Geological Survey of Canada
Commission géologique du Canada

BULLETIN 392

MID-CAMBRIAN TRILOBITES FROM THE LOWEST PART OF THE COW HEAD GROUP, WESTERN NEWFOUNDLAND

Graham A. Young
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Energy, Mines and Resources Canada
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Available in Canada through

authorized bookstore agents and other bookstores

or by mail from

Canadian Government Publishing Centre
Supply and Services Canada
Ottawa, Canada K1A 0S9

and from

Geological Survey of Canada offices:

601 Booth Street
Ottawa, Canada K1A 0E8

3303-33rd Street N.W
Calgary, Alberta T2L 2A7

A deposit copy of this publication is also available
for reference in public libraries across Canada

Cat. No. M42-392E
ISBN 0-660-13251-6

Price subject to change without notice

Critical readers

W.H. Fritz
A. Rushton

Authors' addresses

G.A. Young
Department of Geology
University of New Brunswick
Fredericton, New Brunswick E3B 5A3

R. Ludvigsen
Denman Institute for Research on Trilobites
4062 Wren Road
Denman Island
British Columbia V0R 1T0

Manuscript submitted: 88.05.10
Approved for publication: 88.06.06

This monograph is one of several based on the C.H. Kindle Collection of Newfoundland trilobites, deposited in the National Type Collection, Geological Survey of Canada, Ottawa.

PREFACE

The diverse trilobite faunas described in this report belong to the C.H. Kindle collection of western Newfoundland trilobites. In 1978, the Geological Survey of Canada acquired Kindle's collection of approximately 20 000 specimens, which he had painstakingly extracted, over a period of 40 years, from fossiliferous boulders of the mid-Cambrian to Middle Ordovician Cow Head Group conglomerates.

This work is the first systematic study of trilobites from Kindle's collection. Of the 1300 specimens studied, 29 species representing 20 genera are described; eleven of the species are new. Three trilobite biofacies are defined based on the abundance of genera in separate boulders. The association of several genera in one of the biofacies is assigned to a *Zacanthoides gilberti* Fauna, which correlates with the *Ptychagnostus gibbus* Zone of western North America. This zone is a widely distributed biostratigraphic unit that has also been identified in Australia, Scandinavia and Siberia.

As a result of this increased knowledge of the biostratigraphy of the western Newfoundland area, correlations can be made with rock units in other parts of the continent and the world. Correlation of rock units is essential for interpreting the geological history of large regions, and paleontology provides one of the most incisive tools for establishing the time relationships of sedimentary rocks.

Elkanah A. Babcock
Assistant Deputy Minister
Geological Survey of Canada

PRÉFACE

La faune des Trilobites décrite dans ce rapport appartient à la collection de trilobites de l'ouest de Terre-Neuve de C.H. Kindle. En 1978, la Commission géologique du Canada a fait l'acquisition de cette collection d'environ 20 000 espèces que M. Kindle avait mis 40 ans à extraire laborieusement de blocs fossilifères de conglomérats du groupe de Cow Head datant du Cambrien moyen à l'Ordovicien moyen.

Cet ouvrage constitue la première étude systématique des trilobites de la collection de Kindle. Les auteurs y décrivent 29 des 1 300 espèces étudiées. Onze de ces 29 espèces représentant 20 genres sont nouvelles. Trois biofaciès à trilobites y sont définis à partir du nombre de genres qui se trouvent dans des blocs distincts. L'association de plusieurs genres dans l'un des biofaciès est attribuée à la faune de *Zacanthoides gilberti*, laquelle est mise en corrélation avec la zone à *Ptychagnostus gibbus* de l'ouest de l'Amérique du Nord. Cette zone constitue une unité biostratigraphique de vaste étendue que l'on retrouve aussi en Australie, en Scandinavie et en Sibérie.

Ces connaissances accrues de la biostratigraphie de l'ouest de Terre-Neuve permettent d'établir des corrélations avec des unités lithologiques d'autres parties du continent et du monde. La corrélation des unités lithologiques est un élément essentiel à l'interprétation de l'histoire géologique de grandes régions, et la paléontologie est l'un des outils les plus efficaces permettant d'établir les liens chronologiques des roches sédimentaires.

Elkanah A. Babcock
Sous-ministre adjoint
Commission géologique de Canada

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Abstract

Rich mid-Cambrian trilobite faunas were recovered from limestone boulders in conglomerates that form the lowest exposures of the Cow Head Group (Shallow Bay Formation) near Broom Point in western Newfoundland. These boulders were derived from various shelf-edge and upper slope environments along the margin of Laurentia. Twenty-nine species representing twenty genera are described. Three trilobite biofacies are defined based on the abundance of the genera in separate boulders: the Zacanthoidid-*Pagetia*, *Bathyuriscus*, and *Onchocephalites* biofacies. The association of *Zacanthoides gilberti*, *Parkaspis caboti*, *Peronopsis interstricta*, *Pagetia rasettii*, *Elrathia kindlei*, and *Bathyuriscus richardsoni* in the Zacanthoidid-*Pagetia* Biofacies is assigned to a *Zacanthoides gilberti* Fauna, which correlates with the *Ptychagnostus gibbus* Zone of western North America.

Eleven species are new: *Peronopsis mariae*, *Pagetia rasettii*, *P. skraelingi*, *Bathyuriscus terranovensis*, *B. boscaputensis*, *B. richardsoni*, *Tonkinella occidentalis*, *Zacanthoides gilberti*, *Parkaspis caboti*, *Chancia tuberculata*, and *Elrathia kindlei*.

Résumé

Des faunes riches en trilobites du Cambrien moyen ont été récupérées dans des blocs de calcaire de conglomérats qui constituent les expositions les plus basses du groupe de Cow Head (formation de Shallow Bay) près de pointe Broom dan l'ouest de la Terre-Neuve. Ces blocs proviennent de divers milieux de bordure de plate-forme et de partie supérieure de pente le long de la marge de Laurentia. Vingt-neuf espèces représentant vingt genres sont décrits. Trois biofaciès à trilobites sont définis en se fondant sur l'abondance des genres dans différents blocs : les biofaciès à Zacanthoididés-*Pagetia*, à *Bathyuriscus* et à *Onchocephalites*. L'association de *Zacanthoides gilberti*, *Parkaspis caboti*, *Peronopsis interstricta*, *Pagetia raettii*, *Elrathia kindlei* et *Bathyuriscus richardsoni* dans les biofaciès à Zacanthoididés-*Pagetia* est attribuée à une faune qui correspond à la zone à *Ptychagnostus gibbus* de l'ouest de l'Amérique du Nord.

On a recensé onze nouvelles espèces : *Peronopsis mariae*, *Pagetia rasettii*, *P. skraelingi*, *Bathyuriscus terranovensis*, *B. boscaputensis*, *B. richardsoni*, *Tonkinella occidentalis*, *Zacanthoides gilberti*, *Parkaspis caboti*, *Chancia tuberculata* et *Elrathia kindlei*.

Summary

At most localities in eastern North America, Cambrian shelf-margin trilobite faunas are sparse and poorly preserved. There are, however, a few rich faunas, notably in Quebec, but these are difficult to interpret biostratigraphically because they occur in mixed boulders found in conglomerates of Ordovician age. Diverse faunas occur in orderly stratigraphic successions only in a small area of western Newfoundland near the Cow Head Peninsula where well preserved trilobites have been recovered from mid-Cambrian to Middle Ordovician limestone conglomerates of the Cow Head Group. This monograph deals with the biostratigraphy and systematics of trilobites found in boulders collected from conglomerates exposed at the base of the Cow Head Group near Broom Point.

About 1300 trilobites were recovered from 42 numbered boulders from the lowest exposures of the Downes Point Member on both the north and south sides of Anticlinal Cove. The Downes Point is the lowest member of the Shallow Bay Formation, which is the more proximal of two formations of the Cow Head Group. These exposures constitute a 10 m thick sequence of welded conglomerates composed of limestone plates and subequant cobbles with little or no matrix. The limestones are mainly coarse, light brown grainstones and packstones; a few are wackestones.

A biostratigraphic study of these trilobites addresses both their spatial and temporal aspects. Accordingly, we start with a biofacies analysis of specimen abundance of genera (or higher taxa) and then proceed to a zonal analysis of the presence of species.

Three contemporaneous trilobite biofacies are defined for the basal Cow Head Group: the Zacanthoidid-*Pagetia* Biofacies for grainstones and packstones, with diverse faunas numerically dominated by the zacanthoidids *Zacanthoides* and *Parkaspis* and by the eodiscid *Pagetia*; the *Bathyuriscus* Biofacies for packstones and wackstones, dominated by the dolichometopid *Bathyuriscus*; and the *Onchocephalites* Biofacies for lime mudstones and packstones dominated by the ptychopariid *Onchocephalites*. The same suite of genera dominates other mid-Cambrian assemblages from outer platform settings in Quebec, Nevada, Utah, and British Columbia, suggesting a circum-Laurentia distribution for these spatial biostratigraphic units.

The common presence of the species *Zacanthoides gilberti*, *Parkaspis caboti*, *Peronopsis interstricta*, *Bathyuriscus richardsoni*, *Pagetia rasettii* and *Elrathia kindlei* in boulders of the Zacanthoidid-*Pagetia* Biofacies defines the *Zacanthoides gilberti* Fauna. Virtually all these species are new, so correlation of the *Z. gilberti* Fauna must be based on the occurrence of the rare agnostoids *Ptychagnostus gibbus*, *P. intermedius* and *Onymagnostus seminula*. These agnostoids indicate a correlation with the *Pytchagnostus gibbus* Zone; a widely distributed temporal biostratigraphic unit that occurs in western North America, as well as in Australia, Scandinavia and Siberia.

According to a recent proposal, the contact of the *Ptychagnostus gibbus* Zone and the overlying *P. atavus* Zone defines the boundary between a Lower Cambrian Series and an Upper Cambrian Series. Therefore, the *Zacanthoides gilberti* Fauna is latest Early Cambrian in age.

In the section on systematic paleontology, twenty-nine species representing twenty genera are described and illustrated.

Sommaire

Dans la plupart des sites, dans l'est de l'Amérique du Nord, les faunes de trilobites de marge de plate-forme cambrienne sont clairsemées et mal conservées. On trouve, néanmoins, notamment au Québec, quelques faunes riches qui sont toutefois difficiles à interpréter biostratigraphiquement du fait qu'elles sont contenues dans divers blocs de conglomérats ordoviciens. Des successions stratigraphiques ordonnées de diverses faunes n'ont été observées que dans une petite zone de l'ouest de Terre-Neuve, près de la péninsule de Cow Head où des trilobites bien conservés ont été récupérés dans des conglomérats de calcaire, du Cambrien moyen à l'Ordovicien moyen, du groupe de Cow Head. Le présent ouvrage traite de la biostratigraphie et de la systématique des trilobites contenus dans des blocs provenant de conglomérats exposées à la base du groupe de Cow Head près de pointe Broom.

Environ 1300 trilobites ont été récupérés dans 42 blocs numérotés provenant des expositions les plus basses du membre de Downes Point, des côtés nord et sud de l'anticlinal Cove. Le membre de Downes Point est le membre le plus bas de la formation de Shallow Bay qui est la plus proximale des deux formations du groupe de Cow Head. Ces expositions comportent une séquence de dix mètres épaisseur de conglomérats soudés composés de plaques de calcaire et de galets quasi équidimensionnels, parfois liés avec un peu de ciment. Les calcaires sont principalement des grainstones et des packstones grossiers de couleur brun clair. Quelques-uns sont des wackestones.

Une étude biostratigraphique de ces trilobites traite de leurs aspects spatiaux et temporels. C'est pourquoi nous commençons par une analyse par biofaciès de l'abondance des spécimens des genres (ou taxons supérieurs) avant de procéder à une analyse de la présence zonale des espèces.

Trois biofaciès à trilobites contemporains sont définis dans la base du Groupe de Cow Head : le biofaciès à Zacanthoïdidés-*Pagetia* pour le grainstone et le packstone avec diverses faunes comptant surtout les zacanthoïdidés *Zacanthoides* et *Parkaspis* et les éodiscidés *Pagetia*, le biofaciès à *Bathyriscus* pour le packstone et wackestone où abondent les dolichométapidés *Bathyuriscus*, et le biofaciès à *Onchocéphalites* pour les mudstones et les packstones à calcaire où les ptychoparlidés *Onchocéphalites* prédominent. Cette suite de genres prédomine dans d'autres assemblages du Cambrien moyen d'autres sites de partie extérieure de plate-forme, au Québec, au Névada, dans l'Utah et en Colombie-Britannique laissant supposer une distribution circum-Laurentia de ces unités biostratigraphiquement spatiales.

La présence des espèces *Zacanthoides gilberti*, *Parkaspis caboti*, *Peronopsis interstricta*, *Bathyuriscus richardsoni*, *Pagetia rasettii* et *Elrathia kindlei* dans des blocs du biofaciès à Zacanthoïdidés-*Pagetia* est utilisée pour définir la faune de *Zacanthoides gilberti*. Comme pratiquement toutes ces espèces sont nouvelles, il faut pour établir une corrélation de la faune de *Z. gilberti*, se fonder sur la présence des rares agnostidés *Ptychagnostus gibbus*, *P. intermedius* et *Onymagnostus seminula*. Ces agnostidés indiquent une corrélation avec la zone à *Ptychagnostus gibbus*, une unité biostratigraphique à grande distribution temporelle que l'on retrouve dans l'ouest de l'Amérique du Nord ainsi qu'en Australie, en Scandinavie et en Sibérie.

Selon une hypothèse récente, le contact de la zone à *Ptychagnostus gibbus* et la zone à *P. atavus* sus-jacente marquerait la limite entre une série du Cambrien inférieur et une série du Cambrien supérieur. Par conséquent, la faune de *Zacanthoides gilberti* remonterait à la fin du Cambrien inférieur.

Dans la section sur la paléontologie systématique, vingt-neuf espèces représentant vingt genres sont décrites et illustrées.

INTRODUCTION

Spectacular exposures of fossiliferous Cambrian and Ordovician conglomerates at and near the Cow Head Peninsula in western Newfoundland have attracted the interest of many geologists over the past 125 years. The Cow Head Group consists of some 300 to 500 m of limestone conglomerate and interbedded lime mudstone and grainstone, as well as calcareous sandstone, siltstone, and shale. The conglomerate clasts are composed of shelf-edge and slope limestones, some of which are highly fossiliferous, that were transported downslope as debris flows (Kindle and Whittington, 1958). Because shelf-edge sediments are not exposed anywhere in western Newfoundland, the transported boulders are the sole source of data on the nature and variety of physical and biological environments that existed along the margin of this part of Laurentia.

The stratigraphy and sedimentology of strata now assigned to the Cow Head Group were first studied by James Richardson (in Logan, 1863). He described the impressive boulder beds exposed on the Cow Head Peninsula, but did not attempt to explain their origin. Schuchert and Dunbar (1934) suggested that the conglomerates were crush breccias formed along a fault scarp during the Middle Ordovician. By studying the faunas in sequence, Kindle and Whittington (1958) were able to demonstrate that the Cow Head Group comprises an orderly stratigraphic succession of bedded conglomerate and limestone that is of mid-Cambrian age near its base and of Middle Ordovician age at its top. They also showed that the boulders from individual conglomerate layers were largely of the same age and about the same age as the interbeds.

In a recent comprehensive assessment of the stratigraphy, sedimentology, biostratigraphy, and depositional history of the Cow Head Group, James and Stevens (1986) established two formations – a proximal Shallow Bay Formation with four members, which is exposed in the Cow Head Peninsula and Broom Point areas, and a distal Green Point Formation with three members, which is exposed in the Martin Point and Green Point areas. They concluded that the Cow Head sediments accumulated at the base of the continental slope in response to changing conditions on the adjacent shelf.

Cambrian and Ordovician trilobites from the Cow Head have been dealt with by various investigators. Kindle (in Oxley, 1953) first noted the presence of Middle Cambrian trilobites in the Cow Head. Kindle and Whittington (1958) provided extensive faunal lists for the succession of numbered beds on Cow Head Peninsula, and also at White Rock Islets, Stearing Island, and Broom Point. Fortey (1983; in Fortey et al., 1982) described trilobites from the Cambrian–Ordovician boundary interval at Broom Point. Ludvigsen and Westrop (1983) included some Cow Head trilobites in a study of Cambrian–Ordovician boundary biofacies of North America. Kindle (1982) illustrated a number of Cow Head trilobites and assigned them to a sequence of zones numbered from 1 to 8 (Middle Cambrian to Lower Ordovician). James and Stevens (1986) reviewed all previous biostratigraphic determinations of Cow Head fossils, including many trilobites, and allocated these faunas to the seven members of the Shallow Bay and Green Point formations. Ludvigsen and Westrop (1986) augmented Kindle's (1982) biostratigraphic scheme and proposed a sequence of 18 trilobite faunas for mid-Cambrian to lower Ibexian boulders of the Cow Head.

The present work is the first systematic study of mid-Cambrian trilobites from the Cow Head Group; however, similar shelf-edge trilobite faunas have been described from Cambrian boulders in the Lower Ordovician Levis Formation of Quebec (Rasetti, 1948, 1963) and from mostly autochthonous limestones of the Taconic sequence of New York State (Rasetti, 1967). Some of these trilobites were illustrated by Kindle (1982) who assigned them to his Zone 1. Our study is based on about 1300 trilobites from 42 numbered limestone boulders collected from the lowest conglomerate exposed at Anticlinal Cove near Broom Point. In terms of the stratigraphic nomenclature of James and Stevens (1986, Fig. 10), this interval equals Beds 1 and 2 of the lowest Downes Point Member of the Shallow Bay Formation at the Broom Point South section. Boulders 260 to 273 came from the conglomerate on the north side of Anticlinal Cove and boulders 350 to 380 and 433 came from the same conglomerate on the south side (Fig. 1).

The trilobites described here are part of the C.H. Kindle Collection at the Geological Survey of Canada. This important collection consists of about 20 000 prepared trilobites, most of which are from 460 numbered boulders collected from conglomerates of the Cow Head Group exposed at Cow Head Peninsula, White Rock Islets, Stearing Island, St. Paul's Inlet, Western Brook Pond, Martin Point, and the Broom Point area. The entire collection was purchased by the Geological Survey of Canada with a grant from the Government of Canada under the terms of the Cultural Property Export and Import Act.

Stratigraphy and sedimentology

Kindle and Whittington (1958) demonstrated that the stratigraphy of the Cow Head Group was mappable around the periphery of the Cow Head Peninsula, but they were not able to recognize the fourteen numbered beds in other areas of the outcrop belt. James and Stevens' (1986) interpretation of the Cow Head Group as a sediment apron deposited at the base of a continental margin was accompanied by a new regional stratigraphy in which the proximal-distal aspect of the Cow Head Group was expressed as a pair of correlative units – the conglomerate-dominated Shallow Bay Formation with four members, and the shale-dominated Green Point Formation with three members. Only the lowest member of the proximal formation – the Downes Point Member of the Shallow Bay Formation – need concern us here.

The Downes Point Member is about 100 m thick and consists mainly of welded chip and boulder conglomerates that have little matrix, with minor grainstone beds and thin shales. According to James and Stevens (1986, p. 87) these strata represented a deep water sediment apron formed in front of a rapidly accreting platform margin of ooid and skeletal sand shoals and calcified algal buildups.

The lowest exposure of the Downes Point Member is a sequence of massive welded conglomerates outcropping on the north and south sides of Anticlinal Cove south of Broom Point (Fig. 1). These conglomerates consist mainly of limestone plates and subequant cobbles and boulders with little or no matrix (James and Stevens, 1986, p. 61). Forty-two of these boulders yielded the well preserved trilobites described here. The fossiliferous boulders are mainly coarse, light brown grainstone and packstone that contain echinoderm fragments and inarticulate brachiopods, in addition to the trilobites. A few boulders consist of medium to dark brown wackestone with few trilobites and, in some cases, common glauconite. All trilobite elements are dissociated, but none is abraded.

In thin section, trilobites are seen to be common to abundant in the grainstone and packstone, and occur with rare to common echinoderm debris and inarticulate

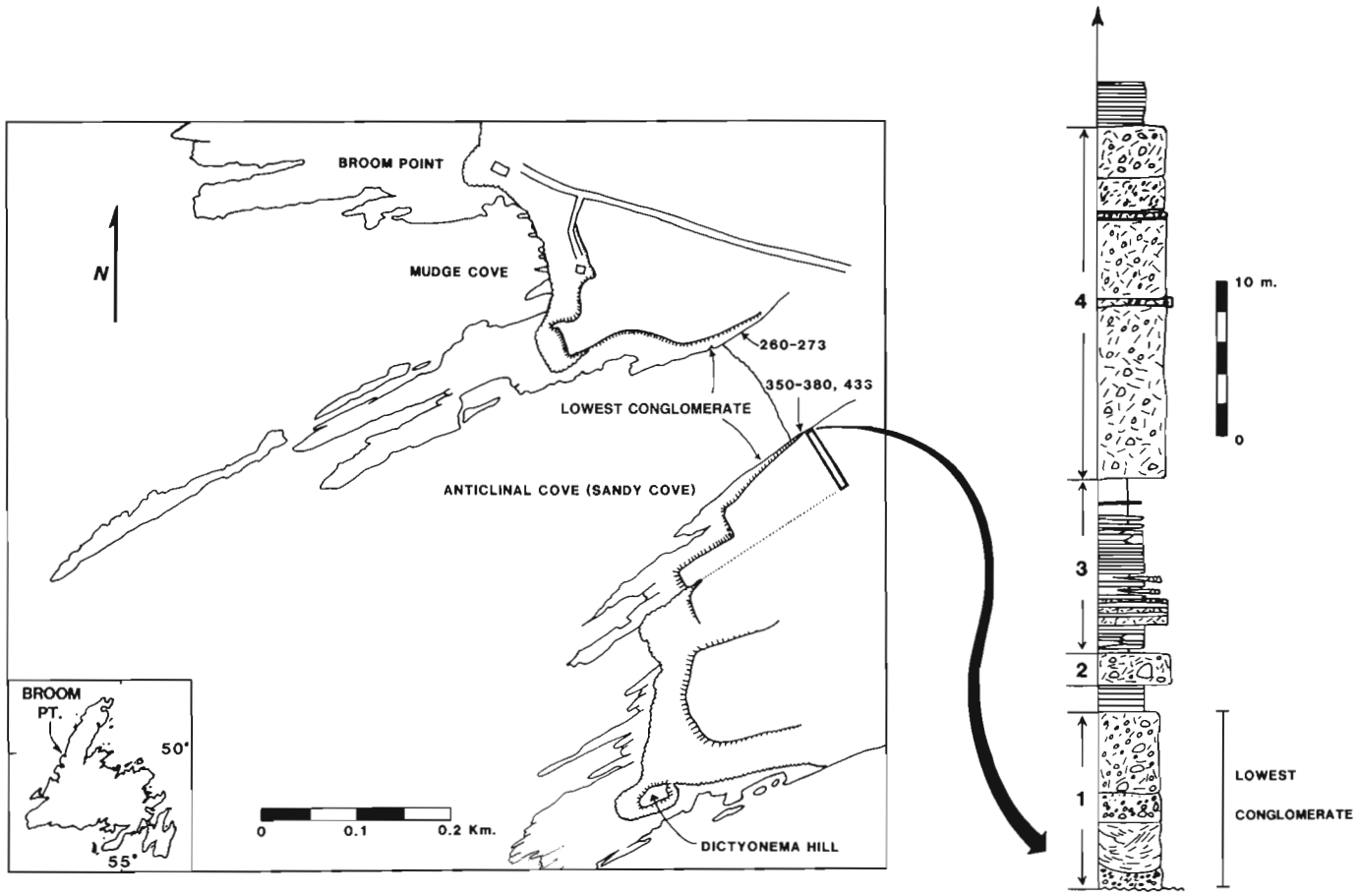


Figure 1. *Locality map of Broom Point area showing location of numbered boulders on the north and south sides of Anticlinal Cove (modified from Kindle, 1982, Figs. 1, 2). Lithological column of lowest exposures of Cow Head Group (modified from James and Stevens, 1986). The entire section is from the Downes Point Member of the Shallow Bay Formation. Probable extent of Zones 1 to 4 of Kindle (1982) are shown. The trilobites described in this study came from the lowest conglomerate.*

brachiopods (Fig. 2A-D, G). Trilobite skeletal material may show recrystallization along margins (Fig. 2A, D). Large patches of spar are present, frequently as shelter porosity cement under trilobite fragments. Mud is rare and usually present internally in trilobite spines (Fig. 2A). Peloids are generally rare, but a few boulders possess large peloidal intraclasts. Glauconite is rare. Wackestone and lime mudstone are less common (Fig. 2E, F, H). Some contain subangular quartz silt and rare terrigenous clay and opaque minerals (Fig. 2H). Trilobite skeletal material and peloids are locally concentrated in stringers, which may represent burrow fills (Fig. 2H).

Biostratigraphy

Studies of Cambrian biostratigraphy of Laurentia have, with few exceptions, dealt solely with the establishment of successions of zones. Regional biofacies have rarely been considered and the sequence of zones established by Rasetti (1951) and by Lochman-Balk and Wilson (1958) has been considered to be a standard for North America.

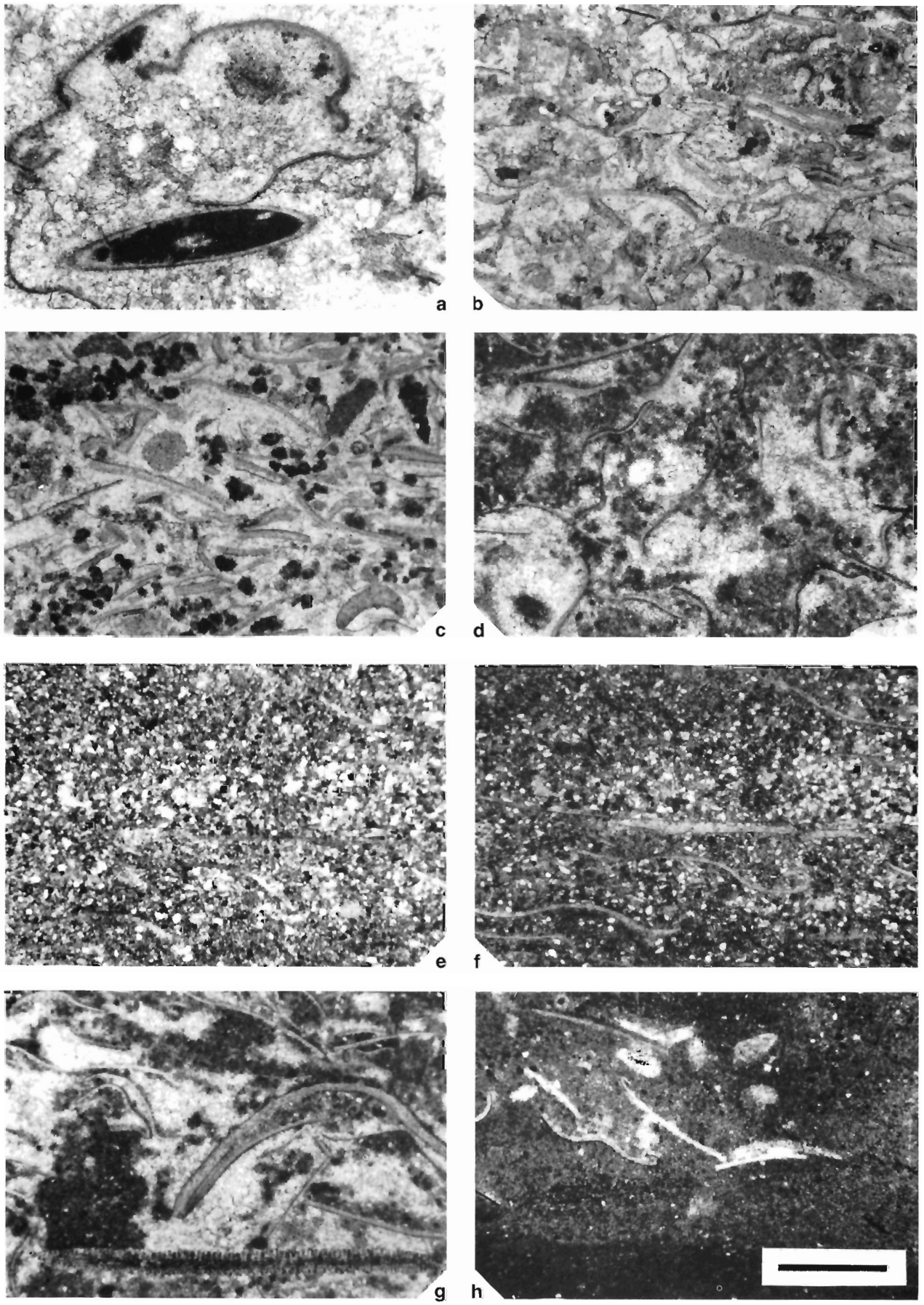
In the Cambrian, most zones have been defined on the basis of occurrence of trilobite genera. In a single area, the sequence of zones based on generic ranges may be nothing more than a succession of environmentally controlled biofacies. Of published North American mid-Cambrian studies, only the agnostoid zonation of Robison (1976, 1982, 1984) and Rowell et al. (1982) employs first occurrences of species as the basis for a durable and widely applicable zonal succession.

An adequate biostratigraphic analysis must address both spatial and temporal aspects of fossils in rocks (see Ludvigsen et al., 1986). Accordingly, our biostratigraphic study of the trilobites from the lowest Downes Point Member of the Shallow Bay Formation at Broom Point starts with a biofacies analysis of specimen *abundance* of genera and then proceeds to a zonal analysis of *presence* of species.

Biofacies analysis

Most studies of Cambrian trilobite biofacies in North America have been qualitative or based on presence-absence data. For this study, all trilobites of the 42 boulders were counted at the genus level.

It was apparent from a visual comparison of the relative abundance data that at least two, and probably three, biofacies in distinct lithofacies were represented in the boulders. To substantiate this impression, Q- and R-mode cluster analyses using Pearson's product-moment correlation coefficient were performed (Sokal and Rohlf, 1969, chapter 15). The data matrix was then replotted with the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boulders in Q-mode clustering order and the genera in R-mode clustering order. Intersections of the clusters define three biofacies (see Young, 1984; Ludvigsen et al., 1986 for details and results of the clustering technique). These biofacies are named after the dominant taxa.

1. The Zacanthoidid-*Pagetia* Biofacies is dominated by the zacanthoidids *Zacanthoides* and *Parkaspis* and by *Pagetia* (Table 1). *Peronopsis* and *Elrathia* are common associates. This highly diverse biofacies occurs in light brown grainstone and packstone with abundant spar and rare lime mud, which is found mostly internally in trilobites (Fig. 2A-C). Sixteen boulders are assignable to this biofacies (Table 2).

2. The *Bathyuriscus* Biofacies is strongly dominated by the nominate trilobite (Table 1). *Peronopsis* and *Eoptychoparia* are locally common. Five boulders of packstone and wackestone (Fig. 2D-F) belong in this biofacies (Table 2).

3. The *Onchocephalites* Biofacies is strongly dominated by the nominate trilobite (Table 1). *Peronopsis*, *Onymagnostus* and *Bathyuriscus* are locally common. Five boulders of peloidal lime mudstone and packstone (Fig. 2G, H) are assignable to this biofacies (Table 2).

Trilobite associations similar to the three Cow Head biofacies are recognizable in mid-Cambrian outer shelf lithofacies in western North America and in other areas of eastern North America.

Robison (1976) divided the carbonate platform of the Great Basin of Utah and Nevada into open-shelf and restricted-shelf facies and established different sets of zones for each. Trilobite associations of the restricted-shelf facies bear little resemblance to any of the Cow Head biofacies, but those of the open-shelf facies are characterized by the following genera that are also common in the Cow Head boulders: *Bathyuriscus*, *Olenoides*, *Zacanthoides*, *Kootenia*, *Peronopsis*, *Ptychagnostus* and *Onymagnostus*.

Figure 2. *Thin section photomicrographs of boulders from the lowest Cow Head Group. Scale bar represents 1 mm. A-C are from the Zacanthoidid-**Pagetia** Biofacies, D-F are from the **Bathyuriscus** Biofacies, G-H are from the **Onchocephalites** Biofacies.*

A. Trilobite grainstone showing internal mud in bioclasts; note recrystallization along borders (boulder 358).

B. Trilobite grainstone with rare peloids (boulder 373).

C. Peloidal trilobite grainstone (boulder 374).

D. Trilobite packstone with common peloids and spar (boulder 378).

E, F. Wackestone with abundant angular quartz silt and rare to common trilobite skeletal material (boulder 357).

G. Trilobite packstone; note large patches of mud and echinoderm fragment (boulder 376).

H. Lime mudstone; band of concentrated trilobite skeletal material and peloids probably represents a burrow fill (boulder 362).

Palmer and Campbell (1976) defined the inner-shelf *Albertella-Mexicella* Biofacies, the platform-margin Zacanthoidid Biofacies, and the upper slope *Ogygopsis* Biofacies for strata in the Great Basin. The inner-shelf biofacies has little in common with the Cow Head biofacies, but the Zacanthoidid Biofacies is characterized by zacanthoidids, eodiscids, and oryctocephalids and the *Ogygopsis* Biofacies is characterized by *Ogygopsis*, agnostids, eodiscids, and oryctocephalids. These taxa are important constituents of the Cow Head biofacies, particularly the Zacanthoidid-*Pagetia* Biofacies.

A *Bathyuriscus* Biofacies is also present in the mid-Cambrian Stephen Formation of eastern British Columbia. A large collection from the "Trilobite Beds" on Mount Stephen, Yoho National Park (Rasetti, 1951) is dominated by *Ogygopsis*, *Bathyuriscus*, *Olenoides* and also includes *Elrathia* and *Zacanthoides* (abundance data provided by D.M. Rudkin, Royal Ontario Museum).

Limestone conglomerates of the Levis Formation of Quebec were deposited under conditions similar to those for deposition of the Cow Head Group (James, 1981) and contain trilobite faunas that strongly resemble those of the Cow Head biofacies. However, from the presence-absence data of species in each Quebec boulder given by Rasetti (1948, Tables 1, 2; 1963, Tables 1, 2), it is not possible to distinguish biofacies to the same degree as for the Cow Head, but there is a high degree of similarity at the generic level to the three Cow Head biofacies and to other outer shelf biofacies. Genera that are common in the Quebec boulders include *Kootenia*, *Olenoides*, *Pagetia*, *Peronopsis*, *Onchocephalites*, and *Elrathia*.

Biofacies data for trilobite assemblages of the lower Cow Head Group of Newfoundland and for assemblages from Quebec, Nevada, Utah, and British Columbia demonstrate that essentially the same suite of genera characterize outer platform assemblages in eastern and western North America.

Zonal analysis

Ranges of trilobite genera contribute little to detailed temporal biostratigraphic schemes for Cambrian rocks in North America (Robison, 1976; Ludvigsen et al., 1986). Many of the genera in the Cow Head boulders studied here range through much of the *Oryctocephalus* and *Bolaspidella* zonal interval in the Great Basin; some starting as low as the *Bonnia-Olenellus* Zone (see Robison, 1976, p. 102, Textfig. 4). The succession of zones that eventually will be established for the Cambrian bank-edge allochthonous boulders of the Cow Head Group must be based on the stratigraphic ranges of commonly occurring species. We begin this process by assigning the name "*Zacanthoides gilberti* Fauna" to the diverse association of species in the sixteen boulders yielding the Zacanthoidid-*Pagetia* Biofacies (Table 1). This name replaces the designation "Zone 1" applied by Kindle (1982).

The *Z. gilberti* Fauna is characterized by *Zacanthoides gilberti* n. sp., *Parkaspis caboti* n. sp., *Peronopsis interstricta* (White), *Bathyuriscus richardsoni* n. sp., *Pagetia rasettii* n. sp. and *Elrathia kindlei* n. sp. Virtually all the species are new and correlations are accordingly based largely on the presence of rare agnostoids, which permit a comparison with the agnostoid zones first proposed by Westergård (1946) for Scandinavia and, subsequently, modified for North America by Robison (1976, 1982, 1984). In the Great Basin of Nevada and Utah, the base of the *Ptychagnostus gibbus* Zone is marked by the first appearance of *P. gibbus*, *P. intermedius*, *Onymagnostus seminula* and *Peronopsis interstricta*. The presence of these four agnostoid species in the *Z. gilberti* Fauna indicates a correlation with the *P. gibbus* Zone.

TABLE 1

Relative abundance (percentages) of specimens belonging to the ten most abundant genera in nine boulders from the lowest beds of the Downes Point Member at Broom Point (Fig. 1), showing composition of the three trilobite facies

BIOFACIES	Zacanthoidid-*Pagetia*				*Bathyuriscus*			*Onchocephalites*	
BOULDER NUMBER	380	358	379	374	378	357	356	376	362
Zacanthoides	3	19	3	4			26	12	
Parkaspis	6	17	53						
Pagetia	26	13	13	86		12			
Elrathia	12	6	3						
Chancia	4	1							7
Peronopsis	35	33	15	6	48	7		21	19
Onymagnostus	6		2		5			9	28
Bathyuriscus		3	6	2	27	49	29		10
Eoptychoparia		5				1	32		
Onchocephalites					5			56	21

The *Z. gilberti* Fauna is explicitly defined for the species of the Zacanthoidid-*Pagetia* Biofacies, but boulders containing species of the *Bathyuriscus* and *Onchocephalites* biofacies appear to be of the same age. Even though differences in generic composition are considerable, 50 per cent of species of the *Onchocephalites* Biofacies and 74 per cent of species of the *Bathyuriscus* Biofacies also occur in the Zacanthoidid-*Pagetia* Biofacies.

Kindle's (1982) identification and illustrations may be used to suggest tentative correlations of the fossiliferous units overlying the *Z. gilberti* Fauna at Broom Point (see Fig. 1). These strata belong to the Downes Point Member of the Shallow Bay Formation (James and Stevens, 1986, Fig. 47d).

Agnostoids of Kindle's Zone 2 include *Baltagnostus* sp. and *Ptychagnostus gibbus*. The latter occurs only in the *P. gibbus* and *P. atavus* zones. In view of the high degree of similarity to the *Z. gilberti* Fauna, Zone 2 is here also correlated with the *P. gibbus* Zone.

Ptychagnostus atavus, *Tomagnostus fissus* and *Hypagnostus parvifrons* occur in Kindle's Zone 3. The first two are typical of the *P. atavus* Zone (Rowell et al., 1982, Table 2), while the third extends from the *P. atavus* Zone to the *P. punctuosus* Zone. Zone 3 at Broom Point appears to correlate with the *P. atavus* Zone.

The "50 foot conglomerate" at Broom Point was assigned by Kindle to his Zone 4. Agnostoids present include *Ptychagnostus aculeatus* and *Phalacroma glandiforme*, both characteristic of the *Lejopyge laevigata* Zone in the Great Basin (Robison, 1984).

The succession of agnostoid species in the Downes Point Member at Broom Point permits correlation of the *Zacanthoides gilberti* Fauna and Kindle's Zone 2 with the *Ptychagnostus gibbus* Zone, Zone 3 with the *Ptychagnostus atavus* Zone, and Zone 4 with the *Lejopyge laevigata* Zone (Fig. 3; see also Ludvigsen and Westrop, 1986). According to the recent revision of Upper Cambrian biostratigraphy of North America by Ludvigsen and Westrop (1985), the *P. atavus* Zone defines the base of the Marjuman Stage, the lowest of three new stages of an expanded Upper Cambrian Series, above an expanded Lower Cambrian Series. Therefore, in the stratigraphic section exposed south of Anticlinal Cove, the contact of the Lower and Upper Cambrian series falls at the base of Kindle's (1982) Zone 3 and at the base of Unit 8 of the Broom Point South section of James and Stevens (1986, p. 129). These biostratigraphic assignments differ from those required by the conventional threefold division of the Cambrian (e.g., Palmer, 1977) in which the *Z. gilberti* Fauna would correlate with a position halfway through the Middle Cambrian (Fig. 3).

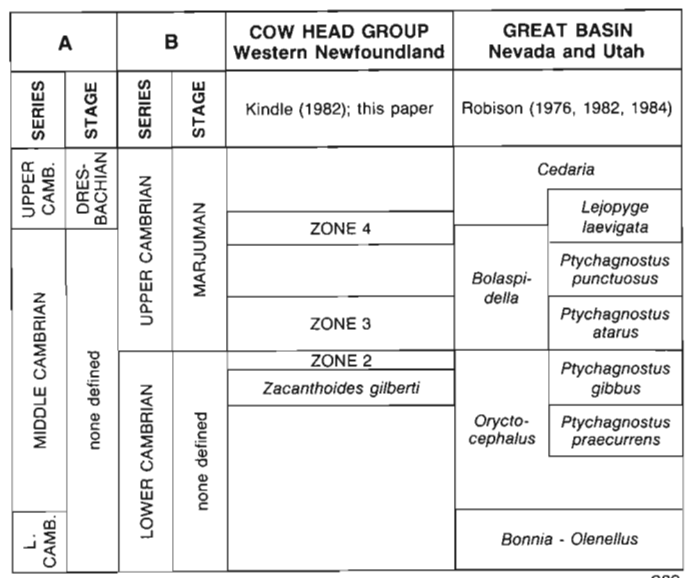


Figure 3. *Correlation of the open-shelf polymeroid and agnostoid zones in the Great Basin of Nevada and Utah (Robison, 1976, 1982, 1984) with the* ***Zacanthoides gilberti*** *Fauna established herein and the numbered zones of Kindle (1982) from the lower Shallow Bay Formation of the Cow Head Group exposed near Broom Point. The columns are aligned against (A) a conventional tripartite division of the Cambrian (e.g., Palmer, 1977), and (B) a bipartite division of the Cambrian System in North America in which the base of the* ***Ptychagnostus atavus*** *Zone defines the base of an Upper Cambrian Series (Ludvigsen and Westrop, 1985).*

TABLE 2

Distribution and specimen abundance of 29 species of trilobites in 42 numbered boulders from the lowest beds of the Downes Point Member at Broom Point (Fig. 1). Biofacies assignments are indicated for 26 boulders: Z-P (Zacanthoidid-*Pagetia* Biofacies, B (*Bathyuriscus* Biofacies), and O (*Onchocephalites* Biofacies).

SPECIES \ BOULDERS	260	261	262	263	264	265	266	267	268	269	270	271	272	273	350	351	351A	351B	352	354	356	357	358	359	360	361	362	363	364	369	370	371	372	373	374	375	376	377	378	379	380	433	TOTAL
Peronopsis mariae	8								1		2					1						3	1		4	7								3	3					15	70		118
Peronopsis interstricta			1	7			1			3													77				4				2				6	7		24				132
Peronoposis fallax		4							6			8	5	1	2	2										11													17				56
Ptychagnostus gibbus																										2											1						3
Ptychagnostus sp. cf. *P. intermedius*																																									1		1
Onymagnostus seminula																									1		16										3		4	2	12		38
Tomagnostus? sp.																						3	1										1							11		16
Pagetia rasettii	3		1	2	2					1	10												31	17	4	7				1			14	43					13	51		200
Pagetia skraelingi		28																				5										34										67
Bathyuriscus terranovensis																	2					21				2																25
Bathyuriscus boscaputensis								4	2						1			2									6												18			33
Bathyuriscus sp. cf. *B. boscaputensis*																																							5			5
Bathyuriscus richardsoni									3		2										10		8			2		10					2	1			2		6			46
Bathyuriscidella sp.																																									2	2
Kootenia elongata								1					2				2	4		4							4									2			13				32
Olenoides foveolatus																						2	1																3			6
Ogygopsis klotzi																						8																				8
Tonkinella occidentalis																					1		1																	4	1	7
Zacanthoides gilberti	8		1						6		1		6		3	1			4		9		46	3	2	5		16					1		2		4	9		3	6	17	153
Parkaspis caboti							1	1			2				1	11			2				40		8			11											53	13	7	157
Alokistocare sp.																																3										3
Chancia tuberculata									1							3					1		3	1				2				1								8	1	21
Chancia sp.																											4																4
Elrathia kindlei											1												14		2	4													3	23		47
Elrathina parallela										1											2						3	5								4		3		3				21
Eoptychoparia convexa	2						5			3						4					11	1	13	2				2			1		5									49
Onchocephalites spinulosus						4		1							5		2										12		4	6		1					19		4				58
Onchocephalites punctatus													3																														3
Spencella spinosa													1	1																													2
BIOFACIES	Z-P	Z-P				O		B			Z-P				O			B	Z-P		B	B	Z-P	Z-P	Z-P	Z-P	O	Z-P		O			Z-P	Z-P	Z-P		O	Z-P	B	Z-P	Z-P	Z-P	

Acknowledgments

We are principally indebted to Cecil H. Kindle who collected, painstakingly prepared, and carefully curated these trilobites from the Cow Head Group. T.E. Bolton and M.J. Copeland of the Geological Survey of Canada arranged the loan of these collections at very short notice. We thank N.P. James of Queen's University for stratigraphic and sedimentological information; and R.A. Robison of the University of Kansas, W.H. Fritz of the Geological Survey of Canada, and A.W.A. Rushton of the British Geological Survey for critically reading the manuscript.

Young was the recipient of a National Sciences and Engineering Research Council Canada postgraduate scholarship during the period 1981-83. This study was supported by NSERC Operating Grant A-3825 to Ludvigsen.

SYSTEMATIC PALEONTOLOGY

Most of the morphological terms used in the trilobite descriptions are defined in the 'Treatise on Invertebrate Paleontology' (Moore, 1959). Additional terms for the Agnostina are from Robison (1964, 1982) and the Eodiscina from Jell (1975). Lateral axial furrows of the glabella and pygidial axis of the Agnostina are designated F1 to F3 from either the posterior of the glabella or the anterior of the pygidium. For the Corynexochida and Ptychopariida, lateral glabellar furrows are designated 1s to 4s from the posterior of the glabella.

All material is housed with the Geological Survey of Canada (GSC prefix).

Class TRILOBITA Walch, 1771

Order AGNOSTIDA Kobayashi, 1935

Suborder AGNOSTINA Salter, 1864

Family SPINAGNOSTIDAE Howell, 1935

Genus *Peronopsis* Corda, 1847

Type species. *Battus integer* Beyrich (1845) from Bohemia (by monotypy).

Peronopsis mariae n. sp.

Plate 1, figures 1-12; Figure 4A

1967 *Peronopsis* sp. 2, Rasetti, p. 32, Pl. 10, figs. 13-18.

1982 *Peronopsis* sp., Kindle, Pl. 1.1, fig. 9.

Diagnosis. A species of *Peronopsis* with a subrectangular cephalon, length slightly greater than width. Glabella narrow, moderately long, slightly tapered anteriorly. Median node weak. F3 transverse, moderately short and shallow. Cephalic border furrow deep and wide. Border wide, narrowing posteriorly. Pygidium subcircular in outline, width slightly greater than length. Axis moderately wide, slightly less than one half pygidial width. Median tubercle large, raised. Pygidial border furrow wide, shallow. Pygidial border wide, narrowing anteriorly. Cephalon and pygidium smooth.

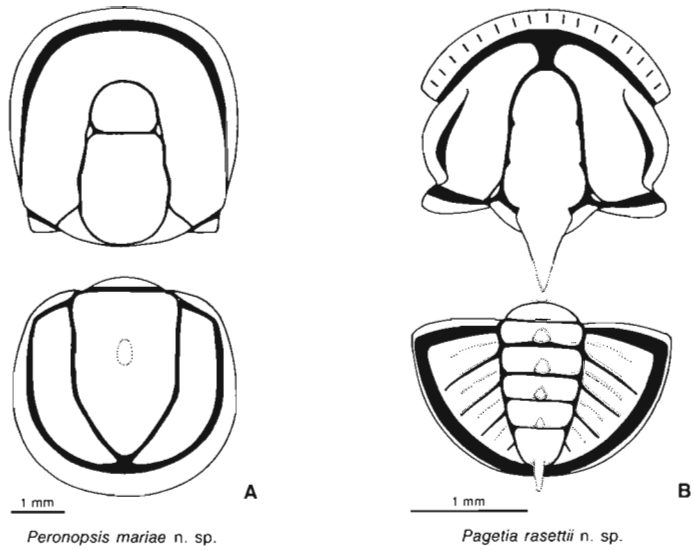


Figure 4. *Reconstructions of species of* ***Peronopsis*** *and* ***Pagetia.***

Holotype. A cephalon (GSC 77296) from boulder 380, illustrated in Plate 1, figures 1, 2.

Etymology. Named for G.Y.'s mother, C.M. Young, whose encouragement and knowledge of biology have been of great assistance.

Occurrences. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland; *Bathyuriscus-Elrathina* Zone, New York State.

Material. 48 cephala, 70 pygidia (Table 2).

Description. Cephalon subrectangular in outline, moderately to strongly convex, width at widest point slightly less than length. Glabella narrow, about one third cephalic width; moderately long, slightly more than two thirds cephalic length, slightly tapered and rounded anteriorly, moderately to strongly arched. Axial furrow moderately wide and shallow, tapered anteriorly. Preglabellar furrow short, shallow. Basal lobe simple, wide, subtriangular. Basal furrow short, moderately shallow. Posteroglabella two thirds glabellar length, expanded medially. Median node very weak, located at midpoint of posteroglabella. Furrows F1 and F2 absent. F3 transverse, moderately short and shallow, dividing abaxially into two distinct furrows before joining axial furrow. Anteroglabella semicircular. Preglabellar median furrow absent. Preglabellar field moderately long. Cephalic border furrow deep and wide, narrower posteriorly. Border wide, narrowing posteriorly, convex. Posterolateral spine absent. Cephalon smooth.

Pygidium subcircular in outline, width slightly greater than or equal to length, moderately convex. Axis broad, slightly less than one half pygidial width, extending posteriorly to border furrow in larger specimens, connected to border furrow by a moderately shallow postaxial median furrow in smaller specimens. Furrow F1 and F2 absent. Median tubercle large, raised. Secondary median node very weak or absent. Posteroaxis slightly ogival in shape. Axial furrow moderately wide and shallow. Pygidial border furrow broad, shallow. Pygidial border wide, narrowing anteriorly, convex. Posterolateral spine absent. Pygidium smooth.

Discussion. *Peronopsis mariae* n. sp. is distinguished from most other species of *Peronopsis* by its subrectangular cephalon, wide cephalic and pygidial border furrows, and absence of both pygidial furrows F1 and F2 and posterolateral spines. *Peronopsis* sp. 2 Rasetti (1967, Pl. 10, figs. 13-18) from the *Ptychagnostus gibbus* faunule of the *Bathyuriscus-Elrathina* Zone of New York State differs from the specimens described here only by possessing very short pygidial furrows F1 and F2; the two taxa are therefore considered conspecific.

Peronopsis mariae is similar to *P. gaspensis* Rasetti (1948, Pl. 45, figs. 1-3) from the lower St. Lawrence Valley and from the *Ptychagnostus gibbus* Zone of the Great Basin (Robison, 1976, p. 105). This species differs by having a slightly longer glabella, a shorter pygidial axis, and pygidial posterolateral spines. *Peronopsis coreanicus* (Kobayashi, 1935, Pl. 14, figs. 4, 5, Textfig. 10) from Korea has a subquadrate cephalon similar in shape to that of *P. mariae*, but the cephala are poorly preserved and no pygidia are illustrated, therefore a thorough comparison cannot be made. *Peronopsis lautus* (Resser, 1939) from the Spence Shale in the Wasatch Mountains of Idaho and Utah has a subquadrate cephalon as well, but differs slightly from *P. mariae* by lacking a minute lobe where the F3 furrow meets the axial furrow on the cephalon and by having a distinct F1 furrow on the pygidial axis.

Other species, including *P. rakuorensis* (Kobayashi, 1935, Pl. 14, figs. 17-18, Pl. 21, figs. 1-2, Textfig. 9) from Korea and Manchuria, *P. interstricta* (White) illustrated by Robison (1964, Pl. 81, fig. 29, Pl. 82, figs. 1-15, 18; 1982, Pl. 6, figs. 9-11) and by Gunther and Gunther (1981, Pl. 44, fig. B) from the *Bolaspidella* Zone of Utah and *P. acadicus* (Hartt) illustrated by Matthew (1896, Pl. 15, figs. 10a-b, 11a-d) from New Brunswick, have pygidia similar to that of *P. mariae*, but have broader, subcircular or semiovate cephala with narrower border furrows.

Peronopsis interstricta (White, 1874)

Plate 1, figures 21-26; Plate 2, figures 1, 2

1951 *Peronopsis interstricta* (White), Rasetti, p. 135.

1954 *Peronopsis interstrictus* (White), Palmer, p. 60, Pl. 13, fig. 6.

1964 *Peronopsis interstricta* (White), Robison, p. 530, Pl. 81, fig. 29, Pl. 82, figs. 1-15, 18 (includes extensive synonymy).

1981 *Peronopsis interstricta* (White), Gunther and Gunther, p. 58, Pl. 44, fig. B.

1982 *Peronopsis interstricta* (White), Robison, p. 156-157, Pl. 6, figs. 9-11.

Diagnosis. A species of *Peronopsis* with a convex, subovate cephalon, length about nine tenths width. Glabella elongate; tapered and flattened anteriorly. Axial furrow moderately wide, shallow. Basal lobes simple, connected posteriorly. Median node weak. F3 transverse, shallow. Cephalic border furrow shallow, wide. Border very wide, flattened, slightly indented medially in larger specimens. Pygidium subovate in outline, slightly wider than long. Axis narrow. Median tubercle moderately large, raised. Pygidial border furrow wide and shallow. Border very wide, flattened, slightly swollen posterolaterally. Cephalon and pygidium smooth.

Occurences. *Zacanthoides gilberti* Fauna, Cow Head Group, Newfoundland; *Ptychagnostus gibbus*, *Ptychagnostus atavus* and *Ptychagnostus punctuosus* zones, Nevada and Utah.

Material. 70 cephala, 62 pygidia (Table 2).

Discussion. The pygidia of *Peronopsis interstricta* illustrated by Robison (1964, Pl. 82, figs. 10-15, 18; 1982, Pl. 6, figs. 9, 11) have somewhat shorter axes and longer postaxial median furrows than those illustrated here (Pl. 1, figs. 21, 25, 26; Pl. 2, fig. 2), and have rudimentary posterolateral spines rather than slight marginal swellings. The axial indentation of the cephalic border of larger Cow Head specimens is seen only in the largest cephala illustrated by Robison (1964, Pl. 82, fig. 1; 1982, Pl. 6, fig. 10), and is apparently size related in both cases.

Peronopsis interstricta is similar to *P. gaspensis* Rasetti (1948, Pl. 45, figs. 1-3) and to *P.* sp. cf. *P. gaspensis* Rasetti (1948, Pl. 45, figs. 4, 5), both from the lower St. Lawrence Valley. These taxa have approximately the same cephalic and pygidial proportions but have narrower cephalic borders, more distinct pygidial furrows F1 and F2, and distinct posterolateral pygidial spines.

Peronopsis fallax (Linnarsson, 1869)

Plate 1, figures 16-20

1886 *Agnostus vir* Matthew, p. 69, Pl. 7, fig. 3.

1886 *Agnostus vir* var. *concinnus* Matthew, p. 70, Pl. 7, fig. 4a-c.

1896 *Agnostus fallax* Linnarsson, Matthew, p. 214, Pl. 10, fig. 8.

1896 *Agnostus fallax vir* Matthew, p. 215, Pl. 15, fig. 6.

1896 *Agnostus fallax* var. *concinnus* Matthew, p. 216, Pl. 15, fig. 7a-c.

1906 *Agnostus fallax* Linnarsson, Lake, p. 20, Pl. 2, fig. 12.

1946 *Peronopsis fallax* (Linnarsson), Westergård, p. 37, Pl. 2, figs. 18-24.

1948 *Peronopsis* sp. undet. no. 1, Rasetti, p. 320, Pl. 45, figs. 8-11.

1954 *Peronopsis bidens* (Meek), Palmer, p. 62.

1967 *Peronopsis* species no. 1, Rasetti, p. 31, Pl. 10, figs. 9-12.

1972 *Peronopsis* sp. cf. *P. fallax* (Linnarsson), Palmer and Gatehouse, p. 10, Pl. 4, figs. 6, 7.

1979 *Peronopsis tramitis* Öpik, p. 58-60, Pl. 2, figs. 1-3.

1982 *Peronopsis fallax* (Linnarsson), Robison, p. 152-156, Pl. 6, figs. 5-8 (includes extensive synonymy).

Diagnosis. A species of *Peronopsis* with a semiovate cephalon. Glabella narrow, moderately long, very slightly tapered anteriorly. Median node weak. F3 very short, shallow, slightly backcurved adaxially, does not reach axial

furrow laterally. Axial furrow shallow, moderately narrow. Preglabellar median furrow occurs as a trace in front of glabella in some specimens. Cephalic border furrow very wide, moderately shallow. Pygidium subrectangular in outline. Axis moderately wide, about two fifths pygidial width. Median tubercle large. Border furrow very wide; border narrow, flattened. Posterolateral spines moderately short, narrow. Cephalon and pygidium smooth.

Occurrences. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland; *Hypagnostus parvifrons* Zone of Sweden; *Ptychagnostus gibbus* and *Ptychagnostus atavus* zones of Nevada and Utah; also occurs in Norway, England, Spain, Poland, Siberia, Australia, Antarctica, New Brunswick, Quebec, New York, Montana, and Greenland (Robison, 1982).

Material. 27 cephala, 29 pygidia (Table 2).

Discussion. Robison (1982, p. 152-156) redefined *Peronopsis fallax* (Linnarsson) and presented a thorough discussion of this species. He noted that a number of characters vary considerably with ontogeny, stratigraphic and geographic position, and mode of preservation.

Family PTYCHAGNOSTIDAE Kobayashi

Genus *Ptychagnostus* Jaeckel, 1909

Type species. *Agnostus punctuosus* Angelin (1851) from Sweden (subsequent designation by Vogdes, 1925).

Discussion. See Robison (1982, p. 135-136; 1984) for a diagnosis and discussion of *Ptychagnostus*.

Ptychagnostus gibbus (Linnarsson, 1869)

Plate 2, figures 13-16

1946 *Ptychagnostus* (*Triplagnostus*) *gibbus* (Linnarsson), Westergård, p. 70-71, Pl. 9, figs. 17-24.

1959 *Triplagnostus gibbus* (Linnarsson), Howell in Harrington et al., Fig. 117.3A, B.

1967 *Ptychagnostus gibbus* (Linnarsson), Rasetti, p. 28, Pl. 10, figs. 1-8.

1979 *Triplagnostus gibbus* (Linnarsson), Öpik, p. 117-120, Pl. 23, figs. 1-5, Pl. 24, figs. 1-5, Pl. 25, figs. 1-3, Pl. 27, fig. 2.

1979 *Triplagnostus quasigibbus* Öpik, p. 120-121, Pl. 27, fig. 1.

1982 *Ptychagnostus gibbus* (Linnarsson), Robison, p. 139-143, Pl. 2, figs. 1-13 (includes extensive synonymy).

1982 *Ptychagnostus gibbus* (Linnarsson), Rowell, Robison, and Strickland, p. 161-182.

1982 *Ptychagnostus* sp. cf. *P. gibbus* (Linnarsson), Kindle, Pl. 1.1, figs. 13, 18.

1984 *Ptychagnostus gibbus* (Linnarsson), Robison, Fig. 13.

Occurrences. *Zacanthoides gilberti* Fauna and Zone 2, Cow Head Group, western Newfoundland; *Ptychagnostus gibbus* and *Ptychagnostus atavus* zones of Utah, Nevada, New York, Greenland, Sweden, Norway, Poland, Soviet Union, Australia, and Antarctica.

Material. 3 cephala (Table 2).

Discussion. The features of these two specimens agree with Robison's (1982, p. 141) diagnosis of *Ptychagnostus gibbus* (Linnarsson). This species has been thoroughly discussed by Robison (1982, p. 141-143; 1984) and by Rowell, Robison, and Strickland (1982, p. 162-170). Kindle (1982, Pl. 1.1, fig. 18) illustrated a pygidium of *P. gibbus* from the "4 foot conglomerate" (Zone 2) of the Cow Head Group.

Ptychagnostus sp. cf. *P. intermedius* (Tullberg, 1880)

Plate 2, figures 17, 18

1946 *Ptychagnostus* (*Ptychagnostus*) *atavus* (Tullberg), Westergård, Pl. 11, figs. 19-23 (not figs. 8-18, 24, 25).

non 1979 *Ptychagnostus intermedius* (Tullberg), Öpik, p. 95, Pl. 41, fig. 8.

1982 *Ptychagnostus intermedius* (Tullberg), Robison, p. 143-145, Pl. 3, figs. 1-9.

1984 *Ptychagnostus intermedius* (Tullberg), Robison, fig. 15.

Occurrences. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland; *Ptychagnostus gibbus* Zone, Nevada, Utah, British Columbia, Sweden, Norway, China, and Greenland.

Material. 1 cephalon (Table 2).

Discussion. This specimen is referred to *Ptychagnostus intermedius* (Tullberg) on the basis of its tapered cephalic axis, narrow F2, elongate and weakly divided basal lobes, its median node situated near the posteroglabellar midpoint, and moderately scrobiculate cheeks with crescentic scrobicules near the anterior end of the glabella. Robison (1982, p. 137) notes that several pygidial features of the similar *P. atavus* (Tullberg) are different from those of *P. intermedius*, but the cephala are distinguished only by the position of the median node. No pygidium of either species was found in these Cow Head collections, so a definite assignation of its cephalon cannot be made.

Genus *Onymagnostus* Öpik, 1979

Type species. *Onymagnostus angulatus* Öpik, 1979 from Australia (by original designation).

Onymagnostus seminula (Whitehouse, 1939)

Plate 2, figures 3-10

non 1979 *Ptychagnostus seminula* (Whitehouse), Öpik, p. 112, Pl. 52, figs. 3-5; Pl. 53, fig. 1.

1982 *Ptychagnostus seminula* (Whitehouse), Robison, p. 148-150, Pl. 4, figs. 1-6 (includes extensive synonymy).

1984 *Onymagnostus seminula* (Whitehouse), Robison, fig. 32.

Diagnosis. A species of *Onymagnostus* with a moderately to strongly convex cephalon. Axis long, narrow. Basal lobes entire, elongate. F2 very narrow and shallow. F3 short, shallow. Anteroglabella rounded anteriorly. Pygidium highly convex. Axis elongate, moderately narrow, strongly arched. F1 short, complete, deflected forward. F2 very shallow, deflected backward around large, strongly raised median tubercle. Posteroaxis ogival. Margin commonly has posterolateral swellings. Cephalon and pygidium smooth.

Occurrences. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland; *Ptychagnostus gibbus* Zone, Nevada and Utah; Australia and Greenland; possible occurrences in Scandinavia.

Material. 18 cephala, 20 pygidia (Table 2).

Description. Cephalon highly convex, semiovate in outline, width slightly greater than length. Glabella narrow, less than one third cephalic width; long, about five sixths of length of cephalon; strongly inflated posteriorly. Axial furrow narrow, very shallow anteriorly. Basal lobes elongate, entire, triangular; confluent adaxially. Basal furrow shallow. Posteroglabella two thirds of glabellar length, slightly expanded medially. Median node very weak, situated anterior of midpoint of posteroglabella. F2 very narrow and shallow. F3 short, shallow, transverse or slightly backcurved medially. Anteroglabella flattened, rounded anteriorly. Preglabellar median furrow moderately narrow and shallow. Cephalic border furrow moderately deep and narrow. Border narrow. Cephalon smooth.

Pygidium semiovate in outline, width slightly greater than length, about two fifths of pygidial width, strongly arched; connected to border furrow by a short, shallow postaxial median furrow in smaller specimens. F1 short, moderately shallow, complete, deflected forward adaxially. F2 very short and shallow, strongly deflected backward around median tubercle. Median tubercle large, strongly raised, elongate. Secondary median node absent. Posteroaxis ogival in shape. Axial furrow moderately narrow and shallow. Border furrow moderately wide and deep. Border moderately narrow. Slight posterolateral marginal swellings are present in larger pygidia. Pygidium smooth.

Discussion. This species is assigned to *Onymagnostus* Öpik on the basis of its convex exoskeleton, narrow and elongate pygidial axis, elongate pygidial median tubercle, and the absence of pygidial marginal spines and effacement of the postaxial median furrow (see Robison, 1984).

Robison (1982, p. 148-150) gave an extensive diagnosis and discussion of *Ptychagnostus seminula* (Whitehouse). *Onymagnostus seminula* is distinguished from *O. hybridus* (Brögger) illustrated by Westergård (1946, Pl. 9, figs. 25, 26, Pl. 10, fig. 2; not Pl. 10, fig. 1) from Sweden and by Robison (1964, Pl. 79, figs. 10, 11, 13, 14) from the *Bolaspidella* Zone of Utah by its longer glabella with a more rounded anteroglabella and less expanded posteroglabella, and longer basal lobes.

Family DIPLAGNOSTIDAE Whitehouse

Genus *Tomagnostus* Howell, 1935

Type species. *Agnostus fissus* Lundgren in Linnarsson, 1879 from the Exsulans Limestone of Sweden (by original designation).

Tomagnostus? sp.

Plate 1, figures 13-15; Plate 2, figures 11, 12

Occurrence. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland.

Material. 3 cephala, 15 pygidia (Table 2).

Discussion. These cephala and cranidia are provisionally associated with each other and they are attributed only tentatively to *Tomagnostus* because the cephalon lacks the cleft anteroglabella that is characteristic of the genus. The pygidium, which bears a long, narrow lanceolate axis that is crossed by a backwardly curved F3, is reminiscent of species such as *Tomagnostus perrugatus* (Gronwall) and *T. gracilis* (Illing) (see Rushton, 1979, Fig. 6C-G).

Suborder EODISCINA Kobayashi

Family EODISCIDAE Raymond

Genus *Pagetia* Walcott, 1916

Type species. *Pagetia bootes* (Walcott, 1916) from the Stephen Formation, British Columbia (by original designation).

Discussion. See Jell (1975, p. 30-34) for an exhaustive diagnosis of *Pagetia.*

Pagetia rasettii n. sp.

Plate 2, figures 19-30; Figure 4B

Diagnosis. A species of *Pagetia* with a semiovate cranidium. Glabella long, highly convex, gently tapered anteriorly. Preglabellar field short, very shallow. Anterior border furrow very long, shallow, strongly curved. Anterior border moderately long, bears 16 to 19 scrobicules. Palpebral lobe very long, narrow, moderately curved. Pygidium strongly convex, semiovate in outline. Axis broad, strongly arched; composed of four or five rings and a terminal piece. Each axial ring bears a large, raised tubercle. Interpleural furrows very short and shallow. Pleural furrows moderately long, shallow. Cranidial and pygidial prosopon coarsely granulate.

Holotype. A pygidium (GSC 77331) from boulder 380, illustrated in Plate 2, figures 28-30.

Etymology. For Franco Rasetti, whose work contributed greatly to the understanding of the North American species of *Pagetia.*

Occurrence. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland.

Material. 120 cranidia, 80 pygidia (Table 2).

Description. Cranidium semiovate in outline; width across palpebral lobes slightly greater than length. Glabella long, narrow, highly convex, slightly constricted medially, gently tapered anteriorly. Axial furrow shallow, wide, narrowing slightly anteriorly. Transglabellar furrow absent. Occipital furrow deep laterally, absent or very shallow medially. Occipital ring short, narrow; extended into a short, broad, tapered spine. Bacculae distinct, flattened. Preglabellar

field short, very shallow. Anterior border furrow long, shallow, strongly curved. Anterior border moderately long, flattened, not raised above border furrow; bears 16 to 19 narrow, variably impressed scrobicules that extend to border furrow but do not quite reach anterior margin. Epiborder furrow absent. Palpebral lobe very long, narrow, moderately curved. Palpebral furrow wide, shallow. Palpebral area moderately wide, sloping downward slightly from palpebral lobe to axial furrow. Posterior fixed cheek narrow, short. Posterior border furrow moderately short and deep. Anterior branches of facial suture straight, strongly divergent. Posterior branches of suture slightly divergent. Cranidial prosopon coarsely granulate, granules of variable strength.

Pygidium strongly convex, semiovate in outline, wider than long. Axis broad, about one third pygidial width; strongly arched, tapered, extending to pygidial border posteriorly; composed of four or five rings and a terminal piece. Each axial ring bears a large, raised tubercle; terminal piece has a short spine. Axial ring furrows deep, moderately long. Axial furrows shallow and wide. Pleurae strongly arched. Interpleural furrows very short and shallow, slightly curved. Pleural furrows moderately long, shallow. Border moderately wide, concave. Pygidial prosopon coarsely granulate.

Discussion. *Pagetia rasettii* n. sp. belongs to a small group of species composed of *P. clytioides* Rasetti, *P. fossula* Resser, *P. leptoskolos* Jell, *P. pollosta* Jell, and *P. resseri* Kobayashi, which is distinguished by the long glabella, anterior cranidial border of moderate length, long palpebral lobes, broad pygidial axis, and distinct pygidial pleural furrows.

Pagetia rasettii is very similar to *P. clytioides* Rasetti (1967, Pl. 13, figs. 8-16) from New York State, and to *P. leptoskolos* Jell (1975, Pl. 8, figs. 1-7, Textfig. 15a) and *P. pollosta* Jell (1975, Pl. 24, figs. 3, 5-14, Textfig. 15c), both from Australia. These three species are almost identical and may be conspecific. They differ from *P. rasettii* by having longer anterior borders with a greater number of scrobicules, pygidial axes with three rather than four or five rings and weaker pygidial pleural furrows.

Pagetia fossula Resser illustrated by Rasetti (1966, Pl. 59, figs. 29-34) from Idaho has a pygidium very similar to that of *P. rasettii* but differs in possessing a smooth cranidium with a shorter palpebral lobe and a strongly inflated palpebral area. *Pagetia rasettii* is distinguished from *P. resseri* Kobayashi illustrated by Rasetti (1966, Pl. 60, figs. 19-25) from Idaho by its less tapered glabella, longer, more strongly curved palpebral lobe, much shallower pygidial pleural and interpleural furrows, and granulate prosopon.

Pagetia skraelingi n. sp.

Plate 2, figures 31-33; Plate 3, figures 1-5

1982 *Pagetia* sp. Kindle, Pl. 1.1, figs. 16, 17.

Diagnosis. A species of *Pagetia* with a broad, semiovate cranidium. Glabella wide, rounded anteriorly. Occipital spine very long and broad, bearing a small median occipital tubercle. Preglabellar field very short. Anterior border furrow very long and shallow. Anterior border long, bearing about 18 weak scrobicules. Palpebral lobe elongate. Pygidium strongly convex, semiovate in outline. Axis moderately wide, slightly tapered, composed of four rings and a terminal piece; variably effaced. Interpleural and pleural furrows absent. Cranidium and pygidium smooth.

Holotype. A cranidium (GSC 69509) from boulder 372, illustrated by Kindle (1982, Pl. 1.1, fig. 16) and here (Pl. 3, figs. 1, 2).

Etymology. From *Skraelings*, the name the Norse gave to the Dorset Eskimos who occupied the west coast of Newfoundland during the first millenium A.D.

Occurrence. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland.

Material. 46 cranidia, 21 pygidia (Table 2).

Discussion. The variation in effacement of the pygidial axis of *Pagetia skraelingi* n. sp. could be considered sufficient to divide it into two distinct species if only the most extreme samples (Pl. 2, fig. 32, Pl. 3, fig. 5) were known. Because the other specimens show continuous variation between these end points, and because other features, such as the ratio of the widths of the axis and pleurae and the tapering of the axis exhibit no such change, it is likely that this variation is intraspecific. *Pagetia billingsi* Rasetti (1948, Pl. 46, figs. 5-7; 1966, Pl. 59, figs. 14-21) from the lower St. Lawrence Valley of Quebec is distinguished from *P. skraelingi* by its longer preglabellar field, more tapered glabella, rounded anterior cranidial border, and smaller occipital spine, and exhibits a similar variation in effacement of the pygidial axis, though to a lesser degree.

Other similar species include *P. ellsi* Rasetti (1948, Pl. 46, fig. 1; 1966, Pl. 59, figs. 1-4) and *P. quebecensis* Rasetti (1948, Pl. 46, figs. 1-3; 1966, Pl. 59, figs. 5-10) both from the lower St. Lawrence Valley, and *P. stenoloma* Palmer (1968, Pl. 4, figs. 6, 7) from east-central Alaska. *Pagetia ellsi* and *P. quebecensis* differ from *P. skraelingi* by having very long anterior cranidial borders, broader and more strongly tapered glabellas, and narrower pygidial axes. *Pagetia stenoloma* has distinct eye ridges, a rounded pygidial anterior cranidial border, and a more strongly tapered pygidial axis.

Order CORYNEXOCHIDA Kobayashi, 1935

Family DOLICHOMETOPIDAE Walcott, 1916

Genus *Bathyuriscus* Meek, 1873

Type species. *Bathyurus* (?) *haydeni* Meek, 1873 from Montana (by original designation).

Diagnosis. A genus of Dolichometopidae with subtrapezoidal cranidium. Glabella parallel-sided or anteriorly expanding. 1s, 2s, and 4s furrows shallow and narrow. 3s furrow shallow or absent. Palpebral lobe crescentic, about one third to one half cranidial length. Posterior fixed cheek wide and short. Pygidium large, subovate or semicircular in outline. Pleural furrows long, interpleural furrows short but distinct. Pygidial border narrow. Prosopon finely granulate.

Discussion. Meek (1873) proposed the genus *Bathyuriscus* in case it should be found later that *Bathyurus* (?) *haydeni* was not congeneric with *Bathyurus extans* (Hall), but he did not clearly establish it as a new genus. Walcott (1886) assigned *B. haydeni* and two other species to *Bathyuriscus*. He discussed and redefined the genus in 1916 (p. 330-334), and assigned twenty-two species belonging to two subgenera. The subgenus *Bathyuriscus* (*Poliella*) Walcott (1916, p. 349) is characterized by a small ovate pygidium of few segments with effaced pleurae. It has since been elevated to the generic level.

Robison (1964) included nine species in the genus: *B. adaeus* Walcott, *B. atossa* Walcott, *B. brighamensis* Resser, *B. elegans* (Walcott), *B. fimbriatus* Robison, *B. gaspensis* (Rasetti), *B. haydeni* (Meek), *B. politus* Resser, and *B. rotundatus* Rominger. *Bathyuriscus eboracensis* Rasetti (1967, Pl. 11, figs. 1-14), *B. punctatus* Palmer (1968, Pl. 6, figs. 3, 4), *B. petalus* Fritz (1968, Pl. 43, figs. 27-30), *B. terranovensis* n. sp., *B. boscaputensis* n. sp., and *B. richardsoni* n. sp. can now be added to this list.

Among the species included in *Bathyuriscus* by Robison are several previously referred to the genera *Orria* Walcott (1916) and *Orriella* Rasetti (1948). Both of these were distinguished from *Bathyuriscus* principally on the basis of their large pygidia, but they fit readily into the present definition of the genus, and both should be considered junior synonyms.

Bathyuriscus terranovensis n. sp.

Plate 3, figures 6-12; Figure 5A

Diagnosis. A species of *Bathyuriscus* with an elongate occipital ring possessing a median tubercle. Posterior fixed cheek broad. Pygidium subovate with width about one and a half times the length. Axis moderately arched with six axial rings and a terminal piece. Each pleura consists of a long pleural furrow bounded by raised ridges anteriorly and posteriorly; interpleural furrows short but distinct.

Holotype. A cranidium (GSC 77340) from boulder 357, illustrated in Pl. 3, figs. 8-9.

Etymology. From the latin, *Terra Nova* (Newfoundland).

Occurrences. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland.

Material. 15 cranidia, 1 free cheek, 9 pygidia (Table 2).

Description. Cranidium subtrapezoidal in outline; width across posterior portion of palpebral lobes slightly greater than length. Clavate and moderately vaulted glabella expanding anteriorly to maximum width across anterior lobe. Moderately deep axial furrows diverge forward. 1s furrow moderately long and deep, directed obliquely backward; 2s narrower and shallower. 3s and 4s narrow and very shallow. Occipital furrow very shallow and transverse. Occipital ring elongate, extending posteriorly in a broad curve. Median occipital tubercle is small but distinct. Anterior border very short, curved; expanding laterally. Palpebral lobe crescentic, elongate, about half the length of cranidium; outside curvature increases markedly posteriorly. Palpebral furrow broad and shallow. Palpebral area inflated, standing markedly above palpebral lobe in lateral view. Posterior fixed cheek moderately wide and short. Posterior border furrow deep, broadening abaxially. Anterior branches of facial suture divergent, convex. Posterior branches of suture strongly divergent, sinuous. Cranidial prosopon of very fine granules.

Free cheek flattened, has slightly raised border broadening posteriorly. Border furrow shallow and broad.

Pygidium subovate in outline, wider than long. Axis moderately arched, tapering only slightly posteriorly, extending to pygidial border. Axis composed of six rings and blunt terminal piece. Axial ring furrows moderately long and deep. Axial furrows shallow, fading out just ahead of pygidial border. Pleural furrows very long, moderately shallow, backcurved abaxially, covering most of each pleura; bounded by narrow ridges anteriorly and posteriorly. Interpleural furrows short but distinct. Border narrow; moderately broad in smaller specimens. Pygidial prosopon of very fine, sparse granules.

Discussion. *Bathyuriscus terranovensis* is most similar to *B. haydeni* (Meek) illustrated by Walcott (1916, Pl. 46, figs. 2, 2a-b). It differs by having a more elongate occipital ring, narrower lateral glabellar furrows, and more pygidial axial rings. *Bathyuriscus terranovensis* is also similar to *B. punctatus* Palmer (1968, Pl. 6, figs. 3-4) from the *Bolaspidella* Zone of east-central Alaska and *B. rotundatus* (Rominger) illustrated by Walcott (1916, Pl. 47, figs. 2, 2a-b) from the *Bathyuriscus-Elrathina* Zone of the Stephen Formation, British Columbia. *Bathyuriscus terranovensis* has a glabella and occipital ring very similar to those of *B. punctatus*, but has a distinct median occipital tubercle, more pygidial axial furrows, and a granulate rather than pitted prosopon. It differs from *B. rotundatus* in having an occipital tubercle, a more elongate occipital ring, much narrower anterior fixed cheek, and much longer (exsag.), more outcurved palpebral lobes.

Bathyuriscus boscaputensis n. sp.

Plate 3, figures 13-18; Plate 4, figures 1, 2
Figure 5C

?1948 *Bathyuriscus* sp. undet. Rasetti, p. 322, Pl. 48, fig. 24.

1982 *Bathyuriscus* sp. Kindle, Pl. 1.1, fig. 21.

Diagnosis. A species of *Bathyuriscus* with an elongate occipital ring bearing a short thorn-like spine. Median occipital tubercle small, located on anterior half of spine. Posterior fixed cheek short and very wide. Palpebral lobe elongate, broad, deflected slightly outward with curvature increasing posteriorly. Pygidium subovate, wider than long. Axis moderately arched, consisting of four rings and a terminal piece. Postaxial ridge extending back from terminal piece to pygidial border. Each pleura consists of long pleural border bounded by raised ridges.

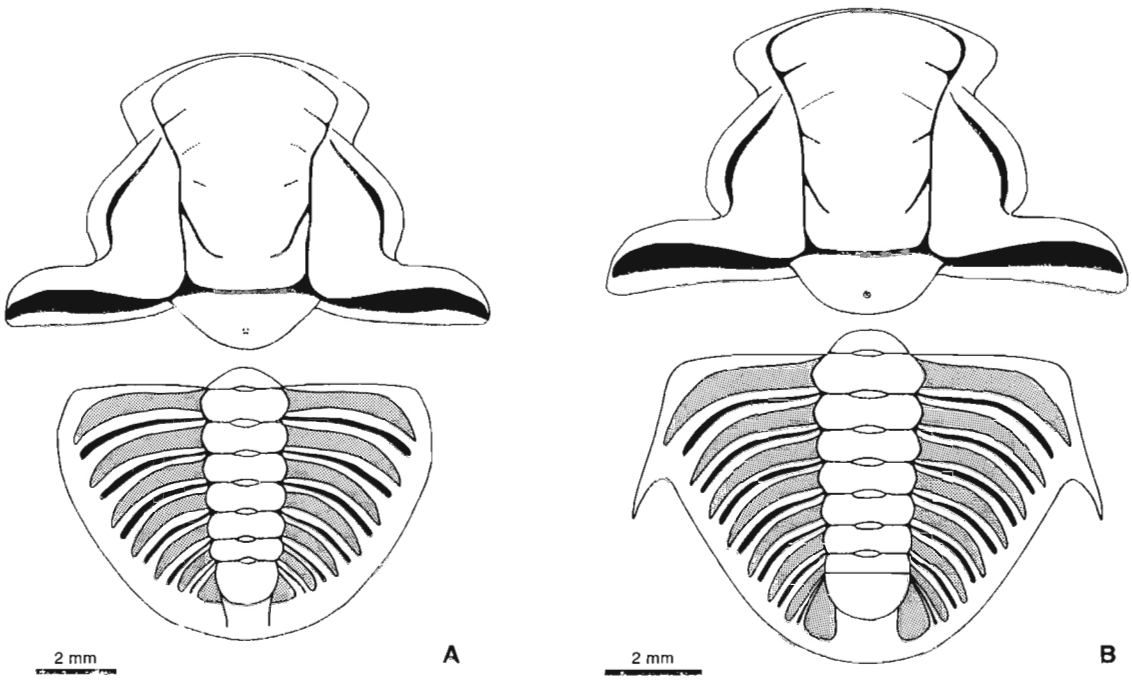
Holotype. A cranidium (GSC 77344) from boulder 378, illustrated in Plate 3, figures 15-17.

Etymology. From the latin *bos* (cow) and *caput* (head); a species of *Bathyuriscus* from the Cow Head Group.

Occurrence. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland.

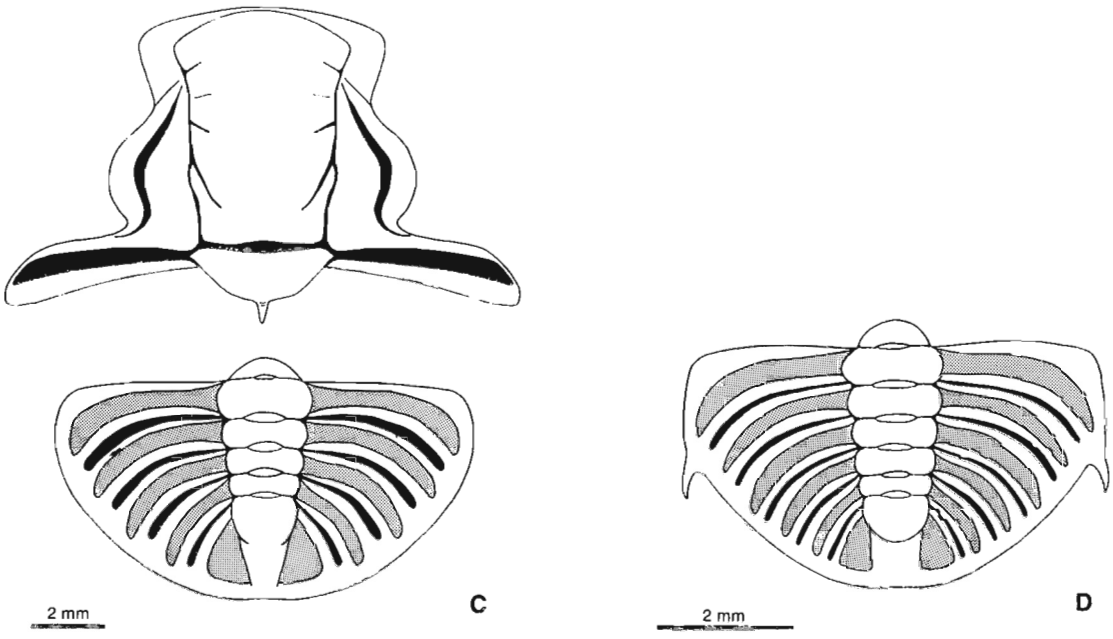
Material. 13 cranidia, 20 pygidia (Table 2).

Discussion. The presence of an occipital spine and absence of anterolateral pygidial spines distinguish *Bathyuriscus boscaputensis* n. sp. from most other species of *Bathyuriscus*. *Bathyuriscus gaspensis* (Rasetti, 1948, Pl. 48, figs. 18-23) from the lower St. Lawrence Valley is most similar to *B. boscaputensis* but possesses a much larger occipital spine, a conspicuous 3s furrow, and a more elongate pygidium with a pygidial axis that terminates in front of the pygidial border. *Bathyuriscus boscaputensis* is distinguished from *B. brighamensis* Resser illustrated by Gunther and Gunther (1981, Pl. 9) from Utah by its very weak or absent 3s furrow, more pronounced occipital spine, broader posterior fixed cheek, more elongate palpebral lobe, and more transverse pygidium. *Bathyuriscus elegans* (Walcott, 1916, Pl. 66,



Bathyuriscus terranovensis n. sp.

Bathyuriscus richardsoni n. sp.



Bathyuriscus boscaputensis n. sp.

Bathyuriscus sp. cf. *B. boscaputensis*

Figure 5. *Reconstructions of species of* ***Bathyuriscus.***

figs. 2-2b) and *B. fimbriatus* Robison (1964, Pl. 83, figs. 6-11, 15), both from the *Bolaspidella* Zone of Utah, differ from *B. boscaputensis* by having transverse occipital rings and much more elongate pygidia with seven and six axial rings, respectively.

Bathyuriscus sp. cf. *B. boscaputensis* n. sp.

Plate 4, figures 3, 4; Figure 5D

Occurrence. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland.

Material. 5 pygidia (Table 2).

Discussion. The important diagnostic features of these pygidia are the anterolateral spines, the four or five axial rings, and the lack of granulate prosopon. All of these features, except the anterolateral spines, are very similar to those of *Bathyuriscus boscaputensis* n. sp., with which *B.* sp. cf. *B. boscaputensis* n. sp. is associated in boulder 378. The spine may be a dimorphic character, a feature not sufficient to distinguish this species from *B. boscaputensis.*

Bathyuriscus richardsoni n. sp.

Plate 4, figures 5-12; Figure 5B

1982 *Bathyuriscus adaeus* Walcott, Kindle, Pl. 1.1, fig. 5.

Diagnosis. A species of *Bathyuriscus* with a shallow, but distinct 3s furrow; other lateral glabellar furrows are short and moderately deep. Occipital ring elongate, with median tubercle. Palpebral lobe crescentic, flattened, deflected moderately outward. Pygidium subovate; width about one and a third times the length. Axis moderately to strongly arched with six or seven axial rings and a terminal piece; extending to pygidial border. Pleural furrows moderately long, bounded by raised ridges. Anterolateral pygidial spine moderately short, thorn-like. Pygidial border very narrow.

Holotype. A cranidium (GSC 77351) from boulder 363, illustrated in Plate 4, figures 6-8.

Etymology. For James Richardson, who was the first to study the boulder beds of the Cow Head Group.

Occurrences. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland.

Material. 15 cranidia, 31 pygidia (Table 2).

Discussion. *Bathyuriscus richardsoni* n. sp. is most similar to *B. adaeus* Walcott (1916, Pl. 47, figs. 3, 3a-c) from the *Bathyuriscus-Elrathina* Zone of the Stephen Formation, British Columbia. *Bathyuriscus adaeus* lacks a distinct 3s furrow, has posteriorly deflected 2s and 4s furrows, an elongate anterior cranidial border, and short, narrow palpebral lobes. *Bathyuriscus richardsoni* differs from *B. atossa* Walcott (1916, Pl. 47, figs. 2, 2a-b) from Idaho by having stronger lateral glabellar furrows, a shorter cranidial anterior border, more pygidial axial rings, and longer anterolateral pygidial spines. It is distinguished from most other species of *Bathyuriscus*, including *B. rotundatus* (Rominger) illustrated by Walcott (1916, Pl. 47, figs. 2, 2a-b), and *B. terranovensis* n. sp., but its strong anterolateral pygidial spines, very narrow pygidial border, very short anterior cranidial border, and very wide 3s furrow.

Genus *Bathyuriscidella* Rasetti, 1948

Type species. *Bathyuriscidella socialis* Rasetti (1948), from the lower St. Lawrence Valley (by original designation).

Bathyuriscidella sp.

Plate 4, figure 13

Occurrence. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland.

Material. 2 cranidia (Table 2).

Discussion. These cranidia are referred to *Bathyuriscidella* rather than to *Bathyuriscus* Meek on the basis of the narrow, anteriorly expanded glabella, which reaches the anterior cranidial margin, and the broad occipital ring, narrow palpebral lobes, wide anterior fixed cheeks, and elongate posterior fixed cheeks. A pygidium is not known.

This species is most similar to *Bathyuriscidella expansa* Rasetti (1948, Pl. 48, figs. 10-16) from the lower St. Lawrence Valley, which has a more strongly expanded glabella with a distinct 3s furrow, and a shorter, wider palpebral lobe.

Family DORYPYGIDAE Kobayashi, 1935

Genus *Kootenia* Walcott, 1889

Type species. *Bathyuriscus (Kootenia) dawsoni* Walcott (1889) from the Stephen Formation, British Columbia (by original designation).

Diagnosis. A genus of Dorypygidae with broad, parallel-sided or anteriorly expanded glabella. Lateral glabellar furrows very shallow or absent. Palpebral lobe short, posterior fixed cheek narrow. Pygidium large, semiovate to semicircular in outline. Axis of three to five rings and a terminal piece. Pleural furrows long and deep. Interpleural furrows very shallow or absent. Border bears five to seven pairs of marginal spines.

Discussion. Generic diagnoses for *Kootenia* have been presented by Palmer (1968, p. 47) and Fritz (1972, p. 35). *Kootenia* is distinguished from other members of the Dorpygidae by its pygidium with marginal spines and very shallow or absent interpleural furrows. *Bonnia* Walcott (1916) is very similar to *Kootenia*, having virtually identical cranidial features and a semicircular pygidium with up to three pairs of marginal spines, and it may be congeneric.

The emphasis placed by some workers on the length of the pygidial marginal spines as a species-level diagnostic feature should be questioned. Palmer (1968, p. 48) suggested that the development of these spines may be susceptible to minor ecological variation. The variability seen in specimens of *K. elongata* (Pl. 5, figs. 4, 8) supports this suggestion.

Kootenia elongata Rasetti, 1948

Plate 4, figures 14, 15; Plate 5, figures 1-8; Figure 6A

1948 *Kootenia elongata* Rasetti, p. 332, Pl. 49, figs. 1-6.

1982 *Kootenia* sp. Kindle, Pl. 1.1, fig. 15.

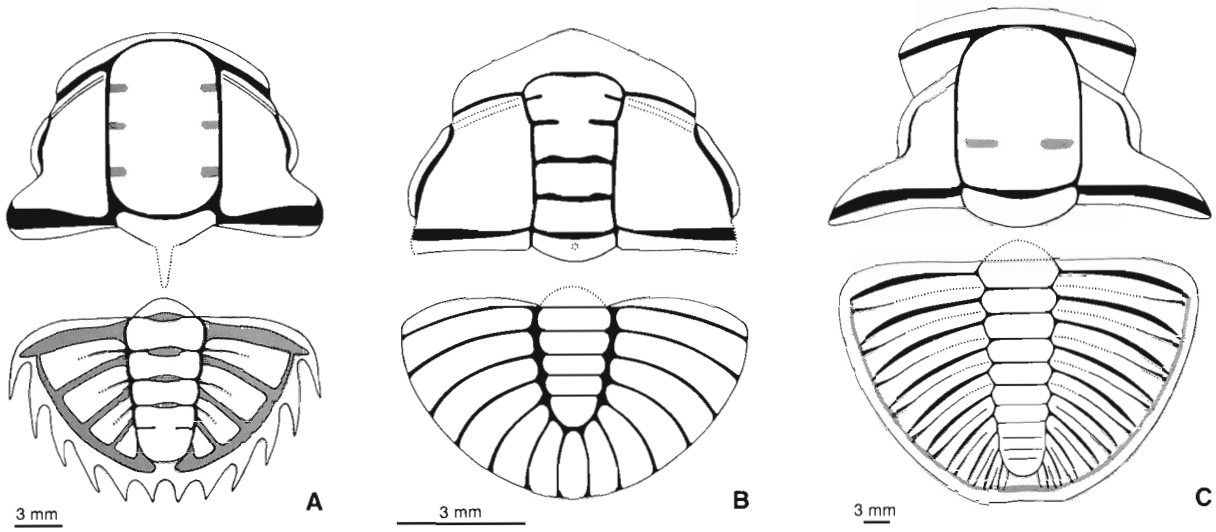


Figure 6. *Reconstructions of species of* ***Kootenia***, ***Tonkinella***, *and* ***Ogygopsis.***

Diagnosis. A species of *Kootenia* with parallel-sided glabella. Occipital spine moderately short. Fixed cheek wide. Palpebral lobe short, deflected slightly outward posteriorly. Cranidial prosopon very finely granulate; very fine terrace ridges on anterior border. Pygidium subsemicircular, width twice length. Axis moderately arched, with three or four rings and blunt terminal piece. Pygidial border flattened, with six short, backcurved spines. Pygidium smooth.

Occurrences. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland; lower St. Lawrence Valley, Quebec.

Material. 15 cranidia, 17 pygidia (Table 2).

Description. Cranidium subtrapezoidal in outline; width across palpebral lobes slightly more than length. Glabella rectangular, strongly vaulted and arched, parallel-sided or slightly expanded forward. Axial furrows well incised. Lateral glabellar furrows absent. Occipital furrow deep, slightly convex backward. Occipital ring semielliptical in outline, standing somewhat below highest part of glabella; extending posteriorly into a moderately thick spine. Anterior border moderately short in front of glabella, lengthening slightly abaxially. Preglabellar furrow short, moderately posteriorly shallow; continuing laterally into moderately long, shallow, posteriorly deflected anterior border furrow. Anterior fixed cheek moderately broad. Eye ridge conspicuous. Palpebral lobe short, narrow, crescentic, one quarter of cranidial length; deflected very slightly outward posteriorly with outside curvature remaining constant. Palpebral furrow shallow, very wide. Palpebral area strongly inflated, standing well above palpebral lobe in anterior view. Posterior fixed cheek narrow, elongate. Posterior border furrow deep, extending outward from posterior edge of occipital ring; deflected slightly forward, becoming much longer and shallower abaxially.

Anterior branches of facial suture convergent, convex. Posterior branches of suture divergent, convex. Cranidial prosopon very finely granulate. Fine terrace ridges on anterior border are modified on anterior part of fixed cheek and glabella into scale-like granules, and into round granules posteriorly.

Pygidium subsemicircular in outline; width slightly less than twice length. Axis moderately arched, more strongly arched in smaller pygidia; one third to one quarter the width of pygidium; composed of three to four convex rings and a semiovate terminal piece, extending almost to pygidial border posteriorly. Axial ring forrows moderately shallow. Axial furrows very wide, shallow. Pleurae moderately arched and inflated (tr.). Anterior edge of pleura forms a short raised ridge. First pleural furrow very long, deep. Other pleural furrows long, shallow, straight, deflected posteriorly. Interpleural furrows deflected slightly posteriorly; short and very weak or absent. Pygidial border flattened, moderately narrow. Six moderately long, backcurved spines extend outward, one from each pleura. Pygidium smooth.

Discussion. The specimens described here differ slightly from the type material of *Kootenia elongata* Rasetti in having somewhat shorter pygidial spines, and obliquely rather than exsagitally oriented palpebral lobes, which are located slightly farther out and slightly farther forward on the cheeks. These features are probably not significant for a distinction at the species level to be made.

Kootenia burgessensis Resser illustrated by Rasetti (1951, Pl. 28, figs. 9-11) from the *Bathyuriscus-Elrathina* Zone of the Stephen Formation, British Columbia is most similar to *K. elongata.* It differs by having a more inflated glabella, larger palpebral lobes, and a more elongate pygidium with broad, short border spines. Other similar species include *K.* sp. cf. *K. serrata* (Meek) and *Kootenia* sp. 1 (Palmer, 1968, Pl. 4, figs. 14-21) both from east-central Alaska, *K. billingsi* Rasetti (1948, Pl. 49, figs. 15-19) from the lower St. Lawrence Valley, and *K. germana* (Resser) illustrated by Palmer and Halley (1979, Pl. 11, figs. 22-24, 27-30) from the *Albertella* Zone of the Carrara Formation, Nevada. *Kootenia* sp. 1, and *K.* sp. cf. *K. serrata* are known only from pygidia. The pygidium of *Kootenia* sp. 1 is triangular in outline and more elongate than that of *K.* sp. cf. *K. elongata*, while that of *K.* sp. cf. *K. serrata* has very short, broad border spines. *Kootenia elongata* has a similar cranidial prosopon to *K. billingsi* and *K. germana*, but possesses a narrower, less expanded glabella and much weaker eye ridges.

Genus *Olenoides* Meek, 1877

Type species. *Paradoxides* (?) *nevadensis* Meek (1870) from Nevada (by original designation).

Discussion. Diagnoses and discussions of *Olenoides* are given by Palmer (1954, p. 62-63) and Robison (1964, p. 537).

Olenoides foveolatus Rasetti, 1948

Plate 5, figures 9, 10

1948 *Olenoides foveolatus* Rasetti, p. 338-339, Pl. 51, figs. 10-14.

Occurrences. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland; lower St. Lawrence Valley, Quebec.

Material. 3 cranidia, 3 pygidia (Table 2).

Discussion. This material does not differ in any obvious way from that of *Olenoides foveolatus* illustrated by Rasetti. The parallel-sided glabella with deep lateral furrows serves to distinguish *O. foveolatus* from most other species of *Olenoides*. The most similar species is *O. brevispinosus* Rasetti (1948, p. 336-337, Pl. 52, figs. 12-15) from the lower St. Lawrence Valley, which possesses a narrower glabella, a longer and wider palpebral lobe, and a much heavier eye ridge. Other similar species include *O. nevadensis* (Meek) illustrated by Palmer (1954, Pl. 14, fig. 9), Robison (1971, Pl. 89, figs. 13-15), and Gunther and Gunther (1981, Pl. 36) and *O. wahsatchensis* (Hall and Whitfield) illustrated by Palmer (1954, Pl. 14, figs. 6, 8), both from Utah. These are distinguished from *O. foveolatus* by their shallow and short pygidial interpleural furrows, and very deep, short pleural furrows.

Family OGYGOPSIDAE Resser, 1951

Genus *Ogygopsis* Walcott, 1889

Type species. *Ogygia klotzi* Rominger (1887) from the Stephen Formation, British Columbia (by original designation).

Discussion. See Palmer (1964, p. 6-7) for a description and discussion of *Ogygopsis*.

Ogygopsis klotzi (Rominger, 1887)

Plate 5, figure 11; Plate 6, figures 1-4; Figure 6C

1916 *Ogygopsis klotzi* (Rominger), Walcott, p. 377, Pl. 66, figs. 1, 1a-b.

1951 *Ogygopsis klotzi* (Rominger), Rasetti, p. 191-192, Pl. 12, figs. 1-5, Pl. 21, figs. 1-3, Pl. 29, figs. 6-8.

1959 *Ogygopsis klotzi* (Rominger), Rasetti in Harrington et al., Fig. 160.

1971 *Ogygopsis klotzi* (Rominger), Campbell, p. 437-440.

1979 *Ogygopsis klotzi* (Rominger), Rudkin, Fig. 1a-h.

1984 *Ogygopsis klotzi* (Rominger), McNamara and Rudkin, p. 164-168, Figs. 9, 10.

Diagnosis. A species of *Ogygopsis* with a very broad and low glabella. 1s furrow shallow. Eye ridge very strong. Palpebral lobes short, slightly curved. Cranidial prosopon finely granulate; terrace ridges on anterior border, fine ridges on glabella, and genal caeca on fixed cheek. Free cheek with wide border. Pygidium semicircular, slightly wider than long. Axis of nine to ten rings and a terminal piece. Pleural furrows long and deep. Interpleural furrows shallow near pygidial border, very shallow or absent axially. Pygidial border narrow. Pygidium smooth or with very finely granulate prosopon.

Occurrences. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland; *Wenkchemnia-Stephenaspis* Zone to *Bathyuriscus-Elrathina* Zone, Mount Whyte and Stephen formations, British Columbia; southeastern Pennsylvania.

Material. 5 cranidia, 1 free cheek, 2 pygidia (Table 2).

Description. Cranidium subtrapezoidal in outline; width across palpebral lobes slightly greater than length. Glabella broad, parallel-sided or slightly expanded, rounded anteriorly; low and slightly arched. Axial furrows shallow, broad. 1s furrow very shallow, long, and transverse, or absent. 2s, 3s and 4s absent. Occipital furrow deep, short, slightly convex backward. Occipital ring short, semielliptical, standing slightly below highest part of glabella. Anterior border curved, elongate, flattened. Preglabellar furrow long, very shallow; continuing laterally into long, shallow anterior border furrow. Anterior fixed cheek broad. Eye ridge very strong, deflected posteriorly. Palpebral lobe moderately short, slightly curved, posteriorly raised. Palpebral furrow moderately deep. Palpebral area narrow, sloping slightly away from glabella. Posterior fixed cheek short, wide. Posterior border furrow deep, long. Anterior branch of facial suture convex, evenly curved. Posterior branch of suture deflected strongly outward from palpebral lobe, crossing posterior border at an acute angle. Anterior border possessing fine terrace ridges. Prosopon of glabella and occipital ring of fine granules and fine irregular ridges. Fixed cheek has fine granules and variably pronounced genal caeca.

Free cheek flattened with wide border. Border furrow is shallow and broad. Small terrace ridges are present on border. Genal caeca are well developed.

Pygidium semicircular in outline, width about one and a third times the length. Axis weakly arched, one fifth of pygidial width, evenly tapered, extending to pygidial border posteriorly. Axis of nine to ten rings and a blunt terminal piece. Axial ring furrows short, shallow. Axial furrows narrow, shallow. Pleural furrows long, deep, curved slightly posteriorly, extending to pygidial border furrow. Interpleural furrows shallow and short near pygidial border, becoming very shallow or absent adaxially. Pygidial border furrow shallow, wide. Pygidial border narrow. Pygidium smooth or with very finely granulate prosopon.

Discussion. The illustrations of *Ogygopsis klotzi* (Rominger) by Walcott (1916, Pl. 66, figs. 1, 1a-b) and Rasetti (1951, Pl. 12, figs. 1-5, Pl. 21, figs. 1-3, Pl. 29, figs. 6-8) show considerable variation in features such as glabellar width, strength of eye ridges, convexity of anterior border, and strength of interpleural furrows.

The only other species of *Ogygopsis* known from both cranidia and pygidia is *O. typicalis* (Resser) illustrated by Palmer and Halley (1979, Pl. 12, figs. 1-4) and by Gunther and Gunther (1981, Pl. 34) from the *Albertella* Zone of Nevada and Utah. This species is distinguished from *O. klotzi* by its elliptical glabella, broader and longer anterior border, and shorter, more transverse pygidium with very weak interpleural furrows.

Family ORYCTOCEPHALIDAE Beecher

Genus *Tonkinella* Mansuy, 1916

Type species. *Tonkinella flabelliformis* Mansuy, 1916 from southeast Asia (by original designation).

Diagnosis. A genus of Oryctocephalidae with glabella moderately narrow, evenly expanded anteriorly. 1s furrow transglabellar. 2s to 4s furrows transverse. Anterior border of variable length, rounded or triangular. Eye ridge weak. Palpebral lobe opposite midpoint of glabella. Pygidium large, subsemicircular. Axis narrow, tapered, of four to six rings and a terminal piece. Interpleural furrows deep, pleurae swollen, pleural furrows absent.

Discussion. *Tonkinella* has a wide distribution in eastern Asia and in North America. The type species was described in detail by Mansuy (1916), but a generic concept was not defined until 1935 when Kobayashi diagnosed *Tonkinella*. Chernysheva (1962, p. 27-33) assessed all thirteen species of *Tonkinella* and reviewed their distribution. The North American species have each been found at only a single locality: *T. appalachia* Resser in Alabama, *T. idahoensis* Resser in Idaho, *T. stephensis* Kobayashi in eastern British Columbia, and now *T. occidentalis* n. sp. in western Newfoundland.

Among the other oryctocephalid genera, only *Orcytocara* Walcott and *Sandoveria* Shergold, 1969 possess pygidia which, like that of *Tonkinella*, lack marginal spines. *Oryctocara* differs from both by possessing a parallel-sided glabella, very broad posterior fixed cheeks, and pygidial pleural furrows.

Tonkinella occidentalis n. sp.

Plate 6, figures 5-11; Figure 6B

1982 *Tonkinella* sp. 1, Kindle, Pl. 1.1, figs. 8, 12

Diagnosis. A species of *Tonkinella* with a very narrow, low glabella. 1s furrow is transglabellar. Anterior border long, flattened, triangular. Eye ridge weak. Palpebral lobe long and curved. Pygidium subsemicircular, wider than long. Axis of four rings and a terminal piece. Interpleural furrows short, deep. Pleural furrows absent. Cranidial and pygidial prosopon very finely granulate.

Holotype. A cranidium (GSC 69500) from boulder 380, illustrated by Kindle (1982, Pl. 1.1, fig. 8) and here (Pl. 6, figs. 9, 10).

Etymology. For the Occident, by contrast with Kobayashi's *T. orientalis*.

Occurrences. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland.

Material. 4 cranidium, 3 cranidia (Table 2).

Description. Cranidium subtrapezoidal in outline; width across palpebral lobes slightly greater than length. Glabella very narrow, low, slightly arched; slightly expanded anteriorly to maximum width across anterior lobe. Axial furrow moderately deep and wide. 1s furrows joined to form a single transglabellar furrow; deep, long, slightly convex posteriorly. 2s may be joined to form transglabellar furrow in smaller specimens. 3s and 4s short, narrow, transverse. Occipital furrow deep, moderately long, slightly convex posteriorly. Preglabellar furrow short, shallow; transverse with slight backcurve at midpoint. Anterior border furrow short, shallow. Anterior border long, flattened, triangular. Eye ridge weak, deflected slightly posteriorly from 1s furrow. Palpebral lobe long, about one half of cranidial length. Palpebral area broad, moderately inflated, standing slightly below glabella in anterior view. Posterior border furrow long, deep. Anterior branches of facial suture convergent. Cranidial prosopon finely granulate.

Pygidium subsemicircular in outline, wider than long. Axis moderately arched, tapered, narrow, composed of four rings and semiovate terminal piece, extending two thirds of pygidial length. Axial ring furrows short, deep. Each pleura is moderately arched, curving posteriorly laterally. Interpleural furrows deep, moderately long, curving posteriorly. Pleural furrows and pygidial border absent. Pygidial prosopon finely granulate.

Discussion. This is the second reported occurrence of *Tonkinella* in eastern North America, the only other being the undescribed and poorly illustrated *T. appalachia* Resser (1938). Although comparison with other species of this genus is made more difficult by their often poor preservation and illustration, it is apparent from the generic diagnosis of Kobayashi (1935, p. 147-148) that the long, triangular anterior border and presence of an eye ridge distinguish *T. occidentalis* n. sp. from all other known species. It is probably most similar to *T. flabelliformis* Mansuy (1916) discussed by Kobayashi (1935, p. 150) from Viet Nam, which also has a pygidial axis of four rings and a terminal piece. *Tonkinella stephensis* Kobayashi (1935, Pl. 15, figs. 2-5) illustrated by Rasetti (1951, Pl. 31, figs. 13-18) from the *Bathyuriscus-Elrathina* Zone of the Stephen Formation of British Columbia and *T. breviceps* Kobayashi (1935, Pl. 15, figs. 6, 8, 9) from Korea are both characterized by a longer, narrower pygidial axis of five rings plus a terminal piece, and a broader glabella, which is more strongly expanded anteriorly.

Family ZACANTHOIDIDAE Swinnerton

Discussion. Palmer (in Palmer and Halley, 1979, p. 85-86) argued convincingly that *Ptarmiganoides* Rasetti, 1951 should be assigned to the family Zacanthoididae on the basis of its spinose pygidium and distinct metafixigenal spine. These characters are shared by *Parkaspis* Rasetti, 1951 and, here, that genus is also assigned to this family. Both genera were assigned to the Dolichometopidae by Rasetti (1951; in Moore, 1959).

Genus *Zacanthoides* Walcott, 1888

Type species. *Embolimus spinosa* Rominger, 1887 (=*Zacanthoides romingeri* Resser) from the Stephen Formation, British Columbia (subsequent designation by Resser, 1942).

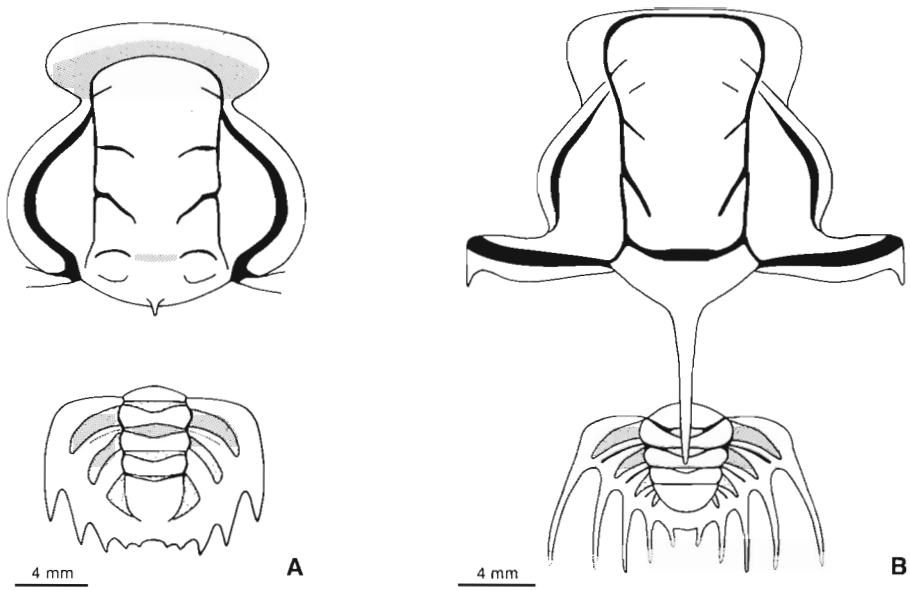


Figure 7. *Reconstructions of species of* ***Zacanthoides*** *and* ***Parkaspis.***

Diagnosis. A genus of Zacanthoididae with a rectangular glabella and a metafixigenal spine. Anterior border and preglabellar field present. Occipital ring short. Palpebral lobe elongate and strongly curved. Pygidium semielliptical. Broad axis of three or four rings stands well above flattened pleural field. Pleural furrows shallow; border furrow indistinct. Four or five pairs of flat marginal spines.

Zacanthoides gilberti n. sp.

Plate 6, figures 12-16; Plate 7, figures 1-3; Figure 7A

1982 *Zacanthoides* sp. 1, Kindle, Pl. 1.1, figs. 2, 6.

Diagnosis. A species of *Zacanthoides* with a moderately long, rectangular glabella. Occipital ring extended into a very small spine. Palpebral lobe long, semilunate. Cranidial prosopon finely granulate. Pygidium subovate, wider than long. Axis of three rings and a terminal piece. Pleural furrows very long, shallow. Interpleural furrows very shallow or absent. Four pairs of short, flattened marginal spines decrease in length posteriorly. Pygidial prosopon of coarse, sparse granules.

Holotype. A cranidium (GSC 69493) from boulder 358, illustrated by Kindle (Pl. 1.1, fig. 2) and here (Pl. 7, figs. 2, 3).

Etymology. For Sir Humphrey Gilbert, who claimed Newfoundland as a British colony in 1583.

Occurrence. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland.

Material. 85 cranidia, 6 free cheeks, 62 pygidia (Table 2).

Description. Cranidium subrectangular in outline; width across palpebral lobes slightly greater than length. Glabella is rectangular, slightly rounded anteriorly, moderately arched and vaulted. Axial furrows broad, shallow. 1s furrow deep, very wide, deflected posteriorly, geniculate or bigeniculate. 2s deep, deflected slightly posteriorly. 3s transverse, moderately deep, narrow. 4s narrow, short, moderately deep, transverse. Occipital ring short, semielliptical in outline, three times as wide as long, including a pair of circular lateral occipital lobes. Occipital furrow deep and short laterally, shallow and transverse medially. Occipital ring is extended into a very small spine. Anterior border moderately long, convex. Preglabellar furrow long, deep, slightly curved. Palpebral lobe long, moderately wide, semilunate, raised markedly above palpebral area, and two thirds of cranidial length, extending from 4s to back of lateral occipital lobe, with curvature increasing slightly posteriorly. Palpebral furrow wide, shallow. Palpebral area broad and flattened. Anterior branches of facial suture strongly divergent, slightly curved. Cranidial prosopon very finely granulate. Fine genal caeca may be present on palpebral area.

Free cheek has moderately wide, curved, raised border. Border furrow is shallow and moderately wide. Genal spine broad, elongate, situated slightly anterior to genal corner. Genal caeca are weak. Irregular terrace ridges are present on border.

Pygidium subovate in outline, wider than long. Axis moderately arched, slightly tapered; extending to pygidial border posteriorly; composed of three rings and a rounded terminal piece. Axial ring furrows very long, moderately deep. Axial furrows very shallow, narrow. Pleurae flattened. Pleural furrows very long, shallow, strongly curved posteriorly, becoming shorter abaxially. Interpleural furrows very shallow or absent. Pygidial border very broad, flattened. Marginal spines short, wide, flattened, becoming shorter posteriorly. Pygidial prosopon of coarse, sparse granules.

Discussion. The small occipital spine, broad pygidium, short flat pygidial marginal spines, and the shallow pleural furrows distinguish *Zacanthoides gilberti* n. sp. from most other species of *Zacanthoides*. *Zacanthoides gilberti* is very similar to *Z. divergens* Rasetti (1951, Pl. 32, figs. 8-10) from the *Bathyuriscus-Elrathina* Zone of the Stephen Formation, British Columbia, which possesses a broader anterior cranidial border, deeper pygidial pleural furrows, and deep, well developed interpleural furrows, and to *Z. demissus* Fritz (1968, p. 211, Pl. 42, figs. 1-6) from the Pioche Shale of Nevada, which has a much narrower pygidium with only three pairs of spines.

Other similar species include *Z. spinosus* (Walcott) illustrated by Palmer (1954, Pl. 15, figs. 5, 7) from Nevada and *Zacanthoides* sp. indet. of Rasetti (1948, Pl. 52, figs. 1-6) from the lower St. Lawrence Valley. *Zacanthoides spinosus* has a longer anterior border, smaller palpebral lobes, and a longer pygidium with deeper pleural and interpleural furrows than those of *Z. gilberti*, while *Zacanthoides* sp. indet. has a pygidium with a more tapered axis, much deeper pleural and interpleural furrows, and much longer marginal spines.

Genus *Parkaspis* Rasetti, 1951

Type species. *Parkaspis endecamera* Rasetti, 1951 from the Stephen Formation of British Columbia (by original designation).

Diagnosis. A genus of Zacanthoididae with an anteriorly expanding glabella nearly reaching anterior margin and a metafixigenal spine. Palpebral lobe long and moderately curved. Pygidium semicircular; convex axis of three rings; pleural furrows distinct. Four or five pairs of tubular marginal spines.

Parkaspis caboti n. sp.

Plate 7, figures 4-12; Plate 8, figure 1; Figure 7B

1982 aff. *Parkaspis* sp., Kindle, Pl. 1.1, figs. 3, 7, 11.

Diagnosis. A species of *Parkaspis* with glabella moderately arched, slightly expanded anteriorly. 1s deep and wide, strongly deflected posteriorly. 2s, 3s and 4s shallow. Occipital ring extended posteriorly into a long spine. Anterior border very short, slightly curved. Palpebral lobe long, wide, about one half of cranidial length. Posterior fixed cheek wide and short, possessing a short metafixigenal spine. Cranidial prosopon of dense medium-sized granules; fine genal caeca present on fixed cheek. Free cheek wide, with very wide, flattened border. Genal spine narrow, length slightly greater than one half of length of cheek. Pygidium semiovate, wider than long. Axis broad, tapered; composed of three rings and a terminal piece. Pleural furrows long, deep. Interpleural furrows moderately deep, short. Five pairs of long, straight, tubular spines extend from margin, becoming shorter posteriorly. Pygidial prosopon of granules.

Holotype. A cranidium (GSC 69495) from boulder 358, illustrated by Kindle (1982, Pl. 1.1, fig. 3) and here (Pl. 7, figs. 4, 5).

Etymology. For John Cabot, who in 1497 made the first recorded post-Norse voyage to Newfoundland.

Occurrence. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland.

Material. 82 cranidia, 2 free cheeks, 6 thoracic segments, 67 pygidia (Table 2).

Discussion. *Parkaspis caboti* n. sp. differs from *P. endecamera* Rasetti from the *Bathyuriscus-Elrathina* Zone of the Stephen Formation, British Columbia by possessing a slightly wider glabella, shallower glabellar furrows and, most obviously, by having much longer pygidial spines. *Parkaspis decamera* Rasetti, the only other species, is based on a single, poorly preserved and crushed specimen from the Stephen Formation that cannot be compared to the well preserved material in full relief from the Cow Head Group.

Order PTYCHOPARIIDA Swinnerton

Family ALOKISTOCARIDAE Resser

Genus *Alokistocare* Lorenz, 1906

Type species. *Conocephalites subcoronatus* Hall and Whitfield (1877) from Utah (by original designation).

Discussion. This genus has been assessed recently by Rasetti (1951, p. 202-203), Palmer (1954, p. 71-72), Robison (1971, p. 802), and Palmer and Halley (1979, p. 99).

Alokistocare sp.

Plate 8, figures 2-3

1982 *Alokistocare* sp., Kindle, Pl. 1.1, fig. 20.

Occurrence. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland.

Material. 2 cranidia, 1 free cheek (Table 2).

Discussion. This species is assigned to *Alokistocare* on the basis of its tapered, truncate glabella, elongate frontal area, convex preglabellar field, and palpebral lobes of moderate size (Robison, 1971, p. 802). Of the other North American members of the genus, *Alokistocare* sp. is very similar in cranidial and glabellar proportions to *A. piochensis* (Walcott) illustrated by Palmer (1954, Pl. 16, figs. 1, 2, 5) from Nevada, which has stronger lateral glabellar furrows and does not possess the convex preglabellar field.

Genus *Chancia* Walcott, 1924

Type species. *Chancia ebdome* Walcott, 1924 from Idaho (by original designation).

Discussion. The characters of *Chancia* have been discussed recently by Palmer and Halley (1979, p. 103).

Chancia tuberculata n. sp.

Plate 8, figures 4-7; Figure 8A

1982 *Chancia* sp., Kindle, Pl. 1.1, fig. 4.

Diagnosis. A species of *Chancia* with a triangular glabella. 1s furrow deflected posteriorly, extending almost to occipital furrow. 1s to 3s shallow. Occipital ring extended posteriorly into a short, narrow spine. Preglabellar field short. Palpebral lobe short, strongly curved. Palpebral area and posterior fixed cheek both broad. Eye ridge moderately strong, short. Dense cranidial prosopon of large tubercles.

Holotype. A cranidium (GSC 77382) from boulder 380, illustrated in Plate 8, figures 6, 7.

Name. This is the only species of *Chancia* with coarsely tuberculate prosopon.

Occurrence. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland.

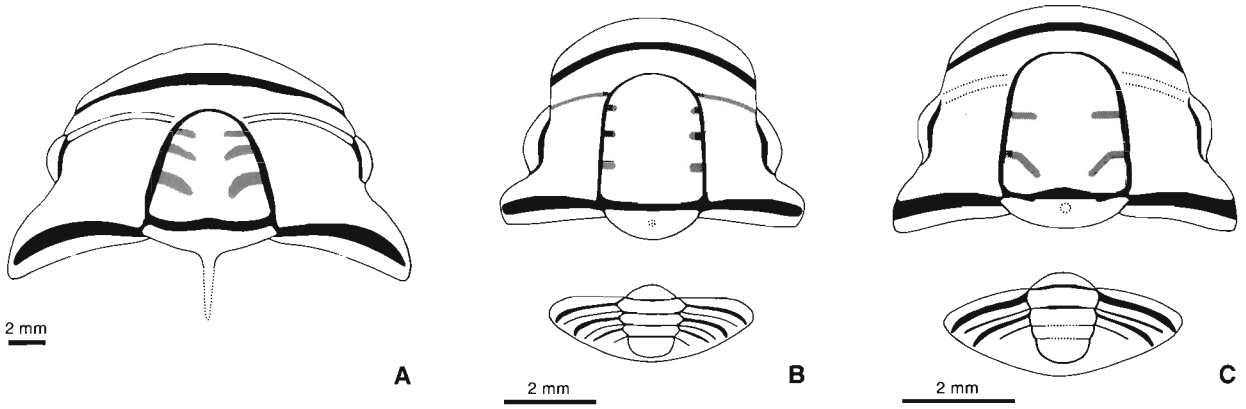


Figure 8. *Reconstruction of species of* ***Chancia, Elrathia,*** *and* ***Eoptychoparia.***

Material. 21 cranidia (Table 2).

Description. Cranidium subtrapezoidal in outline; width across palpebral lobes slightly greater than length. Glabella moderately arched, narrow, strongly tapered anteriorly. Axial furrow moderately wide and deep. 1s furrow deflected posteriorly, almost to occipital furrow. 2s shorter, shallower, and narrower than 1s. 3s very shallow, narrow, transverse.

Occipital furrow deep, moderately long, convex, straight in smaller specimens. Occipital ring very short, semielliptical, extending posteriorly into a short, narrow spine. Preglabellar furrow short, shallow. Preglabellar field short, convex. Anterior border furrow long, moderately shallow, curved. Anterior border moderately long medially, shorter abaxially, strongly curved, slightly convex. Palpebral lobe short, wide, strongly curved. Palpebral furrow narrow, shallow. Eye ridge moderately strong, short, slightly curved posteriorly. Palpebral area broad, slightly inflated. Posterior fixed cheek moderately wide. Posterior border furrow long, deep. Anterior branches of facial suture convergent. Posterior branches of suture divergent. Cranidial prosopon of large, dense tubercles.

Discussion. *Chancia tuberculata* is distinguished from all other members of the genus by its occipital spine and by its coarsely tuberculate prosopon. It is most similar to *Chancia? maladensis* (Resser) illustrated by Palmer and Halley (1979, Pl. 15, fig. 4) from the *Albertella* Zone of Nevada, which has a similarly shaped cranidium, a convex anterior cranidial border, a short preglabellar field, and a narrow glabella. *Chancia tuberculata* differs by possessing a more strongly tapered glabella, coarser prosopon, and occipital spine. Other species, including *C. ebdome* Walcott (1924, Pl. 10, fig. 4; 1925, Pl. 17, fig. 26) and *C. evax* Walcott (1925, Pl. 17, fig. 27), both from Idaho, are similar to *C. tuberculata* in general cranidial and glabellar shape, but have broader anterior borders and much longer preglabellar fields.

Chancia sp.

Plate 8, figures 8, 9

Occurrence. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland.

Material. 4 cranidia (Table 2).

Discussion. This species is assigned to the genus *Chancia* Walcott on the basis of its wide cranidium with broad fixed cheeks, tapered glabella, eye ridge, and strong anterior border furrow. *Chancia* sp. is most similar to *C. odarayensis* Rasetti (1951, p. 216, Pl. 8, fig. 20) from the *Bathyuriscus-Elrathina* Zone of the Stephen Formation, British Columbia, which has a glabella of the same shape with similar lateral glabellar furrows, and a finely granulate prosopon, but which differs by having shorter palpebral lobes, narrower palpebral areas, and broader posterior fixed cheeks. *Chancia tuberculata* n. sp. has a more strongly tapered glabella, an occipital spine, coarsely tuberculate prosopon, and a more strongly curved anterior border than that of *Chancia* sp.

Genus *Elrathia* Walcott, 1924

Type series. *Conocoryphe (Conocephalites) kingii* Meek, 1870 from Utah (by original designation).

Elrathia kindlei n. sp.

Plate 8, figures 10-13; Plate 9, figures 1-7; Figure 8B

Diagnosis. A species of *Elrathia* with a narrow glabella and three shallow lateral glabellar furrows. Occipital ring carries raised median tubercle. Preglabellar field moderately long. Anterior border long, strongly curved. Palpebral lobe narrow, weakly curved. Anterior branches of facial suture parallel or slightly divergent ahead of palpebral lobe, strongly convergent in front of anterior border furrow. Cranidial prosopon of dense granules and isolated tubercles. Pygidium semielliptical, width about three times length. Axis of two or three rings and a terminal piece. Pygidial prosopon of abundant medium-sized granules with a few large tubercles.

Holotype. A cranidium (GSC 77388) from boulder 380, illustrated in Plate 9, figures 1, 2.

Etymology. Named for C.H. Kindle who collected and prepared thousands of trilobites from the Cow Head Group.

Occurrence. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland.

Material. 42 cranidia, 5 pygidia (Table 2).

Description. Cranidium subtrapezoidal in outline; width across palpebral lobes slightly greater than length. Glabella moderately arched, narrow, tapered anteriorly. Axial furrows moderately wide and well incised. 1s, 2s and 3s furrows very shallow. Occipital furrow moderately deep, transverse. Occipital ring semiovate, three times as wide as long. Median occipital tubercle large. Preglabellar furrow short, shallow. Preglabellar field moderately long, sloping steeply to long, shallow, anterior border furrow. Anterior border long, convex, curved. Anterior fixed cheek narrow. Palpebral lobe long, narrow, weakly curved, about one third of cranidial length. Palpebral furrow shallow. Eye ridge weak. Palpebral area moderately wide, very parallel. Anterior branches of facial suture parallel. Cranidial prosopon of large granules and sparse, regularly arranged tubercles; fine irregular terrace ridges on anterior border.

Pygidium semielliptical in outline, width about three times length. Axis weakly arched, moderately tapered, about one third of pygidial width, extending almost to posterior margin; composed of two to three rings and a broad, rounded terminal piece. Pleurae moderately arched. Interpleural furrows short, very shallow, deflected slightly posteriorly. Pleural furrows moderately long and shallow, curved posteriorly abaxially. Pygidial border absent. Pygidial prosopon of abundant medium-sized granules and a few large tubercles.

Discussion. *Elrathia kindlei* is most similar to *E. grazierensis* Rasetti (1965, Pl. 119, figs. 21-28) from central Pennsylvania, which differs by possessing a broader, more tapered glabella, a longer anterior border, wider palpebral lobes, a longer occipital ring without a distinct tubercle, and a less transverse pygidium with a broader axis. Other similar species include *E. alaskensis* Palmer (1968, Pl. 5, figs. 10-13) from the *Bolaspidella* Zone of east-central Alaska and *E. sulcata* Rasetti (1963, Pl. 69, figs. 19-24) from the lower St. Lawrence Valley. *Elrathia alaskensis* has a more elongate cranidium than that of *E. kindlei*, with a more tapered glabella, shorter palpebral lobes, and a narrower pygidial axis with more axial rings, while *E. sulcata* possesses a broader, more globose glabella, wider posterior fixed cheeks, and lacks a distinct occipital tubercle.

Genus *Elrathina* Resser, 1937

Type species. *Conocephalites cordillerae* Rominger (1887) from the Stephen Formation, British Columbia (by original designation).

Diagnosis. A genus of Alokistocaridae with a broad, subtrapezoidal cranidium. Glabella broad, parallel-sided or tapered anteriorly. Palpebral lobe small, situated slightly anterior to mid length of glabella. Posterior fixed cheek long. Anterior branches of facial suture convergent. Pygidium small, transverse. Pygidial axis broad.

Discussion. Most species of *Elrathina* are from the Stephen Formation of British Columbia. Rasetti (1951, p. 221) noted that intraspecific variation and imperfect preservation cast doubt on the validity of these species. The consistency of this genus, while contributing to the difficulty of species-level taxonomy, makes *Elrathina* a readily discernable taxonomic unit. *Elrathina* is probably most similar to *Elrathia* Walcott, from which it differs by possessing a shorter palpebral lobe and convergent anterior facial sutures.

Elrathina parallela Rasetti, 1951

Plate 9, figures 8-13

1951 *Elrathina parallela* Rasetti, p. 222-223, Pl. 33, figs. 19-22.

1982 *Elrathina* sp., Kindle, Pl. 1.1, fig. 10.

Diagnosis. A species of *Elrathina* with a narrow glabella. 1s to 3s furrows long and shallow. Occipital ring semielliptical, bearing large median tubercle. Anterior border long, convex, strongly curved. Palpebral lobe very short, narrow. Eye ridge weak or absent. Anterior branches of facial suture convergent, convex. Cranidium smooth; smallest specimens bear granulate prosopon.

Occurrences. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland; *Bathyuriscus-Elrathina* Zone, Stephen Formation, British Columbia.

Material. 21 cranidia (Table 2).

Discussion. *Elrathina parallela* is distinguished from most other species of *Elrathina* by its narrow glabella and convergent facial sutures. It is most similar to *E. brevifrons* Rasetti (1951, p. 223, Pl. 26, fig. 6), also from the *Bathyuriscus-Elrathina* Zone of the Stephen Formation, which differs by having less strongly convergent anterior sutures, a shorter frontal area, and stronger lateral glabellar furrows.

Family PTYCHOPARIIDAE Matthew

Genus *Eoptychoparia* Rasetti, 1955

Type species. *Eoptychoparia normalis* Rasetti (1955) from the St. Lawrence Valley (by original designation).

Discussion. A diagnosis of *Eoptychoparia* can be found in Rasetti (1955).

Eoptychoparia convexa Rasetti, 1963

Plate 9, figure 14; Plate 10, figures 1-4; Figure 8C

1963 *Eoptychoparia convexa* Rasetti, p. 582-583, Pl. 66, figs. 11-15.

Diagnosis. A species of *Eoptychoparia* with a broad glabella. 1s and 2s furrows very shallow. Occipital ring semielliptical, bearing large median tubercle. Anterior border short, strongly curved, convex. Palpebral lobe short, semielliptical, deflected slightly outward posteriorly. Eye ridge weak. Anterior branches of facial suture convergent. Cranidial prosopon of abundant large granules and a few large tubercles. Pygidium subelliptical, twice as wide as long. Axis broad, composed of two or three rings and a terminal piece. Pleural furrows moderately long and shallow. Interpleural furrows short, shallow. Border absent. Pygidial prosopon of fine granules and a few large tubercles.

Occurrences. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland; lower St. Lawrence Valley.

Material. 45 cranidia, 4 pygidia (Table 2).

Discussion. *Eoptychoparia convexa* Rasetti is distinguished from other species by its broader, anteriorly rounded glabella, and weak lateral glabellar furrows and eye ridges. The specimens described here differ slightly from those illustrated by Rasetti, having more anteriorly placed palpebral lobes and convergent anterior cranidial sutures.

Genus *Onchocephalites* Rasetti, 1957

Type species. *Onchocephalites laevis* Rasetti (1957) from the Mt. Whyte Formation of British Columbia (by original designation).

Discussion. Rasetti (1957, p. 562) and Palmer (1968, p. 91) provided diagnoses and discussions of *Onchocephalites*. Members of this genus vary in cranidial proportions and in degree of effacement, but all have strongly convex cranidia with poorly defined palpebral lobes, strongly convergent anterior facial sutures, and short, steep frontal areas. Species here referred to *Onchocephalites* include *Onchocephalites laevis* Rasetti, *O. punctatus* Rasetti, *O. redpathi* (Walcott), *O. spinulosus* Rasetti, and *O. versilis* Palmer. Rasetti (1963) tentatively referred *O.? angustifrons* Rasetti to the genus, but because of its narrow glabella and broad fixed cheeks, it is unlikely that it belongs to this genus.

Onchocephalites spinulosus Rasetti, 1963

Plate 10, figures 5-11

1963 *Onchocephalites spinulosus* Rasetti, p. 588, Pl. 67, figs. 15-18.

Diagnosis. A species of *Onchocephalites* with a highly convex cranidium. Lateral glabellar furrows very shallow or absent. Occipital ring moderately long, semiovate, bearing a large median tubercle. Preglabellar field and anterior border short, sloping steeply. Palpebral lobe short. Eye ridge very weak, short. Cranidial prosopon of fine granules on glabella and numerous fine pits on cheeks and anterior border.

Occurrences. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland; lower St. Lawrence Valley, Quebec.

Material. 58 cranidia (Table 2).

Discussion. The specimens described here differ from the type material of *Onchocephalites spinulosus* Rasetti (1963, Pl. 67, figs. 15-18) only in having a large median occipital tubercle instead of the short occipital spine. Rasetti noted that *O. spinulosus* was most similar to *O. redpathi* (Walcott), also illustrated by Rasetti (1963, Pl. 67, figs. 11-14) from the lower St. Lawrence Valley, being distinguished from the latter by its more convex glabella, deeper axial and occipital furrows, and more transverse cranidium. *Onchocephalites laevis* Rasetti (1957, Textfig. 2, Pl. 121, figs. 5-9) from the Mt. Whyte Formation of British Columbia and *O. punctatus* Rasetti (1963, Pl. 67, figs. 22-25) from the lower St. Lawrence Valley differ from *O. spinulosus* by having much more strongly effaced cranidia with indistinct preglabellar furrows.

Onchocephalites punctatus Rasetti, 1963

Plate 10, figures 12-15

1963 *Onchocephalites punctatus* Rasetti, p. 588, Pl. 67, figs. 22-25.

Diagnosis. A species of *Onchocephalites* with a strongly effaced cranidium. Lateral glabellar furrows very shallow. Occipital ring semielliptical; median tubercle very small. Axial and preglabellar furrows very shallow, anterior border furrow absent. Palpebral lobe moderately long, narrow. Eye ridge very weak. Cranidial prosopon of dense pits.

Occurrences. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland; lower St. Lawrence Valley.

Material. 3 cranidia (Table 2).

Discussion. Of the other species of *Onchocephalites*, only *O. laevis* Rasetti (1957, Pl. 121, figs. 5-9, Textfig. 2) from the *Plagiura-Kochaspis* Zone of the Mt. Whyte Formation of British Columbia is effaced to the same degree as *O. punctatus*. *Onchocephalites laevis* has a slightly more elongate cranidium with palpebral lobes more posteriorly placed than those of *O. punctatus*.

Family SOLENOPLEURIDAE Angelin

Genus *Spencella* Rasetti, 1963

Type species. *Spencella montanensis* Rasetti (1963) from the Middle Cambrian of Montana (by original designation).

Spencella spinosa Rasetti, 1963

Plate 10, figure 16

1963 *Spencella spinosa* Rasetti, p. 592, Pl. 68, figs. 12-15.

Occurrences. *Zacanthoides gilberti* Fauna, Cow Head Group, western Newfoundland; lower St. Lawrence Valley, Quebec.

Material. 2 cranidia (Table 2).

Discussion. These specimens are identical to *Spencella spinosa* Rasetti in all observable features. *Spencella spinosa* is most similar to *S. acanthina* Palmer (1968, p. 98, Pl. 5, figs. 14-16) from the *Bolaspidella* Zone of east-central Alaska, which differs by having a shorter occipital ring, a more globose glabella, and a granulate prosopon in the frontal area.

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PLATES 1 to 10

All specimens were blackened with photographic opaque and lightly coated with ammonium chloride prior to photography.

In the plate descriptions, (T) indicates a testate or largely testate specimen, (E) indicates an exfoliated or largely exfoliated specimen.

PLATE 1

Peronopsis mariae n. sp.
(All from boulder 380; x 12.0)

1, 2. Cephalon (T), holotype, dorsal and lateral views, GSC 77296.

3. Pygidium (T), dorsal view, GSC 77297.

4. Cephalon (T), dorsal view, GSC 77300.

5. Pygidium (T), dorsal view, GSC 77302.

6. Cephalon (T), dorsal view, GSC 77301.

7, 8. Pygidium (E), dorsal and posterior views, GSC 77298.

9. Pygidium (T), dorsal view, GSC 77299.

10. Cephalon (T), dorsal view, GSC 77303.

11, 12. Cephalon (T), anterior and dorsal views, GSC 77304.

Tomagnostus ? sp.
(Both from boulder 380; x 12.0)

13. Pygidium (T), dorsal view, GSC 77305.

14, 15. Pygidium (T), posterior and dorsal views, GSC 69501.

Peronopsis fallax (Linnarsson, 1869).
(All from boulder 378; x 12.0)

16, 17. Cephalon (T), lateral and dorsal views, GSC 77306.

18. Pygidium (T), dorsal view, GSC 77307.

19. Pygidium (T), dorsal view, GSC 77308.

20. Cephalon (T), dorsal view, GSC 77309.

Peronopsis interstricta (White, 1874)
(All from boulder 378; x 12.0).

21. Pygidium (T), dorsal view, GSC 77311.

22. Cephalon (T), dorsal view, GSC 77312.

23, 24. Cephalon (T), dorsal and lateral views, GSC 77310.

25, 26. Pygidium (T), dorsal and posterior views, GSC 77313.

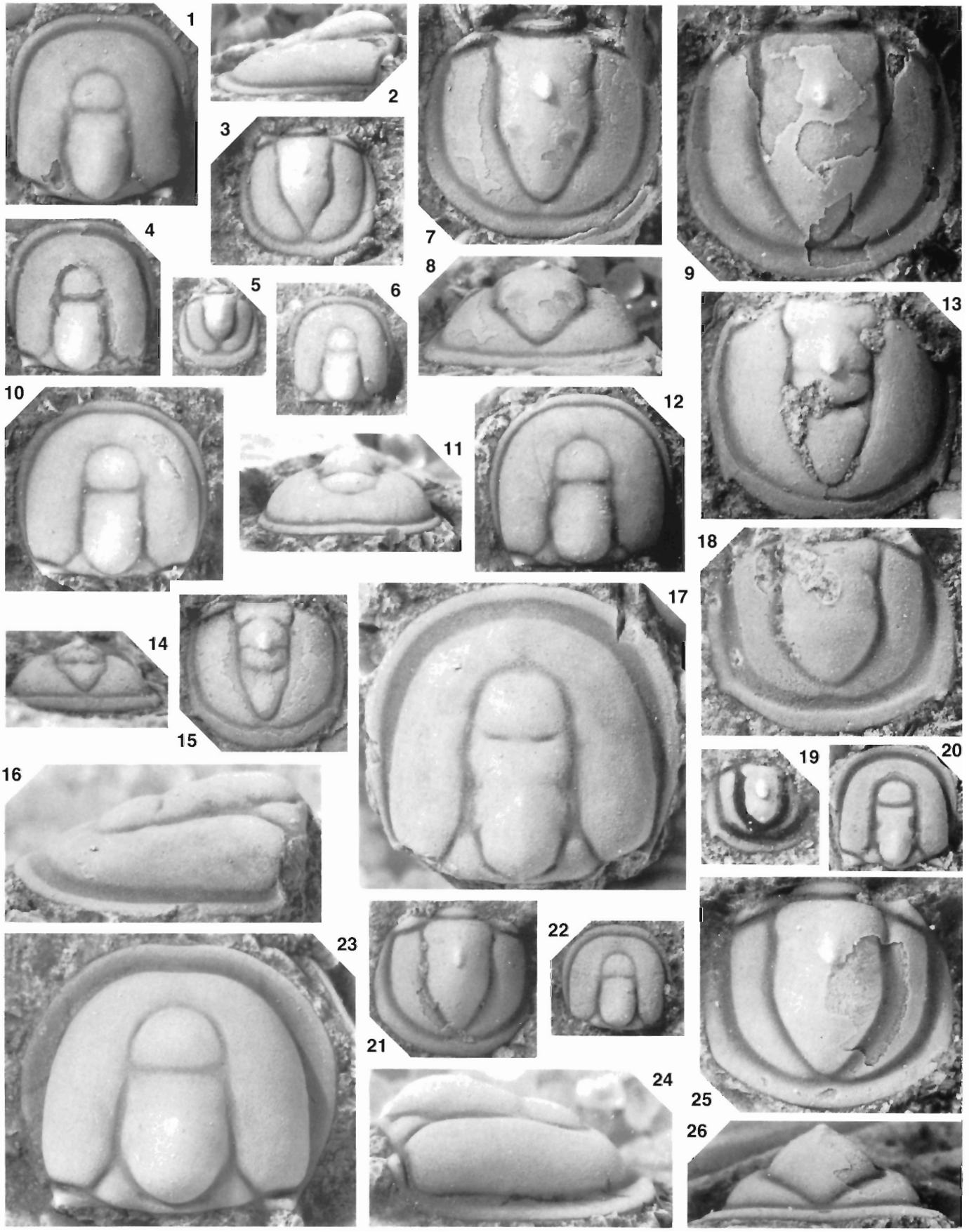
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PLATE 2

Peronopsis interstricta (White, 1874)
(Both from boulder 378; x 12.0.)

1. Cephalon (T), dorsal view, GSC 77314.
2. Pygidium (T), dorsal view, GSC 77315.

Onymagnostus seminula (Whitehouse, 1939)
(All x 12.0).

3. Cephalon (T), dorsal view, boulder 362, GSC 77316.
4. Pygidium (T), dorsal view, boulder 362, GSC 77317.
5, 6. Pygidium (T), lateral and dorsal views, boulder 376, GSC 77318.
7, 8. Cephalon (E), dorsal and lateral views, boulder 380, GSC 77319.
9. Pygidium (T), dorsal view, boulder 362, GSC 77320.
10. Pygidium (E), dorsal view, boulder 362, GSC 77321.

Tomagnostus ? sp.
(Both from boulder 380; x 12.0).

11. Cephalon (T), dorsal view, GSC 77322.
12. Cephalon (T), dorsal view, GSC 77323.

Ptychagnostus gibbus (Linnarsson, 1869)

13, 14. Cephalon (T), dorsal and anterior views, x 12.0, boulder 362, GSC 69504.
15, 16. Cephalon (T), lateral and dorsal views, x 12.0, boulder 376, GSC 77324.

Ptychagnostus sp. cf. *P. intermedius* (Tullberg, 1880).

17, 18. Cephalon (T), dorsal and anterior views, x 12.0, boulder 380, GSC 77325.

Pagetia rasettii n. sp.
(All from boulder 380; x 14.0).

19, 20. Cranidium (T), dorsal and anterior oblique views, GSC 77326.
21. Cranidium (T), dorsal view, GSC 77327.
22, 23. Cranidium (T), dorsal and anterior views, GSC 77328.
24. Cranidium (T), dorsal view, GSC 77329.
25. Pygidium (T), dorsal view, GSC 77330.
26. Pygidium (T), dorsal view, GSC 77333.
27. Pygidium (T), dorsal view, GSC 77332.
28-30. Pygidium (T), holotype, dorsal, posterior, and lateral views, GSC 77331.

Pagetia skraelingi n. sp.

31. Cranidium (T), dorsal view, x 14.0, boulder 357, GSC 77334.
32, 33. Pygidium (T), dorsal and lateral views, x 14.0, boulder 372, GSC 69510.

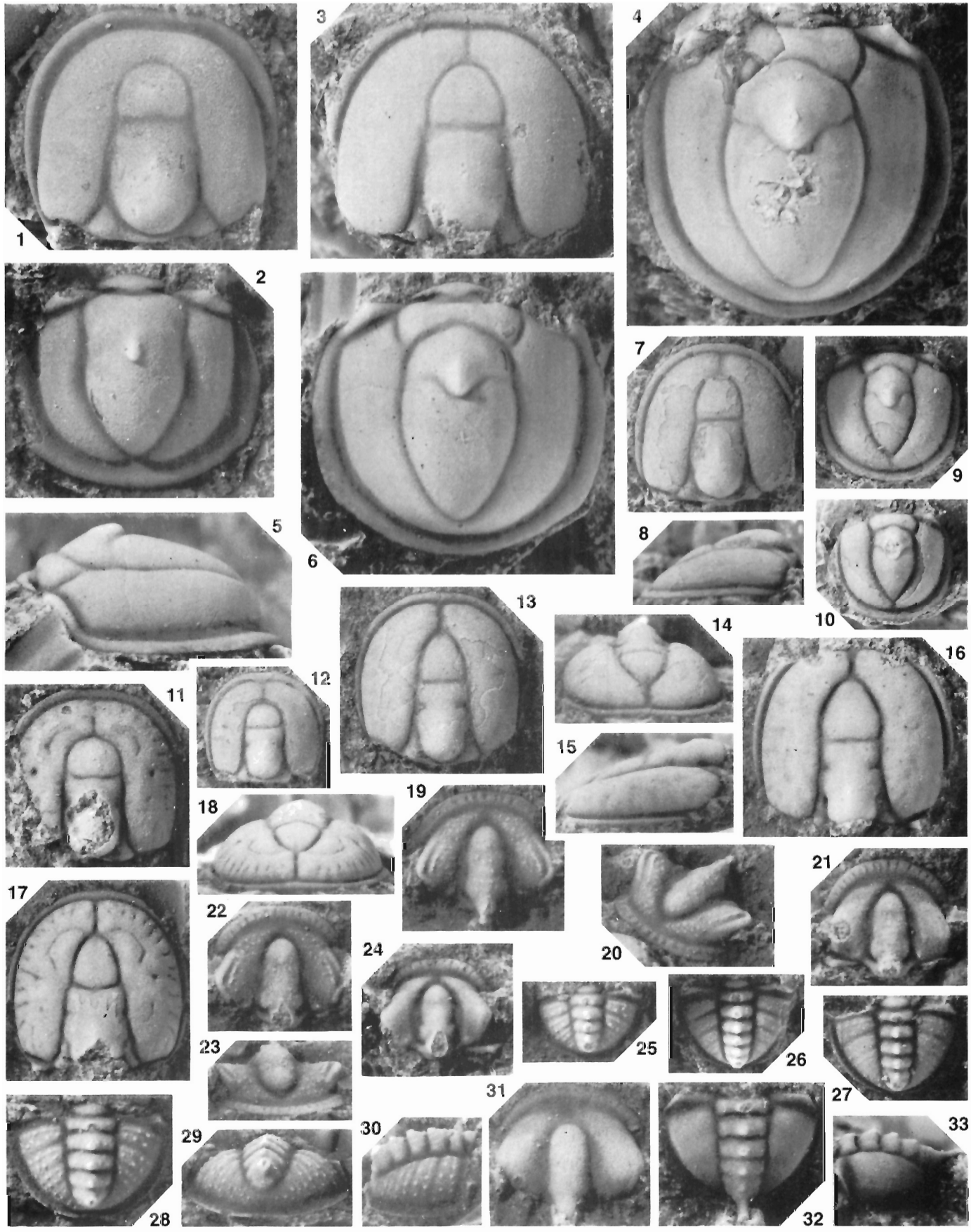
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PLATE 3

Pagetia skraelingi n. sp.
(All x 14.0).

1, 2. Cranidium (T), holotype, dorsal and oblique anterior views, boulder 372, GSC 69509.

3. Pygidium (T), dorsal view, boulder 372, GSC 77335.

4. Cranidium (T), dorsal view, boulder 261, GSC 77336.

5. Pygidium (T), dorsal view, boulder 372, GSC 77337.

Bathyuriscus terranovensis n. sp.
(All from boulder 357).

6. Pygidium (T), dorsal view, x 5.0, GSC 77338.

7. Free cheek (T), dorsal view, x 7.0, GSC 77339.

8, 9. Cranidium (T), holotype, dorsal and oblique anterior views, x 5.5, GSC 77340.

10. Cranidium (T), dorsal view, x 8.0, GSC 77341.

11. Cranidium (T), dorsal view, x 7.0, GSC 77342.

12. Pygidium (T), dorsal view, x 7.0, GSC 77343.

Bathyuriscus boscaputensis n. sp.
(All from boulder 378).

13. Pygidium (T), dorsal view, x 7.0, GSC 69512.

14. Pygidium (T), dorsal view, x 11.0, GSC 77345.

15-17. Cranidium (T), holotype, anterior, dorsal, and oblique anterior views, x 7.0, GSC 77344.

18. Cranidium (T), dorsal view, x 7.0, GSC 77346.

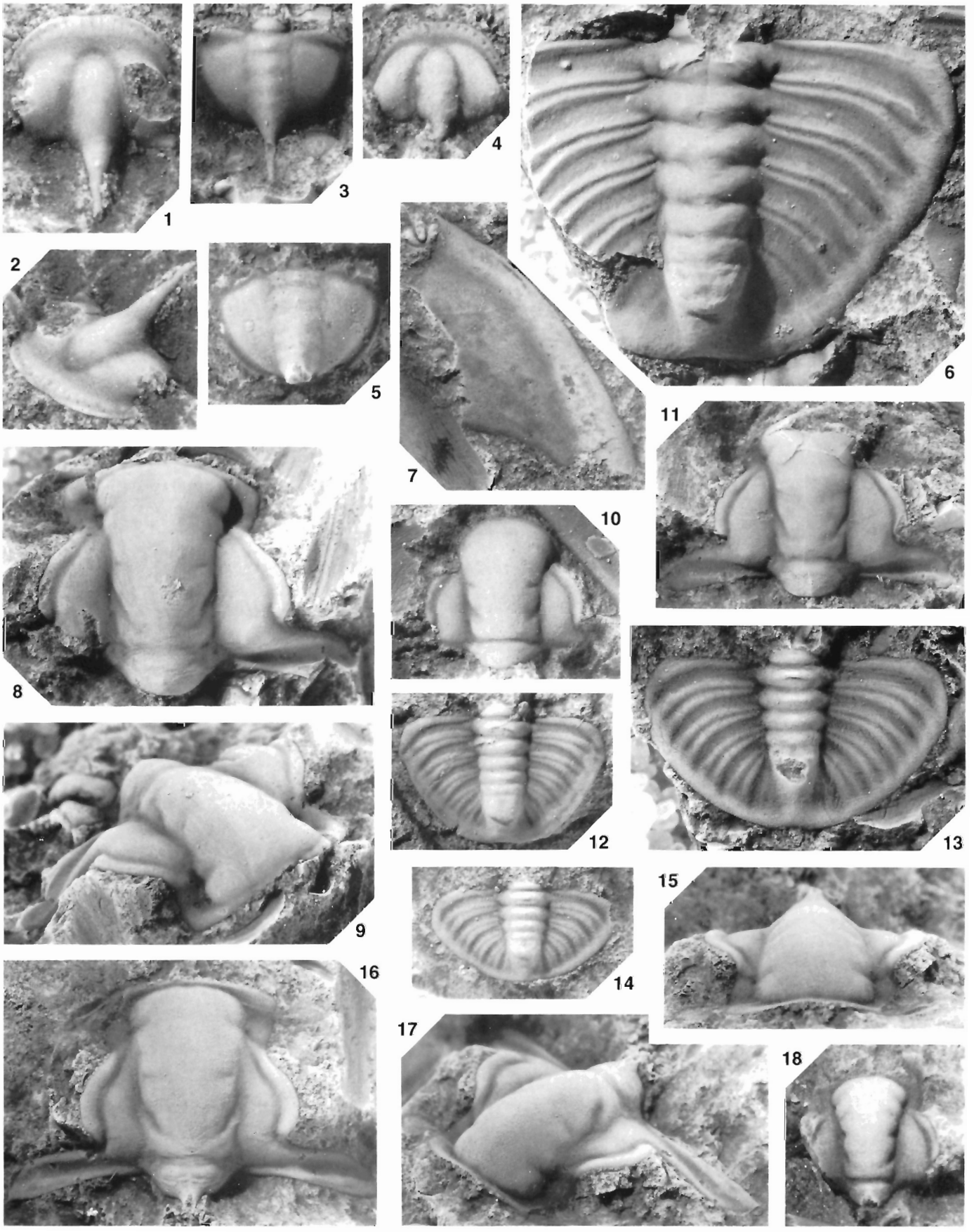
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PLATE 4

Bathyuriscus boscaputensis n. sp.
(Both from boulder 378; x 7.0).

1. Cranidium (T), dorsal view, GSC 77347.

2. Pygidium (T), dorsal view, GSC 77348.

Bathyuriscus sp. cf. *B. boscaputensis* n. sp.
(Both from boulder 378; x 7.0).

3. Pygidium (T), dorsal view, GSC 77349.

4. Pygidium (T), dorsal view, GSC 77350.

Bathyuriscus richardsoni n. sp.

5. Cranidium (T), dorsal view, x 10.0, boulder 363, GSC 77352.

6-8. Cranidium (T), holotype, dorsal, oblique anterior, and lateral views, x 10.0, boulder 363, GSC 77351.

9. Pygidium (T), dorsal view, x 7.0, boulder 358, GSC 77353.

10. Pygidium (T), dorsal view, x 8.0, boulder 363, GSC 69499.

11. Cranidium (T), dorsal view, x 12.0, boulder 363, GSC 77354.

12. Pygidium (T), dorsal view, x 10.0, boulder 358, GSC 77355.

Bathyuriscidella sp.

13. Cranidium (T), dorsal view, x 5.0, boulder 433, GSC 77356.

Kootenia elongata Rasetti, 1948
(Both from boulder 378).

14. Cranidium (T), dorsal view, x 10.0, GSC 77357.

15. Cranidium (T), dorsal view, x 5.0, GSC 77358.


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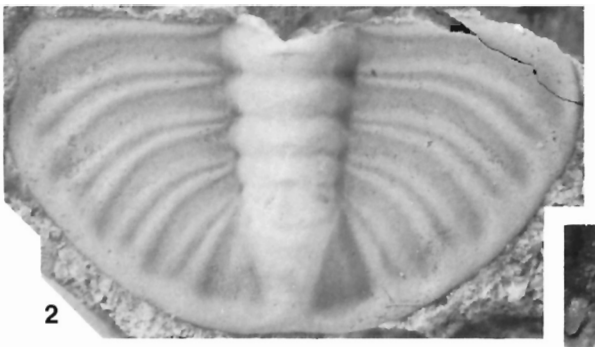
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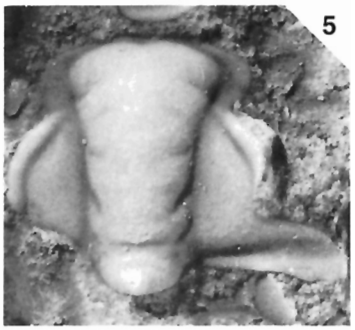
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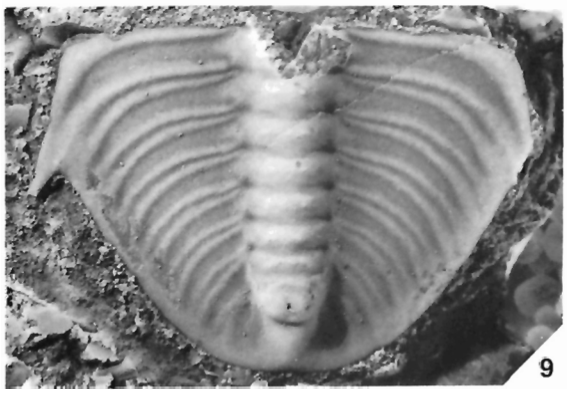
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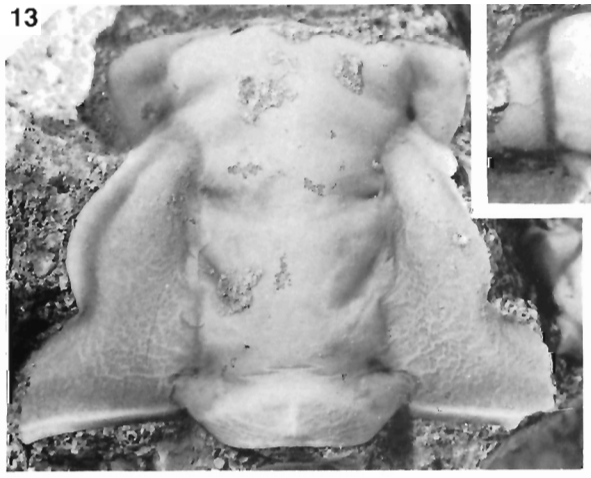
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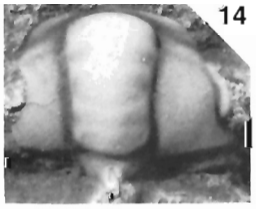
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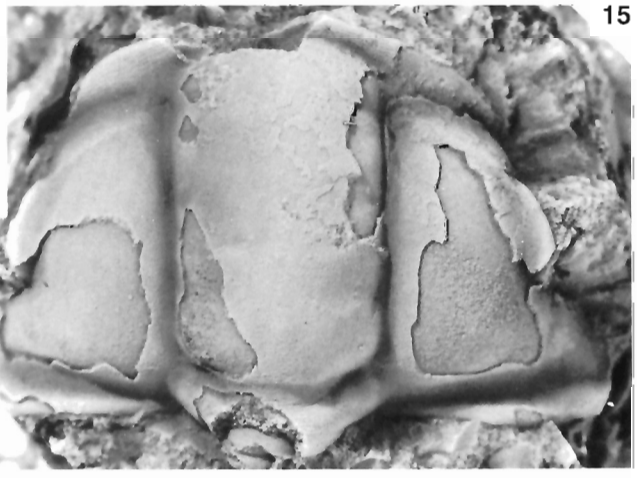
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PLATE 5

Kootenia elongata Rasetti, 1948.
(All from boulder 378).

1, 2. Cranidium (E), dorsal and oblique anterior views, x 5.0, GSC 77359.

3. Cranidium (T), dorsal view, x 6.0, GSC 77360.

4. Pygidium (E), dorsal view, x 5.0, GSC 69508.

5, 6. Pygidium (T), posterior and dorsal views, x 8.5, GSC 77361.

7, 8. Pygidium (E), lateral and dorsal views, x 5.0, GSC 77362.

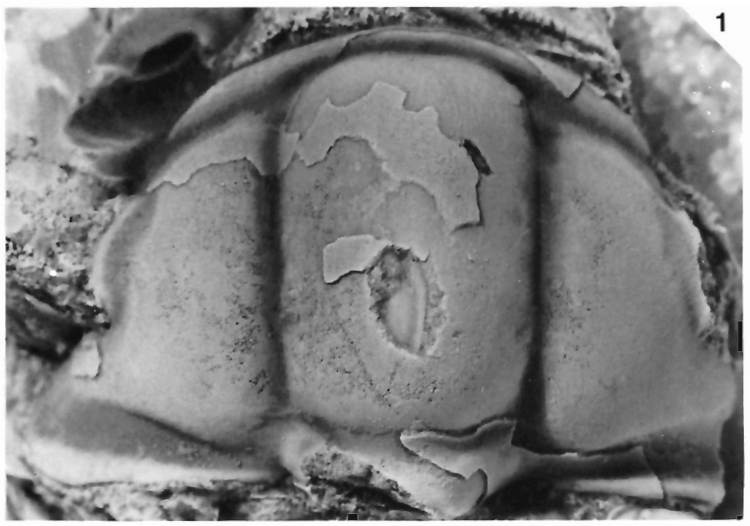
Olenoides foveolatus Rasetti, 1948.
(Both x 2.0).

9. Fragment of cranidium (T), dorsal view, boulder 357, GSC 77364.

10. Pygidium (T), dorsal view, boulder 379, GSC 77363.

Ogygopsis klotzi (Rominger, 1887).

11. Cranidium (T), dorsal view, x 2.2, boulder 357, GSC 77365.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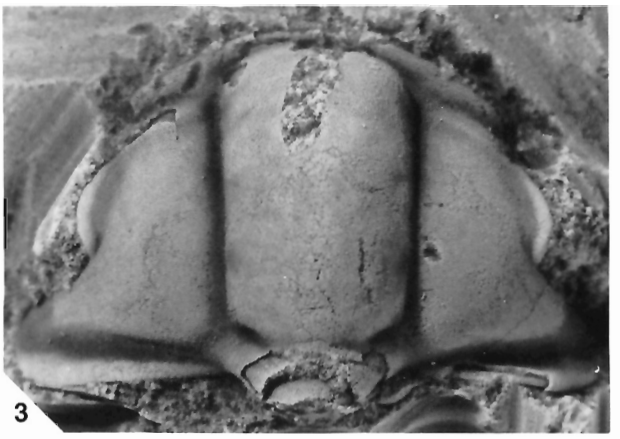
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PLATE 6

Ogygopsis klotzi (Rominger, 1887)
(All from boulder 357).

1, 3. Fragment of cranidium (T), dorsal and anterior views, x 2.0, GSC 77366.

2. Free cheek (T), dorsal view, x 2.0, GSC 77367.

4. Pygidium (T), dorsal view, x 4.0, GSC 77368.

Tonkinella occidentalis n. sp.

5. Pygidium (T), dorsal view, x 13.0, boulder 380, GSC 69502.

6, 7. Pygidium (T), dorsal and posterior views, x 7.0, boulder 433, GSC 77369.

8. Latex impression of external mould of holotype cranidium, dorsal view, x 11.0, boulder 380, GSC 69500.

9, 10. Cranidium (T), holotype, dorsal and oblique anterior views, x 11.0, boulder 380, GSC 69500.

11. Cranidium (T), dorsal view, x 12.0, boulder 380, GSC 77370.

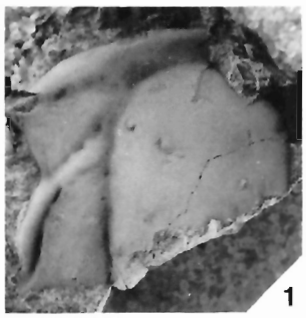
Zacanthoides gilberti n. sp.
(All from boulder 358).

12. Cranidium (T), dorsal view, x 8.0, GSC 77372.

13. Pygidium (T), dorsal view, x 8.0, GSC 77373.

14, 15. Pygidium (T), dorsal and posterior views, x 7.0, GSC 77371.

16. Pygidium (T), dorsal view, x 6.0, GSC 77374.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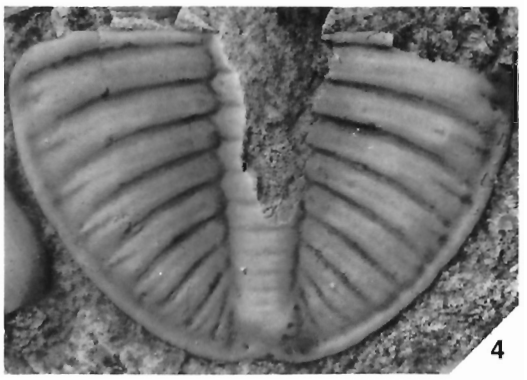
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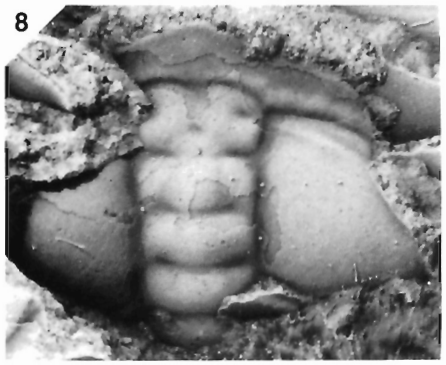
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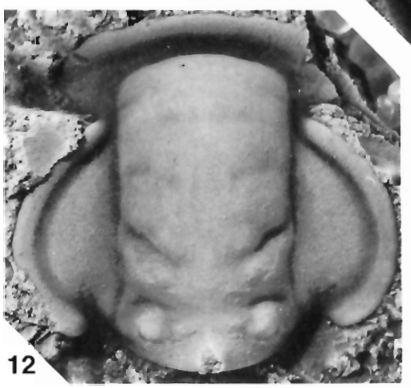
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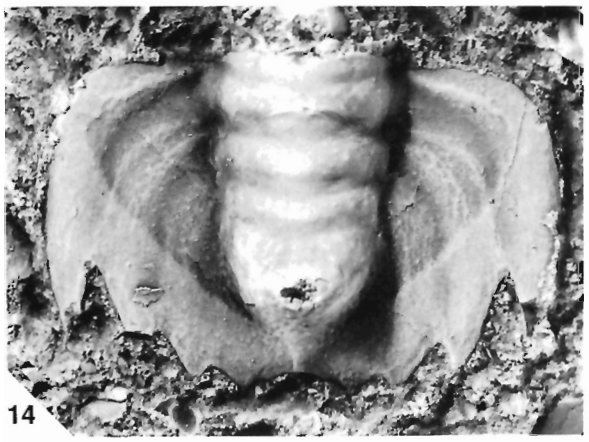
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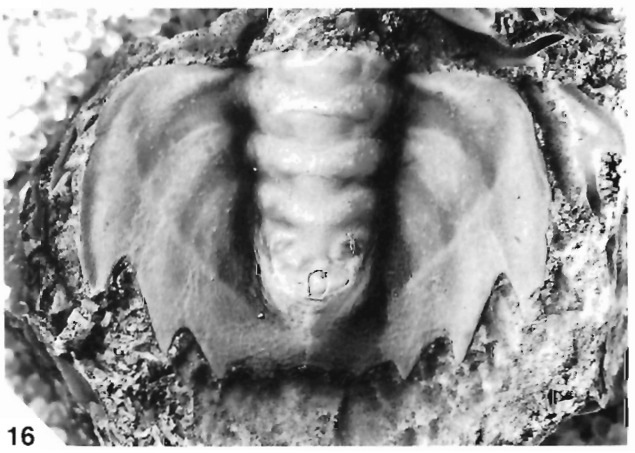
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PLATE 7

Zacanthoides gilberti n. sp.
(Both from boulder 358).

1. Free cheek (T), dorsal view, x 5.0, GSC 77375.

2, 3. Cranidium (T), holotype, dorsal and oblique anterior views, x 6.5, GSC 69493.

Parkaspis caboti n. sp.
(All from boulder 358, with the exception of figures 8 and 12).

4, 5. Cranidium (T), holotype, dorsal and lateral views, x 7.0, GSC 69495.

6. Thoracic segment (T), dorsal view, x 10.0, GSC 77376.

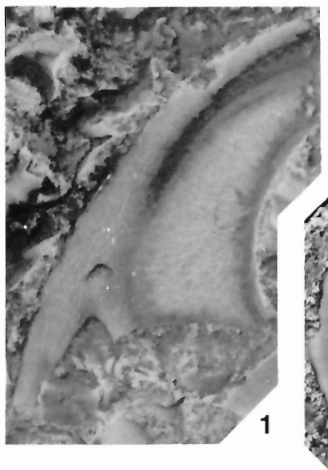
7. Cranidium (T), dorsal view, x 10.0, GSC 77377.

8. Free cheek (T), dorsal view, x 4.0, boulder 380, GSC 77378.

9, 10. Pygidium (T), dorsal and posterior views, x 8.0, GSC 69497.

11. Pygidium (T), dorsal view, x 11.0, GSC 77379.

12. Pygidium (T), dorsal view, x 9.0, boulder 379, GSC 69496.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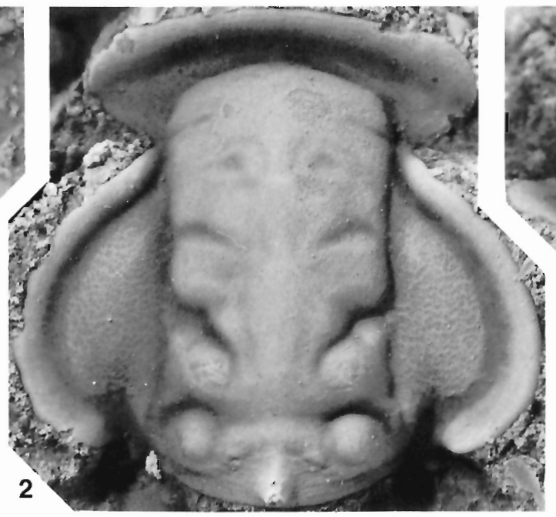
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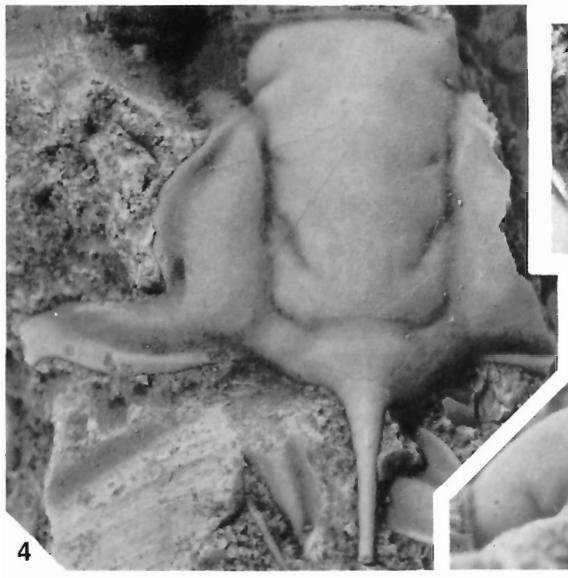
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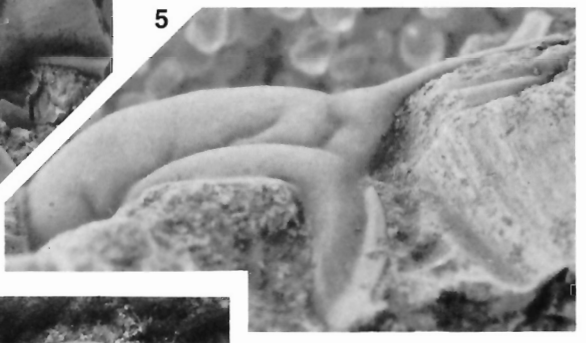
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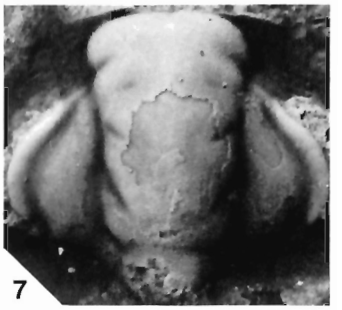
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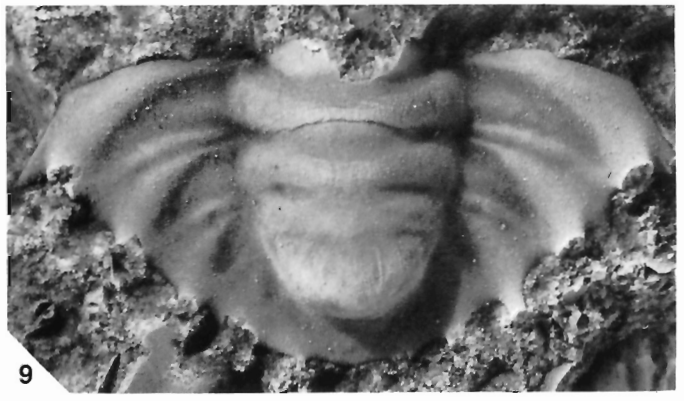
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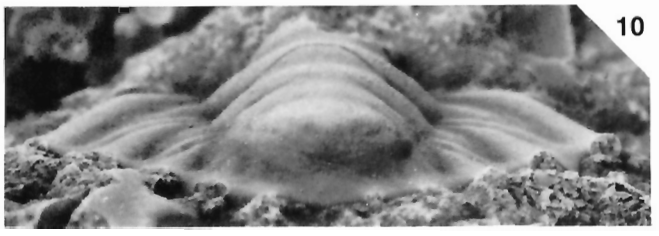
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PLATE 8

Parkaspis caboti n. sp.

1. Cranidium (T), dorsal view, x 10.0, boulder 358, GSC 77380.

Alokistocare sp.
(Both from boulder 372).

2. Cranidium (T), dorsal view, x 11.0, GSC 69511.

3. Free cheek (T), dorsal view, x 7.0, GSC 77381.

Chancia tuberculata n. sp.
(Both from boulder 380; x 6.0).

4, 5. Cranidium (E), oblique anterior and dorsal views, GSC 69498.

6, 7. Cranidium (T), holotype, lateral and dorsal views, GSC 77382.

Chancia sp.
(Both from boulder 362; x 7.5).

8. Cranidium (T), dorsal view, GSC 77383.

9. Cranidium (E), dorsal view, GSC 77384.

Elrathia kindlei n. sp.
(All from boulder 380).

10, 11. Cranidium (T), dorsal and lateral views, x 12.0, GSC 77385.

12. Pygidium (T), dorsal view, x 12.0, GSC 77386.

13. Cranidium (T), dorsal view, x 14.0, GSC 77387.


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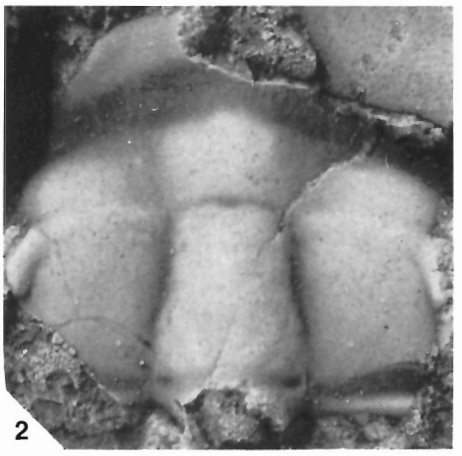
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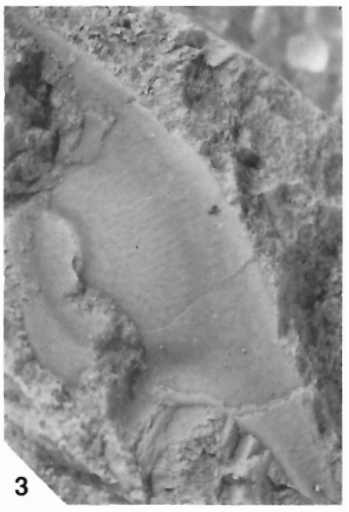
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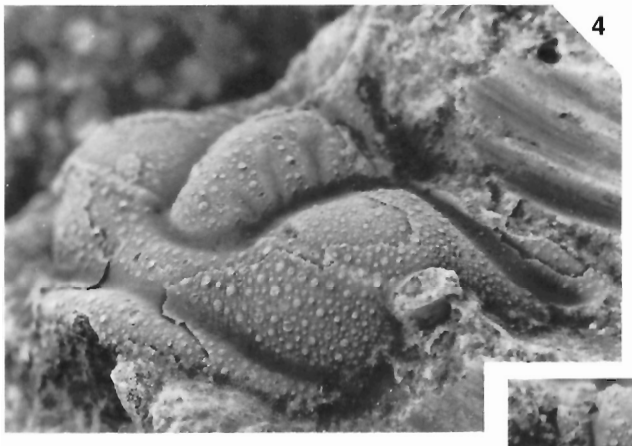
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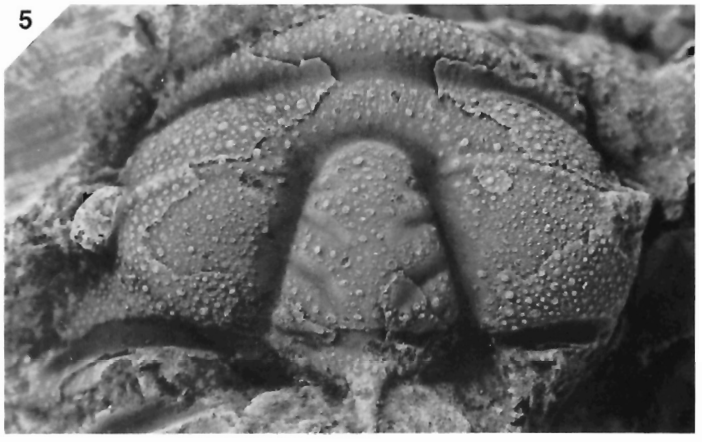
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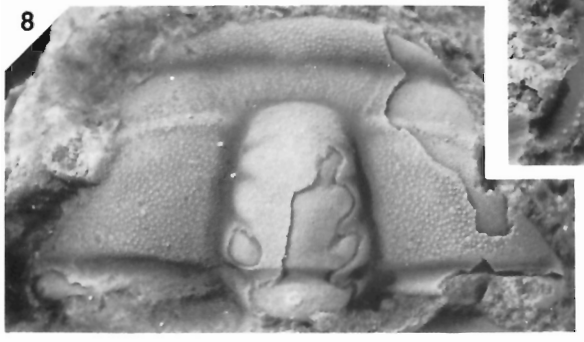
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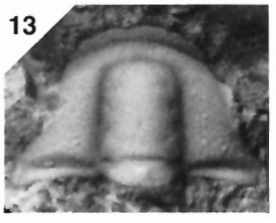
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PLATE 9

Elrathia kindlei n. sp.

1, 2. Cranidium (E), holotype, dorsal and oblique anterior views, x 12.0, boulder 380, GSC 77388.

3. Pygidium (T), dorsal view, x 12.0, boulder 380, GSC 77389.

4. Cranidium (T), dorsal view, x 12.0, boulder 358, GSC 77390.

5, 6. Cranidium (T), dorsal and oblique anterior views, x 8.5, boulder 358, GSC 77391.

7. Pygidium (T), dorsal view, x 11.0, boulder 358, GSC 77392.

Elrathina parallela Rasetti, 1951.

8. Cranidium (T), dorsal view, x 16.0, boulder 363, GSC 77393.

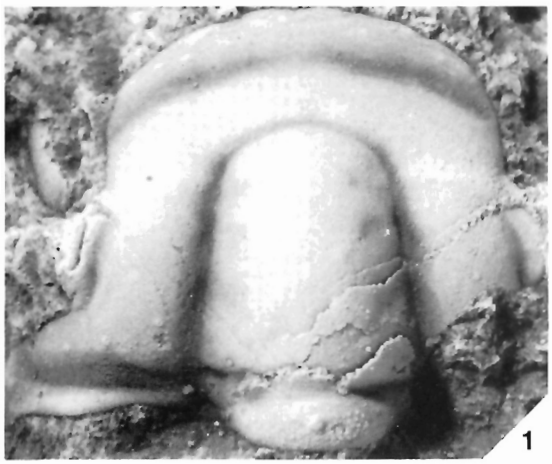
9, 10. Cranidium (T), oblique anterior and dorsal views, x 10.0, boulder 376, GSC 69503.

11. Cranidium (T), dorsal view, x 24.0, boulder 269, GSC 77394.

12, 13. Cranidium (T), lateral and dorsal views, x 7.0, boulder 375, GSC 77395.

Eoptychoparia convexa Rasetti, 1963.

14. Cranidium (T), dorsal view, x 12.0, boulder 358, GSC 77396.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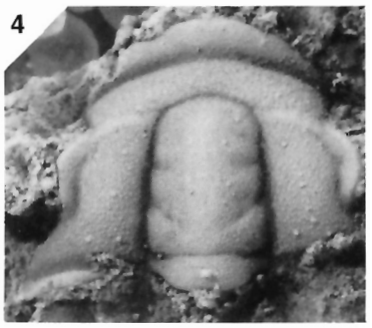
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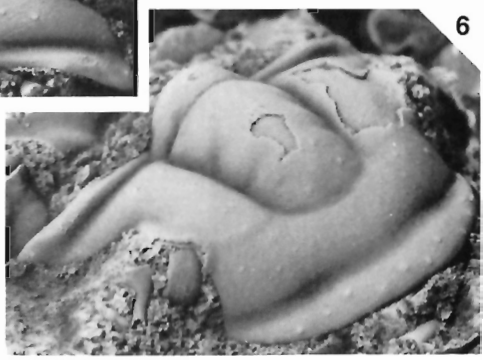
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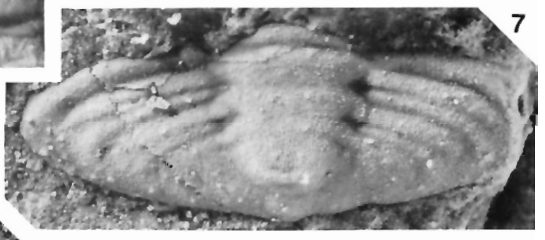
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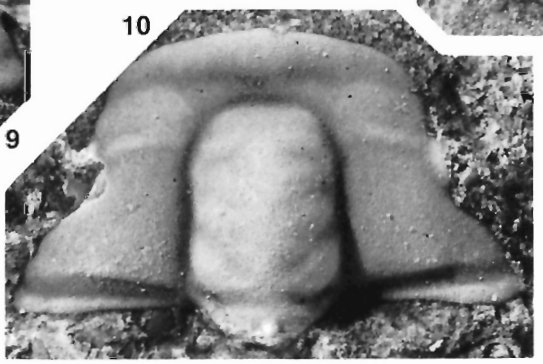
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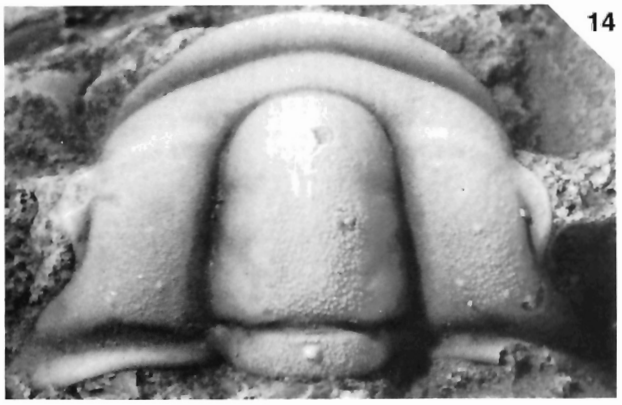
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PLATE 10

Eoptychoparia convexa Rasetti, 1963
(All from boulder 358).

1. Cranidium (T), dorsal view, x 12.0, GSC 77397.

2. Pygidium (T), dorsal view, x 11.0, GSC 77398.

3, 4. Cranidium (T), dorsal and oblique anterior views, x 13.0, GSC 77399.

Onchocephalites spinulosus Rasetti, 1963.

5. Cranidium (T), dorsal view, x 12.0, boulder 350, GSC 77400.

6, 7. Cranidium (E), dorsal and oblique anterior views, x 8.5, boulder 376, GSC 77401.

8. Cranidium (T), dorsal view, x 10.0, boulder 351A, GSC 77402.

9. Cranidium (E), dorsal view, x 8.5, boulder 376, GSC 77403.

10, 11. Cranidium (T), dorsal and lateral views, x 10.0, boulder 378, GSC 77404.

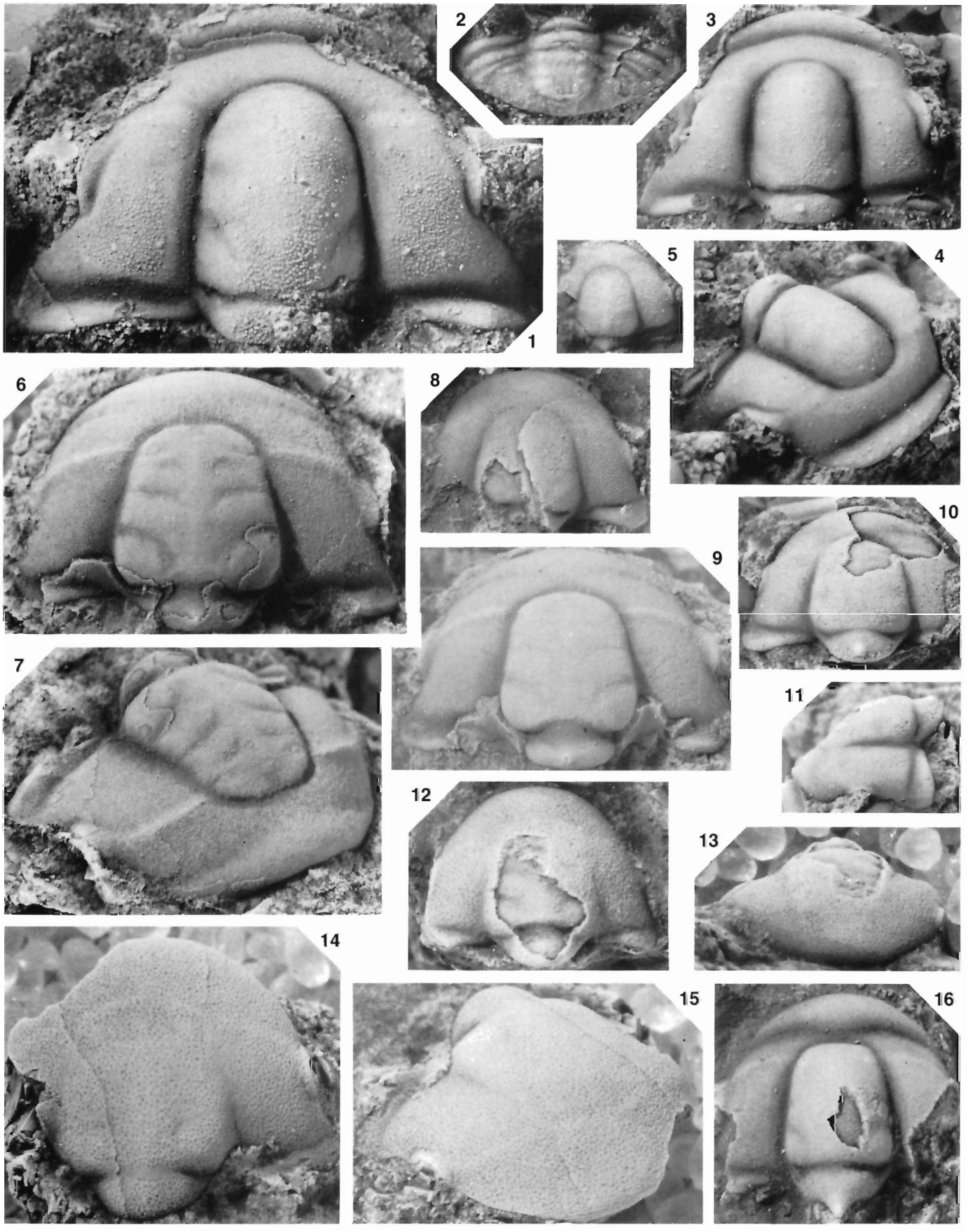
Onchocephalites punctatus Rasetti, 1963
(Both from boulder 272; x 12.0).

12, 13. Cranidium (T), dorsal and anterior views, GSC 77405.

14, 15. Cranidium (T), dorsal and oblique anterior views, GSC 77406.

Spencella spinosa Rasetti, 1963

16. Cranidium (T), dorsal view, x 13.0, boulder 272, GSC 77407.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