Cambrian Trilobites of East-Central Alaska

GEOLOGICAL SURVEY PROFESSIONAL PAPER 559-B

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By ALLISON R. PALMER

LOWER PALEOZOIC PALEONTOLOGY AND STRATIGRAPHY OF EAST-CENTRAL ALASKA

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Biostratigraphy and geological history of Cambrian deposits of east-central Alaska; 127 species representing 97 genera of trilobites of Cambrian age are described

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CAMBRIAN TRILOBITES OF EAST-CENTRAL ALASKA

By Allison R. Palmer

ABSTRACT

Undoubted Cambrian rocks have been found in Alaska only in a belt about 12 miles wide that extends northwestward from the Canadian border for about 30 miles on the north side of the Yukon River. Eighty collections of either well-preserved or stratigraphically and paleogeographically important trilobites from eight principal areas or sections are the subject of this paper. The trilobites are assigned to 11 stratigraphically distinct faunas: three are of Early Cambrian age; two are of Middle Cambrian age; and the Dresbachian, Franconian, and Trempealeauan Stages of Late Cambrian age are each represented by two faunas. The faunas within the Lower and Middle Cambrian Series and the Late Cambrian stages are numbered from oldest to youngest.

The Early Cambrian–1 fauna includes nine species and has its greatest affinities with medial Early Cambrian faunas of Siberia. Olenellids have not been obtained from this fauna. The Early Cambrian–2 fauna also includes nine species, but their affinities are almost completely with other North American Early Cambrian species. Only a species of *Aldonaia* indicates affinities to Siberia. Olenellids are present in this fauna. The Early Cambrian–3 fauna includes seven species of North American aspect. Olenellids are not known in this fauna and its Early Cambrian age is based on the presence of *Pagetides*.

Both Middle Cambrian faunas are assigned a late Middle Cambrian age. The Middle Cambrian–1 fauna includes 22 species representing genera of both North American and Asiatic aspect. It is correlated with the lower *Bolaspidella* zone of the western conterminous United States. The Middle Cambrian–2 fauna includes 13 species representing ubiquitous agnostid genera and North American nonagnostids. It is correlated with the middle and upper parts of the *Bolaspidella* zone.

The six Late Cambrian faunas present the greatest diversity of any of the Alaskan Cambrian faunas. The Dresbachian–1 fauna is the smallest fauna, represented by only two species of widely ranging genera that indicate an early Dresbachian age. The Dresbachian–2 fauna includes 23 species that are predominantly North American in aspect. The major exception is a species of *Corynexochus* that is the first Late Cambrian record of this genus outside of Australia. The species with American affinities indicate a correlation with either the lower part of the *Dunderbergia* zone or immediately underlying beds in the western conterminous United States.

The Franconian–1 fauna is represented by six species entirely of Asiatic aspect. It includes the first valid North American record of *Proceratopyge* and other trilobites of the Ceratopygidae. This fauna is correlated with the *Elvinia* zone of early Franconian age. The Franconian–2 fauna includes 19 species that have affinities with either central or eastern Asia, or with other peripheral parts of North America. It is assigned a late Franconian age and correlated with the *Ptychaspis-Prosaukia* zone of western North America because of the presence of *Drumaspis*.

The Trempealeauan–1 fauna includes 10 species whose greatest affinities are with other peripheral North American faunas. The Trempealeauan–2 fauna includes five species that have affinities with either Asia or North America.

Biogeographic analysis indicates that North America was flanked by two or three faunal facies belts containing typically American elements during the Cambrian. The content of Asiatic or European elements in the Cambrian faunas is significant only in the areas closest to either Asia or Europe.

Stratigraphic study indicates the presence of two contrasting lithofacies. Limestone edgewise and boulder conglomerates, abrupt local changes in thickness of small lithologic units, and marked lithologic variation of generally silty limestone both within and between nearby Cambrian sections in the western part of the area contrast strongly with a monotonous succession of thin- to massive-bedded relatively clean limestone to the east. Local disconformities are present at several levels in sections through both facies. The contrast in facies seems to be between a bank or shoal of clean carbonate sediments that existed along what is now the international boundary and the debris from this bank that was shed westward into a deeper and more argillaceous environment.

The trilobite faunas include 127 species representing 97 genera; of these, 54 species and 7 genera are new. New taxa are: *Geragnostus intermedius* n. sp., *Homagnostus alaskensis* n. sp., *Peratagnostus hillardensis* n. sp., *Calodiscus nanus* n. sp., *Neocobboldia spinosa* n. sp., *Pagetia stenoloma* n. sp., *Pagetides appolinis* n. sp., *Pagetides granulosus* n. sp., *Pagetides occidentalis* n. sp., *Yukonia intermedia* n. gen., n. sp., *Churkinia yukonensis* n. gen., n. sp., *Athabaskiella ardis* n. sp., *Bathyuriscus punctatus* n. sp., *Bonnia tatondukensis* n. sp., *Kootenia granulospinosa* n. sp., *Polliaxis inflata* n. gen., n. sp., *Ogygopsis antiqua* n. sp., *Aldonaia alaskensis* n. sp., *Yüpingia glabra* n. sp., *Cheilocephalus expansus* n. sp., *Dinesus arcticus* n. sp., *Iddingsia relativa* n. sp., *Dunderbergia seducta* n. sp., *Elburgia disgranosa* n. sp., *Modocia compressa* n. sp., *Modocia transversa* n. sp., *Hardyoides aspinosa* n. sp., *Prohedinia brevifrons* n. sp., *Cernuolimbus arcticus* n. sp., *Cernuolimbus longifrons* n. sp., *Pterocephalia constricta* n. sp., *Sigmocheilus? compressus* n. sp., *"Antagmus" laminatus* n. sp., *Onchocephalus profectus*

n. sp., *Pareuloma spinosa* n. sp., *Richardsonella nuchastria* n. sp., *Richardsonella quadrispinosa* n. sp., *Gelasene acanthinos* n. gen., n. sp., *Asiocephalus indigator* n. gen., n. sp., *Brabbia pustulomarginata* n. gen., n. sp., *Comanchia burlingi* n. sp., *Elrathia alaskensis* n. sp., *Hungaia burlingi* n. sp., *Liostracinoides? yukonensis* n. sp., *Loganellus? arcus* n. sp., *Onchocephalites? versilis* n. sp., *Onchonotopsis occidentalis* n. sp., *Onchonotus antiqus* n. sp., *Onchonotus brevifrons* n. sp., *Quebecaspis aspinosa* n. sp., *Semisphaerocephalus latus* n. sp., *Spencella acanthina* n. sp., *Tholifrons advena* n. gen., n. sp., *Tholifrons minutus* n. sp.

INTRODUCTION

Undoubted Cambrian rocks have been found in Alaska only in a belt about 12 miles wide that extends northwestward from the Canadian border for about 30 miles on the north side of the Yukon River (fig. 1). This belt continues eastward for a few miles into Canada, but almost all information about both stratigraphy and faunas of the Cambrian rocks of the area has been obtained from the Alaskan side of the boundary. The area that includes the Cambrian outcrops in Alaska is forested, uninhabited, and deeply dissected by the drainage systems of the Yukon and Tatonduk Rivers and Hard Luck Creek. Good exposures are principally either at water level along the major drainages or on ridges (Brabb, 1967, figs. 4–11).

Vehicles can reach the village of Eagle, Alaska, on the west bank of the Yukon River, a few miles south of the Cambrian area during the summer months by way of Taylor Highway. WIEN Alaska airlines provides biweekly air service to Eagle from Fairbanks. Cambrian exposures along the Yukon and Tatonduk Rivers can be reached from Eagle by boat and by foot traverses from the river banks, but the Hillard Peak, Hard Luck Creek, and Jones Ridge areas and the area north of Montauk Bluff are accessible for practical purposes only by helicopter. The majority of the trilobites described in this report were collected between July 8 and 18, 1963, when the availability of both a boat and a helicopter together with an unusually favorable period of weather permitted access to most of the significant Cambrian outcrops and offered an unparalleled opportunity to obtain some relatively large collections.

Although this report contains much new information, it still represents only a reconnaissance study. Many problems concerning details of stratigraphy and geologic history cannot be resolved with the data at hand, but they can be brought into focus for future examination. The purposes of this report are to describe the Cambrian trilobites from Alaska, to relate them wherever possible to the physical stratigraphy, to draw tentative conclusions from the biostratigraphic data about the Cambrian history of the region, and to outline projects for potentially profitable further research.

Cairnes (1914) first identified some Alaskan rocks in the Yukon-Tatonduk region as Cambrian in a report of reconnaissance during 1911 and 1912 along the international boundary.

L. D. Burling spent 4 weeks in 1913 collecting fossils from measured sections of Paleozoic rocks in the Jones Ridge, Squaw Mountain, and Hillard Peak areas. Except for brief comments by Mertie (1933, p. 397, 403, 404; 1937, p. 79, 80), Burling's information has never been published. Faunal and stratigraphic data about the Cambrian beds from Burling's excellent notes and collections from the Jones Ridge, Squaw Mountain and Hillard Peak areas have made a significant contribution to our knowledge of the Cambrian faunas and stratigraphy of Alaska. Information from Burling's notes and collections, and new information about the Cambrian collections of Cairnes, are reported here with the permission of the Geological Survey of Canada. Mertie (1930, 1933) made reconnaissance studies of the Tatonduk-Nation and Eagle-Circle districts on the Alaskan side of the international boundary and established much of the stratigraphic framework currently in use. Kobayashi (1935a, 1936a) and Ulrich and Cooper (1936, 1938) described some of the Late Cambrian fossils from collections of both Cairnes and Mertie, and Cooper (1936) described Middle Cambrian brachiopods from some Mertie collections. Stratigraphic columns showing some of the recent Cambrian collections and giving preliminary faunal determinations are presented by Churkin and Brabb (1965) in connection with their paper on the Ordovician and Silurian stratigraphy of east-central Alaska. These papers contain all the information relating to the Cambrian stratigraphy and faunas of Alaska published prior to this report.

Beginning in 1960 and continuing through 1963, E. E. Brabb and Michael Churkin, Jr., studied the geology of the Cambrian rocks of eastern Alaska while mapping parts of the Charley River and Eagle 1:250,000 quadrangles. In addition to the collections made by Brabb and Churkin during the mapping program, R. J. Ross, Jr., made a series of collections from Upper Cambrian rocks along Hard Luck Creek at the west end of Jones Ridge in 1962. During July, 1963, I spent 11 days with Brabb and Churkin collecting from the principal sections of Cambrian rocks in the area.

More than 100 collections of Cambrian fossils have been obtained from Alaska. Only those collections containing either well-preserved or stratigraphically

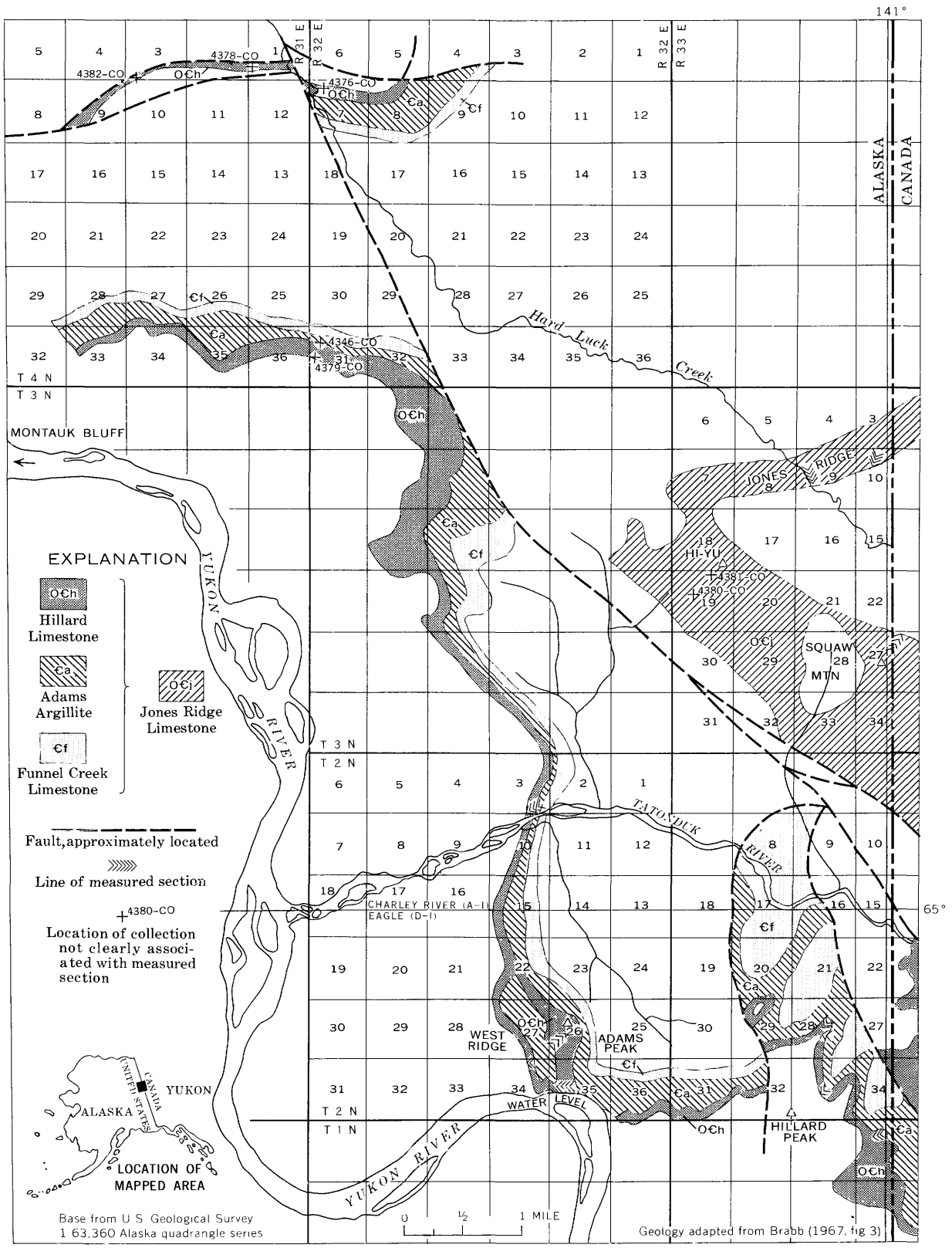

FIGURE 1.—Index map showing outcrop areas of Cambrian rocks in eastern Alaska and immediately adjacent parts of Canada.

and paleogeographically important trilobites are dealt with in this report. These collections total 80 and represent nearly all parts of the Cambrian System. Eight collections are of Early Cambrian age, 15 are from beds of late Middle Cambrian age, 18 are of Dresbach age, 14 are of probable Franconia age, and 25 are of Trempealeau age. Most of the collections that have undescribed material contain fragmentary trilobites that are inadequate for description or discussion. A few contain archaeocyathids, brachiopods, or molluscs that have not been studied.

The trilobite faunas include 127 species representing 97 genera; 54 of the species are new. Seven new genera are also described. The grouping of these species into faunas and their significance for age and correlation of the Alaskan rocks are discussed following the brief summary of the stratigraphy given below. A detailed account of the physical stratigraphy is given by Brabb (1967).

ACKNOWLEDGMENTS

In addition to collections obtained by U.S. Geological Survey personnel during the 1960's, I have had access to all Cambrian material collected earlier in Alaska and now housed in either the U.S. National Museum or the Geological Survey of Canada. These collections were made available to me for study by Dr. R. S. Boardman (U.S. National Museum) and by Dr. W. H. Fritz (Geological Survey of Canada). Dr. Fritz also located Burling's 1913 field notebooks and supplied me with copies. Permission to use the data in these notebooks and to illustrate specimens from the Canadian collections was obtained from Dr. D. J. McLaren of the Geological Survey of Canada. Helpful correspondence regarding identification and relationships of some of the trilobites was received from Dr. A. A. Öpik, Bureau of Mineral Resources, Canberra, Australia, and Dr. N. P. Suvorova, Paleontological Institute, Academy of Sciences, U.S.S.R., Moscow. Dr. Franco Rasetti, The Johns Hopkins University, Baltimore, Md., made his large collection of Late Cambrian trilobites from the Levis area of Quebec available to me, and we had several fruitful discussions about the systematics of these trilobites. Most photographs of specimens at magnifications through × 5 were prepared by R. H. McKinney. All photographs at higher magnifications and photographs of some silicified material at lower magnifications were prepared by D. H. Massie. Logistical support for my collecting trip of July 1963 was provided by E. E. Brabb, U.S. Geological Survey, who also supplied me with the manuscript of his report on the stratigraphy (Brabb, 1967) so that I could complete the introductory part of this paper.

GENERAL STRATIGRAPHY AND PRINCIPAL COLLECTING AREAS

Two strikingly different sequences of Cambrian rocks are present in the Alaska-Yukon boundary area (Brabb, 1967). North of the Tatonduk River and east of a major northwest-trending fault (fig. 1) an arcuate outcrop area includes Jones Ridge, Hi-yu triangulation station, and Squaw Mountain. The Cambrian sequence in this area, from the top of the Precambrian Tindir Group to the Ordovician beds is composed entirely of carbonate rocks of the lower member of the Jones Ridge Limestone and is about 3,000 feet thick. Archaeocyathids have been found about 500 feet above the Tindir Group on the west side of Hi-yu triangulation station, but the only trilobites are Late Cambrian forms that have been obtained from the upper 400–500 feet of the Cambrian sequence. The youngest of these are of latest Trempealeau age. Lowermost Ordovician beds of the Jones Ridge Limestone (lower member) seem to be conformable on the latest Cambrian beds, and no apparent change in sedimentation is reflected at the system boundary.

West of the major northwest-trending fault and east of the Yukon River, in a narrow sinuous belt largely paralleling the river, the Cambrian sequence consists of three distinct formations. The lowest formation is the Funnel Creek Limestone, a predominantly massive-bedded and unfossiliferous carbonate unit estimated to be about 1,000 feet thick. It rests with apparent conformity on the upper unit of the Tindir Group and is overlain by the Adams Argillite. The Adams Argillite is a sequence of argillaceous and arenaceous rocks 500 or more feet thick that has one or more thin archaeocyathid-bearing limestone units. Above the Adams Argillite is the Hillard Limestone, which is as much as 400 feet thick. It contains a variety of thin-bedded limestone and intraformational edgewise conglomerate ranging in age from Early to Late Cambrian and possibly Early Ordovician, and has at its base a limestone boulder conglomerate unit as much as 50 feet thick. The upper contact of the Hillard Limestone is a disconformity with Ordovician parts of the overlying Road River Formation (Churkin and Brabb, 1965).

The faunas described in this paper were obtained from eight principal areas which are discussed below and shown on figure 1 and plate 16. Occurrence data at the end of each species description refer to these areas and the stratigraphic placement of each collection, if known, is shown on plate 16.

Jones Ridge area.—The Cambrian rocks here are part of a steep southeast dipping monocline. Trilobites were collected from several partial sections across

Jones Ridge northeast of Hard Luck Creek in secs. 9 and 10, T. 3 N., R. 33 E., Charley River (A–1) quadrangle.

Hi-yu area.—The Jones Ridge Limestone is so badly broken up here that a section could not be measured. An excellent trilobite fauna of Dresbach age was obtained, however, from the crest of the ridge about 1,000 feet south of the Hi-yu triangulation station in the north half of sec. 19. The same fauna was found on the crest of the spur extending southwest from Hi-yu in the southwest quarter of sec. 19. Both localities are in T. 3 N., R. 33 E., Charley River (A–1) quadrangle. On the slopes between these two occurrences of Late Cambrian trilobites, excellent archaeocyathid limestones crop out.

Squaw Mountain area.—Trilobites have been collected from a partial section across the Jones Ridge Limestone exposed on the spur northeast of Squaw Mountain on the Canadian side of the boundary in the E ½ sec. 27, T. 3 N., R. 33 E.

Correlation of the section on Squaw Mountain and the partial sections on Jones Ridge with sections north of Hillard Peak is shown in figure 2 (p. B18). The stratigraphic significance of this correlation is discussed on page B19.

Hillard Peak area.—Many collections of Late Cambrian age have been obtained from the Hillard Limestone on the east slopes and north ridge of hill 3630, north of Hillard Peak, in the center of sec. 28, T. 2 N., R. 33 E. This hill is referred to in Burling's 1913 notes as Interformation Mountain. Trilobites were also obtained from partial sections through the upper part of the Hillard Limestone on the west side of the stream in the center of sec. 33, T. 2 N., R. 33 E., and through an interval of Middle Cambrian limestone in the north central part of sec. 3, T. 1 N., R. 33 E., southeast of Hillard Peak. All these localities are on the Eagle (D–1) quadrangle. The only Middle Cambrian collection made by Cairnes in 1912 was obtained less than one-half mile east of the international boundary at the latitude of Hillard Peak.

Yukon River area.—Trilobites were collected from three partial sections of the Hillard Limestone on the north side of the Yukon River in an area about 1 square mile south and west of Adams Peak. These are referred to as the Water Level, West Ridge, and Adams Peak subareas. The Water Level subarea includes the outcrops on the north bank of the Yukon River in the W ½ sec. 35; the West Ridge subarea is a west dipping hogback exposed in the E½, secs. 27 and 34; the Adams Peak subarea includes a well-exposed section in the southwest part of sec. 26, all in T. 2N, R. 32 E., Eagle (D–1) quadrangle.

Tatonduk River area.—A well exposed but sparingly fossiliferous section through west-dipping rocks of the Hillard Limestone is present along the north bank of the Tatonduk River in the NW¼NE¼, sec. 10, T. 2 N., R. 32 E., Charley River (A–1) quadrangle.

Montauk Bluff area.—Two collections were made from a south-dipping section through the Hillard Limestone south of the saddle in the northwestern part of sec. 31, T. 4 N., R. 32 E., Charley River (A–1) quadrangle.

Hard Luck Creek area.—Trilobites from this area were obtained from a partial section through the Hillard Limestone on the west bank of Hard Luck Creek in the northwestern part of sec. 7, T 4 N., R. 31 E., and the southwestern parts of secs. 1 and 3, T. 4 N., R. 32 E., in the Charley River (A–1) quadrangle.

COMPOSITION AND CORRELATION OF THE FAUNAS

At least 11 Cambrian trilobite faunas can be recognized in eastern Alaska. Three of these are of Early Cambrian age, two are of Middle Cambrian age, and six are of Late Cambrian age. In stratigraphic context, these faunas indicate a complex history of sedimentation and facies contrasts throughout the Cambrian Period in eastern Alaska. Before the Cambrian history can be considered, however, the composition of each fauna and the evidence used to establish its relative age must be presented. The faunas are therefore discussed below. Within the Lower and Middle Cambrian Series and the Late Cambrian stages, the numbers given to the faunas indicate their probable relative ages, beginning with the oldest. Collections marked with an asterisk (*) are from the measured stratigraphic sections shown on plate 16.

EARLY CAMBRIAN FAUNAS

Three totally distinct faunas are assigned an Early Cambrian age. The placement of these faunas relative to each other within the Alaskan sequence can be only partly determined by their stratigraphic context. The presence of the Early Cambrian–3 fauna in limestone interbeds in the upper part of the boulder conglomerate that forms the lowest unit of the Hillard Limestone clearly establishes its age as younger than a boulder with the Early Cambrian–2 fauna from the lower part of the conglomerate. The bedded limestone from the underlying Adams Argillite, with the Early Cambrian–1 fauna is clearly older than the boulder conglomerate. Evidence from the Early Cambrian–3 fauna that boulders in the upper part of the conglomerate may not be much older than the matrix (see p. B6), if applied to the boulders in the lower part of the conglomerate, would indicate that the Early Cambrian–2 fauna is correctly placed as

younger than the Early Cambrian–1 fauna. However, many of the boulders in the conglomerate were derived from pisolitic limestone. Such limestone is in situ only in the Funnel Creek Limestone below the Adams Argillite. Thus, if the fossiliferous boulder containing the Early Cambrian–2 fauna was derived from the same source as the associated pisolitic boulders, it is possible that it is older than the Early Cambrian–1 fauna. Until the source of the boulders is clearly established, however, the faunas are recorded here in the order of their present stratigraphic occurrence.

EARLY CAMBRIAN–1

The Early Cambrian–1 fauna includes nine trilobite species from three collections. The collections all seem to be from a limestone unit within the Adams Argillite. This limestone is the lowest known trilobite-bearing stratigraphic unit in the eastern Alaskan section. Collections 4295-CO and 4296-CO were obtained from the Yukon River (Water Level) area, where the limestone is faulted against the boulder conglomerate at the base of the Hillard Limestone. The third collection (4449-CO) of the Early Cambrian–1 fauna was sent to me in 1964 by A. L. Bowsher and Norman Johnson of the Sinclair Oil and Gas Co. It was collected from a fault zone 1.75 miles northeast of international boundary monument 105 (McCann Hill) and about 8 miles east-southeast of the Yukon River locality. Bowsher and Johnson (written commun., June 1964) believe that this limestone is the same as one that they found within the unit now called the Adams Argillite.

The identified trilobites from these three collections are listed below. In addition, all three contain archaeocyathids of the *Ethmophyllum*-type.

YUKON RIVER (WATER LEVEL) AREA

*USGS colln. 4295–CO:
- *Calodiscus nanus* n. sp.
- *Dinesus* sp.
- *Neocobboldia spinosa* n. sp.
- *Pagetides granulosus* n. sp.
- *Serrodiscus* sp.

*USGS colln. 4296–CO:
- *Churkinia yukonensis* n. gen., n. sp.
- *Dinesus arcticus* n. sp.
- *Gelasene acanthinos* n. gen., n. sp.
- *Neocobboldia spinosa* n. sp.
- *Polliaxis inflata* n. gen., n. sp.
- *Yukonia intermedia* n. gen., n. sp.

HILLARD PEAK AREA

USGS colln. 4449–CO:
- *Dinesus sp.*
- *Neocobboldia spinosa* n. sp.
- *Polliaxis* sp.

The presence of *Neocobboldia* and archaeocyathids in each collection confirms the dating of this fauna as Early Cambrian. Only one of the trilobite genera (*Polliaxis* n. gen.) is known elsewhere in western North America. Some of the genera are known from northeastern North America, Europe, North Africa, or Australia, but the fauna as a whole has its greatest affinities with Asia and, particularly, with Siberia.

Neocobboldia, *Calodiscus*, and *Serrodiscus* are recorded from many Siberian localities. *Dinesus arcticus* n. sp. is congeneric with the Siberian species described as *Erbia graulosa* Lermontova (see p. B60) and the type species of the genus is Australian. *Pagetides granulosus* n. sp. is congeneric with the Siberian species described as *Neopagetina rjonsnitzkii* (Lermontova). (See p. B37.) *Polliaxis inflata* n. gen., n. sp., and *Churkinia yukonensis* n. gen., n. sp., seem to be related to suprageneric taxa (Edelsteinaspidae, Redlichiacea) known principally in Asia. Northeastern North American, western European, and North African affinities are shown by *Calodiscus*, *Serrodiscus*, and *Pagetides*.

Only the Siberian and western Canadian occurrences of elements of the Early Cambrian–1 fauna provide stratigraphic evidence for the placement of this fauna relative to other known Early Cambrian faunas. Ranges for the eodiscids, pagetiids, and *Erbia granulosa* have been reported in recent papers by Demokidov and Lazarenko (1964) for northern Siberia, and by Repina and others (1964) and Khomentovskiy and Repina (1965) for southern Siberia. The fauna of the Sanashtykgol'skiy complex of the Altay region of southern Siberia (Repina and others, 1964, p. 109) seems to have the greatest number of forms closely related to those of the Early Cambrian–1 fauna. According to the latest revision of the southern Siberian biostratigraphy, the Sanashtykgol'skiy complex corresponds to the whole of the Botoma stage of the middle part of the Early Cambrian (Khomentovskiy and Repina, 1965, p. 94). Thus, the Early Cambrian–1 fauna is probably no older than medial Early Cambrian in Siberian terms.

During a visit to Dr. W. H. Fritz at the Geological Survey of Canada in Ottawa in January 1965, I was shown a collection from the Tah Member of the Gog Group in northern British Columbia which contains a species of *Polliaxis* n. gen, and several olenellids that are related to older Early Cambrian faunas. This fauna is at least 800 feet below beds having olenellids characteristic of the youngest Early Cambrian. Although correlation of faunas having only one genus in common is tenuous, the Canadian occurrence seems to agree with the analysis of the Siberian faunas that the Early Cambrian–1 fauna in Alaska is not from the youngest Early Cambrian.

EARLY CAMBRIAN–2

The Early Cambrian–2 fauna includes nine species from a single boulder in the lower part of the conglomerate at the base of the Hillard Limestone in the Tatonduk River section.

*USGS colln. 4302–CO:
Aldonaia alaskensis n. sp.
"Antagmus" laminatus n. sp.
Bonnia tatondukensis n. sp.
Onchocephalus profectus n. sp.
Ogygopsis antiqua n. sp.
Olenellid undetermined 1
Olenellid undetermined 2
Genus and species undetermined 2
Genus and species undetermined 3

The presence of olenellids, *Bonnia*, *Aldonaia*, and ptychoparioids of the *"Antagmus"-Onchocephalus* group clearly establishes the age of this collectiton as Early Cambrian. *Ogygopsis* is a long-ranging genus, but the number of pleural furrows on the pygidium of *O. antiqua* n. sp. is typical of other Early Cambrian species and seems to be a reliable dating criterion (Palmer, 1964, p. 7). Except for *Aldonaia*, which has not previously been reported from the Western Hemisphere, the generic assemblage of trilobites in this fauna resembles most closely assemblages present in collections from the upper parts of the Lower Cambrian sequences of western North America. *Aldonaia* is recorded from several horizons within the upper part of the Lower Cambrian of Siberia.

At the species level, the characteristics of *Bonnia tatondukensis* are most like those of an undescribed species from a Lower Cambrian boulder at Bic, Quebec (p. B46); and the reticulate ornamentation of olenellid undetermined 1, a species that most nearly resembles forms assigned to *Olenellus* s. s. (p. B39), is known elsewhere on species of *Ollenellus* only from northwestern Europe and eastern Canada. Species of *Aldonaia* are recorded by Pokrovskaya (1959) and Suvorova (1960b) from the Lena Stage, the upper division of the Siberian Lower Cambrian. Korobov (1963) has recorded a species from the upper part of the underlying Aldan Stage in Siberia. I submitted a latex replica of *A. alaskensis* to N.P. Suvorova of the Paleontological Institute, U.S.S.R. Academy of Sciences, Moscow, for comment. She replied (written commun., March 1965) that it is most similar to an undescribed Siberian species (p. B52) from the Sanashtykgol' horizon of the Botoma Stage.

All available evidence indicates that this fauna is from the middle or upper part of the Lower Cambrian and that its geographic affinities are greatest with the Early Cambrian faunas of eastern Canada.

EARLY CAMBRIAN–3

The Early Cambrian–3 fauna includes seven species from four collections from the Yukon River (West Ridge) area. These collections are from the upper part of the boulder conglomerate that is the basal unit of the Hillard Limestone. Two of the collections (4333–CO and 4334–CO) are from limestone interbedded with the conglomerate, and a third collection (4335–CO) is from a boulder in the conglomerate between collections 4333–CO and 4334–CO. The fourth collection (3715–CO) was made in the vicinity of the other three during the early stages of reconnaissance of the area and its exact stratigraphic relationship to them is not known. The identified trilobites from each collection are listed below:

USGS colln. 3715–CO:
Kootenia sp. indet.
Onchocephalites? versilis n. sp.
Pagetia sp. indet.
*USGS colln. 4333–CO:
Kootenia sp. 1
Pagetia stenoloma n. sp.
Pagetides occidentalis n. sp.
Zacanthoides sp. 1
*USGS colln. 4334–CO:
Kootenia sp. 1
Onchocephalites? versilis n. sp.
Pagetia spp.
Pagetides appolinis n. sp.
Zacanthoides sp. 1?
*USGS colln. 4335–CO:
Kootenia sp. indet.
Onchocephalites? versilis n. sp.
Zacanthoides? sp. indet.

The presence in the bedded limestone, of *Pagetides*, a genus known only from rocks of Early Cambrian age, is the evidence for dating these beds as Early Cambrian. All the trilobites in this fauna have North American affinities. Although *Pagetides*, as used here (p. B34), is known from the Early Cambrian of both Siberia and Quebec, the affinities of the Alaskan specimens are closest to the Quebec species. *Onchocephalites* is a generalized ptychoparioid that has been reported by Rasetti (1957) from the lowest Middle Cambrian Mount Whyte Formation of British Columbia. He has also identified it in boulders from conglomerates in Quebec which are dated as Middle Cambrian (Rasetti, 1963). *Zacanthoides* is a widely distributed and long-ranging Middle Cambrian genus in North America. Although both of these genera suggest a Middle Cambrian age for the fauna, in conflict with the age indicated by *Pagetides*, they represent either long-ranging or generalized groups. Generalized ptychoparioids are notoriously difficult to use for precise dating of Early Cambrian and early Middle Cambrian deposits. The occurrence of some long-

ranging and supposedly characteristic Middle Cambrian corynexochoid genera in Lower Cambrian deposits of the United States located near the continental margins, such as those at Austinville, Va., (Resser, 1938) and western Nevada (Palmer, 1964), suggests that the long-ranging corynexochoid elements of the Middle Cambrian must be used with care for precise dating. Therefore, I give the most weight for dating the Early Cambrian–3 fauna to *Pagetides* because pagetiids at present seem to be reliable indicators for regional correlation. This fauna is certainly the youngest of the three Early Cambrian Alaskan faunas.

Onchocephalites? versilis n. sp. and species of *Kootenia* are present in a boulder from the conglomerate (4335–CO) as well as the upper limestone interbed (4334–CO). Their presence indicates that at least some of the boulders in the upper part of the conglomerate may not be greatly different in age from the strata with which they are interbedded.

MIDDLE CAMBRIAN FAUNAS

All the Middle Cambrian faunal assemblages so far identified in eastern Alaska seem to come from beds correlative with the *Bolaspidella* zone of the upper part of the Middle Cambrian of the Cordilleran region to the south. Two faunas, a lower *Bolaspidella* zone fauna (Middle Cambrian–1) and an upper *Bolaspidella* zone fauna (Middle Cambrian–2), can be distinguished. The evidence for the age and correlation of each of these faunas is discussed below.

The identification by Resser of *Albertella*, a characteristic early Middle Cambrian genus, in a collection made by Mertie (1930, p. 65) is apparently erroneous. Unfortunately, Resser never labeled the trilobites in this collection (4424–CO of this report). However, I have examined all the material of the collection that is preserved in the U.S. National Museum and I can find no evidence to support identification of any one of the included trilobites as *Albertella*. The only trilobite that could possibly have been mistaken for *Albertella* is an indeterminate dolichometopid (pl. 4, fig. 16) represented only by cranidia. The cranidia, however, have the morphology of trilobites of the Dolichometopidae, and not of the Zacanthoididae to which *Albertella* belongs. (See p. B46.) The associated trilobites are correlative with the lower *Bolaspidella* zone. Therefore, the Middle Cambrian collections now known from Alaska afford no evidence for any faunas significantly older than the late Middle Cambrian.

MIDDLE CAMBRIAN–1

The Middle Cambrian–1 fauna includes 22 species from eight collections scattered among the Hillard Peak, Yukon River, Tatonduk River, Montauk Bluff, and Hard Luck Creek areas.

In the Yukon River and Tatonduk River areas, collections containing the Middle Cambrian–1 fauna are found only in the beds immediately overlying the boulder conglomerate that forms the basal unit of the Hillard Limestone. In the Yukon River area, collections containing the Middle Cambrian–2 fauna have been made within 20 feet of the top of the boulder conglomerate; thus the stratigraphic range of the Middle Cambrian–1 fauna in this area is limited to less than 20 feet. In the Tatonduk River area, limits to the range of the Middle Cambrian–1 fauna have not been closely established. However, both collections with this fauna came from a sugary-textured magnesian limestone that is less than 50 feet above the basal boulder conglomerate of the Hillard Limestone. East of Hillard Peak, at least 45 feet of beds below the horizon of the uppermost collection contain a Middle Cambrian–1 fauna. At other localities from which collections of the Middle Cambrian–1 fauna have been obtained, there is not enough stratigraphic information available to determine the range of the fauna. The identified trilobites in each collection are listed below:

YUKON RIVER (WATER LEVEL) AREA

*USGS colln. 4330–CO: *Spencella montanensis* Rasetti

YUKON RIVER (ADAMS PEAK) AREA

*USGS colln. 4424–CO:
- cf. *Alokistocare lobatum* Rasetti
- Dolichometopid, genus and species undetermined
- *Kootenia granulospinosa* n. sp.
- *Kootenia* cf. *K. serrata* (Meek)
- *Spencella montanensis* Rasetti

YUKON RIVER (WEST RIDGE) AREA

*USGS colln. 4348–CO: ?*Kootenia* cf. *K. serrata* (Meek)

HARD LUCK CREEK AREA

USGS colln. 4382–CO:
- *Kootenia* cf. *K. serrata* (Meek)
- *Modocia transversa* n. sp.
- *Semisphaerocephalus latus* n. sp.
- *Spencella montanensis* Rasetti

TATONDUK RIVER AREA

*USGS colln. 4303–CO:
- *Dorypyge* cf. *D. olenekensis* Lazarenko
- *Prohedinia brevifrons* n. sp.
- *Semisphaerocephalus latus* n. sp.
- *Spencella acanthina* n. sp.
- *Spencella*? sp.
- Genus and species undetermined 5
- Genus and species undetermined 6

*USGS colln. 4339–CO:
- *Prohedinia brevifrons* n. sp.
- *Semisphaerocephalus latus* n. sp.

HILLARD PEAK AREA

*USGS colln. 4341–CO:
Bathyuriscus punctatus n. sp.
Bolaspidella wellsvillensis (Lochman and Duncan)
Elrathia alaskensis n. sp.
Modocia compressa n. sp.
Peronopsis cf. *P. gaspensis* Rasetti
Ptychagnostus (*Ptychagnostus*) *punctuosus affinis* (Brögger)
Semisphaerocephalus latus n .sp.
Zacanthoides sp. 2

MONTAUK BLUFF AREA

USGS colln. 4346–CO:
cf. *Cotalagnostus lens claudicans* Westergard
Corynexochid, genus and species undetermined
Ptychagnostus sp. undet.

Four of the collections, 4330–CO, 4424–CO, 4348–CO and 4382–CO, contain either *Spencella montanensis* Rasetti or *Kootenia* cf. *K. serrata* (Meek). Both are forms closely related to, or conspecific with, trilobites from the lower part of the Meagher Limestone in the Three Forks area of southwestern Montana. *S. montanensis* was considered by Rasetti (1963, p. 591) to be characteristic of the *Bathyuriscus-Elrathina* zone. However, in 1956, I collected several agnostids, including *Ptychagnostus atavus* (Tullberg), from the lower 40 feet of the Meagher Limestone (Robinson, 1963, p. 19). According to Robison (1964b, p. 990), beds with *P. atavus* correlate with beds assigned to the lower *Bolaspidella* zone of the western American faunal succession. Thus, the lower part of the Meagher Limestone in the Three Forks area, and the four collections listed above, are probably no older than the lower *Bolaspidella* zone. Further confirmation of this correlation is the presence of a species of *Modocia*, a typical *Bolaspidella* zone genus, in 4382–CO. Typical *Bolaspidella* zone genera, *Modocia*, *Elrathia*, and *Bolaspidella*, are also present in collection 4341–CO. Both 4382–CO and 4341–CO also contain *Semisphaerocephalus latus* n. sp.; the other two collections with this species (4303–CO and 4339–CO) thus are probably also correlative with the *Bolaspidella* zone.

In Kazakhstan, *Semisphaerocephalus* is placed by Ivshin (1953) in the uppermost Middle Cambrian *Anomocare-Phoidagnostus bituberculatus* zone. This age assignment strengthens the assignment of the Alaskan species of *Semisphaerocephalus* to the late Middle Cambrian. In collections 4303–CO and 4339–CO, another species, *Prohedinia brevifrons* n. sp., is congeneric with *P. attenuata* Lermontova and Chernysheva and *P. sors* (Öpik) from the latest Middle Cambrian of Siberia and Australia, respectively, and with *P. palliseri* (Walcott) from the *Bathyuriscus-Elrathina* zone of British Columbia (see p. B69). *Prohedinia* thus has a range throughout most of the interval represented by the *Bolaspidella* zone. Collection 4303–CO also contains *Dorypyge* cf. *D. olenekensis* Lazarenko. This species is reported by Lazarenko (in Markovskiy 1960, p. 219) to be characteristic of the lower Maya Stage of northern Siberia and is shown by Pokrovskaya and others (1963) to be associated with *Ptychagnostus atavus* (Tullberg) and *P. punctuosus* (Angelin). Both of the agnostids characterize zones correlated by Robison (1964b, p. 990) with the *Bolaspidella* zone. This correlation adds further support to the correlation of the trilobites in collection 4303–CO with the *Bolaspidella* zone.

The assignment of collection 4346–CO to the Middle Cambrian–1 fauna is based on the presence of an agnostid closely related to *Cotalagnostus lens claudicans* Westergard. This species is found only in the *Ptychagnostus atavus* zone or younger beds in Sweden (Westergård, 1946), and the subspecies is restricted to the *P. atavus* zone. As noted above, this zone is correlated by Robison (1964b, p. 990) with the lower *Bolaspidella* zone.

On the basis of the evidence given above, all the collections here assigned to the Middle Cambrian–1 fauna contain trilobites that can be correlated directly or indirectly with the *Bolaspidella* zone of the late Middle Cambrian, and most probably with the lower part of that zone.

MIDDLE CAMBRIAN–2

The Middle Cambrian–2 fauna includes 13 species from seven collections obtained from the Tatonduk River, Yukon River, and Hillard Peak areas. In the Yukon River area, three collections (3832–CO, 4337–CO, and 4347–CO) have been made. Two of these (3832–CO and 4347–CO) are from the West Ridge subarea, and 4337–CO is from the Adams Peak subarea. All three were collected from bedded limestone within 20–30 feet above the basal boulder conglomerate of the Hillard Limestone. On the Tatonduk River, the single collection assigned to the Middle Cambrian–2 fauna (4310–CO) was found more than 150 feet above the basal conglomerate. In the Hillard Peak area, three collections are assigned to the Middle Cambrian–2 fauna. Two of these (4344–CO and 4345–CO) were obtained from a partial section of the lower part of the Hillard Limestone east of Hillard Peak. In this section there is at least 100 feet of limestone below the youngest Middle Cambrian–2 fauna. The third collection (GSC 282) was collected just east of the international boundary by Cairnes in 1912 and its exact stratigraphic position

is unknown. The trilobites identified in each of the collections are listed below:

TATONDUK RIVER AREA

*USGS colln. 4310–CO: cf. *Marjumia callas* Walcott

YUKON RIVER (WEST RIDGE) AREA

*USGS colln. 3832–CO:
Lejopyge laevigata (Dalman)
Genus and species undetermined 4
*USGS colln. 4347–CO:
Lejopyge sp.
Onchonotopsis sp.

YUKON RIVER (ADAMS PEAK) AREA

*USGS colln. 4337–CO:
Athabaskiella ardis n. sp.
Hemirhodon sp.
Lejopyge calva Robison
Onchonotopsis occidentalis n. sp.

HILLARD PEAK AREA

*USGS colln. 4344–CO:
Bathyuriscidella socialis Rasetti
Hemirhodon? sp.
*USGS colln. 4345–CO: *Lejopyge laevigata* (Dalman)
GSC 282:
Lejopyge calva Robison
Phalagnostus bituberculatus (Angelin)
Ptychagnostus (*P.*) *aculeatus* (Angelin)
Genus and species undetermined 1
Genus and species undetermined 8
Genus and species undetermined 9

Lejopyge is a well-known and geographically widespread guide to beds of latest Middle Cambrian age. In the western European reference section of Sweden, the *Lejopyge laevigata* zone is the terminal zone of the Middle Cambrian, although *L. laevigata* is shown by Westergård (1946) to range downward into the underlying *Solenopleura brachymetopa* zone. In western United States, the *L. calva* subzone is the uppermost division of the latest Middle Cambrian *Bolaspidella* zone. This subzone has been correlated by Robison (1964a, p. 512) with the *L. laevigata* zone of Sweden. Five of the Middle Cambrian–2 collections contain species of *Lejopyge* (3832–CO, 4337–CO, 4345–CO, 4347–CO, and GSC 282), and the presence of these species is the strongest evidence for dating this fauna as latest Middle Cambrian.

In GSC collection 282, *Lejopyge calva* Robison is associated with *Ptychagnostus aculeatus* (Angelin) and *Phalagnostus bituberculatus* (Angelin). Both of these species are reported only from the *Solenopleura brachymetopa* zone of Sweden, although Öpik (1961a) has shown that *P. aculeatus* ranges through beds equivalent to both the *S. brachymetopa* and *L. laevigata* zones in Australia. Three interpretations of this information are possible: (1) *L. calva* may be older than indicated by Robison, (2) the range of *L. calva* may be greater than indicated by the Utah material alone, or (3) the range of *P. bituberculatus* may be greater than indicated by Westergård. The Alaskan collections do not provide evidence to determine which interpretation is correct, but they do indicate that minor revision of the Middle Cambrian agnostid ranges or correlations is needed.

Collection 4344–CO, which contains *Bathyuriscidella socialis* Rasetti and *Hemirhodon*? sp., is found in the partial section east of Hillard Peak midway between collections containing *Ptychagnostus punctuosus affinis* (Middle Cambrian–1) and *Lejopyge laevigata* (Middle Cambrian–2). These agnostids characterize intervals in the Swedish Middle Cambrian that Robison (1964b) correlates with the lower and upper parts respectively of the *Bolaspidella* zone. Robison (1964a, p. 512) records species of *Bathyuriscidella* and *Hemirhodon* from just above the middle of the *Bolaspidella* zone but below the range of *Lejopyge calva* in Utah. Collection 4344–CO is here arbitrarily assigned to the Middle Cambrian–2 fauna because the only other Alaskan specimens assigned to *Hemirhodon* are associated with *L. calva* in 4337–CO.

Collection 4310–CO, which contains only *Marjumia* cf. *M. callas* Walcott, is assigned to the Middle Cambrian–2 fauna because *M. callas* is reported by Robison (1964a, p. 512) only from the upper part of the *Bolaspidella zone.*

The evidence presented above indicates that the collections assigned to the Middle Cambrian–2 fauna are collectively correlative with the middle and upper parts of the *Bolaspidella* zone and are, on the basis of their faunal content, younger than those assigned to the Middle Cambrian–1 fauna. The only Alaskan sections where collections from the two Middle Cambrian faunas were actually collected in sequence are the Tatonduk River section and the partial section east of Hillard Peak. In these areas, the faunal evidence and stratigraphic evidence are in agreement. In the Yukon River area, all the Middle Cambrian collections come from an interval about 30 feet thick and no two collections were obtained in sequence, so the relative ages of collections assigned to the two faunas can only be determined by faunal analysis.

LATE CAMBRIAN FAUNAS

The six Late Cambrian faunas present the greatest diversity of any of the Alaskan Cambrian faunas. Each of the standard American Late Cambrian stages is represented by two distinct faunas. Only the Jones Ridge, Squaw Mountain, and Hillard Peak areas have

yielded more than one fauna, however, and even in these areas no more than three faunas have been found in succession in any one section.

DRESBACHIAN–1

The oldest of the Late Cambrian trilobite faunas is represented by only two small collections. One of these (4376–CO) is the only Cambrian collection from a partial section in the Hard Luck Creek area, and the other (4326–CO) is from the upper part of the Tatonduk River section. Both collections are 100 feet or less from the disconformable contact between the Hillard Limestone and the overlying Road River Formation. The identified trilobites from these collections are listed below:

TATONDUK RIVER AREA

*USGS colln. 4326–CO:
Hypagnostus sp.
Cedaria sp.

HARD LUCK CREEK AREA

USGS colln. 4376–CO: *Cedaria* sp.

Both collections contain a well-preserved, distinctive, and largely new fauna of inarticulate brachiopods not found in any older or younger Alaskan collections. The presence of *Cedaria*, a well-known and widely distributed trilobite of early or middle Dresbachian age, is the principal evidence for including these collections in the Late Cambrian.

DRESBACHIAN–2

Sixteen collections, including 23 species, from the Yukon River (West Ridge), Hillard Peak, Jones Ridge, Hi-yu, and Squaw Mountain areas are assigned to the Dresbachian–2 fauna. Collection 3717–CO from the Yukon River (West Ridge) area came from a bed of limestone very near the top of a unit of black siltstone that seems to be locally developed along the Yukon River and in the West Ridge subarea above the Middle Cambrian limestone and below the edgewise intraformational conglomerate of the Upper Cambrian part of the Hillard Limestone. In the section of Hillard Limestone on Adams Peak less than a mile to the east, which seems to be completely exposed, this black siltstone unit was not seen.

The Hi-yu area yielded two collections (4380–CO and 4381–CO) both from structurally disturbed parts of the Jones Ridge Limestone. Collection 4381–CO contains one of the largest single assemblages of species of Dresbachian age of which I am aware. In addition to 14 named species and 2 unnamed species that are assigned to 12 genera and described later in this report, at least 5 additional species are represented by inadequate material. This is also the only Cambrian collection in Alaska that has yielded a significant number of silicified trilobites. Elements of this fauna are also found in the Jones Ridge and Hillard Peak areas, and it is one of the key faunas for correlating part of the Jones Ridge Limestone with the Hillard Limestone. Three collections from the Jones Ridge area (4361–CO, GSC 4674, and GSC 4676) and one collection from Squaw Mountain (GSC 4719) complete the Dresbachian faunas known from the Jones Ridge Limestone. Present stratigraphic evidence indicates that these collections came from beds about 250 feet below the base of the Ordovician part of the lower member of the Jones Ridge Limestone.

Two sections that include the Dresbachian–2 fauna were measured on slightly different parts of the spur northeast of Hillard Peak referred to by Burling in his 1913 notes as Interformation Mountain. The section examined by Brabb and me yielded only a single collection of this fauna (4360–CO). Burling measured a section at the tip of the spur about one-fourth of a mile north of our section. In the lower 40 feet of this section, he obtained seven collections that are assigned to this fauna. An eighth collection (GSC 4635) was obtained from float near the base of his section.

The identified trilobites from each Dresbachian–2 collection are listed below. The collections from Burling's section are listed in stratigraphic order beginning with the youngest.

YUKON RIVER (WEST RIDGE) AREA

USGS colln. 3717–CO:
Corynexochus plumula Whitehouse
Olenaspella evansi? (Kobayshi)
Pseudagnostus sp.

HI-YU AREA

USGS colln. 4380–CO:
Homagnostus tumidosus (Hall and Whitfield)
?*Iddingsia relativa* n. sp.
Pseudagnostus communis (Hall and Whitfield)
Quebecaspis sp.
Sigmocheilus? *compresssus* n. sp.
USGS colln. 4381–CO:
Acmarhachis acutus (Kobayashi)
Cernuolimbus longifrons n. sp.
Dytremacephalus? sp.
Elburgia disgranosa n. sp.
Homagnostus alaskensis n. sp.
Homagnostus tumidosus (Hall and Whitfield)
Homagnostus sp.
Iddingsia relativa n. sp.
Olenaspella evansi (Kobayashi)

Pseudagnostus communis (Hall and Whitfield)
Pterocephalia constricta n. sp.
Quebecaspis aspinosa n. sp.
Quebecaspis conifrons? Rasetti
Sigmocheilus? *compressus* n. sp.
Tholifrons advena n. gen., n. sp.
Tholifrons minutus n. gen., n. sp.

JONES RIDGE AREA

*USGS colln. 4361–CO:
Cheilocephalus expansus n. sp.
Dunderbergia seducta n. sp.
Hardyoides aspinosa n. sp.
*GSC 4674:
Cheilocephalus sp.
Quebecaspis sp.
*GSC 4676:
Elburgia? sp.
Quebecaspis aspinosa n. sp.

SQUAW MOUNTAIN

*GSC 4719:
Cheiloccphalus expansus n. sp.

HILLARD PEAK AREA

*USGS colln. 4360–CO:
Cernuolimbus arcticus n. sp.
Iddingsia sp.
Oligometopus breviceps? (Walcott)
Quebecaspis sp.
Tholifrons advena n. gen., n. sp.
GSC 4635:
Cernuolimbus arcticus? n. sp.
Cheilocephalus sp.
Dunderbergia sp.
Quebecaspis sp.
Tholifrons advena n. gen., n. sp.

HILLARD PEAK AREA

Burling section

*GSC 4645 (=4728):
Acmarhachis acutus (Kobayashi)
Cernuolimbus arcticus n. sp.
Cheilocephalus granulosus? Palmer
Comanchia burlingi n. sp.
Dunderbergia? sp.
Homagnostus tumidosus (Hall and Whitfield)
Iddingsia sp.
Oligometopus breviceps? (Walcott)
Tholifrons advena n. gen., n. sp.
*GSC 4646:
Cernuolimbus arcticus n. sp.
Comanchia burlingi n. sp.
Elburgia sp.
Quebecaspis sp.
Tholifrons advena n. gen., n. sp.
*GSC 4643:
Comanchia burlingi n. sp.
Oligometopus breviceps? (Walcott)
Pseudagnostus communis (Hall and Whitfield)
Tholifrons advena n. gen., n. sp.
*GSC 4637:
Cheilocephalus sp.
*GSC 4722:
Acmarhachis acutus (Kobayashi)
Cheilocephalus cf. *C. granulosus* Palmer
Homagnostus sp.
Iddingsia sp.
Olenaspella? sp.
Pseudagnostus sp.
Quebecaspis aspinosa n. sp.
*GSC 4639:
Cernuolimbus arcticus? n. sp.
Sigmocheilus cf. *S. grata* (Resser)
*GSC 4641:
Glyptagnostus reticulatus (Angelin)

Evidence from all the collections assigned to the Dresbachian–2 fauna indicates the presence of two or three assemblages that differ in faunal content but are perhaps not greatly different in age. They indicate an interval approximately equivalent to the lower *Dunderbergia* zone or immediately underlying beds in the Great Basin of the conterminous United States.

The key for dating most of the collections of the Dresbachian–2 fauna is 4381–CO, the large silicified assemblage from the Hi-yu area. The presence of *Cernuolimbus*, *Sigmocheilus*, and an early species of *Iddingsia* indicates an age approximately correlative with the lower part of the *Dunderbergia* zone of the Great Basin (Palmer, 1965). In addition, the collection is characterized by *Quebecaspis* and *Tholifrons* n. gen. Eleven of the Dresbachian–2 collections contain species or genera relating them directly to collection 4381–CO. These are: 4380–CO (Hi-yu area); GSC 4674 and GSC 4676 (Jones Ridge area); and 4360–CO, GSC 4635, GSC 4645, GSC 4646, GSC 4643, GSC 4722, and GSC 4639 (Hillard peak area). Collection GSC 4637, which contains only *Cheilocephalus* sp., is bracketed in Burling's section by collections related to 4381–CO and therefore must also be related to that collection. Although most of the trilobites in these collections have affinities with the Great Basin faunas, species of *Quebecaspis* are known elsewhere only in eastern North America, and *Iddingsia relativa* n. sp. is most similar to a species identified as *Dunderbergia* cf. *D. variagranula* by Rasetti from the Frederick Limestone of Maryland. The lack of *Quebecaspis* in any of the many Great Basin *Dunderbergia* zone collections indicates that *Quebecaspis* was not a significant element of the western shelf faunas at that latitude. Therefore, its occurrence in both northwestern and eastern North America indicates the probable presence of a marine connection around the north part of North America during the Late Cambrian.

Collections 4361–CO and GSC 4719, both from the Jones Ridge Limestone, have *Cheilocephalus expan-*

sus n. sp., and 4361–CO also has *Dunderbergia seducta* n. sp. and *Hardyoides aspinosa* n. sp. Both *Cheilocephalus* and *Hardyoides* are relatively long ranging genera, and the new species do not provide any clues to their placement within the generic ranges. *Dunderbergia seducta*, however, has relatively well defined glabellar furrows that seem to characterize the older species of the genus. Therefore, the assemblage is probably no younger than the early *Dunderbergia* zone. Its age relative to the assemblage of 4381–CO cannot be established by stratigraphic evidence although the faunal evidence indicates that the two assemblages are not greatly different in age.

The presence of *Olenaspella evansi*? (Kobayashi) in 3717–CO establishes the age of this collection somewhere in the interval from the *Aphelaspis* zone through the *Dunderbergia* zone of the late Dresbachian. The associated species, *Corynexochus plumula* Whitehouse, characterizes a zone in the middle of the Idamean Stage of Öpik (1963) in Australia. The faunas of the Idamean Stage correlate almost exactly with the faunas of the Pterocephaliid biomere of late Dresbachian and early Franconian age (Palmer, 1965). In the Australian section the *Corynexochus plumula* zone is overlain by the *Erixanium sentum* zone, and in the Pterocephaliid biomere *Erixanium* is a rare but characteristic element of the *Dunderbergia* zone. Available evidence thus indicates that the *C. plumula* zone is probably slightly older than the *Dunderbergia* zone, and collection 3717–CO may be slightly older than the Alaskan collections correlated with the *Dunderbergia* zone.

Glyptagnostus reticulatus (Angelin) is represented by a single specimen in collection GSC 4641. This species is characteristic of beds no older than the *Aphelaspis* zone of late Dresbachian age (Palmer, 1962). In British Columbia it is associated with *Olenaspella evansi* (Kobayashi) which has been identified in Alaskan collections that seem to be as young as the *Dunderbergia* zone. Thus, the age range of *G. reticulatus*, which was previously thought to be largely restricted to the *Aphelaspis* zone, may have to be extended. *G. reticulatus* came from the lowest collection in place in Burling's section near Hillard Peak. Therefore, it is dated as older than the assemblages grouped with 4381–CO and is correlated with the lower *Dunderbergia* zone.

FRANCONIAN–1

The Franconian–1 fauna is represented by three collections, containing six species, from a 60 foot interval in Burling's measured section on the spur northeast of Hillard Peak. The identified trilobites are:

HILLARD PEAK AREA

Burling section

*GSC 4648: *Peratagnostus hillardensis* n. sp.
*GSC 4638 (=GSC 4727):
Iwayaspis cf. *I. asaphoides* Kobayashi
Olenid, genus and species indeterminate 1
Olenid, genus and species indeterminate 2
Peratagnostus hillardensis n. sp.
Proceratopyge cf. *P. chuhsiensis* Lu
Proceratopyge (*Lopnorites*) *rectispinatus* (Troedsson)
*GSC 4642:
Peratagnostus sp.
Proceratopyge sp.

These three collections are grouped together in a single fauna because of the presence of the agnostid genus *Peratagnostus*. The entire aspect of this fauna is Asiatic. *Peratagnostus*, *Proceratopyge*, and *Iwayaspis* are present in the Late Cambrian faunas of Korea (Kobayashi, 1962); *Proceratopyge* and *Peratagnostus* are associated in the upper part of the Idamean Stage of Öpik (1963) in Australia (Öpik, 1967); and *Proceratopyge* (*Lopnorites*) *rectispinatus* was originally described from northwestern China by Troedsson (1937). The olenids are nondescript forms without apparent regional affinities.

The fauna is dated as early Franconian because in both Australia and Korea *Peratagnostus* and *Proceratopyge* are associated with early species of *Irvingella*, which is a characteristic genus of the basal Franconian *Elvinia* zone in North America.

FRANCONIAN–2

The Franconian–2 fauna is represented by 11 collections containing 19 species. Eight of the collections are from partial sections of the upper 200 feet of the Hillard Limestone in the Hillard Peak area (pl. 16). Two of the remaining three collections (3710–CO and 4379–CO) were from the upper 20 feet of the Hillard Limestone: from west of Hillard Peak and from the Montauk Bluff area, respectively. The third collection (GSC 264) was from an unknown level within the Jones Ridge Limestone in the Squaw Mountain area by Cairnes in 1912.

Identified trilobites from these collections are listed below. The collections from measured sections are listed in stratigraphic order, beginning with the youngest.

HILLARD PARK AREA

Burling section

*GSC 4661 (=GSC 4705):
Asiocephalus indigator n. gen., n. sp.
Brabbia pustulomarginata n. gen., n. sp.
Drumaspis idahoensis Resser

Hungaia burlingi n. sp.
Loganellus ? arcus n. sp.
Pareuloma spinosa n. sp.
Richardsonella cf. *R. quadrispinosa* n. sp.
Yüpingia glabra n. sp.
*GSC 4649 (= GSC 4704):
Pareuloma spinosa n. sp.
Yüpingia glabra n. sp.

Brabb-Palmer sections

*USGS colln. 3709–CO:
Bienvillia sp.
?Hungaia burlingi n. sp.
Onchonotus brevifrons n. sp.
Richardsonella quadrispinosa n. sp.
Richardsonella sp. 3
Genus and species undetermined 7
*USGS colln. 4355–CO:
Geragnostus intermedius n. sp.
?Hungaia burlingi n. sp.
?Lauzonella? tripunctata (Kobayashi)
Lotagnostus? sp.
Onchonotus brevifrons n. sp.
Pseudagnostus vulgaris Rozova
Richardsonella quadrispinosa n. sp.
Richardsonella sp. 3
*USGS colln. 4356–CO:
Brabbia pustulomarginata n. gen., n. sp.
?Hungaia burlingi n. sp.
Onchonotus antiqus n. sp.
Pseudagnostus vulgaris Rozova
Richardsonella cf. *R. quadrispinosa* n. sp.
*USGS colln. 4357–CO:
Drumaspis idahoensis Resser
Hungaia burlingi n. sp.
Onchonotus antiqus n. sp.
Pareuloma spinosa? n. sp.
Richardsonella cf. *R. quadrispinosa* n. sp.
*USGS colln. 4358–CO:
Brabbia pustulomarginata n. gen., n. sp.
Drumaspis idahoensis Resser
Hedinaspis sp.
Hungaia burlingi n. sp.
Loganellus? arcus n. sp.
Onchonotus antiqus n. sp.
Pareuloma spinosa n. sp.
Richardsonella cf. *R. quadrispinosa* n. sp.
*USGS colln. 4359–CO: *Loganellus? arcus* n. sp.

HILLARD PARK AREA (WEST SIDE)

USGS colln. 3710–CO:
Loganellus? arcus n. sp.
Onchonotus antiqus? n. sp.

MONTAUK BLUFF AREA

USGS colln. 4379–CO:
?Brabbia pustulomarginata n. gen., n. sp.

SQUAW MOUNTAIN AREA

GSC 264: *Onchonotus brevifrons?* n .sp.

The most important trilobite for dating the Franconian–2 faunas is *Drumaspis idahoensis* Resser, a characteristic species of the *Ptychaspis-Prosaukia* zone in the northern Rocky Mountain region of western conterminus United States. All the remaining trilobites in this fauna with North American affinities are known elsewhere only from boulders bearing the *Hungaia magnifica* fauna in conglomerates from eastern United States and Canada (Rasetti, 1943, 1944, 1945a) or from unstudied sections in the Great Basin in western United States. The *H. magnifica* fauna was considered as a lateral equivalent of the *Ptychaspis-Prosaukia* (late Franconian) and *Saukia* (early Trempealeauan) zone faunas by Lochman and Wilson (1958, p. 339). Correlation of at least some elements of the fauna with the older zone is borne out by the Alaskan study.

In the Hillard Peak area, collections assigned to the Franconian–2 fauna were obtained from an interval at least 180 feet thick. The upper two collections (3709–CO and 4355–CO) do not contain *Drumaspis* and have different species of *Onchonotus* and *Richardsonella* from the remaining collections. However, *Hungaia burlingi* ranges through the section in the Hillard Peak area and indicates that age differences between the collections are probably not great. Because of similarity of the upper collections at the generic level with those bearing *Drumaspis* and lack of any definitive Trempealeauan elements, all the collections are considered here to represent a faunal complex of late Franconian age.

The characteristic trilobites of this fauna besides *Drumaspis idahoensis* and *Hungaia burlingi*, are species of *Onchonotus* and *Richardsonella*, *Pareuloma spinosa* n. sp., and *Loganellus? arcus* n. sp. Burling's section in the Hillard Peak area includes not only most of the characteristic North American genera, but also two trilobites with strong Asiatic affinities (*Asiocephalus indigator* n. gen., n. sp., and *Yüpingia glabra* n. sp.). *Hedinaspis*, another Asiatic genus, is represented in this fauna by a fragment of one of its very unusual and distinctive thoracic segments. *Pseudagnostus vulgaris* Rozova is a species from the upper part of the Tolstochikhin Limestone in the Salair region of southwestern Siberia. Rozova (1960, p. 85) concluded that the age of the Tolstochikhin fauna was late Franconian to early Trempealeauan, a conclusion which agrees very well with the suggested age for the beds containing *P. vulgaris* in Alaska.

TREMPEALEAUAN–1

Except for the relatively rich assemblage described by Kobayashi (1935a), Trempealeauan collections from Alaska contain few specimens and species of trilobites. The Trempealeauan–1 fauna is represented by 10 col-

lections including at least 10 species, all from the Jones Ridge Limestone. Eight of the collections are from the Jones Ridge area, and two are from the Squaw Mountain area. In several partial sections of the Jones Ridge Limestone, this fauna is found in the lowest beds that can be dated as Trempealeauan.

In one of the Jones Ridge sections, less than 100 feet separate a Trempealeauan–1 collection (GSC 4679) from a Dresbachian–2 collection (GSC 4674). Correlation of the several partial sections of the Jones Ridge Limestone (fig. 2, p. B18) shows that the Trempealeauan–1 fauna occurs about 200 feet below the first identifiable Lower Ordovician collection.

The trilobites identified in each collection are listed below. Within each partial section, collections are listed from youngest to oldest.

SQUAW MOUNTAIN AREA

Burling section

*GSC 4717:
Tatonaspis alaskensis Kobayashi
Richardsonella sp.

*GSC 4718:
Tatonaspis? sp.
Richardsonella sp.

JONES RIDGE AREA

Burling international boundary section

*GSC 4669: *Richardsonella* sp.

*GSC 4671 (=GSC 4736):
"Briscoia" elegans (Kobayashi)
Lauzonella? *tripunctata* Kobayashi
Pseudagnostus clarki Kobayashi
Richardsonella sp. 4
Tatonaspis alaskensis Kobayashi

*GSC 4679:
Pseudagnostus sp.
Richardsonella sp.

Ross traverse, south end of Jones Ridge

USGS colln. 3833–CO:
Rasettia cf. *R. capax* (Billings)
Richardsonella nuchastria n. sp.

USGS colln. 3834–CO:
Hungaia sp.
Pseudagnostus sp.
Pseudosaukia cf. *P. brevifrons* (Clark)
Richardsonella nuchastria n. sp.

USGS colln. 3835–CO:
Briscoia septentrionalis Kobayashi
Lauzonella? *tripunctata* (Kobayashi)
Pseudagnostus sp.
Richardsonella? sp. 2
Tatonaspis alaskensis Kobayashi

Brabb and Churkin international boundary section

*USGS colln. 4362–CO:
Richardsonella nuchastria n. sp.
Richardsonella sp. 1

Mertie, south end of Jones Ridge

USNM loc. 25o: *Briscoia septentrionalis* Kobayashi
"Briscoia" elegans (Kobayashi)
Chuangiella intermedia Kobayashi
Hungaia pacifica Kobayashi
Lauzonella? *tripunctata* (Kobayashi)
Pseudagnostus clarki Kobayashi
Tatonaspis alaskensis Kobayashi

The most characteristic trilobites of this fauna are *Tatonaspis alaskensis* Kobayashi and species of *Richardsonella*. The species of *Briscoia*, although rare and generally fragmentary, also seem to be characteristic elements. Most of the trilobites have their affinities with species described from boulders in the Levis conglomerate of Quebec (Rasetti, 1944, 1945a) and their assignment to a Trempealeauan age is based largely on their association with the dikelocephalid *Briscoia* or on their stratigraphic position above *Briscoia*. *Tatonaspis* and *Pseudagnostus clarki* Kobayashi have also been found at several localities in Nevada in association with the characteristic Trempealeauan genera *Eurekia* and *Idiomesus*. *Rasettia* is a rare but persistent element of the Trempealeauan faunas in the central and western conterminous United States.

TREMPEALEAUAN–2

The youngest Cambrian fauna in Alaska is represented by 15 collections that include a restricted trilobite fauna of four or five species, only two of which are named. Thirteen of the collections are from the upper 100 feet of the Cambrian part of the Jones Ridge Limestone in the Jones Ridge and Squaw Mountain areas (pl. 16). Two collections (4351–CO and 4352–CO) are from the upper 30 feet of the Hillard Limestone in the Yukon River (Adams Peak) area.

In the Jones Ridge Limestone on Jones Ridge there is no apparent change in lithology or bedding characteristics of the limestone at the Cambrian-Ordovician boundary. The basal Ordovician can be recognized by the relatively common occurrence of the trilobite *Symphysurina* and the associated orthoid brachiopod *Apheoorthis*. Less than 30 feet of limestone separate the highest unequivocally dated Cambrian collections from the lowest Ordovician collections.

In the Yukon River (Adams Peak) area, the Cambrian beds are unconformable beneath the Middle Ordovician part of the Road River Formation (Churkin and Brabb, 1965, fig. 4, col. 4).

The identified trilobites from each collection are listed below. Within each partial section the collections are listed from youngest to oldest.

YUKON RIVER (ADAMS PEAK) AREA

*USGS colln. 4351–CO:
Hedinaspis sp.
Liostracinoidcs? yukonensis n. sp.
Yukonaspis kindlei Kobayashi
*USGS colln. 4352–CO:
Hedinaspis sp.
Rasettia? sp.

SQUAW MOUNTAIN AREA

Burling section

*GSC 4685:
Yukonaspis kindlei Kobayashi
Undetermined eurekiid
*GSC 4732:
Yukonaspis kindlei Kobayashi
Undetermined eurekiid
*GSC 4744:
Pseudagnostus clarki Kobayashi
Yukonaspis kindlei Kobayashi
Undetermined eurekiid

JONES RIDGE AREA

Burling section, south end of Jones Ridge

*GSC 4628 (=GSC 4749):
Bayfieldia? sp.
Pseudagnostus sp.
Yukonaspis kindlei Kobayashi
*GSC 4629:
Bayfieldia? sp.
Pseudagnostus sp.
Yukonaspis kindlei Kobayashi
*GSC 4634: *Yukonaspis kindlei* Kobayashi
*GSC 4631:
Bayfieldia sp.
Pseudagnostus sp.
Yukonaspis kindlei Kobayashi
*GSC 4691: *Yukonaspis kindlei* Kobayashi
*GSC 4632:
Yukonaspis kindlei Kobayashi
Undetermined eurekiid

Brabb and Churkin, international boundary section

*4371–CO:
Bayfieldia sp.
Pseudagnostus sp.
*4363–CO:
Bayfieldia sp.
Pseudagnostus sp.
*4374–CO: *Bayfieldia* sp.

Cairnes collection

GSC 266: *Pseudagnostus* sp.
Yukonaspis kindlei Kobayashi
Undetermined eurekiid

This small fauna is characterized by *Yukonaspis kindlei* Kobayashi and scraps of eurekiid trilobites, some of which can be identified as *Bayfieldia*. Eurekiidae are found throughout central and western conterminous United States in the uppermost beds of the Cambrian System and are probably the most reliable guides to beds of Trempealeauan age.

BIOGEOGRAPHIC SIGNIFICANCE OF THE ALASKAN CAMBRIAN TRILOBITES

Evidence obtained from analysis of the regional relationships of the Alaskan Cambrian trilobites suggests a remarkable symmetry to the distribution of Cambrian faunas in North America. This symmetry can best be shown by consideration of the Upper Cambrian facies and faunas for the whole of North America.

During Late Cambrian time, the continental interior was flanked by three principal facies belts whose shifting marginal relationships and gradual movement towards the continental interior produced the stratigraphic framework as it is now understood (Palmer, 1960b, c). The continental shoreline was always flanked by a broad belt of sandy and silty, often glauconitic, sediments. Seaward of this belt, a broad belt of relatively detritus free limestone and dolomite developed. Much of this clean limestone and dolomites is oolitic or calcarenitic and crossbedded, and it must have accumulated under high energy conditions. Algal stromatolites are also characteristic of rocks in this belt. Both lines of evidence indicate that the carbonates of this belt represent a bank or coalescing complex of banks that was never very far below sea level. Still further from the continental interior, on the oceanic side of the carbonate belt, another belt of generally silty sediments accumulated. In contrast to the inner detrital belt, sediments of this outer belt generally formed dark, often pyritic or organic-rich siltstone and limestone. The limestone is fine grained and thin bedded and many of the beds are laminated—a feature that suggests relatively deep and quiet conditions of deposition.

Each of the belts has its characteristic fauna which differs from the adjacent belt, or belts, generally at the species level and in the relative abundance of certain genera. Thus, in beds of Dresbachian age, the *Crepicephalus* zone includes abundant individuals of *Crepicephalus* and *Lonchocephalus* in the inner detrital belt but both genera are rare in the carbonate belt and outer detrital belt. On the other hand, *Tricrepicephalus* is common in the *Crepicephalus* zone faunas of the carbonate belt but is relatively rare in the detrital belts; and species of the *Cedaria prolifica* species-group are found only in the *Crepicephalus* zone faunas of the outer detrital belt (Palmer, 1962). In beds of late Franconian age, *Ptychaspis* is a common genus in the inner detrital belt, but it is relatively rare in the carbonate belt and almost completely

absent in the outer detrital belt. On the other hand, in the late Franconian faunas of the outer detrital belt, *Richardsonella* is a common genus that is rare or absent in the carbonate and inner detrital belts.

In Alaska, both the lithology and the faunas of the nonconglomeratic parts of the Hillard Limestone are suggestive of the outer detrital belt, whereas the lower member of the Jones Ridge Limestone to the east represents almost pure carbonate sedimentation throughout much of the Cambrian.

Although two faunas (Early Cambrian–1 and Franconian–1) are almost entirely Asiatic in their affinities, and scattered Asiatic genera are present in other faunas, most of the Alaskan trilobites have affinities with forms found elsewhere in North America. When the North American affinities of the Cambrian trilobites of all ages are examined more closely, about half of the Alaskan species have affinities with species known from the southern Cordilleran region, and about one-fourth of the species have affinities with species known either from Cambrian boulders in the Levis Conglomerate of Quebec or from localities in Eastern United States. The absence of Alaskan Dresbachian–2 genera such as *Quebecaspis* (p. B12) from the reasonably well known faunas of comparable age to the south (Palmer, 1965) suggests that a trans-Arctic migration route was available between eastern and western North America at that time, and probably throughout the Cambrian. During the Late Cambrian, at least, there was also a marine connection around the southern part of North America as evidenced by the distribution of the *Cedaria prolifica* species group (Palmer, 1962, p. 26). Thus, the picture that emerges is one of a continental core surrounded by concentric facies belts with generally characteristic faunas.

Lochman and Wilson (1958) have shown a somewhat similar pattern of faunal facies belts. Their cratonic biofacies includes the faunas of the carbonate and inner detrital belts described above. Their extracratonic biofacies roughly coincides with the faunas of the outer detrital belt. However, their subdivision of the extracratonic biofacies into the extracratonic-intermediate and extracratonic-euxinic realms needs reevaluation. Most of the faunas that they assign to the extracratonic-intermediate realm are those that I would describe as typical American outer-detrital belt faunas. On the Pacific side of the continent, non-American elements in these faunas have Asiatic affinities, and the Asiatic elements increase as Asia is approached. On the Atlantic side of the continent, the non-American elements have strong European affinities, which also increase as Europe is approached.

The western American faunas were still poorly known at the time of the study by Lochman and Wilson. Thus, Lochman and Wilson believed that the faunas with European affinities, which they identified primarily with their extracratonic-euxinic realm, formed a continuous belt around the continent. However, most of the supposed European affinities of trilobites from Western United States are due to overgeneralization of some morphologic tendencies. *Olenaspella*, for example, was cited as a western American olenid. Although *Olenaspella* does have some common characteristics with early olenids, its close affinities are with early pterocephaliid trilobites of Siberia and Australia (Palmer, 1965, p. 64). Likewise, the olenids that are present in western North America have different pygidial structures from olenids found in eastern North America and western Europe, and their affinities seem to be with other olenids of the Pacific region (Palmer, 1965, p. 56). Thus, an extracratonic-euxinic fauna characterized by European elements and flanking both sides of the continent does not seem to exist. The important biogeographic contribution from the Alaskan study is the evidence that an outer detrital belt with peripheral, but typically American, faunas probably circumscribed North America. In addition, the non-American elements in this belt are related to the nearest adjacent continent and do not themselves constitute an even more peripheral belt.

GEOLOGICAL HISTORY OF THE CAMBRIAN OF EASTERN ALASKA

Although there are many questions about details of the Cambrian history of eastern Alaska that cannot be answered from present knowledge, enough has now been learned to permit description of at least some of the significant happenings in the area during the Cambrian Period.

Credit for valuable data that helped to demonstrate the complicated sedimentary history of the Late Cambrian must be given here to L. D. Burling of the Geological Survey of Canada. Between August 20 and September 16, 1913, Burling studied the Jones Ridge, Squaw Mountain, and Hillard Peak areas on foot from campsites along Hard Luck Creek at the base of Jones Ridge, and on the Tatonduk River at the international boundary. During much of this time, snow covered many parts of the working areas and fieldwork was conducted in below-freezing temperatures. Nevertheless, Burling measured in considerable detail, and carefully located, more than 30 valuable Late Cambrian collections in four sections: two on Jones Ridge, one on Squaw Mountain, and one on the north end of the high spur northeast of Hillard Peak that

he refers to in his notes as Interformation Mountain. This information, together with subsequent information obtained by Brabb, Churkin, and me, is summarized in figure 2.

Prior to the Cambrian, and into the earliest Cambrian, sedimentation in the eastern Alaska area seems to have been reasonably continuous, as shown by the parallel distribution of the units of the Tindir Group and the massive carbonate rocks representing the Funnel Creek Limestone and the lower part of the Jones Ridge Limestone (Brabb, 1967). However, during the Early Cambrian, carbonate sedimentation was replaced

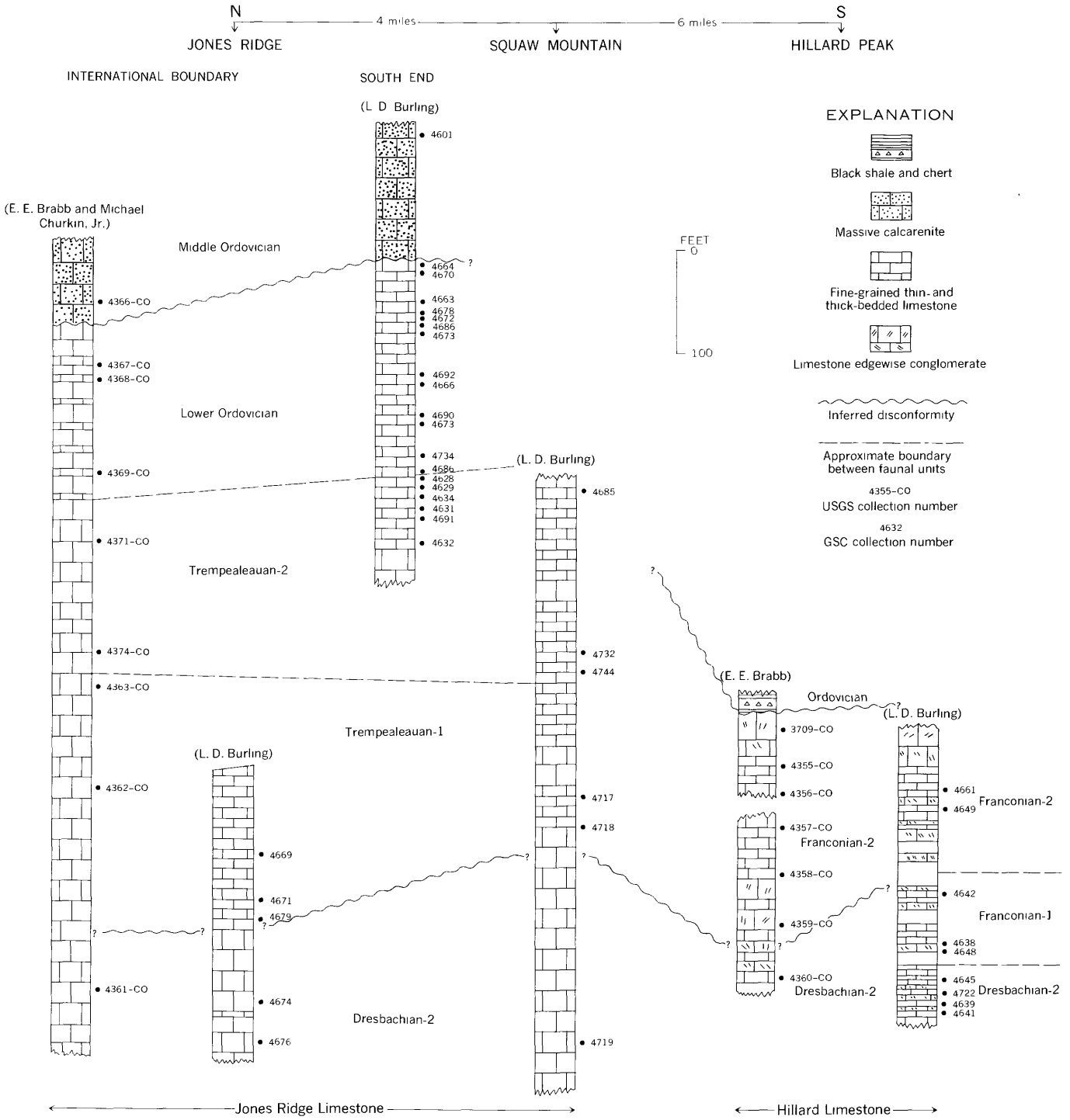

FIGURE 2.—Correlation of the Upper Cambrian parts of the Hillard and Jones Ridge Limestones showing facies contrasts and evidence for local disconformities.

by deposition of argillaceous and arenaceous detritus of the Adams Argillite in the western part of the area. No direct evidence of interruption of carbonate sedimentation during the Early Cambrian is apparent in areas now bearing the Jones Ridge Limestone, but there may have been periods of erosion of the carbonate sediments to produce the boulder conglomerate that is within the Adams Argillite and that also marks the base of the overlying Hillard Limestone. Faunal evidence from the upper part of the basal Hillard Limestone conglomerate (Early Cambrian–3) indicates that this conglomerate reflects one of the terminal events of Early Cambrian time in the present Cambrian area. There is no faunal evidence to indicate the presence of any lower Middle Cambrian strata in eastern Alaska, although there is adequate room for such strata in the thick and largely unfossiliferous lower part of the Jones Ridge Limestone. In the Hillard Limestone, the Lower Cambrian boulder conglomerate is directly and perhaps disconformably overlain by beds of late Middle Cambrian age (Middle Cambrian–1). From this time on to the end of the Cambrian, the materials that compose the Hillard Limestone accumulated in an irregular manner.

On the Tatonduk River, more than 200 feet of upper Middle Cambrian thin-bedded limestone is present, and there are no significant units of edgewise conglomerate. Six miles to the southeast in the Hillard Peak area, a comparable thickness of upper Middle Cambrian rocks that are almost entirely massive limestone, in part with units of edgewise conglomerate, makes up the Hillard Limestone. About 4 miles from both of these areas, in the Yukon River area, the entire Middle and Upper Cambrian section is only slightly more than 100 feet thick and not more than 50 feet of beds, including oolitic limestone, edgewise conglomerate, and possibly an impersistent black siltstone, can represent late Middle Cambrian time (pl. 16).

Upper Dresbachian rocks are present in both the Hillard and Jones Ridge Limestones. The Dresbachian–2 fauna from these rocks provides an important datum for correlation between sections of the two formations (fig. 2). Above this datum in the Hillard Peak area, the section measured by Burling in 1913 contains a more or less continuous sequence of faunas of early and late Franconian age (Franconian–1 and –2). However, less than a mile to the south of Burling's section, the Franconian–1 fauna, which has a minimum vertical range of 60 feet, was not found, and only 40 feet separate a Franconian–2 fauna from the Dresbachian–2 fauna. An oblique view of the mountainside in the area of this section, and the lateral changes in thickness of the edgewise conglomerate units in the section are shown by Brabb (1967, fig. 6, p. 10).

At least 200 feet of trilobite-bearing beds of Franconian age are interbedded with edgewise conglomerate in the Hillard Peak area, but no Trempealeauan trilobites have been collected. The Hillard Limestone is disconformably overlain here by the Lower Ordovician part of the Road River Formation. On Jones Ridge at the international boundary, 9 miles north of the Hillard Peak area, less than 100 feet of massive Jones Ridge Limestone separates the Dresbachian–2 fauna from the lowest Trempealeauan–1 collection. Thus, either a reduction in rate of carbonate sedimentation took place in the area of the Jones Ridge Limestone or an unsuspected disconformity exists there. The presence of a Trempealeauan–2 fauna at the top of the Hillard Limestone in the Yukon River (Adams Peak) area is evidence that the area southwest of Jones Ridge received some sediments until the end of the Cambrian. However, in the Adams Peak section, less than 100 feet separates the Middle Cambrian–2 faunas from the Trempealeauan–2 faunas. Beds including the intervening Dresbachian and Franconian faunas are a minimum of 220 feet thick in the Hillard Peak area, and beds containing Desbachian–2 through Trempealeauan–1 faunas are a minimum of 300 feet thick on Jones Ridge. The lateral changes in thickness and lithology of Middle and Upper Cambrian beds within the Hillard Limestone and the possible Late Cambrian disconformity within the Jones Ridge Limestone indicate a more complicated history of sedimentation of the Cambrian in eastern Alaska than is apparent from a look at the geologic map.

My suggested interpretation is that Jones Ridge Limestone represents a carbonate bank deposit at the seaward edge of the carbonate belt, and that the Hillard Limestone includes, in part, the debris eroded from this bank and deposited as talus on its western flank and, in part, sediment accumulating normally in deeper water adjacent to the bank. Some evidence supporting this conclusion is indicated by the edgewise conglomerate units of the Hillard Limestone. The edgewise conglomerate units occupy a greater stratigraphic thickness and have more parts of the Cambrian represented eastward towards the Jones Ridge area. The contrast between the even bedding of the Tatonduk River section and the abundant edgewise conglomerate of the other sections may reflect different local positions relative to the main talus accumulations from bank deposits of the Jones Ridge Limestone.

Sedimentation continued from the Cambrian into the Early Ordovician without apparent interruption in the Jones Ridge Limestone area. Except for a collection containing the Early Ordovician trilobite *Symphysurina* in the Tatonduk River area (but not in the Water Level section), no Early Ordovician faunas have been identified from the Hillard Limestone, and it is everywhere overlain disconformably by younger Ordovician parts of the Road River Formation.

PROBLEMS FOR FUTURE INVESTIGATION

Much of the preceding section is speculative. However, there are no immediate prospects for future work on the Cambrian of eastern Alaska and it is hoped that the interpretations of facies relationships and Cambrian history are not too inaccurate. Important points concerned with the demonstrability of the local unconformities in the Hillard Peak area can be resolved by careful lateral tracing of units in the good exposures north and east of Hillard Peak. The nature of the facies changes in the more or less continuous strike belt connecting the Hillard Peak, Yukon River, and Tatonduk River areas may be resolved by following the reasonably good outcrops of the Hillard Limestone, which have not been closely examined in the intervening areas. Additional examination of the Yukon River area is needed to determine if the black siltstone just above river level near the center of section 35, T. 3 N., R. 32 E., is really a lens or wedge, as suspected, or if its absence in the apparently continuous section less than a mile to the north on the south flank of Adams Peak is due to an undetected bedding fault.

Evidence concerning the possible existence of Cambrian and Ordovician talus along the flanks of a bank represented by the Jones Ridge Limestone may be obtained by examination of a puzzling breccia, made up of large jumbled angular blocks of limestone that caps the spur extending southwest from the Hi-yu area in the southwest part of sec. 19, T., 2 N., R. 33 E.

Nature and magnitude of the movement on the fault that separates outcrops of Jones Ridge Limestone from those of the Hillard Limestone must be studied. It is easy to assume that the contrasts between the Jones Ridge-Squaw Peak areas and the Hillard Peak area result from tectonic juxtaposition of formerly widely separated areas. However, the similarity of the Dresbachian–2 faunas on both sides of the fault, the presence of Hillard Limestone on the Jones Ridge side of the fault in the Hard Luck Creek area, and the occurrence of the same units of the Tindir Group on both sides of the fault may be evidence that tectonic displacement has not significantly complicated the interpretation of the Cambrian history of the area.

SYSTEMATIC PALEONTOLOGY

The classification of the Cambrian trilobites from Alaska is summarized below. The taxa are listed in the order that they appear on the following pages. A diagnosis or description is provided for each species and for most supraspecific taxa. Lack of discussion of a suprageneric taxon indicates acceptance of this taxon as it is constituted in part O of the "Treatise on Invertebrate Paleontology" (Harrington and others, 1959). Most descriptive terms used here are defined or illustrated in the treatise on pages 42, 44, 46, 47 and 117–126. "Plectrum" is a term apparently introduced by Öpik (1961a) for a posteriorly directed median expansion of the cranidial border.

Catalog numbers of specimens deposited in the collections of either the U.S. National Museum or the Geological Survey of Canada are given in the plate descriptions and preceded by USNM or GSC, respectively. Collecting localities mentioned in the section on "Occurrence" following each species description are recorded in the U.S. Geological Survey (USGS colln.) or Geological Survey of Canada (GSC colln.) locality catalogs.

All figures show the exterior of the exoskeleton unless otherwise specified. All dimensions in the vertical plane that includes the axis of symmetry of the trilobite are sagittal dimensions, those in planes parallel to the sagittal plane are exsagittal dimensions, and those in a vertical plane at right angles to the sagittal plane are transverse dimensions. Particular dimensions on cranidia were measured as straight-line distances between furrows or from margins to furrows as described earlier (Palmer, 1965, p. 23).

Summary of classification of Alaskan Cambrian trilobites

Order AGNOSTIDA Kobayashi

Suborder AGNOSTINA Salter

The agnostids so far identified from Alaska represent 13 genera that are here assigned to four families. The suprageneric classification within this suborder is not yet stabilized, and there are important differences of opinion concerning criteria for meaningful taxonomic relationship between genera. The family groupings used here are listed and discussed below.

Quadragnostidae: *Cotalagnostus, Hypagnostus, Peronopsis, Phalagnostus*
Glyptagnostidae: *Glyptagnostus, Lejopyge, Ptychagnostus*
Agnostidae: *Geragnostus, Homagnostus, Lotagnostus, Peratagnostus*
Pseudagnostidae: *Acmarhachis, Pseudagnostus*

Quadragnostidae.—*Cotalagnostus*, *Hypagnostus*, and *Peronopsis*, were shown by Westergård (1946) to be phylogenetically related Middle Cambrian genera and this relation was confirmed by Robison (1964a). Robison also suggested that *Homagnostus* might be a part of this phylogenetic complex, on the basis of his identification of a Middle Cambrian species that I do not consider to be congeneric with typical Late Cambrian members of *Homagnostus* (p. B24). However, his suggestion of a possible phylogenetic relationship between the late Dresbachian and younger genera (grouped here with *Homagnostus* in the Agnostidae) and the Middle Cambrian genera (that he assigned to the Spinagnostidae following Howell, 1959) can be tested when the agnostid faunas of the beds of early Dresbachian age in the Great Basin of the Western United States are described. Öpik (1961a) restricted the Spinagnostidae to the nominal genus *Spinagnostus* and included *Peronopsis*, *Phalagnostus*, and *Hypagnostus* in the Quadragnostidae. Robison did not comment on this, and I have no reason to reject Öpik's interpretation. Therefore Quadragnostidae is used here for *Phalagnostus* and for the genera that Robison assigned to the Spinagnostidae, exclusive of *Homagnostus*.

Glyptagnostidae.—The phylogenetic relationship of the Middle Cambrian genera *Lejopyge* and *Ptychagnostus* is well supported by evidence of both morphologic and stratigraphic continuity (Westergård, 1946, p. 87; Öpik, 1961a, p. 75–86). The continuation of this lineage into the Late Cambrian genus *Glyptagnostus* has been suggested by both Öpik (1961a, p. 76) and Palmer (1962, p. 16). Thus *Lejopyge* and *Ptychagnostus* are here assigned to a family taxon Glyptagnostidae comparable to the Glyptagnostinae of Öpik (1961a).

Agnostidae and Pseudagnostidae.—Öpik (1963, p. 37, 38) recently revised the Glyptagnostidae and placed great stress on the higher taxonomic importance of the identification of genal caecae on the agnostid pygidium. This revision has resulted in a grouping of *Pseudagnostus* and *Lotagnostus* in the same family with *Glyptagnostus* and obscures what I consider to be important morphologic differences and stratigraphic trends. The Late Cambrian agnostid genera from Alaska are grouped here into the Agnostidae (*Homagnostus*, *Geragnostus*, *Peratagnostus*, *Lotagnostus*) and Pseudagnostidae (*Pseudagnostus*, *Acmarhachis*). I have discussed the reasons for this grouping earlier (Palmer, 1962, p. 11, 18; exclusive of *Peratagnostus*). The criterion of axial lobe morphology on the pygidium—the same criterion that underlies the classification of the Middle Cambrian agnostids—was emphasized as an important suprageneric grouping character.

Family AGNOSTIDAE M'Coy

Genus GERAGNOSTUS Howell

Geragnostus Howell, 1935b, p. 231; Kobayashi, 1939, p. 167; Shaw, 1951, p. 110; Sdzuy, 1955, p. 14; Howell, 1959, p. 176; Pokrovskaya, 1960, p. 61.

Type species.—*Agnostus sidenbladhi* Linnarsson, 1869, p. 82, pl. 2, figs. 60, 61.

Discussion.—In some of my earlier papers (Palmer, 1954b, 1955) I considered *Homagnostus* and *Geragnostus* to be synonymous. The genera are certainly related and *Geragnostus* probably includes descendants of *Homagnostus*. However, all species of *Homagnostus* have the pygidial axis reaching nearly to the posterior border furrow and they are all known from rocks of either late Dresbachian or early Franconian age. Species that I would now assign to *Geragnostus* and that conform to the diagnoses listed in the synonymy above have a shorter pygidial axis that is well separated from the posterior border furrow. These species range in age from late Franconian to Early Ordovician. Cephala of *Geragnostus* species cannot be generically separated from cephala of *Homagnostus* species.

Geragnostus intermedius n. sp.

Plate 12, figures 1, 2

Description.—Cephalon semielliptical, evenly rounded anteriorly. Glabella has anterior lobe well defined by deep transglabellar furrow. Glabellar node poorly defined, situated about at midlength of posterior glabella lobe. Preglabellar median furrow extended forward of anterior glabellar lobe for short distance; length variable. Basal glabellar lobes simple. Border narrow, well defined by broad, shallow border furrow.

Pygidium subquadrate, posterior margin broadly rounded. Axis broad, sides subparallel; posterior end strongly rounded. Pleural field confluent behind axis; sagittal length of postaxial part of pleural field about equal to sagittal length of inner end of lateral lobe of first axial segment. Furrows between first and second axial segments directed inward and slightly forward for one-third width of axis, then turned strongly forward parallel to axial line to divide first axial segment into three parts. Posterior margin of middle part of first axial segment not defined. Furrow between second axial segment and posterior part of axial lobe straight, interrupted by end of axial node. Pygidial border broad laterally, slightly narrower between short posterolateral border spines. Border furrow broad, shallow.

Discussion.—The relatively long axis and presence of a partial preglabellar axial furrow on some specimens distinguishes *Geragnostus intermedius* n. sp. from others assigned to *Geragnostus*. The distinct tripartite division of the first axial segment of the pygidium and the relatively greater sagittal length of the pleural field behind the pygidial axis distinguish the pygidium of this species from similar pygidia of older Alaskan species assigned to *Homagnostus*. This species is intermediate both morphologically and stratigraphically between *Homagnostus* and more typical species of *Geragnostus* that are characteristic of rocks of Trempealeau and younger ages and that have still shorter pygidial axes.

Occurrence.—Franconian–2 fauna. Moderately rare (2 cephala, 4 pygidia), USGS colln. 4355–CO, Hillard Peak area.

Genus HOMAGNOSTUS Howell

Homagnostus Howell, 1935c, 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; Howell, 1959, p. 173; Porkrovskaya, 1960, p. 61; Palmer, 1960a, p. 62; Palmer, 1962, p. 12; Robison, 1964a, p. 531.

Oncagnostus Whitehouse, 1936, p. 84.

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

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

Discussion.—*Homagnostus* is a common genus that has nearly worldwide distribution in beds of late Dresbachian and early Franconian age. Robison (1964a) has expanded the concept of *Homagnostus* to include a late Middle Cambrian species that lacks well-defined transverse axial furrows on the pygidium. However, the lack of any morphologically and stratigraphically intermediate forms between this species and more typical forms of *Homagnostus* weakens the possibility of a real genetic relationship between the species. The range of the genus also is greatly extended by Robison's action. Until we know more about the evolutionary development of the agnostids, I prefer not to accept Robison's emendation of the concept and range of *Homagnostus*. The description and discussion that I have given earlier (Palmer, 1960a) summarize my concept of this genus.

Homagnostus alaskensis n. sp.

Plate 7, figures 4, 9, 14, 15

Description.—Cephalon semielliptical, moderately convex transversely and longitudinally, evenly rounded anteriorly. Glabella well defined by deep axial furrows, tapered slightly forward. Anterior lobe lower than posterior lobe, well defined by deep transglabellar furrow. Glabellar node poorly defined, located slightly anterior to midlength of posterior glabellar lobe. Preglabellar median furrow deep, reaches nearly to border furrow. Border narrow, of nearly constant width around anterior margin of cephalon. Basal glabellar lobes simple, well defined, triangular. Posterior border furrow deep, continuous with axial furrow on outside of basal glabellar lobe.

Pygidium semielliptical, moderately to strongly convex transversely and longitudinally. Axis broad; sides slightly concave opposite second axial segment; posterior lobe slightly expanded posteriorly. Posterior margin of first axial segment defined at distal ends by short straight deep furrows that extend inward and slightly forward from axial furrows about one-third width of axis. Posterior margin of second axial segment defined distally by straight deep transverse furrows that are interrupted by prominent median node that extends onto posterior axial lobe for distance more than half sagittal length of second axial segment. Border well defined by deep border furrow; width nearly constant. Short border spines present.

Discussion.—*Homagnostus alaskensis* n. sp. is most similar to *H. obesus* (Belt), from which it differs by

lacking distinct trilobation of the first axial segment on the pygidium and by having a nearly complete median preglabellar furrow. Pygidia differ from associated pygidia of *H. tumidosus* (Hall and Whitfield) by having an inflated posterior lobe, deeper furrows on the axis, and a much longer and larger axial node.

Occurrence.—Dresbachian–2 fauna. Common (more than 10 cephala and pygidia), USGS colln. 4381–CO, Hi-yu area.

Homagnostus tumidosus (Hall and Whitfield)

Plate 7, figures 3, 8

Agnostus tumidosus Hall and Whitfield, 1877, p. 231, pl. 1, fig. 32.

Geragnostus cf. *G. tumidosus* (Hall and Whitfield). Palmer, 1954b, p. 719, pl. 76, figs. 4, 6.

Geragnostus tumidosus (Hall and Whitfield). Palmer, 1955, p. 89, pl. 19, figs. 3, 4; pl. 20, figs. 1–3, 12, 15; Robison, 1960, p. 11, pl. 1, fig. 3.

Homagnostus tumidosus (Hall and Whitfield). Palmer, 1960a, p. 63, pl. 4, figs. 1, 2; Bell and Ellinwood, 1962, p. 388, pl. 51, figs. 1–4.

Discussion.—The diagnosis of *Homagnostus tumidosus* (Hall and Whitfield) that I have given earlier (Palmer, 1960a) applies fully to the excellent silicified material of *H. tumidosus* from Alaska. Cephala of this species can be distinguished from very similar associated cephala of *Acmarhachis acutus* (Kobayashi) (pl. 7, figs. 1, 2) by the presence of a smaller anterior glabellar lobe, which causes the glabella to be slightly tapered forward. The glabella of *Acmarhachis* has subparallel sides. Pygidia of *H. tumidosus* are most similar to associated pygidia of *H. alaskensis* n. sp., but they can be distinguished by their shallower transverse axial furrows and shorter median node that barely extends onto the posterior lobe of the pygidial axis. The posterior lobe of the axis is also less inflated.

Occurrence.—Dresbachian–2 fauna. Common (more than 10 cephala and pygidia), USGS colln. 4381–CO; rare (1 cephalon, 1 pygidium), USGS colln. 4380–CO; Hy-yu area. Rare (1 cephalon, 1 pygidium), GSC colln. 4645, Hillard Peak area.

Homagnostus? sp.

Plate 7, figure 13

Discussion.—Two pygidia associated with *Acmarhachis acutus* (Kobayashi), *Homagnostus tumidosus* (Hall and Whitfield) and *H. alaskensis* n. sp. represent a fourth species of agnostid that has a broad axis with a well-defined posterior part. The transverse furrow between the first and second axial segments is straight and not continuous across the axis. The transverse furrow between the second axial segment and the posterior part of the axis is directed inward and slightly backward to the sides of a large median node that extends slightly onto the posterior part of the axis. The sides of the pygidium converge slightly backward to the bases of slender border spines.

The posterior lobe of this species is slightly expanded posteriorly and extended to the border furrow; in this respect the species resembles *Acmarhachis*. However, the shape of the axis indicates that the closest affinities of this species are to *Homagnostus alaskensis* n. sp. The transverse furrow behind the second segment is more posteriorly directed than in *H. alaskensis*, the axis reaches to the border furrow, the pygidial sides are more convergent posteriorly, and the median node does not extend as far onto the posterior part of the axis. These differences are at least of specific value. Without knowledge of a cephalon for this species, it cannot be satisfactorily assigned. It is tentatively placed in *Homagnostus*, even though the well-defined posterior part of the axis reaches the posterior border furrow.

Occurrence.—Dresbachian–2 fauna. Rare (2 pygidia), USGS colln, 4381–CO, Hi-yu area.

Genus LOTAGNOSTUS Whitehouse

Lotagnostus Whitehouse, 1936, p. 101; Kobayashi, 1939, p. 164; Palmer, 1955, p. 91; Howell ,1959, p. 178; Pokrovskaya, 1960, p. 61; Öpik, 1963, p. 53.

Type species.—*Agnostus trisectus* Salter, 1864, p. 10, pl. 1, fig. 11.

Discussion.—The Alaskan specimens discussed below accord with my interpretation of *Lotagnostus* presented earlier (Palmer, 1955).

Lotagnostus? sp.

Plate 12, figures 3, 4

Discussion.—Several cephala and a pygidium associated with *Pseudagnostus vulgaris* Rozova and *Geragnostus intermedius* n. sp. may represent a species of *Lotagnostus*. The cephala have a bilobed glabella and a narrow shallow preglabellar median furrow. The pygidium has a short narrow well-defined axis that is strongly rounded posteriorly and short border spines. The first segment of the pygidial axis is trilobate, the second segment has a strong median node, and the third segment is smooth and undivided. The cephalon has a shallower preglabellar furrow and a better defined frontal glabellar lobe than similar cephala of *P. vulgaris*. The pygidium has a narrower and shorter axis than *G. intermedius*. *Lotagnostus* essentially includes Late Cambrian agnostids with a

Pseudagnostus-like cephalon and a *Geragnostus*-like pygidium. Thus, the association of the cephala and pygidium described above as parts of a single species is probably correct. However, until more material can be found to confirm the association, the specimens can only tentatively be assigned to *Lotagnostus*.

Occurrence.—Franconian–2 fauna. Moderately rare (3 cephala, 1 pygidium), USGS colln. 4355–CO, Hillard Peak area.

Genus PERATAGNOSTUS Öpik

Peratagnostus Öpik, 1967, p. B86.

Type species.—*Peratagnostus nobilis* Öpik, 1967, p. 86–90, pl. 52, figs. 10, 11c; pl. 53, figs. 1–11; text fig. 18.

Description.—Cephalon semiovate, gently to moderately convex transversely and longitudinally; all axial furrows effaced. Border narrow, continues slope of cheeks, moderately to poorly defined along sides and front of cephalon. Posterior border furrow deep directly behind glabella. Basal lobes weakly defined only at rear. Glabellar node low, situated slightly posterior to glabellar midlength.

Pygidium semiovate, moderately to strongly convex transversely and longitudinally, highest at position of low poorly defined axial node. Axial furrows narrow and shallow or effaced. Axial lobe narrow, short, posteriorly tapered, does not reach border; width at anterior end less than one-half width of pygidium; transverse furrows absent; terminal node present. Border broad, well defined by narrow border furrow that is continuous in smooth curve with anterior lateral furrow. Border spines absent. Articulating ring simple.

Discussion.—*Peratagnostus* is a distinctive effaced Late Cambrian genus that differs from all other superficially similar genera by having a short narrow pygidial axis with a terminal node and contrasting definition of the cephalic and pygidial borders. *Phalacroma*, *Phalagnostus*, *Gallagnostus*, and *Ciceragnostus* all have wide pygidial axes; *Grandagnostus* and *Litagnostus* have the terminal node adjacent to the posterior border furrow which indicates a long pygidial axis; *Phoidagnostus* and *Lejopyge* (considered synonyms by Öpik, 1961a) have the posterior axial node on the axial lobe and not at its terminus, comparable to the position in *Ptychagnostus; Leiagnostus* lacks both cephalic and pygidial borders and axial nodes; and *Gallagnostoides* has narrow cephalic and pygidial borders, no apparent axial nodes, and no distinct anterior lateral pygidial furrows.

Besides the type species from Australia, and *Peratagnostus hillardensis* n. sp. from Alaska, *Agnostus* (subsequently *Phoidagnostus*) *obsoletus* Kobayashi (1935b, 1962) from the *Eochuangia* zone of south Korea seems to represent this genus. I have excellent replicas of the Australian species obtained on my visit there in 1961; it differs from *P. hillardensis* by having the pygidial axis slightly longer and the cephalic border narrow and poorly defined. Kobayashi's reference (1935b, p. 106) to an *Agnostus*-like axis for his species *obsoletus*, together with the fair illustrations and the knowledge that this species is from a fauna near the same age as the ones from Alaska and Australia, rather than from Middle Cambrian beds as first described, all indicate the probability that this species, which is reported to lack a defined cephalic border, belongs to *Peratagnostus*.

Another species possibly belonging to *Peratagnostus* is *Lejopyge? controversa* Krys'kov (in Borovikov and Krys'kov, 1963) from southern Kazakhstan. This species, which is associated with *Glyptagnostus*, seems to have the smooth curve between the border furrow and the anterior lateral furrow on the pygidium and the posteriorly tapered pygidial axis characteristic of *Peratagnostus*. I cannot determine from the illustrations or description either the exact length of the axis or whether the axis has a terminal node or a node that is distinctly anterior to the terminus. If the node is distinctly anterior to the terminus, then the suggested relationship to *Lejopyge* is more probably correct.

Because of the structure of the pygidial axis, which is short and narrow and has a terminal node, *Peratagnostus* is here considered to be an effaced member of the Agnostidae. None of the cephala show the glabellar outline clearly, but there is some indication, when a whitened specimen is observed in strongly oblique light, that the frontal lobe of the glabella may be lacking.

Peratagnostus hillardensis n. sp.

Plate 10, figures 17, 18, 23, 24

Diagnosis.—Cephalic border continues slope of surface of cephalon; moderately well defined by shallow narrow border furrow. Distance from end of axis to border furrow about twice sagittal length of posterior border.

Discussion.—The generic description presents most of the characteristics of *Peratagnostus hillardensis* n. sp. The principal features that differentiate this from other species in the genus are the details of definition of the cephalic border and length of the pygidial axis described above. The axis is slightly shorter than the axis of *Peratagnostus nobilis* Öpik.

Occurrence.—Franconian–1 fauna. Moderately common (3 cephala, 12 pygidia), GSC colln. 4638 (= 4727); moderately rare (1 cephalon, 1 pygidium), GSC colln. 4648; both from Hillard Peak area.

Family GLYPTAGNOSTIDAE Whitehouse

Genus GLYPTAGNOSTUS Whitehouse

Glyptagnostus Whitehouse, 1936, p. 101; Kobayashi, 1939, p. 155; Shimer and Shrock, 1944, p. 600; Kobayashi, 1949, p. 1–6; Öpik, 1961b, p. 428; Palmer, 1962, p. 15.

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

Discussion.—The characteristics of this distinctively ornamented Late Cambrian genus have recently been described in considerable detail (Öpik, 1961b; Palmer, 1962), and the single pygidium recorded from Alaska contributes no new morphologic information.

Glyptagnostus reticulatus (Angelin)

Plate 7, figure 11

Agnostus reticulatus Angelin, 1851, p. 8, pl. 6, fig. 10.

Glyptagnostus reticulatus (Angelin). Palmer, 1962, p. 16, pl. 2, figs. 1, 3, 4, 6–8, 11 [this paper gives full synonymy through 1961]; Kobayashi, 1962, p. 27, pl. 9, figs. 10–15; Öpik, 1963, p. 38, pl. 2, figs. 6–9; Borovikov and Krys'kov, 1963, p. 273, pl. 1, figs. 10, 11, 12.

Discussion.—The single pygidium illustrated here conforms in all characteristics to *Glyptagnostus reticulatus reticulatus* (Angelin), the youngest subspecies of the genus (Palmer, 1962, pl. 2, figs. 1, 3). Unfortunately, the specimen is not associated with other trilobites. It was collected by L. D. Burling about 5 feet below collections containing *Cernuolimbus*, *Sigmocheilus*, and other elements of a *Dunderbergia* zone fauna. Thus it can be no younger than the *Dunderbergia* zone. In the conterminous United States, this subspecies is found only in beds of the *Aphelaspis* zone. In western Canada, it is associated with *Olenaspella evansi* (Kobayashi) which has also been found in Alaska in a *Dunderbergia* zone fauna. This evidence now seems to indicate that the total time range of *G. reticulatus reticulatus* may have to be extended from the *Aphelaspis* zone to the *Dunderbergia* zone; the value of this widespread subspecies for precise intercontinental correlation is thus slightly decreased.

The occurrences of *Glyptagnostus reticulatus* in Alaska and in southern Kazakhstan (Borovikov and Krys'kov, 1963) significantly increase the known geographic range of *Glyptagnostus* shown earlier (Palmer, 1962, p. 2, fig. 1).

Occurrence.—Dresbachian–2 fauna. Rare (1 pygidium), GSC colln. 4641, Hillard Peak area.

Genus LEJOPYGE Corda

Lejopyge Corda in Hawle and Corda, 1847, p. 51; Kobayashi, 1939, p. 131; Lermontova, 1940, p. 130; Westergård, 1946, p. 87; Pokrovskaya, 1958, p. 72; Öpik, 1961a, p. 85; Robison, 1964a, p. 521.

Type species.—*Battus laevigatus* Dalman, 1828, p. 136.

Diagnosis.—Cephalon nearly smooth: only basal lobes, posterior parts of axial furrows, and border furrows apparent on external surface. Median glabellar node usually present. Lateral and anterior borders narrow; not visible in dorsal view of uncrushed specimens. Pygidium nearly smooth; only anterior parts of axial furrows apparent on external surface. Small median node on second axial segment usually present. Border distinctly wider than cephalic border. Border spines present or absent.

Discussion.—Westergård (1946, p. 75) and Öpik (1961a, p. 76) have discussed the characteristics of *Lejopyge* and its included species most fully. Because of the small number of characteristics available for specific discrimination, few species of *Lejopyge* have been recognized. Two different forms are present in the Alaskan collections. One has axial furrows on the cephalon that are shorter than the basal glabellar lobes and axial furrows on the pygidium that outline only the lateral parts of the first axial segment. The other, known only from pygidia, has the lateral parts of the first two axial segments outlined by the axial furrows. These axial features are the characteristics, respectively, of *L. calva* Robison and *L. laevigata* (Dalman), to which the Alaskan specimens are therefore assigned.

Lejopyge calva Robison

Plate 6, figure 15–18

Lejopyge calva Robison, 1964a, p. 521, pl. 83, figs. 1–4.

Diagnosis.—Cephalon has axial furrows poorly developed anterior to basal lobes; length generally less than length of basal lobes. Pygidium has axial furrows outlining lateral parts of first axial segment only. Border of pygidium without border spines.

Discussion.—*Lejopyge calva* Robison was first described from the uppermost Middle Cambrian beds of the Great Basin in Nevada and Utah where it is characteristic of the upper part of the *Bolaspidella* zone. It is therefore one of the critical species for precise correlation of the Alaskan Cambrian succession with that of the western conterminous United States.

A collection made by Cairnes in 1912 from just east of the Alaskan boundary east of Hillard Peak has cephala of this species showing both the external surface and surface of the mold (pl. 6, fig. 16). The exfoliated specimen shows the outline of a large anterior glabellar lobe and rugose cephalic flanks typical of the Ptychagnostidae.

Occurrence.—Middle Cambrian–2 fauna. Moderately common (4 cephala, 4 pygidia), USGS colln.

4337–CO, Yukon River (Adams Peak) area; 5 cephala, GSC colln. 282, Hillard Peak area.

Lejopyge laevigata (Dalman)

Plate 6, figure 19

Battus laevigatus Dalman, 1828, p. 136.
Lejopyge laevigata Dalman. Westergård, 1946, p. 87, pl. 13, figs. 18–26, pl. 16, fig. 9 [synonymy to that date]; Pokrovskaya, 1958, p. 76, pl. 5, figs. 16, 17; Öpik, 1961a, p. 85, pl. 21, figs. 5—9b.

Diagnosis.—Cephalon has axial furrows generally as long or longer than basal glabellar lobes. Pygidium has axial furrows outlining lateral parts of first two axial segments.

Discussion.—The Alaskan pygidia assigned to *Lejopyge laevigata* (Dalman) lack border spines and are thus referable to the typical subspecies *L. laevigata laevigata*, a widespread subspecies that has been described from beds of late Middle Cambrian age in northwestern Europe, Siberia, and Australia.

Occurrence.—Middle Cambrian–2 fauna. Rare (1 pygidium), USGS colln. 4345–CO, Hillard Park area; 1 pygidium, USGS colln. 3832–CO, Yukon River (West Ridge) area.

Genus PTYCHAGNOSTUS Jaekel

Ptychagnostus Jaekel, 1909, p. 401; Kobayashi, 1939, p. 152; Westergård, 1946, p. 67; Öpik, 1961a, p. 76; Robinson, 1964a, p. 522.
Triplagnostus Howell, 1935c, p. 14.
Goniagnostus Howell, 1935c, p. 13.
Doryagostus Kobayashi, 1939, p. 148.

Type species.—*Agnostus punctuosus* Angelin, 1851, p. 8, pl. 6, fig. 11.

Diagnosis.—Cephalon has scrobiculate cheeks and pointed anterior glabellar lobe. Pygidium has nonscrobiculate pleural fields and well-defined furrows outlining anterior two axial segments. Granular ornamentation present on most species.

Discussion.—Öpik (1961a, p. 76–79) has given a thorough review of the content and concept of *Ptychagnostus*. The diagnosis given above is derived from his revision. He recognized two subgenera: *P.* (*Ptychagnostus*), which generally lacks pygidial border spines and a distinct transverse secondary division of the posterior lobe of the pygidial axis, and *P.* (*Goniagnostus*), which has both of these features. The Alaskan specimens described below have the diagnostic characteristics of *P.* (*Ptychagnostus*).

Ptychagnostus (Ptychagnostus) aculeatus (Angelin)

Plate 6, figure 20

Agnostus aculeatus Angelin, 1851, p. 8, pl. 6, fig. 12; Brögger, 1878, p. 71, pl. 5, fig. 5a,b; Tullberg, 1880, p. 23, pl. 1, fig. 11; Strand, 1929, p. 345, pl. 1, fig. 7.
Ptychagnostus (*Ptychagnostus*) *aculeatus* (Angelin). Westergård, 1946, p. 79, pl. 12, figs. 8–11; Öpik, 1961a, p. 80, pl. 21, figs. 3, 4a,b.

Discussion.—A single pygidium has the long axial node extending for a considerable distance along the anterior part of the posterior lobe of the pygidial axis, the coarse granular ornamentation on all parts, and the nonspined border characteristic of this distinctive species of *Ptychagnostus*. The ornamentation and structure of the axial lobe distinguish this species from all other Alaskan agnostids.

Occurrence.—Middle Cambrian–2 fauna. Rare (1 pygidium), GSC colln. 282, Hillard Peak area.

Ptychagnostus (Ptychagnostus) punctuosus affinis (Brögger)

Plate 4, figures 26, 27

Agnostus punctuosus affinis Brögger, 1878, p. 68, pl. 5, fig. 2 a,b.
Agnostus intermedius Thorslund [not Tullberg], *in* Asklund and Thorslund, 1935, p. 106, pl. 1, figs. 5–7.
Ptychagnostus (*Ptychagnostus*) *punctuosus affinis* (Brögger). Westergård, 1946, pl. 11, figs. 26–33.

Diagnosis.—Cephalon has glabella well defined by axial furrows, posterolateral spines short, and granular ornamentation generally not apparent. Pygidium has axis and transverse furrows well defined, postaxial median furrow generally present, incipient transverse depression on posterior axial lobe, and subdued granular ornamentation on pleural fields.

Discussion.—Westergård (1946, p. 78) discussed the characteristics of *Ptychagnostus punctuosus* and noted that considerable variability exists in ornamentation, division of the basal glabellar lobes, width of the pygidial axis, and degree of development of the postaxial furrow on the pygidium. Only one distinctive variant, *P. punctuosus affinis*, which seemed to be intermediate in an evolutionary series between the older *P. atavus* and the younger *P. punctuosus*, was recognized. The Alaskan specimens lack distinct granular ornamentation on the cephalon, and the pygidium has subdued granular ornamentation. Westergård described this type of ornamentation as the distinctive feature of *P. affinis*. Therefore, although the Alaskan sample is small, it is assigned to the subspecific taxon described by Westergård.

Occurrence.—Middle Cambrian–1 fauna. Moderately rare (3 cephala, 3 pygidia), USGS colln. 4341–CO, Hillard Peak area.

Family PSEUDAGNOSTIDAE Whitehouse

Genus ACMARHACHIS Resser

Acmarhachis Resser, 1938, p. 47; Howell, 1959, p. 173; Palmer, 1962, p. 19.
Oedorhachis Resser, 1938, p. 48; Shimer and Shrock, 1944, p. 601; Howell, 1959, p. 185.

Cyclagnostus Lermontova, 1940, p. 126; Howell, 1959, p. 182; Pokrovskaya, 1960, p. 58.

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

Discussion.—I have recently reviewed the content and concept of *Acmarhachis* (Palmer, 1962), and the excellent silicified material of *A. acutus* (Kobayashi) from Alaska does not provide any new information. The presence of a completely defined deuterolobe on the pygidium distinguishes this genus from other associated agnostids.

Acmarhachis acutus (Kobayashi)

Plate 7, figures 1, 2, 6, 7, 12

Homagnostus acutus Kobayashi, 1938, p. 172, pl. 16, figs. 18–22.
Pseudagnostus? acutus (Kobayashi). Palmer, 1960a, p. 62, pl. 4, figs. 10–12.
Acmarhachis acutus (Kobayashi). Rasetti, 1961, p. 109, pl. 23, figs. 1–8; Palmer, 1962, p. 20, pl. 2, figs. 14, 15.

Discussion.—The silicified specimens from Alaska conform in all respects to the diagnosis of *Acmarhachis acutus* (Kobayashi) that I have presented earlier (Palmer, 1962). The shape of the deuterolobe in the Alaskan sample is slightly variable. In some specimens the posterior part is pointed, in others this part is bluntly rounded. However, a continuous series of intermediate forms is present, and all other characteristics are common to the end members; all of the associated specimens of *Acmarhachis* are therefore considered to represent a single species. The cephala are very similar to associated cephala of *Homagnostus tumidosus* (Hall and Whitfield) but can be recognized by the relatively large frontal lobe of the glabella that causes the glabella to have subparallel sides rather than to taper slightly forward.

Occurrence.—Dresbachian–2 fauna. Moderately common (8 cephala, 16 pygidia), USGS colln. 4381–CO, Hi-yu area. Rare (1 pygidium), GSC colln. 4722; rare (1 pygidium), GSC colln. 4645, Hillard Peak area.

Genus PSEUDAGNOSTUS Jaekel

Pseudagnostus Jaekel, 1909, p. 400; Kobayashi, 1935b, p. 107; Kobayashi, 1937, p. 451; Kobayashi, 1939, p. 157; Lermontova, 1940, p. 125; Shimer and Shrock, 1944, p. 601; Shaw, 1951, p. 112; Palmer, 1954b, p. 719; Palmer, 1955, p. 93; Ivshin, 1956, p. 11; Howell, 1959, p. 182; Palmer, 1960a, p. 61; Rozova, 1960, p. 7; Palmer, 1962, p. 21; Öpik, 1963, p. 48.

Type species.—*Agnostus cyclopyge* Tullberg, 1880, p. 26.

Discussion.—*Pseudagnostus* is one of the most common Late Cambrian trilobites in western North America, but specimens are rarely found in sufficient numbers to determine adequately meaningful specific characteristics. Öpik (1963) has given the most complete modern summary of the generic features of *Pseudagnostus*. Although specimens assignable to *Pseudagnostus* have been identified in 13 of the Late Cambrian collections from Alaska, only 2 collections contain a sufficient number of specimens to allow adequate species identification. Specimens from two additional collections can be related to these species. A third species, *P. clarki* Kobayashi, is known from only three specimens in one of Mertie's collections and has not been collected again. It can be distinguished from the other identified Alaskan species, however. The remaining material is specifically indeterminate.

Pseudagnostus clarki Kobayashi

Plate 15, figures 10, 13, 14

Pseudagnostus (Plethagnostus) clarki Kobayashi, 1935a, p. 47, pl. 9, figs. 1, 2.
Pseudagnostus laevis Palmer, 1955, p. 97, pl. 19, figs. 8, 9, 11, 12.

Discussion.—When I described *Pseudagnostus laevis* (Palmer, 1955), the only apparent difference between it and *P. clarki* was the absence of the preglabellar median furrow on the only known cephalon of *P. clarki*. Among the limestone blocks collected by Mertie that yielded *P. clarki* and the associated species *Tatonaspis alaskensis*, *Briscoia septentrionalis*, and "*B.*" *elegans*, I have since found one mold of an exfoliated cephalon of *P. clarki* that has a shallow preglabellar median furrow. Thus there are no longer any apparent differences between *P. clarki* and *P. laevis*. This species differs from other Alaskan species of *Pseudagnostus* by having all furrows nearly effaced on the external surface of the exoskeleton. It is also the youngest species of *Pseudagnostus* in Alaska.

Occurrence.—Trempealeauan–1 and Trempealeauan–2 faunas. Rare (2 cephala, 1 pygidium), USNM loc. 25o (=AMt 147), Trempealeauan–1; 1 pygidium, GSC colln. 4671, Trempealeauan–2; both from Jones Ridge area.

Pseudagnostus communis (Hall and Whitfield)

Plate 7, figures 5, 10

Agnostus communis Hall and Whitfield, 1877, p. 228, pl. 1, figs. 28, 29.
Agnostus neon Hall and Whitfield, 1877, p. 229, pl. 1, figs. 26, 27.
Pseudagnostus communis (Hall and Whitfield). Palmer, 1954b, p. 720, pl. 76, figs. 1–3; Palmer, 1955, p. 94, pl. 19, figs. 16, 19–21; pl. 20, figs. 4–11, 14; Palmer, 1960a, p. 61, pl. 4, figs. 3, 4; Robison, 1960, p. 14, pl. 1, figs. 2, 5; Rasetti, 1961, p. 109, pl. 23, figs. 13–17; Rasetti, 1965, p. 39, pl. 10, figs. 23–25.

[Not] *Pseudagnostus communis* Bell and Ellinwood, 1962, p. 389, pl. 51, figs. 7–21.

Discussion.—*Pseudagnostus communis* (Hall and Whitfield) has already been described in considerable detail (Palmer, 1955) on the basis of limestone specimens from the type area in the Eureka district, Nevada. The excellently silicified Alaskan specimens differ from the Nevada material principally by having the deuterolobe less well defined. Enough material of this species from many localities has now been examined so that this minor difference is probably not of specific value. Bell and Ellinwood (1962) adopted a very loose taxonomic approach to this species and illustrated many specimens identified as *P. communis* that probably represent other species. *P. communis* is one of the oldest species of *Pseudagnostus*. The cephalon is characterized by having deep axial furrows around the glabella, a relatively shallow preglabellar furrow, and a relatively shallow transglabellar furrow outlining the anterior glabellar lobe. The pygidium has deep axial furrows adjacent to the anterior two axial segments, the anterior part of the deuterolobe is only partly defined, the transverse furrow behind the second axial segment is poorly defined or absent, the sides of the pygidium are subparallel, and the posterior border spines are small.

Among described species, nine named forms seem to have the general characteristics of *Pseudagnostus communis*. One *P. neon* (Hall and Whitfield), has already been considered a synonym of *P. communis*. The others may be either synonyms or closely related species that together with *P. communis* form a distinctive species group of early Late Cambrian age. These species are here assigned to a "*P. communis* species group" pending an opportunity to study the entire complex of species of this common and widespread Late Cambrian genus. Besides *P. communis*, (synonym, *P. neon*) the group includes *P. chinensis* (Dames, 1883), *P. orientalis* (Kobayashi, 1935b), *P. nuperus* (Whitehouse, 1936), *P. latus* (Kobayashi, 1938), *P. rotundatus* (Lermontova, 1940), *P. pseudocyclopyge* (Ivshin, 1956), *P. angustilobus*, (Ivshin, 1956), and *P. marginisulcatus* (Kobayashi, 1962).

Occurrence.—Dresbachian–2 fauna. Common (more than 20 cephala and pygidia), USGS colln. 4381–CO; moderately common (2 cephala, 1 pygidium), USGS colln. 4380–CO; both from Hi-yu area.

Pseudagnostus vulgaris Rozova

Plate 12, figures 5, 6

Pseudagnostus vulgaris Rozova, 1960, p. 14, pl. 1, figs. 5–13.

Description.—Cephalon slightly elongate, strongly and evenly rounded anteriorly. Glabella well defined by moderately deep axial furrows. Basal lobes simple. Anterior lobe defined by shallow transglabellar furrow. Preglabellar median furrow deep. Border well defined by deep border furrow.

Pygidium subquadrate. Axis defined only at sides opposite anterior two segments. Deuterolobe not defined. Axial node distinct. Ring furrow across axis posterior to axial node shallow or absent. Border broad, flattened; deep border furrow lacking; sagittal length one-third or slightly more than one-third transverse width of anterior part of axis. Border spines small, situated well forward from posterior margin.

Discussion.—The only described species of *Pseudagnostus* that has features comparable to the Alaskan specimens is *P. vulgaris* Rozova from the Tolstochikhin Group near the top of the Upper Cambrian succession in the Salair region of western Siberia. The relatively broad pygidial border, poor development of the second ring furrow on the pygidial axis, deep preglabellar furrow, and relatively poor definition of the frontal lobe of the glabella are the most distinctive characteristics of this species. Both the Alaskan and Siberian specimens are associated with species of the Richardsonellidae.

Occurrence.—Franconian–2 fauna. Moderately common (4 cephala, 7 pygidia), USGS colln. 4355–CO; moderately rare (2 pygidia), USGS colln. 4356–CO; both from Hillard Peak area.

Family QUADRAGNOSTIDAE Howell

?Genus COTALAGNOSTUS Whitehouse

cf. Cotalagnostus lens claudicans Westergård

Plate 4, figure 30

Cotalagnostus lens claudicans Westergård, 1946, p. 54, pl. 6, figs. 20–27.

Discussion.—Two incomplete slightly crushed agnostid pygidia have a short subparallel-sided axis and a postaxial furrow and lack posterior border spines. Associated with them is a badly crushed cephalon that has a glabella lacking definition of the frontal lobe and a specifically indeterminate cephalon of *Ptychagnostus*. Comparison with the Middle Cambrian agnostids from Sweden illustrated by Westergård (1946) shows that only *Cotalagnostus lens claudicans* has a pygidium comparable to the observed features of the Alaskan specimens. One other species that has a pygidium with a similar short axis, postaxial furrow, and lack of border spines is *Hypagnostus sublatus* (Ivshin, 1953, p. 21, pl. 2, figs. 10–12) from medial to upper Middle Cambrian beds in Kazakhstan. However, Ivshin's specimens do not show the anterior median inbend of the border furrow that characterizes the Alaskan and Swedish specimens. The lack of a preserved top to the axis

and of a well-preserved cephalon makes the Alaskan specimens unsatisfactory for adequate indentification or description.

Occurrence.—Middle Cambrian–1 fauna. Rare (2 pygidia, (?)1 cephalon), USGS colln. 4346–CO, Montauk Bluff area.

Genus HYPAGNOSTUS Jaekel

Hypagnostus Jaekel, 1909, p. 399; Kobayashi, 1939, p. 122; Lermontova, 1940, p. 129; Westergård, 1946, p. 43; Ivshin, 1953, p. 17; Howell, 1959, p. 184; Öpik, 1961a, p. 57; Robison, 1964a, p. 529.
Spinagnostus Howell, 1935a, p. 219; Kobayashi, 1939, p. 128; Howell, 1959, p. 184.
Cyclopagnostus Howell, 1937, p. 1166; Howell, 1959, p. 175.
Tomagnostella Kobayashi, 1939, p. 150; Howell, 1959, p. 186.

Type species.—*Agnostus parvifrons* Linnarsson, 1869, p. 82, pl. 2, figs. 56, 57.

Discussion.—The concept and content of *Hypagnostus* have been fully discussed by Westergård (1946), Öpik (1961a), and Robison (1964a); their conclusions regarding diagnostic characteristics and synonymy are followed here. The Alaskan specimen described below conforms in all respects to the characteristics of the genus.

Hypagnostus sp.

Plate 6, figure 26

Description.—Cephalon subquadrate; anterior margin broadly rounded. Glabella represented only by posterior lobe that is strongly rounded anteriorly and well defined by axial and transglabellar furrows of equal depth; sagittal length slightly less than one-half sagittal length of cephalon. Low axial node present slightly anterior to midlength of posterior glabellar lobe. Basal lobes moderately large, undivided; exsagittal length slightly more than two-fifths sagittal length of posterior glabellar lobe. Border of cephalon flat, moderately wide; sagittal length about one-eighth sagittal length of cephalon.

Discussion.—A single cephalon of an undetermined species of *Hypagnostus* is present about 80 feet below the top of the Cambrian section along the Tatonduk River in association with specimens of a species of *Cedaria*, a genus that is diagnostic of beds of earliest Late Cambrian age. It seems to differ from cephala of most described species of *Hypagnostus* by having larger basal glabellar lobes, a more nearly subcentral node on the posterior lobe of the glabella, and a relatively wide cephalic border. This cephalon may represent an undescribed species of *Hypagnostus*, but the specific characteristics cannot be adequately determined without knowledge of more specimens.

Occurrence.—Dresbachian–1 fauna. Rare (1 cephalon), USGS colln. 4326–CO, Tatonduk River area.

Genus PERONOPSIS Corda

Peronopsis Corda in Hawle and Corda, 1847, p. 115; Kobayashi, 1939, p. 115; Westergård, 1946, p. 36; Rasetti, 1951, p. 133; Ivshin, 1953, p. 7; Palmer, 1954a, p. 60; Howell, 1959, p. 186; Robison, 1964a, p. 529.
Mesophenicus Corda *in* Hawle and Corda, 1847, p. 46.
Diplorrhina Corda *in* Hawle and Corda, 1847, p. 46; Whitehouse, 1936, p. 88.
Mesagnostus Jaekel, 1909, p. 398.
Acadagnostus Kobayashi, 1939, p. 113; Shimer and Shrock, 1944, p. 600; Howell, 1959, p. 184.

Type species.—*Battus integer* Beyrich, 1845, p. 44, pl. 1, fig. 19.

Discussion.—Robison (1964a, p. 529) has presented the most recent diagnosis of this common Middle Cambrian genus. The small collection from Alaska conforms in all respects to Robison's diagnosis.

Peronopsis cf. P. gaspensis Rasetti

Plate 4, figures 28, 29

Peronopsis gaspensis Rasetti, 1948b, p. 319, pl. 45, figs. 1–3.

Diagnosis.—Cephalon subquadrate, bluntly rounded anteriorly. Glabella bilobed, transverse furrow at back of anterior lobe straight; median tubercule barely apparent or absent. Pygidium subquadrate; margin with pair of short spines; border between spines broadly curved posteriorly. Axis subparallel sided in anterior two-thirds, tapered to sharp point, connected to posterior border by postaxial longitudinal furrow; length about three-fourths length of pygidium. Transverse furrows absent. Median tubercule present.

Discussion.—Most species of *Peronopsis* that have a distinct longitudinal postaxial furrow on the pygidium lack marginal pygidial spines. The only species with the combination of pygidial spines and a postaxial longitudinal furrow are *P. interstrictus* (White) (Robison, 1964a), *P. fallax* (Linnarsson) (Westergård, 1946), *P. taitzehoensis* Lu (1957), and *P. gaspensis* Rasetti (1948b). *P. interstrictus* differs from the Alaskan specimens by having the border spines on the pygidium barely developed. *P. fallax* is a variable species in which the postaxial furrow is not a characteristic feature although it is present on some specimens. *P. taitzehoensis* and *P. gaspensis* are possibly conspecific with each other and with the Alaskan specimens. The apparent differences are minor when compared to the considerable variability in the related species *P. fallax*, as described by Westergård. If the specimens of *Peronopsis* from China, Alaska, and eastern Canada are really conspecific, the oldest name

is *P. gaspensis*. I cannot find an objective criterion for separating these forms, but they are all represented by small samples and the apparent relationship may be superficial. The Alaskan specimens differ from *P. gaspensis* by lacking the slight deflection of the anterior end of the axial furrow on the pygidium and by having a barely apparent median node on the glabella.

Occurrence.—Middle Cambrian–1 fauna. Moderately rare (5 cephala, 3 pygidia), USGS colln. 4341–CO, Hillard Peak area.

Genus PHALAGNOSTUS Howell

Phalagnostus Howell, 1955, p. 926; Snajdr, 1958, p. 76; Howell, 1959, p. 181.

Type species.—*Battus nudus* Beyrich, 1845, p. 46, fig. 20.

Phalagnostus bituberculatus (Angelin)

Plate 6, figure 13

Agnostus bituberculatus Angelin, 1851, p. 6, pl. 6, fig. 2; Holm and Westergård, 1930, p. 11, pl. 1, figs. 10–12; pl. 4, figs. 4–6.

Phoidagnostus bituberculatus (Angelin). Lermontova, 1940, p. 130, pl. 36, figs. 6, 6a-d; Westergård, 1946, p. 91, pl. 14, figs. 10–14; Ivshin, 1953, p. 25, pl. 1, figs. 1–6; Pokrovskaya, 1958, p. 39, pl. 3, figs. 13, 14; Chernysheva, 1960, pl. 1, figs. 24, 25; Rozova, 1964, p. 19, pl. 3, figs. 13–20.

Discussion.—A single nearly featureless exfoliated cephalon that has only an elongate axial node located slightly anterior to its midlength and has moderately well defined basal glabellar lobes is indistinguishable from the broad form of *Phoidagnostus bituberculatus* illustrated by Westergård (1946, pl. 14, fig. 12). Whitehouse (1936, p. 93) included *Agnostus bituberculatus* in his new genus *Phoidagnostus*, an assignment accepted by most subsequent paleontologists. However, Öpik (1961a, p. 86) concluded that the types of *P. limbatus*, the type species of *Phoidagnostus*, which were distinguished from *P. bituberculatus* by having a narrow cephalic border, are crushed specimens of *Lejopyge*. He suggested (Öpik, 1961a, p. 54) that *P. bituberculatus* should be reassigned to *Phalagnostus*. The type species of *Phalagnostus*, *P. nudus* (Snajdr, 1957, pl. 1, fig. 7), has poorly defined basal lobes on an otherwise featureless cephalon; Snajdr also suggested that *bituberculatus* belongs in *Phalagnostus*. Thus, Öpik's suggestion that *Phoidagnostus bituberculatus* is a species of *Phalagnostus* characterized by the presence of an anteriorly located elongate axial node is accepted here.

Occurrence.—Middle Cambrian–2 fauna. Rare, (1 cephalon), GSC colln. 282, Hillard Peak area.

Suborder EODISCINA Kobayashi
Family EODISCIDAE Raymond

Genus CALODISCUS Howell

Goniodiscus Raymond, 1913, p. 101 [not Muller and Troschel, 1842].

Calodiscus Howell, 1935b, p. 223; Kobayashi, 1943a, p. 38; Kobayashi, 1944, p. 47; Rasetti, 1952, p. 440; Howell, 1959, p. 188; Pokrovskaya, 1959, p. 167; Pokrovskaya, 1960, p. 55; Poletaeva, 1960, p. 58; Repina and others, 1964, p. 262; Lazarenko, 1964, p. 166.

Brevidiscus Kobayashi, 1943a, p. 39.

Type species.—*Agnostus lobatus* Hall, 1847, p. 258, pl. 57, figs. 5a–f.

Discussion.—The current concept of *Calodiscus* Howell was established by Rasetti (1952) and has not been modified by subsequent authors. It includes small blind eodiscids that have semicircular cephala and pygidia, an elongate glabella reaching nearly to the border furrow, and generally six or fewer well-defined segments in the pygidial axis. Border spines and nodes are generally absent.

Calodiscus nanus n. sp.

Plate 2, figures 20, 21, 25, 26

Description.—Cephalon broadly rounded anteriorly; width slightly greater than length; moderately convex transversely and longitudinally. Glabella long, tapered forward, extended to border furrow, divided into three lobes of unequal length. Anterior lobe subovate; length slightly more than two-fifths length of glabella. Middle lobe short, sunken between anterior and posterior lobes, bounded by pair of shallow, straight transverse furrows; length slightly less than one-sixth length of glabella. Posterior lobe subovate; length slightly less than one-half length of glabella. Occipital ring differentiated from glabella only adjacent to axial furrow by shallow, short occipital furrow. Occipital spine or node absent. Border well defined by deep border furrow that is distinctly bent backward on axial line; width greatest on axial line, decreases laterally. Fixed cheeks convex, steepest near border furrow; no evidence for eyes or ocular ridges.

Thorax not known.

Pygidium elongate, semielliptical. Axis long, slender, reaches to border furrow, crossed by six ring furrows posterior to articulating furrow; depth of furrows decreases posteriorly. Pleural regions convex, unfurrowed. Border narrow, without nodes or spines.

Ornamentation of both cephalon and pygidium consists of closely spaced shallow pits.

Discussion.—This distinctive species seems to fit best into the current concept of *Calodiscus*. The form of the cephalon is most like that of *C. helena* (Rasetti, 1952, pl. 54, figs. 18–20; Lazarenko, 1964, pl. 1, figs. 1, 4–6), particularly in proportions of glabellar segments and glabellar profile. The associated pygidium has smooth pleurae and a relatively slender axis that has six well-defined segments, thus is intermediate in form between typical members of *Calodiscus* and *Serrodiscus*. The combined features of the cephalon and pygidium distinguish this species from all known eodiscids.

Occurrence.—Early Cambrian–1 fauna. Moderately rare (5 cephala, 3 pygidia), USGS colln. 4295–CO, Yukon River (Water Level) area.

Genus SERRODISCUS Richter and Richter

Serrodiscus Richter and Richter, 1941, p. 23; Rasetti, 1952, p. 444; Hupé, 1952, p. 109; Howell, 1959, p. 188; Pokrovskaya, 1959, p. 170; Pokrovskaya, 1960, p. 55; Poletaeva, 1960, p. 54.
Paradiscus Kobayashi, 1943a, p. 38; 1944, p. 50.
Eodiscus (*Serrodiscus*), Shaw, 1950, p. 582.
Eodiscus (*Paradiscus*), Shaw, 1950, p. 582.

Type species.—Eodiscus (*Serrodiscus*) *serratus* Richter and Richter, 1941, p. 24, pl. 1, figs. 1–10; pl. 2, figs. 22–24; pl. 4, fig. 59.

Diagnosis.—Cephalon semielliptical. Glabella long, tapered forward, reaches to, or nearly to, border furrow; furrows shallow or absent. Occipital ring smooth or has short spine. Pygidium semielliptical. Axis has seven or more segments, extends to posterior border. Pleural regions generally smooth. Border narrow; ventral part generally has short downward-directed spines.

Discussion.—Rasetti (1952) has presented a careful analysis of the characteristics of *Serrodiscus* that is largely followed here. This genus includes generally large eodiscids that lack well-developed axial spines and that have seven or more axial segments on the pygidium.

Serrodiscus sp.

Plate 2, figure 4

Discussion.—A single incomplete pygidium of a large eodiscid has the characteristic smooth pleurae and ventrally directed border spines of *Serrodiscus*. Not enough of the specimen is preserved to compare it adequately with the described species of *Serrodiscus*.

Occurrence.—Early Cambrian–1 fauna. Rare, USGS colln. 4295–CO, Yukon River (Water Level) area.

Family PAGETIIDAE

At least seven distinct Alaskan species are assignable to the Pagetiidae. Four present no problems for generic indentification: *Yukonia intermedia* n. gen., n. sp., differs from all other species in the family by having the facial sutures fused and by having a large median spine on the second axial segment of the pygidium; *Pagetia stenoloma* n. sp. and *Pagetia* sp. have pygidia with smooth pleurae and a terminal axial spine and with poorly developed palpebral lobes, which are characteristic of *Pagetia;* and *Neocobboldia spinosa* n. sp. has the cephalic and pygidial morphology typical of *Neocobboldia* but differs from all described species by having an occipital spine and a large axial spine on the third segment of the pygidium. The remaining three species indicate a real problem in the consistent discrimination of species of *Neopagetina* and *Pagetides*.

Neopagetina has been used only by the Russian paleontologists for species from Siberia. The only foreign species that they include is *Pagetia significans* (Etheridge). The principal grouping characteristics seem to be the presence of pleural furrows on the pygidium and an occipital spine on the cranidium. A terminal or subterminal axial spine on the pygidium may be present or absent. It is absent on the type species, *N. rjonsnitzkii* (Lermontova).

Pagetides has been used only by Rasetti (1945b, 1948a, 1966) and Lazarenko (1959) for species that have nearly smooth pygidial pleurae, an occipital spine, and no axial pygidial spines. The species described by Rasetti are all of Early Cambrian age whereas those described by Lazarenko are all from the Middle Cambrian. Lazarenko's species all have a swollen terminal part of the pygidial axis. Rasetti (1966) has compared these species with *Pagetia maladensis* Resser and assigned them to *Pagetia*.

The three problematical Alaskan species all have pygidia that lack axial pygidial spines. One of these has a short glabella and deep pleural furrows representing all segments of the pygidium and is closely related to *Neopagetina rjonsnitzkii*. The other two species are closely related to each other, differing only by degree of development of the pleural furrows on the pygidium. One of these, which has the pleural furrows barely apparent, conforms to the concept of *Pagetides*, but the other, which has distinct pleural furrows, should be assigned to *Neopagetina* under the current scheme of classification within the Pagetiidae. However, I think that the Russians have placed too much emphasis on the presence of pleural furrows and have therefore included a variety of possibly unrelated forms in *Neopagetina*.

Neopagetina significans (Etheridge), *N. glabrata* (Lermontova), *N. orbiculata* Lazarenko, and *N. venusta* Lazarenko, all of which have terminal or subter-

minal axial spines, are morphologically very similar to typical species of *Pagetia* and might better be placed in that genus. If these species are removed from *Neopagetina*, the remaining forms all lack significant development of axial pygidial spines. This interpretation leaves only the degree of development of the pleural furrows as a criterion for discriminating *Neopagetina* from *Pagetides*, and Rasetti (1966) has cast doubt on the value of this criterion for species of the closely related genus *Pagetia*. Cranidia assigned to *Neopagetina* and *Pagetides* show considerable variety, and no consistent discriminating generic characteristics are apparent. Therefore, the Alaskan specimens are all assigned to the older named genus, *Pagetides*, which has been characterized by Rasetti (1966, p. 503) as a genus of Pagetiidae including all species bearing an upturned occipital spine and well-defined palpebral furrows on the cranidium but lacking any well-developed axial spines on the pygidium.

Genus NEOCOBBOLDIA Rasetti

Cobboldia Lermontova, 1940, p. 120; Lermontova, 1951, p. 22; Egorova and others, 1955, p. 105 [not *Cobboldia*, Brauer, 1887].

Neocobboldia Rasetti, 1952, p. 438; Pokrovskaya, 1960, p. 56; Egorova, 1961, p. 218; Repina and others, 1964, p. 255; Lazarenko, 1964, p. 178.

Type species.—*Cobboldia dentata* Lermontova, 1940, p. 120, pl. 35, figs. 3, 3a–e.

Discussion.—The genus *Neocobboldia* is presently known from three species in Early Cambrian faunas of Siberia and a questionably assigned species from the Lower Cambrian of North Africa. A pygidium has been described only for the type species, *N. dentata* (Lermontova). The most distinctive characteristics of cranidia of *Neocobboldia* seem to be: a broad, flat or concave frontal area that has a narrow border, a subcylindrical, unfurrowed glabella, and large palpebral lobes that are well defined by a deep narrow palpebral furrow and are situated near the lateral cephalic margins. Two Alaskan collections contain a species with cranidia that have the typical characteristics of *Neocobboldia*. The associated pygidia have marginal nodes or denticles comparable to those of *N. dentata* (Lermontova). However, the Alaskan pygidia have a strong median axial spine on the third segment that distinguishes them from *N. dentata*. There are so many similarities between the Alaskan and Siberian species that I consider the presence of the axial spine on the pygidium to have only specific value and to be the principal distinguishing characteristic of *N. spinosa* n. sp. described below.

Neocobboldia spinosa n. sp.

Plate 2, figures 7–13; text figure 3

Description.—Cephalon semicircular, moderately convex transversely and longitudinally. Glabella long, gently tapered forward, strongly rounded at front, evenly sloped forward in longitudinal profile, well defined at sides by deep axial furrows, defined at front by abrupt change in slope of exoskeleton. Glabellar furrows absent. Occipital furrow deep at sides of glabella, relatively shallow to barely apparent across top. Occipital ring has slender, broad-based, posteriorly directed median spine. Frontal area concave; sagittal length about one-third sagittal length of glabella, exclusive of occipital ring. Border narrow, convex, of constant width; sagittal length about one-third sagittal length of frontal area. Inner margin of

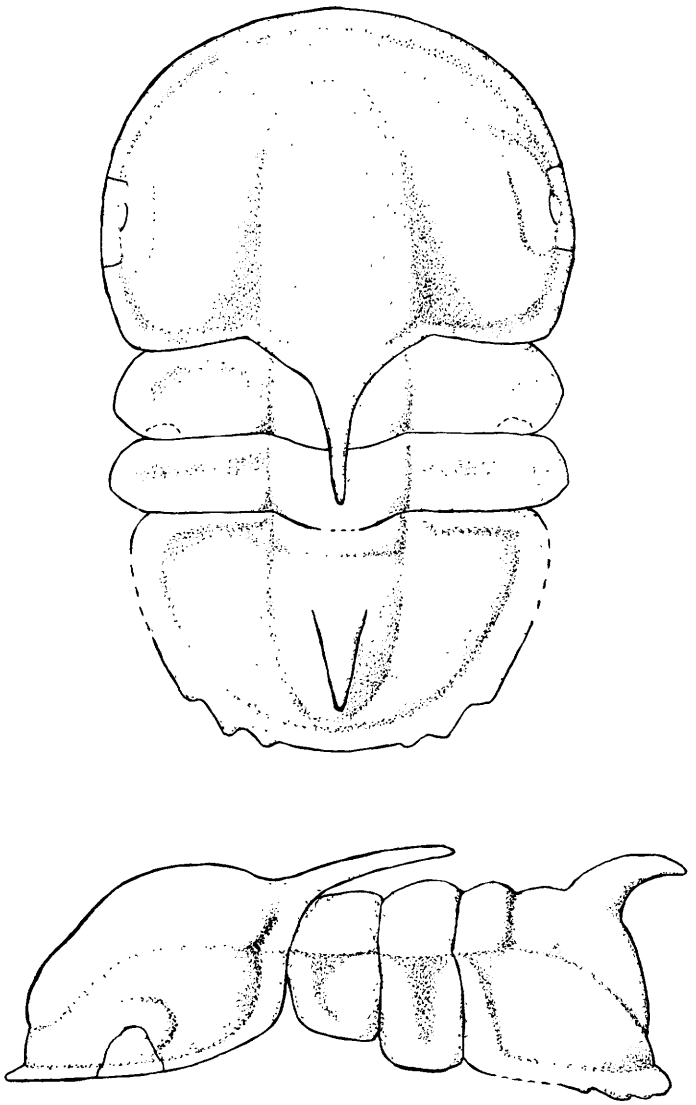

FIGURE 3.—Reconstruction of dorsal and left lateral views of *Neocobboldia spinosa* n. sp. × 40.

frontal area marked by very sharp change in slope of anterior part of fixed cheeks. Fixed cheek broad, moderately convex, nearly horizontal; width, exclusive of palpebral lobe, slightly more than two-thirds basal glabellar width. Palpebral lobe large, convex, well defined along inner and posterior margins by deep narrow palpebral furrow; length about two-fifths sagittal glabellar length, exclusive of occipital ring. Anterior margin poorly defined. Posterior limb short, blunt, barely extended laterally beyond palpebral lobe. Posterior border furrow broad, deep.

Free cheek tiny, consists of subtriangular plate bearing small convex eye surface and narrow border. Maximum length about equal to length of palpebral lobe.

Thorax composed of two segments. Pleural furrows broad, deep; distal tips of segments blunt. First segment may have short spines developed from posterior band at geniculation.

Pygidium semicircular, moderately to strongly convex transversely and longitudinally. Axis moderately wide, tapered backward nearly to border furrow, strongly rounded at rear, well defined by narrow axial furrows. One deep complete ring furrow present posterior to articulating furrow. At least two additional segments indicated by shallow indentations of sides of axis adjacent to axial furrows. Third axial segment bears large median spine directed upward and then backward from top of axis. Pleural fields have only deep pleural furrow of first segment. Border narrow, well defined by border furrow. Several pairs of marginal nodes or short blunt spines present.

External surfaces of well-preserved specimens have very fine grained closely spaced granules and scattered, very shallow pits. Less well preserved specimens appear to be smooth.

Discussion.—*Neocobboldia spinosa* differs from all others in *Neocobboldia* by having an occipital spine on the cranidium and a median axial spine on the pygidium. The presence of a single well-defined axial segment and only an anterior pleural furrow are further distinguishing features. A single complete specimen, (pl. 2, figs. 7, 8) shows that this species has only two thoracic segments, compared to three segments in *N. dentata* (Lermontova).

Neocobboldia spinosa is associated, in USGS colln. 4296–CO, with a small eodiscid, *Yukonia intermedia* n. gen., n. sp., that also has an axial spine on the pygidium; however the spine is on the second axial segment. Furthermore, the cephalon of *Y. intermedia* lacks distinct palpebral lobes, and the thorax consists of three segments.

Occurrence.—Early Cambrian–1 fauna. Moderately rare (9 cephala or cranidia, 2 pygidia), USGS colln. 4296–CO; 1 cranidium, 1 pygidium, USGS colln. 4295–CO, Yukon River (Water Level) area; 1 complete specimen, 1 pygidium, USGS colln. 4449–CO, Canada, east of Hillard Peak area.

Genus PAGETIA Walcott

Pagetia Walcott, 1916, p. 407; Cobbold, 1931, p. 462; Lermontova, 1940, p. 121; Richter and Richter, 1941, p. 17; Kobayashi, 1943a, p. 40; Kobayashi, 1944, p. 63; Shimer and Shrock, 1944, p. 615; Rasetti, 1945b, p. 315; Lermontova, 1951, p. 36; Howell, 1959, p. 189; Pokrovskaya, 1960, p. 55; Egorova, 1961, p. 215; Egorova and others, 1955, p. 104; Poletaeva, 1960, p. 154; Repina and others, 1964, p. 253; Lazarenko, 1964, p. 176; Rasetti, 1966, p. 503.

Type species.—*Pagetia bootes* Walcott, 1916, p. 408, pl. 67, figs. 1–1f.

Discussion.—*Pagetia* Walcott has been described and discussed many times, and its characteristics are well shown and summarized by Rasetti (1966). The Alaskan specimens, although relatively uncommon, have the terminal axial spine on the pygidium, which is the most distinctive feature of *Pagetia*. Associated cranidia differ from cranidia of other Pagetiidae in the same collections by lacking distinct development of palpebral lobes.

Pagetia stenoloma n. sp.

Plate 4, figures 6, 7

Description.—Cranidium subquadrate, moderately to strongly rounded anteriorly. Glabella slender, tapered forward, strongly rounded at front, well defined by broad shallow axial furrows. Glabellar and occipital furrows not apparent. Occipital ring extended posteriorly into long slender nearly horizontal spine. Border narrow, convex, without radial grooves; sagittal length less than one-half sagittal length of frontal area. Border furrow broad, shallow. Axial furrow connected to border furrow by broad, shallow preglabellar median furrow. Fixed cheek upsloping, moderately convex; width slightly greater than basal glabellar width. Palpebral lobe at highest part of cheek; palpebral furrow absent. Narrow eye ridge barely apparent on largest cranidium. Posterior border furrow deep. Posterior border expanded slightly distally.

Pygidium semielliptical, moderately convex transversely. Axis narrow, posterior tip slightly separated from posterior border. Four deep narrow ring furrows define four anterior axial segments; fifth and sixth segments not clearly differentiated; sixth segment has long slender nearly horizontal, posteriorly directed median spine. Pleural fields moderately con-

vex, downsloping to depressed; inner parts have three shallow pleural furrows barely apparent. Border well defined, narrow.

Ornamentation consists of barely apparent median axial nodes on first four pygidial segments and barely apparent fine granules on pygidial border. First two axial segments on pygidia of some specimens have pair of low nodes flanking median node. Cranidium without apparent ornamentation.

Discussion.—*Pagetia stenoloma* n. sp. differs from all others in the genus by having a narrow cranidial border that lacks radial grooves. Of the 20 species presently included in *Pagetia*, *P. clytia* (Walcott) and *P. connexa* (Walcott) are the most similar to *P. stenoloma*. The remaining species differ in either glabellar shape, width of the cranidial border, number of axial segments or presence of complete pleural furrows on the pygidium. *P. connexa*, from the Lower Cambrian of New York, has a relatively narrow cranidial border, but it has distinct radial grooves. Furthermore, the pygidium of *P. connexa* shows no evidence of either pleural furrows or axial nodes. The pygidium of *P. clytia*, from the lower Middle Cambrian of the Cordilleran region, however, has shallow pleural furrows near the axis, and median axial nodes and cannot be certainly distinguished from that of *P. stenoloma*. The cranidium of *P. clytia*, however, has a broad border with distinct radial grooves.

Occurrence.—Early Cambrian–3 fauna. Moderately common (2 cranidia, 9 pygidia), USGS colln. 4333–CO, Yukon River (West Ridge) area.

Pagetia spp.

Plate 4, figures 8–10

Discussion.—A pygidium and three associated cranidia representing *Pagetia* may be conspecific. The pygidium could represent either *P. stenoloma* n. sp., *P. connexa* (Walcott), or *P. clytia* Walcott. It lacks evidence of pleural furrows and thus resembles *P. connexa*, but it has tiny axial nodes which are apparently present only on *P. clytia* and *P. stenoloma*. The cranidium has distinct radial grooves in the border. These grooves are the characteristics that distinguish *P. clytia* and *P. connexa* from *P. stenoloma*. The border is also narrow; this feature is more like *P. connexa* than *P. clytia*. If the parts are correctly associated, the most comparable species seems to be *P. connexa*, an Early Cambrian species from New York. However, the cranidium has a pitted ornamentation of the convex parts of the glabella and fixed cheeks, and the pygidium is smooth. Thus the association may be incorrect, and two species of *Pagetia* may be present.

Occurrence.—Early Cambrian–3 fauna. Rare (3 cranidia, 1 pygidium), USGS colln. 4334–CO, Yukon River (West Ridge) area.

Genus PAGETIDES Rasetti

Pagetides Rasetti, 1945b, p. 311; Howell, 1959, p. 190; Lazarenko, 1959, p. 5; Pokrovskaya, 1960, p. 55; Chernysheva, 1961, p. 42.

?*Pagetina* Lermontova, 1940, p. 121 [not *Pagetina*, Barnard, 1931]; Lermontova, 1951, p. 27.

?*Neopagetina* Pokrovskaya, 1960, p. 56; Egorova, 1961, p. 217; Lazarenko, 1962, p. 37; Lazarenko, 1964, p. 177.

Type species.— *Pagetides elegans* Rasetti, 1945b, p. 313, pl. 1, figs. 15–18.

Diagnosis.—Pagetiidae that have a well-developed strongly upturned occipital spine and well-defined palpebral furrows, and they lack significant development of axial pygidial spines.

Discussion.—The problems of generic discrimination between *Pagetides* and *Neopagetina* are discussed on page B33. Of the three species described below, *P. granulosus* n. sp. is most similar to *P. rjonsnitzkii* (Lermontova), the type species of *Neopagetina*, and, if satisfactory criteria can be determined for the separate recognition of both genera, *P. granulosus* should be included in *Neopagetina*. The remaining two species, *P. appolinis* n. sp. and *P. occidentalis* n. sp., are most like the Early Cambrian species of *Pagetides* described by Rasetti, except for the presence of axial nodes on the pygidium.

Pagetides appolinis n. sp.

Plate 4, figure 11

Description.—Pygidium semielliptical in outline. Axis slender, convex, raised above convex, downsloping to depressed pleural fields; width at anterior end about one-third width of pygidium. Five complete narrow deep ring furrows behind articulating furrow define five axial segments and short terminal part that does not quite reach to posterior border. Pleural fields crossed by four subparallel pleural furrows exclusive of the anterior marginal furrow. Interpleural furrows barely apparent. Border narrow. Ornamentation consists of distinct median nodes on each axial segment and barely apparent scattered granules on pleural fields.

Discussion.—*Pagetides appolinis* n. sp., although represented by only two pygidia, has furrowed pleural fields and a well-segmented axis that lacks a terminal spine. It differs from all described species by having five distinct axial segments and four subparallel pleural furrows exclusive of the anterior marginal furrow.

The most similar species is *P. occidentalis* n. sp., from slightly younger beds, which has one less complete ring furrow on the axis and lacks distinct development of the pleural furrows.

Occurrence.—Early Cambrian–3 fauna. Rare (2 pygidia), USGS colln, 4334–CO, Yukon River (West Ridge) area.

Pagetides granulosus n. sp.

Plate 2, figures 15, 16, 24

Description.—Cephalon semicircular, gently to moderately convex transversely and longitudinally. Glabella unfurrowed, tapered forward, well defined by deep axial furrows, connected to border by shallow median longitudinal furrow; occipital ring produced into long slender posteriorly directed axial spine; sagittal glabellar length, exclusive of occipital ring, about two-thirds sagittal length of cranidium. Border narrow, separated from cheeks by broad border furrow. Fixed cheeks wide; convexity greatest on small specimens; width, including palpebral lobes, almost equal to greatest cranidial width. Palpebral lobes small, well defined by abrupt change in slope; situated below level of cheek about opposite anterior third of glabella; length between one-fifth and one-sixth sagittal cranidial length, exclusive of occipital spine. Ornamentation consists of scattered coarse granules on all convex surfaces except palpebral lobes.

Free cheeks and thorax not known.

Pygidium semicircular, moderately convex transversely and longitudinally. Axis slender, reaching to posterior border furrow; seven axial segments well defined by deep ring furrows; each segment has well-developed median node. Pleural fields crossed by five deep pleural furrows exclusive of anterior marginal furrow; angle of each furrow with axis decreases posteriorly. Interpleural furrows barely visible on some whitened specimens. Ornamentation consists of single coarse granules flanking each axial node, two rows of granules on anterior three or four pleural segments, and single rows of granules on posterior pleural segments; border smooth.

Discussion.—*Pagetides granulosus* n. sp. differs from all others in the genus by having well developed coarse granular ornamentation on all convex parts. In all other respects it is most similar to *Pagetides? rjonsnitzkii* (Lermontova), the type species of *Neopagetina.*

Occurrence.—Early Cambrian–1 fauna. Moderately common, USGS colln. 4295–CO, Yukon River (Water Level) area.

Pagetides occidentalis n. sp.

Plate 4, figures 12, 13

Description.—Cranidium subquadrate, strongly and evenly rounded anteriorly. Glabella elongate, tapered forward, bluntly pointed anteriorly, well defined by moderately deep axial furrows. Two pairs of short glabellar furrows present only at sides of glabella; posterior pair directed obliquely backward. Occipital furrow deep, narrow distally; shallow, curved slightly forward over axis; long slender gently upsloping median spine directed backward from axial part of occipital ring. Border gently convex, has many short radially directed, generally poorly defined grooves; sagittal length about one-half sagittal length of frontal area. Broad shallow longitudinal depression connects front of glabella to border furrow. Fixed cheek gently convex, about as wide as glabella. Palpebral lobe moderately well defined by isolated curved narrow palpebral furrow. Form of posterior limb unknown.

Anterior section of facial suture strongly divergent forward from palpebral lobe to anterolateral cranidial margin. Course of posterior section unknown.

Pygidium semielliptical. Axis long, slender, convex, elevated above convex downsloping to depressed pleural fields; width at anterior end one-third width of pygidium. Four complete ring furrows behind the articulating furrow outline four distinct axial segments; fifth segment poorly differentiated from short terminal part that does not quite reach posterior border. Each axial segment has small median node. Pleural fields nearly smooth. Border narrow, well defined.

Ornamentation absent except for axial nodes on pygidium.

Discussion.—*Pagetides occidentalis* n. sp. differs from all others in the genus by having four distinct axial rings, a poorly defined fifth ring, and a short terminal part. It is most similar to *P. appolinis* n. sp., which occurs in slightly older beds and has one more distinct ring furrow and distinct pleural furrows. It is also similar to *P. elegans* (Rasetti, 1948a, pl. 1, figs. 1–3) from which it differs by having a broader axis, axial nodes, and one less axial segment on the pygidium and by having the palpebral lobes located at about the same level as the cheek surface and incompletely defined by the palpebral furrow.

Occurrence.—Early Cambrian–3 fauna. Moderately rare (2 cranidia, 4 pygidia), USGS colln. 4333–CO, Yukon River (West Ridge) area.

Genus YUKONIA n. gen.

Type species.—*Yukonia intermedia* n. sp.

Diagnosis.—Eodiscinae having glabella unfurrowed, prominent eyes and eye lines, and fused facial sutures.

Discussion.—Only one other eodiscid genus, *Opsidiscus* (Westergård, 1946, as *Aulacodiscus*) has well-developed eyes and fused facial sutures. However, the only known species has a well-defined transglabellar furrow outlining an anterior agnostiform glabellar lobe, a morphologic difference of probable major significance; the two genera may not even be closely related. Because *Yukonia* is at present a monotypic genus, the species description gives all of its known characteristics.

Yukonia intermedia n. sp.

Plate 2, figures 14, 17–19, 22, 23, 27, 28; text figure 4

Description.—Cephalon semicircular, gently to moderately convex transversely and longitudinally. Glabella long, tapered forward, strongly rounded at front, well defined by narrow axial furrows. Glabellar furrows lacking. Occipital furrow present only adjacent to axial furrow, lacking across axial line. Occipital ring has long slender posteriorly directed median spine. Frontal area concave; sagittal length about one-third sagittal length of glabella, exclusive of occipital spine. Border narrow, convex, width constant; sagittal length about one-third sagittal length of frontal area. Fixed cheeks very convex, forming a low broad-based cone having its apex near outer margin and above strongly developed eye node. Narrow eye ridge extends from eye node inward across cheek towards anterolateral part of glabella. Lateral margin adjacent to eye node indented slightly, interrupting course of cephalic border. Posterolateral corner of cephalon nearly a right angle. Well-preserved specimens have only a short ridge connecting posterior end of eye node to inner edge of marginal indentation.

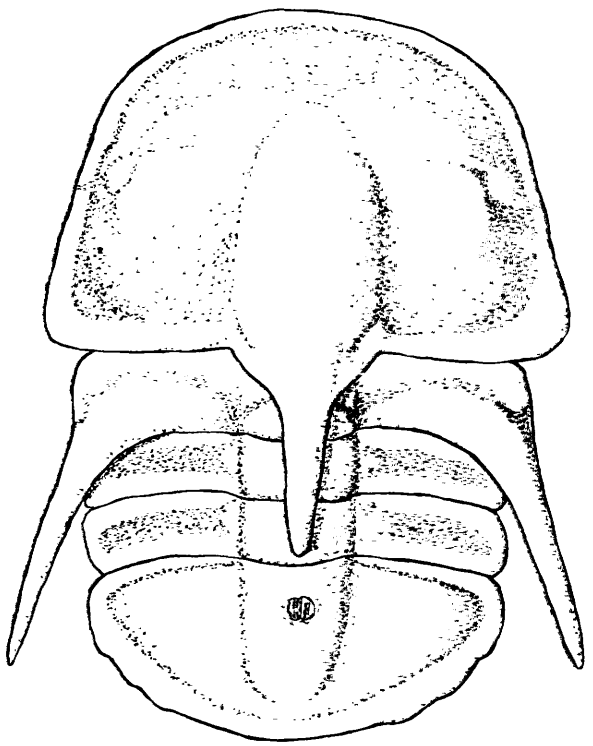

FIGURE 4.—Reconstruction of dorsal view of *Yukonia intermedia* n. gen., n. sp. × 30.

Thorax composed of three segments. First segment has pair of long posterolaterally directed spines developed from distal parts of posterior band; pleural furrow curved strongly forward; axial part without spine. Second and third segments lack lateral spines, have straight pleural furrows, and at least third segment also lacks axial spine.

Pygidium semicircular, gently to moderately convex transversely and longitudinally. Axis strongly convex, tapered posteriorly nearly to border furrow, well defined by abrupt change in slope of exoskeleton. Distinct axial furrows lacking posterior to articulating furrow. Second axial segment bears broad-based dorsally directed median spine. Pleural regions crossed only by single deep anterior pleural furrow. Border narrow, irregular margin on some specimens indicates possible marginal nodes.

External surfaces of all parts smooth.

Discussion.—No described eodiscid closely resembles *Yukonia intermedia*. It is tentatively included in the Pagetiidae because, although it lacks functional facial sutures, it has well-developed eyes and eye ridges, one of the principal characters for separating the Pagetiidae from the blind eodiscids of the Eodiscidae.

Occurrence.—Early Cambrian–1 fauna. Moderately common (more than 10 cephala and pygidia, many immature), USGS colln. 4296–CO, Yukon River (Water Level) area.

Order REDLICHIIDA Richter
Suborder OLENELLINA Resser

Olenellid species undetermined 1

Plate 3, figure 1

Description.—Cephalon semicircular; genal spine slender, continuing curvature of cephalic margin, slightly advanced; short intergenal spine present. Anterior end of glabella separated from convex border by narrow brim; narrow parafrontal band barely apparent. Palpebral lobe long, curved, divided by deep longitudinal furrow into wide proximal band and narrow distal band. External surfaces of all parts, including

furrows, covered with reticulate meshwork of raised ridges. Other details not known.

Discussion.—Olenellid species undetermined 1 has the cephalic form of *Olenellus*, to which it may belong. The distinctive reticulate ornamentation has not been observed previously on a species of this genus from western North America, but species of most olenellid genera in regions surrounding the Atlantic Ocean are characterized by this kind of ornamentation. The most complete specimen of this species is illustrated. Information about the axial part of the cephalon in front of the glabella came from much smaller scraps identified by their characteristic ornamentation.

Occurrence.—Early Cambrian–2 fauna. Moderately common (12 fragments), USGS colln. 4302–CO, Tatonduk River area.

Olenellid species undetermined 2

Plate 3, figure 2

Description.—Cephalon semicircular, genal spine slender, not noticeably advanced, continues curvature of cephalic margin. Intergenal spine not apparent. Anterior end of glabella separated from border by narrow brim. Palpebral lobe long, evenly curved. Ornamentation consists of fine terrace lines arranged parallel to border furrow on extraocular cheek and forming chevron-shaped pattern pointing forward on border. Additional details unknown.

Discussion.—The structure of the posterolateral part of the cephalon of olenellid species undetermined 2 is characteristic of *Paedeumias*, and a comparable ornamentation has been observed on some species of that genus. The best specimen is illustrated. Additional information was obtained from a poorly preserved incomplete cephalon.

Occurrence.—Early Cambrian–2 fauna. Moderately rare (2 fragments), USGS colln. 4302–CO, Tatonduk River area.

?Superfamily REDLICHIACEA Poulsen

Genus CHURKINIA n. gen.

Type species.—*Churkinia yukonensis* n. sp.

Diagnosis.—Redlichiacea? that have subparallel anterior sections of facial sutures, anterior ends of palpebral lobes widely separated from glabella, relatively short palpebral lobes terminating opposite preoccipital furrow, and long broad posterior limbs on cranidium. Free cheeks have short slightly advanced genal spines. Thoracic segments have slender distal spines developed only from anterior pleural ridges; posterior parts of pleural tips strongly angular. Pygidium small; axis broad, poorly defined, occupies most of pygidial area.

Discussion.—The characteristics cited in the diagnosis summarize the features of the type species that are probably of generic value. The suprageneric position of this species seems to be within the Redlichiacea, but recent classifications of trilobites within this superfamily (Henningsmoen, 1951; Poulsen, 1959; Suvorova, 1960a) indicate a considerable divergence of opinion about the nature and content of the included families and subfamilies. Although this genus does not fit into any of the currently recognized families, I am reluctant to propose a monotypic taxon above the rank of genus in a systematic framework that already seems somewhat unstable. Therefore the species is assigned with question to the Redlichiacea, and no smaller taxon of suprageneric rank is recognized. Possible affinities of the type species are discussed after the species description.

Churkinia yukonensis n. sp.

Plate 1, figures 3, 5–16; text figure 5

Description.—Cranidium subtrapezoidal; anterior and posterior margins straight; sagittal cranidial length and cranidial width between anterior branches of facial sutures at anterior margin both about one-half width between tips of posterior limbs.

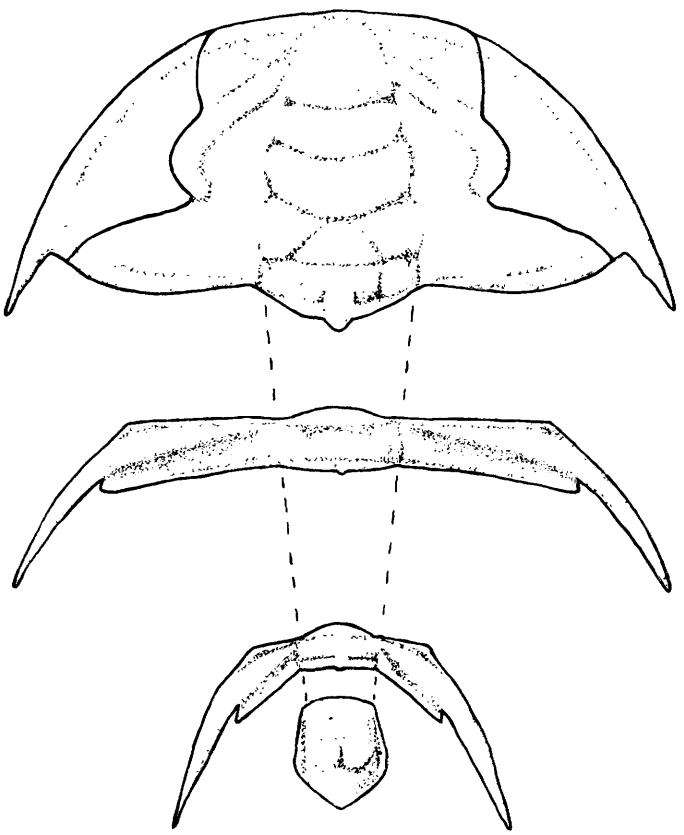

FIGURE 5.—Reconstruction of dorsal view of *Churkinia yukonensis* n. gen., n. sp. × 1.

Glabella long, slender, evenly tapered forward, strongly rounded at front, reaches nearly to anterior margin, separated from adjacent parts of cranidium by change in slope. Axial and preglabellar furrows absent. Three transglabellar furrows present anterior to occipital furrow. Posterior furrow strongly curved backward on axial line; anterior two furrows nearly straight. Preoccipital segment divided transversely into three parts by pair of shallow posteriorly divergent furrows that originate from posterior transglabellar furrow near axial line. Sagittal lengths of preoccipital and third glabellar segments distinctly less than sagittal lengths of second and anterior glabellar segments. Occipital furrow straight, deepest at sides of glabella. Occipital ring has large short blunt median spine at posterior margin, surmounted by tiny median node. This spine interrupts a shallow furrow that parallels the posterior margin of occipital ring and divides it into anterior and posterior sections. Anterior section of occipital ring subequally divided transversely into three parts by short, shallow longitudinal furrows.

Frontal area consists only of narrow nearly flat border on axial line. Laterally, border is separated from flat downsloping brim by shallow border furrow.

Fixed cheeks moderately wide, gently upsloping; width, including palpebral lobes, decreases from slightly more than one-half basal glabellar width on smallest specimens to slightly less than one-half basal glabellar width on largest specimens. Eye ridges well defined, raised, directed posterolaterally from about midlength of anterior glabellar segment, continuous with strongly curved well-defined palpebral lobes.

Posterior limbs long transversely; tips sharply rounded. Posterior border consists of narrow raised ridge and narrower depressed marginal flange.

Course of anterior section of facial suture slightly divergent forward from palpebral lobe to border furrow, then curved inward to cut anterior cranidial margin near anterolateral cranidial corners. Posterior section of facial suture directed posterolaterally about parallel to eye ridge, curved more strongly backward near tip, but cuts cranidial margin slightly anterior to posterior edge of limb.

Ornamentation of most cranidia consists of well-defined terrace lines on glabella, border, eye ridges, palpebral lobes and posterior limbs. Brim, fixed cheeks, and most of posterior limbs except for posterior border have scattered fine granules, and generally distinct network of caecal ridges. All specimens have two pairs of especially well developed caecal ridges. One pair is directed anterolaterally across brim from near proximal ends of eye ridges to border furrow about midway between anterior end of glabella and anterolateral cranidial corners. Many specimens have tiny node or accentuation of terrace lines on anterior margin directly in front of junction between each caecal ridge and border furrow. The other pair of caecal ridges extends posterolaterally across posterior limbs from near posterior tips of palpebral lobes almost to tips of limbs. Most specimens have a low circular knob on proximal part of each posterior limb near posterolateral margins of preoccipital glabellar segment. The degree of definition of all ornamentation and of the axial parts of the transglabellar furrows is slightly variable among specimens of all sizes.

Free cheek large, nearly flat. Lateral border long, gently curved, well defined by shallow border furrow that curves sharply inward near base of genal spine to intersect posterior sutural margin. Posterior border short; length about equal to basal width of genal spine. Genal spine short, slender; length about one-third length of posterior sutural margin; inner spine angle slightly acute. Ornamentation includes many well-defined anastomosing caecal ridges on ocular platform, rows of fine granules on tops of these ridges on many specimens, and coarse terrace lines on anterior part of border that grade backward into close-spaced moderately coarse granules on posterior part of border and genal spine.

Number of thoracic segments unknown. Axial ring convex. Articulating furrow deep. Articulating half ring sagittally convex; sagittal length nearly one-half sagittal length of segment. Distinct transaxial furrow divides remainder of segment into narrow posterior and wider anterior sections. Posterior section has small marginal median node. Pleural regions flat, sides subparallel, lateral geniculation absent. Each region consists of a broad subcentral trough flanked by narrow strongly raised ridges that are separated from anterior and posterior margins of segment by narrow flanges. Anterior pleural ridge continues laterally into slender slightly curved spine. Posterior pleural ridge decreases in height laterally and merges with segmental surface. Distal tip of segment behind spine is nearly a right-angle. Some specimens have small distal marginal node posterior to base of spine. Ornamentation consists of coarse terrace lines on axial ring and pleural ridges; coarse close-spaced granules on lateral spine, and fine scattered granules on remaining parts of pleurae. Pleural regions of anterior thoracic segments relatively wide transversely, directed straight laterally. Pleural regions of posterior thoracic segments are shorter and directed posterolaterally.

Pygidium small, outline pentagonal; anterior margin nearly straight; posterior end bluntly pointed. Axis poorly defined, broad, occupies nearly all of pygidium.

Narrow pleural regions present only along anterior two-thirds of pygidium. Anterior half of axis poorly differentiated into two segments and articulating half ring. Posterior half has pair of large round knobs separated by deep median cleft; behind knobs, broad smooth region slopes down to posterior margin. Ornamentation poorly developed, consists of scattered fine granules in area behind knobs and low terrace lines in median part of axial region anterior to knobs and in cleft between knobs.

Hypostome subquadrate, strongly convex transversely, moderately convex longitudinally, posterior margin broadly rounded. Anterior margin upturned into narrow flange. Midde body undivided. Lateral border convex, narrow, well defined by border furrow; posterior border narrow, poorly defined. Anterior wings short. Posterior wings slender, pointed, dorsally directed. Ornamentation consists of irregular terrace lines, similar to those on glabella, which cover middle body and convex parts of border.

Discussion.—Churkinia yukonensis n. sp. is represented by more than 50 cranidia and somewhat fewer pygidia, free cheeks, hypostomes and thoracic segments. The cephalon, as a whole, is unlike that of any described trilobite. However, the glabellar form, the presence of "facial lines" on the brim, and the structure of the thoracic segments and pygidium indicate some relationship to *Redlichia.* The anteriorly tapered glabella that has well-defined transglabellar furrows is a characteristic Redlichia feature. Öpik (1958, p. 31) has described "facial lines" similar to the anterolaterally directed caecal ridges of the Alaskan species (pl. 1, figs. 7, 10, 11) as characteristic features of Australian species of *Redlichia.* The change of direction of thoracic pleurae from laterally directed in the anterior part of the thorax to posterolaterally directed in the posterior part of the thorax (text fig. 5) is analogous to that in *R. forresti* (Etheridge) (Öpik, 1958, pl. 1, fig. 2). The well-developed knobs at the end of the wide pygidial axis and the narrow pleural regions that are present only along the anterolateral parts of the pygidium (pl. 1, figs. 3, 5, 9, 13) are characteristics of female pygidia of *R. forresti* (Öpik, 1958, pl. 1, figs. 2, 3, 6).

Although more than 20 pygidia were examined, no dimorphs such as described by Öpik (1958, p. 16) were observed. Öpik noted, however, that the male dimorph is relatively rare. Thus, material in the Alaskan collection may be insufficient to determine adequately the real absence of such pygidia from the collection.

The relatively small palpebral lobes of *Churkinia yukonensis* and the relatively strong development of the two anterior transglabellar furrows distinguish this species from all species of *Redlichia.* The form of the cranidium is remarkably like that of *Paleofossus zaicevi* Pokrovskaya (1959, pl. 8) except that *P. zaicevi* has a slight constriction of the glabella across the second segment anterior to the occipital ring. Furthermore, the pygidium assigned to *P. zaicevi* is totally different from that of *C. yukonensis* but nearly identical with that of *Polliaxis inflata* n. sp. (pl. 1, figs. 19, 20). The cranidial similarities therefore may not indicate any real relationship between these species.

The glabellar shape and segmentation of *Churkinia yukonensis* is similar to that of the early Olenellid, *Nevadella addeyensis* Okulitch. The pygidium of *C. yukonensis*, as noted above, is similar to that of *Redlichia*, and Öpik (1958) has pointed out similarities between pygidia of *Redlichia* and some olenellids. Thus, *C. yukonensis* may be a descendant of the Nevadiinae characterized by the appearance of facial sutures. Similar evolution from sutureless to sutured forms seems to take place between the Olenellidae and Paradoxididae.

Occurrence.—Early Cambrian–1 fauna. Common (more than 50 cranidia, pygidia, cheeks, hypostomes and thoracic segments), USGS colln. 4296–CO, Yukon River (Water Level) area.

Order CORYNEXOCHIDA Kobayashi
Family CORYNEXOCHIDAE Angelin

Genus BONNASPIS Resser

Bonnaspis Resser, 1936, p. 5; Poulsen, 1959, p. 227; Suvorova, 1960a, p. 78; Suvorova, 1964, p. 219.

Type species.—Karlia stephenensis Walcott, 1889, p. 445.

Discussion.—Walcott (1889, p. 445) proposed the name *Karlia stephensis* for a species represented by a specimen from Mount Stephen, British Columbia, that Rominger (1887, p. 16) had identified as *Menocephalus salteri*(?) Devine. Subsequently, Resser (1936) made this species the type species of *Bonnaspis.*

Resser based his concept of *Bonnaspis* on a reconstruction of the type species published by Walcott (as *Corynexochus stephenensis*, 1916) and derived from material in Walcott's collection. I have found that Walcott, and later Rasetti (1951), have included specimens assignable to two different corynexochid species in *stephenensis.* Both species have small palpebral lobes well separated from the axial furrows. One of these species (Walcott, 1916, pl. 55, fig. 5a; Rasetti, 1951, pl. 28, figs. 4, 6) has a distinct occipital furrow, a smooth occipital ring and a thorax nearly as wide as the posterior margin of the cranidium. The anterior expansion of the glabella of this species begins just in front of the posterior pair of glabellar furrows,

and the free cheek has a short nub of a genal spine that is well shown on a specimen illustrated by Rasetti (1951, pl. 28, fig. 6). This species is much more common in the collections from Mount Stephen than the associated second species and is the species to which the holotype specimen of *stephenensis* in Rominger's collection belongs.

The second species (Walcott, 1916, pl. 55, fig. 5c; Rasetti, 1951, pl. 28, fig. 5) has a poorly defined occipital furrow, an occipital spine, a thorax that is much narrower than the width of the posterior cranidial margin, and slightly smaller palpebral lobes. The anterior expansion of the glabella begins just anterior to the second pair of glabellar furrows, and the free cheek has a long genal spine. A complete specimen of this species has not yet been found. The reconstruction of *stephenensis* published by Walcott (1908, pl. 3, fig. 4; 1916, pl. 55, fig. 5) was compiled from the posterior part of one species and the anterior part of the other!

The common species must bear the name *stephenensis* and must be the species from which the characteristics of *Bonnaspis* are derived. Information for a correct diagnosis of the cephalic and thoracic characteristics of *Bonnaspis* is given in the second paragraph of this discussion. The cephalic characteristics cited in all existing diagnoses of *Bonnaspis* are those of the less common species, which is now without a name. Two Alaskan cranidia are congeneric with the now unnamed species and all the material is, in my opinion, generically distinct from *Bonnaspis* in structure of the cephalon and thorax. However, although this material probably represents a new genus, too few specimens are known and they provide no information about the form of the pygidium which is so important in corynexochid systematics. Therefore, the Alaskan material is described below as corynexochid, genus and species undetermined.

Corynexochid, genus and species undetermined

Plate 6, figure 2

Description.—Cranidium trapezoidal. Glabella slender in posterior half, expands and increases in height toward front, reaches to cranidial margin, sides slightly concave. Two pairs of distinct shallow glabellar furrows present; anterior pair situated about at glabellar midlength. Occipital furrow moderately deep at sides of glabella, shallow across axial line. Occipital ring incomplete on known specimens, possibly has axial spine at posterior margin. Cranidial border very narrow, present only lateral to glabella. Fixed cheeks gently convex, slightly downsloping; width at palpebral lobes slightly less than narrowest part of glabella. Palpebral lobes small, situated opposite glabellar midlength. Low ocular ridge connects anterior end of palpebral lobe to axial furrow near anterolateral end of glabella. Distinct anterolateral fossulae present just anterior to junction of ocular ridges and axial furrows. Posterior limbs large; transverse length distinctly greater than basal glabellar width. Posterior border furrow moderately deep. External surface covered with obscure fine granules.

Course of anterior section of facial suture slightly divergent forward; course of posterior section of facial suture divergent in broad curve from palpebral lobe to posterior cranidial margin.

Discussion.—The Alaskan corynexochid specimens are most similar to congeneric specimens identified as *Bonnaspis stephenensis* and illustrated by Walcott (1916, pl. 55, fig. 5c) and Rasetti (1951, pl. 28, fig. 5). They are inadequate for comparison at the specific level.

Occurrence.—Middle Cambrian–1 fauna. Moderately rare (2 cranidia), USGS colln. 4346–CO, Montauk Bluff area.

Genus CORYNEXOCHUS Angelin

Corynexochus Angelin, 1854, p. 59; Gronwall, 1902, p. 136; Walcott, 1916, p. 309; Lake, 1934, p. 180; Resser, 1936, p. 22; Whitehouse, 1939, p. 233; Lermontova, 1940, p. 144; Ivshin, 1953, p. 71; Poulsen, 1959, p. 227; Suvorova 1960a, p. 77; Öpik, 1967, p. 177.

Karlia Walcott, 1889, p. 444.

Type species.—*Corynexochus spinulosus* Angelin, 1854, p. 59, pl. 33, fig. 9 [only].

Discussion.—*Corynexochus* is well described and discussed in papers by Whitehouse (1939) and Ivshin (1953). The diagnosis given by Poulsen (1959) presents the essential generic characteristics. All the described species assigned by Whitehouse and subsequent authors to *Corynexochus*, except *C. plumula* Whitehouse, have come from beds of Middle Cambrian age. *C. plumula* is from approximately correlative beds of Late Cambrian age in both Australia and Alaska. The palpebral lobes of the Late Cambrian species seem to be smaller and more anteriorly placed than those of the Middle Cambrian species, but all other characteristics are typical for the genus. Thus *Corynexochus* is one of the most long-lived nonagnostid Cambrian trilobite genera.

Corynexochus plumula Whitehouse

Plate 10, figures 15, 16, 19–22

Corynexochus plumula Whitehouse, 1939, p. 234, pl. 24, figs. 8–10; Öpik, 1967, p. 178, pl. 3, figs. 1–11; text fig. 57.

Description.—Cranidium subtrapezoidal, tapered forward, bluntly rounded anteriorly. Glabella long, expanded anteriorly, moderately convex transversely, longitudinal convexity greatest at anterior end, extended to anterior margin of cranidium; width at anterior end slightly less than twice basal glabellar width. Glabellar furrows barely apparent. Occipital furrow broad, straight, moderately deep. Occipital ring convex, has low median node. Axial furrows broad, curved, moderately deep. Small deep fossula present in each axial furrow adjacent to anterior end of palpebral lobe. Frontal area small, present only lateral to anterior end of glabella; width slightly less than one-seventh width of anterior end of glabella. Fixed cheek and posterior limb together form large convex triangular area with small poorly defined palpebral lobe near anterior angle and slightly anterior to glabellar midlength; length of palpebral lobe variable between one-fourth and one-seventh sagittal glabellar length, exclusive of occipital ring; smallest on large cranidia. Posterior border furrow deep near occipital ring, curves forward and becomes broader and shallower distally; transverse width of posterior limb about 1½ times basal glabellar width.

Course of anterior section of facial suture nearly straight forward from palpebral lobe to anterior cranidial margin. Course of posterior section of facial suture moderately to strongly convex, forms even curve with posterior cranidial margin.

Pygidium semielliptical, gently convex transversely and longitudinally. Axis convex, tapered slightly posteriorly, strongly rounded at rear, well defined laterally and posteriorly by shallow axial furrows; sagittal length, exclusive of articulating half ring, slightly more than seven-eighths sagittal pygidial length. One distinct ring furrow present posterior to deep articulating furrow. Two additional shallow ring furrows are barely apparent on most specimens. Pleural regions lack distinct border but have marginal zone of barely apparent terrace lines. Two broad deep pleural furrows extend laterally from axial furrows but disappear before reaching pygidial margin. Pygidial margin smoothly curved.

External surfaces of all parts except border region of pygidium smooth.

Discussion.—The small anteriorly placed palpebral lobes of *Corynexochus plumula* Whitehouse distinguish it from all other species in the genus.

Occurrence.—Common (more than 15 cranidia and pygidia), USGS colln. 3717-CO, Yukon River (West Ridge) area.

Family DOLICHOMETOPIDAE Walcott

Genus ATHABASKIELLA Kobayashi

Athabaskiella Kobayashi, 1942b, p. 471; Poulsen, 1959, p. 222.

Type species.—*Bathyuriscus* (*Poliella*) *probus* Walcott, 1916, p. 354, pl. 65, figs. 2, 2a.

Description.—Cranidium subtrapezoidal, gently to moderately convex transversely and longitudinally, anterior margin gently rounded. Glabella long, expanded forward, reaches nearly to anterior margin of cranidium; sides slightly concave. Posterior glabellar furrows deep, oblique; remaining glabellar furrows shallow. Occipital furrow moderately deep, slightly sinuous. Occipital ring nearly flat, has small median node. Frontal area very narrow in front of glabella. Fixed cheek gently convex; width, exclusive of palpebral lobe, about three-tenths basal glabellar width. Palpebral lobe slender, arcuate; length about one-third sagittal glabellar length, exclusive of occipital ring; anterior end distinctly separated from glabella by short ocular ridge. Line tangent to posterior ends of palpebral lobes passes across glabella posterior to junction of posterior glabellar furrows and axial furrow. Posterior limb long, slender, tapered to point; transverse length distinctly greater than basal glabellar width.

Course of anterior section of facial suture divergent forward from palpebral lobe to anterior margin. Course of posterior section of facial suture strongly divergent behind palpebral lobe, subparallel to posterior margin for most of length of posterior limb, curved strongly backward distally.

Pygidium semielliptical to subtriangular. Axis short, broad, has one or two ring furrows posterior to articulating furrow. Pleural regions lack well-defined border. Two or three pleural furrows and one or two interpleural furrows extend obliquely across pleural regions but do not reach pygidial margin.

Discussion.—Rasetti (1948b) included *Bathyuriscus* (*Poliella*) *probus* (Walcott) in his new genus *Bathyuriscidella* without apparently being aware that Kobayashi (1942b) had made this species the type of *Athabaskiella*. Poulsen (1959), however, recognized both genera and noted that the presence of a narrow frontal area distinguished *Athabaskiella* from *Bathyuriscidella*. Rasetti had compared *probus* with *Bathyuriscidella longicauda* Rasetti, which he considered an atypical species of the genus because of its narrow frontal area, more posteriorly placed palpebral lobes, and relatively short pygidial axis. A species having most of these characteristics is also present in the Alaskan collections. Thus several species share

these characteristics and are here assigned to *Athabaskiella* and considered to be generically distinct from *Bathyuriscidella*. The generic description is based on examination of all available specimens of *A. probus* (Walcott) and *A. ardis* n. sp. and of Rasetti's excellent illustrations of *A. longicauda* (Rasetti).

Athabaskiella ardis n. sp.

Plate 6, figure 9

Description.—Pygidium triangular; anterolateral corners strongly rounded; sides slightly concave; posterior margin produced into long tapered median spine that has low median keel. Axis convex; sides subparallel, defined by abrupt change in slope of pygidial surface. Two shallow ring furrows present posterior to articulating furrow. Pleural regions gently convex. Two pairs of pleural and interpleural furrows outline posterior bands of two segments. These bands narrower than anterior bands, tapered laterally and curved distally so that ends, before merging with lateral part of pygidium, are subparallel to axis.

External surface smooth except for obscure fine granular ornamentation on tops of axial rings.

Discussion.—Fragmentary cranidia associated with the pygidia described above conform in all observable characteristics with cranidia of *Athabaskiella probus* (Walcott). None of them show the size and position of the palpebral lobes, however, and all are too incomplete for illustration. The pygidia have a short axial lobe comparable in structure to other species of *Athabaskiella*, but they are easily distinguished by the presence of a long median marginal spine.

Occurrence.—Middle Cambrian–2 fauna. Moderately common (3 cranidia, 3 pygidia), USGS colln. 4337–CO, Yukon River (Adams Peak) area.

Genus BATHYURISCIDELLA Rasetti

Bathyuriscidella Rasetti, 1948b, p. 322; Poulsen, 1959, p. 222.

Type species.—*Bathyuriscidella socialis* Rasetti, 1948b, p. 322, pl. 47, figs. 1–12.

Discussion.—Rasetti has given a full description of *Bathyuriscidella*, to which the Alaskan specimen adds no new information.

Bathyuriscidella socialis Rasetti

Plate 6, figure 8

Bathyuriscidella socialis Rasetti, 1948b, p. 322, pl. 47, figs. 1–12.

Description.—Pygidium subsemicircular. Axis broad, convex, reaches to inner edge of narrow border; short postaxial ridge continues to posterior margin. Two ring furrows present posterior to articulating furrow, most deeply impressed at sides of axis. Pleural regions gently convex, triangular. Pleural field crossed by two pleural furrows and one or two interpleural furrows of about equal depth. Posterior band of first pleural segment noticeably tapered distally. Border flat, tapered towards axial line; greatest width slightly more than one-third width of pleural field. Short anterolateral border spines present. External surface obscurely granular.

Discussion.—This pygidium has the outline, anterolateral spine, number of axial furrows, and pattern of pleural furrows of *Bathyuriscidella socialis* Rasetti from Quebec. Although Rasetti states that the surface of *B. socialis* is smooth, I examined paratypes from Boulder 33 at Grosses Roches, Quebec, and found that they have an obscure granular ornamentation when whitened. Thus there are no reliable means of distinguishing the Alaskan specimen from the Quebec specimens, and they are here considered to be conspecific.

Occurrence.—Middle Cambrian–2 fauna. Rare (1 pygidium), USGS colln. 4344–CO, Hillard Peak area.

Genus BATHYURISCUS Meek

Bathyuriscus Meek, 1873, p. 484; Walcott, 1886, p. 215; Walcott, 1916, p. 330–334; Resser, 1935, p. 13; Kobayashi, 1942a, p. 155; Kobayashi, 1942b, p. 471; Lake, 1934, p. 186; Shimer and Schrock, 1944, p. 607; Poulsen, 1959, p. 224; Robison, 1964a, p. 534.

Orria Walcott, 1916, p. 379; Kobayashi, 1942a, p. 172; Kobayashi, 1942b, p. 473; Shimer and Schrock, 1944, p. 613; Poulsen, 1959, p. 224.

Orriella Rasetti, 1948b, p. 329; Poulsen, 1959, p. 225.

Type species.—*Bathyurus? haydeni* Meek, 1873, p. 484.

Discussion.—Robison (1964a, p. 534) has recently reviewed the content and concept of *Bathyuriscus* and described it fully. The Alaskan specimens described below conform in all respects to this description.

Bathyuriscus punctatus n. sp.

Plate 6, figures 3, 4

Description.—Cranidium subtrapezoidal in outline, gently to moderately convex transversely and longitudinally. Glabella long, slender posteriorly, expanded evenly forward, extended nearly to anterior margin of cranidium. Glabellar furows shallow, barely apparent. Occipital furrow shallow, straight. Occipital ring nearly flat, lacks distinct median node or spine. Frontal area barely present in front of glabella; lateral parts narrow transversely; width less than one-eighth width of anterior end of glabella. Fixed cheek gently convex, very slightly downsloping; width about three-fifths basal glabellar width. Palpebral lobe gently curved, moderately well defined by shallow palpebral furrow; anterior end of palpebral furrow touches axial furrow just posterior to moderately deep fossula. Length of

palpebral lobe about one-half sagittal glabellar length, exclusive of occipital ring. Posterior limb long, slender, slightly backswept; length nearly 1½ times basal glabellar width. Posterior border furrow shallow, crosses posterior limb diagonally. External surfaces of all parts covered with fine pits barely apparent even after whitening.

Pygidium semicircular, anterior width about twice sagittal length; margin evenly curved, marginal spines absent. Axis slender, convex, reaches to inner edge of narrow border. Width of axis slightly less than one-fourth anterior pygidial width. Four ring furrows present posterior to articulating furrow. Axial rings lack axial nodes. Pleural fields gently convex, crossed by five moderately broad pleural furrows and four narrower interpleural furrows that reach to inner edge of border. External surfaces of all parts covered with shallow pits barely apparent even after whitening.

Discussion.—*Bathyuriscus punctatus* n. sp. is most like *B. haydeni* (Meek) from medial Middle Cambrian limestone beds in Montana. It differs by having an obscurely pitted rather than fine granular ornamentation and by lacking a distinct occipital node. The relatively small number of pygidial segments and the lack of anterolateral pygidial spines distinguish *B. punctatus* from all other species assigned to the genus. Walcott's statement (1916, p. 342) that *B. haydeni* has axial nodes on the pygidium is incorrect. The artist who retouched the photograph for illustration (Walcott, 1916, pl. 46, fig. 2) accentuated imperfections on the illustrated specimen.

The relatively long palpebral lobes of the Alaskan species probably are not a valid specific character. Although Robison (1964a, p. 534) stated in the generic description of *Bathyuriscus* that the palpebral lobes are one-third of the cranidial length, a growth series of *B. formosus* Deiss (=*B. haydeni*) from USNM locality 19z, Nixon Gulch, Mont., shows that the length of the palpebral lobe decreases relative to the glabellar and cranidial length as the size of the cranidium increases. Small cranidia, comparable in size to the Alaskan specimen, also have palpebral lobes about one-half the length of the glabella, exclusive of the occipital ring, whereas larger cranidia have palpebral lobes more nearly one-third of the glabellar length.

Occurrence.—Middle Cambrian–1 fauna. Rare (1 cranidium, 1 pygidium), USGS colln. 4341–CO, Hillard Peak area.

Genus HEMIRHODON Raymond

Hemirhodon Raymond, 1937, p. 1104; Kobayashi, 1942a, p. 173; Kobayashi, 1942b, p. 473; Rasetti, 1946, p. 452; Poulsen, 1959, p. 224; Robison, 1964a, p. 536.

Type species.—*Hemirhodon schucherti* Raymond, 1937, p. 1104, pl. 2, figs. 12, 13.

Discussion.—Poulsen (1959, p. 224) has presented an adequate diagnosis of *Hemirhodon*. The relatively large anteriorly expanded glabella that reaches to the cranidial margin and the small palpebral lobes characterize cranidia of *Hemirhodon*. Pygidia seem to be characterized by lack of a clearly defined border and by pleural and interpleural furrows of about equal depth that extend nearly to the pygidial margin.

Hemirhodon spp.

Plate 6, figures 5–7

Discussion.—Several small incomplete cranidia in one collection have a strongly expanded glabella that reaches to the cranidial margin, and small palpebral lobes. Associated larger pygidia have three pairs of pleural and interpleural furrows that are about equally deep and that reach nearly to the pygidial margin. The depth of the furrows is shallowest on the largest pygidium and therefore this depth may be inversely related to size during holaspid development. The characteristics of both the cranidia and pygidia are those of *Hemirhodon*. The specimens are too incomplete, however, for adequate comparison with other species of the genus, although the pygidia are most similar to those of *Hemirhodon amplipyge* Robison (1964a, p. 536) in shape and in distribution of furrows on the pleural region.

A second collection has one small pygidium possibly referable to *Hemirhodon* that is characterized by six evenly spaced deep pleural and interpleural furrows that extend nearly to the pygidial margin. The furrows on the pleural region are deeper and more evenly spaced than those on the pygidia described above, but the specimen is also only about one-half the size of the smallest known pygidium in that collection. The differences between this specimen and the larger pygidia may be due principally to the suggested change in depth of furrows during holaspid development.

Occurrence.—Middle Cambrian–2 fauna. Moderately common (3 cranidia, 5 pygidia), USGS colln. 4337–CO, Yukon River (Adams Peak) area. Rare (1 pygidium), USGS colln. 4344–CO, Hillard Peak area.

Dolichometopid, genus and species undetermined

Plate 4, figure 16

Discussion.—Resser (in Mertie, 1933, p. 398) listed a new species *Albertella merteii* from Mertie's collection 25AMt148 (4424–CO of this report), but this trilobite was never described or figured, and the name is a nomen nudum. I have relocated all the material

from Mertie's collection in the U.S. National Museum; there is only one trilobite to which Resser could have applied the name *Albertella merteii*. This trilobite is represented by several cranidia that have a long glabella reaching to the anterior cranidial margin, small lateral parts to the frontal area, long palpebral lobes, and slender posterior limbs. This cranidium is typical of trilobites of the Dolichometopidae and not of the Zacanthoididae to which *Albertella* presently belongs. The associated trilobites are characteristic late Middle Cambrian forms of the lower *Bolaspidella* zone rather than the early Middle Cambrian *Albertella* zone. Furthermore, I have not found any pygidia resembling those of *Albertella* in Mertie's collection. Trilobites of the Dolichometopidae cannot be certainly identified even generically without knowledge of their pygidia. Resser's generic identification is therefore probably incorrect, and the cranidia to which he applied the name *Albertella merteii* are not adequate for naming. The best specimen is illustrated here to show the material on which Resser's identification was based.

Occurrence.—Middle Cambrian–1 fauna. Moderately rare (3 cranidia), USGS colln. 4424–CO, Yukon River (Adams Peak) area.

Family DORYPYGIDAE Kobayashi

Genus BONNIA Walcott

Corynexochus (Bonnia) Walcott, 1916, p. 325.

Bonnia Walcott. Raymond, 1928, p. 309; Resser, 1936, p. 6; Resser, 1937a, p. 44; Lermontova, 1940, p. 142; Lochman, 1947, p. 68; Rasetti, 1948a, p. 14; Lermontova, 1951, p. 118; Pokrovskaya, 1959, p. 135; Poulsen, 1959, p. 217; Suvorova, 1960a, p. 80; Egorova, 1961, p. 225; Palmer, 1964, p. 5.

Type species.—*Bathyurus parvulus* Billings, in Hitchcock and others, 1861, p. 953, fig. 361.

Discussion.—*Bonnia* has been described many times, and there is no longer much disagreement as to its included species. Rasetti (1948a) has presented the most complete discussion of the species from the type region in eastern Canada. *Bonnia tatondukensis* n. sp. described below, may be conspecific with one of these eastern Canadian species.

Bonnia tatondukensis n. sp.

Plate 3, figures 6, 7

Description.—Cranidium subquadrate, gently rounded anteriorly, moderately to strongly convex transversely and longitudinally. Glabella well defined by narrow axial furrows, moderately to strongly convex transversely and longitudinally, extended onto inner part of border. Glabellar furrows absent. Occipital furrows deep, straight. Occipital ring has short median spine. Border narrow, flat, separated from brim laterally by abrupt change in slope. Fixed cheek gently convex, downsloping; width about one-half basal glabellar width. Eye ridge barely apparent. Palpebral lobe gently curved, upsloping, separated from cheek by broad, shallow palpebral furrow; length about one-third sagittal glabellar length. Posterior limb moderately broad; transverse length of distal part slightly less than one-half length of limb. Border furrow deep, broad. Ornamentation of small cranidia (sagittal length < 2 mm) consists of strong concentric pattern of terrace lines on glabella and occipital ring, scattered fine granules on fixed cheeks and posterior limb, and transverse terrace lines on border. On larger cranidia, concentric terrace lines subdued and granules on cheeks and posterior limb merged into short irregular ridges increasing in abundance with size of specimen.

Course of anterior section of facial suture convergent forward in gentle curve from palpebral lobe to anterior margin. Course of posterior section straight, at 45° to axial line from palpebral lobe to border furrow, then curved strongly backward to posterior margin.

Free cheek, hypostone, and thoracic segments unknown.

Pygidium semicircular, gently to moderately convex transversely and longitudinally. Axis convex, tapered slightly posteriorly, connected to posterior border by short broad terminal ridge; anterior width slightly less than one-third anterior pygidial width. Three complete ring furrows present posterior to articulating furrow. Pleural field crossed by three shallow pleural furrows. Margin opposite ends of two anterior furrows has short slender spines; margin opposite end of posterior pleural furrow has incipient spine. Anterior pleural furrow continues to base of anterolateral border spine. Border furrow shallow, extends between ridge at end of axis and anterior pleural furrow. Ornamentation consists of low granules grading into irregular short ridges on tops of all convex areas and outer part of border; barely apparent on some specimens. Furrows and sides of axis smooth.

Discussion.—*Bonnia tatondukensis* n. sp. is characterized by the presence of an occipital spine, two pairs of short, slender anterolateral pygidial spines, and an incipient third pair of spines. Specimens that seem to be conspecific with *Bonnia tatondukensis* are present in USNM collection 2o, from a boulder in a conglomerate at Bic, Quebec. The pygidium of this species was figured by Walcott (1916, pl. 57, fig. 3a, USNM 62749) as a paratype of *Corynexochus* (now *Bonnia*) *brennus*.

I have examined the figured specimens of *B. brennus* and a large collection of unfigured specimens from USNM locality 2o. There are two species of *Bonnia* in the collection: one has no occipital spine, a single pair of anterolateral pygidial spines, and a generally well developed ornamentation of terrace lines; the other has an occipital spine, two pairs of pygidial spines and an incipient third pair, and an ornamentation that is variable but includes granules on the cranidium and pygidium. Specimens of the two species have not been found associated on the same piece of rock, so they may originally have come from separate boulders. The first species includes Walcott's designated type specimen and was subsequently redescribed by Rasetti (1948a, p. 16). However, Rasetti fails to mention the fact that Walcott's paratype pygidium, representing the second species in USNM collection 2o, does not agree with his redescription of the species. Thus the second species has never been recognized or described. The specimens from Bic and Alaska are not identical, but both samples show a moderate amount of variation. No previously described species of *Bonnia* has a pygidial structure comparable to *B. tatondukensis*.

Occurrence.—Early Cambrian–2 fauna. Moderately rare (6 mostly fragmentary cranidia, 3 pygidia), USGS colln. 4302–CO, Tatonduk River area.

Genus DORYPYGE Dames

Dorypyge Dames, 1883, p. 23; Matthew, 1897, p. 186; Gronwall, 1902, p. 126; Walcott, 1913, p. 107; Kobayashi, 1935b, p. 145; Lake, 1938, p. 250; Lermontova, 1940, p. 141; Resser, 1942a, p. 15; Whitehouse, 1945, p. 118; Poulsen, 1959, p. 217.

Type species.—*Dorypyge richtofeni* Dames, 1883, p. 24, pl. 1, figs. 1–6.

Discussion.—The characterization of the widespread Middle Cambrian genus *Dorypyge* given by Poulsen (1959) is adequate and needs to be modified only slightly to include the four-spined Alaskan and Siberian specimens, discussed below, that have been discovered since that date.

Dorypyge cf. D. olenekensis Lazarenko

Plate 4, figure 25

Dorypyge olenekensis Lazarenko, *in* Markovskiy, 1960, p. 218, pl. 50, fig. 4.

Description.—Pygidium semielliptical. Axis strongly convex, extends nearly to posterior pygidial margin. Three broad shallow ring furrows present posterior to articulating furrow; terminal unfurrowed part of axis moderately long. Pleural fields convex, crossed by three broad shallow pleural furrows that reach to inner edge of poorly defined border. Interpleural furrows indistinct or absent. Border has four pairs of spines; three anterior pairs short, sharp, subequal in length; posterior pair long, slender. External surfaces not distinctly ornamented.

Discussion.—A single incomplete pygidium has the general characteristics of the Dorypygidae. Its closest relationship seems to be with *Dorypyge*, which has a similar arrangement of one long pair of border spines and several short pairs. Pygidia of almost all species of *Dorypyge* have at least five pairs of border spines, and generally the fifth pair is considerably longer than the others. However, four species, (*D. bispinosa* Walcott, *D. danica* Gronwall, *D. grandispinosa* Resser and Endo, and *D. olenekensis* Lazarenko) have the fourth pair of spines long. *D. bispinosa* and *D. danica* also have the fifth pair of spines long, and *D. grandispinosa* has a short fifth pair of spines. *D. olenekensis*, from Siberia, is the only species having only four pairs of spines, of which the fourth is the longest. The anterior border spines on the Siberian species seem to be longer than those on the Alaskan specimen, and the pygidial outline is more nearly semicircular. More knowledge of other parts of the trilobite and of intraspecific variability is needed before the Alaskan species can be distinguished reliably from the Siberian species.

Occurrence.—Middle Cambrian–1 fauna. Rare (1 pygidium), USGS colln. 4303–CO, Tatonduk River area.

Genus KOOTENIA Walcott

Bathyuriscus (*Kootenia*) Walcott, 1889, p. 446.
Kootenia Walcott, 1925, p. 92; Kobayashi, 1935b, p. 156; Lermontova, 1940, p. 139; Shimer and Shrock, 1944, p. 613; Rasetti, 1948b, p. 332; Thorslund, 1949, p. 4; Lermontova, 1951, p. 122; Palmer, 1954a, p. 64; Hupé, 1955, p. 91; Ivshin, 1957, p. 37; Poulsen, 1959, p. 218; Suvorova, 1960a, p. 78; Chernysheva, 1961, p. 126; Lazarenko, 1962, p. 60.
Notasaphus Gregory, 1903, p. 155; Whitehouse, 1939, p. 241.

Type species.—*Bathyuriscus* (*Kootenia*) *dawsoni* Walcott, 1889, p. 446.

Diagnosis.—Cranidium has long moderately broad unfurrowed anteriorly expanded glabella that reaches onto border. Fixed cheeks convex, slightly downsloping. Palpebral lobes small, situated opposite middle third of glabella.

Pygidium has well-defined axis generally reaching to inner edge of moderately well defined border. Three to five ring furrows present. Pleural fields crossed by three to five generally deep pleural furrows; interpleural furrows barely apparent or absent. Border has from five to seven pairs of spines, generally more or less evenly spaced along margin.

Discussion.—*Kootenia* is a widespread genus of the Dorypygidae that is characterized particularly by a

pygidium that has a spinose margin and that lacks well-defined interpleural furrows. At many localities, two or more strikingly different species of *Kootenia* may be associated. Lack of consistent pairing or grouping of species indicates that these differences are probably not the result of dimorphism or polymorphism, nor do they seem to represent extreme intraspecific variability. Perhaps the development of the pygidial spines, which is the principal characteristic used for discrimination of species, is particularly susceptible to minor ecologic differences.

Kootenia granulospinosa n. sp.

Plate 4, figures 22–24

Description.—Cranidium subquadrate, moderately convex transversely and longitudinally. Glabella long, moderately broad, unfurrowed, expanded slightly forward, evenly rounded at front, extended onto border and nearly to anterior cranidial margin, well defined by narrow axial furrows. Occipital furrow deep, straight. Occipital ring has short axial spine at posterior margin. Cranidial border very narrow in front of glabella, slightly wider in front of fixed cheeks. Fixed cheek moderately convex, downsloping; width about one-half basal glabellar width. Palpebral lobe distinct, depressed below surface of cheek; length about one-third sagittal length of glabella, exclusive of occipital ring. Transverse length of posterior limb about equal to basal glabellar width. Posterior border furrow moderately deep. External surfaces of all parts except occipital ring smooth. Occipital ring and axial spine have granular ornamentation.

Course of anterior section of facial suture slightly convergent forward in gentle curve from palpebral lobe to anterior cranidial margin. Course of posterior section divergent in broad curve from palpebral lobe to posterior cranidial margin.

Pygidium semicircular. Axis well defined, convex, reaches to inner edge of border; three complete ring furrows present posterior to articulating furrow. Pleural fields crossed by three distinct pleural furrows. Exfoliated specimens show one additional shallow ring furrow and pleural furrow. Border nearly flat, moderately well defined, has six pairs of short slender border spines; length of spines nearly uniform, equal to about one-half width of axis. Distance between posterior pair of border spines slightly greater than distance between other spines. Surfaces of all parts except border spines smooth; border spines have granular ornamentation.

Discussion.—The granular ornamentation of only the occipital ring, occipital spine, and the pygidial border spines distinguishes *Kootenia granulospinosa* n. sp. from other similar species in *Kootenia*. Pygidia described below as *Kootenia* sp. 1 are closely similar in form to *K. granulospinosa*, but the notches between the border spines are narrower, the gap between the last pair of spines is not noticeably greater than between other spines, and the entire pygidial surface is granular.

Occurrence.—Middle Cambrian–1 fauna. Moderately common (7 cranidia, 6 pygidia), USGS colln. 4424–CO, Yukon River (Adams Peak) area.

Kootenia cf. K. serrata (Meek)

Plate 4, figure 21

Bathyurus serratus Meek, 1873, p. 480.
Kootenia serrata Resser, 1937b, p. 16.

Description.—Pygidium semicircular. Axis convex, reaches to inner edge of border; three ring furrows present posterior to articulating furrow; exfoliated specimens have narrow postaxial ridge extending to posterior margin. Pleural fields crossed by three pleural furrows; exfoliated specimens have one additional shallow furrow near end of axis; anterior pleural furrow continues to pygidial margin. Border moderately well defined, has six pairs of short broad slightly hooked border spines; length of spines approximately uniform, less than width of border. Surfaces of spines and at least parts of pleural fields covered with granules; ornamentation of remaining surfaces not known.

Discussion.—The Alaskan specimens have virtually the same form as pygidia of *Kootenia serrata* (Meek). However, without associated cranidia or a knowledge of the ornamentation of *K. serrata*, specific identity cannot be certainly determined. Rasetti (1948b) described *K. parallela* which has a pygidium nearly indistinguishable from *K. serrata* but a different cranidium. Pygidia of Rasetti's species lack distinct ornamentation. Thus, the Alaskan specimens can be distinguished from *K. parallela* but not certainly from *K. serrata*.

Occurrence.—Middle Cambrian–1 fauna. Rare (2 pygidia), USGS colln. 4424–CO, Yukon River (Adams Peak) area; ? 1 pygidium, USGS colln. 4348–CO, Yukon River (West Ridge) area; 2 pygidia USGS colln. 4382–CO, Hard Luck Creek area.

Kootenia sp. 1

Plate 4, figures 14, 15

Description.—Pygidium semicircular. Axis convex, reaches nearly to inner edge of border; three ring furrows present posterior to articulating furrow. Pleural fields crossed by three distinct pleural fur-

rows. Border moderately well defined, has six pairs of slender border spines; length of spines approximately uniform, equal to about one-half width of axis. All surfaces except furrows covered with low scattered granules.

Discussion.—Differences between pygidia of *Kootenia* sp. 1 and pygidia of superficially similar *K. granulospinosa* are discussed under that species. None of the other Alaskan species discovered so far have pygidia similar to those described above. Although the available material is not adequate for determining all the characteristics necessary for description of a new species, I can find no other *Kootenia* pygidia that seem to be identical with these Alaskan specimens.

Occurrence.—Early Cambrian–3 fauna. Moderately common (4 pygidia), USGS colln. 4333–CO; rare (1 pygidium), USGS colln. 4334–CO, about 20 feet stratigraphically below 4333–CO; Yukon River (West Ridge) area.

Family EDELSTEINASPIDAE Hupé

Genus POLLIAXIS n. gen.

Type species.—*Polliaxis inflata* n. sp.

Diagnosis.—Glabella large, slightly expanded anteriorly, extended onto anterior border; fixed cheeks narrow; palpebral lobes strongly arcuate; posterior limbs long, slender. Pygidium has slender axis; pleural regions sigmoid in profile; six well-defined axial and pleural segments; and interpleural furrows that extend nearly to pygidial margin.

Discussion.—The diagnosis cites the principal characteristics of probable generic importance that were observed on the type species. Cranidia, except for the long slender posterior limbs, have a general resemblance to cranidia of *Paradoxides*. However, the associated pygidia are relatively large and multisegmented, totally unlike pygidia of the Paradoxididae but comparable in all features with pygidia of *Edelsteinaspis* (Lermontova, 1940). The cranidia share many characteristics with *Edelsteinaspis* including long glabella that has a posterior transglabellar furrow and a relatively large unfurrowed anterior part, narrow fixed cheeks, and long slender posterior limbs. Thus, when all parts are considered, *Polliaxis* has its greatest affinities with *Edelsteinaspis*. It is here considered to be a member of the Edelsteinaspidae characterized by an anteriorly expanded and inflated glabella.

Polliaxis inflata n. sp.

Plate 1, figures 17–20

Description.—Cranidium, exclusive of posterior limbs, subquadrate. Glabella, large, moderately to strongly convex transversely and longitudinally, slightly expanded forward, well defined at sides by deep axial furrows, strongly rounded at front, extended onto border. Three pairs of glabellar furrows present on posterior two-thirds of glabella; anterior two pairs narrow, nearly straight, extended inward and slightly backward from axial furrows across about one-third of glabellar width; posterior pair connected across top of glabella. Occipital furrow narrow, slightly curved forward on axial line. Occipital ring narrow, convex; sagittal length about equal to sagittal length of posterior glabellar segment; median node present. Frontal area consists only of narrow border in front of glabella; border slightly wider laterally; exsagittal length of border only slightly less than exsagittal length of downsloping brim. Border furrow broad, shallow, intersects axial furrow near anterior end of glabella. Fixed cheek narrow, upsloping; width, exclusive of palpebral lobe, about one-third basal glabellar width. Ocular ridge poorly defined, directed strongly posterolaterally, intersects axial furrow just anterior to first glabellar furrow. Palpebral lobe strongly curved, well defined by broad deep arcuate palpebral furrow; length about one-third sagittal glabellar length, exclusive of occipital ring. Posterior limb long, slender, directed at nearly right-angle to axis; posterior border furrow broad, deep; posterior border expanded slightly toward tip of limb.

Anterior section of facial suture slightly divergent forward from palpebral lobe to border furrow, then curved inward to intersect anterior margin near anterolateral cranidial corner. Posterior section divergent-sinuous.

Free cheek, thoracic segments and ventral structures not known.

Pygidium elongate, semiovate; posterior margin with slight median indentation. Axis narrow, strongly convex, elevated above pleural regions; crossed by six complete ring furrows posterior to articulating furrow; depth of furrows decreases slightly posteriorly; terminal section short; length of axis about three-fifths sagittal length of pygidium; width at anterior end slightly less than one-third greatest pygidial width. Pleural regions have sigmoid profile; inner and outer parts gently downsloping; middle part steeply downsloping. Six pleural segments outlined by narrow interpleural furrows that extend from axis nearly to pygidial margin; distal parts of anterior segment strongly curved posteriorly; angle between proximal part of each interpleural furrow and axis decreases posteriorly. Each segment has deep pleural furrow on inner half subparallel to adjacent interpleural furrows.

External surfaces of all convex parts thickly covered with coarse and medium-sized granules.

Discussion.—Although *Polliaxis inflata* n. sp. is relatively uncommon in the Early Cambrian–1 fauna, the association of cranidium and pygidium as parts of the same species is here considered to be reasonably certain for the following reasons: both are found in about equal numbers in the faunule, have similar external ornamentation, and have affinities to the respective parts of *Edelsteinaspis* (Lermontova, 1940, pl. 45, figs. 1a–e), a Siberian genus for which a complete individual is known. *Dinesus arcticus* n. sp. is the only trilobite in the Early Cambrian–1 fauna that does not have a pygidium assigned to it. However, it represents a genus known from complete individuals in Australia. Pygidia of *Dinesus* are small and have few segments, totally unlike the pygidium here assigned to *Polliaxis*.

Occurrence.—Early Cambrian–1 fauna. Moderately rare (6 cranidia, 6 pygidia), USGS colln. 4296–CO, Yukon River (Water Level) area.

Family OGYGOPSIDAE Rasetti

Genus OGYGOPSIS Walcott

Ogygopsis Walcott, 1889, p. 446; Walcott, 1916, p. 375; Raymond, 1912, p. 116; Shimer and Shrock, 1944, p. 613; Rasetti, 1951, p. 190; Rasetti, 1959, p. 219; Palmer, 1964, p. 6.
Taxioura Resser, 1939, p. 62; Shimer and Shrock, 1944, p. 617.

Type species.—*Ogygia klotzi* Rominger, 1887, p. 12, pl. 1, fig. 1.

Discussion.—I have recently presented a description of *Ogygopsis* and a review of the characteristics of all species known to that time (Palmer, 1964, p. 6, 7). The specimens described below provide no new information about the characteristics of the genus.

Ogygopsis antiqua n. sp.

Plate 3, figures 3, 4

Description.—Cranidium known only from a single incomplete specimen questionably assigned to the species. Glabella long; sides subparallel; anterior end strongly rounded, extends onto border. Border narrow, well defined by shallow border furrow. Exsagittal length of brim lateral to glabella about equal to exsagittal length of border. Eye ridges poorly defined. Fixed cheek gently convex, downsloping. Other morphologic details not preserved.

Glabella covered by irregular network of anastomosing terrace lines; fixed cheek has closely spaced fine granules; anterior part of border has transversely arranged subparallel terrace lines.

Pygidium semicircular in outline. Axis long, slender, tapered posteriorly, extended to border furrow. Six complete ring furrows present posterior to articulating furrow; seventh ring furrow incomplete. Pleural fields crossed by five deep pleural furrows. Shallow diagonal interpleural furrows barely apparent on all segments. Border narrow, posterior margin has slight median indentation. Anterior two or three segments of pygidium have short slender border spines.

Ornamentation consists of closely spaced anastomosing network of terrace lines on all parts.

Discussion.—The cranidium tentatively assigned to *Ogygopsis antiqua* n. sp. may be a specimen of the associated species of *Bonnia*. The ornamentation differs from the associated specimens assigned to *Bonnia*, which have a concentric arrangement of terrace lines on the glabella, by having a dense network of terrace lines of the glabella more similar to the ornamentation of the pleural regions of the *Ogygopsis* pygidia. However, the anterior end of the glabella extends onto the border, a characteristic more like *Bonnia* and not previously observed in *Ogygopsis*. Thus, the pygidium of *O. antiqua* presents all the diagnostic characteristics of this species. It differs from all others in the genus by having two or three pairs of short marginal spines and only six complete ring furrows on the axis. The small number of pleural furrows is characteristic of other Early Cambrian species of *Ogygopsis* and distinguishes them as a group from all known Middle Cambrian species, which have at least seven pleural furrows.

Occurrence.—Early Cambrian–2 fauna. Moderately rare (? 1 cranidium, 5 pygidia), USGS colln. 4302–CO, Tatonduk River area.

Family ZACANTHOIDIDAE Swinnerton

Genus ZACANTHOIDES Walcott

Embolimus Rominger, 1887, p. 15 [not *Embolemus* Westwood, 1833—Hymenoptera].
Zacanthoides Walcott, 1888, p. 165; Kobayashi, 1935b, p. 123; Shimer and Shrock, 1944, p. 619; Palmer, 1954a, p. 69; Rasetti, 1959, p. 227; Suvorova, 1960a, p. 77.

Type species.—*Embolimus spinosa* Rominger, 1887, p. 15, pl. 1, fig. 3.

Discussion.—The species described below conform in all characteristics to the description of *Zacanthoides* presented earlier (Palmer, 1954a).

Zacanthoides sp. 1

Plate 4, figures 18–20

Description.—Cranidium elongate, subquadrate. Glabella long, slender, slightly expanded forward, broadly rounded anteriorly, well defined at front and sides by abrupt change in slope of cranidial surface. Two pairs of short glabellar furrows present; posterior pair oblique. Occipital furrow straight, narrow. Occi-

pital ring broad, nearly flat. Frontal area short, flat, subequally divided on axial line into brim and border by barely apparent, gently curved border furrow; sagittal length of frontal area slightly more than one-eighth sagittal length of glabella, exclusive of occipital ring. Lateral parts of frontal area subtriangular. Fixed cheeks moderately broad, gently convex, horizontal; width slightly more than one-half basal glabellar width. Palpebral lobe long, slender, arcuate, raised above surface of cheek, well defined by shallow, narrow palpebral furrow; anterior end touches axial furrow; line tangent to posterior ends of palpebral lobes passes over anterior part of occipital ring. Form of posterior limb not known.

Course of anterior section of facial suture strongly divergent anterolaterally from palpebral lobe to border furrow, then strongly curved forward and inward to anterior margin. Course of posterior section of facial suture not known.

Free cheek subpentagonal; anterolateral margin gently curved and posterolateral margin nearly straight. Genal spine large, advanced; length unknown. Border moderately broad, gently convex; width slightly more than one-half anterior width of ocular platform. Lateral border furrow curved inward at base of genal spine and continuous with posterior border furrow.

Pygidium subelliptical. Axis moderately wide, convex, reaches nearly to posterior margin; width slightly more than one-fourth greatest width of pygidium. Two anterior ring furrows shallow, narrow, complete; one posterior ring furrow present only at sides of axis. Pleural regions gently convex, crossed by two or three broad shallow pleural furrows that do not reach pygidial margin. Posterior margin has four pairs of spines. Size and shape of anterior spine not known but probably larger than remaining spines. Three posterior spines short, sharp, of nearly equal length.

Surfaces of all parts obscurely covered with closely spaced fine granules. Rare scattered poorly defined coarse granules also present on fixed cheeks of cranidium and on axis and pleural regions of pygidium.

Discussion.—Although *Zacanthoides* sp. 1 is represented by a cranidium, free cheeks, and pygidium, all the parts are fragmentary and knowledge of the morphology of the species is inadequate for proper naming. Nevertheless, none of the described species for which all parts are known has the combination of characteristics observed on the Alaskan species.

Occurrence.—Early Cambrian–3 fauna. Moderately rare (1 cranidium, 2 free cheeks, 1 pygidium), USGS colln. 4333–CO; (?)rare (pygidial fragment), USGS colln. 4334–CO, about 20 feet stratigraphically below 4333–CO; Yukon River (West Ridge) area.

Zacanthoides sp. 2

Plate 4, figure 17

Description.—Cranidium, exclusive of posterior limbs, elongate, subquadrate, gently to moderately convex transversely and longitudinally. Glabella long, slender, gently to moderately convex transversely and longitudinally, expanded slightly forward, broadly rounded at front. Glabellar furrows barely apparent. Occipital furrow deep, straight. Occipital ring has strong posteriorly directed axial spine developed from posterior margin. Frontal area nearly flat; sagittal length less than one-fifth sagittal glabellar length, exclusive of occipital ring. Border convex, well defined by evenly curved border furrow that parallels anterior margin; sagittal length of border slightly more than sagittal length of brim. Brim has pair of poorly defined ridges extending anterolaterally from shallow fossulae at anterolateral corners of glabella. Fixed cheeks approximately horizontal; width, exclusive of palpebral lobe, slightly more than one-half basal glabellar width. Palpebral lobe long, arcuate, well defined by palpebral furrow; anterior end touches axial furrow; width slightly more than one-fourth width of interocular area of fixed cheek. Line tangent to posterior ends of palpebral lobes passes just posterior to occipital furrow. Form of posterior limb unknown. External surfaces of all parts smooth.

Course of anterior section of facial suture strongly divergent forward from palpebral lobe. Course of posterior section of facial suture unknown.

Discussion.—Without knowledge of at least the form of the pygidium, *Zacanthoides* sp. 2 cannot be adequately compared with other species of *Zacanthoides*. However, the cranidium differs from that of the other Alaskan species described above by having a well-defined border, narrower palpebral lobes, and a smooth rather than slightly granular surface.

Occurrence.—Middle Cambrian–1 fauna. Rare (1 cranidium), USGS colln. 4341–CO, Hillard Peak area.

Order PTYCHOPARIIDA Swinnerton

Family ALDONAIIDAE Hupé

Hupé (1952) originally proposed the Aldonaiinae as a subfamily of the Protolenidae and this proposal was followed by Henningsmoen (1959). Sdzuy (1961a) included *Aldonaia* in the Protolenidae and preferred not to recognize separate subfamily groupings. Pokrovskaya (1959) and Suvorova (1960a,b) have raised Hupé's taxon to family rank. Because the Russian paleontologists are working more closely with *Aldonaia* and related trilobites than Hupé,

Sdzuy, or Henningsmoen, their classification is followed here.

Genus ALDONAIA Lermontova

Aldonaia Lermontova, 1940, p. 133; Richter and Richter, 1948, p. 29; Lermontova, 1951, p. 144; Hupé, 1952, p. 157; Hupé, 1953, p. 96; Henningsmoen, 1959, p. 212; Pokrovskaya, 1959, p. 89; Suvorova, 1960a, p. 70; Suvorova, 1960b, p. 76; Sdzuy, 1961a, p. 572.

Type species.—*Aldonaia ornata* Lermontova, 1940, p. 133, pl. 37, figs. 2, 2a–e.

Discussion.—The content and concept of *Aldonaia* have been discussed most thoroughly by Pokrovskaya (1959) and Suvorova (1960b). Several Alaskan specimens have the wide flat fixed cheeks, subcylindrical glabella with slightly concave sides, posteriorly located palpebral lobes, and small slender posterior limbs that characterize species of *Aldonaia*. I sent photographs of the best specimen to Dr. N. P. Suvorova at the Paleontologic Institute of the Academy of Sciences, U.S.S.R., and she confirmed the generic identification.

Aldonaia alaskensis n. sp.

Plate 3, figure 15

Description.—Cranidium elongate, subquadrate, strongly rounded anteriorly. Glabella slender, semicylindrical; sides slightly concave; anterior end truncated. Three shallow pairs of furrows present, connected nearly straight across glabella on surface of mold, deepest at sides of glabella. Occipital furrow straight, deepest at sides of glabella. Occipital ring extended posteriorly into moderately large median spine. Frontal area long, concave; sagittal length about three-fifths sagittal glabellar length. Border narrow, upturned, of nearly constant width; sagittal length about two-fifths that of flat brim. Fixed cheeks broad, flat, upsloping; width about equal to basal glabellar width. Palpebral lobes long, elevated, situated opposite posterior third of glabella; length about one-half sagittal glabellar length. Eye ridges low, posterolaterally directed, barely apparent. Distal part of posterior limb short, depressed; transverse length about one half length of proximal part. Border furrow broad, deep.

Course of anterior section of facial suture nearly straight forward from palpebral lobe to anterior cranidial margin. Course of posterior section of facial suture convex from palpebral lobe to posterior cranidial margin.

Other parts unknown.

Discussion.—*Aldonaia alaskensis* n. sp. differs from all described species of *Aldonaia* by having a subdued granular ornamentation and a moderately large occipital spine, and by lacking a deep narrow occipital furrow across the axial line. Dr. N. P. Suvorova has sent me a photograph of an undescribed Siberian species from the Sanashtykgol' horizon of the Botoma Stage that also lacks strong ornamentation and a distinct occipital furrow and that may have an occipital spine. The Siberian species differs from the Alaskan species by having strongly convex areas of the fixed cheek adjacent to the posterior end of the palpebral lobe and having eye lines that are less strongly directed posterolaterally.

Occurrence.—Early Cambrian–2 fauna. Moderately rare (3 cranidia), USGS colln. 4302–CO, Tatonduk River area.

Family CEDARIIDAE Raymond

Genus CEDARIA Walcott

Cedaria Walcott, 1924b, p. 55; Walcott, 1925, p. 78; Shimer and Shrock, 1944, p. 621; Palmer, 1954b, p. 726; Lochman, 1959, p. 301; Palmer, 1962, p. 24.

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

Discussion.—The characteristics of the fragmentary specimens described below conform in all respects to those described for *Cedaria* (Palmer, 1962, p. 24).

Cedaria sp.

Plate 6, figures 24, 25

Description.—Glabella unfurrowed, tapered forward, strongly rounded at front, well defined by shallow narrow axial and preglabellar furrows. Frontal area moderately long; sagittal length about three-fifths sagittal length of glabella exclusive of occipital ring. Border gently convex anteriorly, turned down steeply on inner edge into narrow furrow that is evenly curved and contains a row of pits, each of which has a tiny central granule. Sagittal length of border about one-half sagittal length of nearly flat brim. Fixed cheek narrow; width exclusive of palpebral lobe slightly more than one-fourth basal glabellar width. Course of anterior section of facial suture strongly divergent forward. External surfaces of all parts smooth.

Pygidium semicircular. Axis slender, tapered posteriorly, not quite reaching to inner edge of narrow, gently convex border of nearly constant breadth. Narrow postaxial ridge extends to inner edge of border. Pleural fields gently convex, crossed by five shallow narrow nearly straight pleural furrows.

Discussion.—This species of *Cedaria* is represented by imperfect specimens that do not have preserved the occipital ring, posterior limb, palpebral lobe, pygidial axis, or external pygidial surface. Neverthe-

less, they have the characteristic narrow pygidial border of species of the geographically widespread *Cedaria prolifica* group (Palmer, 1962, p. 26). The narrow cranidial border may prove to be a distinctive specific characteristic when more and better material of this species is discovered. In addition to the specimens described above, scraps that seem referable to *Cedaria* are associated with *Hypagnostus* sp. (p. B31) in collection 4326–CO from the upper part of the Tatonduk River section. Collections 4326–CO and 4372–CO, from which the described *Cedaria* specimens were obtained, have very similar faunas of undescribed inarticulate brachiopods. *Cedaria* has not yet been reported from rocks older than Late Cambrian and these collections are therefore here recognized as the earliest Late Cambrian collections from Alaska.

Occurrence.—Dresbachian–1 fauna. Rare (1 cranidium, 1 pygidium), USGS colln. 4376–CO, Hard Luck Creek area. Rare (scraps of 1 cranidium, 1 pygidium), USGS colln. 4326–CO, Tatonduk River area.

Family CERATOPYGIDAE Raymond

Genus IWAYASPIS Kobayashi

Iwayaspis Kobayashi, 1962, p. 122.

Discussion.—Kobayashi has diagnosed *Iwayaspis* as "Similar to *Proceratopyge* but possesses no spine on pygidium." In the collection with *Proceratopyge* (*Lopnorites*) *rectispinatus* are several pygidia and a headless individual with nine thoracic segments that conform in all observable aspects to the characteristics of *Iwayaspis*. The assignment of these specimens to the Ceratopygidae is supported by the structure of the first pygidial segment which is larger than the more posterior segments and has its posterior margin defined by an interpleural furrow that extends nearly to the pygidial border.

Kobayashi assigned this genus to a new subfamily, the Iwayaspidinae, having the same characteristics as the type genus. Such a monotypic taxon has little meaning, and no supergeneric assignment below family is used here.

Iwayaspis cf. I. asaphoides Kobayashi

Plate 10, figures 9, 10

Iwayaspis asaphoides Kobayashi, 1962, p. 122, pl. 6, figs. 1–10.

Description.—Thorax composed of nine segments. Pleural tips of each segment have short curved spine. Pleural furrows shallow near axis, increase in depth to geniculation which lies two-thirds the width of pleural region from axial furrow.

Pygidium semicircular, posterior margin evenly rounded. Axis slender, long, tapered, extended onto inner edge of moderately narrow concave border. Six or seven shallow ring furrows present posterior to articulating furrow. Pleural regions gently to moderately convex. First pleural segment larger than more posterior segments, expanded distally. Interpleural furrow between first and second pleural segments extends nearly to pygidial margin. Shallow pleural and interpleural furrows indicating two or three additional pleural segments extend across pleural field but not onto border. Border furrow shallow, interrupted by end of axis. External surface smooth.

Discussion.—Several pygidia having the characteristics described above seem to be at least congeneric and possibly conspecific with *Iwayaspis asaphoides* Kobayashi, the only species presently known in *Iwayaspis*. Without knowledge of the associated cranidium, a more exact identification cannot be attempted.

Occurrence.—Franconian–1 fauna. Moderately rare (1 thorax and pygidium, 4 pygidia), GSC colln. 4638 (= 4727), Hillard Peak area.

Genus PROCERATOPYGE Wallerius

Proceratopyge Wallerius, 1895, p. 56; Westergård, 1922, p. 120; Troedsson, 1937, p. 33; Whitehouse, 1939, p. 245; Lermontova, 1940, p. 157; Westergård, 1947, p. 9; Kobayashi and Ichikawa, 1955, p. 68; Ivshin, 1956, p. 21; Poulsen, 1959, p. 364; Balashova, 1960, p. 103; Ivshin, 1962, p. 286; Kobayashi, 1962, p. 119; Öpik, 1963, p. 97.
Kogenium Kobayashi, 1935b, p. 273.
Lopnorites Troedsson, 1937, p. 34.

Type species.—*Proceratopyge conifrons* Wallerius, 1895, p. 57, pl. 1, fig. 6.

Discussion.—Westergård (1947) has given a satisfactory diagnosis of *Proceratopyge*. He does not mention the presence of an axial glabellar node, however, which seems to be characteristic of most species of the genus, as noted by Ivshin (1956, p. 22). In the Alaskan sample, the glabellar node is most apparent on small specimens. It is very small and can easily be overlooked on large specimens. This node is an important morphologic feature and not just casual external ornamentation, so all species of *Proceratopyge* probably should have such a node. In addition to the glabellar node, *Proceratopyge* is characterized by a subparallel-sided or slightly conical generally poorly furrowed glabella; flat poorly defined palpebral lobes; nine thoracic segments; and a pair of large posteriorly directed spines clearly developed from the pleural part of the first segment of the pygidium.

Lopnorites (Troedsson, 1937) was considered by Westergård (1947) to be a synonym of *Proceratopyge*, and Kobayashi and Ichikawa (1955) placed *Kogenium* (Kobayashi, 1935b) also in the synonymy of *Proceratopyge*. Kobayashi and Ichikawa considered both

Lopnorites and *Kogenium* to be subgenera of *Proceratopyge*. *Kogenium* was characterized by its long pygidium, and *Lopnorites* was characterized by its subparallel-sided glabella. Öpik (1963) criticized the subgeneric criteria of Kobayashi and Ichikawa and suggested that the subgenus *Lopnorites* could be characterized better by pygidia that have six or more axial rings in contrast to pygidia of *Proceratopyge* that have five rings or less.

Two distinct species assignable to *Proceratopyge* are associated in one Alaskan collection. One has relatively small anteriorly placed palpebral lobes and therefore exsagittally long posterior limbs. The other has large arcuate medially located palpebral lobes and relatively narrow straplike posterior limbs; it also has a well-defined plectrum. The first cranidium cannot be objectively distinguished from the cranidium of *Lopnorites rectispinatus* Troedsson, the type species of *Lopnorites*. The second cannot be objectively distinguished from the cranidium of *Proceratopyge* (*Lopnorites*) *chuhsiensis* Lu (1965b, pl. 1) and from the cranidium of an Australian species compared with *P. chuhsiensis* by Öpik (1963, p. 99). The two Alaskan species represent extremes in cranidial characteristics of species included in *Proceratopyge*. If the genus is to have meaningful subgenera, it is unlikely that both species will represent the same subgenus—the situation that exists now. Thus, none of the criteria currently suggested for subgeneric division of *Proceratopyge* seem to be satisfactory. If *Lopnorites* is to remain as a viable taxon, the Alaskan species identified below as *P.* (*L.*) *rectispinatus* will certainly belong to it. The other species may represent the typical subgenus, or yet another subgeneric taxon. It is certainly a species of *Proceratopyge* as now defined, but because of uncertainty of the value of current subgeneric concepts, it is identified below only as *P.* cf. *P. chuhsiensis* Lu.

Proceratopyge (Lopnorites) rectispinatus (Troedsson)

Plate 10, figures 1–6

Lopnorites rectispinatus Troedsson, 1937, p. 35, pl. 2, figs. 1–2.
Proceratopyge (*Lopnorites*) *rectispinatus* (Troedsson). Lu, 1957, p. 281, pl. 145, figs. 10, 11; Kobayashi, 1962, p. 120, pl. 6, figs. 11, 12.

Description.—Cranidium subtrapezoidal, anterior margin gently rounded. Glabella large, low, gently convex transversely and longitudinally, tapered slightly forward, bluntly rounded at front, well defined at sides and front by abrupt changes in slope of exoskeleton surface. Median glabellar node situated posterior to line connecting posterior tips of palpebral lobes. Occipital furrow shallow. Occipital ring simple. Frontal area short, sagittal length variable between one-fourth and three-eighths sagittal length of glabella, exclusive of occipital ring. Border slightly unsloping, poorly defined only by change in slope of frontal area; sagittal length equal to or less than sagittal length of brim. Fixed cheek narrow, nearly flat; width, including palperbral lobe about two-fifths basal glabellar width. Palpebral lobe short, poorly defined, connected to glabella by low barely apparent ocular ridge; situated opposite anterior third of glabella; exsagittal length variable, from slightly more to slightly less than one-third sagittal glabellar length, exclusive of occipital ring. Posterior limb large; exsagittal length behind palpebral lobe greater than exsagittal length of palpebral lobe; transverse width slightly greater than basal glabellar width. Posterior border furrow broad, moderately deep, straight. External surface smooth.

Course of anterior section of facial suture slightly divergent forward from palpebral lobe, then curved broadly inward across border to intersect anterior margin between point directly anterior to anterolateral corners of glabella and axial line. Course of posterior section gently convex.

Free cheek certainly known only on holotype. Genal spine short, sharp; length about equal to length of posterior section of facial suture. Lateral and posterior border furrows moderately distinct, not joined at genal angle. Posterior border furrow continues short distance onto inner part of genal spine.

Thorax consists of nine simple segments that have short pointed tips. Pleural furrows increase in depth outward from axis to point of geniculation which is near tip of pleuron.

Pygidium semicircular. Axis narrow, elongate, evenly tapered, reaches onto inner part of border. Six or seven ring furrows present posterior to articulating furrow. Width of axis at anterior end about one-fifth anterior width of pygidium. Pleural regions gently convex. Anterior pleural segment well defined, expanded distally, continued into large long lateral spine that is directed straight backward. Interpleural furrow between first and second segments extended nearly to pygidial margin. Pleural furrow of first segment moderately deep, curved distally and extended for short distance onto anterolateral spine. Pleural field posterior to first segment has shallow pleural and interpleural furrows that indicate two or three additional segments. These furrows do not cross shallow border furrow. Border concave, narrow, slightly downsloping behind axis. Ornamentation subdued. Best preserved specimens have covering of very fine closely spaced granules barely visible in extreme

oblique light. Areas of muscle scars on each axial ring are smooth. In addition, scattered coarse granules are also barely apparently on the border and, on one specimen, in pairs on each axial ring. Well-defined terrace lines are present along the outer edge of the border and along the pygidial spine.

Discussion.—The Alaskan specimens described above agree in all observable details with the complete individual that is the holotype of *Lopnorites rectispinatus* Troedsson from eastern T'ien Shan, China. A replica of this specimen—cast from a latex mold made on my visit to the Riksmuseet in Stockholm, Sweden, in 1962—is illustrated here (pl. 10, fig. 1) to show some details that are not apparent in the published illustration. In the Alaskan collection, *Proceratopyge* (*Lopnorites*) *rectispinatus* is associated with *P.* cf. *P. chuhsiensis* Lu. *P. chuhsiensis* is represented by many cranidia, and at first the relatively common *Proceratopyge* pygidia were assigned to that species. However, the complete meraspid individual (p. 10, fig. 4) shows that a pygidium comparable to *P. rectispinatus* belongs to a trilobite having small palpebral lobes and large posterior limbs. Comparable sized meraspid cranidia of *P. chuhsiensis* (pl. 10, fig. 13) have large palpebral lobes and slender posterior limbs. Thus the characters of the palperbral lobe and posterior limb that separate the two associated species of *Proceratopyge* are recognizable even on immature specimens, and the common pygidia are here associated with relatively rare cranidia that have small anteriorly placed palpebral lobes and are assigned to *P. rectispinatus.* Only one fragmentary pygidium seems to belong with the relatively common cranidia of *P.* cf. *P. chuhsiensis.*

Occurrence.—Franconian–1 fauna. Moderately common (5 mature cranidia, 3 meraspid cranidia, 8 mature pygidia, 2 protopygidia), GSC colln. 4638 (= GSC 4727), Hillard Peak area.

Proceratopyge cf. P. chuhsiensis Lu

Plate 10, figures 11–14

Proceratopyge (*Lopnorites*) *chuhsiensis* Lu, 1956b, p. 280, pl. 1, figs. 1–6

Proceratoypge cf. *P. chuhsiensis* Lu. Öpik, 1963, p. 99, pl. 5, fig. AA, text fig. 37

Description.—Cranidium, exclusive of posterior limbs, elongate, subquadrate. Glabella long, low, unfurrowed; sides very slightly tapered forward; front bluntly rounded; well defined all around by abrupt changes in slope of exoskeleton. Occipital furrows very shallow on mature cranidia, present only across top of axis. Occipital ring simple. Axial glabellar node situated adjacent to posterior edge of line connecting posterior tips of palpebral lobes. Meraspid cranidia have deep occipital furrow and very prominent axial node. Frontal area moderately long, concave; sagittal length between four-tenths and one-half sagittal glabellar length, exclusive of occipital ring. Border furrow extends inward from facial suture in broad curve to anterolateral margin of glabella outlining broad low plectrum. Pair of shallow longitudinal furrows outline low narrow axial ridge on inner part of plectrum. Fixed cheeks horizontal. Palpebral lobe large, semicircular, not differentiated from inner part of cheek, situated opposite middle third of glabella. Width of fixed cheek including palpebral lobe variable from slightly more to slightly less than one-half basal glabellar width. Width of fixed cheek at anterior end of palpebral lobe about one-fifth basal glabellar width. Exsagittal length of palpebral lobe about two-fifths sagittal glabellar length, exclusive of occipital ring. Posterior limb slender; exsagittal length behind palpebral lobe about equal to exsagittal length of palpebral lobe. Posterior border furrow moderately deep, straight.

Pygidium semicircular. Axis moderately broad, tapered posteriorly, extended to inner edge of poorly defined narrow concave border. Four or five ring furrows present posterior to articulating furrow. Pleural regions gently convex. First pleural segment expanded distally and continued into posterolaterally directed spine. Interpleural furrow between first and second pleural segments extended nearly to pygidial margin. Shallow pleural and interpleural furrows of one or two additional segments present. External surfaces of all observed parts smooth.

Discussion.—The large crescentic palpebral lobes, slender posterior limbs, and well-developed plectrum seem to be the characteristics of *Proceratopyge* cf. *P. chuhsiensis* Lu. It is very closely related to, if not conspecific with, the species figured by Lu (1956b) from Anhwei, China, and by Öpik (1963) from Queensland, Australia. Lu's material is poorly preserved, and the presence of a plectrum cannot be determined. The number of pygidial segments on the Chinese specimen seems comparable to the Alaskan specimen. The single cranidium illustrated by Öpik seems to be identical with the Alaskan specimens. The pygidium of *P.* cf. *P. chuhsiensis* from Alaska differs from the associated pygidia of *P.* (*Lopnorites*) *rectispinatus* by having fewer axial and pleural segments.

Occurrence.—Franconian–1 fauna. Moderately common (10 mature cranidia, 3 meraspid cranidia, 1 pygidium), GSC colln. 4638 (= 4727), Hillard Peak area.

Genus YÜPINGIA Lu

Yüpingia Lu, 1956a, p. 377; Jaanusson, *in* Harrington and others, 1959, p. 350.

Type species.—*Yüpingia niobiformis* Lu, 1956a, p. 378, pl. 1, figs. 6–13.

Diagnosis.—Cranidium, including posterior limbs subtrapezoidal, anterior margin broadly rounded. Glabella large, unfurrowed, tapered slightly forward, bluntly rounded at front. Axial glabellar node present on line tangent to posterior ends of palpebral lobes. Occipital furrow barely apparent, frontal area short, concave; border poorly differentiated from brim. Fixed cheek consists almost entirely of large semicircular flap of palpebral lobe located opposite glabellar midlength. Posterior limb slender; transverse length slightly less than basal glabellar width.

Course of anterior section of facial suture convex outward in broad, nearly even curve from palpebral lobe to near axial line. Course of posterior section divergent and sinuous.

Free cheek narrow. Ocular platform triangular, narrow at anterior sutural margin. Genal spine short.

Pygidium semicircular. Axis moderately wide, convex, well defined, tapered to inner edge of border. Ring furrows shallow. Pleural regions have poorly defined pleural furrows on anterior part. Border narrower than anterior width of pleural field, poorly defined. Posterior margin evenly curved.

Discussion.—The large palpebral lobes, narrow fixed cheeks, short frontal area and simple, relatively unfurrowed and unspined pygidium distinguish *Yüpingia* Lu from other similar genera. The presence of an axial glabellar node and large palpebral lobes indicates affinity with the slightly older Alaskan species, *Proceratopyge* cf. *P. chuhsiensis* Lu (pl. 10 figs. 11–14). However, *P. chuhsiensis* has a distinct plectrum, slightly wider fixed cheeks, and anterolateral pygidial spines. *Iwayaspis* is a member of the Ceratopygidae that has pygidia lacking anterolateral spines, but the first pleural segment is well defined and the anterior interpleural furrow extends nearly to the pygidial margin. The palpebral lobes of *Iwayaspis* are also situated somewhat more anteriorly than those of *Yüpingia*, so the posterior limbs have a more triangular outline. Lu (1956a) and Jaanusson (1959) have included *Yüpingia* in the Asaphidae, but the subparallel-sided moderately well defined glabella and large crescentic palpebral lobe indicate to me a closer relationship to the Ceratopygidae. The glabellar tubercule seems to be an important morphologic feature of both the Ceratopygidae and Asaphidae, and the families are probably closely related.

Yüpingia glabra n. sp.

Plate 13, figures 9, 12–16

Description.—Cranidium, including posterior limbs, subtrapezoidal, moderately rounded anteriorly. Glabella large, low, unfurrowed, tapered slightly forward, bluntly rounded anteriorly, moderately well defined by changes in slope of exoskeleton. Low obscure axial glabellar node present on line tangent to posterior ends of palpebral lobes. Occipital furrow barely apparent. Occipital ring simple. Frontal area short, concave, barely differentiated into brim and border of subequal sagittal length. Sagittal length of frontal area variable between one-third and one-fourth sagittal glabellar length, including occipital ring. Fixed cheek narrow; palpebral lobe large, semicircular, nearly horizontal, not separated from inner part of cheek, situated opposite middle third of glabella. Width of cheek, including palpebral lobe, variable between one-half and one-third basal glabellar width, greatest on small specimens. Posterior limb slender, short; transverse length variable from subequal to basal glabellar width on small specimens to about three-fourths basal glabellar width on larger specimens.

Course of anterior section of facial suture divergent forward from palpebral lobe in broad, outwardly convex curve that continues across frontal area nearly to axial line. Course of posterior section strongly divergent and sinuous behind palpebral lobe.

Free cheek narrow, triangular. Lateral border poorly defined in anterior part by shallow border furrow; width about equal to anterior sutural width of ocular platform. Lateral margin of cheek moderately curved at anterior end, nearly straight posteriorly along margin of moderately short convex genal spine. Length of spine slightly more than one-half length of posterior sutural margin.

Pygidium subsemicircular. Axis well defined at sides by narrow axial furrows, convex, tapered posteriorly, poorly defined at end, reaches to inner edge of obscure border. Only first ring furrow barely apparent on axis. Pleural regions gently convex; only first pleural furrow moderately distinct; remaining area lacks distinct furrows. Border barely defined, downsloping; width less than greatest width of pleural platform. Posterior margin smoothly curved.

External surfaces of all parts smooth.

Discussion.—*Yüpingia glabra* n. sp. differs from the genotype and only other species in the genus, *Y. niobiformis* Lu, by having the glabellar tubercule poorly defined, fewer defined segments on the pygidium, and an evenly downsloping rather than concave pygidial border. Among the Alaskan species, the cranidium as-

signed to *Proceratopyge* cf. *P. chuhsiensis* Lu and the pygidium assigned to *Iwayaspis* cf. *I. asaphoides* Kobayashi, both from older beds, most nearly resemble the respective parts of *Y. glabra*. *P. chuhsiensis* has a distinct plectrum, however, and the pygidium of *I. asaphoides* has a distinctly defined anterior pleural segment.

Occurrence.—Franconian–2 fauna. Moderately common (7 cranidia, 1 free cheek, 10 pygidia), GSC colln. 4649 (=4704); rare (1 cranidium, 1 pygidium), GSC colln. 4661 (=4705); both from Hillard Peak area.

Family CHEILOCEPHALIDAE Shaw

Genus CHEILOCEPHALUS Berkey

Cheilocephalus Berkey, 1898, p. 289; Palmer, 1954b, p. 757; Lochman, 1959, p. 312; Palmer, 1965, p. 29.

Pseudolisania Kobayashi, 1935b, p. 162; Shimer and Shrock, 1944, p. 621.

Type species.—*Cheilocephalus st. croixensis* Berkey, 1898, p. 290, pl. 17, fig. 1; pl. 20, figs. 7, 8; pl. 21, fig. 19.

Discussion.—*Cheilocephalus* is represented by one distinctive species in the Alaskan fauna. It conforms in all characteristics to the descriptions or diagnoses that I have given earlier. In addition, the free cheek, which has not previously been reported for any species of *Cheilocephalus*, has been found in association with the Alaskan species. It is narrow transversely and has a short broad-based genal spine. The posterior section of the facial suture is intersected by the lateral border furrow. The free cheek demonstrates clearly, therefore, that *Cheilocephalus* is an opisthoparian trilobite with cedariiform facial sutures as suggested by Lochman (1959, p. 312) and not a proparian trilobite as suggested by Shaw (1956, p. 49).

Cheilocephalus expansus n. sp.

Plate 9, figures 1–7

Description.—Cranidium trapezoidal; anterior margin gently rounded. Glabella large, well defined, tapered forward, bluntly rounded anteriorly, extended onto inner part of nearly flat cranidial border. Glabellar furrows obscure. Occiptial furrow deep at sides of glabella, curved slightly forward near axial furrow, shallow and relatively broad across top of glabella. Occipital ring narrow, has small median node. Frontal area consists only of nearly flat border; sagittal length about one-seventh sagittal length of glabella, including occiptal ring. Fixed cheek narrow, gently to moderately convex, slightly downsloping, has well-defined eye ridge; width of cheek, exclusive of palpebral lobe, slightly less than one-third basal glabellar width. Palpebral lobe poorly defined, slightly upsloping, situated slightly anterior to glabellar midlength; exsagittal length slightly less than one-fourth sagittal length of glabella, including occipital ring. Posterior limb moderately broad; posterior border furrow deep near axial furrow, disappears laterally; posterior border has distinct "elbow" about two-fifths transverse length of limb from axial furrow.

External surfaces of all convex parts except areas of muscle scars covered with fine, moderately closely spaced granules. Anterior part of border has narrow zone of terrace lines.

Free cheek long, moderately narrow. Border wide anteriorly, constricted posteriorly at base of genal spine by distal part of posterior section of facial suture, poorly defined by shallow lateral border furrow that intersects posterior section of facial suture at about its midlength. Ocular platform narrow; width opposite eye less than one-fourth width of border. Genal spine short, broad based, pointed; length slightly less than one-half length of posterior section of facial suture. Surfaces of all parts covered with closely spaced fine granules.

Hypostome large. Anterior lobe of middle body convex, strongly rounded anteriorly, bluntly rounded posteriorly, separated from smaller, less convex posterior lobe by curved furrows that are indistinct on axial line. Anterior border narrow, nearly flat, curved sharply downward into short, sharp alae. Lateral border strongly expanded posterolaterally opposite midlength of hypostome. Posterior border broad, gently undulating. Maculae not apparent. Ornamentation consists of strongly developed terrace lines on anterior lobe of middle body and on posterior border. Posterior lobe of middle body and anterior border have closely spaced fine granules.

Pygidium semicircular. Axis well defined, tapered posteriorly, continued onto inner part of border. Six ring furrows present posterior to articulating furrow. Pleural region broad; width nearly twice greatest width of axis. Pleural field gently convex, separated from broad concave border by poorly defined shallow border furrow; width of border slightly greater than greatest width of pleural field. Anterior pleural furrow deep, continued nearly to lateral pygidial margin. Anterior band of first segment strongly expanded distally. Remaining pleural and interpleural furrows shallow, evenly spaced, continuing laterally onto inner part of border in anterior half of pygidium. Surfaces of all parts covered by closely spaced fine granules, most apparent on axis and outer part of border.

Discussion.—Meraspid cranidia of *Cheilocephalus expansus* n. sp. (pl. 9, fig. 6) have virtually the same cranidial outline as holaspid cranidia, but the glabella is distinctly more parallel sided. Small pygidia (pl. 9

fig. 7) have more clearly defined pleural and interpleural furrows than large pygidia, and nearly all the furrows extend a short distance onto the border. This species is most similar to *C. granulosus* (Palmer, 1965, p. 31, pl. 1 figs. 6–8) in all features except width of the pygidial border and perhaps in a slightly more posterior position of the palpebral lobes. The width of the pygidial border of *C. granulosus* is equal to or narrower than the width of the pleural field, whereas in the Alaskan species the border on both small and large pygidia is broader than the pleural field.

Fragmentary cranidia in GSC collections 4722 and 4728, Hillard Peak area, have the characteristic complete granular ornamentation of *Cheilocephalus expansus* and *C. granulosus*. Small associated pygidia have a relatively narrow border, and the specimens may therefore represent *C. granulosus*. The material is unsatisfactory for description or illustration.

Occurrence.—Dresbachian–2 fauna. Common (10 cranidia, 2 cheeks, 1 hypostome, 5 pygidia), USGS colln. 4361–CO, Jones Ridge area; 4 cranidia, 4 pygidia, GSC colln. 4719, Squaw Mountain.

Genus OLIGOMETOPUS Resser

Oligometopus Resser, 1936, p. 28; Palmer, 1960a, p. 100; Palmer, 1965, p. 31.
Bernicella Frederickson, 1949, p. 347.

Type species.—*Ptychoparia* (*Solenopleura*?) *breviceps* Walcott, 1884, p. 49, pl. 10, fig. 9.

Diagnosis.—Glabella broad, tapered, unfurrowed, strongly rounded at front, reaches to deep nearly straight anterior border furrow. Fixed cheeks wide, convex, slightly downsloping. Palpebral lobes situated opposite or slightly anterior to glabellar midlength.

Discussion.—I have recently described *Oligometopus* Resser and discussed its content. The Alaskan material conforms in all respects to the published description.

Oligometopus breviceps? (Walcott)

Plate 7, figures 30, 31

Ptychoparia (*Solenopleura*?) *breviceps* Walcott, 1884, p. 49, pl. 10, fig. 9.
Oligometopus breviceps (Walcott). Resser, 1936, p. 29; Palmer, 1960a, p. 100, pl. 10, figs. 19, 20; Palmer, 1965, p. 32, pl. 1, fig. 3.

Discussion.—Three cranidia from three different collections represent one or more species of *Oligometopus*. One of the cranidia, slightly more than 1 mm long, has a coarse granular external ornamentation and wide fixed cheeks that I have considered to be characteristic of *O. breviceps*. The other two cranidia are slightly larger and have the proportions of *O. breviceps*, but they are exfoliated. The external surfaces of these specimens are not known, but they have a coarsely pitted surface on the mold. Specimens of *O. breviceps* from Nevada also have a coarsely pitted surface on the cranidial mold. Thus, the Alaskan specimens may all represent *O. breviceps*. They are illustrated here primarily to record a significant increase in the known geographic range of this rare genus.

Occurrence.—Dresbachian–2 fauna. Rare (1 cranidium), USGS colln. 4360–CO; 1 cranidium, GSC colln. 4643; 1 cranidium, GSC colln. 4645; all from Hillard Peak area.

Family DIKELOCEPHALIDAE Miller

Genus BRISCOIA Walcott

Briscoia Walcott, 1924a, p. 37; Walcott, 1925, p. 74; Ulrich and Resser, 1930, p. 59; Kobayashi, 1935a, p. 50; Shimer and Shrock, 1944, p. 621; Lochman, 1959, p. 254; Suvorova, 1960a, p. 89.

Type species.—*Briscoia sinclairensis* Walcott, 1924a, p. 37, text fig. 9.

Discussion.—The current concept of the generic characters of *Briscoia* is summarized by Lochman (1959). Kobayashi (1935a) assigned to *Briscoia* the Alaskan species *B. septentrionalis*, *B. robusta*, and *B. mertiei*. At the same time he described a new genus *Parabriscoia* on the basis of pygidia assigned to *P. elegans* and *P. stenorachis*. All specimens of all five species came from a single collection made by Mertie along Harrington Creek in the Jones Ridge area. All this material has been reexamined in the course of the present study. The only additional Alaskan material of *Briscoia* consists of a few pygidial and cranidial fragments from approximately Mertie's locality collected by R. J. Ross in 1962 and a small collection from the Jones Ridge section made by L. D. Burling in 1913.

Most of the material of *Briscoia* in Mertie's collection was assigned by Kobayashi to *B. septentrionalis*. This includes 10 cranidia, three pygidia, and one free cheek. *B. robusta* is represented by a single broken pygidium that does not have its posterior margin preserved. *B. mertiei* is represented by a single cranidium and a free cheek. The characteristics that distinguish *B. mertiei* and *B. robusta* from *B. septentrionalis* are superficial, and I cannot agree that there is a valid reason for their specific separation. *B. mertiei* and *B. robusta* are therefore considered here to be synonyms of *B. septentrionalis*. For the same reasons, *Parabriscoia stenorhachis* is considered here to be a synonym of *P. elegans*.

The six pygidia assigned to *Parabriscoia elegans* are identical in every feature except for the presence of distinct border spines to the pygidia of *Briscoia*

septentrionalis. They are also remarkably similar in all features to pygidia from Nevada described by Kobayashi as *Parabriscoia dolichorachis*. Lochman (1956) has shown that the Nevada pygidia are the pygidia of *Elkia nasuta* Walcott, the type and only known species of *Elkia* (Walcott, 1924b). For this reason, Lochman placed *Parabriscoia* in synonomy with *Elkia*. In the Alaskan collection, however, there are only *Briscoia* cranidia, which differ strikingly from *Elkia* cranidia by having a narrow poorly defined border instead of a broad inflated triangular border. Furthermore, two of the three pygidia of *B. septentrionalis* have incipient border spines at the same positions as the well-developed border spines of *P. elegans*, the type species of *Parabriscoia* (pl. 15, figs. 6, 7). Thus it seems unlikely that the differences between the pygidia of *B. septentrionalis* and *P. elegans* are more than specific. I have not been able to demonstrate that pygidia of these two species are actually associated, and thus I cannot determine whether they came from slightly different limestone beds, or whether they might possibly represent an unusual kind of dimorphism. At the present time, therefore, *B. septentrionalis* and *P. elegans* are kept as separate but congeneric species and *P. elegans* is tentatively assigned to *Briscoia*. This solution to the generic relationships of the species is not totally satisfactory because *Briscoia* is generally considered to include only species with a nonspinose pygidium. However, because all the cranidia in the collection are fully characteristic of *Briscoia* and differ, by the presence of a narrow poorly defined border, from cranidia of either *Dikelocephalus* or *Elkia*, the only other possibly related genera, no other generic assignment except the possible resurrection of *Parabriscoia* seems reasonable. A reexamination of the generic groupings within the Dikelocephalinae is needed, but it must await more knowledge of the stratigraphic and geographic distribution of dikelocephaline species, most of which are rare and generally represented by fragmentary material in Upper Cambrian rocks.

Briscoia septentrionalis Kobayashi

Plate 15, figures 1–5

Briscoia septentrionalis Kobayashi, 1935a, p. 51, pl. 9, figs. 10–17.
Briscoia robusta Kobayashi, 1935a, p. 52, pl. 9, fig. 18.
Briscoia mertiei Kobayashi, 1935a, p. 53, pl. 10, figs. 6, 7.

Description.—Cranidium elongate, subquadrate, anterior margin broadly rounded, has very small downsloping median point. Glabella large, low, moderately convex transversely and longitudinally, tapered slightly forward, bluntly rounded at front, well defined by abrupt changes in slope of exoskeleton surface. Two pairs of glabellar furrows present; anterior pair very shallow, barely apparent; posterior pair deep at sides of glabella, connected across top by shallow transverse furrow. Occipital furrow deep at sides, shallow across axis. Occipital ring gently convex, simple. Frontal area moderately broad, concave; sagittal length slightly variable from one-half to slightly less than one-half sagittal length of glabella, exclusive of occipital ring. Border poorly defined by shallow border furrow; sagittal length slightly less than sagittal length of brim. Fixed cheek narrow, slightly upsloping; width, exclusive of palpebral lobe, variable from slightly more to slightly less than one-fifth basal glabellar width; greatest on smaller cranidia. Palpebral lobe large, arcuate, well defined by shallow palpebral furrow, situated opposite posterior third of glabella; exsagittal length about one-half sagittal length of glabella, exclusive of occipital ring. Posterior limb short, slender; transverse length distinctly less than basal glabellar width. Posterior border furrow moderately deep.

Course of anterior section of facial suture divergent forward from palpebral lobe to border furrow, then curved inward along anterior margin of cranidium to axial line. Ventral course not known. Course of posterior section of facial suture nearly at right angles to axial line behind palpebral lobe, curved abruptly backward to posterior cranidial margin at distal end of posterior limb.

Free cheek broad, triangular. Narrow lateral border poorly defined by shallow lateral border furrow that disappears near base of genal spine. Posterior border furrow moderately deep, parallels posterior margin of cheek, extends short distance onto slender genal spine.

Pygidium transversely elliptical. Axis convex, elevated above pleural regions, tapered slightly posteriorly, lacks well-defined end. Four distinct ring furrows present posterior to articulating furrow. Pleural regions broad, concave, lack separately defined border. Anterior pleural furrow broad, deep, continued nearly to pygidial margin. Interpleural furrows as deep as pleural furrows; pleural furrows of each segment close to anterior margin of segment, so pygidium has three or four pairs of closely spaced pleural and interpleural furrows that disappear towards lateral margin. Posterior pygidial margin faintly scalloped; has four pairs of incipient posterior projections on most specimens. Slight median indentation present.

External surfaces of all known parts smooth.

Discussion.—The asymmetrical position of the pleural furrows on the pygidium, which produces a narrow

anterior band and wide posterior band for each pygidial segment, distinguishes *Briscoia septentrionalis* Kobayashi from all other described species of *Briscoia*. A similar pattern of furrows is present on pygidia assigned to *Dikelocephalus inequalis* Ulrich and Resser, *Elkia nasuta* Walcott, and "*Briscoia*" *elegans* (Kobayashi). *E. nasuta and "B." elegans* each have well-developed pygidial border spines. *D. inequalis* does not have its posterior margin preserved and cannot be adequately compared with other species.

Occurrence.—Trempealeauan–1 fauna. Common (11 cranidia, 2 free cheeks, 4 pygidia), USNM colln. 25o (= Mertie collection 30AMt147); ?rare (fragments of 3 cranidia and 3 pygidia), USGS colln, 3835–CO; both from Jones Ridge area (south end), possibly same locality.

"Briscoia" elegans (Kobayashi)

Plate 15, figures 6, 7

Parabriscoia elegans Kobayashi, 1935a, p. 53, pl. 10, figs. 8–10.
Parabriscoia stenorachis Kobayashi, 1935a, p. 53, pl. 10, fig. 12.

Description.—Pygidium identical to *B. septentrionalis* except for posterior margin. Four pairs of marginal spines present. Three anterior pairs of comparable size, slender, moderately long, sharply pointed, evenly spaced. Posterior pair very short, sharp, situated directly lateral to third pair of spines and closer to spine than to axial line. Posterior margin between posterior pair of spines convex forward. External surfaces of all parts smooth.

Discussion.—"*Briscoia*" *elegans* (Kobayashi) differs from all described dikelocephalids in the pattern of the posterior marginal spines. If the pygidia are not considered in relation to other dikelocephalid parts, they would seem to be congeneric with the pygidium of *Elkia nasuta* Walcott which was described by Kobayashi (1935a) as *Parabriscoia dolichorachis*. However, all associated dikelocephalid parts in the collection are characteristic of *Briscoia*, and the associated pygidia of *B. septentrionalis* have incipient border spines in the same positions as the border spines of "*B.*" *elegans*. Therefore it is most probable that the two species are congeneric, or perhaps really only represent well-defined dimorphs of a single species. (See also generic discussion.)

Kobayashi's illustrations were improperly retouched to show the fourth marginal spine as moderately long and slender. I prepared the molds of his illustrated specimens with a vibro-tool, and the latex casts illustrated here show the correct appearance of the pygidial spines. The illustration of this species in Harrington and others (1959, figure 191–4c) is completely erroneous.

Occurrence.—Trempealeauan–1 fauna. Moderately common (6 pygidia), USNM loc. 25o (= Mertie colln. 30AMt147); 1 cranidium, 3 pygidia, GSC colln. 4671; both from Jones Ridge area.

Family DINESIDAE Lermontova

Genus DINESUS Etheridge

Dinesus Etheridge, 1896, p. 56; Gregory, 1903, p. 154; Chapman, 1917, p. 98; Kobayashi, 1935b, p. 132; Whitehouse, 1939, p. 228; Lermontova, 1951, p. 113; Lochman, 1959, p. 230; Ivshin, 1960, p. 124.

Type species.—*Dinesus ida* Etheridge, 1896, p. 56, pl. 1, figs. 1–4 only.

Diagnosis.—Cranidium subquadrate. Glabella long, subparallel sided. Preglabellar furrow tangent to border furrow. Single posterior glabellar furrow extends inward obliquely from axial line to occipital furrow outlining triangular posterior glabellar lobes. Pair of furrows extends anterolaterally from axial furrows near front of glabella outlining triangular lobes on inner part of brim. Fixed cheeks moderately wide. Palpebral lobes small, situated opposite middle third of glabella. Anterior section of facial suture directed nearly straight forward. Posterior section divergent slightly posteriorly. Ornamentation partly or wholly granular.

Discussion.—For many years *Dinesus* has been a monotypic genus, containing only *D. ida* from beds assigned to the Middle Cambrian in Australia. Whitehouse (1939, p. 228) suggested that *Solenopleura* (?) *sibirica* (Schmidt) (Von Toll, 1899) belonged to *Dinesus*, but Lermontova (1940, p. 145) made it the type of *Erbia*. She recognized the relationship between the genera, however, by including them in the Dinesidae.

Kobayashi (1943b, p. 317) pointed out that the principal generic distinction between *Dinesus ida* and *Erbia sibirica* is the presence of isolated triangular lobes adjacent to the anterior end of the glabella on *D. ida*. These lobes are also characteristic of *E. granulosa* Lermontova and of *D. arctica* n. sp. These three species are here considered to be congeneric and to represent *Dinesus*, which differs from *Erbia* in the characteristic discussed above.

The statement in the generic diagnosis about ornamentation conflicts with a statement by Kobayashi (1943b, p. 317) that *Dinessus ida* is smooth. I have examined the specimen figured by Kobayashi (1935a, p. 22, fig. 3); when it is whitened, a faint granular ornamentation can be seen on the glabella, the tops of the anterolateral lobes, and the fixed cheeks. This specimen is an internal mold, but granular ornamentation on an internal mold is generally a reflection of original external surface ornamentation.

Dinesus arcticus n. sp.

Plate 1, figures 1, 2, 4

Description.—Cranidium subquadrate, moderately to strongly convex transversely and longitudinally. Glabella well defined at sides by deep subparallel axial furrows, strongly convex transversely and longitudinally; front evenly and strongly rounded, reaches nearly to border. Single transglabellar furrow crosses posterior part of glabella; axial part tangent to occipital furrow and thus outlines small elongate posterolateral glabellar lobes. Occipital furrow deep, straight except for anteriorly deflected distal ends. Occipital ring moderately wide on axial line, distinctly narrower at distal ends, has prominent median axial node. Axial furrows branched forward adjacent to anterior end of glabella; inner branches deepest, outline anterior end of glabella, and are tangent to border furrow on axial line; outer branches slightly divergent forward across inner part of brim to border furrow outlining lateral parts of small triangular lobes. Posterior ends of axial furrows deflected laterally from bases of posterolateral glabellar lobes to border furrow by distal ends of occipital ring. Frontal area short; sagittal length about one-fourth sagittal length of glabella, exclusive of occipital ring. Border convex, of nearly constant width. Area between border and anterior end of glabella on axial line concave. Lateral parts of brim convex, depressed. Fixed cheek gently convex, horizontal; width about one-half or slightly more than one-half basal glabellar width. Ocular ridge absent. Palpebral lobe small, convex, situated opposite midde third of glabella; inner and posterior margins defined by shallow palpebral furrow; anterior end continuous with surface of cheek; length slightly less than one-third sagittal length of glabella exclusive of occipital ring. Distal part of posterior limb short, depressed. Posterior border furrow deep. Posterior border has distinct angulation on line directly behind palpebral lobe, directed slightly forward lateral to this angulation.

Thorax composed of at least seven segments, tapers slightly posteriorly. Axis broad, convex; width slightly greater than width of adjacent pleural regions. Each axial ring has short, blunt median spinule. Pleurae of each segment have broad deep pleural furrow extending to tip of segment. Anterior band of each segment extended into short curved terminal spine.

External parts of all convex surfaces except palpebral lobes covered with closely spaced coarse granules. External surfaces of palpebral lobes smooth or obscurely pitted.

Discussion.—*Dinesus arcticus* n. sp. is most similar to *Erbia granulosa* Lermontova, from which it differs by having less strongly granular ornamentation that is lacking on the palpebral lobes, a broader border and frontal area, and shallower furrows outlining the lateral parts of the triangular lobes adjacent to the anterolateral parts of the glabella. Both species differ from *E. sibirica* (Schmidt), the type species of *Erbia*, by lacking a distinct brim on the axial line and thus having isolated ornamented triangular lobes on the frontal area between the anteriorly divergent furrows that connect the axial furrows to the border furrow. This characteristic has been cited by Lermontova (1951) and Suvorova (1960a,b) as one of the principal features that distinguishes *Dinesus* from *Erbia*.

Dinesus arctica differs from *D. ida* Etheridge by lacking an occipital spine and an externally expressed eye ridge and by having relatively smaller eyes.

Occurrence.—Early Cambrian–1 fauna. Moderately rare (5 cranidia, 1 partly articulated specimen), USGS colln. 4296–CO; ?rare (1 cranidial fragment), USGS colln. 4295–CO; both from Yukon River (Water Level) area. ?Rare (2 cranidia), USGS colln. 4449–CO, Canada, east of Hillard Peak area.

Family ELVINIIDAE Kobayashi
Subfamily DOKIMOCEPHALINAE Kobayashi

Genus IDDINGSIA Walcott

Iddingsia Walcott, 1924b, p. 58; Walcott, 1925, p. 97; Shimer and Shrock, 1944, p. 627; Bell and others, 1952, p. 184; Lochman, 1959, p. 282; Palmer, 1960a, p. 95; Palmer, 1965, p. 35.

Type species.—*Ptychoparia similis* Walcott, 1884, p. 52, pl. 10, fig. 10.

Discussion.—The species described below conforms in most respects to the characteristics of *Iddingsia* that I have described earlier (Palmer, 1965, p. 35).

Iddingsia relativa n. sp.

Plate 7, figures 16, 17, 22

Description.—Cranidium, exclusive of posterior limbs, subquadrate. Glabella moderately convex transversely and longitudinally, tapered slightly forward, bluntly rounded anteriorly, moderately well defined at sides by axial furrow, less well defined across front by shallow preglabellar furrow. Glabellar furrows shallow; posterior pair bigeniculate. Occipital ring moderately convex. Occipital furrow broad, moderately deep, nearly straight. Frontal area short, downsloping, subequally divided into gently convex brim and border by moderately deep border furrow that is bluntly angular on axial line; sagittal length slightly less than one-half sagittal length of glabella, exclusive of occipital ring. Fixed cheek narrow, upsloping; width, exclusive of palpebral lobe, slightly more than two-fifths basal

glabellar width. Palpebral lobe large, arcuate, raised slightly above level of cheek, well defined by broad shallow palpebral furrow; situated opposite glabellar midlength; width between one-half and three-fourths width of interocular part of cheek; exsagittal length about three-fifths sagittal glabellar length exclusive of occipital ring. Ocular ridge low, poorly defined.

Posterior limb slender, sharply pointed; transverse length about equal to basal glabellar width.

Course of anterior section of facial suture slightly divergent forward from palpebral lobe to border furrow, then curved sharply inward across border to intersect anterior margin directly anterior to juncture of ocular ridge and axial furrow.

Free cheek broad; lateral margin strongly curved. Genal spine long, slender, cylindrical, directed upward and outward from genal angle in broad curve; length on largest specimens nearly three times length of posterior sutural margin. Lateral and posterior border furrows moderately deep, interrupted at base of genal spine. Width of lateral border slightly less than one-half anterior width of ocular platform. Infraocular ring well defined.

Pygidium subtrapezoidal; sides slightly convergent posteriorly; posterior margin bluntly rounded. Axis prominent, slightly tapered and bluntly rounded posteriorly, not extended to poorly defined border; postaxial ridge barely apparent. Two distinct ring furrows present posterior to articulating furrow; first furrow broad, deep; second furrow shallow. A third furrow barely apparent. Pleural fields gently convex, nearly horizontal, crossed by two shallow pleural furrows and one interpleural furrow. Border narrow, wirelike, not distinctly separated from pleural fields.

External surfaces of all parts covered thickly with fine closely spaced granules. Scattered coarse granules with median perforations present on all parts except palpebral lobes, genal spines, and pygidial border.

Discussion.—*Iddingsia relativa* n. sp. is well represented by many excellently silicified cranidia and free cheeks, but only one pygidium was found. The suggestion of a close genetic relationship between *Dunderbergia* and *Iddingsia* that I have discussed earlier (Palmer, 1965, p. 33) is supported by the characteristics of *I. relativa*. The structure of the free cheek is typical of the Dokimocephalinae by having the lateral and posterior border furrows interrupted by the base of the genal spine and by having the genal spine directed outward and upward at an angle to the lateral margin. However, the cranidium is very similar to cranidia of *Dunderbergia* in its ornamentation, poor development of glabellar furrows, and tendency towards a median angulation of the border furrow. These characteristics also distinguish *I. relativa* from other species of *Iddingsia*. The palpebral lobes are larger than those of typical species of *Dunderbergia*, and the cranidial border is relatively wider.

Rasetti (1961, pl. 24, figs. 7–9) has illustrated a species identified as *Dunderbergia* cf. *D. variagranula* Palmer that has a free cheek typical of the Dokimocephalinae and relatively deep posterior glabellar furrows. These features are charactristics of the early species of *Iddingsia*. The species differs from *I. relativa* by having smaller palpebral lobes, a narrower cranidial border, and a greater development of coarse granules in its ornamentation. However, the affinities of the species illustrated by Rasetti are certainly more with *I. relativa* than with *D. variagranula*, and it should be considered as an unnamed species of *Iddingsia*.

Dunderbergia seducta n. sp. is superficially similar to *Iddingsia relativa*. The cranidium has a similar ornamentation, but it has a narrower border and smaller palpebral lobes, and the associated free cheek has the lateral and posterior border furrows joined at the genal angle.

Occurrence.—Dresbachian–2 fauna. Moderately common (more than 20 cranidia and free cheeks, 1 pygidium), USGS colln. 4381–CO; ?rare (3 cranidia), USGS colln. 4380–CO, Hi-yu area.

Genus DUNDERBERGIA Walcott

Dunderbergia Walcott, 1924b,, p. 56; Walcott, 1925, p. 84; Resser, 1935, p. 23; Raymond, 1937, p. 1112; Kobayashi, 1938, p. 181; Shimer and Shrock, 1944, p. 625; Palmer, 1954b, p. 760; Howell, 1959, p. 238; Palmer, 1960a, p. 65; Palmer, 1965, p. 39.

Discussion.—*Dunderbergia* has recently been reviewed (Palmer, 1960a, p. 65; 1965, p. 39), and the species described below conforms in all respects to the generic characteristics.

Dunderbergia seducta n. sp.

Plate 7, figures 21, 26–28

Description.—Cranidium has outline subquadrate; anterior margin bluntly pointed. Glabella moderately convex transversely and longitudinally, tapered forward, bluntly rounded anteriorly, well defined by shallow axial and preglabellar furrows. Two pairs of shallow glabellar furrows apparent; posterior pair directed distinctly inward and backward from axial furrows. Occipital furrow deep, moderately wide. Occipital ring narrow, convex, has small median tubercule. Frontal area downsloping, divided into moderately convex brim and border by narrow border furrow that has slight median angulation; sagittal length of border about two-thirds sagittal length of

brim. Fixed cheek gently convex, horizontal or slightly upsloping; width, exclusive of palpebral lobe, about one-half basal glabellar width. Eye ridge well defined. Palpebral lobe arcuate, well defined by moderately curved palpebral furrow; exsagittal length about three-eighths sagittal glabellar length, exclusive of occipital ring. Form of posterior limb not known.

Free cheek has gently curved lateral margin and moderately long genal spine; length of spine slightly greater than length of posterior section of facial suture. Lateral and posterior border furrows joined at genal angle. Border gently convex; width at anterior end about one-half width of ocular platform.

Pygidium semicircular. Axis broad, prominent, subparallel-sided, bluntly rounded posteriorly, connected to narrow convex well-defined border by broad postaxial ridge. Two distinct ring furrows present posterior to articulating furrow; third furrow barely apparent. Pleural regions gently convex; pleural fields crossed by three broad, shallow pleural furrows. Width of pleural region about two thirds anterior width of axis.

Ornamentation consists of closely spaced fine granules and scattered coarse granules on the cranidium and free cheek and closely spaced fine granules on the pygidium.

Discussion.—The mixture of fine and coarse granules in the ornamentation of *Dunderbergia seducta* n. sp. and the moderately well-developed posterior pair of glabellar furrows are characteristics of the early species of *Dunberbergia* (cf. *D. brevispina* and *D. calculosa*, Palmer, 1965, pl. 5, figs. 6–13, 15). *D. seducta* differs from both of these by having a relatively longer genal spine. The width of the fixed cheek is significantly greater than that of *D. calculosa*, and the development of coarse granules is intermediate between that of *D. calculosa* and *D. brevispina.*

The cranidium of this species is quite similar to that of *Iddingsia relativa* n. sp. (pl. 7, fig. 17). It differs principally by having a consistently narrower border and smaller palpebral lobes. The free cheeks of the two species are strikingly different. The similarity of the cranidia of the species, however, emphasizes the close relationship of *Iddingsia* to *Dunderbergia* as discussed earlier (Palmer, 1965, p. 33).

Occurrence.—Dresbachian–2 fauna. Moderately rare (4 cranidia, 2 free cheeks, 1 pygidium), USGS colln. 4361–CO, Jones Ridge area.

Genus ELBURGIA Palmer

Elburgia Palmer, 1960a, p. 68, 69; Palmer, 1965, p. 42.

Type species.—*Crepicephalus* (*Loganellus*) *granulosus* Hall and Whitfield, 1877, p. 214, pl. 2, figs. 2, 3.

Discussion.—The species described below conforms in all respects with the characteristics of *Elburgia* that I have described earlier (Palmer, 1965, p. 42).

Elburgia disgranosa n. sp.

Plate 7, figures 18–20, 23–25

Description.—Cranidium, exclusive of posterior limbs, subquadrate, moderately rounded anteriorly. Glabella moderately convex transversely, gently convex longitudinally, tapered slightly forward, bluntly rounded at front, well defined by moderately deep axial and preglabellar furrows. Two distinct pairs of glabellar furrows present. Occipital furrow deep, straight. Occipital ring gently convex. Frontal area downsloping; sagittal length about one-half sagittal length of glabella, exclusive of occipital ring. Border moderately convex, well defined by deep border furrow that has slight median angulation; sagittal length about two-thirds sagittal length of gently convex brim. Fixed cheeek slightly upsloping, nearly flat; width, exclusive of palpebral lobe, slightly less than one-half basal glabellar width. Ocular ridge indistinct. Palpebral lobe arcuate, well defined by curved palpebral furrow; exsagittal length slightly less than one-half sagittal glabellar length, exclusive of occipital ring; width slightly less than one-half width of infraocular part of cheek. Posterior limb tapered evenly to sharp point; transverse length about equal to basal glabellar width.

Free cheek has moderately curved lateral margin and short slightly divergent genal spine; length of genal spine about one-half length of posterior sutural margin of cheek. Border convex, well defined by lateral border furrow that joins posterior border furrow at genal angle; width of border slightly less than one-third width of anterior sutural margin.

Course of anterior section of facial suture slightly divergent forward from palpebral lobe to border furrow, then turned abruptly inward to intersect anterior margin directly anterior to juncture of ocular ridge and axial furrow. Course of posterior section of facial suture strongly divergent, slightly sinuous, from palpebral lobe to posterior cranidial margin.

Pygidium semicircular. Axis large, convex, tapered slightly posteriorly, bluntly rounded at back, reaches nearly to inner edge of narrow convex border, connected to border by broad low median ridge. Two distinct ring furrows present posterior to articulating furrow; anterior furrow broadest and deepest. Pleural regions nearly flat; width slightly less than three-fourths width of axis. Pleural fields crossed by two shallow pleural furrows; anterior furrow continuous with border furrow.

All parts of external surface except furrows, outer parts of palpebral lobes, and genal spines thickly covered with moderately coarse granules of one size.

Discussion.—*Elburgia disgranosa* n. sp. is most like *E. granulosa* (Hall and Whitfield) in posessing granular ornamentation on nearly all parts. It differs by having a longer genal spine and by having the granules much more closely spaced and evenly distributed over the external surface of the exoskeleton. The genal spine on large specimens has pits along its outer margin similar to the pits observed on the genal spine of *E. granulosa.*

Cranidia from Nevada that were questionably assigned to *Elburgia granulosa* (Palmer, 1965, p. 43, pl. 5 fig. 18) have an ornamentation comparable to that of *E. disgranosa* n. sp. and may be more properly assigned to the Alaskan species when more is learned about the associated free cheeks.

Occurrence.—Dresbachian–2 fauna. Moderately rare (4 cranidia, 5 free cheeks, 3 or more pygidia), USGS colln. 4381–CO, Hi-yu area.

Family EUREKIIDAE Hupé

Genus BAYFIELDIA Clark

Bayfieldia Clark, 1924, p. 31; Kobayashi, 1935b, p. 317; Rasetti, 1944, p. 239; Lochman, 1959, p. 325.

Type species.—*Bayfieldia tumifrons* Clark, 1924, p. 31, pl. 4, fig. 6.

Discussion.—Lochman (1959) has given the most complete diagnosis of *Bayfieldia.*

Bayfieldia spp.

Plate 15, figures 8, 11, 12

Discussion.—At least two species referable to *Bayfieldia* are present in the Alaskan collections. Cranidia of both species have the palpebral lobes moderately long and situated close to the glabella slightly posterior to the glabellar midlength. The frontal area of each species is narrow, but its exact nature is not clear because the outer surface of the exoskeleton of most specimens of the Eurekiidae clings to the matrix so that the specimens are characteristically exfoliated. The surface of the mold of species 1 is coarsely granular (pl. 15, fig. 12). The surface of the mold of species 2 (pl. 15, fig. 8) is smooth, but a fragment of the exoskeleton on the occipital ring shows that the external surface was coarsely granular.

A pygidium associated with the cranidium of species 2 has five pairs of short border spines and a single deep ring furrow crossing the axis. This specimen, although exfoliated, has all the characteristics of the pygidium of *Corbinia horatio* (Walcott, 1925, pl. 16, fig. 22). However, the cranidium of *C. horatio* has smaller and more anteriorly placed palpebral lobes than the Alaskan cranidium.

The specimens that are here assigned to *Bayfieldia* are too few and too poorly preserved to resolve any questions about the systematics of the Eurekiidae. They are illustrated to show the presence of these characteristic latest Cambrian trilobites in the Alaskan section.

Occurrence.—Trempealeauan–2 fauna. Species 1, rare (1 cranidium), USGS colln. 4363–CO. Species 2, rare (1 cranidium), USGS colln. 4371–CO; 3 cranidia, 1 pygidium, USGS colln. 4374–CO. All from Jones Ridge area.

Family MARJUMIIDAE Kobayashi

Genus MARJUMIA Walcott

Marjumia Walcott, 1916, p. 401; Shimer and Shrock, 1944, p. 613; Lochman, 1959, p. 306; Robison, 1964a, p. 547.

Type species.—*Marjumia typa* Walcott, 1916, p. 402, pl. 65, figs. 4, 4a,b.

Discussion.—Robison (1964a) has recently reviewed the concept and content of *Marjumia.* The pygidium described below has the bluntly terminated axis, few axial segments, deep anterior pleural furrows, and marginal spines that together characterize pygidia of *Marjumia.*

cf. Marjumia callas Walcott

Plate 6, figure 10

Marjumia callas Walcott, 1916, p. 402, pl. 65, figs. 3, 3a, b; Robison, 1964a, p. 549, pl. 86, figs. 17–21.

Description.—Pygidium semicircular. Axis short, convex, bluntly terminated posteriorly. One distinct ring furrow posterior to articulating furrow. Pleural region lacks distinct border, crossed by single anterior pleural furrow that extends to base of small anterolateral marginal spine.

Discussion.—A single pygidium associated with a scrap of a marjumiid cranidium is remarkably similar to the pygidia of *Marjumia callas* Walcott figured by Robison (1964a). The principal difference is that the Alaskan specimen has only one ring furrow on the pygidial axis posterior to the articulating furrow. This distinction may be of specific value, but without additional pygidia and associated exoskeletal parts, the importance of the difference cannot be adequately evaluated. The species is certainly more closely related to *M. callas* than to any other marjumiid.

Occurrence.—Middle Cambrian–2 fauna. Rare (1 pygidium), USGS colln. 4310–CO, Tatonduk River area.

Genus MODOCIA Walcott

Modocia Walcott, 1924b, p. 59; Walcott, 1925, p. 105; Kobayashi, 1935b, p. 291; Kobayashi, 1943b, p. 322; Resser, 1935, p. 41; Resser, 1936, p. 25; Shimer and Shrock, 1944, p. 629; Tasch, 1951, p. 301; Palmer, 1954a, p. 81; Palmer, 1954b, p. 762; Lochman, 1959, p. 306; Robison, 1964a, p. 550; Rasetti, 1965, p. 106.

Armonia Walcott, 1924b, p. 54; Walcott, 1925, p. 69; Resser, 1936, p. 4; Shimer and Shrock, 1944, p. 605.

Metisia Resser, 1937b, p. 19.

Perioura Resser, 1938, p. 94; Resser, 1942a, p. 38; Howell, 1959, p. 241.

Semnocephalus Resser, 1942a, p. 50.

Type species.—*Arionellus* (*Crepicephalus*) *oweni* Meek and Hayden, 1861, p. 436.

Discussion.—Robison (1964a, p. 550–552) has reviewed the content and concept of *Modocia* and his description is followed here. He has shown the importance of knowledge of pygidia as well as cranidia for adequate identification of trilobites in this genus and also the need to know the nature of ornamentation to identify species. Although several collections contain cranidia of probable marjumiid trilobites, only two collections have associated pygidia and free cheeks and preserved external surfaces that permit comparison with other species of *Modocia*. These specimens show that there are at least two species of *Modocia* in Alaska.

Modocia compressa n. sp.

Plate 5, figures 6–8

Description.—Cranidium elongate, subquadrate. Glabella long, tapered slightly forward, strongly and evenly rounded at front, well defined by axial and preglabellar furrows of nearly constant depth; basal glabellar width slightly more than three-fourths sagittal glabellar length. Glabellar furrows absent. Occipital furrow straight, moderately deep. Occipital ring convex, has small median node. Frontal area short, downsloping, subequally divided into brim and border by broad, gently curved border furrow that has slight median inbend. Fixed cheeks narrow, slightly downsloping; width about one-fourth basal glabellar width. Palpebral lobes long, arcuate, moderately well defined by shallow palpebral furrow. Form of posterior limbs not known. Fragments of preserved exoskeleton at sides of glabella and posterior limb show a finely pitted external ornamentation.

Course of anterior section of facial suture slightly divergent forward from palpebral lobe to border furrow. Course of posterior section divergent-sinuous.

Free cheek has broad convex border well defined by moderately deep lateral border furrow that intersects posterior section of facial suture near genal angle; width of border slightly more than one-half width of ocular platform. Genal spine short; length slightly more than one-half length of posterior section of facial suture.

Pygidium semicircular; width slightly more than twice length. Axis broad, convex, bluntly terminated posteriorly; width slightly less than one-third greatest pygidial width; length about three-fourths sagittal pygidial length. Two distinct ring furrows present posterior to articulating furrow. Pleural regions have only first pleural furrow distinctly defined. Posterior margin lacks spines. External surface has ornamentation of weakly defined pits.

Discussion.—Although the Alaskan specimens described above are largely exfoliated and incomplete, there are enough features preserved to show that they do not belong to any previously described species of *Modocia*. The only previously described species of *Modocia* having a pitted external surface are *M. typicalis* (Resser) (Robison, 1964a, p. 552) and *M. crassimarginata* Rasetti (1965, p. 109). The Alaskan species differs from both of these by having narrower fixed cheeks, a more slender glabella, and less well defined pleural furrows on the pygidium.

Occurrence.—Middle Cambrian–1 fauna. Moderately rare (1 cranidium, 1 free cheek, 6 pygidia), USGS colln. 4341–CO, Hillard Peak area.

Modocia transversa n. sp.

Plate 5, figures 1–5

Description.—Cranidium elongate, subquadrate, gently to moderately convex transversely and longitudinally. Glabella moderately convex transversely, gently convex longitudinally, tapered forward, strongly rounded at front, well defined by moderately deep axial and preglabellar furrows of nearly constant depth. Glabellar furrows absent. Occipital furrow deep, straight. Occipital ring convex, narrow, lacks distinct median node or spine. Frontal area downsloping, subequally divided by broad, gently curved, shallow border furrow into moderately convex, gently downsloping border and gently convex, steeply downsloping brim; sagittal length of frontal area slightly less than one-half sagittal length of glabella, exclusive of occipital ring. Fixed cheek gently convex, slightly downsloping; with between one-third and one-half basal glabellar width. Palpebral lobe well defined, nearly flat, slightly curved, depressed slightly below level of cheek, situated opposite middle third of glabella; length between one-third and one-half sagittal glabellar length, exclusive of occipital ring. Posterior limb bluntly rounded distally; transverse length about

equal to basal glabellar width. Border furrow broad, deep.

Course of anterior section of facial suture slightly divergent forward from palpebral lobe to border furrow, then curved abruptly inward across border to merge imperceptibly with anterior margin. Course of posterior section of facial suture strongly divergent laterally behind palpebral lobe, then curved strongly backward to posterior cranidial margin.

Free cheek has well-defined gently convex, gently curved lateral border; width slightly more than one-half width of ocular platform at anterior margin. Lateral border furrow distinct, shallow, intersects distal part of posterior section of facial suture near genal angle. Genal spine short, sharp; length slightly more than one-third length of posterior section of facial suture.

Pygidium semicircular, margin lacks spines; sagittal length about one-third greatest width. Axis convex, tapered slightly backward, bluntly terminated posteriorly, extended to inner edge of poorly defined border; width between one-third and one-fourth greatest width of pygidium. Two ring furrows present posterior to articulating furrow; anterior one deepest. Pleural regions crossed by three moderately broad pleural furrows and two narrow interpleural furrows. Posterior pleural and interpleural furrows poorly defined on external surface.

External surfaces of all convex parts covered with closely spaced, moderately fine granules.

Discussion.—The relatively short palpebral lobes on the cranidium and short genal spine on the free cheek distinguish *Modocia transversa* n. sp. from all described species of *Modocia* except *M. metisensis* (Walcott). However, *M. metisensis* differs from *M. transversa* by having a strongly convex upturned cranidial border and a broad pygidial axis that is more than one-third the width of the pygidium.

Occurrence.—Middle Cambrian–1 fauna. Moderately common (12 cranidia, 2 free cheeks, 6 pygidia), USGS colln. 4382–CO, Hard Luck Creek area.

Family MENOMONIIDAE Walcott

Genus BOLASPIDELLA Resser

Bolaspidella Resser, 1937b, p. 3; Shimer and Shrock, 1944, p. 609; Shaw, 1952, p. 477; Lochman, 1953, p. 892; Palmer, 1954a, p. 74; Palmer, 1954b, p. 739; Lochman, 1959, p. 304; Robison, 1964a, p. 553.

Hysteropleura Raymond, 1937, p. 1094.

Deissella Howell and Duncan, 1939, p. 7.

Howellaspis Lochman and Denson *in* Lochman and Duncan, 1944, p. 125.

Type species.—*Ptychoparia housensis* Walcott, 1886, p. 201, pl. 25, fig. 5.

Discussion.—The content and concept of *Bolaspidella* have been fully reviewed by Robison (1964a, p. 553–555). His description of the characteristics of *Bolaspidella* is followed here.

Bolaspidella wellsvillensis (Lochman and Denson)

Plate 5, figure 23

Howellaspis wellsvillensis Lochman and Denson *in* Lochman and Duncan, 1944, p. 125, pl. 15, figs. 18–20.

Bolaspidella wellsvillensis (Lochman and Denson). Palmer, 1954b, p. 741, pl. 83, fig. 11; Lochman and Hu, 1961, p. 138, pl. 30, figs. 1–5.

Howellaspis snowyensis Duncan *in* Lochman and Duncan, 1944, p. 126, pl. 15, figs. 14–17.

Description.—Cranidium subtrapezoidal, gently to moderately convex transversely and longitudinally. Glabella well defined, bluntly rounded anteriorly, sides straight, tapered forward. Two pairs of short glabellar furrows present at sides of glabella. Occipital furrow straight, deep. Occipital ring widest on median line, lacks occipital spine. Frontal area subequally divided into downsloping brim and upsloping border by narrow, slightly curved border furrow; sagittal length of frontal area about two-thirds sagittal length of glabella, exclusive of occipital ring. Fixed cheek convex, upsloping; width about two-thirds basal glabella width. Ocular ridge moderately well defined, directed slightly posterolaterally from near anterior end of glabella. Posterior limb long, slender; transverse length significantly greater than basal glabellar width. Ornamentation consists of abundant fine granules on all parts, scattered coarse granules on border, and two longitudinal rows of four granules on top of glabella.

Discussion.—Except for more convex fixed cheeks, the Alaskan specimens described here cannot be objectively distinguished from the types of *Bolaspidella wellsvillensis*. Even the distribution of the scattered coarse granules is comparable.

Occurrence.—Middle Cambrian–1 fauna. Rare (3 cranidia), USGS colln. 4341–CO, Hillard Peak area.

Family NILEIDAE Angelin

Genus TATONASPIS Kobayashi

Tatonaspis Kobayashi, 1935a, p. 48.

Type species.—*Tatonaspis alaskensis* Kobayashi, 1935a, p. 48, pl. 9, figs. 5–7.

Description.—Cranidium, exclusive of posterior limbs, subquadrate, gently convex transversely, moderately convex longitudinally; anterior margin in front view arched. Glabella large, low, poorly defined only at sides on external surface by slight changes in slope of the surface of the exoskeleton, slightly better

defined on surface of mold, extended nearly to anterior cranidial margin. No glabellar furrows apparent. Occipital furrow barely apparent; occipital ring has small median node best defined on surface of mold. Frontal area barely present in front of glabella, forms crescent-shaped area anterior to palpebral area of fixed cheek; lateral corners strongly depressed. Fixed cheek narrow; horizontal; width, including palpebral lobe, about two-fifths basal glabellar width. Palpebral lobe large, flaplike, semicircular, situated about opposite glabellar midlength; palpebral furrow not apparent. Posterior limb slender, sharply pointed; transverse length slightly more than one-half basal glabellar width. Posterior border furrow shallow or absent.

Course of anterior section of facial suture nearly straight forward immediately in front of palpebral lobe, then curved evenly inward to form rounded anterolateral margin of cranidium, and continued intramarginally around front of cranidium. Connective sutures absent. Course of posterior section of facial suture strongly divergent and sinuous.

Free cheeks form a single unit connected by broad nearly vertical cephalic border that has well-defined transversely arranged terrace lines; border in front view tapers laterally to a point, ventral margin gently arched upward, dorsal margin strongly arched upward deflecting course of facial suture; only tiny part of dorsal margin of border remains on cranidium. Lateral parts of cheek moderately broad, strongly depressed, gently convex. Lateral border not defined. Genal spine short, slender. Distinct infraocular ring present.

Discussion.—Kobayashi (1935a) gave only a brief diagnosis of *Tatonaspis* and described only the cranidium of the type species, *T. alaskensis*. Subsequently, Rasetti (1945a) illustrated a magnificent cephalon of a second species, *T. levisensis*. The description given above summarizes all knowledge gained about *Tatonaspis* since 1935.

Lochman (1953, p. 887; 1959, p. 271) stated that *Tatonaspis* is a subjective junior synonym of *Macelloura* (Resser, 1935). However, the relationship of *Tatonaspis* to *M. dia* (Walcott), the type species of *Macelloura*, is at best superficial, and the synonymy is almost certainly incorrect. The glabella of *M. dia* is well defined at its sides and reaches to a deep border furrow that is continuous along the entire anterior cranidial margin. The border is broken from most of the cranidia in the type lot, so its full character cannot be seen; however, fragments show that it was strongly upturned and not plastered to the front of the cranidium only near the axial line as in *Tatonaspis*. The palpebral lobe is slender, arcuate, and moderately well defined on the mold by a shallow palpebral furrow. It is situated close to the glabella, and its posterior end is closer to the glabella than its anterior end. The facial suture is strongly divergent forward from the palpebral lobe in an outwardly convex arc. All these characteristics distinguish *M. dia* from *T. alaskensis*, and all of them are at least of generic value. Thus *Tatonaspis* is resurrected here as a distinctive genus of Late Cambrian age.

Tatonaspis alaskensis Kobayashi

Plate 14, figures 18–20

Tatonaspis alaskensis Kobayashi, 1935a, p. 48, pl. 9, figs. 5–7.

Discussion.—Because ornamentation seems to be the only criterion at present for distinguishing species of *Tatonaspis*, the morphology of *T. alaskensis* Kobayashi is given in the generic description. *T. alaskensis* differs from *T. levisensis* Rasetti, the only other species presently assigned to *Tatonaspis*, by having a smooth rather than strongly pitted surface. New material of this species from Alaska has provided information about the free cheeks, palpebral lobes, and external surface that was not available to Kobayashi. It shows the essential morphologic identity of *T. alaskensis* and *T. levisensis* exclusive of ornamentation, although the nature of the genal spine of *T. alaskensis* is not yet known.

Occurrence.—Trempealeauan–1 fauna. Moderately common (more than 10 cranidia), USNM loc. 25o (=Mertie colln. 30AMt147); 7 cranidia, 1 cheek unit, USGS colln. 3835–CO; both from approximately the same locality, Jones Ridge area. Common (12 cranidia), GSC colln. 4671, Jones Ridge area. Common (10 cranidia), GSC colln. 4717–CO; ?rare (1 cranidium), GSC colln. 4718–CO; both from Squaw Mountain area.

Family NORWOODIIDAE Walcott

Genus HARDYOIDES Kobayashi

Hardyoides Kobayashi, 1938, p. 177; Palmer, 1965, p. 52.
Norwoodina Lochman, 1940, p. 11, 48.

Type species.—*Hardyoides minor* Kobayashi, 1938, p. 177, pl. 16, fig. 29.

Discussion.—*Hardyoides* has recently been reviewed and revised (Palmer, 1965, p. 52). The species described below is unusual because it lacks distinct posterior fixigenal spines and has fixed cheeks somewhat wider than those of other species of the genus. However, all other cranidial characteristics of this species are typical of *Hardyoides*, and it is assigned to the genus without question.

Hardyoides aspinosa n. sp.

Plate 7, figures 32, 33

Description.—Cranidium small, outline subtrapezoidal, anterior margin gently rounded. Glabella long, strongly convex transversely, gently convex longitudinally; sides subparallel; anterior end strongly rounded; well defined by narrow axial and preglabellar furrows. Glabellar furrows not apparent. Occipital furrow deepest adjacent to axial furrow. Occipital ring narrow, has small median node. Frontal area short, subequally divided into convex brim and border by narrow deep border furrow. Fixed cheek gently convex, moderately wide; width, exclusive of palpebral lobe, about two-thirds basal glabellar width. Palpebral lobe small, poorly defined, situated opposite anterior one-fourth of glabella. Eye ridge poorly defined, directed nearly straight laterally from glabella to paplebral lobe. Posterior limb large, moderately convex; exsagittal length one-half sagittal length of glabella, exclusive of occipital ring; transverse width almost twice basal glabellar width. Posterior border furrow deep adjacent to glabella, disappears near distal tip of limb. Distinct posterior fixigenal spine absent. External surfaces of all convex parts have scattered moderately coarse granules.

Other parts not known.

Discussion.—*Hardyoides aspinosa* n. sp. is most like *H. minor* Kobayashi (Palmer, 1965, p. 54) from which it differs by lacking distinct posterior fixigenal spines and by having slightly wider fixed cheeks. It differs from all other species in the genus by lacking an occipital spine.

Occurrence.—Dresbachian–2 fauna. Moderately rare (2 cranidia), USGS colln. 4361–CO, Jones Ridge area.

Family OLENIDAE Burmeister

Genus BIENVILLIA Clark

Bienvillia Clark, 1924, p. 21; Rasetti, 1944, p. 240; Henningsmoen, 1957, p. 142; Poulsen, 1959, p. 267.
Diatemnus Raymond, 1937, p. 1092.

Type species.—*Dikelocephalus? corax* Billings, 1865 [part], p. 334, text. fig. 322a.

Bienvillia sp.

Plate 12, figure 17

Discussion.—Two slightly crushed cranidia in the Alaskan collections have the characteristic straight posterior glabellar furrows connected across the glabella, moderately wide brim, small anteriorly placed palpebral lobes and narrow fixed cheeks of *Bienvillia*. They differ from *B. corax* by having a relatively shorter brim and slightly broader posterior limbs. More material of the Alaskan species will be needed to evaluate the significance of these slight differences.

Occurrence.—Franconian–2 fauna. Rare (2 cranidia), USGS colln. 3709–CO, Hillard Peak area.

Olenid undet. 1

Plate 10, figure 7

Discussion.—Two similar but specifically distinct olenid trilobites are associated with *Proceratopyge*. One of these has relatively well defined glabellar furrows; the fixed cheeks, including the palpebral lobes, are about one-half the glabellar width on a line between the palpebral lobes; the posterior limbs are about as wide, transversely, as the basal glabellar width; and the anterior sections of the facial sutures are divergent forward from the palpebral lobes for a short distance and then curved inward to form an outwardly convex course. The occipital ring has a distinct median node that bears four pits arranged at the corners of a square on the figured specimen. Whittington (1956, p. 177; 1965, p. 297) has noted similar features on some Odontopleuridae and Scutellidae from the Ordovician.

The general aspect of the cranidium of this species seems closest to early species of *Leptoplastus* as described by Henningsmoen (1957, p. 162), but without knowledge of associated parts a meaningful generic assignment for the Alaskan specimens is not possible.

Occurrence.—Franconian–1 fauna. Moderately common (10 cranidia), GSC colln. 4638 (=4727), Hillard Peak area.

Olenid undet. 2

Plate 10, figure 8

Discussion.—Olenid undet. 2, which is found with *Proceratopyge*, differs from the associated species, olenid undet. 1, by having shallower glabellar furrows, more anteriorly flared and less outwardly convex anterior sections of the facial sutures, wider fixed cheeks and longer posterior limbs. The width of the fixed cheek, including the palpebral lobe, is about five-eighths of the width of the glabella on a line through the palpebral lobes; the transverse width of the posterior limbs is consistently greater than the basal glabellar width. The occipital ring of this species also has a small median node that bears four shallow pits arranged at the corners of a square.

This species is probably closely related to olenid undet. 1, but the degree of relationship cannot be determined without knowledge of other parts of the exoskeleton.

Occurrence.—Franconian–1 fauna. Moderately rare (4 cranidia), GSC colln. 4638 (=4727), Hillard Peak area.

Family PAPYRIASPIDIDAE Whitehouse

Genus PROHEDINIA Lermontova and Chernysheva

Prohedinia Lermontova and Chernysheva *in* Chernysheva, 1950, p. 68; Egorova and others, 1955, p. 127; Balashova, 1960, p. 109.

Tosotychia Öpik, 1961a, p. 160.

Type species.—*Prohedinia attenuata* Lermontova and Chernysheva in Chernysheva, 1950, p. 69, pl. 1, figs. 9–12.

Diagnosis.—Cranidium trapezoidal. Glabella slightly tapered forward, bluntly rounded anteriorly. Frontal area has convex border distinctly narrower than brim. Fixed cheeks nearly as wide as glabella, gently convex, horizontal. Palpebral lobes upturned, situated opposite middle third of glabella. Narrow eye ridge present. Distal parts of posterior limbs long. Anterior sections of facial sutures convergent forward.

Discussion.—*Prohedinia attenuata* (Chernysheva, 1950, pl. 1, figs. 9–12), *Chancia palliseri* (Walcott) and *C. odarayensis* Rasetti (Rasetti, 1951, pl. 29, figs. 1–3; pl. 33, fig. 15 only), *Tosotychia sors* (Öpik, 1961a, pl. 15, figs. 1–7), and the Alaskan species described below all have the characteristics cited in the diagnosis just given. These species constitute a distinctive genus of ptychoparioid trilobites of medial to late Middle Cambrian age that seems to have a circum-Pacific distribution.

Öpik (written commun., 1964) reports that Chernysheva pointed out to him the probable synonymy of *Tosotychia* (Öpik, 1961a) with *Prohedinia* (Lermontova and Chernysheva in Chernysheva, 1950) and that he now agrees with her. I had overlooked this relationship and included the Alaskan species in *Tosotychia* prior to Öpik's letter. However, I agree with Öpik that Chernysheva seems to be correct and that *Tosotychia* is a junior synonym of *Prohedinia*.

The only similar American genus is *Chancia*, as noted by Öpik. Typical *Chancia* species, however, have a broad concave cranidial border rather than a narrow convex border. Rasetti (1951) included in *Chancia* species having both concave and convex borders, but I consider the differences in structure of the frontal area to be at least of generic significance, and the forms with convex borders are here placed in *Prohedinia*. As restricted, *Chancia* is found only in beds of early to medial Middle Cambrian age, and *Prohedinia* is found in beds of medial to late Middle Cambrian age.

Prohedinia brevifrons n. sp.

Plate 5, figure 9

Description.—Cranidium subtrapezoidal in outline, gently to moderately convex transversely and longitudinally. Glabella moderately convex transversely, gently convex longitudinally, well defined by shallow axial and preglabellar furrows, tapered slightly forward, bluntly rounded at front. Four pairs of glabellar furrows apparent on best preserved specimen; two anterior pairs weakly defined; two posterior pairs deeper, curved, directed obliquely backward. Occipital furrow deep, straight. Occipital ring convex; median node present. Frontal area short; sagittal length slightly less than one-half sagittal length of glabella, exclusive of occipital ring. Brim gently convex, downsloping. Border furrow broad, deep, nearly straight. Border convex, narrow, nearly horizontal in profile, slightly arched upward in anterior view; sagittal length slightly more than one-half sagittal length of brim. Fixed cheek wide, gently convex, horizontal; width, excluding palpebral lobe almost as great as basal glabellar width. Palpebral lobe small, straight, upturned; length about one-third sagittal glabellar length, exclusive of occipital ring. Eye ridge narrow, gently curved, directed almost straight laterally from near front of glabella; best preserved specimen has shallow median groove dividing eye ridge into anterior and posterior parts. Distal part of posterior limb long; transverse length slightly less than transverse length of proximal part; transverse length of entire limb one and one-half times basal glabellar width. Posterior border furrow broad, deep, curved slightly backward parallel to posterior cranidial margin.

Course of anterior section of facial suture convergent forward in broad curve from palpebral lobe to anterior cranidial margin. Course of posterior section of facial suture nearly straight posterolaterally at angle of about 45° to axial line from palpebral to posterior margin.

External surfaces of all parts except furrows covered with closely spaced fine granules.

Discussion.—*Prohedinia brevifrons* n. sp. is characterized particularly by its short frontal area, wide fixed cheeks, short and upturned palpebral lobes, long distal parts of the posterior limbs, and convex anteriorly convergent anterior section of the facial suture. The most similar trilobites are *Tosotychia sors* (Öpik, 1961a) from beds of late Middle Cambrian age in Australia and *Chancia palliseri* (Walcott) (Rasetti, 1951) from the medial Middle Cambrian *Bathyuriscus-Elrathina* zone in the Canadian Rockies. *T. sors* has cranidial proportions similar to the Alaskan specimens and also has double eye ridges. It differs from the Alaskan specimens by having considerably larger and more arcuate palpebral lobes and a distinct parafrontal band. *C. palliseri* has a relatively longer brim and frontal area than the Alaskan specimens,

and the facial sutures are less convergent anteriorly. The cranidium tentatively assigned to *C. odarayensis* (Rasetti, 1959, pl. 33, fig. 15) has proportions of the frontal area more like the Alaskan specimens, but the border furrow is shallow across the axial line and the border is not upturned relative to the brim.

Occurrence.—Middle Cambrian–1 fauna. Moderately rare (3 cranidia), USGS collns. 4303–CO. 1 cranidium, 4339–CO; Tatonduk River area.

Family PTEROCEPHALIIDAE Kobayashi
Subfamily APHELASPIDINAE Palmer

Genus OLENASPELLA Wilson

Olenaspella Wilson, 1956, p. 1344; Palmer, 1962, p. 36; Ivshin, 1962, p. 68; Palmer, 1965, p. 63.

Type species.—*Parabolinella? evansi* Kobayashi, 1936b, p. 92, figs. 7, 8, 10.

Olenaspella evansi (Kobayashi)

Plate 8, figures 1–4

Parabolinella? evansi Kobayashi, 1936b, p. 92, pl. 15, figs. 7, 8, 10.

Parabolinella evansi Kobayashi, 1938, p. 186, pl. 16, figs. 11, 12(?)

Olenaspella evansi (Kobayashi). Palmer, 1962, p. 37, pl. 5, figs. 4, 5, 7.

Description.—Cranidium, exclusive of posterior limbs, subquadrate; anterior margin broadly and gently rounded. Glabella low, gently convex transversely and longitudinally, well defined by shallow axial and preglabellar furrows; sides subparallel; anterior end bluntly rounded. Glabellar furrows narrow, shallow; posterior pair strongly oblique, deepest. Occipital furrow shallow, straight, deepest distally. Occipital ring has small median node. Frontal area gently downsloping; sagittal length slightly more than one-half sagittal glabellar length, exclusive of occipital ring. Border narrow, convex, well defined by narrow, gently curved border furrow; sagittal length about one-third sagittal length of nearly flat brim. Fixed cheek gently convex, nearly horizontal; width, exclusive of palpebral lobe, slightly less than one-half basal glabellar width. Palpebral lobe slightly upsloping, well defined by broad, shallow, curved palpebral furrow; exsagittal length slightly more than two-fifths sagittal glabellar length, exclusive of occipital ring. Ocular ridge low, poorly defined, directed slightly posterolaterally from axial furrow. Posterior limb slender.

Course of anterior section of facial suture slightly divergent forward from palpebral lobe to border furrow, then turned inward across border to intersect anterior margin anterolateral to anterior corners of glabella. Course of posterior section of facial suture divergent and sinuous.

Free cheek elongate, subtriangular. Lateral margin broadly curved, continuous with margin of slender genal spine. Border gently convex, well defined by deep narrow border furrow; width at anterior margin slightly more than one-third width of gently convex ocular platform. Lateral and posterior border furrows meet in sharp point at base of genal spine. Length of genal spine slightly less than twice length of posterior section of facial suture.

Pygidium transversely elliptical. Axis convex, tapered slightly posteriorly, well defined at sides by narrow axial furrows, poorly defined at rear; sagittal length about four-fifths sagittal pygidial length; width slightly more than one-fourth greatest pygidial width. Two complete ring furrows and one incomplete furrow present posterior to articulating furrow. Pleural regions have three shallow pleural furrows; anterior two furrows curved backward distally, terminated at inner edge of poorly defined border. Shallow interpleural furrow barely apparent between first and second pygidial segments. Posterior margin has three pairs of short evenly spaced border spines.

External surfaces of all parts smooth.

Discussion.—The Alaskan specimens assigned to *Olenaspella evansi* differ from the types principally by having shallower glabellar furrows on the cranidium and shallower pleural furrows on the pygidium. The types are in black limestone from British Columbia that has much evidence for diagenetic compression. This compression has accentuated the furrows of all specimens. Thus, the differences between the uncompressed Alaskan specimens and the slightly crushed Canadian specimens seem to be more apparent than real.

An incomplete pygidium and fragmentary cranidium from a second Alaskan locality are also tentatively referred to *Olenaspella evansi*. The pygidium has the short axis and three pairs of marginal spines diagnostic of this species, but the inner pair of spines is distinctly smaller than the outer two pairs. The pygidium is thus morphologically, and perhaps also stratigraphically, intermediate between that of *O. paucisegmenta* Palmer (1965, p. 64, pl. 10, figs. 1–3) from pre-*Dunderbergia* zone beds of Nevada and typical *O. evansi* which seems to be from beds correlative with the *Dunderbergia* zone. *O. paucisegmenta* has only two pairs of pygidial spines, but *O. regularis* Palmer, an older two-spined species of *Olenaspella*, occasionally has an incipent inner third pair of spines; thus there possibly is a similar development and a transitional morphologic series between *O. paucisegmenta* and *O. evansi*.

Occurrence.—Dresbachian–2 fauna. Moderately rare (3 cranidia, 2 free cheeks, 4 pygidia), USGS colln. 4381–CO, Hi-yu area. ?Rare (1 cranidium, 1 pygidium), USGS colln. 3717–CO, Yukon River (West Ridge) area.

Subfamily PTEROCEPHALIINAE Kobayashi

Genus CERNUOLIMBUS Palmer

Cernuolimbus Palmer, 1960a, p. 84; Palmer, 1965, p. 69.

Type species.—*Cernuolimbus orygmatos* Palmer, 1960a, p. 85, pl. 8, figs. 1, 3, 5, 8, 11.

Discussion.—The species described below conform in all essential respects to the diagnosis of *Cernuolimbus* given earlier (Palmer, 1965, p. 69) except for the unusual sagittal length of their cranidial borders. Species of the only other closely related genus, *Sigmocheilus*, generally have such a relatively broad border. However, they lack the distinctly pointed anterior cranidial margin, the deepest part of the concave border is at about the midlength of the border rather than anterior to the midlength, and the pygidium has a relatively shorter axis and less transversely elliptical outline. Thus the diagnosis of *Cernuolimbus* is here emended to include species that have the sagittal length of the cranidial border as much as five times the sagittal length of the brim.

Cernuolimbus arcticus n. sp.

Plate 8, figures 17–19

Description.—Cranidium, exclusive of posterior limbs, elongate pentagonal, pointed anteriorly. Glabella moderately convex transversely and longitudinally, well defined by deep axial and shallow preglabellar furrows, tapered slightly forward, bluntly rounded anteriorly. Glabellar furrows shallow. Occipital furrow broad. Occipital ring has low median node. Frontal area broad, concave; sagittal length about two thirds sagittal length of glabella, exclusive of occipital ring. Border broad, concave, separated from brim by moderately deep border furrow bearing many pits; sagittal length about 1½ times sagittal length of brim. Fixed cheeks narrow, upsloping; transverse width between one-third and one-fourth basal glabellar width. Palpebral lobes arcuate, well defined by shallow palpebral furrow, situated opposite middle third of glabella; exsagittal length about four-tenths sagittal glabellar length exclusive of occipital ring. Posterior limb slender, tapered to point; transverse length slightly less than basal glabellar width. External surface of at least part of border and of posterior part of glabella covered with low granules.

Course of anterior section of facial suture divergent forward from palpebral lobe to border furrow, then curved sharply inward across border to intersect anterior margin at distinct angle nearly at axial line. Course of posterior section of facial suture divergent-sinuous.

Free cheek has evenly curved lateral margin continuous with margin of genal spine. Lateral and posterior border furrows moderately deep, joined at genal angle. Lateral border concave; width about three-fourths width of ocular platform at anterior margin. Posterior border nearly as wide as lateral border. Genal spine long, broad; length at least twice and probably more than three times length of posterior section of facial suture. External surface has scattered low moderately coarse granules on all parts.

Pygidium transversely elliptical; posterior margin evenly rounded. Axis convex, tapered slightly posteriorly; length about four-fifths pygidial length. Four ring furrows present on mold posterior to articulating furrow. Pleural region lacks separately defined border; lateral margin slightly concave. Two or three broad shallow pleural furrows separated by low moderately sharp pleural ridges cross pleural region but do not reach margin. External surface of pleural region covered with fine granules; surface of axis not known.

Discussion.—Although *Cernuolimbus arcticus* n. sp. is represented by incomplete material that does not show clearly the ornamentation of the cranidium or of the axial part of the pygidium, enough of its characteristics can be observed to show that it differs from all others assigned to *Cernuolimbus*. It differs from the only other described Alaskan species, *C. longifrons* n. sp., by having the sagittal length of the border on the cranidium only 1½ rather than 4–5 times the sagittal length of the brim and by having distinct granular ornamentation on preserved parts of the exoskeleton. The relatively long cranidial border distinguishes *C. arcticus* from all other described species of *Cernuolimbus* except *C. semigranulosus*. It differs from *C. semigranulosus* by having a much broader posterior border on the free cheek, narrower and more strongly upsloping fixed cheeks, more and better defined ring and pleural furrows on the pygidium, a longer pygidial axis, and a more strongly developed granular ornamentation on all observed parts.

Occurrence.—Dresbachian–2 fauna. Moderately rare (6 cranidia, 2 free cheeks, 1 pygidium), USGS colln. 4360–CO; moderately common, GSC colln. 4646; rare (1 cranidium), GSC colln, 4648; ?rare (1 cranidium), GSC 4635; ?rare (1 cranidium), GSC colln. 4639; all from Hillard Peak area.

Cernuolimbus longifrons n. sp.

Plate 8, figures 11–16

Description.—Cranidium, exclusive of posterior limbs, subpentagonal; anterior margin distinctly pointed. Glabella moderately convex transversely, gently convex longitudinally, tapered slightly forward, bluntly rounded at front, well defined at sides by moderately deep axial furrows, less well defined across front by shallow preglabellar furrow. Two pairs of moderately deep glabellar furrows present; posterior pair deepest, directed strongly backward from axial furrow. Occipital furrow moderately broad, deep, nearly straight. Occipital ring has low median node most apparent on small specimens. Frontal area broad, concave; sagittal length about two-thirds sagittal length of glabella, exclusive of occipital ring. Border broad, concave; deepest part of concavity distinctly anterior to midlength of border; sagittal length of border variable between four and five times sagittal length of narrow brim. Border furrow broad, shallow, evenly curved. Fixed cheek moderately convex, upsloping; width, exclusive of palpebral lobe, about two-fifths basal glabellar width. Low, poorly defined posterolaterally directed ocular ridge present. Palpebral lobe arcuate, well defined by curved palpebral furrow; exsagittal length changes during holaspid ontogeny from about three-fourths of sagittal glabellar length, exclusive of occipital ring, on cranidia less than 2mm long, to slightly less than one-half sagittal glabellar length on cranidia 8mm long. Posterior limb slender, tapered to sharp point; transverse length about equal to basal glabellar width.

Course of anterior section of facial suture moderately divergent forward from palpebral lobe onto cranidial border, then turned abruptly inward across border to intersect anterior margin nearly at axial line. Course of posterior section divergent and sinuous.

Free cheek moderately narrow. Lateral margin forms continuous broad curve with margin of long genal spine. Lateral and posterior border furrows joined at genal angle. Lateral border broad, concave; concave depression continues onto genal spine; width of border slightly greater than width of ocular platform at anterior sutural margin. Genal spine moderately broad, tapered to sharp point; length about twice length of posterior section of facial suture. Doublure of cheek joins lateral margin at acute angle; profile of doublure strongly angular, so hollow space exists between doublure and dorsal surface of cheek. Anterior projection truncate, indicating probable median suture.

Pygidium transversely elliptical, lateral margins pointed. Axis convex, tapered slightly posteriorly, reaches nearly to posterior margin, connected to posterior margin by low post-axial ridge. Three or four shallow ring furrows present posterior to articulating furrow. Pleural region not divided into distinct border and pleural field. Three or four broad shallow pleural furrows extend nearly to pygidial margin. Posterolateral parts of pleural regions concave.

External surfaces of all parts lack distinct ornamentation.

Discussion.—*Cernuolimbus longifrons* n. sp. differs from all others in the genus by having the sagittal length of the cranidial border more than four times the sagittal length of the brim. It is also the only species in the genus without any distinct ornamentation.

Two other species of the Pterocephalinae are associated with *Cernuolimbus longifrons*. *Pterocephalia constricta* n. sp. is easily distinguished by its lack of a distinct border furrow on the cranidium and free cheek and by its broader and longer pygidium. *Sigmocheilus compressus* n. sp. is distinguished by its narrower cranidial border, its large palpebral lobes that are closer to the glabella, its shorter and broader genal spine, and by the doublure of the free cheek that nearly parallels the dorsal surface of the cheek.

Occurrence.—Dresbachian–2 fauna. Moderately common (more than 20 cranidia, 12 free cheeks, 5 pygidia), USGS 4381–CO, Hi-yu area.

Genus PTEROCEPHALIA Roemer

Pterocephalia Roemer, 1849, p. 421; Roemer, 1852, p. 92; Bridge *in* Bridge and Girty, 1937, p. 247; Shimer and Shrock, 1944, p. 631; Palmer, 1954b, p. 751; Lochman, 1959, p. 256; Palmer, 1960a, p. 86; Palmer, 1965, p. 71.

Type species.—*Pterocephalia sanctisabae* Roemer, 1849, p. 421.

Discussion.—The species described below conforms in most respects to my recent diagnosis of *Pterocephalia* (Palmer, 1965, p. 71). The principal difference, which does not seem to be of generic significance and requires only a minor emendation of the generic diagnosis, is the nearly complete absence of any indication of the inner edge of the border on either the cranidium or the free cheek. The width of the doublure, however, shows that the borders of both the cranidium and the free cheek were very wide. These characters are typical of other species of the genus.

Pterocephalia constricta n. sp.

Plate 8, figures 5–10

Description.—Cephalon, exclusive of posterior limbs, elongate subquadrate; anterior margin bluntly pointed. Glabella large, low, tapered slightly forward, gently

convex transversely and longitudinally, moderately well defined at sides and front by abrupt changes in slope of exoskeleton, bluntly rounded anteriorly. Two pairs of narrow, moderately well defined glabellar furrows present, directed obliquely backward from sides of glabella. Occipital furrow straight, deepest at distal ends, shallow across axial line. Occipital ring has small median node. Frontal area gently concave; distinction between brim and border not apparent, but inner edge of anterior projection of doublure of cheek passes nearly tangent to front of glabella and indicates that the frontal area consists mostly of border; sagittal length of frontal area about two-thirds sagittal length of glabella, exclusive of occipital ring. Fixed cheeks narrow, slightly upsloping; width, exclusive of palpebral lobe, about one-fifth basal glabellar width. Palpebral lobe large, arcuate, elevated slightly above surface of cheek; exsagittal length slightly more than one-half the sagittal glabellar length, exclusive of occipital ring; width equal to width of infraocular part of cheek. Posterior limb slender.

Course of anterior section of facial suture slightly divergent forward from palpebral lobe to most concave part of frontal area, then curved sharply inward to intersect cranidial margin at axial line and continue ventrally across doublure as median suture. Course of posterior section of facial suture divergent and sinuous.

Free cheek elongate subtriangular, nearly flat; lateral margin gently and evenly curved from anterior projection to tip of genal spine. Border barely defined on anterior part of cheek, nearly as wide as cheek along anterior sutural margin. Low narrow ridges present adjacent and parallel to lateral margin and to inner margin of genal spine. Genal spine broad, flat, tapered to sharp point. Doublure parallel to dorsal surface of cheek. Infraocular ring present.

Pygidium transversely elliptical; length about one-half width; posterior margin has slight median flattening. Axis narrow, convex, tapered slightly posteriorly; terminal part pointed; length slightly less than one-half length of pygidium; width variable between one-half and three-fourths width of pleural region; narrow postaxial ridge extends short distance posteriorly towards margin. Four or five shallow narrow ring furrows present posterior to articulating furrow. Pleural regions broad, concave, lack distinctly defined border. Three or four broad shallow pleural furrows present, disappear distally.

External surfaces of all parts lack distinct ornamentation.

Discussion.—*Pterocephalia constricta* n. sp. differs most significantly from others assigned to *Pterocephalia* by having very narrow fixed cheeks, a relatively short frontal area, and nearly complete absence of any indication of the inner edge of the border on either the cranidium or the free cheek. Absence of a clear indication of the inner margin of the border distinguishes cranidia and cheeks of *P. constricta* from associated parts of *Sigmocheilus? compressus* n. sp. and *Cernuolimbus longifrons* n. sp.

The apparent variability in width of the pygidial axis of *Pterocephalia constricta* may be the result of including in the sample pygidia that should be assigned to *Sigmocheilus? compressus*. No pygidia were certainly identified for *S? compressus*, but pygidia for other species of *Sigmocheilus* such as *S. grata* (Resser) (Palmer, 1965, pl. 15 fig. 18) are very similar to those of species of *Pterocephalia*. Thus, in a small sample such as the Alaskan collection, apparent variability may be an artifact caused by association of morphologically similar pygidia of two distantly related species.

Occurrence.—Dresbachian–2 fauna. Moderately rare (5 cranidia, 10 free cheeks, 9 pygidia), USGS colln. 4381–CO, Hi-yu area.

Genus SIGMOCHEILUS Palmer

Sigmocheilus Palmer, 1960a, p. 89; Palmer, 1965, p. 73.

Type species.—*Dikellocephalus flabellifer* Hall and Whitfield, 1877, p. 227, pl. 2, fig. 29–30.

Sigmocheilus? compressus n. sp.

Plate 8, figures 21–24

Description.—Cranidium, exclusive of posterior limbs, elongate, subquadrate; anterior margin has small median point. Glabella elongate, tapered slightly forward, bluntly rounded anteriorly, moderately convex transversely, gently convex longitudinally, well defined at sides by axial furrows, poorly defined across front. Two pairs of moderately deep glabellar furrows directed obliquely inward and backward from axial furrows; length on external surface less than one-fourth glabellar width, somewhat longer on mold. Occipital ring has low median node. Frontal area concave, divided by shallow narrow border furrow into broad concave border and narrow downsloping brim; sagittal length of frontal area about two-thirds sagittal length of glabella, exclusive of occipital ring; sagittal length of border variable between two and three times sagittal length of brim. Fixed cheek narrow, upsloping; width, exclusive of palpebral lobe, between one-fourth and one-fifth basal glabellar width. Palpebral lobe large, curved, situated slightly pos-

terior to glabellar midlength poorly defined by shallow arcuate palpebral furrow; exsagittal length slightly less than three-fourths sagittal length of galbella, exclusive of occipital ring; width about equal to infraocular part of cheek. Posterior limb slender.

Course of anterior section of facial suture slightly divergent forward from palpebral lobe to border, then curved sharply inward across border to intersect anterior margin on axial line and to connect with ventral median suture. Course of posterior section of facial suture divergent and sinuous.

Free cheek subtriangular; lateral margin evenly curved from anterior projection to tip of genal spine; infraocular ring present. Lateral border furrow distinct, shallow, connected to short section of posterior border furrow near distal end of posterior sutural margin. Border concave; width slightly less than anterior width of ocular platform. Low narrow ridge present near and parallel to outer edge of border. Genal spine broad-based, nearly flat, tapered to sharp tip; length slightly greater than length of posterior section of facial suture. Doublure of cheek closely parallel to upper surface.

External surfaces of all parts lack distinct ornamentation.

Discussion.—*Sigmocheilus? compressus* n. sp. differs in several respects from typical members of *Sigmocheilus* and may represent a new genus of the Pterocephaliinae. Although the frontal area has the characteristic development of *Sigmocheilus*, the large palpebral lobes, narrow fixed cheeks, and relatively short genal spine combine to give the cephalon an appearance unlike any named species of the subfamily.

A single unnamed cranidium from Nevada (Palmer, 1965, p. 92, pl. 16 fig. 19) seems to be congeneric with *Sigmocheilus? compressus* n. sp. It differs principally by having the facial sutures meeting the anterior margin lateral to the axial line so that the anterior margin is evenly rounded rather than pointed. The affinities of both trilobites are closest to *Sigmocheilus*. Until a pygidium can be identified, the full extent of possible generic differences cannot be evaluated, and the species are included in that genus.

Occurrence.—Dresbachian–2 fauna. Moderately rare (9 cranidia, 4 free cheeks), USGS colln. 4381–CO, Hi-yu area.

Sigmocheilus? cf. S. grata (Resser)

Plate 8, figures 20, 25

Sigmocheilus grata (Resser). Palmer, 1965, p. 74, pl. 15, figs. 16–18.

Discussion.—A few fragmentary cranidia and a pygidium represent a species that differs from all other Alaskan Pterocephalinae by having the cranidial border poorly defined and about twice as long, sagittally, as the brim. The width of the fixed cheek is slightly more than one-third the basal glabellar width. The pygidium has four or five ring furrows posterior to the articulating furrow and about four low pleural ridges that extend onto but not across the broad concave border. The sagittal length of the axis is slightly more than one-half the sagittal length of the pygidium.

One cranidium has an external ornamentation of very fine, closely spaced granules on all parts except over the glabellar muscle areas. The granules increase in size and distinctness posteriorly. Exfoliated cranidia have a few low scattered large granules on the occipital ring.

The cranidial and pygidial proportions are closest to those of *Sigmocheilus grata* (Resser) which is a variable species characteristic of the *Dunberbergia* zone in the Great Basin of the conterminous United States. The cranidial border is less well defined than the border in most samples of *S. grata* and more like species of *Pterocephalia*. However, all species of *Pterocephalia* have a very narrow brim and a low ridge on the border parallel to the anterior cranidial margin. Until more can be learned about the Alaskan species, it cannot be satisfactorily named.

Occurrence.—Dresbachian–2 fauna. Moderately rare (4 cranidia, 1 pygidium), GSC colln. 4639, Hillard Peak area.

Family PTYCHOPARIIDAE Matthew
Subfamily ANTAGMINAE Hupé

Genus "ANTAGMUS" Resser

Antagmus Resser, 1936, p. 3; Shimer and Shrock, 1944, p. 605; Lochman, 1947, p. 62; Rasetti, 1955, p. 9; Rasetti, 1959, p. 235.

Antagmus (Antagmus), Shaw, 1962, p. 335.

Type species.—*Antagmus typicalis* Resser (= *Ptychoparia teucer* Walcott, 1886, p. 197, pl. 26, fig. 3.).

Discussion.—The type specimen of *Antagmus typicalis* is a poorly preserved internal mold of a cranidium in weathered dolomite from Vermont. If the generic name based on this specimen had been restricted to the holotype by Lochman (1947) and if a new name based on better material had been proposed for the species assigned at that time to *Antagmus*, we might all be better off. However, the name is now deeply entrenched in the literature, and *Antagmus* is the nominal genus of a family and subfamily.

A decision to assign a specimen to *Antagmus* is fraught with problems. Rasetti (1955) criticized Lochman's stringent criteria for discrimination of Early Cambrian ptychoparioid genera. He presented

a new description of *Antagmus* (Rasetti, 1955, p. 9) based largely on well-preserved limestone specimens from Quebec that he believed might even be conspecific with *A. typicalis*. Shaw (1962) assigned Rasetti's specimens to another family and presented his diagnosis of *Antagmus* supplemented by internal molds that he identified as *A. typicalis* from weathered dolomite 25 miles south of the type locality. Thus *Antagmus* remains as a somewhat vague concept meaning perhaps slightly different things to different people. Assignment of the species described below to this systematic quagmire results from having a small sample (4 specimens) of a specifically distinct ptychoparioid of *Antagmus*-aspect that probably represents a genus as yet unnamed. However, there are already enough problems with Early Cambrian ptychoparioids without adding another generalized monotypic taxon. Until such time as it is possible to have adequate material for a comprehensive revision of the trilobites of *Antagmus*-aspect, no generic assignment for trilobites of this group is going to be very meaningful.

"Antagmus" laminatus n. sp.

Plate 3, figures 16, 17

Description.—Cranidium transversely subquadrate gently to moderately convex transversely and longitudinally; anterior margin gently rounded. Glabella well defined at sides and front by abrupt changes in slope; tapered forward, truncated anteriorly. Glabellar furrows shallow, hardly apparent. Occipital furrow deep, nearly straight. Occipital ring long, semielliptical in outline; sagittal length almost one-half sagittal length of glabella. Frontal area short, subequally divided into convex border and flat or slightly concave brim on axial line; sagittal length about one-half or slightly more than one-half sagittal length of glabella. Low median boss on frontal area crossed by shallow border furrow. Fixed cheek wide, gently convex, nearly horizontal; width slightly less than basal glabellar width. Eye ridge low, nearly straight; interrupts axial furrow at junction with anterior end of glabella; merges with cheek surface just before reaching end of palpebral lobe. Palpebral lobe narrow, gently curved; length slightly more than one-third sagittal glabellar length. Distal part of posterior limb short; transverse length less than one-third length of proximal part of limb. Posterior border furrow broad, deep. Posterior border expanded slightly near distal end.

Anterior section of facial suture convergent forward in nearly straight line from palpebral lobe to anterior margin. Posterior section convex from palpebral lobe to posterior margin.

External surfaces of brim, fixed cheeks, and top of glabella have closely spaced granules. Anterior part of border and flanks of glabella and occipital ring covered by smooth raised layer of exoskeleton having irregular margins.

Discussion.—"*Antagmus*" *laminatus* n. sp. differs from all other Lower Cambrian ptychoparioids by having peculiar extra exoskeletal layers on the anterior part of the border and the flanks of the glabella and occipital ring. The combination of wide fixed cheeks, short frontal area having a median boss on the border, short distal parts of the posterior limbs, and long occipital ring is also unique. The reasons for assigning it to "*Antagmus*" are discussed under the genus.

Occurrence.—Early Cambrian–2 fauna. Moderately rare (4 cranidia), USGS colln. 4302–CO, Tatonduk River area.

Genus ONCHOCEPHALUS Resser

Onchocephalus Resser, 1937b, p. 20; Lochman, 1947, p. 63; Rasetti, 1955, p. 16; Rasetti, 1959, p. 237.
Antagmus (*Onchocephalus*), Shaw, 1962, p. 336.

Type species.—*Ptychoparia thia* Walcott, 1917, p. 96, pl. 12, fig. 6.

Diagnosis.—Cranidium gently convex transversely and longitudinally; glabella low, tapered forward, generally bluntly rounded at front. Border convex. Border furrow generally bent backward on axial line. Fixed cheeks gently convex, horizontal or slightly downsloping. Palpebral lobes poorly defined, situated opposite middle third of glabella. Width of fixed cheeks slightly more than one-half basal glabellar width.

Discussion.—The systematics of the Early Cambrian Ptychoprioidea have been in a state of flux for many years (Lochman, 1947; Rasetti, 1955). The latest revision by Shaw (1962) reduces many genera to subgenera while at the same time proposing new subfamilies. The degree of divergence of opinion on the classification of Early Cambrian Ptychoparioidea is shown in the discussion of "*Antagmus*" (p. B74). *Onchocephalus* is, to me, a genus of small antagmids of generally subdued relief that have the proportions cited in the diagnosis. This concept is more nearly that of Rasetti than it is the subsequent concept of Shaw.

Onchocephalus profectus n. sp.

Plate 3, figures 8–10, 12–14, 18

Description.—Cranidium subquadrate, gently convex transversely and longitudinally, moderately rounded anteriorly. Glabella moderately well defined by shal-

low axial and preglabellar furrows; sides straight; anterior end bluntly rounded; glabellar furrows absent. Occipital furrow straight, shallow, absent from largest cranidia. Occipital ring has tiny median node. Border convex, defined by a shallow border furrow that is distinctly bent backward on axial line, has narrow raised rim along anterior margin; distinctness of border furrow variable, generally decreases with size of cranidium; border barely apparent on largest specimens (sagittal cranidial length 7–8 mm). Brim gently convex; sagittal length variable, averages about two-thirds sagittal length of border. Fixed cheek gently convex, nearly horizontal; palpebral furrow absent. Palpebral lobe gently curved, situated opposite middle third of glabella; length about three-tenths sagittal glabellar length, including occipital ring. Eye ridge expressed on external surface only as shallow depression along anterior edge. Posterior limb short, blunt; length of distal part slightly less than length of proximal part. Posterior border furrow shallow. All furrows and eye ridges better defined on internal mold.

Course of anterior section of facial suture gently curved; directed slightly outward immediately anterior to palpebral lobe; directed slightly inward across border. Posterior section of facial suture directed outward at about a 45° angle from axial line, then curved strongly backward to intersect posterior cranidial margin at nearly a right angle.

Free cheek subtriangular; width increases backward to maximum opposite posterior cranidial margin. Border broad, poorly defined by shallow, gently curved border furrow that intersects posterior section of facial suture at point of greatest curvature. Narrow raised rim present along lateral margin. Genal spine broad based, short; length about equal to length of posterior section of facial suture. Borders of both free cheek and cranidium have narrow, slightly raised rim about one-tenth width of border.

Thorax and hypostome unknown.

Pygidium small, transversely elliptical. Axis broad, unsegmented, reaches to posterior margin. Pleural regions triangular; greatest width less than width of axis.

Ornamentation variable, from closely spaced fine granules on small specimens to mostly pitted on large specimens. Free cheeks of large specimens have pitted surfaces on ocular platforms and the anterior part of the border; the posterior part of the border has closely spaced fine granules.

Discussion.—*Onchocephalus profectus* n. sp., a remarkably variable species, is distinguished by its ornamentation and variability from other species presently assigned to *Onchocephalus*. Among the 17 cranidia that show the external surface, there is a complete range among specimens having pitted ornamentation, from those that have a moderately well defined border to those that hardly have the border defined at all (pl. 3 figs. 8, 9). There is also a complete range in ornamentation from small cranidia that have the ornamentation composed entirely of closely spaced fine granules, through cranidia that have some parts pitted and some granular, to generally large cranidia that have almost entirely pitted ornamentation. I have only seen comparably variable species among Early Cambrian ptychoparioids in Nevada. USGS collection 964–CO, a small collection from a thin limestone bed in the Pioche Shale in the Eureka district, yielded several ptychoparioid cranidia, each of which represented a significant variation on the antagmid theme. Supposedly correlative beds in the Pioche Shale in the Pioche district, Nevada, yielded hundreds of cranidia, both silicified and unsilicified, of a single species having quite uniform characteristics typically found on younger trilobites. The apparently unpredictable variability in some Early Cambrian ptychoparioid samples may have contributed to the present chaos in the systematics of these simple trilobites.

Occurrence.—Early Cambrian–2 fauna. Moderately common (17 cranidia, 3 free cheeks, 1 pygidium), USGS colln. 4302–CO, Tatonduk River area.

Subfamily EULOMINAE Kobayashi

Genus PAREULOMA Rasetti

Pareuloma Rasetti, 1954, p. 583; Rasetti, 1959, p. 234.

Type species.—*Pareuloma brachymetopa* Rasetti, 1954, p. 584, pl. 60, figs. 1–8; text fig. 2.

Discussion.—The species described below conforms in all essential respects with the description of *Pareuloma* given by Rasetti (1954). In addition, new information is provided about the structure of the occipital ring, free cheek, and thoracic segments.

Pareuloma was considered by Rasetti to be of Early Ordovician age. The occurrence of *P. spinosa* n. sp. in beds of probable late Franconian age requires either an extension of the range of *Pareuloma* or a reconsideration of the age of the fauna described by Rasetti.

Pareuloma spinosa n. sp.

Plate 11, figures 1–9

Description.—Cranidium, exclusive of posterior limbs, subquadrate; anterior margin nearly straight. Glabella moderately convex transversely, gently convex longitudinally, tapered forward, truncate anter-

riorly, well defined by deep axial and preglabellar furrows. Two pairs of short glabellar furrows present at sides of glabella. Occipital furrow broad, deep, straight. Occipital ring has large straight median spine directed upward and backward; large axial node present on base of spine. Frontal area long, moderately arched in lateral profile; sagittal length equal to or slightly less than sagittal length of glabella, exclusive of occipital ring. Border narrow, convex, separated from brim by narrow moderately shallow border furrow; sagittal length slightly more than one-fourth sagittal length of brim. Brim has broad, low, poorly defined median swelling. Fixed cheek wide, moderately to strongly convex, strongly upsloping near glabella, slightly downsloping near palpebral lobe; width slightly more than three-fourths basal glabellar width. Palpebral lobe small; situated opposite anterior third of glabella, connected to glabella by narrow well-defined slightly curved ocular ridge. Exsagittal length of palpebral lobe about one-half or slightly less than one-half sagittal length of glabella, exclusive of occipital ring. Posterior limb long, tapered; transverse length significantly greater than basal glabellar width. Posterior border furrow broad, deep. External surfaces variably covered with closely spaced fine granules and scattered coarse granules. Many coarse granules have median perforations.

Course of anterior section of facial suture slightly divergent forward from palpebral lobe to border furrow, then curved abruptly inward across border and along anterior margin nearly to axial line. Ventral course not known. Course of posterior section of facial suture divergent and sinuous.

Free cheek has broad gently convex ocular platform. Lateral border narrow, moderately to strongly curved, well defined by moderately broad border furrow that is continuous with posterior border furrow, but shallow at genal angle. Genal spine long, slender, curved, at distinct angle to cheek margin and advanced in front of genal angle of cephalon; length greater than length of posterior section of facial suture. External surface variably covered with fine closely spaced granules and scattered coarse granules.

Pygidium transverse; greatest width about three times length. Axis moderately short, bluntly terminated, not quite extended to border. One shallow ring furrow present posterior to articulating furrow. Pleural region gently convex, subtriangular. Pleural field crossed by two broad shallow pleural furrows. Border narrow, convex; width constant. External surface covered with closely spaced fine granules and scattered coarse granules.

Discussion.—The external ornamentation of *Pareuloma spinosa* n. sp. is remarkably variable. Some cranidia have predominantly closely spaced fine granular ornamentation on all parts (pl. 11, fig. 4); some clearly have two sizes of granules on all parts (pl. 11, figs. 1–2); some have two sizes of granules, but the fine granular ornamentation is present only on the more convex parts of the fixed cheeks and glabella (pl. 11, fig. 3); and some have only closely spaced fine granules confined to the top of the glabella and posterior parts of the fixed cheeks (pl. 11, fig. 8). Free cheeks are relatively rare but show comparable variability. Extremes of ornamentation have been obtained from the same collection. No consistent pattern can be determined, although the smaller specimens tend to be the smoothest. Except for ornamentation, all the cranidia share the characters given in the description, and I consider them to represent a single unusually variably species.

Pareuloma spinosa n. sp. differs most significantly from *P. impunctata* Rasetti and *P. brachymetopa* Rasetti (1954) by having longer palpebral lobes and a prominent occipital spine. Both of Rasetti's species are from rocks believed to be of Early Ordovician age.

Occurrence.—Franconian–2 fauna. Moderately common (18 cranidia, 2 free cheeks), GSC colln. 4649 (= 4704); moderately rare (6 cranidia, 2 free cheeks, 2 thoracic segments, 1 pygidium), GSC colln, 4661 (= 4705); rare (2 cranidia), USGS colln. 4358–CO; ? cranidium, USGS colln. 4357–CO; all from Hillard Peak area.

Family REMOPLEURIDIDAE Hawle and Corda
Subfamily RICHARDSONELLINAE Raymond

Genus RICHARDSONELLA Raymond

Richardsonella Raymond, 1924, p. 440; Rasetti, 1944, p. 255; Whittington, in Harrington and others, 1959, p. 329; Balashova, 1960, p. 115.

Type species.—Dikelocephalus megalops Billings, 1860, p. 311, fig. 309.

Discussion.—Rasetti (1944) has reviewed the content and concept of *Richardsonella* and has given a diagnosis that represents the currently accepted understanding of the generic characteristics. However, study of the Alaskan trilobites referable to *Richardsonella* and of contemporary related trilobites from undescribed faunas in Nevada indicates that there are possibly two or three genera now included in the concept of *Richardsonella*. Trilobites representing these genera have nearly indistinguishable cranidia, but strikingly different pygidia and perhaps different free cheeks. Pygidia of one of these genera, typified

by *R. quadrispinosa* n. sp. have a long multisegmented axis, and four or more slender border spines. Associated cranidia have nearly straight glabellar sides. At least two species of this genus are present in the Nevada faunas where pygidia of one of them were mistakenly associated with the cranidium of *Tostonia iole* by Walcott (1925, pl. 18, figs. 13, 14). A second kind of pygidium that has a short axis, few axial segments, and short border spines is associated with cranidia that have the glabellar sides slightly bowed outward between the palpebral lobes. This generic type is represented by *R. unisulcata* Rasetti (1944, pl. 39, figs. 54–56). A third genus that would be included in *Richardsonella* if only the cranidium were known is represented by undescribed complete specimens in Nevada that have pygidia lacking any border spines and having a straight-sided glabella. Species of the first two generic types are associated in Nevada.

Most of the species included in *Richardsonella* by Rasetti are known only from cranidia. These species, and undescribed species from Nevada, include all gradations in glabellar shape from straight-sided forms to forms having the sides slightly bowed, and this character alone may not be a reliable generic criterion. All the species assignable to *Richardsonella* s. l. are from beds of Franconian or younger age. *Richardsonella*, as now used, seems to represent a larger taxon comparable to the Aphelaspidinae (Palmer, 1965) in which accurate generic assignment cannot be made from cranidia alone. Unfortunately the type species of *Richardsonella*, *R. megalops* (Billings), is known only from cranidia, and thus which, if any, of the three generic types mentioned above can correctly be called *Richardsonella* in the strict sense cannot be determined at present. Because this problem cannot be resolved using the Alaskan material, *Richardsonella* is used here in the broad sense with the understanding that *R. quadrispinosa* n. sp. may not really be congeneric with *R. nuchastria* n. sp.

Richardsonella nuchastria n. sp.

Plate 14, figures 10–11

Description.—Cranidium elongate, slightly pointed anteriorly. Glabella low, gentle convex transversely and longitudinally, tapered forward, bluntly rounded anteriorly, well defined all around by abrupt change in slope of exoskeleton; sides slightly sigmoid in dorsal view. Glabellar furrows absent. Occipital furrow deep, straight. Occipital ring nearly flat, simple. Frontal area narrow, flared strongly towards anterolateral cranidial corners; sagittal length slightly more than one-third sagittal length of glabella exclusive of occipital ring. Border flat or slightly convex, well defined by shallow border furrow that has many closely spaced pits; sagittal length variable, equal to or slightly less than sagittal length of flat downsloping brim. Fixed cheek very narrow; width, exclusive of palpebral lobe, slightly variable, one-sixth or less basal glabellar width. Palpebral lobe large, long, arcuate; width greater than width of infraocular cheek; exsagittal length about two-thirds sagittal length of glabella, exclusive of occipital ring. Transverse line through occipital furrow passes just posterior to tips of palpebral lobes. Posterior limb not known. External surfaces of all parts except occipital ring, and posterior part of glabella on some specimens, smooth. Occipital ring has well-defined terrace lines.

Course of anterior section of facial suture strongly divergent forward from palpebral lobe to anterior margin, then turned inward to intersect anterior margin near axial line.

Discussion.—This species is most similar to *Richardsonella unisulcata* Rasetti from which it differs by lacking distinct glabellar furrows and by having the terrace-line ornamentation confined principally to the occipital ring. The lack of well-defined glabellar furrows also distinguishes *R. nuchastria* n. sp. from all the other species except *R. cristata* (Billings). However, *R. cristata* has a peculiar highly convex posterior part to the glabella and fully developed terrace-line ornamentation on all parts.

Occurrence.—Trempealeauan–1 fauna. Moderately rare (6 cranidia), USGS colln. 3834–CO; rare (1 cranidium), USGS colln. 3833–CO; (2 cranidia), USGS colln. 4362–CO; all from Jones Ridge area (south end).

Richardsonella quadrispinosa n. sp.

Plate 14, figures 1–4

Description.—Cranidium elongate, evenly rounded anteriorly. Glabella large, low, gently convex transversely and longitudinally, tapered slightly forward, bluntly rounded anteriorly, well defined by abrupt change in slope of exoskeleton surface. Two pairs of shallow straight oblique glabellar furrows present; posterior pair deepest. Occipital furrow broad, deep, straight. Occipital ring simple. Frontal area short, slightly downsloping; sagittal length slightly more than one-third sagittal glabellar length, exclusive of occipital ring. Border narrow, convex, well defined by gently curved, moderately deep border furrow; sagittal length equal to or slightly less than sagittal length of flat brim. Fixed cheek narrow, nearly horizontal; width, exclusive of palpebral lobe, variable between one-third and one-fifth basal glabellar width, greatest on small specimens. Palpebral lobe large, strongly curved, well defined by moderately deep

curved palpebral furrow; width slightly less than width of infraocular part of cheek; exsagittal length about eight-tenths sagittal length of glabella, exclusive of occipital ring; transverse line across occipital furrow passes over posterior ends of palpebral lobes. Posterior limb long, slender.

Course of anterior section of facial suture strongly divergent forward from palpebral lobe to border furrow, then turned abruptly inward and intramarginal around anterior cranidial margin. Connective sutures absent. Course of posterior section of facial suture strongly divergent and sinuous.

Free cheek narrow; lateral margin evenly curved. Lateral border flattened, well defined by narrow deep lateral border furrow that joins posterior border furrow with sharp angle at base of genal spine; width at anterior margin about one-half width of ocular platform. Genal spine long, slender, flattened; length exceeds three times length of posterior section of facial suture.

Pygidium semielliptical. Axis narrow, convex, tapered posteriorly nearly to inner edge of border, continued posteriorly by narrow postaxial ridge that extends onto border. Four distinct ring furrows present posterior to articulating furrow. Pleural regions convex; border moderately well defined by shallow border furrow. Three or four broad, shallow pleural furrows present; anterior two pairs continued laterally into the bases of border spines. Interpleural furrows barely apparent. Border narrower than pleural field, bears four pairs of flattened border spines; three anterior pairs moderately long, posterior pair short.

External surfaces of all parts of exoskeleton covered with a fine swirling pattern of terrace lines.

Discussion.—The cranidium of *Richardsonella quadrispinosa* n. sp. is most similar to that of the type species, *R. megalops* (Billings). The principal difference is that *R. quadrispinosa* has a relatively broader border. The posterior pair of glabellar furrows is also shallower than those on *R. megalops*. The long multisegmented pygidial axis and long pygidial border spines distinguish this species from other *Richardsonella* species for which either the pygidium or the free cheek are known.

Richardsonella unisulcata Rasetti, *R. subcristata* Rasetti, and *R. eurekensis* Kobayashi all have pygidia with short axes, broad borders, and short border spines. They are probably not congeneric with *R. quadrispinosa* n. sp. However, it is not possible at present to determine the full characteristics of the genotype, *R. megalops*, and thus to decide which species should be retained in *Richardsonella*. (See generic discussion.)

Occurrence.—Franconian–2 fauna. Moderately common (6 cranidia, 4 free cheeks, 6 pygidia), USGS colln, 3709–CO; 12 cranidia, 6 free cheeks, 4 pygidia, USGS colln. 4355–CO; both from Hillard Peak area.

Richardsonella cf. R. quadrispinosa n. sp.

Plate 14, figures 7, 8

Discussion.—A species of *Richardsonella* represented only by cranidia and free cheeks is present in beds slightly older than those containing undoubted specimens of *R. quadrispinosa*. It differs from *R. quadrispinosa* principally by having smaller infraocular cheeks on the cranidium so that the width of the palpebral lobe is slightly more than the width of the infraocular cheek. This difference may not be significant, but without associated pygidia which would have more definitive characteristics, the degree of relationship to *R. quadrispinosa* cannot be determined.

Occurrence.—Franconian–2 fauna. Moderately common (4 cranidia, 2 free cheeks), USGS colln. 4358–CO; 6 cranidia, USGS colln. 4356–CO; rare (2 cranidia), USGS colln. 4357–CO; moderately rare (4 cranidia, 2 cheeks, 1 small poorly preserved nearly complete individual lacking pygidium), GSC colln. 4661 (= 4705), all from Hillard Peak area.

Richardsonella sp. 1.

Plate 14, figure 9

Discussion.—A single cranidium associated with *Richardsonella nuchastria* n. sp. represents another species of *Richardsonella*. This cranidium has distinct terrace lines on the occipital ring and very faint terrace lines on the border; the border is slightly longer than the brim; two shallow glabellar furrows are present; and a transverse line across the occipital ring passes over the posterior tips of the palpebral lobes. These differences seem to be at least specific differences, but without more specimens in the sample, the possibility of unusual variation cannot be eliminated and the specimen is not formally named here.

Occurrence.—Trempealeauan–1 fauna. Rare (1 cranidium), USGS colln. 4362–CO, Jones Ridge area.

Richardsonella? sp. 2

Plate 14, figure 16

Discussion.—A single incomplete pygidium seems to represent a species that is congeneric with *Richardsonella quadrispinosa* n. sp. but differs by having six pairs of border spines and at least five distinct ring furrows and pleural furrows. Fragmentary *Richardsonella* cranidia associated with this pygidium have an unfurrowed glabella with the sides slightly bowed outward, relatively short palpebral lobes that are close

to the glabella, and no apparent surface ornamentation. None of these cranidia are well enough preserved for illustration. Although they could be conspecific with the pygidium, the slightly bowed glabellar sides are not characteristic of species of the *R. quadrispinosa* species group to which the pygidium belongs. Cranidia of this type from Nevada belong to species of the *R. eurekensis* species group. More information is needed about the Alaskan specimens before they can be satisfactorily identified.

Occurrence.—Trempealeauan–1 fauna. Rare (1 pygidium), USGS colln. 3835–CO, Jones Ridge area (South end).

Richardsonella sp. 3.

Plate 14, figures 5, 6

Discussion.—Several pygidia have a short tapered axis that does not quite reach to the inner margin of a broad border. The margin of the border is not preserved, but a median notch is indicated. The axis has two ring furrows posterior to the articulating furrow and a postaxial ridge that extends onto the border. The entire outer surface is covered with the characteristic swirling terrace lines of *Richardsonella.* Although the specimens are not well enough preserved for specific identification, they retain enough distinctive features to show that they are probably congeneric with pygidia assigned to *R. unisulcata* Rasetti and *R. eurekensis* Kobayashi. The pygidia are associated with pygidia of *R. quadrispinosa* n. sp.

One of the collections (USGS colln. 3709–CO) containing *Richardsonella quadrispinosa* also has a second kind of *Richardsonella* cranidium that differs from *R. quadrispinosa* by having much more widely flared anterior branches of the facial sutures and a relatively broad infraocular cheek—probably the cranidium of the trilobite represented by the pygidium described above. The specimens are illustrated here to show that two strikingly different kinds of richardsonellids, both presently assigned to *Richardsonella*, are found together in Alaska as well as in Nevada.

Occurrence.—Franconian–2 fauna. Moderately common (5 pygidia), USGS colln. 4355–CO; rare (1 cranidium, 1 pygidium), USGS colln. 3709–CO; both from Hillard Peak area.

Richardsonella sp. 4

Plate 14, figure 12

Discussion.—A single incomplete cranidium represents an unusually ornamented species of *Richardsonella* that is not represented by adequate material for separate naming. The glabella has barely apparent, narrow glabellar furrows, the infraocular cheeks are narrower than the palpebral lobes, the facial sutures are strongly flared anterolaterally, and the border is narrower than the brim. The glabella has low coarsely developed terrace lines, and the occipital ring bears large scattered pustules. No other Alaskan species of the Richardsonellidae has ornamentation comparable to this species.

Occurrence.—Trempealeauan–1 fauna. Rare (1 cranidium), GSC colln. 4671, Jones Ridge section.

Family SOLENOPLEURIDAE Angelin

Genus GELASENE n. gen.

Type species.—*Gelasene acanthinos* n. sp.

Diagnosis.—Micropygous Solenopleuridae. Cephalon has short frontal area; well-defined anteriorly tapered glabella bearing three pairs of deep subparallel oblique furrows; deep pits in axial furrows just anterior to junctions with ocular ridges; broad fixed cheeks; moderately small medially situated palpebral lobes; broad free cheeks; and long slender slightly advanced genal spines. Thorax has pleural regions horizontal except for depressed tips of segments. Pygidium minute; axis large, poorly defined, occupies most of pygidium, consists of one segment and terminal part. Surfaces of all convex parts have strong granular ornamentation.

Discussion.—The diagnosis of *Gelasene* gives the characteristics of the type species that are of probable generic significance. The overall structure of the cephalon, particularly the glabellar shape, wide fixed cheeks, and granular ornamentation indicate affinities with the Solenopleuridae. The deep axial pits and glabellar furrows on the cranidium and general spinosity distinguish the type species from all described trilobites.

Gelasene acanthinos n. sp.

Plate 2, figures 1–3, 5, 6; text figure 6.

Description.—Body subovate, maximum estimated length about 45 mm. Cephalon moderately convex transversely and longitudinally; width about twice length; sagittal length slightly less than one-half total body length; genal spines slightly advanced. Glabella moderately to strongly convex transversely and longitudinally, well defined at sides by broad deep axial furrows that terminate just anterior to proximal ends of ocular ridges in deep circular pits. Broad shallow depressions extend anterolaterally from these pits to border furrow. Glabellar sides bowed slightly outward between occipital furrow and first glabellar furrow, then convergent forward to strongly rounded glabellar front just before reaching the border. Three pairs of deep nearly straight subparallel glabellar

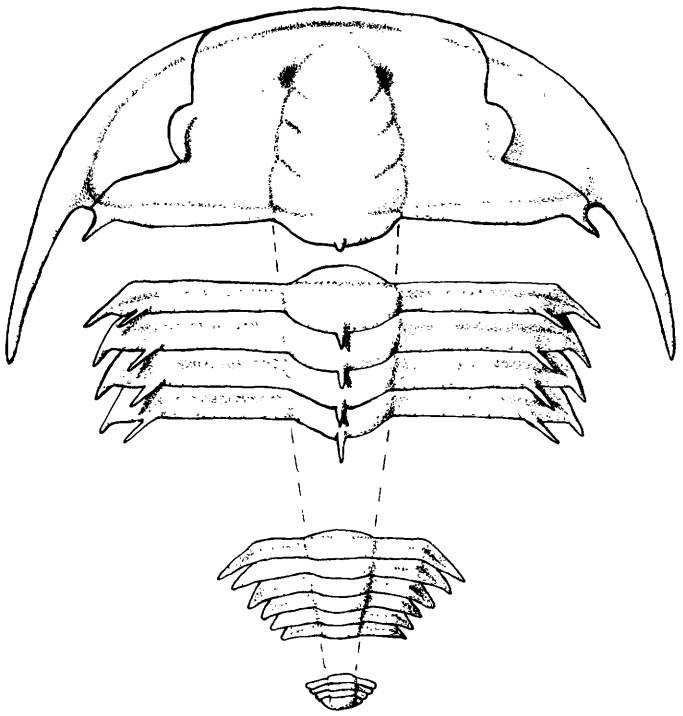

FIGURE 6.—Reconstruction of dorsal view of *Gelasene acanthinos* n. gen., n. sp. × 2.

furrows extend inward and backward from axial furrows about one-third width of glabella. Occipital furrow straight, deepest distally. Occipital ring convex, with short slender median spine directed at steep angle from posterior part. Frontal area short; sagittal length about one-fifth sagittal glabellar length, exclusive of occipital ring. Border convex, of nearly constant width. Brim narrow in front of glabella, slightly concave; lateral parts gently convex, strongly downsloping to broad shallow border furrow. Fixed cheek wide, moderately convex, upsloping; width, exclusive of palpebral lobes, generally slightly more than one-half basal glabellar width. Ocular ridge slender, nearly straight, continuous with inner end of palpebral lobe. Palpebral lobe strongly arcuate, well defined by palpebral furrow, situated opposite middle third of glabella; length about one-third sagittal glabellar length, exclusive of occipital ring. Posterior limb long, slender, tapered slightly distally, strongly rounded a tip. Posterior border furrow broad, deep. Anterior section of facial suture curved slightly outward from palpebral lobe to border furrow, then curved strongly inward to cut anterior margin near anterolateral cranidial corner. Posterior section of facial suture directed strongly outward in nearly straight line to border furrow, then curved abruptly backward to cranidial margin.

Free cheek has broad gently convex ocular platform and well-defined convex border that increases slightly in width towards genal spine. Lateral and posterior border furrows continuous. Genal spine long, slender, slightly curved at tip; length about twice length of posterior section of facial suture. Posterior section of facial suture cuts margin near base of genal spine. Eye surface separated from ocular platform only by abrupt change in slope.

Ornamentation of cephalon consists of close-spaced fine granules on all parts, including furrows, and abundant coarse granules and spinules on all parts except furrows and brim immediately anterior to glabella. Posterior limbs have short slender posterior fixigenal spines near distal ends. Some cranidia have few low longitudinal ridges on brim in front of glabella.

Thorax consists of more than 15 segments; sides convergent posteriorly; length unknown. Pleural regions of each segment nearly horizontal except for depressed distal tips; pleural furrows broad, deep, nearly straight. Tips of each segment pointed. First four or five segments have slender median axial spines that decrease in length posteriorly. Posterior border of each of these segments has long slender posterolaterally directed spine at geniculation. Remaining thoracic segments have no apparent axial spines or spines at geniculation. Ornamentation consists of closely spaced fine granules in pleural furrows and abundant coarse granules and spinules on all convex parts.

Pygidium tiny, consists of one segment and a terminal part; axis occupies nearly all of surface. Border not apparent. Ornamentation consists only of close-spaced coarse granules.

Hypostome not known.

Discussion.—The external ornamentation of *Gelasene acanthinos* is unusual for Early Cambrian trilobites. Several fragments show that many of the coarse "granules" on the outer surface of the exoskeleton are actually bases of small spinules. Thus, in addition to an occipital spine, short posterior fixigenal spines, nearly vertical axial spines, and posterolaterally directed spines at the geniculations of the anterior thoracic segments, the convex surfaces of the cephalon and at least the anterior part of the thorax bristled with spinules.

The only significant variability noted in this species is a decrease in convexity of the glabella from the smallest cranidium, 3 mm long, to the largest cranidium, 20 mm long. Differences in ornamentation are apparent only between the external surface and the surface of the mold. Although coarse granular ornamentation of the convex surfaces is present on both, the fine granular ornamentation of the furrows is present only on the external surface.

Occurrence.—Early Cambrian–1 fauna. Moderately common (more than 20 cranidia, several free cheeks, and parts of thoraxes including 2 with attached pygidia), USGS colln, 4296–CO, Yukon River (Water Level) area.

Unassigned Trilobites
Genus ALOKISTOCARE? Lorenz

cf. Alokistocare lobatum Rasetti

Plate 5, figure 17

Alokistocare lobatum Rasetti, 1963, p. 577, pl. 67, fig. 10.

Description.—Cranidium gently to moderately convex transversely and longitudinally. Glabella well defined by shallow axial and preglabellar furrows, sides slightly concave, anterior end bluntly rounded. Three pairs of shallow straight glabellar furrows present. Occipital furrow straight, narrow. Frontal area moderately broad, concave. Border narrow, convex, well defined by moderately deep evenly curved border furrow. Secondary transverse furrow outlines triangular area on brim adjacent to axial part of border. Sagittal length of frontal area slightly less than one-half sagittal glabellar length, exclusive of occipital ring. Fixed cheeks moderately broad, convex. Ocular ridge moderately distinct, directed posterolaterally from near anterior end of glabella. External surfaces of all parts covered with closely spaced fine granules and scattered coarse granules. Brim shows obscure longitudinal veination.

Discussion.—A single fragmentary cranidium associated with *Spencella montanensis* Rasetti in the Alaskan material is very similar to a single cranidium described as *Alokistocare lobatum* by Rasetti from a boulder including *S. montanensis* in Quebec. The Alaskan specimen lacks its palpebral lobes, occipital ring, and posterior limbs and cannot be adequately compared at the species level. It is certainly congeneric with *A. lobatum* and is illustrated here to emphasize the similarity between the Middle Cambrian faunas of Alaska and Quebec. Two other congeneric forms are *A. sinuatum* Rasetti and *A. cataractense* Rasetti, from the *Bathyuriscus-Elrathina* zone of the Stephen Formation in British Columbia.

Occurrence.—Middle Cambrian–1 fauna. Rare (1 cranidium), USGS colln. 4424–CO, Yukon River (Adams Peak) area.

Genus ASIOCEPHALUS n. gen.

Type species.—*Asiocephalus indigator* n. sp.

Description.—Cranidium, exclusive of posterior limbs, subquadrate; anterior margin very slightly pointed. Glabella elongate, moderately convex transversely, gently convex longitudinally, well defined by shallow axial and preglabellar furrows; sides subparallel, anterior end strongly and evenly rounded. Three or four pairs of glabellar furrows present, represented by pits that are isolated from axial furrows. Glabellar furrows increase in size and depth posteriorly. Axial glabellar node located between posterior pair of glabellar furrows. Occipital furrow straight, deep distally, shallow across axial line. Occipital ring simple. Frontal area gently concave, not clearly subdivided in front of glabella; border furrow extremely shallow, curved inward and backward to anterior end of glabella to form broad obscurely defined plectrum; sagittal length of frontal area about one-half sagittal length of glabella, exclusive of occipital ring. Fixed cheek moderately wide, nearly horizontal; width, exclusive of palpebral lobe about one-half the basal glabellar width. Palpebral lobe short, strongly curved, moderately well defined by shallow, curved palpebral furrow, situated opposite anterior half of glabella; exsagittal length about three-eighths sagittal glabellar length, exclusive of occipital ring. Ocular ridge low, extended straight inward from palpebral lobe to axial furrow at right angle to axial line. Posterior limb moderately large; transverse length probably as great or greater than basal glabellar width.

Course of anterior section of facial suture moderately divergent forward from palpebral lobe nearly to anterior margin, then curved abruptly inward and continued nearly to axial line where it turns and continues ventrally across doublure as median suture. Course of posterior section convex, nearly parallel to lateral cephalic margin.

Free cheek elongate, gently convex. Border poorly defined, concave. Lateral border furrow shallow. joins shallow posterior border furrow in sharp curve at genal angle. Width of border at anterior sutural margin about two-thirds width of ocular platform. Genal spine very slender, flat; lateral margin continuous with lateral margin of cheek. Inner spine angle obtuse. Length of genal spine about equal to length of posterior section of facial suture. Anterior doublure expanded towards axial line, sharply truncated by median suture.

Thorax and hypostome not known.

Pygidium semicircular, gently convex transversely and longitudinally. Axis slender, tapered slightly posteriorly; length about five-sixths total pygidial length. Five or six shallow ring furrows present posterior to articulating furrow; anterior furrows deepest. Pleural region broad, gently convex, width slightly more than twice width of axis. Six pleural segments represented by plueral and interpleural furrows of approximately

equal depth and even spacing. Furrows extend across most of pleural region but do not reach to margin. First pleural segment may or may not be produced into short sharp marginal spine. Posterior margin has slight median indentation, more pronounced on larger specimens.

Surfaces of all parts except ocular platform smooth. Ocular platform has closely spaced veination.

Discussion.—The glabellar pits, median glabellar node, anteriorly placed palpebral lobes, and poorly defined plectrum indicate the close relationship of *Asiocephalus* with *Hedinaspis*, a widespread Asiatic Late Cambrian genus. It differs from *Hedinaspis* by having a large multisegmented pygidium, relatively large palpebral lobes, and an obscure ocular ridge. The first pygidial segment indicates that the thoracic segments may have lacked the distinctive narrow anterior and posterior bands that characterize all species of *Hedinaspis*, and the pleural spines may have been longer. No previously described North American trilobite can be compared with *Asiocephalus*.

Asiocephalus indigator n. sp.

Plate 13, figures 17–22

Discussion.—*Asiocephalus indigator* n. sp. is the only species presently known in *Asiocephalus*, and the generic description is therefore also a description of the species. Anterolateral spines are absent from two pygidia, developed only on the left side of one specimen, and present on a fourth specimen that has only the right side preserved. The potential for developing lateral spines from the first pygidial segment, together with the characteristic presence of an axial glabellar node, suggests that this trilobite may be related to the Ceratopygidae.

Occurrence.—Franconian–2 fauna. Moderately rare (5 cranidia, 3 free cheeks, 5 pygidia), GSC colln. 4661 (= 4705), Hillard Peak area.

Genus BRABBIA n. gen.

Type species.—*Brabbia pustulomarginata* n. sp.

Description.—Cephalon transversely subquadrate; sagittal length about one-half width between bases of genal spines. Genal spines advanced, directed posterolaterally in broad curve. Cranidium subquadrate; anterior margin gently curved; constricted between palpebral lobes. Glabella large, long, moderately convex transversely and longitudinally, well defined by narrow axial furrows, sides subparallel or very slightly tapered forward, anterior end bluntly rounded, tangent to border furrow. Two pairs of glabellar furrows barely apparent; posterior pair directed obliquely backward. Occipital furrow deep, straight. Occipital ring has prominent median node. Frontal area consists entirely of convex border that has outer part flattened and downsloping; sagittal length about one-fifth sagittal length of glabella, exclusive of occipital ring. Border furrow deep, nearly straight. Fixed cheek narrow, slightly upsloping; width, exclusive of palpebral lobe, slightly more than one-fourth basal glabellar width. Palpebral lobe moderately large, arcuate; defined by shallow, curved palpebral furrow, situated opposite posterior third of glabella; exsagittal length one-half or slightly more than one-half sagittal length of glabella, exclusive of occipital ring. Eye ridge short, poorly defined, connects palpebral lobe to axial furrow near anterior glabellar furrow. Posterior limb slender, tapered to sharp point; transverse length slightly less than basal glabellar width.

Course of anterior section of facial suture strongly divergent forward from palpebral lobe to border furrow, then curved inward across border; further course not known. Course of posterior section of facial suture strongly divergent and sinuous.

Free cheek broad, subtriangular. Border well defined in anterior part by deep lateral border furrow that disappears near base of genal spine. Posterior border furrow deep, not connected to lateral border furrow. Genal spine moderately long, flattened; length slightly more than length of posterior section of facial suture. Inner spine angle generally obtuse; slightly acute on partly crushed complete cephalon.

Surfaces of all parts exoskeleton except top of border smooth. Top of border has transverse row of pustules best developed on surface of mold. All furrows much deeper on surface of mold.

Discussion.—*Brabbia* is characterized by its nearly unfurrowed parallel-sided glabella that reaches to the border furrow, narrow fixed cheeks, relatively large posteriorly placed palpebral lobes, moderately broad convex border, and slightly advanced genal spines. It seems to be most nearly related to the Saukiidae but differs from all genera in that family by lacking deep posterior glabellar furrows that are connected across the glabella.

The glabellar shape and relative size indicate a possible relationship to *Leiostegium* and the Leiostegiidae, but the palpebral lobes are smaller than those of *Leiostegium* and the eye ridge intersects the glabella much farther from the anterior end than in *Leiostegium*. Without knowledge of a pygidium for the type species of *Brabbia*, its proper assignment to either the Saukiidae or Leiostegiidae, which have unlike pygidia, cannot be determined.

Brabbia pustulomarginata n. sp.

Plate 11, figures 10–13

Disussion.—*Brabbia pustulomarginata* n. sp. is the only species presently assigned to *Brabbia*, and its characteristics are given in the description of the genus. A possibly related species has been described by Lochman and Hu (1959, p. 413, pl. 57, figs. 2, 22) as *Leiostegium*? sp. It is represented only by a single imperfect cranidium having a granular surface and the glabella extending slightly onto the border; the cranidium is from a fauna comparable in age to the fauna from which *B. pustulomarginata* was obtained.

Fragmentary cranidia and an isolated free cheek associated with the complete cephalon in GSC colln. 4661 are indistinguishable from the slightly younger specimens in USGS colln. 4358–CO and show that the apparent differences in appearance of the frontal area and inner spine angle on the free cheek are due to either size differences or infraspecific variation.

Occurrence.—Franconian–2 fauna. Common (more than 10 cranidia, 3 free cheeks), USGS colln. 4356–CO; rare (2 cranidia), USGS colln. 4358–CO; moderately rare (1 cephalon, 4 cranidia, 1 free cheek), GSC colln. 4661 (= 4705); all from Hillard Peak area. ?Rare (1 fragmentary cranidium), USGS colln. 4379–CO, Montauk Bluff area.

Genus COMANCHIA Frederickson

Comanchia Frederickson, *in* Wilson and Frederickson, 1950, p. 900; Lochman, 1959, p. 252; Palmer, 1965, p. 82.

Type species.—*Ptychopleurites amplooculata* Frederickson, 1948, p. 802, pl. 123, figs. 9–11.

Diagnosis.—Glabella low, subquadrate, tapered slightly forward, bluntly rounded anteriorly. Posterior pair of glabellar furrows moderately distinct, narrow, directed obliquely inward and backward from axial furrows. Frontal area short. Border convex, well defined by narrow evenly curved border furrow; width nearly constant. Fixed cheeks very narrow, flat or gently upsloping; width, including palpebral lobe, one-third or less than one-third basal glabellar width. Posterior limbs slender.

Anterior sections of facial sutures slightly divergent forward from palpebral lobes; intersect anterior margin about in front of anterolateral corners of glabella.

Free cheek has narrow border well defined by narrow lateral border furrow of nearly constant depth that intersects posterior border furrow at acute angle at base of genal spine.

Discussion.—The diagnosis given above presents the salient features of the cranidium and free cheek of *Comanchia* that relate to the Alaskan trilobites here assigned to that genus. A full description of the genus is given elsewhere (Palmer, 1965).

Comanchia burlingi n. sp.

Plate 9, figures 26, 27

Description.—Cranidium subquadrate, gently rounded at front, gently to moderately convex transversely and longitudinally. Glabella low, subquadrate, tapered slightly forward, bluntly rounded anteriorly. Two posterior pairs of glabellar furrows distinct, narrow, shallow; posterior pair directed obliquely backward and inward from axial furrow. Occipital furrow moderately broad, straight. Occipital ring has tiny median node. Frontal area short, subequally divided into narrow convex border and flat brim by moderately deep evenly curved border furrow; sagittal length between one-third and one-half sagittal length of glabella, exclusive of occipital ring. Fixed cheek narrow, gently upsloping; width, including palpebral lobe, about one-third basal glabellar width. Palpebral lobe large, curved, well defined by arcuate palpebral furrow; exsagittal length about two-thirds sagittal length of glabella, exclusive of occipital ring. Posterior limb slender.

Course of anterior section of facial suture moderately to strongly divergent forward from palpebral lobe to border furrow in sinuous course, then curved sharply inward and across border to intersect anterior margin about opposite anterolateral corner of glabella. Course of posterior section strongly divergent and sinuous.

Free cheek nearly flat. Lateral margin moderately curved, continuous with margin of slender genal spine; length of spine slightly more than length of posterior section of facial suture. Lateral and posterior border furrows moderately deep, of nearly equal and constant depth, joined at acute angle near base of genal spine.

External surfaces of all parts smooth.

Discussion.—*Comanchia burlingi* n. sp. differs from the others presently assigned to *Comanchia* by having a relatively longer frontal area and longer palpebral lobes. In addition, the facial sutures are more anteriorly flared than *C. prior* Kurtz (in Bell and others, 1952), which has a subequally divided frontal area; and *C. burlingi* has a longer brim on the cranidium, and a longer genal spine and narrower border on the free cheek than either *C. amplooculata*, *C. lippa* Grant, or *C. minor* Palmer.

This species is the oldest presently assigned to *Comanchia*. *C. prior* is intermediate in age between *C. burlingi* and the *Irvingella* subzone species *C. amplooculata*, *C. lippa*, and *C. minor*. Two possible

morphologic trends within the genus are now indicated. The length of the frontal area and length of the palpebral lobes both decrease progressively from the oldest species to the youngest species. The ancestory of *Comanchia* is still not apparent, however, among other trilobites of the Pterocephaliid biomere (Palmer, 1965).

Occurrence.—Dresbachian–2 fauna. Rare (1 cranidium, 1 free cheek), GSC colln. 4645; 1 cranidium, GSC colln. 4643; 1 cranidium, GSC 4646; all from a 4-foot interval in Burling's measured section, Hillard Peak area.

Genus DRUMASPIS Resser

Drumaspis Resser, 1942b, p. 4, 28; Shimer and Shrock, 1944, p. 623; Kobayashi, 1954, p. 36; Lochman, 1959, p. 297; Grant, 1962, p. 983; Bell and Ellinwood, 1962, p. 390; Grant, 1965, p. 1140.

Type species.—*Drumaspis walcotti* Resser, 1942b, p. 28, pl. 4, figs. 37–41.

Discussion.—Grant (1962) has given a thorough description of *Drumaspis* to which the Alaskan specimens conform in all respects.

Drumaspis idahoensis Resser

Plate 13, figures 1–5

Drumaspis idahoensis Resser, 1942b, p. 29, pl. 4, figs. 32–36; Shimer and Shrock, 1944, pl. 264, figs. 31, 32; Grant, 1965, p. 115, pl. 14, figs. 11–12.

Drumaspis deckeri Resser, 1942b, p. 31, pl. 5, figs. 14–16; Bell and Ellinwood, 1962, p. 391, pl. 52, figs. 10–12, 15.

Drumaspis utahensis Resser, 1942b, p. 34, pl. 5, figs. 31–33.

Description.—Cranidium subtrapezoidal, tapered forward. Glabella large, low, well defined at sides and anterior end by abrupt change in slope of exoskeleton surface, tapered slightly forward; anterior end blunt, has slight median indentation, slightly overhangs brim; transverse convexity gentle across top of glabella, abruptly curved down at glabellar sides. Three pairs of glabellar furrows present; anterior pair short, transverse, narrow, shallow, isolated on anterior part of glabella; middle pair narrow, straight, moderately deep, connected to lateral glabellar margin; posterior pair deep, narrow, oblique to glabellar margin on lateral parts of glabella, connected straight across top of glabella by broad shallow furrow. Occipital furrow deep, straight, narrow. Occipital ring gently convex, lacks node or spine. Frontal area short; sagittal length slightly less than one-sixth sagittal glabellar length exclusive of occipital ring. Border convex, widest on axial line; sagittal length about twice sagittal length of narrow brim. Fixed cheek moderately wide, gently convex, downsloping; width, exclusive of palpebral lobe, variable from slightly less than one-third to about one-half of basal glabellar width, greatest on small specimens. Palpebral lobe long, narrow, arcuate, well defined by broad deep curved palpebral furrow; anterior end adjacent to anterior end of glabella; exsagittal length decreases during ontogeny from slightly less than sagittal glabellar length, exclusive of occipital ring, on specimens less than 2 mm long to about five-eighths sagittal glabellar length on specimens 6 mm long; line connecting widest part of cranidium at palpebral lobes crosses glabella just posterior to middle pair of glabellar furrows. Posterior limb moderately long; distal part triangular, strongly downsloping. Posterior border furrow broad, deep. External surface roughened but lacks well-defined ornamentation.

Course of anterior section of facial suture slightly convergent forward from palpebral lobe to border, then turned inward in straight line across border to intersect anterior margin of cranidium on axial line. Course of posterior section of facial suture divergent and sinuous.

Free cheek small, narrow. Border gently curved, convex, well defined by lateral border furrow; width greater than width of ocular platform at anterior sutural margin. Posterior part of ocular platform subtriangular. Form of genal spine not known.

Discussion.—*Drumaspis idahoensis* Resser differs from all others in the genus by having the posterior pair of glabellar furrows connected across the top of the glabella and by lacking significant ornamentation. I examined all of the well-preserved cranidia in the type lots of all described species of *Drumaspis* and found specimens of two species, *D. deckeri* Resser and *D. utahensis* Resser, that cannot be objectively distinguished from *D. idahoensis*. None of these specimens differ in any significant characters from the cranidia found in Alaska and described above.

Lochman and Hu (1959) included *Drumaspis idahoensis* as a synonym of *D. walcotti* because the apparent range of variability in their sample included characteristic features of cranidia of both species. However, Grant (1962) stated that specimens comparable to the holotype of *D. walcotti* which lack the connection between the posterior glabellar furrows are generally stratigraphically older than specimens comparable to the types of *D. idahoensis* which have the posterior glabellar furrows connected, but that there is a narrow zone of overlap. He concluded that the collection described by Lochman and Hu probably came from this overlap zone and therefore contains specimens of both *D. walcotti* and of *D. idahoensis*. His conclusion is accepted here, and *D. idahoensis* is removed from the synonymy of *D. walcotti*.

Occurrence. — Franconian–2 fauna. Moderately common (7 cranidia), USGS colln. 4357–CO; moderately common (8 cranidia), USGS colln. 4358–CO; moderately rare (4 cranidia, 1 free cheek), GSC colln. 4661 (=4705); all from Hillard Peak area.

Genus DYTREMACEPHALUS Palmer

Dytremacephalus Palmer, 1954b, p. 749; Lochman, 1959, p. 258; Palmer, 1965, p. 84.

Type species.—*Dytremacephalus granulosus* Palmer, 1954b, p. 750, pl. 85, figs. 5, 6.

Dytremacephalus? sp.

Plate 7, figure 29

Description.—Cranidium subquadrate, moderately rounded anteriorly. Glabella moderately convex transversely, gently convex longitudinally, tapered forward, bluntly rounded anteriorly, well defined by axial and preglabellar furrows; distinct shallow pits at anterolateral corners. Two pairs of short deep glabellar furrows present. Occipital furrow straight, deepest distally, shallow on axial line. Occipital ring has large axial node at posterior margin. Frontal area subequally divided into convex border and nearly flat downsloping brim by broad deep evenly curved border furrow; sagittal length about one-half sagittal length of glabella, exclusive of occipital ring. Fixed cheeks gently upsloping; width exclusive of palpebral lobes slightly more than one-third basal glabellar width. Palpebral lobe convex, well defined by slightly curved palpebral furrow; exsaggital length about one-half sagittal length of glabella, exclusive of occipital ring; width slightly more than one-half infraocular part of cheek. Posterior limb tapered to blunt point; length slightly less than basal glabellar width. Posterior border furrow deep.

External surfaces of all parts thickly covered with closely spaced granules.

Course of anterior section of facial suture nearly straight forward from palpebral lobe to border furrow, then turned inward across border to intersect anterior cranidial margin directly in front of junction of low ocular ridge and axial furrow. Course of posterior section gently convex.

Discussion.—This *Dytremacephalus*? species is known only from cranidia that seem to have the characteristic deep glabellar furrows, anterolateral glabellar pits, convex border, and anterior course of the facial suture of *Dytremacephalus*. The palpebral lobes are more posteriorly placed than in species so far included in the genus; therefore, without knowledge of pygidia or free cheeks, a certain assignment to *Dytremacephalus* cannot be made.

Occurrence.—Dresbachian–2 fauna. Rare (4 cranidia), USGS colln. 4381–CO, Hi-yu area.

Genus ELRATHIA Walcott

Elrathia Walcott, 1924b, p. 56; Walcott, 1925, p. 86; Resser, 1935, p. 27; Howell, 1937, p. 1184; Shimer and Shrock, 1944, p. 611; Palmer, 1954a, p. 78; Howell, 1959, p. 240; Robison, 1964a, p. 540.

Type species.—*Conocoryphe* (*Conocephalites*) *kingii* Meek, 1870, p. 63.

Discussion.—Robison (1964a, p. 540–542) has reviewed the content and concept of *Elrathia* and has presented a description of the genus that is followed here.

Elrathia alaskensis n. sp.

Plate 5, figures 10–13

Description.—Cranidium elongate, subquadrate, gently to moderately convex transversely and longitudinally. Glabella long, slender, well defined by axial and preglabellar furrows of nearly constant depth, tapered forward, strongly and evenly rounded at front. Glabellar furrows absent. Occipital furrow deep, straight. Occipital ring moderately convex, width nearly constant. Frontal area downsloping. Border well defined by narrow moderately deep border furrow that is gently curved forward; sagittal length slightly less than sagittal length of brim. Fixed cheek slightly downsloping; width, exclusive of palpebral lobe slightly less than one-half basal glabellar width. Palpebral lobe narrow, well defined by narrow slightly arcuate palpebral furrow; length about one-half length of glabella exclusive of occipital ring. Eye ridge barely apparent, directed slightly posterolaterally. Posterior limb slender; transverse length about equal to basal glaballar width. Posterior border furrow deep, curved slightly forward at distal tip of posterior limb. External surfaces of top of glabella and lateral parts of border covered with closely spaced fine granules; remaining surfaces smooth or finely pitted.

Course of anterior section of facial suture slightly divergent forward from palpebral lobe to border furrow, then turned strongly inward across border to intersect anterior margin in front of fixed cheek. Course of posterior section divergent and sinuous.

Free cheek known only from single imperfect external mold. Border narrow, well defined by narrow border furrow; width slightly less than one-half width of ocular platform. Infraocular ring present, not separated from ocular platform. Posterior parts of border, and perhaps genal spine, have closely spaced fine granular ornamentation. Remainder of border has poorly

defined terrace lines. Surface of ocular platform finely pitted.

Outline of pygidium semicircular; greatest width about three times sagittal length. Axis narrow, convex, has three ring furrows posterior to articulating furrow; width slightly more than one-fifth greatest pygidial width; length slightly more than three-fourths sagittal pygidial length. Pleural regions gently convex. Border not clearly defined. Pleural regions crossed by four broad pleural furrows and three narrow interpleural furrows that reach nearly to pygidial margin. Surfaces of most convex parts covered with closely spaced fine granules.

Discussion.—*Elrathia alaskensis* n. sp. differs from all species assigned to *Elrathia* by Robison (1964a, p. 541, 542), except *E. kingii* (Meek), by having relatively long slender palpebral lobes. *E. gaspensis* Rasetti and *E. quebecensis* Rasetti (1963, p. 580, 581) also have relatively long slender palpebral lobes. However, *E. alaskensis* differs from these long-eyed forms by having a granular ornamentation, downsloping fixed cheeks, a less well defined pygidial border and a relatively narrow pygidial axis. Small cranidia that seem to represent this species have granular ornamentation on all surfaces and a subequally divided frontal area.

Occurrence.—Middle Cambrian–1 fauna. Moderately rare (11 cranidia, 1 free cheek, 1 pygidium), USGS colln. 4341–CO, Hillard Peak area.

Genus HEDINASPIS Troedsson

Hedinia Troedsson, 1937, p. 56 [preoccupied by *Hedinia* Navas, 1936].

Hedinaspis Troedsson, 1951, p. 695; Lu, 1957, p. 277; Poulsen, 1959, p. 269; Kobayashi, 1961, p. 228.

Type species.—*Hedinia regalis* Troedsson, 1937, p. 56, pl. 3, fig. 5; pl. 7, figs. 1-5, 7-11; pl. 8, figs. 3-8.

Hedinaspis sp.

Plate 15, figures 16, 18, 22

Discussion.—Several fragments in three collections represent parts of the peculiar and morphologically distinctive genus *Hedinaspis*. Two cranidial fragments show the typical deep pits in the glabella that represent the glabellar furrows, and one of these fragments has part of the brim with the ornamentation and the narrow ridge at the inner edge of the border preserved. These specimens are not distinguishable from *Hedinaspis regalis* (Troedsson) (pl. 15 figs. 17, 21) which is known from central China and south Korea (Kobayashi, 1961, p. 228).

Two fragments of thoracic segments, including one partial thorax, also represent *Hedinaspis*. They are flat, have subparallel margins, and have a very broad flat-bottomed pleural furrow bounded along both segmental margins by narrow raised anterior and posterior bands. The anterior band is deflected posterolaterally along the lateral margin of the short pleural spine. The thoracic fragment is also indistinguishable from comparable parts of *H. regalis* (Troedsson). The Alaskan specimens are much too fragmentary for adequate specific identification, however, but they do establish without doubt the position of this distinctive Asiatic genus in the American Upper Cambrian.

Occurrence.—Trempealeauan–2 fauna. Rare (2 cranidial fragments), USGS colln. 4352–CO; 1 partial thorax, USGS colln. 4351–CO; both from Yukon River (Adams Peak) area. Franconian–2 fauna. Rare (2 fragments of thoracic segments), USGS colln. 4358–CO, Hillard Peak area.

Genus HUNGAIA Walcott

Hungaia Walcott, 1914, p. 351; Rasetti, 1944, p. 241; Lochman, 1959, p. 332.

Type species.—*Dikelocephalus magnificus* Billings, 1860, p. 307, fig. 5.

Discussion.—Both Rasetti (1944) and Lochman (1959) have given good diagnoses of the characteristics of *Hungaia*. The only new information concerns the course of the facial suture. Free cheeks in the Alaskan collection and also in the biologic collections of the U.S. National Museum show that *Hungaia* had a median suture across the doublure.

The large glabella, the small posteriorly placed palpebral lobes, and the broad concave frontal area on the cranidium; the broad border on the free cheek; and the short axis, the long deeply furrowed pleurae, and the spinose margin on the pygidium distinguish specimens of *Hungaia* from all other associated trilobites in the Alaskan fauna.

Hungaia burlingi n. sp.

Plate 12, figures 7–13

Description.—Cephalon semicircular. Cephalic border broad, concave. Genal spines short, broad-based, pointed. Cranidium, exclusive of posterior limbs, subquadrate, gently convex transversely and longitudinally. Glabella low, large, well defined by abrupt changes in slope of exoskeleton, reaches onto inner part of border, sides subparallel, anterior end bluntly rounded. One or two pairs of short moderately deep glabellar furrows present; posterior pair deepest. Occipital furrow moderately deep, straight. Occipital ring simple. Frontal area broad, concave, bluntly pointed on axial line; sagittal length slightly less than one-half sagittal glabellar length, exclusive of occi-

pital ring. Shallow, nearly straight border furrow interrupted by anterior end of glabella. Fixed cheek narrow, horizontal; width, exclusive of palpebral lobe, slightly more than one-fourth basal glabellar width. Palpebral lobe long, strongly curved, moderately well defined by shallow palpebral furrow situated opposite posterior half of glabella; exsagittal length about one half or slightly less than one half sagittal glabellar length, exclusive of occipital ring. Posterior limb short.

Course of anterior section of facial suture moderately divergent forward from palpebral lobe to border furrow, then curved broadly inward across border to axial line and then ventrally across doublure as median suture. Course of posterior section strongly divergent behind palpebral lobe, then broadly curved to intersect posterior margin at nearly right angle.

Free cheek subtriangular. Border broad, concave. Ocular platform gently convex; width at anterior sutural margin about two-thirds width of border. Lateral border furrow shallow, intersects deeper posterior border furrow at nearly right angle near distal end of facial suture. Posterior border furrow continues parallel to posterior margin of cheek nearly to tip. Narrow ridge present on anterior part of cheek parallel to lateral margin and at about midwidth of border. Anterior doublure broad, long, squarely truncated by median suture.

Pygidium subquadrate; lateral margins slightly flared posteriorly; posterior margin has four pairs of short broad-based flat spines arranged in nearly straight transverse line. Axis short, bluntly terminated posteriorly. Two moderately deep ring furrows usually present posterior to articulating furrow; posterior furrow present only on top of axis. Pleural region has four deep pleural furrows, all nearly parallel to axis in distal parts; anterior two furrows directed laterally near axis; posterior two furrows directed nearly straight backward for entire length. Very short interpleural furrow present near axis between first and second segments.

External surfaces of border regions of cephalon and pygidium covered with terrace lines parallel to external margins. Frontal area crossed by several anteriorly branching caecae(?) that are not interrupted by facial sutures. All other areas of exoskeleton smooth.

Discussion.—*Hungaia burlingi* n. sp. seems to be characterized principally by its subquadrate glabella, moderately deep glabellar furrows, moderately short pygidial spines, and the short interpleural furrow between the first two pygidial segments. It is most similar to *H. puelchana* Rusconi from Argentina. Both species have subquadrate glabellas and moderately deep posterior glabellar furrows. The pygidium of *H. puelchana* has shallower pleural furrows and shorter pygidial spines than the Alaskan species, and the first interpleural furrow on the pygidium is absent. *H. magnifica* (Billings) lacks the first interpleural furrow and has much longer pygidial spines than the Alaskan species, and the anterior end of the glabella is strongly rounded rather than blunt. The free cheeks of the two species are remarkably similar, even in the presence of the peculiar ridge that extends down the middle of the border. *H. pacifica* Kobayashi (pl. 12, fig. 14), also described from Alaska, is represented only by five large fragmentary pygidia, none of which have the posterior margin preserved. Three of these specimens have the axis preserved, and it has three ring furrows posterior to the articulating furrow. On these specimens, also, the third pleural furrow is directed posterolaterally from the axis rather than straight posteriorly and the first interpleural furrow is lacking. Although Kobayashi's specimens can be recognized as *Hungaia* pygidia, they are not really adequate for comparison at the specific level with other described species. In addition to having minor morphologic differences from *H. burlingi*, they are associated with a totally different trilobite fauna. Thus, neither available morphologic evidence nor stratigraphic evidence favors the use of Kobayashi's name for the material described here, and the name *H. pacifica* should be restricted to the fragmentary material in the lot originally described by Kobayashi (1935a).

Occurrence.—Franconian–2 fauna. Moderately common (8 cranidia, 2 free cheeks, 2 pygidia), GSC colln. 4661 (= 4705), rare (1 pygidium), USGS colln. 4358–CO; 1 pygidium, USGS colln. 4357–CO; all from Hillard Peak area. Specimens assigned with question: 1 pygidium, USGS colln. 3709–CO; 3 cranidia, USGS colln. 4355–CO; 1 pygidium, USGS colln. 4356–CO; all from Hillard Peak area.

Hungaia sp.

Plate 12, figure 18

Discussion.—A species that is probably different from *Hungaia burlingi* is represented by pygidia that have relatively long border spines arranged along the margins of a median indentation in the border so that the outer spines extend the farthest posteriorly. These specimens also lack any indication of an interpleural furrow between the first and second pleural segments. They seem to conform in all observable features to small pygidia of *H. magnifica* (Billings) and may possibly represent that species. However, without

knowledge of additional parts, accurate identification cannot be made.

Occurrence: Trempealeauan–1 fauna. Rare (3 pygidia), USGS colln. 3834–CO, Jones Ridge area (south end).

Genus LAUZONELLA Rasetti

Lauzonella Rasetti, 1944, p. 243; Rasetti, 1959, p. 331.

Type species.—Dikelocephalus planifrons Billings, 1860, p. 309, fig. 6.

Lauzonella? tripunctata (Kobayashi)

Plate 14, figures 14, 15

Parabriscoia tripunctata Kobayashi, 1935a, p. 54, pl. 9, fig. 8.

Description.—Cranidium subquadrate; anterior margin broadly and evenly rounded. Glabella low, gently to moderately convex transversely and longitudinally, tapered slightly forward, bluntly rounded anteriorly, well defined by abrupt changes in slope of exoskeleton. Two or three pairs of glabellar furrows present as pits, increasing in size posteriorly, isolated from sides of glabella. Occipital furrow broad, moderately deep. Occipital ring gently convex, has well-defined axial node near posterior margin. Frontal area broad, concave, lacks any indication of border furrow; sagittal length about three-fifths sagittal length of glabella, exclusive of occipital ring. Fixed cheek narrow, upsloping; width about one-fourth basal glabellar width. Palpebral lobe small, poorly defined, situated about opposite glabellar midlength; exsagittal length about one-fourth sagittal glabellar length, exclusive of occipital ring. Posterior limbs not known. External surfaces of convex parts roughened but lack either discrete pits or granules.

Course of anterior section of facial suture divergent forward from palpebral lobe to anterior cranidial margin; further course not known.

Discussion.—Lauzonella? tripunctata (Kobayashi) was based on a single cranidium and questionably assigned to *Parabriscoia*. As discussed elsewhere (p. B59?), *Parabriscoia* probably has a cranidium closely comparable to that of *Briscoia* and thus unlike the cranidium described above.

Rasetti (1944, pl. 37, fig. 10) illustrated a cranidium from the Levis Conglomerate that was described by Clark (1924) as *Dikelokephalina broggeri*. This cranidium, which was assigned to *Lauzonella*, is almost certainly congeneric with the Alaskan specimen of *Parabriscoia? tripunctata* described by Kobayashi. The type species of *Lauzonella*, *L. planifrons* (Billings), has the palpebral lobes adjacent to the glabella and there is practically no infraocular cheek. This characteristic is quite different from the cheek structure of *P.? tripunctata* and *D. broggeri*, and the assignment of these species to *Lauzonella* should at least be questioned until more can be learned about the morphology of other parts of these rare trilobites.

Two of the more recent Alaskan collections have specimens that are congeneric or conspecific with *Lauzonella? tripunctata*. Each collection has only two cranidia. In one collection (3835–CO), the specimens are identical in every respect, including size, with the specimen described and illustrated by Kobayashi. The other collection (4355–CO) and a Burling collection (GSC 4671) have incomplete specimens about three times larger than typical *L.? tripunctata* (pl. 12, fig. 16). They have a relatively longer frontal area that is only slightly shorter than the sagittal glabellar length, exclusive of the occipital ring, and fixed cheeks that are only one-fifth as wide as the basal glabellar width, but agree in all other features with *L.? tripunctata*. In *Pterocephalia concava* Palmer, a species that has a similar broad concave frontal area, the frontal area increases in sagittal length during holaspid ontogeny (Palmer, 1960a, p. 88). If a parallel development takes place in *L.? tripunctata*, the large specimens may be conspecific with the small specimens. The available material is inadequate for the determination of this possibility.

Occurrence.—Trempealeauan–1 fauna. Rare (1 cranidium; holotype), USNM loc. 25o (=Mertie colln. 30AMt147); rare (2 cranidia), USGS colln. 3835–CO; ?2 cranidia GSC colln. 4671; all from Jones Ridge area. Franconian–2 fauna. ?Rare (2 cranidia), USGS colln. 4355–CO, Hillard Peak area.

Genus LIOSTRACINOIDES Raymond

Liostracinoides Raymond, 1937, p. 1092; Howell, 1959, p. 248.

Type species.—Liostracinoides vermontanus Raymond, 1937, p. 1092, pl. 1, fig. 20.

Discussion.—Liostracinoides was proposed by Raymond for a single small imperfect cranidium in the Upper Cambrian of Vermont that is characterized by having a well-defined glabella, small medially situated palpebral lobes, a narrow cranidial border, and a well-defined median preglabellar furrow connecting the axial furrows to the border furrow. Several small cranidia in a Late Cambrian collection in Alaska may represent this genus, but some uncertainty about the assignment will remain until more is known about the type species.

Liostracinoides? yukonensis n. sp.

Plate 15, figure 20

Description.—Cranidium small, elongate, subquadrate, moderately rounded anteriorly. Glabella moderately convex longitudinally, strongly convex trans-

versely, well defined at sides by deep narrow axial furrows that meet at blunt point on axial line. Glabellar furrows absent. Occipital furrow deep, narrow, straight. Occipital ring convex, has small median node. Frontal area consists of narrow well-defined border that has well-defined plectrum; broad shallow longitudinal median furrow connects tip of plectrum to anterior end of glabella. Border furrow deep, narrow distally; shallower around plectrum. Sagittal length of frontal area about one-half sagittal length of glabella, exclusive of occipital ring. Fixed cheek moderately wide, gently convex, nearly horizontal; width, exclusive of palpebral lobe, slightly more than one-half basal glabellar width. Palpebral lobe small, moderately well defined by shallow nearly straight palpebral furrow, situated slightly posterior to glabellar midlength, connected to glabella by poorly defined narrow eye ridge; exsaggital length about one-third sagittal glabellar length exclusive of occipital ring. Posterior limbs not known. All surfaces smooth, except for narrow zone of terrace lines along anterior part of border.

Course of anterior section of facial suture moderately divergent forward from palpebral lobe to border furrow, further course not known.

Discussion.—*Liostracinoides? yukonensis* n. sp. is unlike any other Alaskan Cambrian trilobite by possessing an unfurrowed glabella connected by a median longitudinal furrow across the brim to a well-defined plectrum on the border. The presence of a plectrum on the border, and the absence of glabellar furrows distinguish this species from *L. vermontanus*, the type species of *Liostracinoides*.

Occurrence.—*Trempealeauan*–2 fauna. Moderately common (7 cranidia), USGS colln. 4351–CO, Yukon River (Adams Peak) area.

Genus LOGANELLUS Devine

Loganellus Devine, 1863, p. 98; Rasetti, 1944, p. 246; Rasetti, 1959, p. 331.

Type species.—*Olenus? logani* Devine, 1863, p. 95, figs. 1, 2.

Discussion.—Rasetti (1944) revised the content of *Loganellus* and presented a good description that is followed here.

Loganellus? arcus n. sp.

Plate 13, figures 6–8, 11

Description.—Cranidium, exclusive of posterior limbs, subquadrate; anterior margin nearly straight. Glabella low, tapered slightly forward, bluntly rounded anteriorly, well defined at sides and front by shallow narrow axial preglabellar furrows; preglabellar furrow deepest at anterolateral corners of glabella. Two pairs of deep narrow obliquely directed glabellar furrows present. Occipital furrow straight, narrow, shallow. Occipital ring nearly flat, has small median node. Frontal area narrow in front of glabella, flared laterally; sagittal length slightly less than one-fifth sagittal glabellar length, exclusive of occipital ring. Border convex, well defined by narrow nearly straight border furrow; sagittal length about twice sagittal length of flat brim. Fixed cheek narrow, nearly horizontal; width, exclusive of palpebral lobe, slightly less than one-fourth basal glabellar width. Palpebral lobe large, slightly curved, moderately well defined by shallow palpebral furrow; connected to glabella by low narrow ocular ridge; situated about opposite glabellar midlength; exsagittal length slightly less than sagittal glabellar length exclusive of occipital ring. Posterior limb slender, sharply pointed; transverse length about equal to basal glabellar width. Posterior border furrow moderately deep, narrow.

Course of anterior section of facial suture strongly divergent forward from palpebral lobe in broad outward curve; intersects border furrow at nearly right angle and then turns sharply inward and continues across border nearly to axial line. Course of posterior section of facial suture divergent and sinuous.

Free cheek gently convex; lateral margin broadly curved and continuous with margin of slender genal spine. Border narrow, convex, well defined by broad shallow lateral border furrow that connects with posterior border furrow near base of genal spine; width of border about one-sixth width of ocular platform at anterior sutural margin. Infraocular ring present. Posterior border narrow, moderately long transversely. Inner spine angle slightly obtuse. Length of genal spine about equal to length of posterior section of facial suture.

Pygidium semicircular. Axis convex, tapered posteriorly nearly to inner edge of narrow border, has three or four ring furrows posterior to articulating furrow. Pleural region nearly flat. Border narrow, well defined by shallow border furrow; width at anterolateral margin variable between one-sixth and one-eighth width of pleural region. Pleural field crossed by three or four shallow pleural furrows. Interpleural furrows also present, very shallow.

Border of pygidium has well defined terrace lines. All other parts of exoskeleton smooth.

Discussion.—All the cephalic characteristics of *Loganellus? arcus* n. sp. except the course of the anterior section of the facial suture, seem to conform to those of *Loganellus*. The unusual outwardly convex course

of the facial suture is unlike that of any other species in the genus, and such a striking modification of this suture is usually of more than specific significance. However, the pygidia that are associated with the cranidia have the appearance of pygidia characteristically assigned to *Loganellus*. Until more is known about this species, it is tentatively assigned to *Loganellus*, to which it seems to have the greatest affinity.

Occurrence.—Franconian–2 fauna. Moderately rare (2 cranidia, 1 free cheek, 5 pygidia), USGS colln. 4358–CO; rare (1 cranidium), USGS colln. 4359–CO; rare (1 cranidium), USGS colln. 3710–CO; moderately common (10 cranidia, 6 pygidia, 6 free cheeks), GSC colln. 4661 (=4705); all from Hillard Peak area.

Genus ONCHOCEPHALITES Rasetti

Onchocephalites Rasetti, 1957, p. 962.

Type species.—*Onchocephalites laevis* Rasetti, 1957, pl. 121, figs. 5–9, text fig. 2.

Diagnosis.—Cranidium moderately convex transversely and longitudinally. Glabella low, broad, moderately well to poorly defined, tapered forward, strongly rounded anteriorly. Glabellar furrows poorly defined. Frontal area short; sagittal length less than one-half sagittal glabellar length. Brim and border subequal in sagittal length. Border furrow convex upward in anterior view. Fixed cheeks gently convex, downsloping. Palpebral lobes poorly defined, situated about opposite middle third of glabella. Distal parts of posterior limbs short, blunt.

Discussion.—*Onchocephalites* presently includes species that vary considerably in degree of definition of glabella on the external surface. However, they all have downsloping fixed cheeks, poorly defined palpebral lobes, and a relatively short frontal area that may constitute meaningful generic characteristics. All the species except *O. punctatus*, discussed on page B97, are from beds no younger than early Middle Cambrian in age.

Onchocephalites? versilis n. sp.

Plate 4, figures 1–5

Description.—Cranidium subquadrate in outline, gently rounded anteriorly, moderately convex transversely and longitudinally. Glabella well defined by narrow, shallow axial and preglabellar furrows of constant depth; gently convex transversely and longitudinally, tapered gently forward, evenly rounded anteriorly. Glabellar furrows shallow; two pairs barely visible; posterior pair directed obliquely inward and backward. Occipital furrow deep straight. Occipital ring convex, has distinct median node. Frontal area short; sagittal length variable between one-third and one-half sagittal length of glabella, exclusive of occipital ring. Border convex, moderately wide, well defined by narrow border furrow that is convex upward in anterior view; sagittal length one-half or more than one-half sagittal length of frontal area. Brim convex; sagittal length variable, less than one-half sagittal length of frontal area. Fixed cheeks gently convex, moderately wide, strongly downsloping; width slightly less than one-half basal glabellar width. Transverse line tangent to surface of cheek also tangent to glabella. Palpebral lobes small, defined only by change in slope of cheek surface, situated opposite middle third of glabella; length between one-third and one-fourth sagittal glabellar length. Posterior limbs short, blunt; transverse width less than basal glabellar width. Posterior border furrow broad, deep; posterior border slightly expanded distally.

Course of anterior section of facial suture slightly convergent forward in gentle curve from palpebral lobe to anterior margin. Course of posterior section divergent for short distance behind palpebral lobe, then curved and directed nearly straight backward to posterior margin.

External ornamentation consists of low closely spaced granules principally on glabella and occipital ring; other parts not clearly ornamented. Surface of mold shows strong pitting on cheeks but no pitting on glabella. All furrows better defined on mold.

Discussion.—*Onchocephalites? versilis* n. sp. differs from the species presently included in *Onchocephalites* by Rasetti (1957, 1963) by having smaller palpebral lobes and by having the axial, preglabellar, and border furrows distinctly defined. However, the overall size, distinctly downsloping fixed cheeks, and dorsally convex border furrow indicate a probable relationship of the Alaskan specimens to *Onchocephalites*. No other small ptychoparioid from the early Cambrian or early Middle Cambrian seems sufficiently similar to *O.? versilis* to warrant a different generic assignment.

Occurrence.—Early Cambrian–3 fauna. Moderately common (more than 15 cranidia), USGS collns. 4334–CO, 4335–CO, 3715–CO; Yukon River (West Ridge) area.

Genus ONCHONOTOPSIS Rasetti

Onchonotopsis Rasetti, 1946, p. 460; Rasetti, 1959, p. 519.

Type species.—*Onchonotopsis pergibba* Rasetti, 1946, p. 460, pl. 70, figs. 23–26.

Diagnosis.—Small ptychoparioids. Glabella large, unfurrowed, strongly convex transversely and longitudinally, increases in height posteriorly and partly or completely overhangs deep narrow occipital furrow. Frontal area short, subequally divided into evenly

curved convex border and flat downsloping brim. Fixed cheeks narrow, downsloping. Palpebral lobes small, poorly defined, situated opposite middle third of glabella. Posterior limb subtriangular. Posterior border furrow deep near glabella.

Discussion.—*Onchonotopsis* is a rare genus that seems to be characteristic of faunas at the Middle-Upper Cambrian boundary. The type species, *O. pergibba*, is associated with trilobites having both Middle and Upper Cambrian affinities in a boulder from a presumed Ordovician conglomerate on the western Gaspé Peninsula, Quebec (Rasetti, 1946). The Alaskan species described below is associated with *Lejopyge calva* Robison, an agnostid that is characteristic of the uppermost Middle Cambrian beds of the Great Basin in Nevada and Utah (Robison, 1964a).

Onchonotopsis occidentalis n. sp.

Plate 6, figures 11, 12

Description.—Cranidium subtrapezoidal, strongly convex transversely and longitudinally. Glabella large, unfurrowed, subovate in dorsal outline, strongly convex transversely and longitudinally, increases in height posteriorly so that posterior surface is vertical and directly above deep narrow occipital furrow. Occipital ring narrow, convex, lacks node or spine. Frontal area short, subequally divided into horizontal convex evenly curved border and downsloping flat brim by shallow border furrow; sagittal length of frontal area about one-third sagittal length of glabella, exclusive of occipital ring. Fixed cheek narrow, downsloping; width, including palpebral lobe, slightly more than one-third basal glabellar width. Palpebral lobe short, poorly defined by shallow palpebral furrow, situated opposite middle third of glabella; length about one-third sagittal glabellar length, exclusive of occipital ring. Posterior limb triangular; transverse length slightly more than two-thirds basal glabellar width. Posterior border furrow deep near glabella; broad, shallow distally. Glabella and occipital ring covered with poorly defined, closely spaced fine granules; remainder of cranidium lacks distinct ornamentation.

Course of anterior section of facial suture slightly divergent forward from palpebral lobe to border furrow, then curved strongly inward across border and merged imperceptibly with anterior margin. Course of posterior section of facial suture is broad curve from palpebral lobe to posterior margin.

Discussion.—The cranidium of *Ochonotopsis occidentalis* n. sp. is most similar in general proportions to *O. pergibbus* Rasetti. However, the frontal area is relatively longer and less strongly bowed upward in anterior view, and the fixed cheeks are relatively wider. The back of the glabella of *O. occidentalis* does not overhang the occipital ring as it does in *O. pergibbus*, and the ornamentation of the Alaskan species is granular instead of pitted.

Occurrence.—Middle Cambrian–2 fauna. Rare (1 cranidium), USGS colln. 4337–CO, Yukon River (Adams Peak) area.

Genus ONCHONOTUS Raymond

Onchonotus Raymond, 1924, p. 405; Kobayashi, 1934, p. 543; Kobayashi, 1935b, p. 260; Kobayashi, 1938, p. 187; Ivshin, 1960, p. 120.

Type species.—*Menocephalus globosus* Billings, 1860, p. 317, figs. 17–19.

Description.—Cephalon subglobose, strongly convex transversely and longitudinally. Glabella large, moderately convex transversely and longitudinally, tapered slightly forward, bluntly or strongly rounded at front, defined at sides and front by changes in slope of exoskeleton. Distinct glabellar furrows absent. Occipital furrow broad, deep, straight, has nearly constant depth. Occipital ring simple, convex; small median node present on at least some species. Frontal area short, downsloping; brim concave; border convex, slightly nasute; border furrow deep or shallow. Fixed cheek narrow, horizontal or slightly downsloping. Palpebral lobe moderately small, poorly defined, situated opposite or slightly anterior to glabellar midlength. Posterior limb short, pointed. Posterior border furrow shallow.

Course of anterior section of facial suture nearly straight forward from palpebral lobes to border furrow, then turned abruptly inward and continued across border to intersect anterior margin near axial line. Course of posterior section nearly straight.

Free cheek broad, has strongly curved lateral margin. Border narrow, convex, moderately defined by shallow lateral border furrow that does not connect with shallow posterior border furrow. Genal spine short, directed laterally at slight angle to margin of cheek.

Discussion.—Brief diagnoses of *Onchonotus* have been given by Raymond (1924) and by Ivshin (1960), but no redescription of the genus has yet been presented to incorporate new material obtained since 1924.

Kobayshi (1934, p. 543; 1938, p. 187, 188) added *Onchonotus walcotti* Kobayashi, *O. ovoidea* Kobayashi, and *Bathyurus minor* Sun to *Onchonotus*. *O. walcotti* lacks a preserved frontal area and therefore is not sufficiently preserved to be comparable to other trilobites. *O. ovoidea* is a small trilobite that has a tapered glabella, a narrow straight border furrow, and

an evenly convex border of nearly constant width. These characters are unlike those of typical species of *Onchonotus*, and *O. ovoidea* probably represents another genus. Furthermore, it occurs in a *Dunderbergia* zone fauna and is considerably older than the characteristic species of *Onchonotus*. *Bathyurus minor* Sun is inadequately illustrated and described for meaningful comparison with species of *Onchonotus*.

Raymond (1937) described *Onchonotus eminens*, which was removed to *Onchonotopsis* by Rasetti (1946).

Rasetti (1943, 1944, 1945a) added five species to *Onchonotus*. *O. foveolatus* Rasetti, from beds of Early Ordovician age, and *O. granulatus* and *O. convexus* from beds of Late Cambrian age seem to be fully typical of the genus. *O. sulcatus* Rasetti is a small Late Cambrian trilobite having moderately deep posterior glabellar furrows and distinct axial and preglabellar furrows. These characteristics are atypical for *Onchonotus*, and its generic assignment may be incorrect. *Menocephalus sedgwicki* Billings was questionably assigned to *Onchonotus*, and the presence of deep glabellar furrows and convex fixed cheeks certainly justifies only tentative generic assignment.

Thus, the only species that are unquestionably assigned to *Onchonotus* are *O. globosus* (Billings), *O. convexus* Rasetti, *O. foveolatus* Rasetti, *O. granulatus* Rasetti, *O. nasutus* (Walcott), and *O. richardsoni* (Walcott). The description given above is based on examination of material of *O. nasutus*, *O. richardsoni*, *O. brevifrons* n. sp. and *O. antiqus* n. sp. in the collections of the U.S. National Museum and supplemented by illustrations of the remaining species in Rasetti (1943, 1944).

Onchonotus antiqus n. sp.

Plate 12, figure 20

Description.—Cranidium moderately convex transversely and longitudinally, slightly pointed anteriorly. Glabella large, moderately to strongly convex transversely and longitudinally, tapered slightly forward, defined at sides by change in slope of exoskeleton surface, barely defined at front. Glabellar furrows barely apparent. Occipital furrow broad, moderately deep, straight. Occipital ring convex, has small median node. Frontal area short, downsloping; sagittal length about one-third sagittal length of glabella, exclusive of occipital ring. Border convex, tapered laterally from maximum sagittal length on axial line, well defined by deep border furrow that is bluntly pointed forward on axial line; sagittal length slightly greater than sagittal length of flat brim. Fixed cheek narrow, horizontal. Palpebral lobe flaplike, barely separated from infraocular part of cheek. Width of cheek exclusive of palpebral lobe slightly less than one-sixth basal glabellar width. Exsagittal length of palpebral lobe about one-third sagittal length of glabella, exclusive of occipital ring. Posterior limb triangular; transverse length distinctly less than basal glabellar width. Posterior border furrow shallow. External surface of border has well-defined terrace lines; all other parts smooth.

Discussion.—*Onchonotus antiqus* n. sp. is closely related to the other smooth species of *Onchonotus*, *O. richardsoni*, *O. nasutus*, and *O. convexus* . It differs from all three by having a much deeper border furrow and a relatively wide cranidial border.

Occurrence.—Franconian–2 fauna. Moderately common (4 cranidia), USGS colln. 4357–CO; rare (1 cranidium), USGS colln. 4358–CO; ?rare (1 cranidium), USGS colln. 3710–CO; moderately common (10 cranidia), USGS colln. 4356–CO; all from Hillard Peak area.

Onchonotus brevifrons n. sp.

Plate 12, figures 15, 19

Description.—Cranidium, exclusive of posterior limbs, elongate, subquadrate; anterior margin slightly pointed. Glabella large, moderately to strongly convex transversely and longitudinally, well defined at sides by distinct change in slope of exoskeleton surface, less well defined at front; sides nearly subparallel; anterior end bluntly rounded. Glabellar furrows absent. Occipital furrow broad, deep, straight; deepest across top of glabella. Occipital ring simple, has barely visible median node. Frontal area short, concave; sagittal length variable between one-fourth and one-fifth sagittal length of glabella, exclusive of occipital ring. Brim steeply depressed; sagittal length slightly greater than sagittal length of border. Border narrow, slightly raised, pointed on axial line, resembles forward directed chevron with concave sides. Fixed cheek narrow, horizontal; width, exclusive of palpebral lobe, variable between one-fourth and one-fifth basal glabellar width. Palpebral lobe large, arcuate, poorly defined on external surface by shallow palpebral furrow; better defined on mold; exsagittal length about two-fifths sagittal length of glabella, exclusive of occipital ring. Posterior limb slender, sharply pointed; transverse length slightly less than basal glabellar width. Posterior border furrow moderately deep. External surfaces of all parts smooth.

Course of anterior section of facial suture nearly straight forward but curved slightly outward to border furrow, then turned abruptly inward and continued nearly to axial line in gentle posteriorly concave

curve. Course of posterior section of facial suture divergent and sinuous.

Discussion.—The combination of a short frontal area, large palpebral lobes, and subparallel sides to the glabella distinguish *Onchonotus* brevifrons n. sp. from others assigned to *Onchonotus*. Compared with *O. antiqus* n. sp., the other Alaskan species, the border of *O. brevifrons* is narrower, the border furrow is not as well developed, the anterior margin of the cranidium is more distinctly pointed, and the glabella is less tapered anteriorly.

Most cranidia of *Onchonotus brevifrons* are exfoliated but a few specimens retain parts of the exoskeleton that show the exterior characteristics. The exfoliated specimens have a less distinct anterior border and generally better defined palpebral lobes.

Occurrence.—Franconian–2 fauna. Moderately common (10 cranidia), USGS colln. 3709–CO; common (more than 20 cranidia), USGS colln. 4355–CO; both from Hillard Peak area. Rare (3 cranidia), GSC colln. 264, Squaw Mountain area.

Genus PSEUDOSAUKIA Rasetti

Pseudosaukia Rasetti, 1944, p. 252.

Type species.—*Dikelocephalus sesostris* Billings, 1865, p. 198, fig. 184.

Discussion.—Rasetti (1944) has presented an adequate diagnosis of *Pseudosaukia*, and the Alaskan material does not add any new information.

Pseudosaukia cf. P. brevifrons (Clark)

Plate 15, figure 9

Osceolia brevifrons Clark, 1924, p. 30, pl. 4, fig. 4.
Pseudosaukia brevifrons (Clark). Rasetti, 1944, p. 254, pl. 39, fig. 34.

Description.—Glabella large, low, gently to moderately convex transversely and longitudinally, well defined by narrow axial furrows, reaches nearly to border, anterior end bluntly rounded; width decreases slightly between palpebral lobes, then increases again towards front so that sides are slightly concave. Two pairs of glabellar furrows present, isolated from axial furrows; posterior pair relatively deep, oblique. Occipital furrow deep, straight; ends isolated from axial furrows. Occipital ring flattened, lacks node or spine. Frontal area very short; sagittal length about one-ninth sagittal length of glabella, exclusive of occipital ring. Border strongly convex, wirelike; sagittal length about three times length of slotlike brim. Fixed cheek very narrow; width, exclusive of palpebral lobe, about one-tenth basal glabellar width. Palpebral lobe slightly curved, poorly defined in posterior part by shallow palpebral furrow, situated adjacent to glabella and slightly anterior to glabellar midlength; sagittal length about four-tenths sagittal length of glabella, exclusive of occipital ring. Posterior limbs not known. External surfaces of all parts smooth or faintly roughened.

Discussion.—*Pseudosaukia* cf. *P. brevifrons* (Clark) is very similar to *P. brevifrons* (Clark) in its cranidial proportions but differs by having the posterior part of the glabella more sharply defined and by lacking a transaxial connection between the posterior pair of glabellar furrows. Both of these characteristics may be variable features. Determination of their reliability as meaningful specific distinctions must await more material. The large low subquadrate glabella that has slightly concave sides, the short frontal area, and small palpebral lobes adjacent to the glabella all combine to distinguish this species from all other Alaskan trilobites.

Occurrence.—Trempealeauan–1 fauna. Moderately common (4 cranidia), USGS colln. 3834–CO, Jones Ridge area (South end).

Genus QUEBECASPIS Rasetti

Quebecaspis Rasetti, 1944, p. 254; Rasetti, 1959, p. 279.

Type species.—*Quebecaspis breviceps* Rasetti, 1944, p. 254, pl. 39, figs. 44, 45.

Discussion.—*Quebecaspis* is known only from cranidia assigned to three species. The free cheek of one of the species has been described, but pygidia are as yet unknown. The generic characteristics seem to be the combination of a short frontal area, a broad low tapered glabella having the posterior glabellar furrows nearly outlining posterolateral glabellar lobes, a deep narrow occipital furrow, and narrow fixed cheeks.

Quebecaspis is represented in Alaska by three species. Two of the species, *Q. conifrons*? Rasetti and *Q. breviceps* Rasetti, were originally described from Upper Cambrian collections in Maryland and Quebec, respectively. At all known localities, these species are found in faunas correlative with the early Late Cambrian *Dunderbergia* zone. The fact that *Quebecaspis* is absent from the large fauna in beds of this age in the Great Basin of the Western United States suggests that the geographic range of *Quebecaspis* did not extend around the southern margins of the North American continent during Late Cambrian time. Rather, it becomes supporting evidence for a Late Cambrian marine connection between Alaska and eastern North America across the present Arctic regions.

Ivshin (1962, p. 255–268) has described several species of a new genus *Seletella* from Kazakhstan that may be related to *Quebecaspis*. The cranidia have

similar proportions, but the posterior glabellar furrows are straight in the drawings of the species and so shallow that they are not apparent in the photographs. The Kazakhstan species come from beds approximately comparable in age to those containing *Quebecaspis*. When more is known of the course of the glabellar furrows on the species of *Seletella*, the degree of relationship to *Quebecaspis* can be better determined.

Quebecaspis aspinosa n. sp.

Plate 9, figures 11–15

Description.—Cranidium, exclusive of posterior limbs, subquadrate, gently rounded anteriorly. Glabella large, low, moderately convex transversely and longitudinally, tapered slightly forward, bluntly rounded anteriorly, reaching to, or nearly to, border furrow, well defined at sides by narrow axial furrows, width on larger specimens slightly greater than length. Glabellar furrows shallow; posterior pair curved distinctly backward. Occipital furrow moderately deep, narrow, straight. Occipital ring has small median node. Frontal area short, consisting almost entirely of convex border defined by shallow border furrow. Brim, when present, narrower than border. Sagittal length of frontal area variable between one-fourth and one-sixth sagittal glabellar length, exclusive of occipital ring. Fixed cheek narrow, gently convex, slightly downsloping; width, exclusive of palpebral lobe, variable between one-third and one-fourth basal glabellar width. Palpebral lobe narrow, arcuate, poorly defined by shallow palpebral furrow, situated about opposite glabellar midlength; exsagittal length about three-eights sagittal glabellar length exclusive of occipital ring. Posterior limb short, bluntly rounded distally; transverse length distinctly less than basal glabellar width. Posterior border furrow moderately deep, straight.

Course of anterior section of facial suture slightly convergent forward from palpebral lobe to border furrow, then curved evenly inward to merge imperceptibly with anterior margin of cranidium. Course of posterior section directed posterolaterally in nearly straight line to border furrow, then curved abruptly backward to posterior cranidial margin.

Free cheek slender. Lateral margin evenly curved. Border convex, well defined anteriorly by shallow lateral border furrow that becomes broader and less distinct towards base of short pointed genal spine. Anterior width of border slightly less than width of ocular platform.

External surfaces of all parts lack distinct ornamentation.

Discussion.—*Quebecaspis aspinosa* n. sp. is similar to both *Q. breviceps* Rasetti and *Q. marylandica* Rasetti. However, both of the species described by Rasetti have occipital spines. *Q. aspinosa* is represented by many silicified cranidia in one collection. The smaller cranidia generally have the glabellar length slightly greater than the glabellar width, but the larger cranidia have the glabellar width slightly greater than the glabellar length. A narrow brim is present on some cranidia but absent on others. Differences in proportions of the glabella and in presence or absence of a narrow brim which were used to discriminate *Q. breviceps* from *Q. marylandica* may therefore not be reliable characteristics in this genus.

Although there is a variety of pygidia in the collection containing *Quebecaspis aspinosa*, there is no satisfactory means of determining which of several kinds of transversely elliptical simple pygidia properly belong with this species, and the pygidium must therefore remain unknown.

Occurrence.—Dresbachian–2 fauna. Common (more than 40 cranidia, 6 free cheeks), USGS colln. 4381–CO, Hi-yu area. Rare (2 cranidia), GSC colln. 4722, Hillard Peak area. Rare (2 cranidia), GSC colln. 4676, Jones Ridge area.

Quebecaspis conifrons? Rasetti

Plate 9, figures 8–10

Quebecaspis conifrons Rasetti, 1961, p. 117, pl. 24, figs. 23–25.

Description.—Cranidium subquadrate, moderately rounded anteriorly. Glabella large, low, moderately convex transversely and longitudinally, semielliptical in plan view, well defined by narrow axial and preglabellar furrows. Glabellar furrows barely apparent; posterior pair nearly outlines posterolateral glabellar lobes. Occipital furrow deep, broadest and slightly arched forward on axial line. Occipital ring convex, lacks node or spine. Frontal area short; sagittal length variable between one-third and slightly less than one-fourth sagittal glabellar length, exclusive of occipital ring. Border convex, occupying all of frontal area or separated from narrow nearly flat brim by shallow border furrow; sagittal length of border at least twice sagittal length of brim. Fixed cheek narrow, gently convex, horizontal; width, exclusive of palpebral lobe, variable between one-sixth and one-eighth basal glabellar width. Palpebral lobe arcuate, poorly defined by shallow palpebral furrow, situated about opposite glabellar midlength; exsagittal length about one-half sagittal glabellar length, exclusive of occipital ring. Posterior limb short, bluntly rounded distally; transverse width less than one-half

basal glabellar width. Surface not distinctly ornamented.

Course of anterior section of facial suture nearly straight forward from palpebral lobe to border, then turned abruptly inward across border to intersect anterior margin about one-third of distance to axial line Course of posterior section convex.

Discussion.—The Alaskan specimens represent a variable population that includes specimens both with and without a separate brim on the cranidium. The specimens without a brim are virtually indistinguishable from cranidia described by Rasetti as *Quebecaspis conifrons* from the Frederick Limestone of Maryland. Because Rasetti had only three cranidia, the range of variability of the Maryland population is not known. The unusual glabellar shape and lack of an occipital spine distinguish the Maryland and Alaska sample from the other described species of *Quebecaspis*. In the absence of consistent differences between the Alaska sample and the known specimens of *Q. conifrons*, the Alaskan specimens are tentatively assigned to that species.

Quebecaspis conifrons? differs from the associated species *Q. aspinosa* n. sp. by having a more strongly tapered and anteriorly rounded glabella, barely apparent glabellar furrows, narrower fixed cheeks, and a distinct anterior bending of the axial part of the occipital furrow.

Occurrence.—Dresbachian–2 fauna. Moderately rare (5 cranidia), USGS colln. 4381–CO, Hi-yu area.

Quebecaspis sp.

Plate 9, figure 16

Description.—Cranidium subquadrate, gently rounded anteriorly. Glabella low, broad, tapered slightly forward, bluntly rounded at front, well defined by shallow axial and preglabellar furrows. Glabellar furrows shallow, posterior two pairs deepest; posterior pair bigeniculate; transverse length about one-third glabellar width. Occipital furrow broad, moderately deep. Occipital ring has short median spine at posterior margin. Frontal area short, consists almost entirely of convex border; sagittal length slightly less than one-sixth sagittal glabellar length, exclusive of occipital ring. Border furrow broad, shallow, tangent to preglabellar furrow in front of glabella. Fixed cheek narrow, gently convex, nearly horizontal; width, exclusive of palpebral lobe, about one-fourth basal glabellar width. Palpebral lobe slightly arcuate, well defined by broad shallow palpebral furrow; exsagittal length slightly more than one-third sagittal glabellar length, exclusive of occipital ring. Posterior limb short, rounded distally; transverse width distinctly less than basal glabellar width. Posterior border furrow broad, deep. External surfaces of convex parts of cranidium have fine closely spaced obscure granules.

Course of anterior section of facial suture nearly straight forward from palpebral lobe. Course of posterior section convex.

Discussion.—Several fragmentary cranidia agree in all proportions with cranidia described as *Quebecaspis breviceps* (Rasetti, 1944). However, Rasetti's specimens from the Levis Conglomerate in eastern Canada have a pitted rather than granular external surface and thus probably represent a different species. The Alaskan specimens are inadequate for naming, but they differ from the other Alaskan species of *Quebecaspis* by possessing an occipital spine.

Occurrence.—Dresbachian–2 fauna. Moderately rare (5 cranidia), USGS colln. 4360–CO; rare (1 cranidium), GSC colln. 4646; moderately common (7 cranidia), GSC colln. 4635; all from Hillard Peak area. Rare (1 cranidium), GSC colln. 4674, Jones Ridge area.

Genus RASETTIA Lochman

Platycolpus Raymond, 1913, p. 63; Rasetti, 1944, p. 250; Shimer and Shrock, 1944, p. 629 [not *Platycolpus* Donald, 1901].

Rasettia Lochman, 1953, p. 886; Lochman, 1959, p. 380.

Type species.—*Bathyurus capax* Billings, 1860, p. 318, fig. 20.

Rasettia cf. R. capax (Billings)

Plate 14, figures 13, 17

Platycolpus capax (Billings). Rasetti, 1944, p. 250, pl. 39, figs. 10–12.

Discussion.—A single large fragmentary cranidium is characterized by a large poorly defined glabella that reaches to the edge of a transversely striated border. The border is nearly vertical and appears to be plastered onto the front of the cranidium. The fixed cheek is narrow, and the palpebral furrow is barely preserved but seems to have been curved and moderately well defined. This specimen has all the characteristics of *Rasettia* and may represent *R. capax*, from which it seems to differ only by having shallower axial furrows. Confirmation of the specific identity must await more material.

Occurrence.—Trempealeauan–1 fauna. Rare (1 cranidium), USGS colln. 3833–CO, Jones Ridge area.

Genus SEMISPHAEROCEPHALUS Ivshin

Semisphaerocephalus Ivshin, 1953, p. 87; Suvorova, 1960a, p. 85.

Type species.—*Semisphaerocephalus nominalis* Ivshin, 1953, p. 88, pl. 6, figs. 10–16.

Diagnosis.—Cranidium in form of section of sphere. Glabella low, broad, poorly defined on external sur-

face, moderately well defined by axial and preglabellar furrows on mold, tapered slightly forward, bluntly rounded anteriorly. Glabellar furrows poorly developed. Length of frontal area less than one-half length of cranidium. Brim and border poorly differentiated. Width of fixed cheeks two-fifths to three-fifths basal glabellar width. Palpebral lobes small, situated opposite middle third of glabella. Distal parts of posterior limbs short, blunt. External surfaces of all known species pitted.

Discussion.—*Semisphaerocephalus* may be related to *Onchocephalites* (Rasetti, 1957, 1963) from beds of early Middle Cambrian age. *Onchocephalites* has species that have generally longer palpebral lobes, less semispherical form to the cranidium, a more strongly rounded anterior end to the glabella, and a smooth or granulated external surface. Further discussion of relationships between the genera is given after the description of *Semisphaerocephalus latus* n. sp.

Semisphaerocephalus latus n. sp.

Plate 5, figures 24, 25

Description.—Cranidium subtrapezoidal in outline, broadly and evenly rounded anteriorly, moderately convex transversely and longitudinally; sagittal length about four-fifths width between palpebral lobes. Glabella low, broad, straight sided, bluntly rounded at front, tapered slightly forward; anterior end barely raised above frontal area. Two pairs of short shallow glabellar furrows present on internal mold. Axial furrow shallow, deepest at back of glabella. Occipital furrow deep, broad. Occipital ring convex; median node present. Frontal area gently convex, downsloping; length slightly less than one-half sagittal glabellar length. Border furrow straight, barely apparent even on internal mold, divides frontal area into brim and border of about equal sagittal length. Border tapered laterally. Fixed cheek gently convex, wide, downsloping to same degree as frontal area, giving cranidium form of section of sphere; width about three-fifths basal glabellar width. Palpebral lobe small, situated opposite middle third of glabella; length slightly less than one-fourth sagittal glabellar length. Narrow curved eye ridges cross fixed cheeks on internal mold. Distal part of posterior limb short; transverse width about one-sixth width of proximal part. Posterior border furrow broad, deep.

Course of anterior section of facial suture convergent forward in even curve from palpebral lobe, intersects anterior margin directly in front of anterolateral corners of glabella. Course of posterior section slightly divergent posteriorly, about subparallel to anterior section.

External surfaces of frontal area and fixed cheeks covered with coarse pitted ornamentation. Ornamentation of glabella and occipital ring unknown.

Discussion.—*Semisphaerocephalus latus* n. sp. is represented by several mostly exfoliated cranidia in four collections. Only fragments of the exoskeleton are preserved to show the characteristic pitted ornamentation. Ivshin (1953, p. 87) has described a genus, *Semisphaerocephalus*, from upper Middle Cambrian beds of Kazakhstan that seems to include the Alaskan species. Ivshin's type species, *S. nominalis*, has its fixed cheeks and frontal area downsloping, a low glabella, small palpebral lobes, a pitted surface, and fixed cheeks that are about half as wide as the basal glabellar width. The Alaskan specimens differ principally by having relatively wider fixed cheeks, and they are therefore considered here as another species of *Semisphaerocephalus*.

Most of the specimens from Alaska and Kazakhstan are exfoliated. If their exoskeletons were completely preserved, the specimens would probably have the frontal area undivided, the anterior end of the glabella barely defined, and no evidence of eye ridges—characteristics of *Onchocephalites punctatus* (Rasetti, 1963, p. 588, pl. 67, figs. 22–25) from boulders of late Middle Cambrian age at Levis, Quebec. Thus, *O. punctatus*, which has fixed cheeks slightly less than one-half the basal glabellar width may also belong to *Semisphaerocephalus*.

The type species of *Onchocephalites* is *O. laevis* (Rasetti, 1957) from pre-*Albertella* Middle Cambrian beds in the Canadian Rockies. This species has relatively long palpebral lobes that are more posteriorly located than those of *O. punctatus* and a more rounded anterior end to the glabella. It is also considerably older than *O. punctatus*. Therefore, I consider that a more meaningful taxonomic arrangement of these trilobites is to recognize *Onchocephalites* and *Semisphaerocephalus* as possibly related genera of different ages and to place *O. punctatus*, with its approximately contemporaneous congeners, in *Semisphaerocephalus*. The genera differ principally in ornamentation, size and position of the palpebral lobes, and shape of the anterior end of the glabella. The species of *Semisphaerocephalus* differ principally in width of the fixed cheeks.

Occurrence.—Middle Cambrian–1 fauna. Moderately rare (2 cranidia), USGS colln. 4303–CO; 3 cranidia, USGS colln. 4339–CO; Tatonduk River section; 3 cranidia, USGS colln. 4341–CO, Hillard Peak area; 1 cranidium, USGS colln. 4382–CO, Hard Luck Creek area.

Genus SPENCELLA Rasetti

Spencella Rasetti, 1963, p. 590.

Type species.—*Spencella montanensis* Rasetti, 1963, p. 592, pl. 68, figs. 1–11.

Discussion.—*Spencella* has recently been proposed by Rasetti and its content and concept thoroughly discussed. The specimens described below conform in all features to the diagnostic characteristics of *Spencella.*

Spencella acanthina n. sp.

Plate 5, figures 18, 19

Description.—Cranidium trapezoidal, moderately convex transversely and longitudinally. Glabella well defined, moderately convex transversely and longitudinally, tapered slightly forward, bluntly rounded anteriorly. Glabellar furrows shallow on external surface. Occipital furrow deep. Occipital ring has short axial spine at posterior margin. Frontal area short, border convex, wider than brim; inner margin expanded slightly posteriorly on axial line. Border furrow shallow. Sagittal length of frontal area slightly more than two-fifths sagittal length of glabella, exclusive of occipital ring. Fixed cheek moderately wide, gently convex, downsloping; width about two-thirds basal glabellar width. Palpebral lobes small, situated opposite middle third of glabella; length about one-third sagittal glabellar length, exclusive of occipital ring. Posterior limbs have distal part short; transverse length about one-fifth transverse length of proximal part. Ornamentation of fixed cheeks not known; surface of glabella smooth; surface of frontal area obscurely covered with fine granules.

Course of anterior section of facial suture convergent forward in gentle curve from palpebral lobe to anterior margin. Course of posterior section divergent behind palpebral lobe, then curved abruptly backward and continued in nearly straight line to posterior cranidial margin.

Discussion.—*Spencella acanthina* is the only species in Alaska of *Spencella* that has an occipital spine. In addition to having an obscure granular ornamentation on the frontal area, it differs from *S. spinosa* Rasetti from Middle Cambrian boulders in Quebec by having a narrower occipital ring, more upturned spine, and less convex cranidial border.

Occurrence.—Middle Cambrian–1 fauna. Moderately common (11 cranidia), USGS colln. 4303–CO, Tatonduk River area.

Spencella montanensis Rasetti

Plate 5, figures 14–16

Spencella montanensis Rasetti, 1963, p. 592, pl. 68, figs. 1–11.

Description.—Cranidium subquadrate, moderately convex transversely and longitudinally. Glabella unfurrowed, gently to moderately convex transversely and longitudinally, tapered forward, bluntly rounded anteriorly; sides nearly straight; anterior end and sides well defined by abrupt change in slope of cranidial surface. Occipital furrow deepest at sides of glabella. Occipital ring broad, nearly flat on axial line; sagittal length nearly one-third sagittal glabellar length, exclusive of occipital ring; low axial node present near posterior margin. Frontal area downsloping, divided into broad convex border and narrow downsloping brim of variable width by deep narrow slightly curved border furrow. Sagittal length of frontal area about one-half or slightly more than one-half sagittal glabellar length, exclusive of occipital ring. Fixed cheeks gently convex, downsloping; width, including palpebral lobe, about two-thirds basal glabellar width. Palpebral lobes small, poorly defined, situated slightly anterior to glabellar midlength; length slightly less than one-third sagittal glabellar length, exclusive of occipital ring. Posterior limb short, bluntly terminated; transverse length about three-fourths basal glabellar width. Posterior border furrow deepest near glabella. External surfaces of all parts smooth.

Course of anterior section of facial suture slightly convergent forward in gentle curve from palpebral lobe to anterior margin. Course of posterior section slightly divergent posterolaterally for short distance behind palpebral lobe, then turned abruptly and directed nearly straight backward to posterior margin.

Discussion.—The Alaskan specimens cannot be distinguished by any consistent objective feature from well-preserved limestone specimens of *Spencella montanensis* collected by Rasetti from boulders at Metis, Quebec. The variability of the sagittal length of the brim and differences in angularity of the course of the posterior section of the facial suture are well shown on Rasetti's material in the collections of the U.S. National Museum.

Occurrence.—Middle Cambrian–1 fauna. Moderately common (10 cranidia, all exfoliated), USGS colln. 4382–CO, Hard Luck Creek area; 3 cranidia, USGS colln. 4424–CO, Yukon River (Adams Peak) area; 2 exfoliated cranidia, USGS colln. 4330–CO, Yukon River (Water Level) area.

Spencella? sp.

Plate 5, figures 20, 21

Discussion.—Four cranidia associated with *Spencella acanthina* n. sp. represent a species which differs by having small anteriorly situated palpebral lobes

that are only one-fourth of the sagittal length of the glabella exclusive of the occipital ring, and a median node rather than a median spine on the occipital ring. Specimens of *S. virginica* illustrated by Rasetti (1963, pl. 68, figs. 19–21) have comparable small anteriorly situated palpebral lobes. Perhaps these small but consistent differences from typical species of *Spencella*, which have larger and more posteriorly placed palpebral lobes, indicate a difference at the generic level that will be more apparent when other parts of the exoskeletons of these species become known.

Occurrence.—Middle Cambrian–1 fauna. Moderately rare (4 cranidia), USGS colln. 4303–CO, Tatonduk River section.

Genus THOLIFRONS n. gen.

Type species.—*Tholifrons advena* n. sp.

Diagnosis.—Cranidium, exclusive of posterior limbs, elongate, subquadrate, moderately to strongly rounded anteriorly. Glabella subparallel sided or tapered slightly forward, bluntly rounded anteriorly. Glabellar furrows barely apparent or absent. Occipital ring simple. Frontal area undivided; sagittal length one-half to two-thirds sagittal length of glabella exclusive of occipital ring. Fixed cheek horizontal or slightly upsloping; width, exclusive of palpebral lobe, two-fifths to one-half basal glabellar width. Palpebral lobe small, situated slightly posterior to glabellar midlength. Posterior limb short, has rounded distal tip.

Course of anterior section of facial suture straight forward or slightly divergent for short distance in front of palpebral lobe, then curved broadly and evenly inward to intersect anterior margin imperceptibly near axial line. Course of posterior section convex.

Characters of free cheek and pygidium known only for type species. Details given in species description.

Discussion.—*Tholifrons* does not have any close relationship to any described Late Cambrian genus. Its most distinctive features are the complete absence of a border on either the cranidium or the free cheeks and the posterior placement of the palpebral lobes. The only reasonably similar described species is *Stigmacephalus? distorta* (Wilson, 1951, p. 652, pl. 92, figs. 16, 17) from a fauna that is slightly younger than the one containing *Tholifrons*. This species has an undivided frontal area, but the glabella is fully defined by axial and preglabellar furrows and the palpebral lobes are more anteriorly placed than on either species of *Tholifrons* described here. Wilson's specimens are distorted and incomplete, and when more is learned about the Appalachian species it possibly may be included in *Tholifrons*.

Tholifrons advena n. sp.

Plate 9, figures 17–23, 28

Description.—Cranidium elongate, subquadrate, anterior margin moderately to strongly rounded. Glabella elongate, subquadrate, gently to moderately convex transversely and longitudinally, sides subparallel, bluntly rounded anteriorly, well defined by abrupt changes in slope of exoskeleton surface. Glabellar furrows barely apparent. Occipital furrow broad, shallow. Occipital ring convex, lacks distinct node or spine. Frontal area undivided, arched downward in sagittal plane, anterior margin nearly vertical; sagittal length about two-thirds sagittal length of glabella, exclusive of occipital ring. Fixed cheek horizontal or slightly upsloping; width, exclusive of palpebral lobe, about one-half basal glabellar width. Palpebral lobe moderately wide, arcuate, poorly defined, situated slightly posterior to glabellar midlength; exsagittal length decreases from about one-half sagittal glabellar length to about one-third sagittal glabellar length during holaspid ontogeny. Posterior limbs short, bluntly rounded distally; transverse length decreases from nearly equal basal glabellar width to about four-fifths basal glabellar width during holaspid ontogeny. Posterior border furrow shallow except on smallest holaspid.

Course of anterior section of facial suture slightly divergent forward from palpebral lobe for short distance, then curved broadly and evenly inward to intersect anterior margin imperceptibly near axial line. Course of posterior section of facial suture convex.

Free cheek narrow, tapered both forward and backward, lateral margin broadly and evenly rounded. No border present. Genal spine long, broad, sharply pointed, flattened in cross section, lateral margin sharp; length at least 3 times length of posterior section of facial suture. Anterior doublure directed inward in normal fashion from cephalic margin and then bent abruptly upward and back towards margin forming unusual three-layered exoskeleton in marginal area. Dorsal and ventral surfaces of genal spine have longitudinal terrace lines.

Pygidium(?) semicircular, nearly flat except for narrow convex posteriorly tapered axis. Ring furrows barely apparent. Pleural regions have poorly defined narrow border and are crossed by three or four shallow gently curved pleural furrows.

External surfaces of all parts except genal spine lack apparent ornamentation.

Discussion.—The differences between *Tholifrons advena* n. sp. and *T. minutus* n. sp. are discussed after the description of *T. minutus*. No other trilobite in

the Alaskan fauna is likely to be confused with *T. advena*.

The pygidium described above is assigned to this species because most of the small trilobites associated with *Tholifrons advena* have typical simple ptychoparioid cranidia, and most of the unassigned pygidia are also typical simple ptychoparioid forms. Thus the association of an unusual pygidium with the unusual cranidia and free cheeks of *T. advena* is a reasonable probability.

Occurrence.—Dresbachian–2 fauna. Moderately rare (11 cranidia, 6 free cheeks, 2 pygidia), USGS colln. 4381–CO, Hi-yu area. Moderately common (5 cranidia), GSC colln. 4643; rare (3 cranidia), USGS colln. 4360–CO; 5 cranidia, GSC colln. 4646; 2 cranidia, GSC colln. 4645; 1 cranidium, GSC 4635; all from Hillard peak area.

Tholifrons minutus n. sp.

Plate 9, figures 24, 25

Description.—Tiny trilobite, length of largest observed cranidium slightly more than 2 mm. Cranidium, exclusive of posterior limbs, elongate, subquadrate, moderately to strongly rounded anteriorly. Glabella tapered slightly forward, bluntly rounded anteriorly; transverse profile of posterior part conical; height decreases anteriorly. Axial furrows narrow, deeply incised along posterior two-thirds of glabella; anterior third of glabella poorly defined by only slight change in slope of exoskeleton. Glabellar furrows not apparent. Occipital furrow narrow, straight, deeply incised. Occipital ring convex, lacks either node or spine. Frontal area flat or gently convex, slightly downsloping, undivided; sagittal length about one-half sagittal length of glabella, exclusive of occipital ring. Fixed cheek gently convex, horizontal; width, exclusive of palpebral lobe, about two-fifths basal glabellar width. Palpebral lobe prominent, situated slightly posterior to glabellar midlength, elevated above inner cheek surface, well defined by deep narrow palpebral furrow that continues most of distance across infraocular part of cheek outlining posterior edge of ocular ridge; exsagittal length slightly more than two-fifths sagittal glabellar length, exclusive of occipital ring. Posterior limb slender, bluntly rounded at tip; transverse length about equal to basal glabellar width. Posterior border furrow deep.

Course of anterior section of facial suture straight forward or slightly divergent forward from palpebral lobe for short distance, then curved broadly and evenly inward to intersect anterior margin near axial line. Posterior section of facial suture convex.

External surface lacks apparent ornamentation.

Discussion.—Cranidia assigned to *Tholifrons minutus* n. sp. were first thought to be immature specimens of *T. advena* n. sp., but there are two kinds of cranidia among the suite of 14 *Tholifrons* cranidia less than 2 mm long (pl. 9, figs. 19, 24). One of these has the shallow axial, occipital, and palpebral furrows characteristic of *T. advena*, a relatively low glabella, and short distal parts to the posterior limbs. The rest have the characteristics given in the description above and differ consistently from both small and large cranidia of *T. advena* by having deeper axial, occipital, and palpebral furrows, narrower fixed cheeks, a conical profile across the posterior part of the glabella, and a longer distal part to the posterior limbs. Because they are present on cranidia both larger and smaller than the small specimen that is assigned without question to *T. advena*, these differences are unlikely to be only ontogenetic; the specimens are therefore considered here to represent a second species of *Tholifrons*.

Occurrence.—Dresbachian–2 fauna. Moderately rare (13 cranidia), USGS colln. 4381–CO, Hi-yu area.

Genus YUKONASPIS Kobayashi

Yukonaspis Kobayashi, 1936a, p. 164.

Type species.—*Yukonaspis kindlei* Kobayashi, 1936a, p. 164, pl. 21, figs. 3–6.

Discussion.—*Yukonaspis* was based on three small imperfect cranidia, none of which have the frontal area completely preserved. Fairly numerous specimens of *Y. kindlei* have been found in the youngest Cambrian collection in the Yukon River (Adams Peak) area. Most of the specimens are slightly crushed, so the convexity is less than that on the specimens described by Kobayashi, but in all other respects they are like the specimens from the Jones Ridge area. The description below can be considered as an emended and expanded description of the genus and perhaps the species.

Lochman (1953, p. 887; 1959, p. 271) considered *Yukonaspis* and *Tatonaspis* both to be synonyms of *Macelloura*. However, the poorly defined palpebral lobes and presence of a brim distinguish *Yukonaspis* from *Macelloura*, and the strongly arched convex border and deep border furrow distinguish it from *Tatonaspis*.

Yukonaspis kindlei Kobayashi

Plate 15, figures 15, 19

Yukonaspis kindlei Kobayashi, 1936a, p. 164, pl. 21, figs. 3–6.

Description.—Cranidium elongate, subquadrate, anterior margin strongly arched upward in anterior

view. Glabella low, moderately convex transversely and longitudinally, very slightly tapered forward, bluntly rounded anteriorly, defined at sides by shallow axial furrows, defined at front by abrupt change in slope of surface of exoskeleton. Glabellar furrows absent. Occipital furrow straight, moderately deep across top of glabella, not connected to axial furrows. Occipital ring convex, has poorly defined median node. Frontal area strongly concave; sagittal length about one-fourth or slightly less than one-fourth sagittal glabellar length, exclusive of occipital ring. Border narrow, strongly upsloping, differentiated from brim by abrupt change in slope of exoskeleton surface, nearly straight in dorsal view, strongly arched upward in front view. Fixed cheek very narrow, slightly upsloping; transverse width slightly less than one-ninth basal glabellar width. Palpebral lobe large, semicircular, nearly horizontal, not differentiated from infraocular part of cheek, situated very slightly posterior to glabellar midlength; width about twice width of infraocular part of cheek; exsagittal length slightly less than one-half sagittal glabellar length, exclusive of occipital ring. Posterior limb slender, tapered to sharp point; transverse length slightly less than basal glabellar width. Posterior border furrow moderately deep.

Course of anterior section of facial suture curved very gently inward from palpebral lobe to anterior margin; further course not known. Course of posterior section of facial suture divergent and sinuous.

Discussion.—The specimens described above are like the types of *Yukonaspis kindlei* described by Kobayashi in all observable features.

Occurrence.—Trempealeauan–2 fauna. Common (10 cranidia), USGS colln. 4351–CO, Yukon River (Adams Peak) area. Moderately common (3 cranidia) GSC colln. 266; 1 cranidium, GSC colln. 4628; 8 cranidia, GSC colln. 4629; 9 cranidia, GSC colln. 4631; 3 cranidia, including holotype, GSC colln. 4632; 4 cranidia, GSC colln. 4634; 2 cranidia, GSC colln. 4691; all from Jones Ridge area. Moderately rare (2 cranidia), GSC colln. 4685; 1 cranidium, GSC colln. 4732; 1 cranidium, GSC colln. 4744; all from Squaw Mountain area.

Genus and species undetermined 1

Plate 6, figure 21

Description.—Cranidium subtrapezoidal, gently rounded anteriorly. Glabella low, unfurrowed, tapered forward, bluntly rounded anteriorly, well defined by broad deep lateral and preglabellar furrows. Occipital furrow deep, narrow on axial line, disappears laterally before reaching axial furrows. Occipital ring simple. Frontal area short, undivided, gently downsloping, nearly flat; sagittal length about one-third sagittal length of glabella, exclusive of occipital ring. Fixed cheek gently convex, horizontal; width about one-half basal glabellar width. Palpebral lobe small, poorly defined, situated opposite anterior third of glabella; exsagittal length slightly less than one-fourth sagittal glabellar length, exclusive of occipital ring. Posterior limb triangular; transverse length slightly less than basal glabellar width. External surface of glabella smooth; distal parts of fixed cheeks, frontal area, and posterior limbs have moderately strong terrace lines longitudinally directed and gently convex laterally.

Course of anterior section of facial suture slightly convergent forward from palpebral lobe. Course of posterior section convex.

Discussion.—This unusual small trilobite is unlike any described form known to me in the peculiar lateral longitudinal ornamentation of terrace lines. Otherwise it is a nondescript ptychoparioid having small anteriorly located palpebral lobes, unfurrowed glabella, undivided frontal area, and moderately wide fixed cheeks. More material is needed for formal naming of this species.

Occurrence.—Middle Cambrian–2 fauna. Rare (1 cranidium), GSC colln. 282, Hillard Peak area.

Genus and species undetermined 2

Plate 3, figure 11

Description.—Cephalon subquadrate, gently to moderately convex transversely and longitudinally, anterior margin broadly rounded. Glabella moderately convex transversely, tapered slightly forward, defined at sides by abrupt change in slope; anterior end bluntly rounded, barely differentiated from frontal area by slight change in slope. Three pairs of shallow narrow glabellar furrows present at sides of glabella; posterior pair directed slightly backward. Occipital furrow straight, deepest at sides of glabella. Occipital ring convex, has median node on posterior margin. Frontal area concave; border broad, concave, barely differentiated from brim only lateral to glabella by narrow shallow border furrow; sagittal length of frontal area slightly less than one-half sagittal glabellar length. Fixed cheek broad, nearly flat, gently upsloping; width about two-thirds basal glabellar width. Eye ridge moderately well defined, particularly posterior edge, directed posterolaterally from point just anterior to front pair of glabellar furrows. Palpebral lobe arcuate, strongly upsloping, situated slightly posterior to glabellar midlength, well defined by broad shallow palpebral furrow; length slightly less

than one-half sagittal glabellar length. Posterior limbs broken on all known specimens.

Course of anterior section of facial suture slightly divergent forward from palpebral lobe onto border, then turned sharply inward to intersect anterior margin in front of anterior end of palpebral lobe. Course of posterior section not known.

Ornamentation consists of closely spaced fine granules on axial parts of glabella and occipital ring, palpebral furrows, and palpebral lobes. Remaining areas smooth or have barely apparent scattered low granules.

Other parts unknown.

Discussion.—I have not been able to find any described Early Cambrian trilobite that closely resembles this species. Because its aspect is not like any American trilobites, I sent a replica to Dr. N. P. Suvorova of the Paleontologic Institute of the Academy of Sciences of the U.S.S.R. in Moscow in hope that it might be familiar to her or her colleagues. However, this is a new form to them also. The systematic placement and naming of this species must await more material.

Occurrence.—Early Cambrian–2 fauna. Moderately rare (3 cranidia), USGS colln. 4302–CO, Tatonduk River area.

Genus and species undetermined 3

Plate 3, figure 5

Description.—Cranidium small, subquadrate, moderately convex transversely and longitudinally, gently rounded anteriorly. Glabella large, well defined by shallow axial and preglabellar furrows, moderately convex transversely and longitudinally, reaches to border furrow on axial line. Glabellar furrows absent. Occipital furrow shallow, straight. Occipital ring convex, without node or spine. Frontal area short; border narrow, convex, well defined by shallow border furrow that bends backward on axial line to touch preglabellar furrow; lateral parts of brim gently convex; sagittal length of frontal area slightly more than one-fifth sagittal glabellar length. Fixed cheek gently convex, moderately wide, downsloping; width slightly more than one-third basal glabellar width. Palpebral lobe poorly defined, narrow, situated opposite middle third of glabella; length about one-third sagittal glabellar length. Structure of posterior limb unknown.

Course of anterior section of facial suture nearly straight forward from palpebral lobe for short distance, then curves gently inward to intersect anterior margin directly in front of posterolateral corner of glabella. Course of posterior section strongly divergent from palpebral lobe; distal part unknown.

External surfaces of all parts, including furrows, evenly covered with closely spaced fine granules.

Discussion.—This small generalized ptychoparioid trilobite is differentiated from other associated species by its subquadrate glabella and short frontal area. The most similar described Early Cambrian species is *Solontzella sulcata* Repina (Repina and others, 1964, p. 313, pl. 44, figs. 11, 12) which has deeper glabellar furrows and slightly narrower fixed cheeks. More knowledge of the Alaskan species is needed to provide it with a meaningful name, however.

Occurrence.—Early Cambrian–2 fauna. Rare (4 cranidia), USGS Colln. 4302–CO, Tatonduk River area.

Genus and species undetermined 4

Plate 6, figure 14

Description.—Cranidium subtrapezoidal, gently to moderately convex transversely and longitudinally. Glabella short, broad, moderately convex transversely, tapered forward, truncate anteriorly. Axial and pleural furrows moderately deep. Shallow fossulae present at anterolateral corners of glabella. Glabellar furrows shallow. Occipital furrow deep, nearly straight. Occipital ring narrow, convex. Frontal area short, subequally divided into strongly convex border and nearly flat brim; sagittal length slightly more than one-half sagittal length of glabella, exclusive of occipital ring. Fixed cheeks broad, strongly upsloping from axial furrow to tip of transversely elongate palpebral lobe; distal parts anterior and posterior to palpebral lobe depressed. Width of fixed cheek exclusive of palpebral lobe about equal to basal glabellar width. Palpebral furrow broad, shallow. Transverse width of palpebral lobe about one-fourth width of fixed cheek. Distal part of posterior limb short transversely, triangular. Posterior border furrow deep. External surfaces of all convex parts have scattered coarse granules.

Course of anterior section of facial suture strongly convergent forward from palpebral lobe to anterior margin. Course of posterior section of facial suture directed in nearly straight line posterolaterally from palpebral lobe to posterior cranidial margin.

Discussion.—This trilobite is unlike any described species in the combination of wide, upsloping fixed cheeks, transversely elongate palpebral lobes, and strongly convergent anterior sections of the facial sutures. The most similar described species is *Coenaspis spectabilis* (Resser, 1938, p. 69, pl. 16, fig. 9) from beds of early Late Cambrian age in Tennessee. However, *C. spectablis* lacks strongly convergent anterior sections of the facial sutures, and the palpebral lobes

are even longer transversely than those of the Alaskan specimen. The similarity between the two species may be only superficial, and the Alaskan specimen may represent an undescribed genus. However, the material presently available is inadequate for satisfactory naming.

Occurrence.—Middle Cambrian–2 fauna. Rare (1 cranidium), USGS colln. 3832–CO, Yukon River (West Ridge) area.

Genus and species undetermined 5

Plate 5, figure 22

Description.—Pygidium transversely subquadrate. Axis strongly convex, extends to inner edge of nearly vertical posterior marginal area. Two shallow ring furrows present posterior to articulating furrow. Pleural regions lack border. Two or three shallow pleural furrows barely apparent. Lateral parts of pleural regions extended into long, posterolaterally directed pair of spines. Posterior margin between spines nearly vertical. External surface unknown.

Discussion.—This species, represented by a single exfoliated specimen, is in an assemblage of undoubted Middle Cambrian age. However, it is extremely similar in all characteristics to pygidia of *Prochuangia mansuyi* (Kobayashi, 1935b, p. 186, pl. 10, figs. 6, 7) from beds of early Late Cambrian age in south Korea. More must be learned about the other parts of the Alaskan trilobite before the degree of its relationship to *Prochuangia* can be determined.

Occurrence.—Middle Cambrian–1 fauna. Rare (1 pygidium), USGS, colln. 4303–CO, Tatonduk River area.

Genus and species undetermined 6

Plate 6, figure 1

Description.—Pygidium semicircular, gently convex transversely and longitudinally, posterior margin evenly curved. Axis moderately convex transversely, tapered posteriorly, terminates slightly anterior to inner edge of border; connected to border by low broad postaxial ridge. Four or five shallow ring furrows present posterior to articulating furrow. Pleural regions have distinct slightly concave moderately broad border; width nearly constant, about one-third greatest width of pleural region. Pleural fields crossed by four or five shallow gently curved pleural furrows; on outer surface, furrows shallow and continue slightly onto inner part of border; on surface of mold, furrows longer and slightly deeper. External surfaces of all parts smooth.

Discussion.—This pygidium has the outline, gently concave border of nearly constant width, and gentle convexity of pygidia generally associated with genera of the Anomocaridae (or Anomocarinae). Lack of other associated parts makes adequate generic and specific identification of this specimen uncertain. However, it is remarkably similar to the pygidium of *Metanomocare petaloides* (Lermontova, 1940, p. 91, pl. 47, fig. 5a) from upper Middle Cambrian beds of Siberia. Both species are alike in pygidial outline, length and shape of the axis, and distribution of axial and pleural furrows. The Alaskan species differs from the Siberian species by having a slightly narrower pygidial border and shallower pleural furrows.

Occurrence.—Middle Cambrian–1 fauna.—Rare (1 pygidium), USGS colln. 4303–CO, Tatonduk River area.

Genus and species undetermined 7

Plate 13, figure 10

Description.—Pygidium semicircular, gently convex transversely and longitudinally, all parts weakly defined by shallow furrows. Axis long, tapered posteriorly, tip tangent to inner edge of border; moderately broad postaxial median ridge extends onto border. Four shallow ring furrows barely apparent on mold of axis posterior to articulating furrow. Pleural regions have broad, flattened, smooth border. Pleural fields crossed by four very shallow straight pleural furrows and three comparable interpleural furrows that reach to inner edge of border. External surfaces of all parts smooth.

Discussion.—The pygidia described above are associated with *Onchonotus brevifrons* n. sp. and *Richardsonella quadrispinosa* n. sp. They cannot be assigned with certainty to any described Late Cambrian trilobite, and no possibly conspecific cranidia have been found with them. Pygidia assigned to *Loganellus* have a similar outline and convexity, but in that genus the tip of the axis is anterior to the inner edge of the border instead of touching it.

Occurrence.—Franconian–2 fauna. Moderately rare (4 pygidia), USGS colln. 3709–CO, Hillard Peak area.

Genus and species undetermined 8

Plate 6, figure 27

Description.—Cranidium subtrapezoidal; anterior margin strongly rounded. Glabella well defined, straight sided, tapered forward, bluntly rounded at front, moderately convex transversely, gently convex longitudinally, well defined at sides and front by broad moderately deep axial and preglabellar furrows. Two pairs of glabellar furrows represented by shallow notches adjacent to axial furrows. Occipital furrow deep, broad. Occipital ring simple. Frontal area

moderately long sagittally, gently concave, subequally divided into gently downsloping brim and moderately convex border by broad shallow border furrow; sagittal length about three-fourths sagittal length of glabella, exclusive of occipital ring. Border furrow has two large deep pits directly in front of anterolateral corners of glabella. Fixed cheek moderately wide, strongly upsloping; width about two-thirds basal glabellar width. Palpebral lobe small, situated opposite anterior third of glabella. Posterior limb long, triangular; length greater than basal glabellar width. Posterior border furrow broad, deep, directed forward at distal end of limb. External surface not known; surface of mold has scattered large pustules on all convex parts.

Course of anterior section of facial suture straight forward from palpebral lobe to border furrow; further course not known. Course of posterior section not fully known; distal part crosses posterior part of lateral border furrow rather than posterior border furrow.

Discussion.—This unusual species has the upsloping fixed cheeks, anteriorly situated palpebral lobes, notchlike glabella furrows and large posterior limbs typical of the Menomoniidae. It differs from all trilobites in that family by having large pits in the anterior border furrow. None of the material available shows the outer surface of the exoskeleton, the form of the palpebral lobe, or the course of the posterior section of the facial suture; it is not considered adequate for formal naming.

Occurrence.—Middle Cambrian-2 fauna. Rare (2 cranidia), GSC colln. 282, Hillard Peak area.

Genus and species undetermined 9

Plate 6, figures 22, 23

Description.—Cranidium, exclusive of posterior limbs, subquadrate, moderately rounded anteriorly. Glabella large, long, moderately to strongly convex transversely and longitudinally; sides subparallel or slightly convergent forward; anterior end strongly rounded, reaches to or nearly to border furrow. Glabellar furrows not apparent. Occipital furrow deep, moderately wide. Occipital ring simple. Frontal area short, consists only of downsloping border and narrow border furrow on axial line; sagittal length of border about one-fifth sagittal length of glabella, exclusive of occipital ring. Border furrow nearly straight; border tapered to point laterally. Fixed cheek flat, gently upsloping; width about two-fifths basal glabellar width. Palpebral lobe short, wide, situated opposite glabellar midlength; exsagittal length of palpebral lobe only slightly more than transverse width; lateral margin of lobe sharply curved. Length of palpebral lobe slightly more than one-fourth sagittal glabellar length, exclusive of occipital ring. Transverse length of posterior limb about equal to basal glabellar width. External surface of small specimens has closely spaced fine granular ornamentation on top of glabella only. Surface of mold has few low scattered coarse granules on glabella and fixed cheeks.

Discussion.—Several associated cranidia of different sizes seem to represent a single species. The largest cranidium (length about 6 mm) has a nearly subparallel-sided glabella that reaches to the border furrow and an unusually short and wide palpebral lobe that has a sharply curved lateral margin (pl. 6, fig. 22). The smallest cranidium (length 2.5 mm) has a narrow brim, an anteriorly tapered glabella, and a relatively larger palpebral lobe (pl. 6, fig. 23). A cranidium intermediate in size has a slightly tapered glabella reaching to the border furrow, and slightly smaller palpebral lobes; thus it is intermediate in character between the large and small specimens. This species is characterized particularly by its short wide palpebral lobe and by the absence of a brim on the larger specimens. It is a variation on the generalized ptychoparioid theme that does not seem to represent any described genus. The sample is too small for adequate understanding of the characteristics necessary to make a meaningful name in this complex group of trilobites.

Occurrence.—Middle Cambrian–2 fauna. Moderately rare (4 cranidia), GSC colln. 282, Hillard Peak area.

Indeterminate or undescribed taxa

Three species—*Agnostus subobesus*, *Parabolinella punctolineata*, and *Ptychopleura brevifrons*—were described by Kobayashi (1936a) and assigned a Late Cambrian age. They are all from a single collection from the Jones Ridge section of Burling. The collection is from beds about 50 feet above the highest undoubted Cambrian collection and it lies above a collection that yielded only small brachiopods resembling *Nanorthis*, a characteristic Early Ordovician form. All three species are represented by poor material, and they are not included here in the Cambrian fauna.

Chuangiella intermedia Kobayashi

Chuangiella intermedia Kobayashi, 1935a, p. 47, pl. 9, fig. 3.

Discussion.—*Chuangiella intermedia* Kobayashi is based on one imperfectly preserved exofoliated cranidium. It has an unfurrowed glabella, a flaplike palpebral lobe that is not defined by a palpebral furrow, and narrow fixed cheeks. The frontal area is not

clearly preserved, and the part that Kobayashi interpreted as a border does not belong to the cranidium. No other Alaskan cranidia have been found that seem to represent this species. It is here considered to be indeterminate, and the name should be restricted to the holotype which was adequately figured by Kobayashi.

Occurrence.—Trempealeauan–1 fauna. Rare (1 cranidium), USNM loc. 25o (=Mertie colln. 30AMt147), Jones Ridge area.

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[Italic page numbers indicate descriptions]

PLATES 1–15

PLATE 1

Early Cambrian–1

[All specimens from USGS colln. 4296-CO, Yukon River area]

FIGURES 1, 2, 4. *Dinesus arcticus* n. sp. (p. B61).

1. Stereogram of nearly complete holotype individual, × 5, USNM 146643.
2, 4. Cranidia, × 4, USNM 146644, 146645.

3, 5–16. *Churkinia yukonensis* n. gen., n. sp. (p. B39).

3. Pygidium showing distinct asymmetry, × 3, USNM 146646.
5. Pygidium showing slight asymmetry, × 4, USNM 146647.
6. Free cheek, × 3, USNM 146648.
7. Holotype cranidium, × 3, USNM 146649.
8. Hypostome, × 3, USNM 146650.
9, 13. Small pygidia, × 5, USNM 146651, 146652.
10, 11. Cranidia, × 3, USNM 146653, 146654.
12. Hypostome, × 5, USNM 146655.
14–16. Thoracic segments, × 3, USNM 146656, 146657, 146658.

17–20. *Polliaxis inflata* n. gen., n. sp. (p. B49).

17. Holotype cranidium, × 2, USNM 146659.
18. Cranidium, × 3, USNM 146660.
19. Pygidium, × 2, USNM 146661.
20. Pygidium, × 3, USNM 146662.

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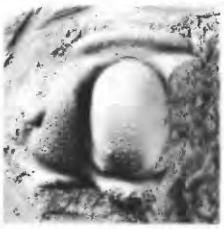

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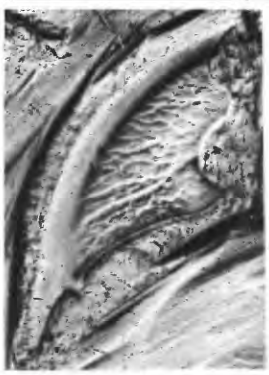

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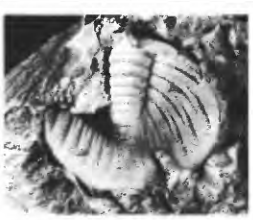

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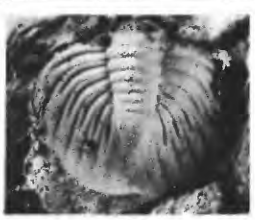

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EARLY CAMBRIAN-1 FAUNA

PLATE 2

Early Cambrian–1

[Figs. 1–6, 9–28 from Yukon River (Water level) area; figs. 7, 8 from Canada, east of Hillard Peak area]

FIGURES 1–3, 5, 6. *Gelasene acanthinos* n. gen., n. sp. (p. B80).
1. Holotype cranidium, × 2, USNM 146663.
2. Latex cast of cranidium showing form of palpebral lobe, × 2, USNM 146664.
3. Pygidium, × 10, USNM 146665.
5. Left free cheek, × 2, USNM 146666.
6. Broken thorax, × 3, USNM 146667.

All from USGS colln. 4296–CO.

4. *Serrodiscus* sp. (p. B33).
Pygidium, × 5, showing broken spinose margin, USNM 146668, USGS colln. 4295–CO.

7–13. *Neocobboldia spinosa* n. sp. (p. B34).
7, 8. Dorsal and left lateral views of nearly complete individual, × 15, USNM 146669, USGS colln. 4449–CO
9, 10. Right lateral and dorsal views of holotype cephalon, × 15, USNM 146670, USGS colln. 4296–CO.
11. Oblique right lateral view of cranidium, USNM 146671, USGS colln. 4295–CO.
12. Pygidium, × 15. USNM 146672, USGS colln. 4295–CO.
13. Pygidium showing curved axial spine, × 15, USNM 146673, USGS colln. 4296–CO.

14, 17–19, 22, 23, 27, 28. *Yukonia intermedia* n. gen., n. sp. (p. B38).
14. Holotype cephalon, × 20, USNM 146674.
17. Right oblique view of latex cast of cephalon, × 20, USNM 146675.
18. Anterior thoracic segment, × 20, USNM 146676.
19, 23. Dorsal and posterior views of meraspid–2 thorax, × 15, USNM 146677.
22. Meraspid pygidium showing bases of axial spine and spine on second(?) thoracic segment, × 20, USNM 146678.
27, 28. Meraspid–2 and holaspid pygidia, × 15, USNM 146679, 146680.

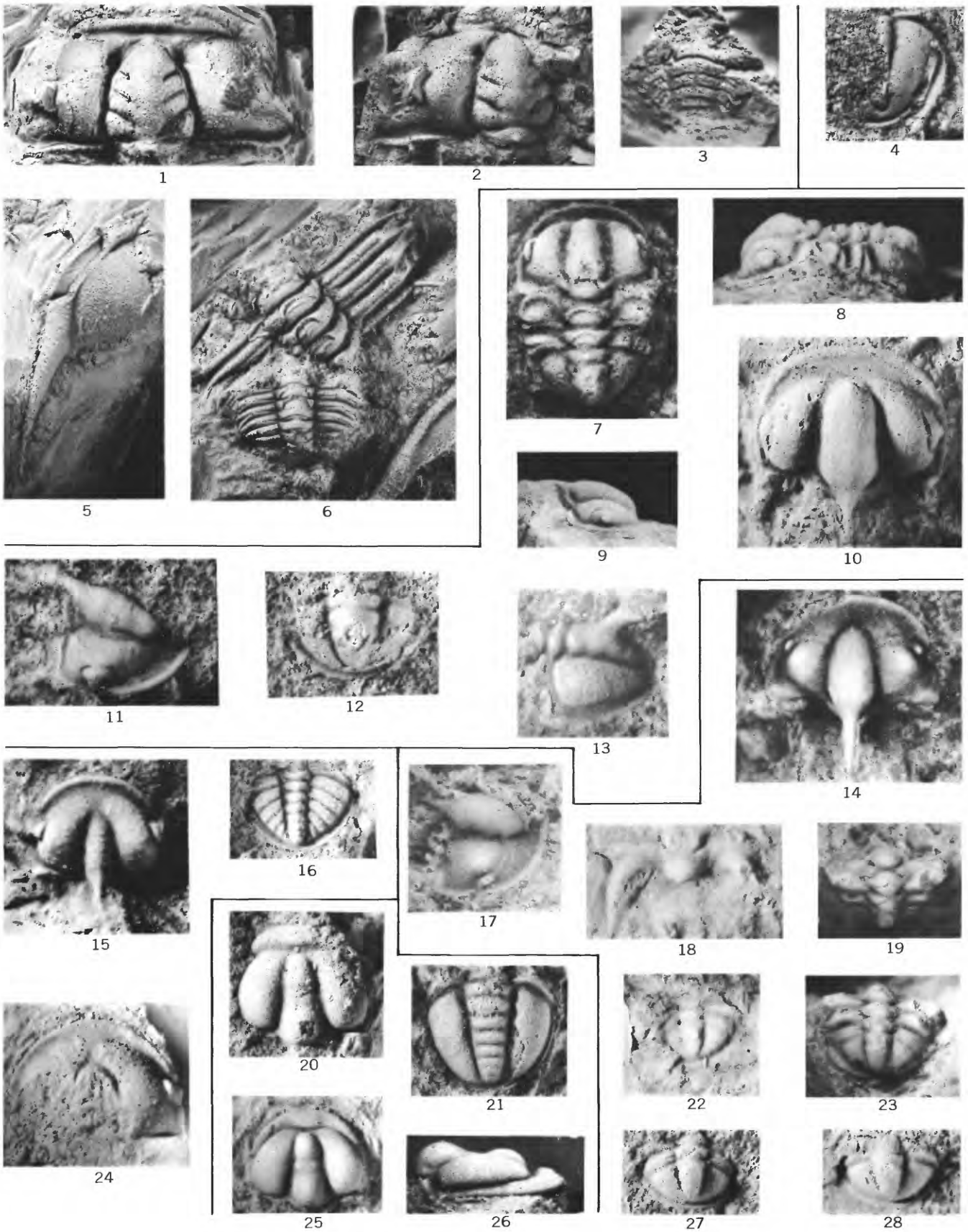
All from USGS colln. 4296–CO.

15, 16, 24. *Pagetides granulosus* n. sp. (p. B37).
15. Small holotype cranidium, × 15, USNM 146681.
16. Pygidium, × 10, USNM 146682.
24. Fragmentary large cranidium, × 10, USNM 146683.

All from USGS colln. 4295–CO.

20, 21, 25, 26. *Calodiscus nanus* n. sp. (p. B32).
20. Latex cast of large cephalon, × 8, USNM 146684.
21. Latex cast of pygidium, × 10, USNM 146685.
25. Holotype cephalon, × 10, USNM 146686.
26. Right side view of cephalon, × 10, USNM 146687.

All from USGS colln. 4295–CO.



EARLY CAMBRIAN-1 FAUNA

PLATE 3

Early Cambrian–2

[All specimens from USGS colln. 4302-CO, Tatonduk River area]

FIGURE 1. Olenellid species undetermined 1, (p. B38).
Latex cast of incomplete cephalon × 5, USNM 146688.

2. Olenellid species undetermined 2, (p. B39).
Fragment of left part of cephalon, × 3, USNM 146689.

3, 4. *Ogygopsis antiqua* n. sp. (p. B50).
3. Fragmentary cranidium, × 3, USNM 146690.
4. Holotype pygidium, note ornamentation, × 5, USNM 146691

5. Genus and species undetermined 3, (p. B102).
Cranidium, × 8, USNM 146692.

6, 7. *Bonnia tatondukensis* n. sp. (p. B46).
6. Pygidium, × 3, USNM 146693.
7. Stereogram of holotype crandiium, × 4, USNM 146694.

8–10, 12–14, 18. *Onchocephalus profectus* n. sp. (p. B75).
8. Stereogram of large holotype cranidium, × 3, USNM 146695.
9, 10. Cranidia showing variation in development of frontal area, × 5, USNM 146696, 146697.
12. Right free cheek, associated with pygidium of *Ogygopsis antiqua* n. sp., × 3, USNM 146698.
13. Cranidium; note granular rather than pitted ornamentation, × 8, USNM 146699.
14. Small cranidium, × 10, USNM 146700.
18. Pygidium, × 10, USNM 146701.

11. Genus and species undetermined 2, (p. B101).
Cranidium, × 4, USNM 146702.

15. *Aldonaia alaskensis* n. sp. (p. B52).
Latex cast of holotype cranidium, × 8, USNM 146703.

16–17. *"Antagmus" laminatus* n. sp. (p. B75).
16. Holotype cranidium, × 4, USNM 146704.
17. Small cranidium, × 5, USNM 146705.

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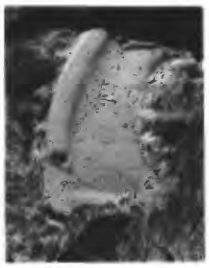

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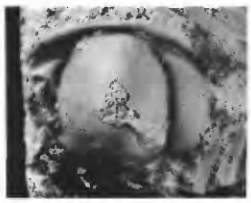

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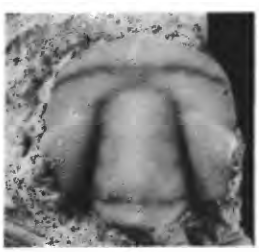

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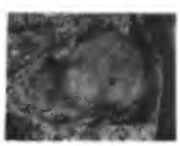

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EARLY CAMBRIAN-2 FAUNA

PLATE 4

Early Cambrian–3

[Figs. 1–15, 18–20 from Yukon River (West Ridge area)]

FIGURES 1–5. *Onchocephalites? versilis* n. sp. (p. B91).
1, 2. Anterior and dorsal views of cranidium, × 6, USNM 146706. USGS colln. 4334–CO.
3, 4. Cranidia, × 5, USNM 146707, 146708, USGS colln. 4335–CO.
5. Holotype cranidium, × 6, USNM 146709, USGS colln. 3715–CO.

6, 7. *Pagetia stenoloma* n. sp. (p. B35).
6. Cranidium, × 15, USNM 146710.
7. Holotype pygidium, × 15, USNM 146711.
Both from USGS colln. 4333–CO.

8–10. *Pagetia* spp. (p. B36).
8, 9. Top and right lateral views of cranidium, × 15, USNM 146712.
10. Pygidium, × 15, USNM 146713.
Both from USGS colln. 4334–CO.

11. *Pagetides appolinis* n. sp. (p. B36).
Holotype pygidium, × 15, USNM 146714, USGS colln. 4334–CO.

12, 13. *Pagetides occidentalis* n. sp. (p. B37).
12. Holotype pygidium, × 15, USNM 146715.
13. Cranidium × 10, USNM 146716.
Both from USGS colln. 4333–CO.

14, 15. *Kootenia* sp. 1 (p. B48).
14. Pygidium, × 3, USNM 146717.
15. Pygidium, × 5, USNM 146718.
Both from USGS colln. 4333–CO.

18–20. *Zacanthoides* sp. 1, (p. B50).
18. Pygidium, × 6, USNM 146721.
19. Cranidium, × 6, USNM 146719.
20. Right free cheek, × 6, USNM 146720.
All from USGS colln. 4333–CO.

Middle Cambrian–1

[Figs. 16, 21–24 from Yukon River (Adams Peak) area; fig. 25 from Tatonduk River area; figs. 17, 26–29 from Hillard Peak area; fig. 30 from Montauk Bluff area]

FIGURE 16. Dolichometopid, species undetermined (p. B45).
Cranidium, × 5, USNM 146722, USGS colln. 4424–CO.

17. *Zacanthoides* sp. 2 (p. B51).
Cranidium, × 5, USNM 146723, USGS colln. 4341–CO.

21. *Kootenia* cf. *K. serrata* (Meek) (p. B48).
Pygidium, × 2, USNM 146724, USGS colln. 4424–CO.

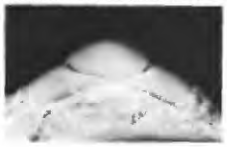
22–24. *Kootenia granulospinosa* n. sp. (p. B48).
22. Latex cast of cranidium, × 2, USNM 146725.
23. Cranidium, × 4, USNM 146726.
24. Holotype pygidium, × 4, USNM 146727.
All from USGS colln. 4424–CO.

25. *Dorypyge* cf. *D. olenekensis* Lazarenko, (p. B47).
Pygidium, × 3, USNM 146728, USGS colln. 4303–CO.

26, 27. *Ptychagnostus* (*Ptychagnostus*) *punctuosus affinis* (Brögger) (p. B28).
26. Cephalon, × 8, USNM 146729.
27. Pygidium, × 10, USNM 146730.
Both from USGS colln. 4341–CO.

28, 29. *Peronopsis* cf. *P. gaspensis* Rasetti (p. B31).
28. Cephalon, × 6, USNM 146731.
29. Pygidium, × 6, USNM 146732.
Both from USGS colln. 4341–CO.

30. cf. *Cotalagnostus lens claudicans* Westergård (p. B30).
Pygidium, × 6, USNM 146733, USGS colln. 4346–CO.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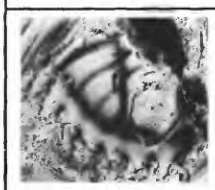
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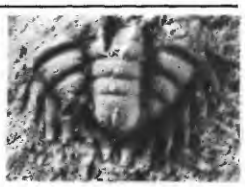
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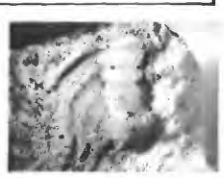
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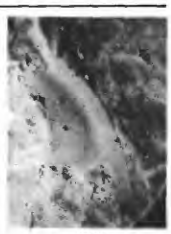
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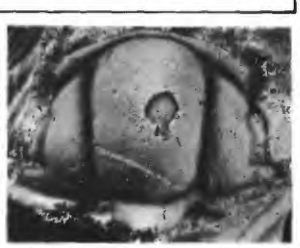
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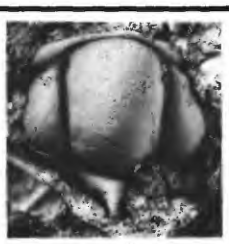
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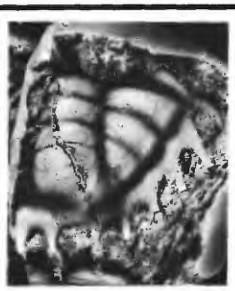
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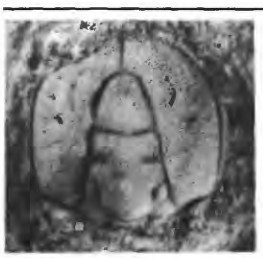
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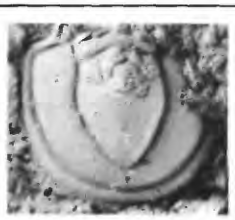
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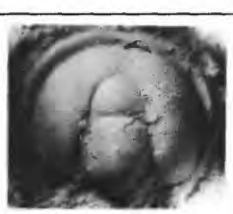
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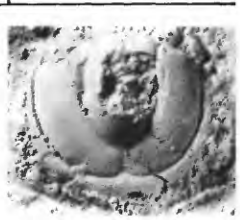
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EARLY CAMBRIAN-3 FAUNA; MIDDLE CAMBRIAN-1 FAUNA

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PLATE 5

Middle Cambrian–1

[Figs. 1–5, 16, from Hard Luck Creek area; figs. 6–8, 10–13, 23, 25 from Hillard Peak area; figs. 9, 18–22, 24 fromTatonduk River area; figs. 14, 15, 17 from Yukon River (Adams Peak) area]

FIGURES 1–5. *Modocia transversa* n. sp. (p. B65).
1. Left free cheek, × 4, USNM 146619.
2. Cranidium, × 4, USNM 146620.
3, 4. Pygidia, × 3, USNM 146621, 146622.
5. Holotype cranidium, × 3, USNM 146623.
All from USGS colln. 4382–CO.

6–8. *Modocia compressa* n. sp. (p. B65).
6. Left free cheek, × 4, USNM 146624.
7. Holotype cranidium, × 4, USNM 146625.
8. Pygidium, × 3, USNM 146626.
All from USGS colln. 4341–CO.

9. *Prohedinia brevifrons* n. sp. (p. B69).
Holotype cranidium, × 4, USNM 146627, USGS colln. 4303–CO.

10–13. *Elrathia alaskensis* n. sp. (p. B86).
10. Left free cheek, × 4, USNM 146628.
11. Holotype cranidium, × 5, USNM 146629.
12. Small cranidium, × 8, USNM 146630.
13. Pygidium, × 4, USNM 146631.
All from USGS colln. 4341–CO.

14–16. *Spencella montanensis* Rasetti (p. B98).
14. Cranidium showing thick exoskeleton, × 5, USNM 146632.
15. Exfoliated cranidium showing variability in form of frontal area, × 5, USNM 146633.
Both from USGS colln. 4424–CO.
16. Exfoliated cranidium × 5, USNM 146634, USGS colln. 4382–CO.

17. cf. *Alokistocare lobatum* Rasetti (p. B82).
Cranidium, × 4, USNM 146635.
USGS colln. 4424–CO.

18, 19. *Spencella acanthina* n. sp. (p. B98).
18. Holotype cranidium, × 5, USNM 146636.
19. Small exfoliated cranidium, × 10, USNM 146637.
Both from USGS colln. 4303–CO.

20, 21. *Spencella*? sp. (p. B98).
Cranidia, × 5, USNM 146638, USGS colln. 4303–CO.

22. Genus and species undetermined 5 (p. B103).
Pygidium, × 5, USNM 146639, USGS colln. 4303–CO.

23. *Bolaspidella wellsvillensis* (Lochman and Denson) (p. B66).
Cranidium, × 8, USNM 146640, USGS colln. 4341–CO.

24, 25. *Semisphaerocephalus latus* n. sp. (p. B97).
24. Exfoliated cranidium, × 5 USNM 146641, USGS colln. 4339–CO.
25. Exfoliated holotype cranidium, USGS 146642, × 5, USGS colln. 4341–CO.


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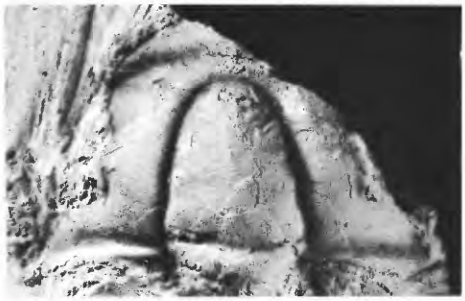
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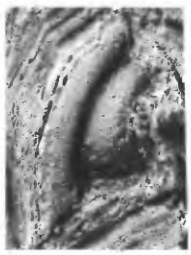
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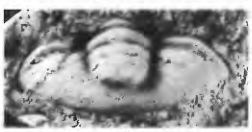
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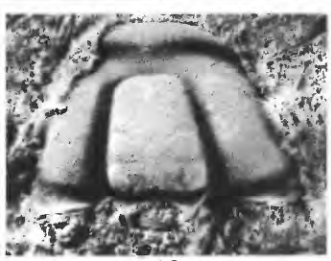
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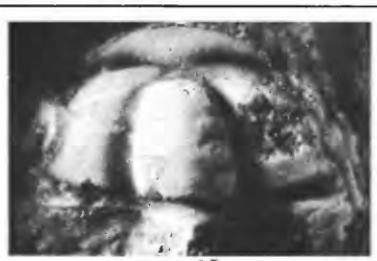
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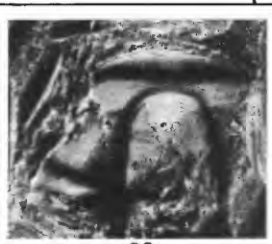
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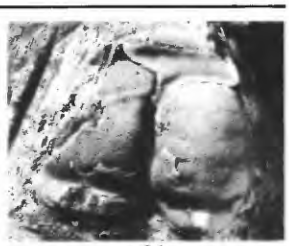
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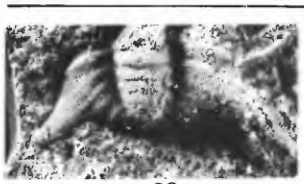
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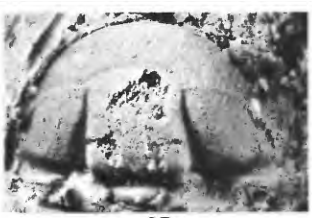
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MIDDLE CAMBRIAN-1 FAUNA

PLATE 6

Middle Cambrian–1

[Fig. 1 from Tatonduk River area; fig. 2 from Montauk Bluff area; figs. 3, 4 from Hillard Peak area]

FIGURE 1. Genus and species undetermined 6 (p. B103).
Pygidium, × 6, USNM 146734. USGS colln. 4303–CO.

2. Corynexochid, genus and species undetermined (p. B42).
Cranidium, × 8, USNM 146735, USGS colln. 4346–CO.

3, 4. *Bathyuriscus punctatus* n. sp. (p. B44).
3. Cranidium, × 6, USNM 146736.
4. Holotype pygidium, × 6, USNM 146737.
Both from USGS colln. 4341–CO.

Middle Cambrian–2

[Figs. 6, 7, 9, 12, 13, 17, 18 from Yukon River area (Adams Peak); figs. 5, 8, from Hillard Pear area; fig. 10 from Tatonduk River area; figs. 11, 15, 16, 19–23, 27 from east of Canadian boundary, Hillard Peak area; fig. 14 from Yukon River area (West Ridge)]

FIGURES 5–7. *Hemirhodon* sp. (p. B45).
5. Pygidium, × 4, USNM 146738, USGS colln. 4344–CO.
6. Cranidium, × 10, USNM 146739.
7. Pygidium, × 2, USNM 146740.
All from USGS colln. 4337–CO.

8. *Bathyuriscidella socialis* Rasetti (p. B44).
Pygidium, × 5, USNM 146741, USGS colln. 4344–CO.

9. *Athabaskiella ardis* n. sp. (p. B44).
Holotype pygidium (composite photograph; anterior part latex cast), × 5, USNM 146742, USGS colln. 4337–CO.

10. cf. *Marjumia callas* Walcott (p. B64).
Pygidium × 6, USNM 146743, USGS colln. 4310–CO.

11, 12. *Onchonotopsis occidentalis* n. sp. (p. B92).
Left side and dorsal views of holotype cranidium, × 8, USNM 146744, USGS colln. 4337–CO.

13. *Phalagnostus bituberculatus* (Angelin) (p. B32).
Cephalon, × 10, GSC 20261, GSC colln. 282.

14. Genus and species undetermined 4 (p. B102).
Cranidium (composite photograph; right anterolateral part latex cast), × 5, USNM 146745, USGS colln. 3832–CO.

15–18. *Lejopyge calva* Robison (p. B27).
15. Cephalon, showing outer surface, × 6, GSC 20262.
16. Exfoliated cephalon, × 6, GSC 20263.
Both from GSC colln. 282.
17. Fragmentary cephalon, × 8, USNM 146746.
18. Pygidium, × 8, USNM 146747.
Both from USGS colln. 4337–CO.

19. *Lejopyge laevigata* (Dalman) (p. B28).
Pygidium, × 8, USNM 146748, USGS colln. 4345–CO.

20. *Ptychagnostus* (*Ptychagnostus*) *aculeatus* (Angelin) (p. B28).
Pygidium, × 10, GSC 20264, GSC colln. 282.

21. Genus and species undetermined 1 (p. B101).
Cranidium, × 10, GSC 20265, GSC colln. 282.

PLATE 6—Continued

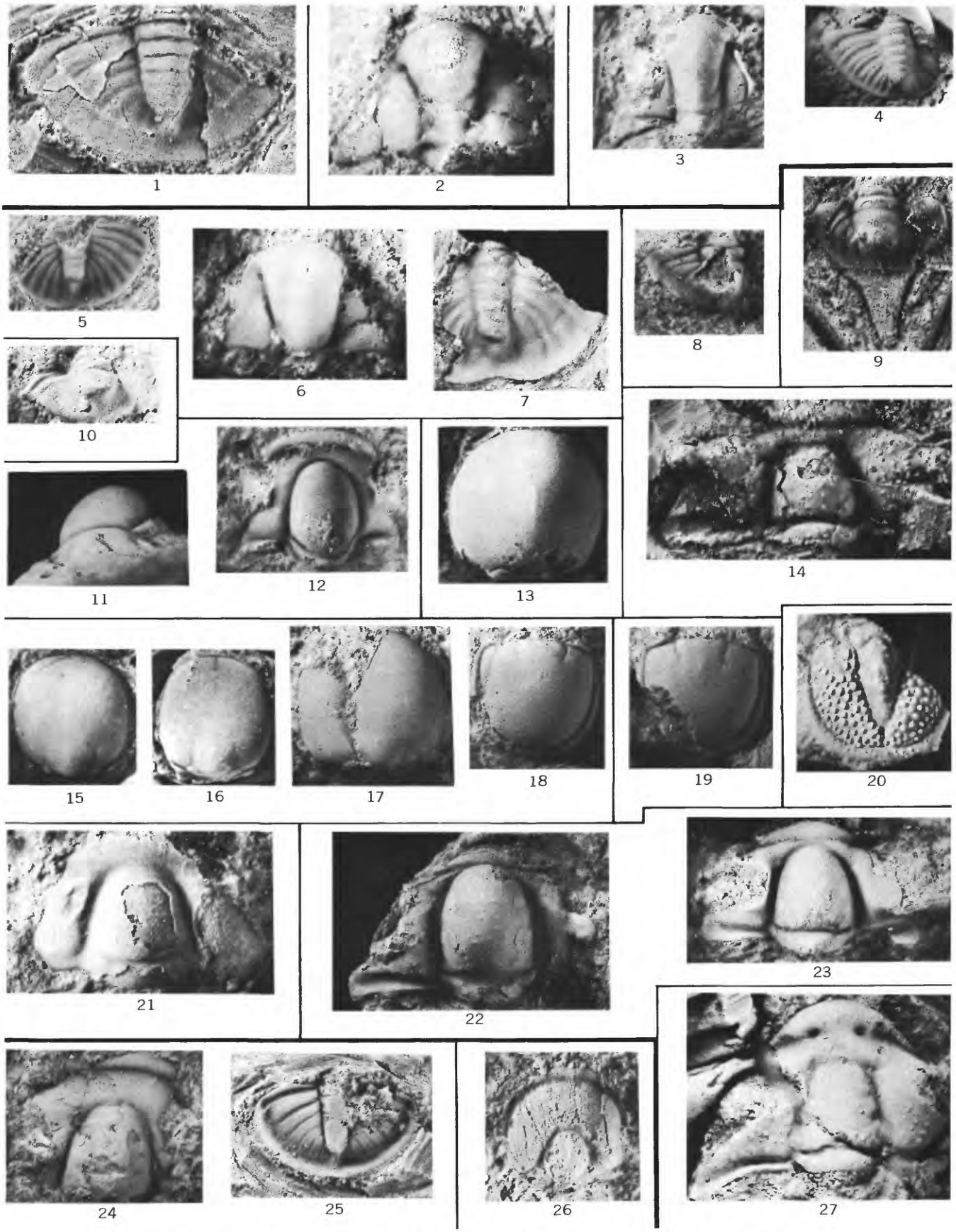
Middle Cambrian–2—Continued

22, 23. Genus and species undetermined 9 (p. B104).
22. Large cranidium, × 5, GSC 20266.
23. Small cranidium, × 10; note change in ornamentation and size of palpebral lobe, GSC 20267.
Both from GSC colln. 282.
27. Genus and species undetermined 8 (p. B103).
Cranidium, × 6, GSC 20268, GSC colln. 282.

Late Cambrian, Dresbachian–1

[Figs. 24, 25 from Hard Luck Creek area; fig. 26 from Tatonduk River area]

FIGURES 24, 25. *Cedaria* sp. (p. B52).
24. Cranidium, × 5 USNM 146749.
25. Pygidium, × 3, USNM 146750.
Both from USGS colln. 4376–CO.
26. *Hypagnostus* sp. (p. B31).
Cephalon, × 10, USNM 146751, USGS colln. 4326–CO.



MIDDLE CAMBRIAN-1, 2 FAUNA; LATE CAMBRIAN, DRESBACHIAN-1 FAUNA

PLATE 7

Late Cambrian, Dresbachian–2

[Figs. 1–10, 12–20, 22–25, 29 from Hi-Yu area; figs. 21, 26–28, 32, 33 from Jones Ridge area; figs. 11, 30, 31 from Hillard Peak area]

FIGURES 1, 2, 6, 7, 12. *Acmarhachis acutus* (Kobayashi) (p. B29).
1, 2. Cephala showing range in variation, × 10, USNM 146752, 146753.
6, 7, 12. Pygidia showing range of variation, × 10, USNM 146754, 146755, 146756.
All from USGS colln. 4381–CO.

3, 8. *Homagnostus tumidosus* (Hall and Whitfield) (p. B25).
3. Cephalon, × 10, USNM 146757.
8. Pygidium, × 10, USNM 146758.
Both from USGS colln. 4381–CO.

4, 9, 14, 15. *Homagnostus alaskensis* n. sp. (p. B24).
4. Cephalon, × 10, USNM 146759.
9. Pygidium, × 10, USNM 146760.
14, 15. Holotype pygidium, top and right side profile, × 10, USNM 146761.
All from USGS colln. 4381–CO.

5, 10. *Pseudagnostus communis* (Hall and Whitfield) (p. B29).
5. Cephalon, × 8, USNM 146762.
10. Pygidium, × 8, USNM 146763.
Both from USGS colln. 4381–CO.

11. *Glyptagnostus reticulatus* (Angelin) (p. B27).
Pygidium, × 5, GSC 20269, GSC colln. 4641.

13. *Homagnostus*? sp. (p. B25).
Pygidium, × 10, USNM 146764, USGS colln. 4381–CO.

16, 17, 22. *Iddingsia relativa* n. sp. (p. B61).
16. Left free cheek, × 3, USNM 146765.
17. Holotype cranidium, × 4, USNM 146766.
22. Pygidium, × 4, USNM 146767.
All from USGS colln. 4381–CO.

18–20, 23–25. *Elburgia disgranosa* n. sp. (p. B63).
18. Left free cheek, × 4, USNM 146768.
19. Cranidium, × 4, USNM 146769.
20. Holotype cranidium, × 4, USNM 146770.
23. Pygidium, × 4, USNM 146771.
24. Pygidium, × 10, USNM 146772.
25. Small cranidium questionably assigned, × 6, USNM 146773.
All from USGS colln. 4381–CO.

21, 26–28. *Dunderbergia seducta* n. sp. (p. B62).
21. Pygidium, × 8, USNM 146774.
26. Holotype cranidium, × 5, USNM 146775.
27. Exfoliated cranidium, × 4, USNM 146776.
28. Right free cheek, × 3, USNM 146777.
All from USGS colln. 4361–CO.

29. *Dytremacephalus*? sp. (p. B86).
Cranidium, × 8, USNM 146778, USGS colln. 4381–CO.

30, 31. *Oligometopus breviceps*? (Walcott) (p. B58).
30. Cranidium, × 8, USNM 146779, USGS colln. 4360–CO.
31. Small cranidium, × 20, GSC 20270, GSC colln. 4643.

32, 33. *Hardyoides aspinosa* n. sp. (p. B68).
32. Holotype cranidium, × 15, USNM 146780.
33. Cranidium, × 15, USNM 146781.
Both from USGS colln. 4361–CO.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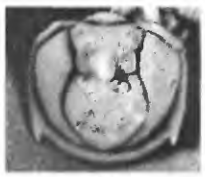
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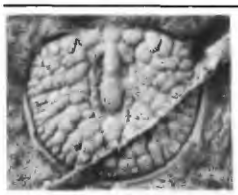
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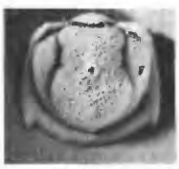
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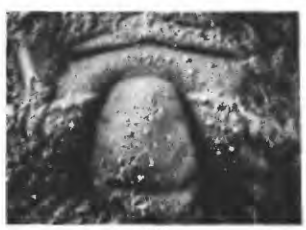
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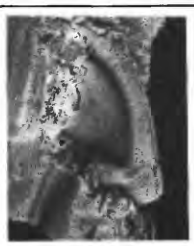
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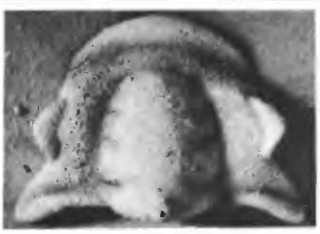
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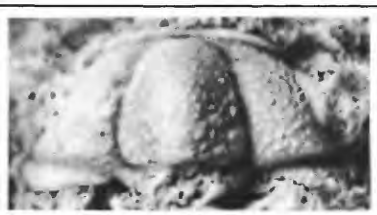
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LATE CAMBRIAN, DRESBACHIAN-2 FAUNA

PLATE 8

Late Cambrian, Dresbachian–2

[Figs. 1–16, 21–24 from Hi-Yu area; figs. 17–20, 25, from Hillard Peak area]

FIGURES 1–4. *Olenaspella evansi* (Kobayashi) (p. B70).
1. Latex cast of cranidium, × 3, USNM 146783.
2. Pygidium, × 3, USNM 146784.
4. Right free cheek, × 3, USNM 146785.
All from USGS colln. 4381–CO.
3. Pygidium questionably assigned, × 3, USNM 146786, USGS colln. 3717–CO.

5–10. *Pterocephalia constricta* n. sp. (p. B72).
5. Pygidium, × 2, USNM 146787.
6. Left free cheek, × 2, USNM 146788.
7. Holotype cranidium, × 3, USNM 146789.
8. Latex cast of small cranidium, × 8, USNM 146790.
9. Pygidium, × 3, USNM 146791.
10. Pygidium questionably assigned, × 5, USNM 146792.
All from USGS colln. 4381–CO.

11–16. *Cernuolimbus longifrons* n. sp. (p. B72).
11. Holotype cranidium, × 4, USNM 146793.
12. Right free cheek, × 5, USNM 146794.
13. Ventral view of left free cheek showing form of doublure, × 6, USNM 146795.
14. Pygidium, × 4, USNM 146796.
15. Small pygidium, × 6, USNM 146797.
16. Small cranidium, × 10, USNM 146798.
All from USGS colln. 4381–CO.

17–19. *Cernuolimbus arcticus* n. sp. (p. B71).
17. Fragmentary left free cheek questionably assigned, × 4, USNM 146799.
18. Holotype cranidium (composite photo; central part latex cast), × 4, USNM 146800.
19. Pygidium, × 5, USNM 146801.
All from USGS colln. 4360–CO.

20, 25. *Sigmocheilus*? cf. *S. grata* (Resser) (p. B74).
20. Cranidium × 4, GSC 20271.
25. Pygidium, × 3, GSC 20272.
Both from GSC colln. 4639.

21–24. *Sigmocheilus compressus* n. sp. (p. B73).
21. Left free cheek, × 3, USNM 146802.
22. Holotype cranidium, × 4, USNM 146803.
23. Cranidium, × 5, USNM 146804.
24. Small cranidium, × 10, USNM 146805.
All from USGS colln. 4381–CO.


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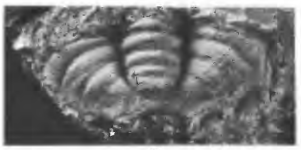
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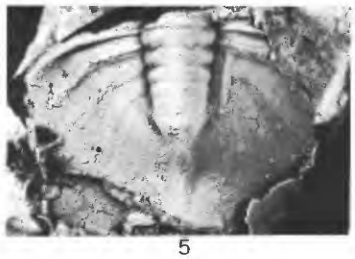
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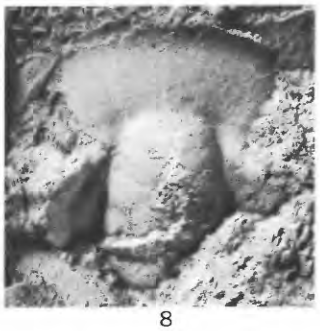
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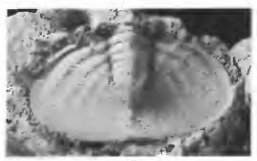
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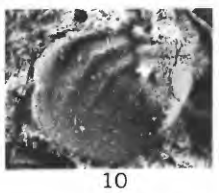
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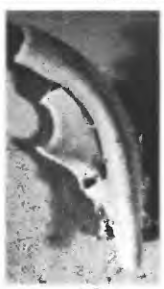
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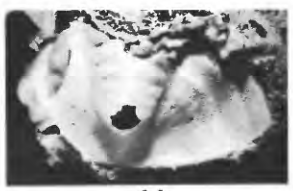
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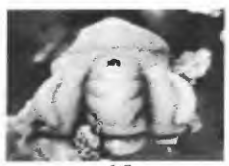
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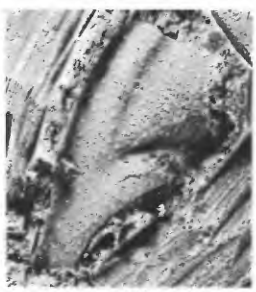
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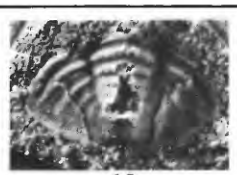
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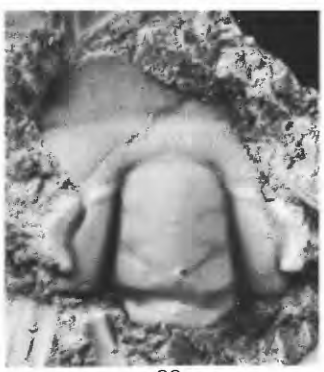
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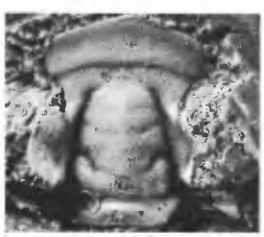
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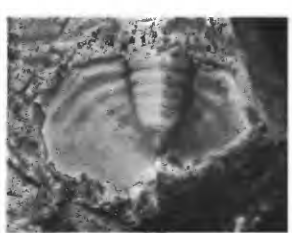
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LATE CAMBRIAN, DRESBACHIAN-2 FAUNA

PLATE 9

Late Cambrian, Dresbachian–2

[Figs. 1–7 from Jones Ridge area; figs. 8–15, 17–25, 28 from Hi-Yu area; figs. 16, 26, 27 from Hillard Peak area]

FIGURES 1–7. *Cheilocephalus expansus* n. sp. (p. B57).
1. Left free cheek, × 5, USNM 146806.
2. Cranidium, × 4, USNM 146807.
3. Cranidium, × 6, USNM 146808.
4. Holotype pygidium, × 2, USNM 146809.
5. Hypostome, × 4, USNM 146810.
6. Meraspid cranidium, × 15, USNM 146811.
7. Small pygidium, × 6, USNM 146812.

All from USGS colln. 4361–CO.

8–10. *Quebecaspis conifrons*? Rasetti (p. B95).
8, 9. Cranidia, × 8, USNM 146813, 146814.
10. Cranidium, × 10, USNM 146815.

Both from USGS colln. 4381–CO.

11–15. *Quebecaspis aspinosa* n. sp. (p. B95).
11. Left free cheek, × 6, USNM 146816.
12. Left free cheek, × 10, USNM 146817.
13. Exfoliated cranidium (composite photo; posterior part latex cast), × 6, USNM 146818.
14. Holotype cranidium, × 8, USNM 146819.
15. Small cranidium, × 10, USNM 146820.

All from USGS colln. 4381–CO.

16. *Quebecaspis* sp. (p. B96).
Cranidium, × 5, USNM 146821, USGS 4360–CO.

17–23, 28. *Tholifrons advena* n. gen., n. sp. (p. B99).
17. Stereogram of holotype cranidium, × 5, USNM 146822.
18. Cranidium, × 8, USNM 146823.
19. Small cranidium, × 15, USNM 146824.
20. Left free cheek, × 3, USNM 146825.
21. Interior view of right free cheek, × 3, USNM 146826.
22. Detail of anterior part of doublure of free cheek in fig. 21, × 10.
23. Right free cheek, × 3, USNM 146827.
28. Pygidium, × 8, USNM 146828.

All from USGS colln. 4381–CO.

24, 25. *Tholifrons minutus* n. gen., n. sp. (p. B100).
24. Holotype cranidium, × 15, USNM 146829.
25. Small cranidium, × 15, USNM 146830.

Both from USGS colln. 4381–CO.

26, 27. *Comanchia burlingi* n. sp. (p. B84).
26. Left free cheek, × 6, GSC 20273, GSC colln. 4728.
27. Holotype cranidium, × 8, GSC 20274, GSC colln. 4643.


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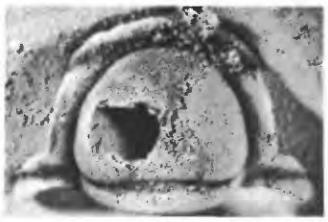
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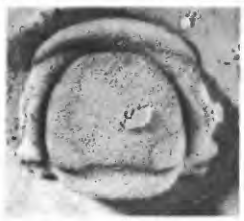
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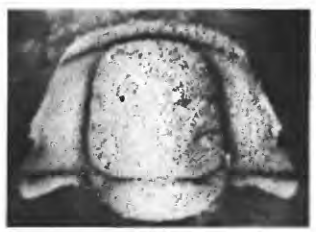
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LATE CAMBRIAN, DRESBACHIAN-2 FAUNA

PLATE 10

Late Cambrian, Franconian–1

[Figs. 2–14, 17, 18, 23, 24 from GSC colln. 4638 (=4727), Hillard Peak area]

FIGURES 1–6. *Proceratopyge* (*Lopnorites*) *rectispinatus* (Troedsson) p. B54).
1. Replica of holotype, complete specimen, × 3, (Troedsson, 1937, pl. 2, fig. 1), eastern T'ien Shan, China.
2. Cranidium, × 4, GSC 20275.
3. Pygidium, × 4, GSC 20276.
4. Meraspid–6, × 8, GSC 20277.
5. Meraspid–0?, × 20, GSC 20278.
6. Right free cheek, × 4, GSC 20279.

7. Olenid undetermined 1 (p. B68).
Cranidium, × 5, GSC 20280.

8. Olenid undetermined 2 (p. B68).
Cranidium, × 3, GSC 20281.

9, 10. *Iwayaspis* cf. *I. asaphoides* Kobayashi (p. B53).
9. Thorax and pygidium × 4, GSC 20282.
10. Pygidium, × 5, GSC 20283.

11–14. *Proceratopyge* cf. *P. chuhsiensis* Lu (p. B55).
11–13. Cranidia, × 4, × 6, × 8; GSC 20284, 20285, 20286.
14. Pygidium, associated with *I. asaphoides* pygidia, × 3, GSC 20287.

17, 18, 23, 24. *Peratagnostus hillardensis* n. sp. (p. B26).
17. Cephalon, × 8, GSC 20288.
18. Holotype pygidium, × 8, GSC 20289.
23, 24. Pygidia, × 10, × 15, GSC 20290, 20291.

Late Cambrian, Dresbachian–2

[Figs. 15, 16, 19–22 from USGS colln. 3717-CO Yukon River (West Ridge) area]

FIGURES 15, 16, 19–22. *Corynexochus plumula* Whitehouse (p. B42).
15, 16, 20. Cranidia, × 8, × 10, × 10, USNM 146831, 146832, 146833.
19. Holotype pygidium, × 4, USNM 146834.
21, 22. Pygidia, × 6, × 8, USNM 146835, 146836.


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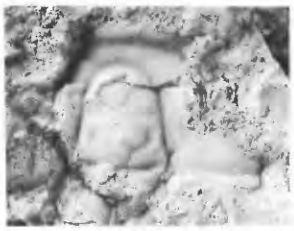
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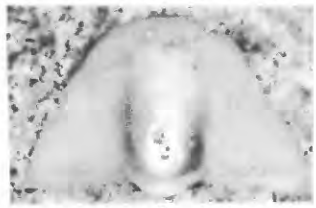
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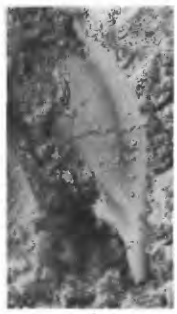
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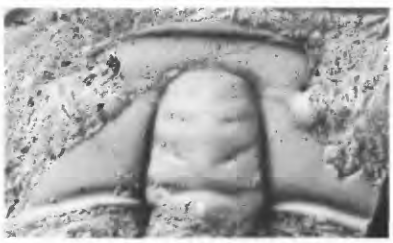
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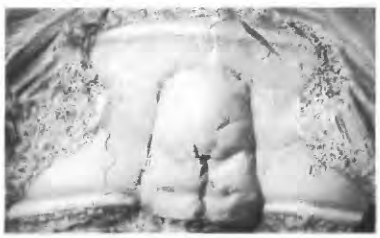
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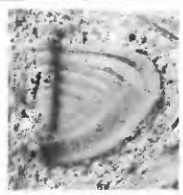
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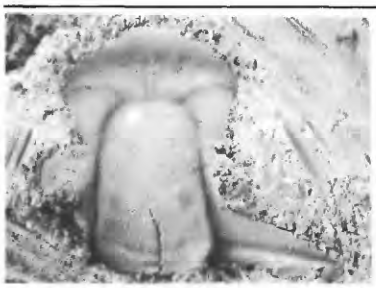
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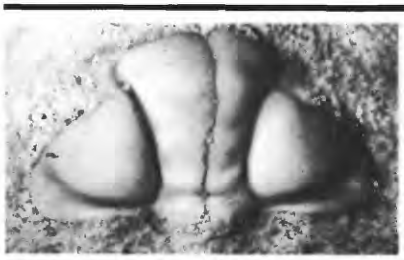
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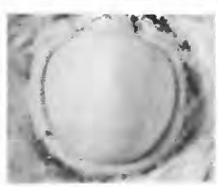
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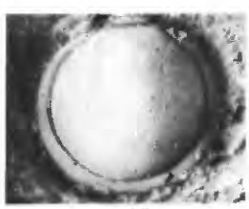
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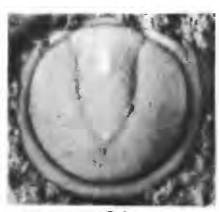
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LATE CAMBRIAN, FRANCONIAN-1 FAUNA; DRESBACHIAN-2 FAUNA

PLATE 11

Late Cambrian, Franconian–2

[All figures from Hillard Peak area]

FIGURES 1–9. *Pareuloma spinosa* n. sp. (p. B76).

1. Holotype cranidium, × 5, GSC 20292.
2, 3. Cranidia, × 6, × 8, GSC 20293, 20294.
5. Right free cheek, × 5, GSC 20295.
7. Pygidium, × 5, GSC 20296.

All from GSC colln. 4649 (= 4704).

4, 6. Cranidia, × 5, × 10 (larger specimen crushed), GSC 20297, 20298.
9. Right free cheek, × 3, GSC 20299.

All from GSC colln. 4661 (= 4705).

8. Cranidium, × 6, USNM 146837, USGS colln. 4358–CO.

10–13. *Brabbia pustulomarginata* n. gen., n. sp. (p. B84).

10. Small incomplete cephalon, × 10, GSC 20300, GSC colln. 4661 (= 4705).
11. Stereogram of holotype cranidium, × 3, USNM 146838, USGS colln. 4356–CO.
12. Small cranidium, × 5, USNM 146839, USGS colln. 4358–CO.
13. Right free cheek, × 3, USNM 146840, USGS colln. 4356–CO.

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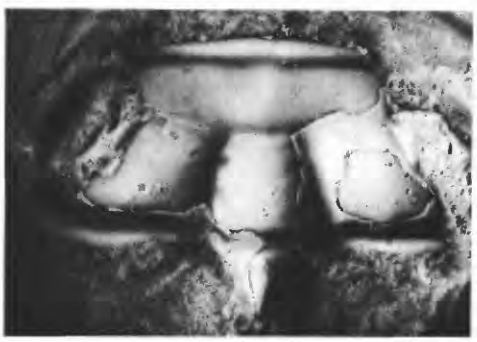

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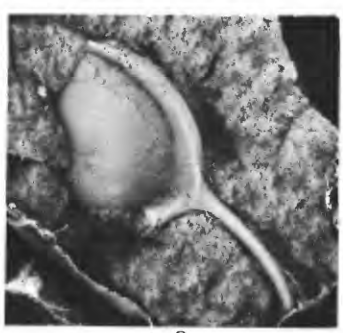

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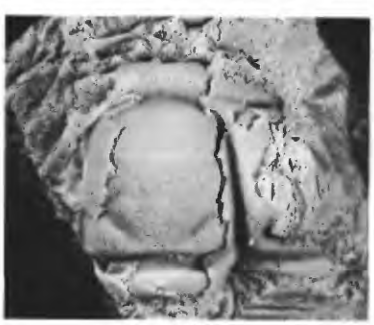

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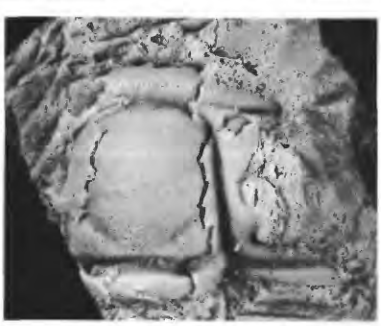

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LATE CAMBRIAN, FRANCONIAN-2 FAUNA

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PLATE 12

Late Cambrian, Franconian–2

[All figures except fig. 18 from Hillard Peak area; fig. 18, Late Cambrian, Trempealeauan–1, Jones Ridge area]

FIGURES

1, 2. *Geragnostus intermedius* n. sp. (p. B24).
1. Cephalon, × 10, USNM 146841.
2. Holotype pygidium, × 10, USNM 146842.
Both from USGS colln. 4355–CO.

3, 4. *Lotagnostus*? sp. (p. B25).
3. Cephalon, × 8, USNM 146843.
4. Pygidium, × 8, USNM 146844.
Both from USGS colln. 4355–CO.

5, 6. *Pseudagnostus vulgaris* Rozova (p. B30).
5. Cephalon, × 10, USNM 146845.
6. Pygidium, × 10, USNM 146846.
Both from USGS colln. 4355–CO.

7–13. *Hungaia burlingi* n. sp. (p. B87).
8. Holotype cranidium, × 4, GSC 20301.
9. Small cranidium showing length of frontal area, × 6, GSC 20302.
10. Right free cheek, × 3, GSC 20303.
13. Pygidium, × 2, GSC 20304.
All from GSC colln. 4661 (= 4705).
7. Cranidium, × 3, USNM 146847, USGS colln. 4355–CO.
11. Pygidium, × 4, USNM 146848, USGS colln. 4358–CO.
12. Pygidium, × 1.5, USNM 146849, USGS colln. 3709–CO.

14. *Hungaia pacifica* Kobayashi (p. B88).
Holotype pygidium, × 1, USNM 93066, USNM loc. 25o.

15, 19. *Onchonotus brevifrons* n. sp. (p. B93).
15. Exfoliated cranidium, × 4, USNM 146850.
19. Stereogram of holotype cranidium, × 5, USNM 146851.
Both from USGS colln. 3709–CO.

16. ?*Lauzonella*? *tripunctata* (Kobayashi) (p. B89).
Fragmentary cranidium, × 3, USNM 146852, USGS colln. 4355–CO.

17. *Bienvillia* sp. (p. B68).
Cranidium, × 8, USNM 146853, USGS colln. 3709–CO.

18. *Hungaia* sp. (p. B88).
Pygidium, × 6, USNM 146854, USGS colln. 3834–CO.

20. *Onchonotus antiqus* n. sp. (p. B93).
Stereogram of holotype cranidium, × 5, USNM 146855, USGS colln. 4357–CO.


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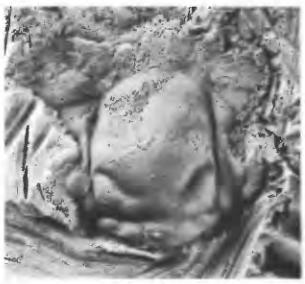
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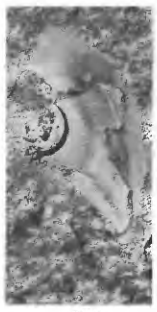
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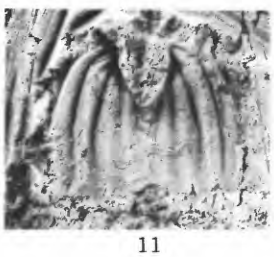
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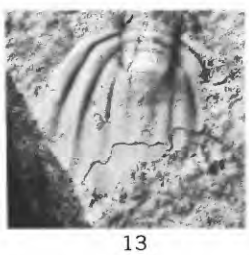
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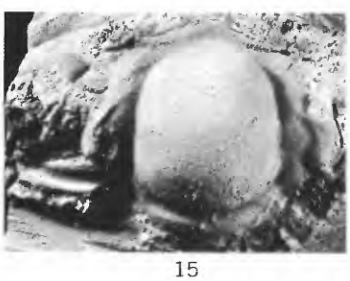
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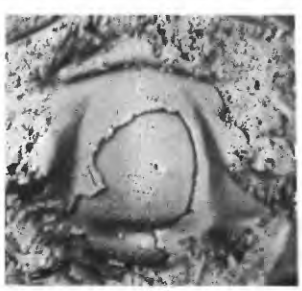
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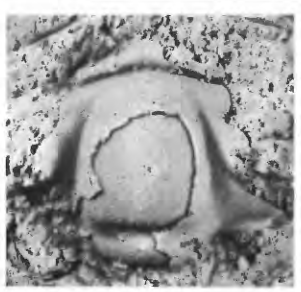

LATE CAMBRIAN, FRANCONIAN-2 FAUNA

PLATE 13

Late Cambrian, Franconian–2

[All figures from Hillard Peak area]

FIGURES

1–5. *Drumaspis idahoensis* Resser (p. B85).
1. Exfoliated cranidium, × 5, GSC 20305, GSC colln. 4661 (= 4705).
2. Cranidium showing external surface, × 4, USNM 146856, USGS colln. 4357–CO.
3. Exfoliated cranidium, × 4, USNM 146857, USGS colln. 4358–CO.
4. Immature cranidium, × 10, USNM 146858, USGS colln. 4358–CO.
5. Left free cheek, × 8, GSC 20306, GSC colln. 4661 (= 4705).

6–8, 11. *Loganellus*? *arcus* n. sp. (p. B90).
6. Holotype cranidium, × 5, USNM 146859.
7. Right free cheek, × 4, USNM 146860.
11. Pygidium, × 3, USNM 146861.
All from USGS colln. 4358–CO.
8. Right free cheek, × 3, GSC 20307, GSC colln. 4661 (= 4705).

9, 12–16. *Yüpingia glabra* n. sp. (p. B56).
9. Holotype cranidium, × 5, GSC 20308.
13. Pygidium, × 4, GSC 20309.
14. Left free cheek, × 5, GSC 20310.
15. Small cranidium, × 5, GSC 20311.
All from GSC colln. 4649 (= 4704).
12. Small cranidium, × 10, GSC 20312.
16. Pygidium, × 10, GSC 20313.
Both from GSC colln. 4661 (= 4705).

10. Genus and species undetermined 7 (p. B103).
Pygidium, × 3, USNM 146862, USGS colln. 3709–CO.

17–22. *Asiocephalus indigator* n. gen., n. sp. (p. B83).
17. Holotype cranidium, × 8, GSC 20314.
18. Cranidium, × 10, GSC 20315.
19. Left free cheek, and associated pygidium of *Loganellus*? *arcus* n. sp., showing anteriorly flared development of doublure, × 3, GSC 20316.
20. Pygidium showing development of marginal spine only on left, × 2, GSC 20317.
21. Pygidium, × 5, GSC 20318.
22. Right free cheek, × 4, GSC 20319.
All from GSC colln. 4661 (= 4705).


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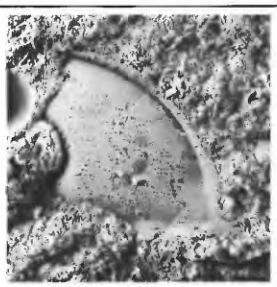
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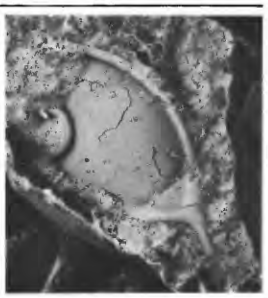
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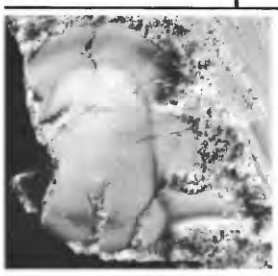
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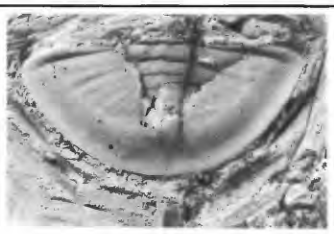
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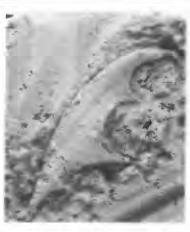
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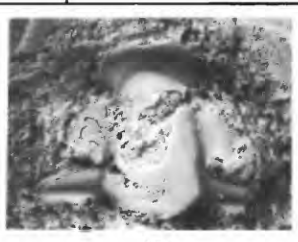
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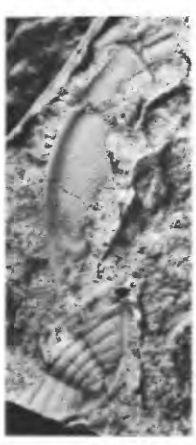
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LATE CAMBRIAN, FRANCONIAN-2 FAUNA

PLATE 14

Late Cambrian, Franconian–2

[Figs. 1–8, Hillard Peak area]

FIGURES 1–4. *Richardsonella quadrispinosa* n. sp. (p. B78).
1. Cranidium, × 4, USNM 146863.
2. Right free cheek, × 3, USNM 146864.
3. Holotype pygidium, × 4, USNM 146865.
4. Pygidium, × 4, USNM 146866.
All from USGS colln. 4355–CO.

5, 6. *Richardsonella* sp. 3. (p. B80).
5. Cranidium, × 6, USNM 146867.
6. Pygidium, × 5, USNM 146868.
Both from USGS colln. 3709–CO.

7, 8. *Richardsonella* cf. *R. quadrispinosa* n. sp. (p. B79).
7. Cranidium, × 6, USNM 146869.
8. Yoked free cheeks, × 6, USNM 146870.
Both from USGS colln. 4358–CO.

Late Cambrian, Trempealeauan–1

[Figs. 9–20 from Jones Ridge area]

FIGURES 9. *Richardsonella* sp. 1 (p. B79).
Cranidium, × 4, USNM 146871, USGS colln. 4362–CO.

10, 11. *Richardsonella nuchastria* n. sp. (p. B78).
10. Fragmentary larger cranidium, × 5, USNM 146872.
11. Holotype cranidium, × 8, USNM 146873.
Both from USGS colln. 3834–CO.

12. Richardsonella sp. 4 (p. B80).
Cranidium, × 8, GSC 20320, GSC colln. 4671.

13, 17. *Rasettia* cf. *R. capax* (Billings) (p. B96).
Dorsal and front views of cranidium, × 1.5, USNM 146874, USGS colln. 3833–CO.

14, 15. *Lauzonella*? *tripunctata* (Kobayashi) (p. B89).
14. Holotype cranidium, × 5, USNM 93056, USNM loc. 25o.
15. Cranidium, × 5, USNM 146875, USGS colln. 3835–CO.

16. *Richardsonella*? sp. 2 (p. B79).
Pygidium, × 3, USNM 146876, USGS colln. 3835–CO.

18–20. *Tatonaspis alaskensis* Kobayashi (p. B67).
18. Exfoliated cranidium, × 3, USNM 146877.
19. Anterior view of yoked free cheeks, × 3, USNM 146878.
Both from USGS colln. 3835–CO.
20. Holotype, exfoliated cranidium, × 3, USNM 93065, USNM loc. 25o.


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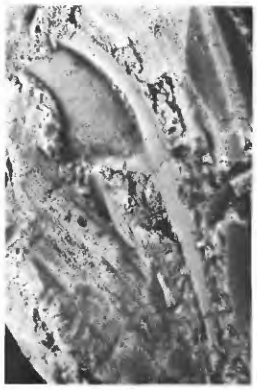
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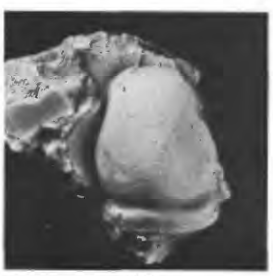
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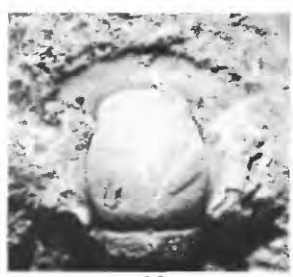
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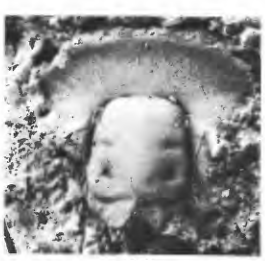
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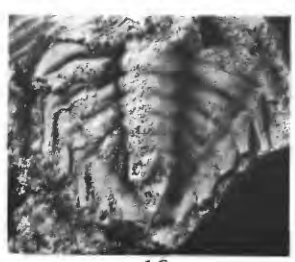
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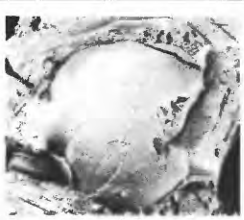
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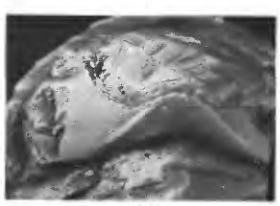
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LATE CAMBRIAN, FRANCONIAN-2 FAUNA; TREMPEALEAUAN-1 FAUNA

PLATE 15

Late Cambrian, Trempealeaun–1

[Figs. 1–7, 9, 10, 13, 14 from Jones Ridge area]

FIGURES 1–5. *Briscoia septentrionalis* Kobayashi (p. B59).
1. Left free cheek, × 1.5, USNM 146879.
2. Cranidium, × 1.5 , USNM 146880.
3. Latex cast of pygidium, × 2, USNM 146881.
4. Latex cast of holotype pygidium, USNM 93060.
5. Cranidium, × 2, USNM 146882.

All from USNM loc. 25o.

6, 7. *"Briscoia" elegans* (Kobayashi) (p. B60).
6. Latex cast of pygidium described by Kobayashi as holotype of *Parabriscoia stenorachis,* × 1.5, USNM 93059.
7. Latex cast of lectotype, × 1.5, USNM 93058.

Both from USNM loc. 25o.

9. *Pseudosaukia* cf. *P. brevifrons* (Clark) (p. B94).
(Cranidium, × 3, USNM 146886, USGS colln. 3834–CO.

10, 13, 14. *Pseudagnostus clarki* Kobayashi (p. B29).
10. Cephalon, × 8, USNM 146887.
13. Lectotype pygidium, × 8, USNM 93062.
14. Exfoliated cephalon showing faint preglabellar furrow, × 8, USNM 146888.

All from USNM loc. 25o.

Late Cambrian, Trempealeauan–2

[Figs. 8, 11, 12 from Jones Ridge area; figs. 15, 16, 18–20, 22 from Yukon River (Adams Peak) area; figs. 17, 21 from eastern T'ien Shan, China]

FIGURES 8, 11, 12. *Bayfieldia* spp. (p. B64).
8. Cranidium, × 3, USNM 146883.
11. Pygidium, × 2, USNM 146884.

Both from USGS colln. 4374–CO.

12. Cranidium, × 3, USNM 146885, USGS colln. 4363–CO.

15, 19. *Yukonaspis kindlei* Kobayashi (p. B100).
Anterior and dorsal views of most complete cranidium, × 10, USNM 146889, USGS colln. 4351–CO.

16, 18, 22. *Hedinaspis* sp. (p. B87)
16, 18. Fragmentary cranidium, × 4, × 5, USNM 146890, 146891, USGS colln. 4352–CO.
22. Partial thorax, × 1.5, USNM 146892, USGS colln. 4351–CO.

17, 21. *Hedinaspis regalis* (Troedsson) (p. B87).
Cranidium and partial thorax, × 2, replicas of specimens illustrated by Troedsson (1937, pl. 7, fig. 9; pl. 8, (fig. 3), for comparison withAlaskan specimens.

20. *Liostracinoides? yukonensis* n. sp. (p. B89).
Cranidium, × 8, USNM 146893, USGS colln. 4351–CO.


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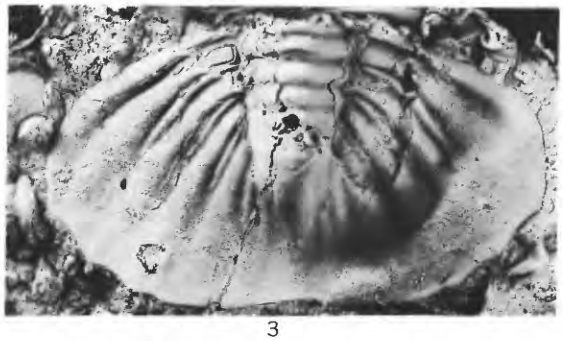
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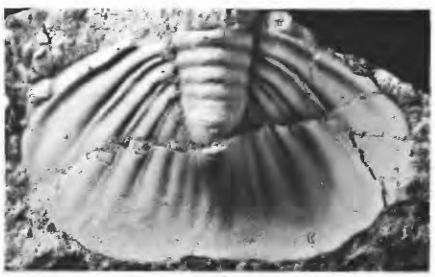
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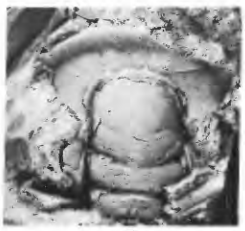
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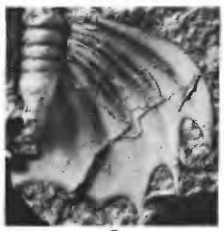
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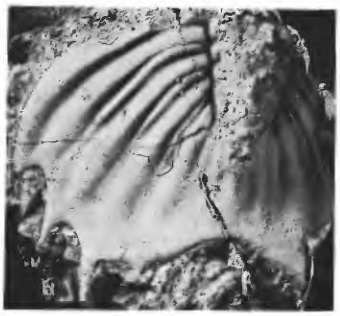
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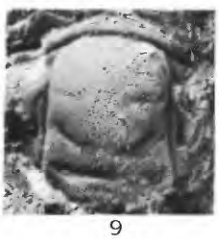
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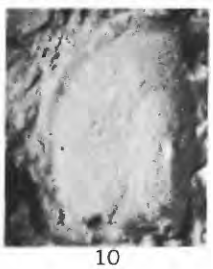
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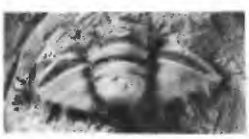
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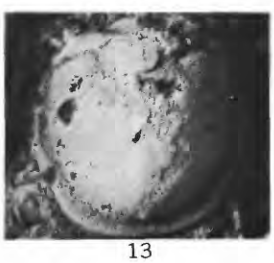
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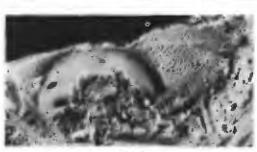
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LATE CAMBRIAN, TREMPEALEAUAN-1, 2 FAUNA

Lower Paleozoic Paleontology and Stratigraphy East-Central Alaska

GEOLOGICAL SURVEY PROFESSIONAL PAPER 559

This volume was published as separate chapters A–B

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CONTENTS

[Letters designate the separately published chapters]

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