diagnosis.—*Pseudagnostidae* with cephalon having bilobed glabella and preglabellar median furrow. Basal glabellar lobes simple.

Pygidium with anterior third of axis defined by subparallel axial furrows; pseudolobe moderately well to poorly defined by accessory furrows that may disappear posterolaterally so that pseudolobe merges with pleural fields. Marginal spines present or absent.

Pseudagnostus spp.

Plate 2, figures 16, 21, 26

Specimens assignable to *Pseudagnostus* have been found in collections with species of *Glyptagnostus* in Alabama and Nevada. These specimens could be assigned to *Pseudagnostus communis* (Hall and Whitfield), as that species is presently recognized, but it is apparent from the large collection of undescribed agnostid material available to the writer that present means of determining species of *Pseudagnostus* are inadequate. Until a review of all Upper Cambrian specimens of *Pseudagnostus* is undertaken meaningful species identification cannot be given.

Occurrence: Conasauga formation: USGS collns. 2875–CO (2 pygidia), 2876–CO (2 pygidia); Cedar Bluff, Ala. Uppermost beds of Swarbrick formation: USGS collns. 3057–CO (23 cephala, 27 pygidia), 3058–CO (5 cephala, 5 pygidia), 3059–CO (6 cephala, 5 pygidia); Tybo, Nev. Unnamed formation: USGS collns. 1370–CO (6 cephala, 2 pygidia); Hot Springs Range, Nev.

Figured specimens:

USNM No.	*USGS colln.*	*Part*
143147a	3058–CO	Cephalon.
143147b	3058–CO	Pygidium.
143148	2875–CO	Pygidium.

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Order PTYCHOPARIIDA Swinnerton
Family ASAPHISCIDAE Raymond
Subfamily BLOUNTIINAE Lochman
Genus BLOUNTIA Walcott

Blountia Walcott, 1916, p. 396. Shimer and Shrock, 1944, p. 619. Palmer, 1954, p. 721. Howell, 1959, p. 292.

Homodictya Raymond, 1937, p. 1114. Rasetti, 1946, p. 454. Shaw, 1952, p. 473. Howell, 1959, p. 292.

Type species.—Blountia mimula Walcott, 1916 (p. 399, pl. 61, figs. 4–4c).

Diagnosis.—Asaphiscidae with cranidium moderately to strongly convex transversely and longitudinally, moderately to strongly rounded anteriorly. Glabella poorly defined on outer surface, well defined on mold by narrow shallow axial furrows, tapered forward, strongly rounded anteriorly; lateral furrows lacking. Occipital ring very short (sagittal), generally not differentiated from glabella on outer surface. Frontal area with distinct border separated from brim by slight to sharp change in slope; brim generally continues longitudinal convexity of glabella; length (sagittal) of border equal to or slightly more than that of brim. Fixed cheeks downsloping, generally continuing transverse convexity of glabella, width about one-half or less basal glabellar width. Palpebral lobes poorly defined, situated anterior to glabellar midlength. Posterior limbs broad, sharply pointed. Posterior border furrow broad, shallow, curved forward near tip of limb.

Course of anterior section of facial sutures nearly straight forward from palpebral lobes to border. Adaxial course and ventral sutures not known. Course of posterior section divergent convex behind palpebral lobe.

Free cheek with border broad, moderately well defined, width about equal to width of ocular platform. Eye small, not differentiated by infraocular ring from ocular platform. Genal spine broad based, rapidly tapered, short, sharp pointed.

Thorax composed of 7 to 9 segments. Each segment with elevated axis and obscure pleural furrow. Tips of segments slender, sharp pointed, laterally directed.

Pygidium subsemicircular to subparabolic in outline, gently to moderately convex transversely and longitudinally. Axis long, slender, poorly defined on outer surface reaching to or across border furrow; mold shows seven or more well-defined ring furrows of nearly constant depth. Border slightly narrower than greatest width of pleural field, moderately to poorly defined, generally downsloping. Pleural fields on mold with numerous shallow pleural and interpleural furrows of comparable depth.

Surfaces of all parts smooth.

Discussion.—This genus differs only slightly from *Maryvillia* (Rasetti, 1956, p. 1267), principally by having the cranidium moderately to strongly convex transversely, rather than flat or gently convex transversely.

Blountia bristolensis Resser

Plate 3, figures 33, 34

Blountia bristolensis Resser, 1938, p. 65, pl. 12, fig. 24.
Maryvillia bristolensis Resser, 1938, p. 87, pl. 12, fig. 38.
Maryvillia hybrida Resser [part], 1942, p. 71, pl. 13, figs. 14, 15.
Blountia nixonensis Lochman, 1944, p. 43, pl. 4, figs. 7–12. Palmer, 1954, p. 722, pl. 79, fig. 4.

Diagnosis.—Members of *Blountia* with cranidium having anterior margin evenly rounded. Width of fixed cheek about one-third basal glabellar width. Length of border (sagittal) slightly greater than length of brim. Pygidium subsemicircular in outline, border furrow moderately well defined at anterolateral margin, becoming shallow towards rear, interrupted by end of axis that extends onto border.

Discussion.—The specimens of *Blountia* at Cedar Bluff, Ala. although somewhat crushed, do not differ in any significant feature from either *B. nixonensis* Lochman, or *B. bristolensis* Resser, here considered synonyms.

Maryvillia bristolensis Resser, represented by cranidia only, was placed in *Blountia* by Rasetti (1956, p. 1268). It comes from the same collection as *Blountia bristolensis* Resser, represented by a pygidium, and they are here considered parts of the same species. Both cranidium and pygidium are indistinguishable from *B. nixonensis* Lochman.

B. bristolensis is perhaps the youngest species of *Blountia*. The principal difference from older species is the moderately well developed border furrow that is interrupted by the end of the axis on the pygidium.

Occurrence: Conasauga formation, USGS colln. 2879–CO (6 cranidia, 11 pygidia), Cedar Bluff, Ala.

Figured specimens:

USNM	*USGS colln.*	*Part*
143167a	2879–CO	Cranidium.
143167b	2879–CO	Pygidium.

Family CATILLICEPHALIDAE Raymond

Genus PEMPHIGASPIS Hall

Pemphigaspis Hall, 1863, p. 221. Palmer, 1951, p. 763. Tasch, 1951, p. 302. Rasetti, 1945, p. 603.
Hallaspis Raasch and Lochman, 1943, p. 230.

Type species.—Pemphigaspis bullata Hall, 1863 (p. 221, pl. 5a, figs. 3–5).

Discussion.—This genus has been fully described in an earlier paper (Palmer, 1951), and the following specimens discussed provide no new information.

Pemphigaspis sp.

Plate 3, figure 32

Two fragmentary cranidia associated with *Glyptagnostus stolidotus* Öpik have the anteriorly expanded glabella, Y-shaped posterior glabellar furrows and granular outer surface characteristic of specimens of *Pemphigaspis*. Neither specimen is well enough preserved to determine its specific identity.

Occurrence: Conasauga formation, USGS colln. 2886–CO (2 cranidia), Woodstock, Ala.

Figured specimen: USNM 143166, USGS colln. 2886–CO, cranidium.

Family CEDARIIDAE Lochman

The Cedariidae are here considered as a family rather than reduced to a subfamily as recently done by Lochman (1959, p. 301). If structure of the glabella, is to mean anything in suprageneric classification, as it seems, for example, in the Pterocephaliidae and Parabolinoididae (Lochman, 1959, p. 256, 272), then the differences between *Cedaria* and the type genera (*Llanoaspis* and *Raymondina*) of the other two subfamilies grouped by Lochman with Cedariinae are at least family differences.

A revised diagnosis of the Cedariidae would require examination of many genera not otherwise included in this study and is beyond the scope of this paper. Some of the characters that seem to be important for members of the family are the obscurely furrowed, anteriorly tapered glabella that is strongly rounded in front, combined with the divergent anterior sections of the facial sutures, and the broad posterior limbs with the border furrow curving forward distally.

Genus CARINAMALA n. gen

Type species.—Carinamala longispina n. sp., text figure 12.

Diagnosis.—Cedariid? trilobites with cranidium having prominent well-defined anteriorly tapered unfurrowed glabella connected to broad concave border by shallow median furrow that crosses narrow brim. Border furrow narrow, shallow. Fixed cheek broad, with prominent raised eye ridge and extremely prominent raised palpebral lobe. Upper surface of palpebral lobe with shallow furrow or several pits.

Anterior section of facial suture nearly vertical in front of palpebral lobe; posterior course nearly perpendicular to axial line immediately behind palpebral lobe.

Free cheek with short (exsagittal) ocular platform merged with large eye surface and separated from border by broad shallow border furrow. Inner edge of cheek with concave notch and spur produced by

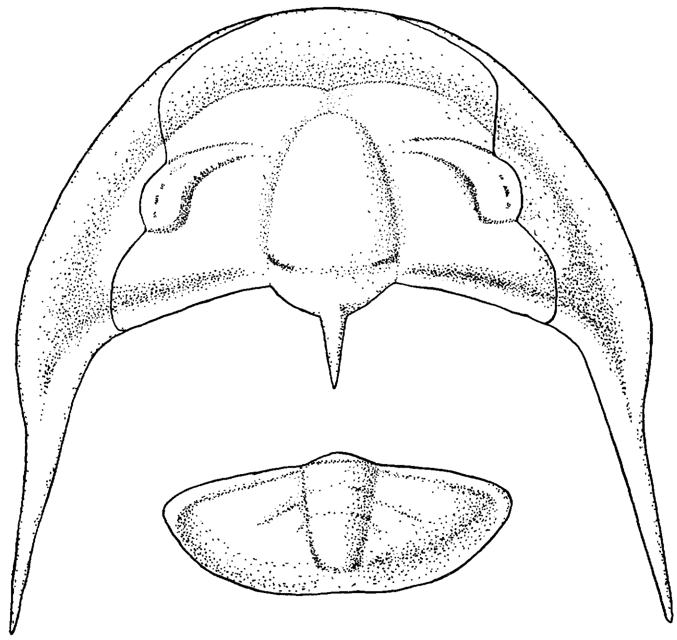

FIGURE 12.—Partial reconstruction of *Carinamala longispina* n. sp., about × 6.

posterior section of facial suture. Outer edge of cheek curved abruptly in to base of slender genal spine.

Rostral plate subtriangular in outline. Hypostome and thorax not known.

Pygidium subsemicircular in outline, with prominent narrow axis reaching nearly to posterior margin, bearing shallow ring furrows. Pleural regions with shallow pleural furrows. Border poorly defined, concave. Posterior margin evenly rounded.

Description.—Small- to medium-sized opisthoparian trilobites (estimated maximum length 45 mm). Cranidium with all parts well defined. Glabella moderately convex transversely, gently convex longitudinally, tapered forward, strongly rounded in front, well defined by broad shallow axial furrow of nearly constant depth; lateral glabellar furrows not apparent. Occipital furrow narrow. Occipital ring with or without median node or spine. Frontal area composed of broad gently concave border with inner margin well defined by shallow narrow border furrow that has slight median posterior inbend and bears single row of pits each with central granule. Brim gently downsloping, with median depression in front of glabella, narrower than border; broadens laterally, becomes vertical adjacent to facial sutures. Fixed cheeks slightly upsloping, gently convex; width, exclusive of palpebral lobe about two-thirds basal glabellar width. Eye ridge prominent, narrow, gently curved posterolaterally, raised above cheek surface, continuous with palpebral lobe. Palpebral lobe extremely elevated, upper surface with groove or several pits. Posterior limbs broad; tip rounded. Posterior border furrow moderately deep, broad.

Anterior section of facial suture nearly vertical from palpebral lobe to marginal furrow, curved strongly across nearly horizontal border and continued along border to cut anterior margin near axial line, then curved strongly backward to cut posterior margin of doublure at nearly right angle. Rostral suture submarginal. Posterior section of facial suture nearly perpendicular to axial line behind palpebral lobe, curved broadly backward and inward to cut posterior margin near base of genal spine.

Rostral plate subtriangular in outline with concave sides and narrow posterior stem.

Free cheek with narrow (exsagittal) ocular platform. Border broad, separated from ocular platform by broad shallow border furrow. Outer margin of border curved abruptly inward to base of genal spine. Inner margin behind eye with concave notch and spur developed from posterior section of facial suture. Genal spine slender, in side view raised above edge of border of cheek. Eye surface faceted only in upper half. Infraocular ring not present.

Hypostome and thorax not known.

Pygidium subsemicircular in outline with length about four-tenths width. Axis narrower than pleural lobes, reaching nearly to posterior margin; 3 or 4 shallow ring furrows apparent behind articulating furrow. Pleural regions gently convex with 1 or 2 shallow pleural furrows and poorly defined broad concave border having raised evenly curved margin.

Discussion.—This genus is tentatively placed in the Cedariidae because of the shape of its glabella, the broad posterior limb on the cranidium, the lack of an infraocular ring and the presence of the curved notch and spur on the free cheek. Its most distinguishing characteristics are the prominent ocular ridges and palpebral lobes on the cranidium, and the constriction of the border of the free cheek at the base of the genal spine.

A specifically indeterminate cranidium of *Carinamala* (pl. 3, fig. 3) is associated with *Glyptagnostus stolidotus* Öpik at Woodstock, Ala. Specimens belonging to *Carinamala* are also present in collections from the Snake and Schell Creek Ranges and at McGill and Cherry Creek, Nev.

Only the type species, *C. longispina* n. sp., from a bed 6 inches below the lowest occurrence of *Glyptagnostus reticulatus* at McGill, Nev., and the specimen from Woodstock, Ala., are here described. *C. longispina* is also present at Cherry Creek, Nev. The Snake Range specimens, which are associated with *Cedaria prolifica* Walcott, represent another species, and the specimens from the Schell Creek Range are specifically indeterminate.

Carinamala longispina n. sp.

Plate 3, figures 1, 2, 4–7; text figure 12

Diagnosis.—Member of *Carinamala* with cranidium having ocular ridge and palpebral lobe continuous, undifferentiated, increasing distally in height above surface of fixed cheek, flat on top. Palpebral lobe with 2 or 3 shallow pits in upper surface. Occipital ring with short median spine directed upward from surface and then curved abruptly backward in a nearly horizontal plane. Free cheek with long slender genal spine. Pygidium known only for this species, its characters same as for genus.

Discussion.—This species differs from the unnamed species associated with *Cedaria prolifica* in the Snake Range by having the palpebral lobe and ocular ridge undifferentiated, pits rather than a groove in the upper surface of the palpebral lobe, an occipital spine, and longer genal spines.

The surface of the eye is unusual in that facets are apparent only on the upper part. The number of facets per square millimeter is about 750, the same as in *Cedaria*, but the eye surface on a *Carinamala* cheek has only about half as many facets as the eye surface on a *Cedaria* cheek of comparable size.

Occurrence: Upper beds of the Hamburg limestone: USGS collns. 2474–CO (37 cranidia, 10 free cheeks, 16 pygidia), 2475–CO (cranidia, 15 free cheeks, 41 pygidia), McGill, Nev. 2470–CO (1 cranidium, 3 pygidia), Cherry Creek, Nev.

Figured specimens:

USNM No.	*USGS colln.*	*Part*
143154	2475–CO	Holotype cranidium.
143155a	2475–CO	Cranidium.
143155b, c	2475–CO	Pygidia.
143155d, e	2475–CO	Free checks.

Carinamala sp.

Plate 3, figure 3

Discussion.—A single poorly preserved cranidium at Woodstock, Ala., associated with *Kingstonia alabamensis* Resser and *Glyptagnostus stolidotus* Opik has the broad border, preglabellar median furrow, nearly vertical anterior course of the facial suture, broad fixed cheek and glabellar shape characteristic of *Carinamala*. Lack of knowledge of the structure of the palpebral lobe, occipital ring, and posterior limb prevents its specific determination.

Occurrence: USNM loc. 90b (1 cranidium), Woodstock, Ala.

Figured specimen: *USNM* 143156, USNM loc. 90b, cranidium.

Genus CEDARIA Walcott

Cedaria Walcott, 1924, p. 55; 1925, p. 78. Shimer and Shrock, 1944. p. 621. Palmer, 1954, p. 726.

Type species.—*Cedaria prolifica* Walcott, 1925 (p. 79, pl. 17, figs. 18–21).

Diagnosis.—Subisopygous pseudoproparian trilobites with cranidium having well-defined border, unfurrowed glabella tapered and strongly rounded anteriorly, narrow fixed cheeks, and generally distally expanded posterior limbs with border furrow curved forward at tip. Free cheek with short (exsagittal) ocular platform and with curved notch and spur on inner margin at base of slender genal spine. Pygidium subsemicircular in outline, nearly as large as cephalon with broad or narrow border of nearly constant width, pleural field crossed by three or more pleural furrows, axis prominent, narrow, reaching to inner part of border.

Description. Subisopygous trilobites with cephalon subsemicircular in outline, gently to moderately convex transversely and longitudinally; genal spines long, slender. Cranidium with glabella well defined, tapered forward, strongly rounded anteriorly, unfurrowed. Occipital furrow narrow. Occipital ring generally without ornament. Frontal area divided into distinct brim and border by shallow border furrow. Border generally of nearly constant breadth, length (sagittal) subequal to or less than that of brim. Fixed cheeks narrow, horizontal or slightly upsloping; width, exclusive of palpebral lobes between ⅓ and ⅕ basal glabellar width. Palpebral lobes flaplike, situated opposite or slightly posterior to midlength. Posterior limb generally broadened outward, less commonly slightly tapered, distal end strongly rounded; border furrow curved forward near tip to cut anterior margin of limb.

Anterior section of facial sutures directed forward and outward from palpebral lobes to marginal furrow, then turned sharply inward across border to smooth juncture with anterior margin before reaching axial line. Connective sutures curved towards axial line. Rostral plate present on all species; shape ranges from broad (transverse) with concave sides to subtriangular. Posterior section of facial suture directed outward at nearly right angles to axial line until across marginal furrow, then curved strongly backward along border to cut posterior margin of cephalon near base of genal spine.

Free cheek with short generally subparallel sided ocular platform. Border generally well defined, with broad curved notch and spur on inner margin at base of slender genal spine. Inner margin of doublure beneath border of cranidium with row of tubercules opposed to pits generally developed in marginal furrow of cranidium. Anterior tip of doublure convex towards axial line. Visual surface of eye holochroal, not separated from ocular platform by infraocular ring.

Hypostome parallel sided, strongly rounded posteriorly, strongly convex transversely, moderately to strongly convex longitudinally. Middle body not divided. Lateral furrows and lateral border distinct. No posterior border.

Thorax composed of 6 or 7 segments. Axis well defined. Pleural region of each segment with broad marginal furrow extended into short slender sharp pleural tip.

Pygidium subsemicircular in outline, nearly as large as cephalon. Axis prominent, with four or more ring furrows apparent behind articulating furrow; reaches to inner part of border. Pleural region gently convex, moderately to poorly divided into broad or narrow, flat or slightly concave border of nearly constant width and subtriangular pleural field crossed by three or more pleural furrows of constant depth. Posterior margin smooth.

Surface of all parts of exoskeleton generally smooth, rarely granular. Pits not present.

Discussion.—This genus presently includes eight distinct species: *C. eurycheilos* Palmer, *C. gaspensis* Rasetti, *C. milleri* Resser, *C. minor* (Walcott), *C. nixonia* Lochman and Duncan, *C. prolifica* Walcott, *C. tennesseensis* Walcott, and *C. woosteri* (Whitfield). Two species, *C. milleri* Deland and Shaw (not Resser) and *C. buttsi* Resser do not belong to the genus. A third species, *C. puelchana* Rusconi is inadequately described and unfigured and cannot be evaluated.

Cedaria milleri Deland and Shaw is represented by two cranidia that differ most conspicuously from any species of *Cedaria* by the presence of a short subequally divided frontal area and a relatively large glabella. The cranidia are more likely referable to an undetermined species of the Crepicephalidae.

Cedaria buttsi Resser has the gross aspect of a species of *Cedaria* but lacks a defined cephalic border, has palpebral lobes placed anterior to the glabellar midlength, and has laterally tapered posterior limbs that do not reach to the lateral cephalic border. None of these are characteristic features of *Cedaria* and indicate that "*C.*" *buttsi* is not referable to *Cedaria* although it may represent an undescribed genus of the Cedariidae.

Cedaria woosteri (Whitfield) is an atypical species with the anterior and posterior branches of the facial sutures fused, so that the free cheek is in two parts: the eye surface and the border bearing the genal spine. Perhaps this species should also be removed from *Cedaria*.

Except for the granular surface of the cranidium of *C. milleri* Resser and a nearly identical cranidium assigned to *C. nixonia* by Lochman and Duncan (1944, pl. 10, fig. 5), all known *Cedaria* cranidia are smooth. The rostral plate has been developed for *C. minor* (Walcott) and *C. prolifica* (pl. 6, figs. 13, 14). The considerable range in structure of the rostral plate within the genus indicates that it has potential value as an additional specific character. The hypostome is certainly known only for *Cedaria minor* (Walcott).

Cedaria prolifica Walcott

Plate 3, figures 9, 10, 14–16, 20; plate 6, figure 14

Cedaria prolifica Walcott, 1925, p. 79, pl. 17, figs. 18–21. Resser, 1938, p. 67, pl. 11, figs. 1, 2, 6, 7. Shimer and Shrock, 1944, pl. 264, figs. 3–7.

Cedaria aff. *C. gaspensis* Rasetti, Wilson, 1954, p. 269, pl. 24, fig. 20.

Diagnosis.—Members of *Cedaria* with cranidium having moderately to strongly flared frontal area. Border convex, well defined by border furrow bearing many close-spaced pits each with small central granule; length (saggital) on large specimens (greater than 4 mm in cranidial length) about equal to length of brim; length on small specimens generally slightly less than length of brim. Length of frontal area slightly greater than one-half length of glabella. Fixed cheeks upsloping. Palpebral lobes strongly arcuate, slightly elevated above surface of fixed cheeks, situated at or slightly posterior to midlength of glabella. Posterior limbs slightly expanded outward from base of palpebral lobe to about midlength of limb, then tapered to tip with broadly curved anterior outline. Occipital ring with small median node near anterior edge.

Free cheek with anterior and posterior edges of ocular platform subparallel or slightly divergent outward.

Rostral plate subtriangular in outline (pl. 6, fig. 14).

Pygidium with number of ring furrows on axis posterior to articulating furrow ranging from 5 or 6 on specimens about 3 mm in length to 7 or 8 on specimens greater than 10 mm in length. Number of pleural furrows ranges from 4 on specimens 3 mm in length to 5 or 6 on specimens greater than 10 mm in length. Length of border (exsagittal) about ⅙ to ⅐ length of pygidium.

Discussion.—This species is distinguished from all other species of the genus on the features given above. The most similar species are *C. gaspensis* Rasetti, *C. minor* (Walcott), and *C. brevifrons* n. sp. that seem to form a species group characterized by a convex cranidial border, only slightly expanded posterior limbs, and a narrow pygidial border. Pygidia of *C. gaspensis* have at least two more axial and pleural segments than comparable sized specimens of other species in the group. *C. minor* has less divergent anterior sections of the facial sutures than *C. prolifica* and a transverse subquadrate rostral plate instead of a subtriangular rostral plate (cf. pl. 6, figs. 13, 14). *C. brevifrons* has a considerably shorter frontal area than any of the other species in the group. It is perhaps significant from a paleoecological viewpoint that all the species in this group come from the most seaward deposits of the *Cedaria* zone. *C. gaspensis* is from the western Gaspé Peninsula; *C. prolifica* is found in Alabama, the Marathon region, Texas, and the Snake Range, Nev.; *C. minor* is from the House Range, Utah; and *C. brevifrons* is from McGill, Nev.

The specimens from Texas that Wilson (1954, p. 269) compared with *C. gaspensis* lack the distinctive number of pygidial segments of that species and conform in all features to *C. prolifica*.

Several free cheeks in USGS colln. 2888–CO, from Woodstock, Ala., have the outer surface of the eye preserved showing the facets. The surface curves through an arc of about 180° and has about 750 facets per square millimeter. On a cephalon about 5 mm long, the estimated total number of facets on the eye is about 1,500.

Exfoliated cranidia at both Woodstock and Cedar Bluff, Ala., show that the posterior pair of glabellar muscle scars were quite large. This may be a useful additional feature in the systematics of these trilobites when more specimens showing the muscle scars have been examined.

Occurrence: USGS colln. 2888–CO (11 cranidia, 4 free cheeks, 23 pygidia), Woodstock, Ala.

Figured specimens:

USNM	*USGS colln.*	*Part*
143159a, d, e	2888–CO	Cranidia.
143159b, c	2888–CO	Pygidia.
143159f	2888–CO	Free cheek.
143196	1208–CO	Rostral plate.

Cedaria brevifrons n. sp.

Plate 3, figures 8, 11–13

Diagnosis.—Members of *Cedaria* with free cheeks and pygidium not distinguishable from *C. prolifica*. Cranidium with length of frontal area about one-third length of glabella exclusive of occipital ring; length of border slightly greater than length of brim; fixed cheeks nearly horizontal. All other cranidial features as in *C. prolifica*. Rostral plate not known.

Discussion.—The short frontal area is the most distinctive character of this species. Its relations to other species of *Cedaria* are reviewed in the discussion of *C. prolifica*.

Occurrence: Uppermost beds of Hamburg limestone: USGS colln. 2475–CO (13 cranidia, 5 free cheeks, 41 pygidia), McGill, Nev.; USGS colln. 3056–CO (8 cranidia, 1 free cheek, 4 pygidia), Cherry Creek, Nev.

Figured specimens:

USNM No.	*USGS colln.*	*Part*
143157	2475–CO	Holotype cranidium.
143158a	2475–CO	Free cheek.
143158b, c	2475–CO	Pygidia.

Family CHEILOCEPHALIDAE Shaw

Genus CHEILOCEPHALUS Berkey

Cheilocephalus Berky, 1898, p. 290. Palmer, 1954, p. 757.
Pseudolisania Kobayashi, 1935, p. 162. Shimer and Shrock, 1944, p. 621.

The fragmentary material associated with *Glyptagnostus* does not add any new information to the description of the genus already given (Palmer, 1954).

Cheilocephalus sp.

Plate 3, figures 30, 31

Several incomplete cranidia from one collection and a pygidial fragment from another collection represent all the identified parts of *Cheilocephalus* so far found associated with *Glyptagnostus*. Two of the cranidia have the exoskeleton preserved. These have a distinctive ornament of scattered small granules on all observed parts except the areas of the glabellar furrows on the glabella.

Ornamented specimens of *Cheilocephalus* have previously been known only from the *Dunderbergia* and *Elvinia* zones, where specimens with a granular external surface of the exoskeleton have been reported (Wilson, 1951; Palmer, 1960a). The species of *Cheilocephalus* from the *Aphelaspis* zone have a smooth external cranidial surface (Palmer, 1954). The specimens here illustrated differ from the younger specimens with similar ornament by having the granules smaller and more scattered on the cranidial surface, and by having a relatively broader and flatter cranidial border.

The pygidium is only a fragment of the right pleural region showing the broad concave pygidial border crossed by pleural furrows, typical of the genus.

Identification of these specimens below the genus level must await more material.

Occurrence: Lower part of Dunderberg formation: USGS collns. 2534–CO (1 pygidium), 2535–CO (4 cranidia, 1 pygidium), Cherry Creek, Nev.

Figured specimens: USNM 143165a, b, USGS colln. 2535–CO cranidia.

Family CREPICEPHALIDAE Kobayashi

Crepicephalidae Kobayashi, 1935, p. 275.
Coosellidae Palmer, 1954, p. 727.

The Crepicephalidae, as used in this paper, is the senior synonym of the Coosellidae as originally proposed and constituted (Palmer, 1954, p. 727). The rejection of Crepicephalidae and the proposal of Coosellidae for a group of related genera including *Crepicephalus* (Palmer, 1954) was intentionally illegal according to the rules of zoological nomenclature. It was done to emphasize the point that the content and concept of the Coosellidae (legally Crepicephalidae) had no resemblance other than *Crepicephalus* to Kobayashi's original content and concept of the Crepicephalidae. This has apparently created more confusion than clarity in the field of trilobite systematics as shown by the use of both Coosellidae and Crepicephalidae as distinct families in different superfamilies in the "Treatise on Invertebrate Paleontology" (Lochman, 1959, p. 248, 309).

An attempt to formulate a rational approach to the composition of the family in trilobite classification has been made by the writer (Palmer, 1960a, p. 59). This states in essence that stratigraphy and paleogeography should play an important supplementary role to morphology in attempts to determine relationships between trilobites. Related trilobites should not only share morphologic similarity but should also come from faunas where stratigraphy and paleogeography indicate a conceivable opportunity for continuous gene flow between the supposedly related forms. Neither stratigraphy nor paleogeography appear to have been considered as factors in the assignment of genera to the Crepicephalidae and Coosellidae in the Treatise. Until the content of these families can be reviewed, which is beyond the scope of this paper, the writer considers them to represent uncritical associations of, in large part, unrelated genera.

Genus COOSIA Walcott

Coosia Walcott, 1911, p. 94; 1913, p 210. Shimer and Shrock, 1944, p. 623. Palmer, 1954, p. 730. Lochman, 1959, p. 309.

Type Species.—*Coosia superba* Walcott, 1911 (p. 94, pl. 16, figs. 1, 1a).

Diagnosis.—Crepicephalidae with cranidium having border generally longer than brim, poorly defined by broad shallow border furrow. Occipital furrow straight, narrow, of nearly constant depth.

Free cheek with short genal spine, or with genal angle bluntly rounded. Border on anterior part about equal in width to acular platform.

Hypostome and rostral plate not known.

Thorax with 12 segments. Pleural furrow of each segment situated close to anterior margin, extended from axial furrow about half length (transverse) of pleural region.

Pygidium subsemicircular in outline, axis prominent, with three ring furrows generally apparent behind articulating furrow. Terminal part of axis merged posteriorly with border. Border broad, flat, or concave, not clearly differentiated from pleural field. Pleural field crossed by one or more shallow pleural furrows and, or some species, interpleural furrows also. Posterior margin evenly rounded or with slight median indentation.

Discussion.—This diagnosis is principally that given by the writer earlier (Palmer, 1954, p. 730) with the addition of information regarding the lack of genal spines in some species and deletion of the statement regarding the shortness of the pygidial axis, which is now known to be longer than half of the pygidial length in some species.

Coosia longocula n. sp.

Plate 3, figures 17–19, 21–24, 27–29

Diagnosis.—Members of *Coosia* with cranidium having frontal area short, subequally divided into brim and border; length slightly more than three-eighths length of glabella. Fixed cheeks gently convex, horizontal; width about one-third basal glabellar. width. Palpebral lobes long, narrow, arcuate; midpoint situated slightly anterior to glabellar midlength; depressed slightly below level of fixed cheek; length averaging slightly less than three-fourths length of glabella. Anterior section of facial suture diverging forward from palpebral lobe to border, then curved inward across border to cut anterior margin about midway between anterolateral cranidial corners and axial line; ventral course not known. External surface of exoskeleton roughened on cranidia as much as 7 mm in length, granular on at least some larger cranidia; terrace lines prominent on borders of all holaspid cranidia.

Free cheek with broad well-defined border. Lateral and posterior border furrows shallow, of comparable depth, joined at genal angle. Genal spine absent, genal angle nearly a right angle. External surface of ocular platform granular; border with prominent terrace lines.

Pygidium subsemicircular in outline; length slightly greater than one-half width. Axis about one-half length of pygidium, bears three shallow straight ring furrows. Border broad, slightly concave, not clearly differentiated from pleural field. Pleural field crossed by 2 or 3 shallow pleural furrows. First interpleural furrow well developed, forms distinct pair with second pleural furrow. External surface of exoskeleton either smooth, except for terrace lines on outer part of border and poorly defined granules along sides of axis, or covered with moderately to poorly developed terrace lines.

Discussion.—The long palpebral lobes on the cranidium, combined with the short subequally divided frontal area; the lack of a genal spine on the free cheek; and the well-developed first interpleural-second pleural furrow pair on the pygidium distinguish this species from all others presently assigned to the genus. Described species with generally similar cranidial and pygidial outlines are *Coosia connata* (Walcott) and *Coosia pernamagna* Wilson. These species have palpebral lobes only about half the length of the glabella and considerably broader (exsagittal) posterior limbs on the cranidium. The pygidia either lack the well-developed first interpleural-second pleural furrow pair (*C. connata*) or have the second interpleural furrow also developed (*C. pernamagna*).

Several immature cranidia of *C. longocula* are present in USGS collns. 2475–CO and 3056–CO (pl. 3, fig. 24). These are characterized by a large low conical swelling on top of the glabella between the palpebral lobes, a depressed area across the brim on the axial line, and 2 or 3 large granules in an arcuate row paralleling the palpebral lobe on the fixed cheek. Although these features may be characteristic of *C. longocula* n. sp., it is possible that they are characteristic of immature specimens of other species of the Crepicephalidae, and they should be looked for in future collections of species in this family.

Occurrence: Upper beds of Hamburg limestone: USGS colln. 2475–CO (6 cranidia, 2 cheeks, 4 pygidia), McGill, Nev.; USGS colln. 3056–CO (13 cranidia, 5 pygidia), Cherry Creek, Nev.

Figured specimens:

USNM	*USGS colln.*	*Part*
143160	2475–CO	Holotype cranidium.
143161a	2475–CO	Free cheek.
143161b, c, e	2475–CO	Pygidia.
143161d, f	2475–CO	Cranidia.
143162a, b	3056–CO	Cranidia.
143162c	3056–CO	Pygidium.

Coosia sp.

Plate 3, figures 25, 26

A second species of *Coosia* is represented by pygidia that are relatively broader and have a longer axis and a narrower border than *C. longocula.* A free cheek with a short genal spine and fragmentary cranidia that seem to have a relatively longer border than *C. longocula* are associated with them. Because samples of both this species and *C. longocula* are small and because specimens of both species are present in USGS colln. 2475–CO, the possibility that all the specimens represent a single species cannot be completely eliminated. The free cheeks with genal spines are smaller than the specimens of *C. longocula* that lack spines, and they lack a distinct granular ornament as do the smaller *C. longocula* cranidia. This could be interpreted as indicating a loss of the genal spine during development. However, small pygidia having the characteristics of each species (pl. 3, figs. 25, 27, 28) indicate that the pygidial features are not related to differing ontogenetic stages. Furthermore, the differences may be population differences because USGS colln. 2474–CO contains only specimens of *Coosia* sp., and colln. 3056–CO contains only specimens of *C. longocula.* Until more specimens of *Coosia* sp. are collected to determine the form of the cranidium and of larger free cheeks, the species cannot be adequately described or compared to known species, although the specimens described above are tentatively considered to represent a species distinct from *C. longocula.*

Occurrence: Upper beds of Hamburg limestone: USGS collns. 2474-CO (7 pygidia, 1 free cheek), 2475-CO (1 pygidium, 1 free cheek); McGill, Nev.

Figured specimens:

USNM	*USGS colln.*	*Part*
143163	2474-CO	Pygidium.
143164	2475-CO	Free cheek.

Family KINGSTONIIDAE Kobayashi

Genus KINGSTONIA Walcott

Kingstonia Walcott, 1924, p. 58; 1925, p. 103. Resser, 1936, p. 24. Shimer and Shrock, 1944, p. 627. Shaw, 1952, p. 471. Tasch, 1952, p. 859. Lochman 1953, p. 886. Palmer, 1954, p. 724.
Ucebia Walcott, 1924, p. 60; 1925, p. 118.

Type species.—Kingstonia apion Walcott, 1925 (p. 103, pl. 16, figs. 27–28a).

Discussion.—This genus has been discussed in recent years by Shaw (1952), Tasch (1952), Lochman (1953), and Palmer (1954). Although there is difference of opinion about the advisability of recognizing subgenera within *Kingstonia,* there is general agreement that the small nearly featureless trilobites from rocks of Dresbach age, with subhemispherical cranidia bearing bluntly rounded or pointed posterior limbs and with or without a narrow border, are congeneric. The specimens here discussed provide no new information on the subgeneric problem.

Kingstonia alabamensis Resser

Plate 6, figures 11, 12

Kingstonia alabamensis Resser, 1938, p. 84, pl. 12, fig. 8.

Cranidia of this species are characterized by long pointed posterior limbs and a narrow border bearing terrace lines. A single almost completely exfoliated pygidium is also present in the type lot. It has a distinctly subtriangular outline, at least eight axial segments, and downsloping rather than depressed lateral parts to the pleural regions. Until the content of *Kingstonia* can be thoroughly reviewed, which is beyond the scope of this paper, comparison of *K. alabamensis* with other species in the genus will have little meaning.

Occurrence: Conasauga formation: USNM loc. 90b (7 cranidia, 1 pygidium), Woodstock, Ala.
Figured specimens: Holotype cranidium and associated pygidium, USNM 94939, USNM loc. 90b.

Family LEIOSTEGIIDAE? Bradley

Genus KOMASPIDELLA Kobayashi

Komaspidella Kobayashi, 1938, p. 174. Raasch and Lochman, 1943, p. 226. Lochman, 1959, p. 315

Type species.—Agraulos? thea Walcott, 1890 (p. 277).

Diagnosis.—Small Leiostegiidae(?) with cranidium subtrapezoidal in outline, gently to moderately convex transversely and longitudinally, gently rounded anteriorly. Glabella prominent, subparallel sided, bluntly to evenly rounded anteriorly, well defined by narrow axial and preglabellar furrows of constant depth. Glabellar furrows hardly apparent. Occipital furrow narrow, deep, of constant depth. Occipital ring short (sagittal) not noticeably tapered distally; low, poorly defined median node present. Frontal area short (sagittal), strongly convex, undivided; length less than one-tenth length of glabella. Fixed cheeks flat to moderately convex, horizontal or slightly downsloping; width, exclusive of palpebral lobes, less than half basal glabellar width. Palpebral lobes moderately to poorly defined, narrow, depressed slightly below surface of cheek, situated slightly posterior to glabellar midlength; length between ⅓ and ½ length of glabella. Posterior limbs narrow, tapered slightly distally; posterior border furrow deep, narrow.

Hypostome, rostral plate, free cheeks, and thoracic segments not known.

Pygidium subtriangular in outline, moderately to strongly convex transversely and longitudinally. Axis well defined, prominent, tapered evenly backward, strongly rounded at posterior end, reaching nearly to posterior margin. Axial segments numerous, short, poorly defined except at anterior end of axis. Pleural regions downsloping near axis, depressed at lateral margins. Border, if present, narrow, poorly defined. Pleural fields smooth or crossed by shallow close spaced pleural and interpleural furrows of nearly equal depth. Posterior band of first pleural segment generally continued across poorly defined border as low narrow ridge. Margin smooth.

External surface of exoskeleton smooth or pitted.

Discussion.—The placement of this distinctive genus in the Leiostegiidae (Lochman, 1959) is only provisionally accepted. Although *Komaspidella* conforms to the present diagnosis of the family, not enough is known of the morphology of the genus to ascertain adequately its relationship to the Early Ordovician genus *Leiostegium.* No known American trilobite of Dresbach age can be confused with *Komaspidella.* The most similar genus is *Ataktaspis* (Lochman and Duncan, 1944) from the *Crepicephalus* zone in Montana; *Ataktaspis,* however, has a pygidium with a long terminal axial spine and a cranidium with a bluntly pointed anterior margin.

In the redescription of *Komaspidella* (Raasch and Lochman, 1943, p. 226), the outer surface of the exoskeleton was stated to be "probably granulated." Because the external surface of *K. occidentalis* n. sp. is smooth, it was important to learn if ornament might be of value in the systematics of species of *Komaspidella*. Collections of the two described species, *K. thea* (Walcott) and *K. seeleyi* (Walcott) in the U.S. National Museum, were examined and latex casts were made of cranidia and pygidia of both species, which are known only from sandstone molds. Several specimens of *K. seeleyi* showed a definite surface ornament of coarse shallow pits, but no granulation was apparent. The sand matrix around all known specimens of *K. thea* is too coarse to permit determination of the nature of the external surface. Granules on *Lonchocephalus chippewaensis* Owen, known from siltstone preservation, are not apparent on specimens of this species associated with *K. thea* in a sandstone matrix. Thus, there is no present evidence for a granular surface of the exoskeleton for any species of *Komaspidella*.

The principal characteristics for species discrimination within *Komaspidella* seem to be the development of ring furrows, pleural and interpleural furrows on the pygidium, and presence or absence and degree of definition of a border on the pygidium. Glabellar shape and degree of convexity of the fixed cheeks of the cranidium are less definitive supplemental characteristics.

Komaspidella occidentalis n. sp.

Plate 6, figures 6, 7

Diagnosis.—Members of *Komaspidella* with cranidium having fixed cheeks nearly flat, slightly downsloping. Pygidium with only one distinct ring furrow behind articulating furrow. Pleural fields with poorly developed pleural and interpleural furrows. Border present, poorly defined, crossed by narrow ridges of the posterior bands of the first two pleural segments. External surface of exoskeleton smooth.

Discussion.—This species differs from *K. thea* (Walcott) and *K. seeleyi* (Walcott) by having less convex fixed cheeks and a slightly more slender glabella on the cranidium. The pygidium has 1 distinct ring furrow behind the articulating furrow, rather than 2 or more, and ridges from more than one posterior band of the anterior pleural segments of the pygidium crossing the border. The border is intermediate in definition between *K. seeleyi*, which has a well-defined border and *K. thea* which lacks a definite border. *K. seeleyi* also lacks any trace of pleural and interpleural furrows on the pleural fields.

Komaspidella loperi (Resser), described as a species of *Kingstonia* by Resser (1942, p. 50) is known only from pygidia. It differs from all of the species discussed above by lacking a border and by lacking ring furrows posterior to the articulating furrow.

Occurrence: Upper beds of Hamburg limestone: USGS collns. 2474–CO (1 cranidium, 3 pygidia), 2475–CO (2 cranidia, 6 pygidia), McGill, Nev.; USGS colln. 3056–CO (1 pygidium), Cherry Creek, Nev.

Figured specimens:

USNM	*USGS colln.*	*Part*
143194	2475–CO	Holotype pygidium.
143195	2475–CO	Cranidium.

Family MENOMONIIDAE Walcott

Genus DEIRACEPHALUS Resser

Deiracephalus Resser, 1935, p. 21.
Asteraspis Kobayashi, 1935, p. 224.

Description.—Cranidium subtrapezoidal in outline, moderately to strongly arched transversely and longitudinally; length as much as about 10 mm. Glabella prominent, tapered forward, bluntly rounded anteriorly, well defined by axial and preglabellar furrows; length slightly more than half that of cranidium. Occipital ring generally with strong median spine, usually directed upward; however, a long axial glabellar spine may be present in place of the occipital spine. Frontal area divided into distinct brim and border; anterolateral corners depressed. Strong median ridge extends forward from preglabellar furrow, broadening anteriorly and merging with border. Brim wider than border. Fixed cheeks upsloping, breadth three-fourths or less basal glabellar width. Palpebral lobes small, situated opposite or slightly posterior to glabellar midlength, at highest point of fixed cheek. Posterior limbs about equal in length (transverse) to basal glabellar width, tapered to point. Posterior marginal furrow deep throughout length of posterior limb. External surface smooth or with 1 or 2 sizes of granules on all parts.

Free cheeks, thorax, pygidium, rostral plate and hypostome unknown.

Discussion.—The discovery of the species described below has required modification of statements in the original generic diagnosis (Resser, 1935, p. 21) concerning structure of the occipital ring. Also, a free cheek in the type lot of *D. aster* (Walcott) cited by Resser (1935) for its faceted eye surface, does not fit the cranidium of this species and is probably not the cheek of a species of *Deiracephalus*.

In the type lot of *D. multisegmentus* (Walcott), the nearly complete specimen figured by Walcott (1916, pl. 24, fig. 5a) for this species has palpebral lobes situated on elevated fixed cheeks, close to and opposite the anterior end of the glabella. This specimen probably represents a species of *Densonella*. The cranidium in figure 5 (Walcott, 1916) is properly referable to *Deiracephalus*.

Deiracephalus unicornis n. sp.

Plate 6, figures 1–4

Diagnosis.—Members of *Deiracephalus* with long strong backswept median spine developed from upper surface of glabella just in front of occipital furrow.

Occipital ring narrow, without median spine. External surface of exoskeleton bears scattered small granules.

Discussion.—This remarkable species is represented only by imperfect cranidia. Nevertheless, the glabellar shape, upsloping fixed cheeks and indication of a median ridge on the brim of one specimen support the identification of the specimen as a species of *Deiracephalus*. No other species of the genus, and in fact, no other American Upper Cambrian trilobite has a strong spine developed from the top of the galbella in front of the occipital furrow.

Since this description was prepared, many cranidia of this species have been observed in collections made by C. H. Kindle and H. B. Whittington from boulders in the Cow Head conglomerate, western Newfoundland.

Two cranidia with the glabellar spine characteristic of this species but with a narrower glabella are present in USGS colln. 3056–CO associated with *Cedaria brevifrons* n. sp. (pl. 6, fig. 4).

Occurrence: Conasauga formation: USNM loc. 90b (1 cranidium), USGS colln. 2886–CO (2 cranidia), Woodstock, Ala.

Figured specimen:

USNM	*USGS colln.*	*Part*
143189	2886–CO	Holotype cranidium.
143190	3056–CO	Cranidium.

Family PTEROCEPHALIIDAE Kobayashi

Diagnosis.—Subisopygous opisthoparian ptychoparioid trilobites with cephalon generally gently to moderately convex transversely and longitudinally. Glabella straight sided, tapered forward, bluntly rounded or truncate anteriorly. Axial furrows deeper than preglabellar furrow. Shallow fossulas developed on many species. Lateral glabellar furrows generally shallow or absent; when present, either straight or slightly bigeniculate. Occipital furrow generally present. Occipital ring of most species with median node; median occipital spine rare. Frontal area generally divided into distinct brim and border. Width of palpebral area more than one-fourth basal glabellar width; eye ridges generally poorly developed. Palpebral lobes arcuate, situated opposite middle third of glabella. Posterior limbs slender, sharp pointed; posterior border furrow nearly straight.

Anterior section of facial suture straight forward or slightly divergent from front of palpebral lobe to border, then curved inward to cut anterior margin more than one-half distance from anterolateral corners of cranidium to axial line. Rostral suture, when present, barely submarginal. Connective sutures convex towards axial line, joined to form median suture only in later members of family. Posterior section of facial suture invariably divergent sinuous, cuts posterior margin of cephalon adaxial to base of genal spine.

Hypostome with poorly differentiated median body and posterior lobe. Lateral border generally well defined, narrow. Posterior border poorly defined or absent and, when present, narrow.

Rostral plate, when present, subtrapezoidal to subtriangular in outline, with concave sides (pl. 6, figs. 15–19).

Free cheek with border generally well developed. Genal spine present, lateral margin continuous with margin of main part of cheek. Eye surface on all known specimens separated from ocular platform by infraocular ring.

Thorax of 12 to 13 segments. Axis moderately to strongly convex transversely, generally prominent.

Pygidium with prominent posteriorly tapered axis, moderately to strongly convex transversely and raised above pleural regions. Width of axis generally less than width of pleural region. Border generally poorly defined, on most specimens narrowed behind axis. Pleural field with pleural furrows, when developed, broader and deeper than interpleural furrows.

Discussion.—The arrangement of the trilobites grouped here in the Pterocephaliidae is in accordance with principles outlined earlier (Palmer, 1960a, p. 59). Differences in assignment of some genera from those given in Harrington and others (1959) result from restudy of the trilobites concerned and from new information about their morphology and stratigraphic relationships. American trilobites sharing the characteristics given in the diagnosis are: *Aphelaspis* Resser (synonyms *Proaulacopleura* Kobayashi, *Labiostria* Palmer), *Blandicephalus* Palmer, *Cernuolimbus* Palmer, *Listroa* n. gen., *Litocephalus* Resser (synonym *Pterocephalina* Resser), *Olenaspella* Wilson, *Pterocephalia* Roemer, *Pterocephalops* Rasetti, *Sigmocheilus* Palmer, and *Taenora* Palmer. Some foreign genera, particularly *Eugonocare* Whitehouse from Australia, *Olentella* Ivshin from Kazakhstan, Russia, and *Nericia* Westergard from the late Middle Cambrian of Sweden, seem to belong to this family. *Maladioidella* Endo from the Upper Cambrian of Manchuria has a cranidium characteristic of the Pterocephaliidae, but a pygidium atypical of the group and is questionably retained in the family. *Pedinocephalus* Ivshin, from the Upper Cambrian of Kasakhstan, Russia, has peculiar concave sides to the glabella but might also belong to the Pterocephaliidae.

Six of the genera included in the Pterocephaliidae by Lochman (1959) are removed or retained in the family uncritically for reasons given below. *Dikelocephalites* Sun and *Iranella* Hupé could not be restudied and available illustrations and descriptions do not allow proper evaluation of their characteristics. They appear similar to some Pterocephaliidae and are retained in the family with the understanding that until they can be critically restudied their family relationships are really uncertain.

Kazelia Walcott and Resser is represented by distorted cranidia having a downsloping convex frontal area with a poorly defined border. This is structurally unlike any genera here retained in the Pterocephaliidae. The type species, *K. speciosa* Walcott and Resser, is too poorly preserved to be critically compared to other trilobites. Its position in a suprageneric classification is not at the moment satisfactorily determinable.

Camaraspis Ulrich and Resser and *Camaraspoides* Frederickson are represented by nearly smooth cranidia, moderately convex transversely and longitudinally, with downsloping frontal area and fixed cheeks, posteriorly placed poorly defined palpebral lobes, and short posterior limbs. These characteristics are unlike those of any other Pterocephaliid genus, and these genera probably represent another family as yet undetermined.

Dytremacephalus Palmer has a narrow convex border and glabellar shape suggestive more of the Elviniidae (Palmer, 1960a, p. 64), where it is tentatively placed, than the Pterocephaliidae.

The family of trilobites most closely related to the Pterocephaliidae is the Olenidae. *Olenus* (s. s.) has many features in common with older genera of the Pterocephaliidae, particularly in the structure of the pygidium—cf. *Olenaspella separata* n. sp. with *Olenus gibbosus* (Wahlenberg) and *O. transversus* Westergard. However, the totality of characters of the Olenidae, particularly with regard to the development of the glabellar furrows, shape of the glabella and size and position of the palpebral lobes, distinguish the Olenidae, which seem to be dominant in the early Upper Cambrian principally in the North Atlantic region, from the Pterocephaliidae, which dominate partly contemporaneous deposits on the southern and western margins of Cambrian North America. (Compare illustrations of Olenidae in Henningsmoen, 1957, with those of Pterocephaliidae, Palmer, 1960a, and this paper.)

Subfamily APHELASPIDINAE Palmer

Diagnosis.—Pterocephaliid trilobites with border on cephalon commonly well defined, convex (sagittal); less commonly flat or slightly concave. Pygidium with border subequal in width or narrower than pleural field; always narrowest behind axis. Margin with or without spines.

Discussion.—The diagnosis given above is modified slightly from that originally given (Palmer, 1960a, p. 80) to include *Olenaspella* Wilson from North America, *Eugonocare* Whitehouse from Australia, and *Nericia* Westergård from Sweden which have somewhat narrower pygidial borders than the genera previously included. At some later date it may be preferable to remove these genera to a separate subfamily, but aside from their pygidial features they agree fully with other genera in the Aphelaspidinae. As the subfamily now stands, it includes: *Aphelaspis* Resser, *Eugonocare* Whitehouse, *Litocephalus* Resser, *Nericia* Westergård, *Olenaspella* Wilson, and *Taenora* Palmer.

Genus APHELASPIS Resser

Aphelaspis Resser, 1935, p. 11. Shimer and Shrock, 1944, p. 619. Palmer, 1954, p. 643. Ivshin, 1956, p. 31. Lochman 1959, p. 256.
Proaulacopleura Kobayashi, 1936, p. 93. Howell, 1959, p. 269.
Clevelandella Resser, 1938, p. 68.
Labiostria Palmer, 1954, p. 750. Lochman, 1959, p. 258.

Type species.—*Aphelaspis walcotti* Resser, 1938 (p. 59, pl. 13, fig. 14). (See Palmer, 1953, p. 157, for discussion.)

Diagnosis.—Aphelaspidinae with border furrow on cranidium present or absent. Glabella generally without well defined lateral furrows. Free cheek with lateral and posterior border furrows, when present, joined at genal angle, extended short distance onto base of genal spine.

Thorax with 13 segments.

Pygidium transverse subovate in outline. Axis with 1 to 5 ring furrows posterior to articulating furrow. Pleural regions with pleural furrows hardly apparent on most specimens. Border poorly defined, narrowest at axial line, broadens laterally. Posterior margin smooth, evenly curved or slightly angular at posterolateral corners.

Description.—Small- to medium-sized aphelaspinid trilobites (greatest length about 40 mm). Cranidium with glabella straight sided, tapered forward, bluntly rounded or truncate anteriorly; lateral glabellar furrows generally shallow, straight, obscure. Occipital furrow shallow, always present across axial line. Occipital ring with small median node or spine. Frontal area divided into brim and border. Border furrow present or absent. Length of border variable. Fixed cheeks horizontal or slightly upsloping; width about one-half or less basal glabellar width; palpebral lobes moderately to poorly defined by shallow arcuate palpebral furrow, situated about opposite midlength of glabella; eye ridge generally low, poorly defined. Posterior limbs long, narrow, tapered to sharp points; posterior border furrow moderately deep.

Free cheek with lateral and posterior border furrows, when present, joined at genal angle and extended onto long, slender genal spine.

Anterior section of facial sutures slightly divergent forward from palpebral lobes to border furrow, then curved sharply inward across border to cut anterior margin about two-thirds distance from anterolateral cranidial corners to axial line. Connective sutures curved towards axial line but cut margin of doublure before reaching axial line, outlining subtriangular to subtrapezoidal concave-sided rostal plate. Posterior section of facial sutures divergent sinuous.

Hypostome without distinctive generic characteristics.

Thorax with 12 or 13 segments; axis narrower than pleural lobes; pleural tips of each segment short, sharp.

Pygidium transversely subovate in outline with posterior margin smoothly curved or slightly angular posterolaterally, with or without median inbend. Axis prominent, tapered posteriorly, reaches to inner edge of poorly defined border that is narrowest on axial line; 1 to 5 ring furrows apparent behind articulating furrow. Pleural regions with shallow, generally obscure pleural furrows.

Discussion.—From study of abundant material of early Aphelaspidinae from Nevada, it has become increasingly apparent that the characteristics of *Aphelaspis, Labiostria,* and *Proaulacopleura* overlap sufficiently to prevent satisfactory recognition of three distinct taxa. The classification adopted here groups together in *Aphelaspis* all Aphelaspidinae with simple pygidia that lack either marginal spines or a median notch. *Labiostria* and *Proaulacopleura* are considered subjective synonyms of *Aphelaspis.* Species are definable on characteristics of the border furrow of the cephalon, structure of the free cheek, development of ring furrows on the axis of the pygidium, and details of length of the cephalic border and pygidial shape.

Clevelandella Resser, although represented only by molds of cranidia in shale, is most likely a synonym of *Aphelaspis.* Not enough is known of the type species, *Saratogia aruno* Walcott, to define it or to compare it adequately with other species of *Aphelaspis.*

The genus as defined above includes 10 described American species: *Aphelaspis walcotti* Resser (synonym *A. hamblenensis* Resser), *A. quadrata* Resser (synonym *A. laxa* Resser(?)-only cranidia known), *A. simulans* Resser, *A. haguei* (Hall and Whitfield), *A. buttsi* (Kobayashi), *A. constricta* Palmer, *A. conveximarginatus* (Palmer), *A. longifrons* Palmer, *A. spinosus* Palmer, and *A. brachyphasis* n. sp.

Aphelaspis tumifrons Resser, previously considered a distinct species of *Aphelaspis* (Palmer, 1954, p. 744), differs from all other aphelaspid trilobites by having anteriorly placed poorly defined palpebral lobes. It probably represents a new genus related to the Housiidae.

Aphelaspid cranidia lacking a border furrow are at present found only among species of *Aphelaspis.* Cranidia of species of *Aphelaspis* that have a border furrow cannot be consistently distinguished from those of *Litocephalus* and *Olenaspella* in the absence of associated pygidia.

Aphelaspis brachyphasis n. sp.

Plate 4, figures 1–19

Diagnosis.—Members of *Aphelaspis* with cranidium having a length of frontal area about six-tenths length of glabella exclusive of occipital ring. Border slightly downsloping, flat or very gently convex; length (sagittal) variable, generally between ½ and ¾ length (sagittal) of brim. Border furrow hardly apparent. Palpebral lobe hardly defined by palpebral furrow. Free cheek with broad-based genal spine tapered rapidly to sharp point.

Pygidium transversely subovate in outline with sharply rounded lateral margins and slight median indentation behind axis. Axis well defined, bearing 1 or 2 distinct ring furrows posterior to articulating furrow. A much shallower additional ring furrow apparent on some specimens. Border poorly defined, variable in width from ⅓ to ⅙ that of pleural region.

Discussion.—This species is represented by abundant silicified specimens of all parts in USGS colln. 2466–CO, as well as many limestone specimens. One of the most unusual features is the variability in width of the doublure of the pygidium (pl. 4, figs. 6–10, 16, 17). Specimens with the widest doublure (pl. 4, figs. 9, 10) have a broad slightly concave border. Specimens with the narrowest doublure (pl. 4, figs. 6, 7) have a relatively narrow, slightly downsloping border. In a small sample these differencies might be thought to be specific; however, a complete series of specimens showing gradual changes in the breadth of the doublure between the two extremes is present in the silicified sample. The gradational series in one size class rules out the possibility that this is a dimorphic character. The full range of variation among pygidia of all sizes, rules out the possibility that this is an ontogenetic character. The variation seems to be merely a more striking example than usual of intraspecific variability.

A. brachyphasis is most similar to *A. walcotti* Resser from which it differs primarily by having a consistently shorter frontal area. More than 30 cranidia covering all holaspid sizes in the type lot of *A. walcotti* and in the silicified sample of *A. brachyphasis* were compared for this character. Regressions for length of frontal area against length of glabella for both species (fig. 13) show the difference to be significant. Although this could be a geographic difference, the Nevada specimens are apparently older than the Virginia specimens (table 1), and the populations are here considered to represent different species.

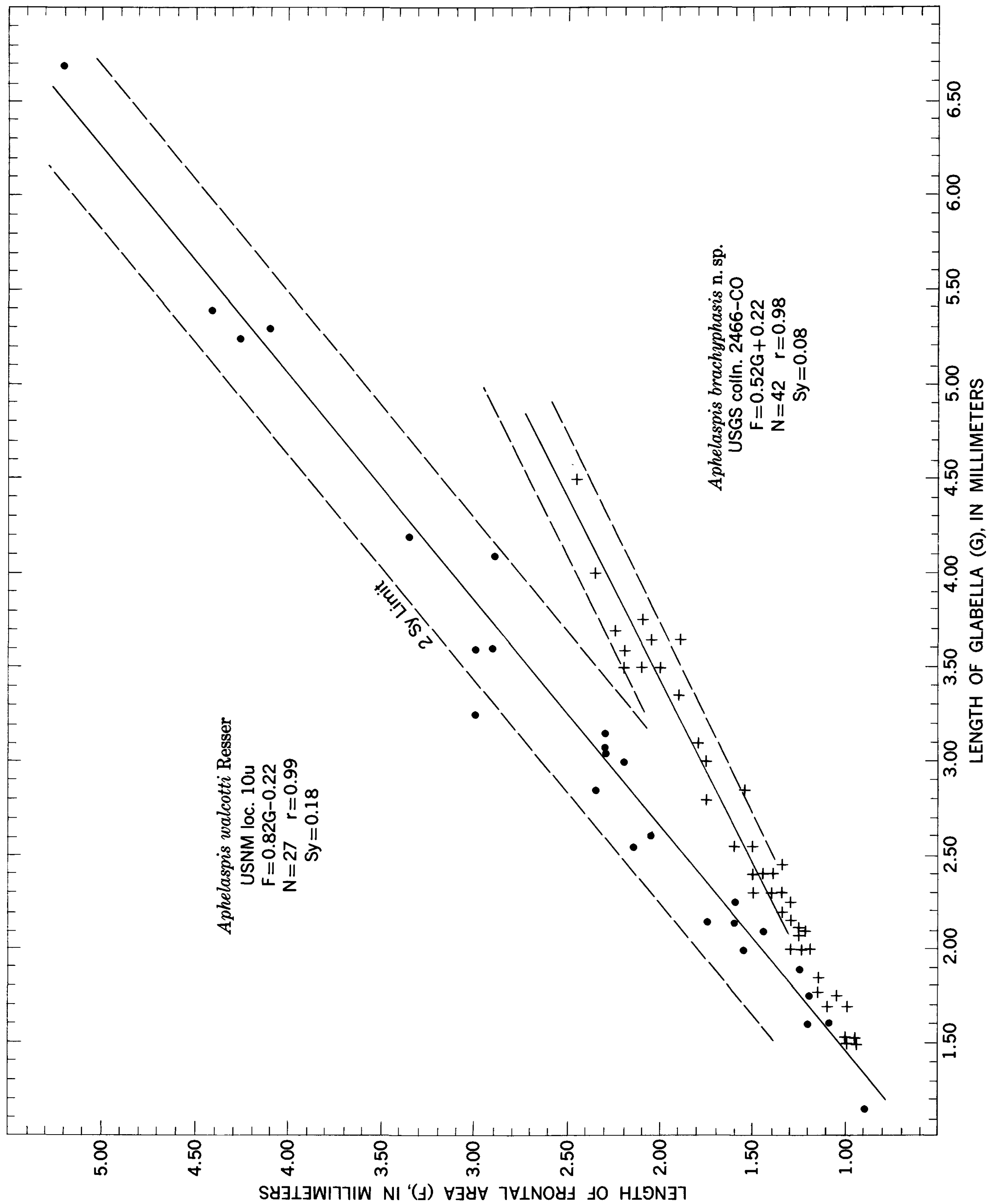

FIGURE 13.—Comparison of length of frontal area to length of glabella for the type lots of *Aphelaspis walcotti* Resser and *A. brachyphasis* n. sp.

A cranidium, free cheek, and pygidium from the type lot of *A. walcotti* Resser are illustrated (pl. 4, figs. 23, 28, 33) for comparison with *A. brachyphasis*.

Occurrence: Lower part of Dunderberg formation: USGS collns. 2466–CO, 2477–CO, 2478–CO, 2479–CO, 2480–CO, 3020–CO, 3041–CO, 3043–CO, 3044–CO, 3045–CO, 3046–CO, 3049–CO, 3050–CO, 3051–CO, 3052–CO, 3053–CO, 3054–CO, 3055–CO (all collections except 2477–CO, 3040–CO, and 3051–CO have more than 20 specimens), McGill, Nev. USGS colln. 1374–CO (more than 20 specimens), Hot Springs Range, Nev.

Figured specimens:

USNM	*USGS colln.*	*Part*
143168	2466–CO	Holotype cranidium.
143169a	2466–CO	Cranidium.
143169b	2466–CO	Free cheek.
143169c, d	2466–CO	Thoracic segments.
143169e–i	2466–CO	Pygidia.
143169j, k	2466–CO	Hypostomes.
143170a	2478–CO	Free cheek.
143170b	2478–CO	Cranidium.
143170c	2478–CO	Pygidium.
143171	2479–CO	Thorax and pygidium.
143172a	3055–CO	Cranidium.
143172b, c	3055–CO	Pygidia.

Aphelaspis buttsi Kobayashi

Plate 4, figures 23, 26, 31, 32

Olenus cf. *O. truncatus* Butts, 1926, p. 77, pl. 9, figs. 6, 7.
Proaulacopleura buttsi Kobayashi, 1936, p. 93, pl. 15, fig. 6. Resser, 1938, p. 95, pl. 16, fig. 18.

Diagnosis.—Members of *Aphelaspis* with cephalon bearing long slender genal spines reaching nearly to posterior end of thorax on largest specimens; length from point where posterior section of facial suture cuts cephalic margin to tip of genal spine twice or more length of posterior section of facial suture. Eye ridges directed laterally at right angle to axial line. Posterior pair of lateral glabellar furrows moderately well impressed, straight, inclined posteriorly. Border furrow evenly curved. Free cheek with lateral and posterior border furrows barely extended onto genal spine.

Thorax with 13 segments, each with short sharp posterolaterally directed pleural spines.

Pygidium with length slightly less than half width. Three ring furrows present on axis posterior to articulating furrow. Pleural fields with 3 or 4 shallow pleural furrows, and shallow pleural grooves between first, second, and sometimes third pleural segments. Furrows and grooves do not extend onto border. Border narrow, breadth one-sixth or less breadth of pleural region.

Discussion.—The short broad pygidium with a narrow border, the long genal spines, and the moderately well defined cranidial border and glabellar furrows are the most distinctive characters of this species. It has the narrowest pygidial border of any species assigned to *Aphelaspis*

Several complete individuals from Cedar Bluff, Ala., show the form of the rostral plate for this species (pl. 6, fig. 15), which is mainly like that determined for *Aphelaspis* by reconstructing the cephalic doublure using well-preserved free cheeks (Palmer, 1960a, fig. 8e, p. 64). Preparation of cranidia and free cheeks of *Olenus gibbosus* Wahlenberg from Westergotland, Sweden, shows that this species had a rostral plate comparable to that of *Aphelaspis buttsi*.

Occurrence: Lowermost beds of Dunderberg formation: USGS colln. 2476–CO (19 cranidia, 8 free cheeks, 18 pygidia), McGill, Nev. Conasauga formation: USGS collns. 2875–CO (1 complete specimen, 4 cranidia, 1 free cheek, 5 pygidia), 2876–CO (6 cephala, 1 free cheek), USGS colln. 2878–CO = USNM loc. 91o (30 specimens showing all parts), Cedar Bluff, Ala.

Figured specimens:

USNM	*USGS colln.*	*Part*
143176a	2476–CO	Cranidium.
143176b	2476–CO	Pygidium.
143176c	2476–CO	Free cheek.
143197	USNM loc. 91o	Complete individual.

Aphelaspis subditus n. sp.

Plate 4, figures 20–22, 25

Diagnosis.—Members of *Aphelaspis* with cranidium having lateral glabellar furrows lacking on outer surface of exoskeleton. Eye ridges directed laterally nearly at right angles to axial line. Border furrow present, evenly curved. Length of border between ½ and ¾ length of brim (sagittal).

Free cheek with lateral and posterior border furrows well defined, joined at genal angle, hardly extended onto genal spine. Genal spine long, slender, reaching to about fifth thoracic segment.

Thorax with 12 segments. Pleural tips curved slightly, pointed, directed posterolaterally.

Pygidium with 2 or 3 ring furrows on axis posterior to articulating furrow. Border barely defined, narrow, horizontal or slightly downsloping; breadth ¼ to ⅕ that of pleural region. Pleural fields without distinct pleural furrows or with first pair moderately developed. Posterior margin with slight median indentation.

Discussion.—This species differs from *A. buttsi* (Kobayashi) by having both glabellar and pygidial furrows much less well developed, shorter genal spines, and a relatively broader less well defined pygidial border. It differs from *A. brachyphasis* n. sp. by having a well-defined border furrow on the cranidium and free cheeks, longer and more slender genal spines, and generally one more ring furrow on the axis of the pygidium.

Occurrence: Lower part of Dunderberg formation: USGS collns. 2471–CO (8 cranidia, 4 pygidia), 2534–CO (2 cranidia, 2 pygidia), 2535–CO (20 specimens), Cherry Creek, Nev. Uppermost beds of Swarbrick formation: USGS collns. 3057–CO, 3058–CO, 3059–CO (each with > 20 specimens), Tybo, Nev.

Figured specimens:

USNM	*USGS colln.*	*Part*
143173	2535–CO	Holotype cranidium.
143174a	2535–CO	Pygidium.
143174b	2535–CO	Cranidium.
143175	Mount Hamilton district.	Complete specimen.

Aphelaspis sp. undet.

Plate 4, figures 27, 29

Cranidia and pygidia associated with *Blountia bristolensis* Resser at Cedar Bluff, Ala., represent a species of *Aphelaspis* with a border furrow on the cranidium. The specimens are crushed, so that accurate specific determination is not possible. However, the fixed cheeks appear narrower, and the palpebral lobes appear somewhat more posteriorly placed than on *A. buttsi.* The pygidium appears to have a slightly wider and less well defined border.

The cranidia resemble *A. subditus* n. sp. more closely than *A. buttsi* in structure of the fixed cheeks, but the pygidia have much better defined axial and pleural furrows than *A. subditus.* The specimens are illustrated here for comparison with other *Aphelaspis* species.

Occurrence: Conasauga formation, 2879–CO (12 cranidia, 3 free cheeks, 4 pygidia), Cedar Bluff, Ala.

Figured specimens:

USNM No.	*USGS colln.*	*Part*
143177a	2879–CO	Cranidium.
143177b	2879–CO	Pygidium.

Genus OLENASPELLA Wilson

Olenaspella Wilson, 1956, p. 1344.

Type species.—*Parabolinella*? *evansi* Kobayashi, 1936 (p. 92, pl. 15, figs. 7, 8, 10).

Diagnosis.—Aphelaspidinae with cephalon having border well defined by narrow border furrow. Free cheek with lateral and posterior marginal furrows joined at genal angle, extended slightly onto base of genal spine. Pygidium transversely subovate to subsemicircular in outline, with axis prominent, generally bearing three or more ring furrows posterior to articulating furrow. Pleural fields flat or gently convex transversely with 3 or 4 broad shallow pleural furrows apparent. Interpleural grooves may be present between first, second, and third pleural segments. Border narrow, poorly defined; margin bears 1 to 3 pairs of slender posteriorly directed spines, anteriormost pair always present, developed from first pygidial segment.

Description.—Small- to medium-sized opisthoparian ptychoparioid trilobites (estimated maximum length about 60 mm) with cephalon subsemicircular in outline, bearing distinct slender genal spines.

Cranidium gently to moderately convex transversely and longitudinally. Outline, exclusive of posterior limbs, subquadrate, width between facial sutures at palperbral lobes about equal to length.

Glabella tapered forward slightly, truncate anteriorly, gently convex longitudinally, moderately convex transversely; sides straight or slightly bowed outward. Axial furrow shallow, distinct, of nearly constant depth, or shallowed slightly at contact with eye ridge. Two pairs of shallow nearly straight oblique lateral glabellar furrows present; posterior pair most distinct, deepest towards axial line. Occipital furrow well defined, shallow across axial line, deepest between axial line and axial furrow, not connected to axial furrow. Occipital ring without ornament or with low median node.

Frontal area with well-defined brim and border. Border flat or gently to moderately convex (sagittal). Width (sagittal) about one-half or less that of brim. Border furrow shallow to moderately deep, of constant depth. Brim gently arched (sagittal).

Fixed cheeks horizontal or gently upsloping; width (excluding palpebral lobes) between ⅓ and ½ basal glabellar width. Palpebral lobes prominent, arcuate, moderately well defined by shallow arcuate palpebral furrow; length on mature specimens from ⅜ to about ½ length of glabella. Eye ridge barely apparent on most specimens, extending across cheek at nearly right angle to axial line.

Posterior limbs narrow, tapered to sharp point. Posterior border furrow well defined, moderately deep. Posterior margin straight near glabella, angled slightly backward beyond point where tip of limb begins to slope downward.

Posterior section of facial sutures divergent sinuous; anterior section divergent straight from palpebral lobe to border furrow, then curved abruptly toward axial line and continued straight across border to cut anterior margin at slight angle about four-fifths of distance from lateral corner of cranidium to axial line. Connective sutures converge posteriorly to cut posterior margin of doublure near axial line. Rostral suture straight, nearly marginal.

Rostral plate subtrapezoidal in outline, narrowing posteriorly, with concave sides.

Hypostome moderately to strongly convex transversely and longitudinally. Anterior margin nearly straight near axial line, abruptly curved back to anterior wing. Anterior border concave (sagittal). Middle body not divided into anterior and posterior lobes. Middle furrow apparent only adjacent to lateral furrow. Anterior wings slender, tapered to sharply rounded tips with single prominent wing process shown by dimple in outer surface. Lateral border well defined by lateral furrow. No posterior marginal furrow or border. Posterior wings prominent, directed nearly vertically, tapered to sharp point. Doublure hardly present at axial line along posterior margin.

Free cheek with lateral margin gently to moderately curved, merged imperceptibly with margin of genal spine. Genal spine slender, tapered to sharp point. Lateral and posterior border furrows moderately well defined, connected and extended for short distance onto base of genal spine, nearer to inner than outer margins of spine. Inner spine angle greater than 90°. Anterior projection of cheek long, slender; doublure broadest opposite point where facial suture reaches anterior margin, then tapered to a sharply rounded point along inner margin.

Thorax of 12 or 13 segments, length and width about equal; axis narrower than pleural regions. Pleural furrow distinct, not extended onto pleural spine.

Pygidium with axis well defined, tapered posteriorly; profile flat or slightly upturned at posterior end. Length of axis generally more than eight-tenths length of pygidium. Articulating furrow and 2 to 4 ring furrows generally distinct, extending across axis; 1 or 2 incomplete additional ring furrows sometimes apparent. Outline of articulating half ring generally present on first axial ring. Pleural regions flat or gently arched transversely; width equal to or as much as about 1½ times broader than width of axis. Two, or more commonly 3 or 4, broad, shallow pleural furrows apparent, abruptly curved backward distally. Interpleural furrows may be apparent between first, second, and third pleural segments. Border narrow, poorly defined; width one-fourth or less that of pleural region. Margin bears one or more pairs of posteriorly directed spines, outer pair generally longest. Marginal spines always developed from first pygidial segment. Doublure narrow.

External surfaces of all parts of exoskeleton smooth finely pitted or finely granular.

Discussion.—The most distinctive features of the cephalon of trilobites of this genus are the narrow well-defined border, the moderately broad fixed cheeks with moderately long palpebral lobes, and the nearly straight posterior glabellar furrows. The pygidium, which appears to be more distinctive than the cephalon, is characterized by its narrow border bearing 1 to 3 pairs of marginal spines, the presence, generally, of three or more ring furrows behind the articulating furrow on the axis, the general presence of an interpleural groove between the first and second pleural segments, and the axial lobe profile that is either flat or slightly turned up at the end.

Two other aphelaspid genera with pygidial spines are known: an unnamed genus (p. F-40) has pygidia with only a single pair of broad-based flat marginal spines, lacks well-defined pleural furrows, and has a relatively broader and less furrowed axis; *Nericia* Westergård (1948, p. 15) has pygidia with short evenly spaced marginal spines and an axis that seems to be structurally similar to that of *Olenaspella.* The cranidia, however, have short poorly defined palpebral lobes and broad-based posterior limbs which distinguish them from most American species of the Aphelaspidinae.

Wilson (1954, p. 1345) included *Parabolinella occidentalis* (Wilson, 1951, p. 651, pl. 95, figs. 2–5, 11) in *Olenaspella.* The cranidia are characterized by two pairs of deep slightly curved glabellar furrows and a rounded anterior end to the glabella. The free cheeks have the lateral and posterior border furrows separated. These features indicate a closer affinity of *O. occidentalis* with *Kindbladia*, and the species is not considered here to belong to *Olenaspella.*

Olenaspella evansi (Kobayashi)

Plate 5, figures 4, 5, 7

Parabolinella? evansi Kobayashi, 1936, p. 92, pl. 15, figs. 7–10.
Parabolinella evansi Kobayashi, 1938, p. 186, pl. 16, figs. 11, 12(?). (Figs. 13–15 are specifically indeterminate; fig. 14 is an olenid.)

Diagnosis.—Members of *Olenaspella* with pygidium having length about four-tenths width; axis with 2 or 3 ring furrows present behind articulating furrow; pleural regions without well-defined border, crossed by three shallow pleural furrows. Margin with three pairs of moderately short slender evenly spaced posteriorly directed spines.

Discussion.—Although this species does not occur in association with *Glyptagnostus*, there has been some confusion about its identiy that has a bearing on the concept of the genus *Olenaspella.*

The types of this species are specimens sent by C. S. Evans, of the Geological Survey of Canada, to C. E. Resser, of the U.S. National Museum, for identification in preparation of a report on the Brisco-Dogtooth map area of British Columbia (Evans, 1933). These were studied by Kobayashi on his visit to the United States in 1933 and subsequently described and figured (Kobayashi, 1936.) The remainder of Evans' material is in the collection of the Geological Survey of Canada and was studied by Kobayashi and described at a later date (Kobayashi, 1938).

In the original description of *Parabolinella? evansi* (Kobayashi, 1936, p. 92), the only locality listed was "north of Jubilee Mountain, British Columbia." The illustrations are good and show a pygidium with 3 pairs of marginal spines although the text states that only 4 spines (2 pairs) are present. Several pygidia with 3 pairs of marginal spines are present in the type lot. Other specimens identified as *Parabolinella evansi* were illustrated later (Kobayashi, 1938) from collection P 6/5, "north of Jubilee Mountain, west side of the Columbia River, west of Harrogate," British Columbia. No pygidia were illustrated in this paper. A pygidium from west Texas with two pairs of marginal spines was described, figured, and identified by Wilson (1954, p. 281) as *Parabolinella evansi* Kobayashi. He apparently placed more emphasis on Kobayashi's text describing a 4-spined pygidium than on the illustration showing a pygidium with 6 marginal spines. This is borne out by the fact that the 1936 reference to *Parabolinella*? *evansi* in Wilson's synonymy excludes citation of the figure of the six-spined pygidium. In the text, however, he states, "Kobayashi mentions only 4 spines on the posterior margin, but his figure shows 6. The writer's material shows 4: it is probable that the number of spines increases with size of the pygidium." No evidence is presented to support this statement. Wilson (1956, p. 1344) reported a small 4-spined pygidium associated with the cranidium of *Parabolinella evansi* figured by Kobayashi in 1938, plate 16, figure 11. At this time, Wilson also chose a lectotype for *Parabolinella evansi* from among the specimens illustrated in 1938 and described a new genus *Olenaspella* with *O. evansi* as type species. It is thus necessary for proper identification of the type species of *Olenaspella* to review all evidence concerning the morphology of *Parabolinella*? *evansi*. All the specimens in the U.S. National Museum and in the collections of the Geological Survey of Canada that have a bearing on this problem have been reexamined.

Kobayashi (1938, p. 154) listed *Pseudagnostus latus* Kobayashi, *Homagnostus acutus* Kobayashi, and *Dunderbergia canadensis* Kobayashi as species associated with the figured specimens of *Parabolinella evansi* from locality P 6/5. The blocks containing the illustrated specimens of *P. latus* and *H. acutus* also have cranidia and free cheeks of *Parabolinella evansi* together with several pygidia bearing three pairs of marginal spines and identical in all respects with the pygidium illustrated by Kobayashi in 1936. Thus it is reasonably certain that the trilobite described as *Parabolinella evansi* in both 1936 and 1938 is a species with three pairs of marginal pygidial spines and that the original description is in error.

Search was made for the 4-spined pygidium reported by Wilson to be associated with the illustrated cranidium of *P. evansi* (Kobayashi, 1938, p. 186), but no such pygidum was observed, and there is no evidence to support the statement that the 4-spined pygidium is an early stage of the 6-spined form or that a trilobite with such a pygidium is even associated with *P. evansi*. Wilson's "topotype" material of "*P. evansi*" (Wilson, 1956, p. 1344) contains only 4-spined pygidia, comparable in size to the 6-spined pygidia of *P. evansi* in the Evans collections. The trilobites with the 4-spined pygidium are considered here to represent another species, *Olenaspella regularis* n. sp.

Also, inasmuch as Kobayashi's 1938 specimens were not part of the type lot of *Parabolinella evansi*, the choice of a lectotype from among them was invalid. A new lectotype, GSC 15150, the pygidium originally illustrated by Kobayashi (1936, pl. 15, fig. 10), is here designated.

Figured specimens: Geological Survey of Canada No. (GSC) 15147 cranidium, 15148 free cheek, 15151 pygidium. From Evans collection P 6/5, north of Jubilee Mountain, British Columbia, Canada.

Olenaspella regularis n. sp.

Plate 5, figures 1–3

Parabolinella evansi Wilson, 1954 [not Kobayashi, 1936, 1938], p. 281, pl. 25, figs. 10, 15–17.

Diagnosis.—Members of *Olenaspella* with pygidium having 3 or 4 ring furrows behind articulating furrow on axis. Pleural regions with 2 or 3 shallow pleural furrows curved abruptly backward near inner edge of poorly defined narrow border, and extended onto border. Shallow interpleural grooves apparent between first and second pleural segments near outer edge of pleural field. Margin with 2 or 3 pairs of spines. Most specimens with two pairs of spines, outer pair longest; each pair connected to posterior band of first or second pleural segment by low narrow ridge. Third pair of spines, if present, short, adjacent to inner edge of second pair of spines (pl. 5, fig. 3).

Discussion.—The pygidium figured by Wilson (1954, pl. 25, fig. 16) as *Parabolinella evansi* is identical with the pygidia of *O. regularis*. It is unlikely that it represents the same species as the pygidium originally illustrated as *P. evansi* by Kobayashi (1936, pl. 15, fig. 10) (see p. F–37, pl. 5, fig. 5), which has 3 pairs of evenly spaced marginal spines and only 2 ring furrows posterior to the articulating furrow.

This species is definitely younger than *O. separata* n. sp. (table 1), but its age relationship to *O. evansi* (Kobayashi) is not yet certain. Infraspecific variability is also apparent in *O. regularis* as it is in *O. separata* n. sp. with regard to details of shape of both cranidia and pygidia in samples from different localities. The geographic range of *O. regularis* extends throughout the Cordilleran region. It was described from west Texas as *Parabolinella*? *evansi* by Wilson (1954, p. 281) and also reported by Wilson (1956, p. 1344) as topotype material of *Parabolinella*? *evansi* from near Jubilee Mountain, British Columbia. It has now been found in four areas in Nevada (fig. 2): the Hot Springs Range, Mount Hamilton, Cherry Creek, and McGill.

Occurrence: Lower part of Dunderberg formation: USGS colln. 2471-CO (4 cranidia, 1 free cheek, 8 pygidia), 2534-CO (22 cranidia, 1 free cheek, 7 pygidia), Cherry Creek, Nev. Unnamed formation: USGS colln. 1370-CO (2 cranidia, 1 free cheek, 7 pygidia), Hot Springs Range, Nev. Woods Hollow shale: Boulder BM-4 (>20 specimens), Marathon region, Texas.

Figured specimens:

USNM	*USGS colln.*	*Part*
143179	2534-CO	Holotype pygidium.
143180	2534-CO	Cranidium.
143199	2471-CO	Pygidium.

Olenaspella separata n. sp.

Plate 5, figures 6, 8-21, 23-26, 28, 30-32

Diagnosis.—Members of *Olenaspella* with pygidium having length about one-half width. Axis generally with 4 to 5 ring furrows behind articulating furrow. Pleural regions crossed by 3 or 4 shallow pleural furrows; narrow interpleural furrow between first and second segments developed on some specimens. Border poorly defined. Posterior margin with 1 to 3 pairs of spines, one pair of long slender spines always developed from first pleural segment; second pair always short, developed either from second pleural segment or from border between first and second pleural segments; third pair, when present, slightly longer than second pair, always developed from second pleural segment. Second and third pairs of spines always placed nearer to first pair of spines than to axial line.

Discussion.—This species is characterized by the spacing of the marginal pygidial spines. Even when three pairs of spines are present, they are grouped near the lateral margin of the pygidium leaving a long nonspinous medial part of the margin. This characteristic distinguishes *O. separata* from *O. regularis* n. sp., which has two pairs of approximately evenly spaced prominent marginal spines, and *O. evansi* (Kobayashi), which has three pairs of evenly spaced, equally developed marginal spines.

If larger collections and more detail about stratigraphic distribution of specimens assigned to this species are obtained, several subspecies may be recognizable, or the species may be considered to be too inclusive. At McGill, Nev. *O. separata* ranges through about 35 feet of beds in association with *Glyptagnostus reticulatus angelini*. In the lower part of its range, pygidia are slightly shorter and broader than those in the upper part of its range (cf. pl. 5, figs. 6, 15). Some specimens have a short second pair of marginal spines from the second pleural segment. Only one pair of marginal spines has been observed on specimens from the upper part of the range of the species at McGill (cf. pl. 5, figs. 6 and 24 with 15 and 16). Specimens from northwestern Nevada and Cedar Bluff, Ala., have the pygidial outline like that of specimens from the lower part of the range of the species at McGill, but they have 1, 2, or 3 pairs of marginal spines without any apparent correlation of number of spines with size. All the specimens discussed above are considered here to represent a single species whose populations vary slightly in both space and time. It is definitely older than *O. regularis* (table 1) and may be older than *O. evansi.*

One sample, USGS colln. 2466-CO, contains moderately abundant silicified parts of *O. separata* from the lower part of its range at McGill, Nev. The holaspid pygidia show a distinct morphologic series from smaller specimens with only one pair of pygidial spines to larger specimens with a short second pair of spines (pl. 5, figs. 17-19, 23, 24).

In addition to the observed variability in development of pygidial spines in this species, the cranidial border is also noticeably variable in both length (sagittal) and convexity (pl. 5, figs. 12, 13, 26). This variation adds to the problem of determining characteristics of this species and also prohibits certain species identification of isolated cranidia.

Occurrence: Lower part of Dunderberg formation: USGS collns. 2466-CO (>30 specimens of all parts), 2477-CO (16 cranidia, 4 free cheeks, 8 pygidia), 2478-CO (4 pygidia), 2479-CO (1 cranidium, 1 free cheek, 4 pygidia), 2480-CO (2 free cheeks, 2 pygidia), 3020-CO (3 cranidia, 2 free cheeks, 4 pygidia), 3039-CO (1 specimen complete except for free cheeks), 3040-CO (1 cranidium, 3 pygidia), 3045-CO (2 cranidia, 1 pygidium), 3046-CO (4 cranidia, 4 free cheeks, 5 pygidia), 3049-CO (1 pygidium, 1 free cheek), 3050-CO (1 cranidium, 1 free cheek, 2 pygidia), 3051-CO (1 pygidium), 3052-CO (1 pygidium), 3053-CO (2 pygidia), 3054-CO (4 pygidia), 3055-CO (3 cranidia, 3 3 free cheeks, 8 pygidia), McGill, Nev. Conasauga formation: USNM loc. 89d (22 cranidia, 3 free cheeks, 10 pygidia), Cedar Bluff, Ala. Unnamed formation: USGS colln. 1370-CO (8 cranidia, 2 free cheeks, 15 pygidia), Hot Springs Range, Nev.; USGS colln. 3106-CO (3 cranidia, 1 free cheek, 3 pygidia), Mt. Hamilton, Nev.

Figured specimens:

USNM	*USGS colln.*	*Part*
143181a, d, e	2477-CO	Pygidia.
143181b, f	2477-CO	Cranidia.
143181c	2477-CO	Free cheek.
143182	3039-CO	Holotype, complete individual.
143183	2480-CO	Pygidium.
143184	3046-CO	Pygidium.
143185a-f	2466-CO	Pygidia.
143185g	2466-CO	Free cheek.
143185h, i	2466-CO	Thoracic segment.
143185j	2466-CO	Thoracic segment.
143187	1374-CO	Pygidium.
143186a, c	USNM loc. 89d	Pygidia.
143186b	USNM loc. 89d	Association slab.

Aphelaspidinae gen. and sp. undet.

Plate 5, figures 22, 27, 29

A new genus of aphelaspid is represented by relatively rare cranidia, free cheeks, and pygidia in USGS colln. 2535–CO. The cranidia are characterized by having prominent, well-defined palpebral lobes, a well-defined moderately convex border, and an obscurely furrowed glabella. The free cheek has well-defined lateral and posterior border furrows joined at the genal angle and extended slightly onto the genal spine. The pygidium is subquadrate in outline and has a short prominent axis with two well-defined ring furrows behind the articulating furrow. The pleural regions are broad, without a well-defined border, but are extended into two well-separated broad-based posteriorly directed marginal spines. All the parts are distinctly pitted. Congeneric and perhaps conspecific specimens are also present in association with *G. reticulatus* at Tybo, Nev.

Similar associations of cranidia, cheeks, and pygidia representing an undescribed genus are known from slightly younger beds at several localities in Nevada. Because of inadequate samples of the species associated with *G. reticulatus*, this genus is not named here. The younger species will be described in a subsequent paper in which the generic and specific relationships of the specimens here illustrated can be discussed.

Occurrence: Lower part of the Dunderberg formation, USGS colln. 2535–CO (5 cranidia, 1 free cheek, 1 pygidium), Cherry Creek, Nev. Uppermost beds of the Swarbrick formation: USGS colln. 3058–CO (4 cranidia, 2 pygidia), Tybo, Nev.

Figured specimens:

USNM	*USGS colln.*	*Part*
143188a	2435–CO	Cranidium.
143188b	2535–CO	Pygidium.
143188c	2535–CO	Free cheek.

Aphelaspinid? sp.

Plate 4, figures 30, 34

Several pygidia associated with *Glyptagnostus reticulatus* and *Olenaspella separata* n. sp. in a small collection in limestone from the Conasauga formation are characterized by being broad and short and having an evenly rounded margin and a slender axis bearing 3 or 4 ring furrows posterior to the articulating furrow. The pleural fields are crossed by three shallow pleural furrows separated by even shallower interpleural furrows. The border is narrow and hardly tapered toward the axial line. The narrow well-segmented axis and narrow border of nearly constant breadth resemble pygidia of the late Middle Cambrian Scandinavian genus *Andrarina* rather than American species of *Aphelaspis*. No *Andrarina*-like cranidia were observed in the small collection examined, and the generic affinities of the pygidia cannot be certainly determined.

Occurrence: Conasauga formation, USNM loc. 89d (3 pygidia), Cedar Bluff Ala.

Figured specimens: USNM 143178 a, b, USNM loc. 89d, pygidia.

Subfamily PTEROCEPHALIINAE

Diagnosis.—"Pterocephaliid trilobites with border of cranidium generally broad, concave, and longer (sagittal) than brim. Border of free cheek generally broad, concave. Pygidium with broad, poorly defined border on most species." Palmer, 1960a, p. 84.

Discussion.—The new genus *Listroa*, which is next described, increases to four the number of genera assigned to this subfamily. This is presently the oldest genus in the subfamily, which now has representatives in North America ranging throughout all but the lowest part of the stratigraphic interval occupied by the Pterocephaliidae. The three younger genera described or reviewed earlier (Palmer, 1960a, p. 84) are *Cernuolimbus* Palmer, *Sigmocheilus* Palmer, and *Pterocephalia* Roemer.

Genus LISTROA n. gen.

Type species.—*Listroa toxoura* n. sp., figure 14.

Diagnosis.—Pterocephaliinae (total length generally less than 40 mm) with cranidium having obscurely furrowed well-defined glabella; border moderately broad, flat or slightly concave; fixed cheeks nearly horizontal; eye ridges moderately well defined, directed posterolaterally from junction with dorsal furrow; and anterior sections of facial sutures cutting anterior margin with distinct angle.

Free cheek with broad, poorly defined, nearly flat border. Lateral and posterior border furrows joined, extended short distance onto genal spine.

Pygidium with short prominent posteriorly tapered axis bearing 2 or 3 ring furrows posterior to articulating furrow; tip somewhat elevated. Pleural regions moderately to strongly convex. Broad, poorly defined border strongly depressed. Posterior margin with strong median identation.

Description.—Pterocephaliinae (estimated maximum length about 40 mm) with cranidium having glabella obscurely furrowed, straight sided, tapered forward, bluntly rounded anteriorly, well defined by shallow narrow axial furrows. Occipital furrow shallow; occipital ring with median node. Frontal area gently to moderately concave, divided into downsloping brim and flat or slightly convex, horizontal or slightly downsloping border by sharp but slight change in slope. Contact between brim and border evenly curved. Length of frontal area between ½ and full length of glabella, longest in larger specimens. Length of border

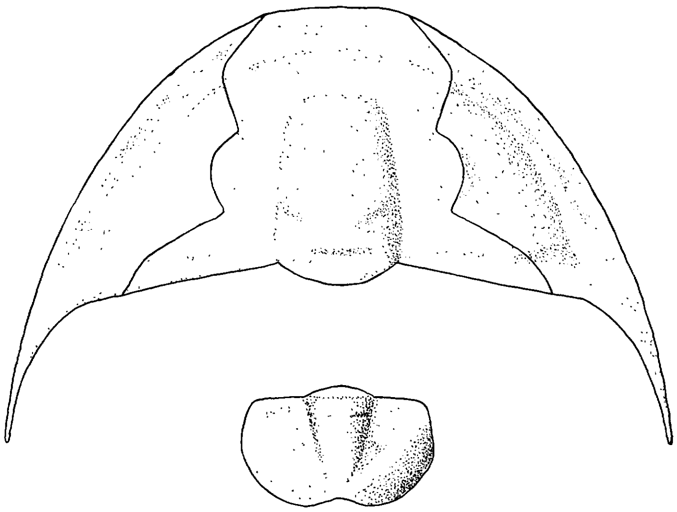

FIGURE 14.—Partial reconstruction of *Listroa toxoura* n. sp.

slightly greater than that of brim. Fixed cheek horizontal, nearly flat; width of palpebral area between ⅓ and ½ basal glabellar width. Palpebral lobe moderately to poorly defined by shallow arcuate palpebral furrow, situated about opposite glabellar midlength. Eye ridges moderately to poorly defined, directed posterolaterally from junction with dorsal furrow. Posterior limbs slender, sharp pointed; posterior border furrow shallow.

Anterior section of facial suture divergent forward from palpebral lobe to marginal furrow, then turned abruptly inward to cross border and cut anterior margin with distinct angle somewhat more than half distance from anterolateral cranidial corner to axial line. Posterior section divergent, sinuous.

Free cheek with poorly defined, broad, nearly flat border separated from ocular platform by shallow lateral border furrow. Posterior border furrow shallow, joined with lateral border furrow at genal angle, extended short distance onto genal spine. Genal spine broad, flat at base, tapered rapidly posteriorly.

Thorax and hypostome not known.

Pygidium with prominent posteriorly tapered axis having tip elevated somewhat, reaching to inner edge of border; 2 or 3 shallow ring furrows present posterior to articulating furrow. Pleural regions moderately to strongly convex with poorly defined downsloping or depressed border generally as broad posterolaterally as pleural field. Low postaxial median ridge generally present. Pleural furrows shallow, extending to or onto border. All furrows better defined on exfoliated specimens. Posterior margin with median indentation.

Surface of exoskeleton smooth or finely pitted. Some specimens show rare scattered granules.

Discussion.—This genus differs from *Aphelaspis* by having a broad border and slightly flared frontal area on the cranidium, and by having a downsloping border and distinct posterior median notch on the pygidium. The structure of the cranidial border is more like that of a pterocephalinid trilobite than like typical members of the Aphelaspidinae, and *Listroa* is tentatively included here in the Pterocephaliinae.

Listroa toxoura n. sp.

Plate 6, figures 5, 8–10; text figure 14

Diagnosis.—Members of *Listroa* with cranidial border nearly flat, slightly downsloping, making gentle angle with brim. Sagittal length of frontal area generally not greater than three-fourths length of glabella. Pygidium with 2 or 3 distinct ring furrows posterior to articulating furrow.

Discussion.—*Aphelaspis longifrons* Palmer (1954, p. 745, pl. 84, figs. 9, 12; pl. 85, figs. 2, 3) is a species now more properly assigned to *Listroa*. It differs from *L. toxoura* by having a longer frontal area, a slightly convex border on many specimens, a much more distinct angle between the brim and the border, and generally one less distinct ring furrow on the axis of the pygidium.

Occurrence: Lower part of the Dunderberg formation: USGS collns. 2471-CO (7 cranidia, 1 free cheek, 1 pygidium), 2534-CO (9 cranidia, 1 pygidium), 2535-CO (4 cranidia, 2 free cheeks), Cherry Creek, Nev. Uppermost beds of Swarbrick formation: USGS collns. 3057-CO (4 cranidia), 3058-CO (4 cranidia), 3059-CO (6 cranidia), Tybo, Nev.

Figured specimens:

USNM	*USGS colln.*	*Part*
143191a	2535-CO	Cranidium.
143191b	2535-CO	Free cheek.
143192	2471-CO	Holotype cranidium.
143193	2534-CO	Pygidium.

LOCALITY INFORMATION AND FAUNAL LISTS

The collections referred to in this paper are cataloged under 1 of 2 sets of numbers. Collections listed in the U.S. National Museum catalog bear green-paper circles with handwritten locality numbers. Collections of the U.S. Geological Survey are listed in the Cambrian-Ordovician locality catalog and bear orange-paper circles or rectangles with machine-printed collection numbers. USGS collection numbers referred to in the text bear the suffix (-CO) to differentiate them from a parallel series of numbers in the Silurian-Devonian locality catalog with suffix (-SD).

All USGS collections, unless otherwise indicated, were made by the writer in 1958 (Nevada) or 1959 (Alabama, Nevada). Names of collectors and collecting dates of USNM localities are indicated with each collection. Faunal lists are given only for collections not shown on figures 4–7.

ALABAMA

Cedar Bluff.—Measured section in shales and a few thin limestones of the Conasauga formation cropping out in a drainage ditch along the west edge of the high school playing field and the continuation of this ditch on the south side of the road at the south edge of the playing field in the town of Cedar Bluff. The distances given are calculated stratigraphic distances above or below the bed at the north end of the culvert beneath the road at the south end of the high school playing field. Although the average dip of the beds is 15° NE., the Conasauga formation in the vicinity of Cedar Bluff is so strongly folded that these beds could be upside down. They are assumed to be in normal sequence, however, in the absence of positive evidence to the contrary.

2875–CO. 35 ft above datum in parting between ½-in. layers of vertical fibers of calcite that make a 1-in. limestone bed in a dominantly shale sequence.

2876–CO. 2 ft below coll. 2875–CO in similar 1-in. limestone bed.

2877–CO. About 5 ft above datum, fossiliferous medium-grained gray limestone concretion, lithically identical with limestone at USNM loc. 89d.

2878–CO. At north end of culvert (datum.) Brown shale.

2879–CO. 3 ft below datum in ditch on south side of road. Thin limestone similar to coll. 2875–CO.

USNM loc. 89d. Two blocks southeast of hotel at Cedar Bluff. Collected by Charles Butts and E. O. Ulrich, 1920. [This is approximately the locality of the 1959 measured section.]

USNM loc. 91o. One-third of a mile east of Cedar Bluff on Rome road. Collected by Cooper Curtice, 1875. [The Rome road of 1875 is now the street at the south edge of the high school playing field. The exact position of this collecting locality might be in an overgrown roadcut on the abandoned part of the old Rome road at the south edge of a churchyard just east of the high school playing field.]

Agnostus inexpectans Kobayashi
Aphelaspis buttsi (Kobayashi)
Aspidagnostus rugosus n. sp.
Glyptagnostus reticulatus angelini (Resser)
Olenaspella separata n. sp.

Woodstock.—A short section of beds of the Conasauga formation is exposed in a partly overgrown railroad cut on the southwest (inner) side of a curved spur track of the Southern Railway about 200 feet southeast of the main street of Woodstock at the west edge of town. Several ledges of nearly flat lying fine grained to very fine grained silty laminated limestone separated by brown-weathering shales crop out for about 15 feet above the level of the railroad track.

2886–CO. 7 ft above railroad track. Dark-gray silty laminated fine-grained limestone, 2 in. thick.

2887–CO. 8 ft above railroad track. Brownish-gray very fine grained silty limestone; bottom part of ledge 2 ft thick.

2888–CO. 11 ft above railroad track. Limestone bed, 1½ in. thick; lower inch light gray, very fine grained; upper ½ in. dark gray, fine grained; contact of dark and light parts irregular.

2889–CO. 12 ft above railroad track. Limestone bed, same as 2886–CO.

USNM loc. 90b. Cut on Louisville and Nashville Railway north of Woodstock, Ala. Collected by Charles Butts, 1904, 1905. [This is probably the same locality as that collected in 1959. There are no other outcrops of the Conasauga formation along the railroad tracks in the vicinity of Woodstock.] Specimens also labeled 90b with *Meteoraspis nuperus* (Resser) and *Deiracephalus aster* (Walcott) (Resser, 1938, pl. 11, figs. 43–45) do not have any associated parts of the trilobites that occur with *Glyptagnostus stolidotus* at this locality and probably came from a bed not located in 1959.

NEVADA

Cherry Creek.—Measured section on east side of Cherry Creek Range, reached by driving 7.1 miles west on paved road from U.S. Highway 93 toward the town of Cherry Creek, then turning north on graded road for 4.0 miles to jeep trail leading up canyon to the west. The Dunderberg formation is exposed in the canyon bottom and on the ridges to the north and south about 1 mile up the canyon beyond the end of the Jeep trail. The section was measured in the canyon bottom.

2470–CO. 3 ft below base of Dunderberg formation on ridge north of measured section. Gray very fine grained crinkly-bedded limestone.

2471–CO. 1 ft above base of Dunderberg formation on ridge north of measured section. Gray fine-grained silty limestone bed 2 in. thick.

2534–CO. 2 ft above base of Dunderberg formation in measured section. Limestone bed, lithology same as 2471–CO.

2535–CO. 11 ft above base of Dunderberg formation in measured section. Limestone bed, lithology same as 2471–CO.

3056–CO. 1½ ft below base of Dunderberg formation in measured section. Limestone, lithology same as 2470–CO.

Hamilton district.—

3106–CO. West side of Pogonip ridge, 500 ft east of the Monte Cristo mine, SW¼ sec. 27, T. 16 N., R. 57 E., Green Springs quadrangle, Nevada. Collected by F. L. Humphrey, 1947.

Glyptagnostus reticulatus (Angelin)
Olenaspella separata n. sp.

Hot Springs Range.—

1374–CO. Limestone lens in structurally disturbed unit of thin-bedded chert and siliceous shale (Roberts and others, 1958, p. 2827). Extreme NE¼NW¼ sec. 31, T. 40 N., R. 41 E. (unsurveyed), Hot Springs Peak quadrangle.

Glyptagnostus reticulatus angelini (Resser)
Homagnostus sp.
Cheilocephalus sp.
Agnostus cf. *A. inexpectans* Kobayashi
Pseudagnostus sp.
Aphelaspis sp.
Olenaspella separata Palmer

1370-CO. Limestone lens in structurally disturbed unit of thin-bedded chert and siliceous shales (Roberts and others, 1958, p. 2827), on ridge S½NE¼SE¼ sec. 28, T. 39 N., R. 40E., Osgood Mountains quadrangle, Nevada.

Agnostus inexpectans Kobayashi
Glyptagnostus reticulatus reticulatus (Angelin)
Olenaspella regularis n. sp.
Pseudagnostus sp.

McGill.—Measured section in small canyon on west side of Duck Creek Range, reached by driving 1.35 miles north of McGill Post Office, turning right onto abandoned section of U.S. Highway 93 and continuing 0.6 mile to trail leading up slope to the right, crossing large pipeline and continuing into small canyon. Exposures of basal beds of Dunderberg formation are west of trail about 100 yards before first switchback.

2474-CO. 1 ft below base of Dunderberg formation. Gray-brown very fine grained crinkly-bedded limestone, 2 in. thick.
2475-CO. Top bed of limestone unit beneath Dunderberg formation. Limestone as in 2474-CO, 2½ in. thick.
2476-CO. 6 in. above base of Dunderberg formation. Gray fine-grained silty laminated-limestone bed 2 in. thick.
2477-CO. 16 ft above base of Dunderberg formation. Limestone as in 2476-CO, 3 in. thick.
2478-CO. 27 ft above base of Dunderberg formation. Limestone as in 2476-CO, 1 ft thick.
2479-CO. 33 ft above base of Dunderberg formation Limestone as in 2476-CO, 2 in. thick.
2480-CO. 40 ft above base of Dunderberg formation. Limestone as in 2476-CO, 2 in. thick.
3039-CO. 5 ft above base of Dunderberg formation. Limestone lens, lithology as in 2476-CO, 2 in. thick.
3040-CO. 20 ft above base of Dunderberg formation. Limestone lens as in 3039-CO.
3041-CO. Same bed as 2478-CO, 27 ft above base of Dunderberg formation.
3043-CO. 30 ft above base of Dunderberg formation. Limestone as in 2476-CO., 1 in. thick.
3044-CO. 32 ft above base of Dunderberg formation. Limestone as in 2476-CO, 1 in. thick.
3045-CO. 35 ft. above base of Dunderberg formation. Limestone as in 2476-CO., 2 in. thick.
3046-CO. 38 ft. above base of Dunderberg formation. Limestone as in 2476-CO, 2 in. thick.
3049-CO. 31 ft above base of Dunderberg formation. Limestone lens as in 3039-CO, 1 in. thick.
3050-CO. 32.5 ft above base of Dunderberg formation. Limestone lens as in 3039-CO, 2 in. thick.
3051-CO. 34 ft above base of Dunderberg formation. Limestone as in 2476-CO, 2 in. thick.
3052-CO. Same as 3045-CO, 35 ft above base of Dunderberg formation.
3053-CO. 37 ft above base of Dunderberg formation. Limestone as in 2476-CO, 2 in. thick.
3054-CO. Same as 3046-CO, 38 ft above base of Dunderberg formation.
3055-CO. 39 ft above base of Dunderberg formation. Limestone as in 2476-CO, 2 in. thick.

Not in measured section—

2466-CO. Lower part of Dunderberg formation on ridge crest north of measured section. Gray fine-grained silty laminated limestone bed 2 in. thick. Excellent silicified trilobites.
3020-CO. 15 ft above base of Dunderberg formation on north facing slope of ridge north of measured section. Limestone as in 2466-CO.

Tybo.—Collections from upper 10 feet of east-dipping beds of Swarbrick formation at east end of exposures, on east side of gully entering Tybo canyon and about 350 feet north of Tybo canyon road.

3057-CO. Gray medium-grained silty limestone bed 3 in. thick.
3058-CO. 1 ft above 3057-CO, similar limestone bed.
3059-CO. 4 ft above 3057-CO, similar limestone bed.

Fauna mainly the same in all three collections:

Aphelaspis subditus n. sp.
Aphelaspidinae, gen. and sp. undet.
Glyptagnostus reticulatus reticulatus (Angelin)
Listroa toxoura n. sp.
Pseudagnostus sp.

TENNESSEE

Henderson Oil Co., Markham No. 1 well, 3.3 miles S. 50° E. of Tiptonville, Lake County, Tenn. (Grohskopf, 1955, p. 127). Paleozoic rocks from 2,230 to 3,242 feet consist "essentially of dark grey dense to medium grained limestone, dark siliceous shales, some of which are definitely slaty, and basic igneous material." (Grohskopf, 1955).

At depths of 2,858, 2,860, and 2,862 ft are specimens of *Glyptagnostus reticulatus* (Angelin).

TEXAS

Limestone boulder, 2 feet in diameter, consisting of "dark gray to brownish black fine-grained limestone, slightly fossiliferous; containing lenses of pebble conglomerate with abundant fragments of * * * trilobites in both the matrix and in the pebbles." Wilson, 1954, p. 256. Woods Hollow shale, East Bourland mountain, Marathon region, Texas.

Agnostus inexpectans Kobayashi
Aphelaspis sp.
Glyptagnostus reticulatus (Angelin)
Homagnostus obesus (Belt)
Listroa sp. undet.
Olenaspella regularis n. sp.
Pseudagnostus cf. *P. communis* (Hall and Whitfield)

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FIGURES 1–11. *Agnostus inexpectans* Kobayashi, × 10 (p. F–12).

1, 6. Cephalon and pygidium from type lot, NMC 12005, loc. P 6/6, north of Jubilee Mtn., west side of Columbia River, west of Harrogate, British Columbia, Canada.

2, 7. Cephalon and pygidium, USNM 143122 a, b. USGS colln. 2534–CO, Cherry Creek, Nev.

3, 8. Cephalon, USNM 143123, from USGS colln. 2875–CO; pygidium, USNM 143124, from USGS colln. 2876–CO, Cedar Bluff, Ala.

4, 5, 9–11. Silicified cephala and pygidia showing changes during holaspid development, USNM 143125 a–e, USGS colln. 2466–CO, McGill, Nev.

12–15. *Homagnostus comptus* n. sp., × 10 (p. F–12).

12. Holotype, silicified cephalon, USNM 143126.

13–15. Silicified paratype pygidium and small holaspid cephalon and pygidium, USNM 143127 a–c. All from USGS colln. 2466–CO, McGill, Nev.

16. *Homagnostus* sp. × 10 (p. F–13).

Latex cast of complete specimen in shale, USNM 143128, USGS colln. 2878–CO, Cedar Bluff, Ala.

17–19, 23. *Proagnostus*? sp., × 10 (p. F–14).

Cephala and pygidia, USNM 143129 a–d, USGS colln. 2888–CO, Woodstock, Ala.

20–22. *Aspidagnostus laevis* n. sp., × 10 (p. F–15).

20. Holotype cephalon, USNM 143130.

21, 22. Paratype pygidium and cephalon, USNM 143131 a, b. All from USGS colln. 2475–CO, McGill, Nev.

24–30. *Aspidagnostus rugosus* n. sp., × 10 (p. F–15).

24. Silicified meraspid 1 pygidium lacking groove in posterior border, USNM 143132, USGS colln. 2466–CO, McGill, Nev.

25. Holotype pygidium, USNM 143133, USGS colln. 3049–CO, McGill, Nev.

26–28. Cephalon and pygidium, USNM 143134 a, b, USGS colln. 2471–CO; Pygidium, USNM 143135, USGS colln. 2535–CO, Cherry Creek, Nev.

29–30. Cephalon and pygidium, USNM 143136 a, b, USGS colln. 2875–CO, Cedar Bluff, Ala.

31–33. Agnostid, gen. and sp. undet. × 10 (p. F–14).

31, 32. Cephalon and pygidium, USNM 143137 a, b, USGS colln. 3056–CO, Cherry Creek, Nev.

33. Pygidium, USNM 143138, USGS colln. 2475–CO, McGill, Nev.

AGNOSTIDAE AND CLAVAGNOSTIDAE

PLATE 2

FIGURES 1, 3. *Glyptagnostus reticulatus reticulatus* (Angelin) × 8 (p. F–18).
Cephalon and pygidium, USNM 143139 a, b, from USGS colln. 2471–CO, Cherry Creek, Nev.

2, 5. *Glyptagnostus stolidotus* Öpik × 6 (p. F–16).
Cephalon and pygidium USNM 143140 a, b, from USGS colln. 2886–CO, Woodstock, Ala.

4, 6, 7, 11. *Glyptagnostus reticulatus angelini* (Resser) (p. F–18).
4. Slab showing infraspecific variation, compare reticulation on cephala in upper half of picture, × 3, USNM 143141, USGS colln. 2476–CO, McGill, Nev.
6, 11. Cephalon and pygidium, silicified, × 10, USNM 143142 a, b, USGS colln. 2466–CO, McGill, Nev.
7. Holotype, nearly complete specimen, × 4, USNM 26314, USNM loc. 89d, chert cobble from Cedar Bluff, Ala.

8. *Glyptagnostus reticulatus reticulatus*? (Angelin) × 6 (p. F–18).
Cephalon from Wilson boulder BM–4, USNM 143143, Marathon region, Texas.

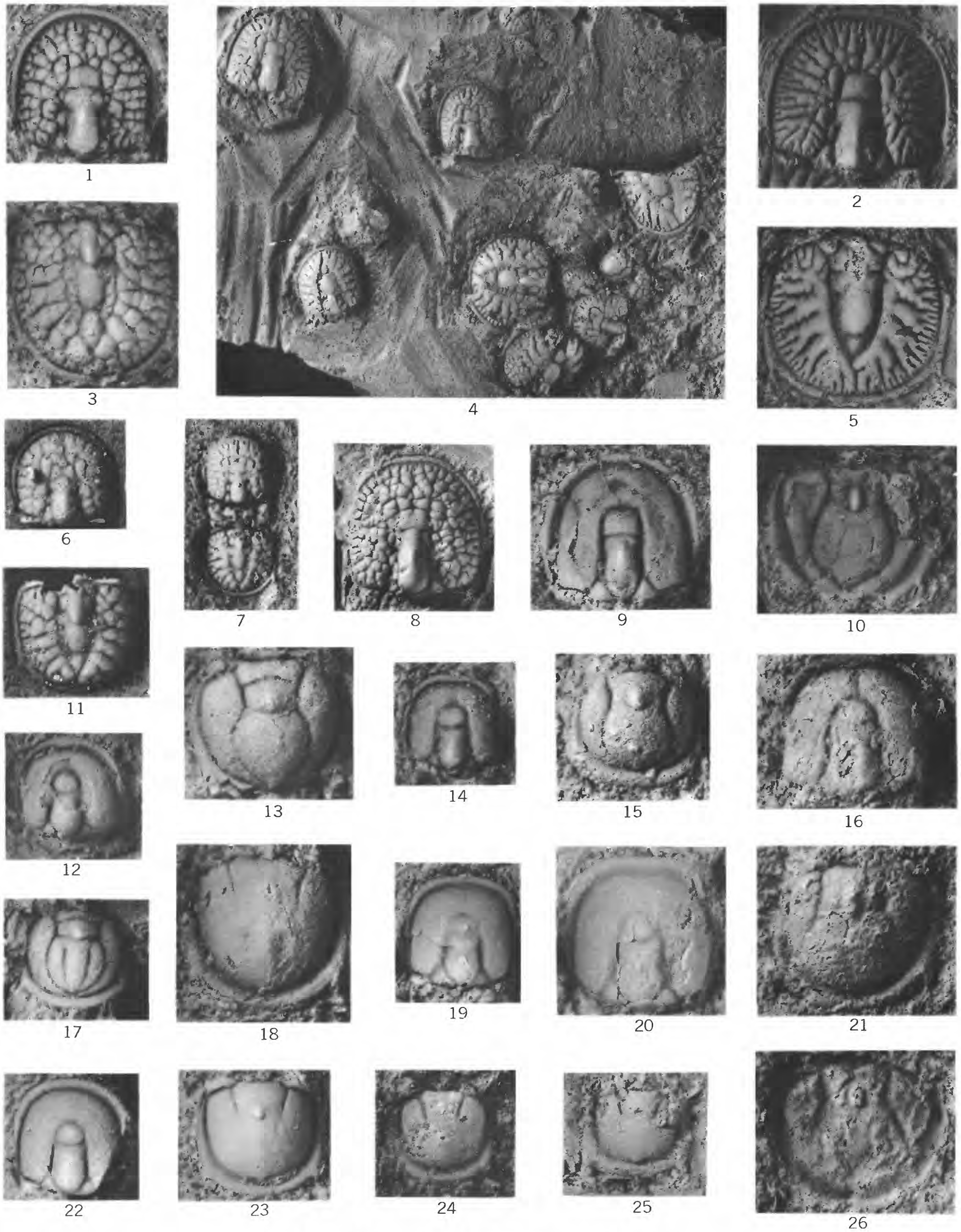
9, 10. *Acmarhachis* sp., × 10 (p. F–20).
Cephalon and pygidium, USNM 143144 a, b, USGS colln. 2886–CO, Woodstock, Ala.

12, 13, 17. *Acmarhachis typicalis* Resser, × 10 (p. F–20).
Cephalon and pygidia, note strong development of muscle scar areas on fig. 17, USNM 143145 a–c, USGS colln. 2465–CO, McGill, Nev.

14, 15. *Acmarhachis acutus* (Kobayashi) × 10 (p. F–20).
Cephalon and pygidium, USNM 143146 a, b, USGS colln. 2471–CO, Cherry Creek, Nev.

16, 21, 26. *Pseudagnostus* spp., × 10 (p. F–21).
16, 21. Cephalon and pygidium, USNM 143147 a, b, USGS colln. 3058–CO, Tybo, Nev.
26. Pygidium, USNM 143148, USGS colln. 2875–CO, Cedar Bluff, Ala.

18–20, 22–25. *Pseudagnostina contracta* n. sp., × 10 (p. F–21).
18, 22. Pygidium and cephalon, note muscle scar pits on fig. 18, USNM 143149 a, b, USGS colln. 2888–CO Woodstock, Ala.
23. Holotype pygidium, USNM 143150, USGS colln. 2888–CO, Woodstock, Ala.
19, 24. Cephalon, USNM 143151, USGS colln. 2475–CO; pygidium, USNM 143152, USGS colln. 2474–CO, McGill, Nev.
20, 25. Cephalon and pygidium, USNM 143153 a, b, USGS colln. 3056–CO, Cherry Creek, Nev.



GLYPTAGNOSTIDAE AND PSEUDAGNOSTIDAE

PLATE 3

FIGURES 1, 2, 4–7. *Carinamala longispina* n. sp. (p. F–24).

1. Stereogram of holotype cranidium, latex cast, × 2, USNM 143154.
2. Cranidium showing posterior limbs, and pits in palpebral lobes, × 3, USNM 143155a.

4, 5. Pygidia, × 3, USNM 143155b, c.

6, 7. Free cheeks, upper surface of genal spine of fig. 6 damaged by grinding, × 2, USNM 143155d, e.

All from USGS colln. 2475–CO, McGill, Nev.

3. *Carinamala* sp. (p. F–24).

Incomplete cranidium, × 3, USNM 143156, USNM loc. 90b, Woodstock Ala.

8, 11–13. *Cedaria brevifrons* n. sp. (p. F–26).

8. Stereogram of holotype cranidium, × 2, USNM 143157.

11. Free cheek, × 2, USNM 143158a.

12, 13. Larger pygidium, × 2; smaller pygidium, × 3, USNM 143158b, c.

All from USGS colln. 2475–CO, McGill, Nev.

9, 10, 14–16, 20. *Cedaria prolifica* Walcott, × 3 (p. F–26).

9. Stereogram of cranidium, USNM 143159a.

10, 16. Pygidia, USNM 143159b, c.

14, 15. Cranidia, smaller cranidium with unusually long frontal area and narrow fixed cheeks for comparison with more common form shown in fig. 9. Larger cranidium exfoliated. USNM 143159d, e.

20. Free cheek, USNM 143159f.

All from USGS colln. 2888–CO, Woodstock, Ala.

17–19, 21–24, 27–29. *Coosia longocula* n. sp. (p. F–28)

17. Stereogram of holotype cranidium, × 5, USNM 143160.

18. Free cheek showing distinctive genal angle, × 3, USNM 143161a.

19. Larger cranidium, × 4, USNM 143162a.

21, 22. Larger pygidia, × 2 and × 3, note difference in ornament, USNM 143161b, c.

27, 28. Smaller pygidia, × 8, showing change in shape with growth, USNM 143161e, 143162c.

23, 24. Smaller cranidia, × 10, note prominent median glabellar swelling and large granules on fixed cheek of smallest specimen, USNM 143162b, 143161d.

29. Closeup of frontal area of large cranidium, × 4, showing fine granular ornament, USNM 143161f.

Figures 17, 18, 21, 22, 24, 27, 29, from USGS colln. 2475–CO, McGill, Nev. Figures 19, 23, 28 from USGS colln. 3056–CO, Cherry Creek, Nev.

25, 26. *Coosia* sp. (p. F–28).

25. Pygidium, × 5, USNM 143163, USGS colln. 2474–CO, McGill, Nev.

26. Free cheek, × 4, USNM 143164, USGS colln. 2475–CO McGill, Nev.

30, 31. *Cheilocephalus* sp. (p. F–27).

30. Small cranidium, × 6, USNM 143165a.

31. Larger cranidium, × 4, with granular surface, USNM 143165b.

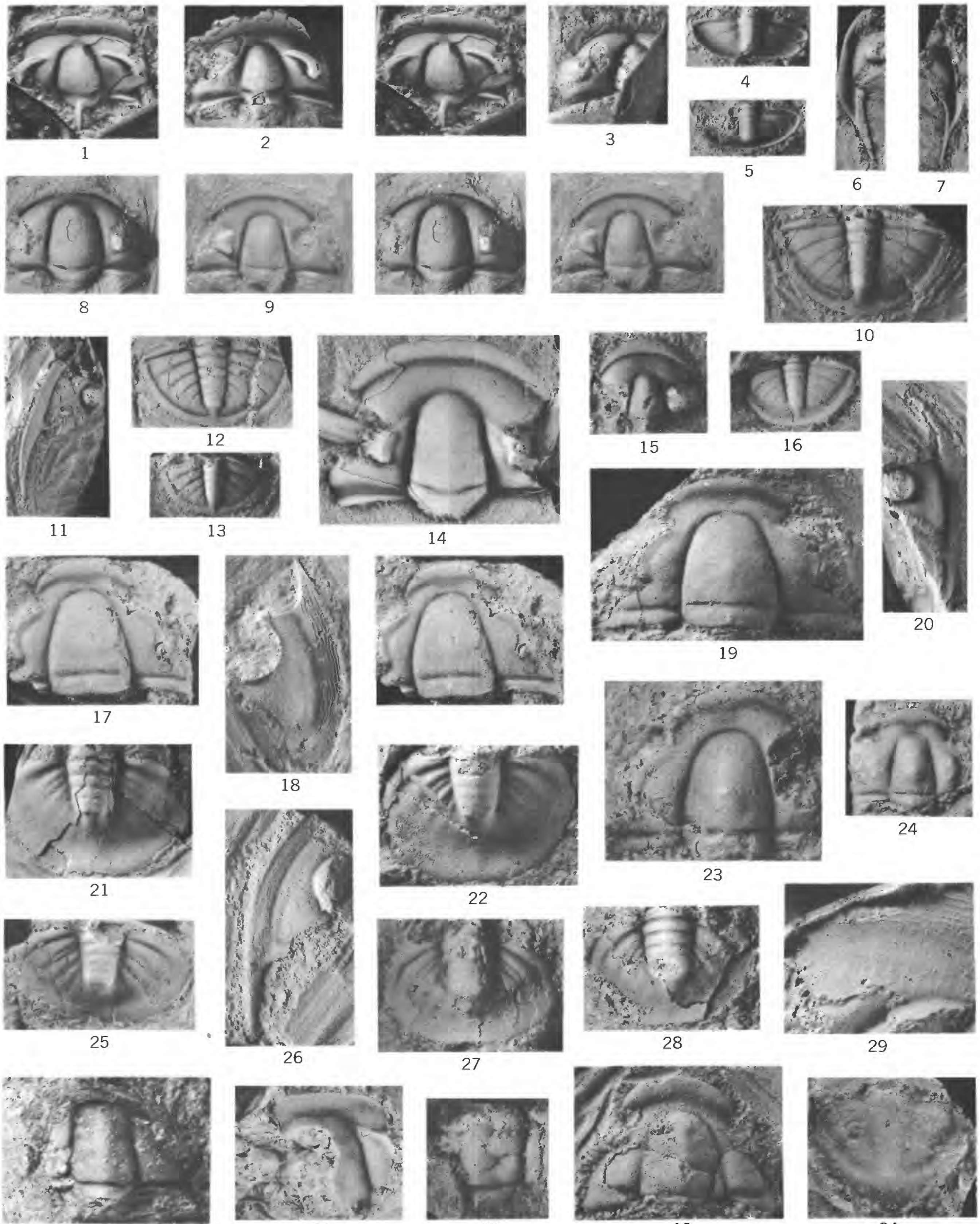
Both from USGS colln. 2535–CO, Cherry Creek, Nev.

32. *Pemphigaspis* sp., × 5 (p. F–23).

Fragmentary cranidium, USNM 143166, USGS colln. 2886–CO, Woodstock, Ala.

33, 34. *Blountia bristolensis* Resser, × 3 (p. F–22).

Exfoliated cranidium and pygidium, USNM 143167a, b, USGS colln. 2879–CO, Cedar Bluff, Ala.



CEDARIIDAE, CREPICEPHALIDAE, CHEILOCEPHALIDAE, CATILLICEPHALIDAE, AND ASAPHISCIDAE

PLATE 4

FIGURES 1–19. *Aphelaspis brachyphasis* n. sp. (p. F–33).

1. Stereogram of holotype cranidium, × 6, USNM 143168.

2. Small cranidium, × 6, for comparison with small cranidium of *Olenaspella separata*, pl. 5, fig. 21. USNM 143169a.

3. Free cheek, × 4. USNM 143169b.

4, 5. Ventral view of anterior and posterior thoracic segments, × 8, USNM 143169c, d.

6–10. Series of pygidia, × 8, showing range of variation of width of doublure and border, USNM 143169e–i.

18, 19. Internal oblique and exterior views of hypostomes belonging to either this species or *Olenaspella separata*, × 6. USNM 143169j, k.

Figures 1–10, 18, 19, silicified specimens from USGS colln. 2466–CO.

11–13. Free cheek, × 4; cranidium, × 3; pygidium, × 4, USNM 143170a–c. USGS colln. 2478–CO.

14. Thorax and pygidium, × 2, USNM 143171. USGS colln. 2479–CO.

15–17. Cranidium and pygidia, × 5, illustrating differences of cranidial form between populations and extremes of variation of pygidial form within a population, USNM 143172a–c. USGS colln. 3055–CO.

All specimens from McGill, Nev.

20–22, 25. *Aphelaspis subditus* n. sp. (p. F–35).

20. Stereogram of cranidium, × 4, USNM 143173a.

21, 22. Pygidium, × 3; and exfoliated cranidium, × 5, USNM 143174b, c.

All from USGS colln. 2535–CO, Cherry Creek, Nev.

25. Complete specimen, × 3, USNM 143175. Associated with *Aphelaspis haquei* (Hall and Whitfield) and *Olenaspella reqularis* n. sp. in a 40th parallel Survey collection from the Hamilton district, Nevada.

23, 26, 31, 32. *Aphelaspis buttsi* (Kobayashi) (p. F–35).

23. Stereogram of characteristic cranidium, × 4, USNM 143176a.

26, 32. Pygidium and free cheek, × 3, USNM 143176b, c. All from USGS colln. 2476–CO, McGill, Nev.

31. Holotype, complete exfoliated specimen, × 2, USNM 93048, USNM loc. 91o, Cedar Bluff, Ala.

24, 28, 33. *Aphelaspis walcotti* Resser (p. F–33).

24. Stereogram of latex cast of internal mold of holotype cranidium, × 3, USNM 94923.

28. Free cheeks on slab with holotype, × 3, USNM 94923.

33. Pygidium, × 4, USNM 94923.

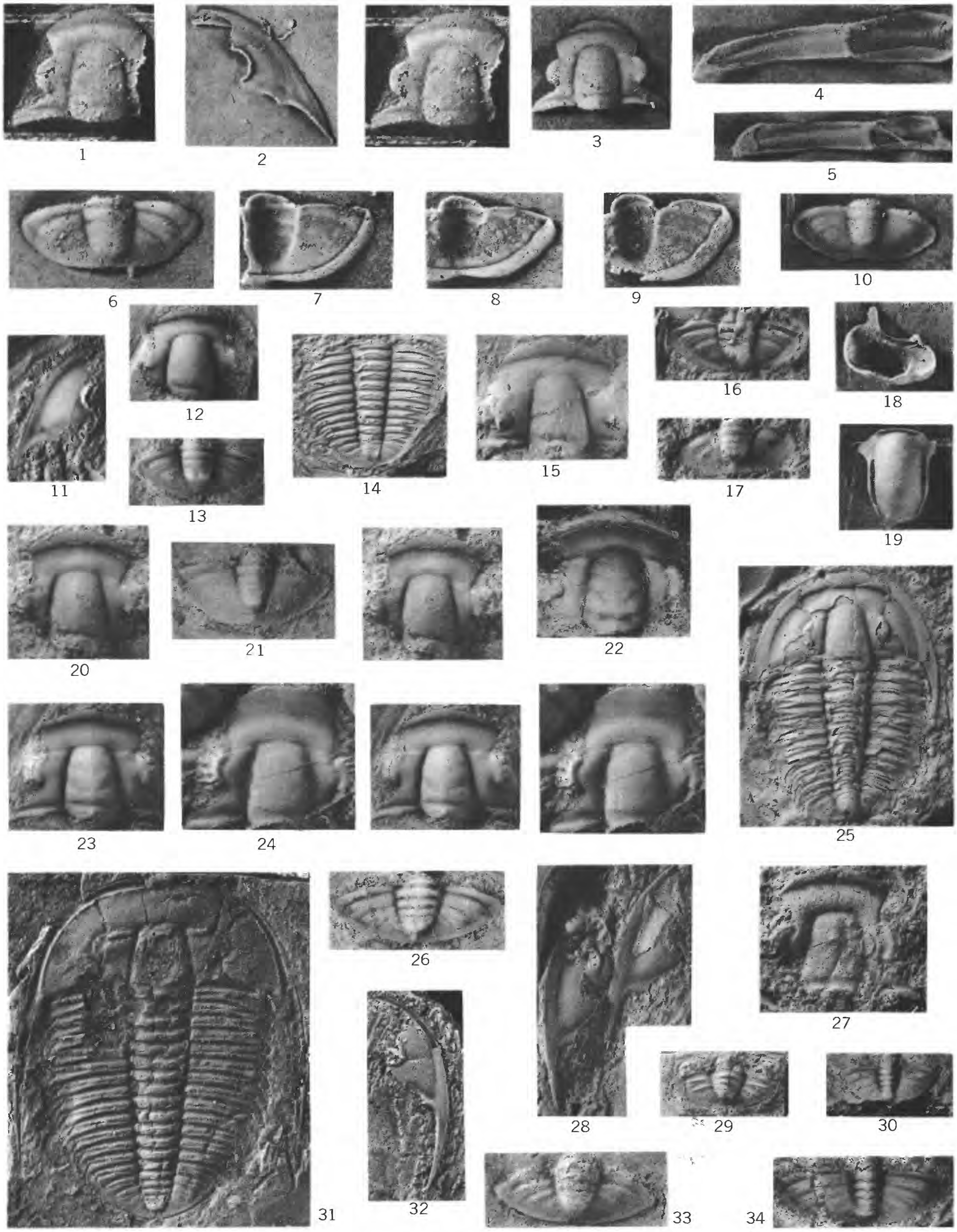
All from USNM loc. 10u, Tin Bridge, 3 miles southwest of Saltville, Va.

27, 29. *Aphelaspis* sp. undet. (p. F–36)

Cranidium, × 3; pygidium, × 2, both exfoliated, USNM 143177a, b. USGS colln. 2879–CO, Cedar Bluff, Ala.

30, 34. Aphelaspinid? sp. (p. F–40)

Pygidia, × 3, for comparison with *Aphelaspis* and *Andrarina*, USNM 143178a, b, USNM loc. 89d. Cedar Bluff, Ala.



APHELASPIDINAE

PLATE 5

FIGURES 1–3. *Olenaspella regularis* n. sp., × 3 (p. F–38).

1. Cranidium, USNM 143180a, USGS colln. 2534–CO.
2. Holotype pygidium, USNM 143170, USGS colln. 2534–CO.
3. Variant pygidium showing development of second pair of inner marginal spines, USNM 143199, USGS colln. 2471–CO.

All specimens from Cherry Creek, Nev.

4, 5, 7. *Olenaspella evansi* (Kobayashi) (p. F–37).

Cranidium, × 2, GSC 15147, pygidium, × 4, GSC 15151; and free cheek, × 2, GSC 15148, from original type lot of *Parabolinella*? *evansi* (Kobayashi, 1936), north of Jubilee Mtn., British Columbia, Canada.

6, 8–21, 23–26, 28, 30–32. *Olenaspella separata* n. sp. (p. F–39)

6. Pygidium, × 3, with single pair of marginal spines, USNM 143181a.
8. Large cranidium, × 1, USNM 143181b.
9. Free cheek, × 3, USNM 143181c.
10, 11. Pygidia, × 2 and × 3 with two pairs of marginal spines, USNM 143181d, e.
12. Smaller cranidium, × 3, USNM 143181f.

Figures 6, 8–12 from USGS colln. 2477–CO, McGill, Nev.

13. Holotype, nearly complete individual, × 2, USNM 143182, USGS coll. 3039–CO, McGill, Nev.
14. Profile of silicified pygidium, × 5, USNM 143185a, USGS colln. 2466–CO, McGill, Nev.
15. Pygidium, × 3, with more elongate form characteristic of specimens in upper part of range of species, USNM 143183, USGS colln. 2480–CO, McGill, Nev.
16. Pygidium, × 4, USNM 143184, USGS colln. 3046–CO, McGill, Nev.
17–19, 23, 24. Growth series of silicified pygidia showing development of inner pair of marginal spines in larger specimens. 17, × 10; 18, × 6; 19, 23, 24, × 4. USNM 143185b–f.
20. Silicified free cheek, × 6, for comparison with associated cheek of *Aphelaspis brachyphasis* (pl. 4, fig. 3), USNM 143185g.
21, 26. Small silicified cranidium, × 6; larger cranidium in limestone, × 4, USNM 143185h, i.
25. Silicified thoracic segment, ventral view, × 8, USNM 143185j.

Figures 14, 17–21, 23–26 from USGS colln. 2466–CO, McGill, Nev.

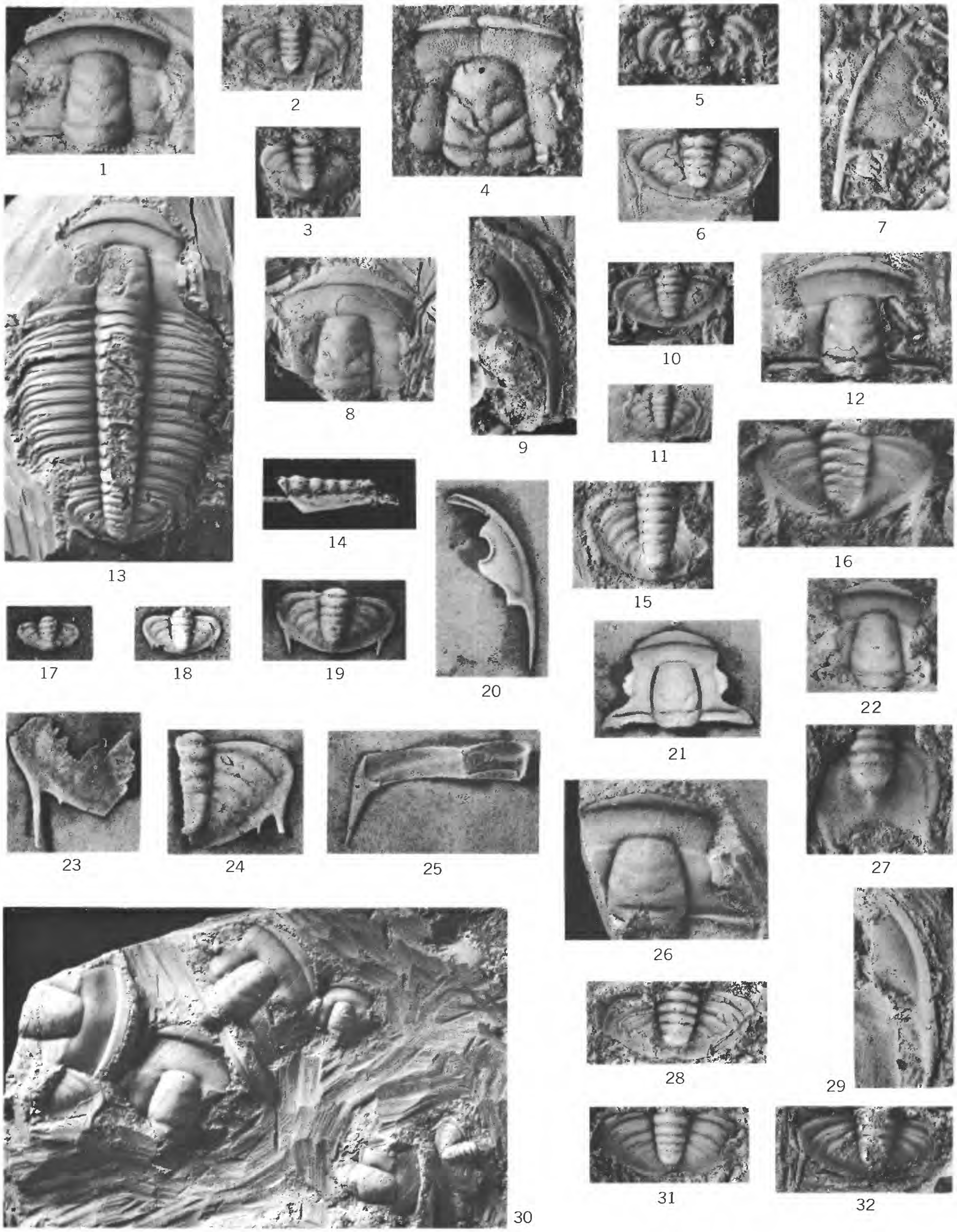
28. Pygidium with tiny second pair of marginal spines on inner side of prominent marginal spine, × 2, USNM 143186a.
30. Cranidia and pygidia with one pair of marginal spines, × 2, USNM 143186b.
31. Pygidium with three close-spaced pairs of marginal spines, × 2, USNM 143186c.

Figures 28, 30, 31 from USNM loc. 89d, Cedar Bluff, Ala.

32. Pygidium with three close-spaced pairs of marginal spines for comparison with fig. 31, × 2, USNM 143187. USGS colln. 1374–CO, Hot Springs Range, Nev.

22, 27, 29. Aphelaspidinae, gen. and sp. undet. (p. F–40).

Cranidium, × 4; pygidium, × 3; free cheek, × 4, USNM 143188a–c, USGS colln. 2535–CO, Cherry Creek Nev.



APHELASPIDINAE

PLATE 6

FIGURES 1–4. *Deiracephalus unicornis* n. sp. (p. F–30).

1–3. Front, top, and side views of holotype, × 2, USNM 143189, USGS colln. 2886–CO, Woodstock, Ala.

4. Incomplete cranidium, × 3, USNM 143190, USGS colln. 3056–CO, Cherry Creek, Nev.

5, 8–10. *Listroa toxoura* n. gen., n. sp., × 6 (p. F–41).

5, 10. Cranidium and free cheek, USNM 143191 a, b. USGS colln. 2535–CO.

8. Stereogram of holotype cranidium, USNM 143192, USGS colln. 2471–CO.

9. Stereogram of pygidium, USNM 143193, USGS colln. 2534–CO.

All from Cherry Creek, Nev.

6, 7. *Komaspidella occidentalis* n. sp. (p. F–30).

6. Stereogram of cranidium, × 5, USNM 143194.

7. Stereogram of holotype pygidium, × 4, USNM 143195.

Both from USGS colln. 2475–CO, McGill, Nev.

11, 12. *Kingstonia alabamensis* Resser, × 6 (p. F–29).

11. Holotype cranidium, USNM 94939.

12. Exfoliated pygidium from type lot, USNM 94939.

Both from USNM loc. 90b, Woodstock, Ala.

13–19. Rostral plates.

13. *Cedaria minor* (Walcott), × 3, USNM 62779, USNM loc. 30N, Weeks formation, House Range, Utah.

14. *Cedaria prolifica* Walcott, × 1, USNM 143196, USGS colln. 1208–CO, Lincoln Peak formation, Snake Range, Nev.

15. *Aphelaspis buttsi* (Kobayashi), × 4, USNM 143197, USNM loc. 91o, Cedar Bluff, Ala.

16–19. External and internal views of silicified rostral plates, × 20, from either *Aphelaspis brachyphasis* or *Olenaspella separata*, USNM 143198 a–d, USGS colln. 3020–CO, McGill, Nev.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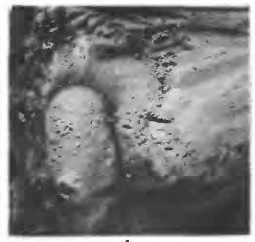
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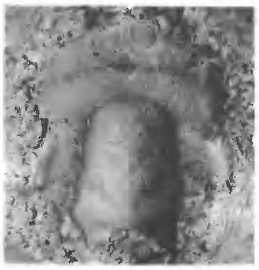
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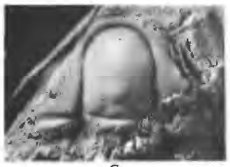
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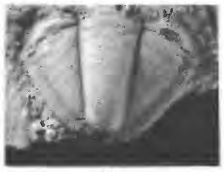
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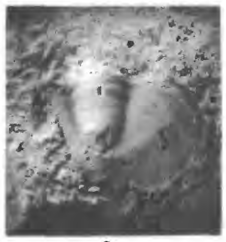
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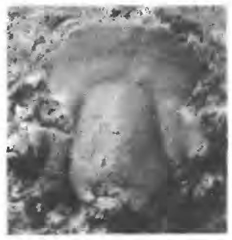

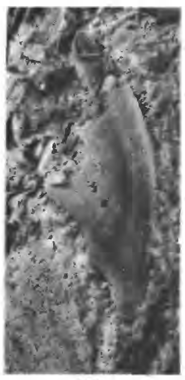
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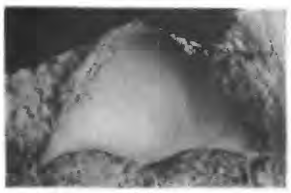
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MENOMONIIDAE, PTEROCEPHALIINAE, LEIOSTEGIIDAE?, KINGSTONIIDAE, AND ROSTRAL PLATES