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BULLETIN 212

**LOWER CAMBRIAN TRILOBITES
FROM THE SEKWI FORMATION TYPE SECTION,
MACKENZIE MOUNTAINS, NORTHWESTERN CANADA**

W. H. Fritz

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NORTHWESTERN CANADA

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BULLETIN 212 — Frühkambrische Trilobiten aus
dem Typprofil der Sekwi-Formation in den Mac-
kenzie Mountains (Nordwest-Kanada)
Von W. H. Fritz

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У. Х. Фриц

PREFACE

Research in systematic paleontology is one of the means by which the Geological Survey of Canada provides data for the standardization of the geological time scale so necessary for precise chronology and correlation of the rocks that make up the geological framework of Canada.

Towards establishing a Lower Cambrian zonation the author of this bulletin has studied numerous collections of trilobites obtained in sequence from an unusually fossiliferous section exposed in the Mackenzie Mountains. Dr. Fritz' research has shown that these trilobite faunas provide an unusually complete and varied sequence representing this part of geological time. This study is valuable because it will contribute to the more accurate understanding and delimitation of Lower Cambrian rocks, not only in Yukon Territory, where deposits of lead and zinc occur in rocks of this age, but also in other parts of the world.

Y. O. FORTIER,

Director, Geological Survey of Canada

OTTAWA, May 7, 1971

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LOWER CAMBRIAN TRILOBITES FROM THE SEKWI FORMATION TYPE SECTION, MACKENZIE MOUNTAINS, NORTHWESTERN CANADA

Abstract

Trilobites from the 2,350-foot type section of the Sekwi Formation, Mackenzie Mountains, were collected from 47 horizons and placed in three zones. The oldest is the *Fallotaspis* Zone (new), recognized in western Canada, California, and Morocco and correlated with the oldest trilobite assemblage in Siberia. Next is the *Nevadella* Zone (new), which can be recognized at various localities in western North America and probably represents the approximate equivalent of the *Callavia* Zone of the Atlantic Faunal Province. The youngest zone, the *Bonnia-Olenellus* Zone, has been defined by Rasetti (1951) and is in concept the same as the *Olenellus* Zone. For the past 80 years, this zone has been equated generally and incorrectly with the whole of the Lower Cambrian in the Pacific Faunal Province. The *Bonnia-Olenellus* Zone is, at least in part, equivalent to the *Protolenus* Zone of the Atlantic Faunal Province.

Twenty-four genera are present including the following which are new: *Bradyfallotaspis*, *Holmiella*, *Keeleaspis*, *Nehanniaspis*, *Parafallotaspis*, *Sekwiaspis*, and *Variopelta*. Fifty-seven species are described, of which 5 were previously known, 29 are new, and 23 are unnamed.

Résumé

Des trilobites de la section-type de 2,350 pieds de longueur de la formation de Sekwi, dans les monts Mackenzie, ont été recueillis dans 47 horizons et classés dans trois zones. La plus ancienne est la zone à *Fallotaspis* (nouvelle), mise à jour dans l'Ouest canadien, en Californie et au Maroc, et dont la corrélation a été établie avec les trilobites les plus anciens de Sibérie. La suivante, est la zone à *Nevadella* (nouvelle), reconnue ailleurs en Amérique du Nord et qui représente probablement l'équivalent approximatif de la zone à *Callavia* de la province faunique de l'Atlantique. La zone la plus récente est celle des *Bonnia-Olenellus*, identifiée par Rasetti en 1951 et qui est similaire à la zone à *Olenellus*. Cette zone a été généralement mais incorrectement liée au Cambrien inférieur de la province faunique du Pacifique depuis 80 ans. La zone à *Bonnia-Olenellus* équivaut, du moins en partie, à la zone à *Protolenus* de l'Atlantique.

Les fouilles ont mis à jour 24 genres de trilobites, dont les suivants sont nouveaux: *Bradyfallotaspis*, *Holmiella*, *Keeleaspis*, *Nehanniaspis*, *Parafallotaspis*, *Sekwiaspis* et *Variopelta*. Le présent texte décrit 57 espèces, dont cinq déjà connues, 29 nouvelle et 23 innommées.

Introduction

As a result of many discussions with H. Gabrielse of the Geological Survey of Canada on the Cambrian of western Canada it became obvious that a major stratigraphic section should be collected in detail to establish a definitive Lower Cambrian trilobite succession for the northern Cordillera. The type section of the Sekwi Formation was chosen and in the summer of 1965 the section was studied in detail with field support provided by Dr. Gabrielse, one of whose field assistants, R. C. Handfield, located the various lithologic contacts described in his paper (1968) on the type Sekwi. Collecting was by the author and his field assistant, J. R. Thomas.

In the laboratory, K. C. Toth assisted in cleaning the specimens. Photography was by the author using a 35 mm, single lens reflex camera following techniques suggested by D. H. Massie of the U. S. Geological Survey. The fossils and photographs were taken to the U. S. National Museum where G. A. Cooper and F. J. Collier, both of the Smithsonian Institution, assisted in locating type material for comparison. Similar comparisons were made at Laval University where R. Bureau helped to locate types. Replicas of other types were provided by A. R. Palmer, State University of New York at Stony Brook, C. Poulsen, Mineralogical and Geological Museum, Copenhagen, P. D. Lane, Sedgwick Museum, Cambridge, and I. Strachan, University of Birmingham, England. Discussions on olenellids were held with Dr. J. W. Price, North Museum, Lancaster, Pennsylvania, and with L. D. Campbell, graduate student, Franklin and Marshall College. The manuscript was read by W. T. Dean, A. R. Palmer, and F. Rasetti. Grateful appreciation is extended to all who assisted in this work.

The trilobites described are from a single stratigraphic section (Fig. 1) in the Mackenzie Mountains, District of Mackenzie, Northwest Territories (lat. $63^{\circ}31'$, long. $128^{\circ}41'$). They are from the type section (Handfield, 1968) of the 2,350-foot Sekwi Formation in overturned strata at the south end of the Sekwi Range.

Access to the section is facilitated by the proximity of June Lake (Sekwi Mtn. sheet 105 P), where a float plane can be landed 1.3 miles to the southeast. An unnamed stream (Handfield, 1968, Fig. 3, right foreground) leads north-northwest from midway along the lake's north shore into the Sekwi Range and passes close to the section. About a mile upstream, the trunk stream is intersected by two closely spaced intermittent streams entering from the west-northwest. Their courses are parallel and about one quarter of a mile apart. Most of the section is on the ridge between the parallel streams, and the top of the overturned section is half a mile from the trunk stream. From the top, the section can be studied by measuring upward (downsection) along the ridge crest and continuing west-northwest in a straight line off the small ridge and upward onto the flank of a large, northwest-trending ridge. The base of the Sekwi Formation (Handfield, 1968, Fig. 3, A-C contact) is near the crest of the large ridge at an elevation of just over 7,000 feet.

The section route is one ridge (one quarter mile) north of the section used by Handfield (1968, pp. 15-18) to describe the type Sekwi. Although there is no appreciable lithologic



FIGURE 1. Index map showing the location of the type section of the Sekwi Formation.

change between the two sections, the one described in this paper was preferred because of better exposures, particularly of the youngest Sekwi beds.

Stratigraphy

Handfield (1968) described the Sekwi Formation in detail, and measured a thickness of 2,525 feet at the site of the type section; the writer measured a thickness of 2,350 feet at the present section. Using footages from the present section, the Sekwi can be divided into three units (*see also* Fig. 3): (1) a basal 735-foot unit of thin, wavy-bedded, light blue-grey weathering limestone, finely crystalline and medium grey on fresh surfaces; (2) a 675-foot unit of medium- to thick-bedded, orange weathering dolomite, light grey and finely crystalline on fresh surfaces; and (3) an upper 940-foot unit of limestone similar to that in the basal unit except for the bedding which is medium and thick in some intervals.

The Sekwi has a sharp basal contact and is underlain by an unnamed formation consisting of medium brownish grey weathering siltstone and sparse interbeds of rusty light brown weathering quartzite. Above the contact is 14 feet of medium-bedded, glauconitic limestone. Glauconite is not present higher in the formation.

An unconformity at the top of the Sekwi could not be precisely located. It lies within a 61-foot barren interval between the highest Lower Cambrian fossil locality (GSC loc. 73075) and the next overlying locality (GSC loc. 73076), which belongs to the late Middle Cambrian *Bolaspidella* Zone. The top of the Sekwi is arbitrarily drawn midway between the two localities.

Biostratigraphy

Until recently, most workers have equated the Lower Cambrian in the Pacific Faunal Province with the range of *Olenellus*, in accordance with a concept put forth in 1890 by C. D. Walcott. Walcott later (1910, p. 306) established the type Lower Cambrian or "Waucoban," in southeastern California and southwestern Nevada where part of the mountain ranges bordering Saline Valley served as type outcrops.

In 1964 Nelson and Hupé announced the discovery of pre-*Olenellus* trilobites in the White-Inyo Mountains of southeastern California. They did not propose a change in the existing Lower Cambrian zonation, but clearly demonstrated a need for at least two additional zones in the Pacific Province: one to accommodate the oldest trilobite assemblage, which Nelson and Hupé recognized as being the same as the oldest assemblage in Morocco (1964, p. 621); and a second zone to accommodate the assemblage above the trilobites of Moroccan aspect and below the first occurrence of *Olenellus*.

The trilobites described in this paper can be grouped into the same major faunules that succeed each other in the White-Inyo Mountains. They have been placed therefore in three zones, two of which are new. The oldest zone is a grouping of Hupé's (1952) Zones I through IV from Morocco. No attempt is made to redesignate the type area from the Anti Atlas Mountains of North Africa where the major faunule was first described. The type area of the next youngest zone (*Nevadella* Zone) is considered to be the type Sekwi as described in this paper. No type area is designated for the *Bonnia-Olenellus* Zone because of questions as to priority, and because no known area contains a complete development of the zone. The writer, however, would rate the type Sekwi as one of the most valuable reference sections for the zone.

In the newly proposed zonal scheme, trilobite genera are used as the principal terms of reference. The ranges of species are shown in detail on Figure 3 (*in pocket*), where various

TYPE SEKWI DISTRICT OF MACKENZIE	NORTHERN CARIBOO MOUNTAINS, BRITISH COLUMBIA	WHITE-INOY MTS. S. E. CALIFORNIA	COMLEY SHROPSHIRE ENGLAND	ANTI ATLAS MTS. MOROCCO	SIBERIAN PLATFORM
this paper	unpublished	interpreted from Nelson and Durham 1966	Cobbold, 1921, 1927	Hupé, 1952	Khomentovskiy and Repina, 1965
Middle Cambrian	Upper Cambrian	Middle Cambrian	Middle Cambrian	Middle Cambrian	Middle Cambrian
— unconformity —	— unconformity —	— unconformity —	— unconformity —	— unconformity —	— faunal position uncertain —
<i>Bonnia- Olenellus</i> Zone	<i>Bonnia- Olenellus</i> Zone	<i>Bonnia- Olenellus</i> Zone	<i>Protolenus</i> Zone	Zones 7, 8	Elanka through Taryna Horizons
<i>Bonnia Olenellus Laudonia</i>	<i>Bonnia Olenellus Laudonia</i>	<i>Bonnia Olenellus Laudonia</i>	<i>Strenuella Protolenus</i>	<i>Strenuella Kingaspis Micmacca</i>	
<i>Nevadella</i> Zone	<i>Nevadella</i> Zone	<i>Nevadella</i> Zone	<i>Callavia</i> Zone	Zones 5, 6	Atdeban Horizon
<i>Nevadella Bradyfallot- aspis Holmiella</i>	<i>Nevadella Judomia</i>	<i>Nevadella Judomia?</i>	<i>Callavia Nevadella</i>	<i>Antiatlasia Callavia Gigantopygus</i>	<i>Judomia</i>
<i>Fallotaspis</i> Zone	<i>Fallotaspis</i> Zone	<i>Fallotaspis</i> Zone	unnamed zone	Zones 1-4 (<i>Fallotaspis</i> Zone)	Kenyada Horizon
<i>Parafallotaspis</i>	<i>Fallotaspis?</i>	<i>Fallotaspis Daguinaspis</i>	<i>Fallotaspis?</i>	<i>Fallotaspis Daguinaspis</i>	<i>Fallotaspis Profallot- aspis</i>

FIGURE 2. Lower Cambrian correlation chart. The three North American areas shown at the left are located on Figure 1.

species have been arranged in order of first occurrence. As far as space allows, species also have been arranged on Plates 1–20 in the same order.

On Figure 2 an attempt is made to correlate the present Lower Cambrian zonation for the North American Province with major biostratigraphic subdivisions in other provinces. Dashed lines indicate a degree of uncertainty as to boundary levels; trilobite correlations between Lower Cambrian faunal provinces are far from precise.

Fallotaspis Zone

The oldest zone in the Sekwi type section is the *Fallotaspis* Zone, which is based on an assemblage of trilobites described by Hupé (1952) from the Anti Atlas Mountains of Morocco. This assemblage is dominated by the genus *Fallotaspis* and is particularly useful for wide correlation (Fig. 2). Hupé divided the assemblage into Zones I through IV (considered as subzones by the writer) and based his zones on the presence of certain species.

Nelson and Hupé (1964, p. 621) noted that *Fallotaspis* is present in the middle of the Campito Formation in the White-Inyo Mountains of southeast California. In both Morocco and California *Fallotaspis* is accompanied by *Daguinaspis*, which lends credibility to the extension of the *Fallotaspis* Zone into the North American Faunal Province. Closely overlying *Fallotaspis*-bearing beds in California are trilobites (loc. cit.; Cloud and Nelson, 1966, Fig. 2) that the writer includes in his proposed *Nevadella* Zone. In Morocco, *Callavia*, a genus similar to *Nevadella*, is reported (Hupé, 1952, p. 135) to occur in strata overlying *Fallotaspis*.

In the Canadian Cordillera, trilobites belonging to the *Fallotaspis* Zone have been found in three localities. The first is the type Sekwi where the zone is represented by *Parafallotaspis* collected 6 feet above the basal contact. The second is an undescribed section 120 miles northwest of the type Sekwi, where *Parafallotaspis* and *Fallotaspis* occur together (GSC locs. 84300–84303) near the base of the Sekwi Formation. The third is in the northern Cariboo Range, British Columbia (Fig. 1) where *Fallotaspis*? is present (GSC loc. 82768) near the base of the lower limestone member of the Mural Formation. At all these Canadian localities, trilobites assigned to the proposed *Nevadella* Zone are present in strata directly overlying the *Fallotaspis* Zone.

Strata in the Kenyada "Horizon" of the Aldan Stage in eastern Siberia can be correlated with the *Fallotaspis* Zone. It is suggested that the boundary between the Kenyada and overlying Atdaban "Horizon" of the Aldan may be equivalent approximately to the boundary between the *Fallotaspis* and proposed *Nevadella* Zone in the North American Faunal Province. Below the Kenyada–Atdaban boundary in Siberia, Khomentovskiy and Repina (1965, tables 5, 9) report *Profallotaspis* and *Fallotaspis*. Above the Kenyada–Atdaban boundary (loc. cit.) are "*Paedeumias*", *Judomia*, and *Archaeaspis*, genera which closely resemble *Nevadella* in North America. This correlation is supported by the presence of *Judomia* in beds immediately overlying *Fallotaspis* in the undescribed section 120 miles northwest of the type Sekwi. *Judomia*(?) also closely overlies *Fallotaspis* and *Daguinaspis* in the White-Inyo Mountains of California (Nelson and Durham, 1966, Fig. 1).

Beds as old as those in the *Fallotaspis* Zone may be present in the Comley Sandstone of Shropshire, England. This suggestion is based upon Hupé's (1952, p. 127) observation that a specimen (Raw, 1936, Pl. 20, figs. 3a, 3b) from the lowest trilobite horizon in the Comley may belong to *Fallotaspis*. Overlying this specimen are strata containing *Callavia* and possibly *Nevadella*. Since only one poorly preserved *Fallotaspis*-like specimen is known from the Comley Sandstone, the last correlation must be considered tentative.

Nevadella Zone

Trilobites assigned to this zone are present in localities ranging from 190 to 694 feet above the base of the type Sekwi (Fig. 3, *in pocket*). Genera from this interval that are considered diagnostic of the *Nevadella* Zone are *Bradyfallotaspis*, *Holmiella*, and *Nevadella*. *Judomia* was not found in the type Sekwi, but is considered an equally important zone indicator because of its occurrence within the zone elsewhere in the North American Cordillera.

In the northern Cariboo Mountains, British Columbia, most of the lower limestone member of the Mural Formation and part of the middle shale member belong to the *Nevadella* Zone.

To the east, in the Main Ranges of the Rocky Mountains, Walcott (1913) reported *Nevadella* in talus found in the Mumm Glacier, Alberta. The find dates part of the Gog Group as belonging to the *Nevadella* Zone, but has caused confusion (Raw, 1936, p. 250; Tasch, 1952, p. 485) as to the ranges of *Olenellus* and *Nevadella*. When Walcott reported the two genera from one locality, he clearly implied an overlap in the ranges of the genera. In reviewing Walcott's large talus collection, the writer found that *Nevadella* and *Olenellus* do not occur together on any one piece of talus, and therefore, he concludes that the genera are from different horizons. It might be added that the writer knows of no documented overlap of *Nevadella* and *Olenellus*.

Only isolated occurrences of trilobites from the *Nevadella* Zone, such as in the Addy Quartzite of Washington State (Okulitch, 1951), are known for a considerable distance south of the northern Cariboo Range. This is because much of the Lower Cambrian consists of barren quartzite known as the Gog in Alberta and British Columbia, as the Brigham in Idaho, as the Tintic in Utah, and as the Prospect Mountain in Nevada.

In the White-Inyo Mountains of southeastern California, the upper part of the Campito Formation, lower member of the Poleta Formation, and a part of the upper Poleta belong to the *Nevadella* Zone. There *Nevadella*, *Holmia*, and *Judomia*(?) (Nelson and Durham, 1966, Fig. 1) are considered by the writer to represent the *Nevadella* Zone. These fossils are underlain by trilobites in the middle Campito that are assigned to the *Fallotaspis* Zone.

Trilobite faunules that correlate with the *Nevadella* Zone have not been found in that part of the Appalachian geosyncline assigned to the Pacific Province by Wilson (1966). The lack of trilobites of this age or older is attributed to an unfavourable environment during sandstone deposition. That part of the Appalachian geosyncline assigned to the Atlantic Province by Wilson contains older faunas in a condensed section. The *Callavia* Zone trilobites of the Smith Point and Brigus Formation of southeastern Newfoundland (Hutchinson, 1962, p. 50), and *Callavia* beds in the Boston area, Massachusetts, can tentatively be correlated with the *Nevadella* Zone. One of the chief reasons for correlating the *Callavia* and *Nevadella* Zones is the presence of *Nevadella burri* (Walcott) in the *Callavia* beds near North Weymouth, Massachusetts (Walcott, 1910, p. 281).

The *Callavia* limestone in Shropshire, England, likewise can be correlated with the *Nevadella* Zone. There *Nevadella cartlandi* (Raw) is probably associated with *Callavia* (Walcott, 1910, p. 282).

The Atdaban Horizon of the upper Aldan Stage on the Siberian Platform can be correlated tentatively with the *Nevadella* Zone. *Archaeaspis*, "*Paedeumias*", and *Judomia* are genera in the Atdaban (Khomentovskiy and Repina, 1965, tables 5, 9) that closely resemble *Nevadella*. In terms of abundance, *Judomia* is one of the most important genera in the Atdaban. As mentioned above, this genus may be present in the *Nevadella* Zone in California and western Canada.

Bonnia-Olenellus Zone

The youngest Lower Cambrian zone recognized in the type Sekwi Formation, or elsewhere in the Pacific Faunal Province, is the *Bonnia-Olenellus* Zone as defined by Rasetti (1951, pp. 81-83). The base of the zone is placed here at the first appearance of *Olenellus*. The top has thus far been found to be marked by a regional unconformity (Rasetti, 1951, p. 87). Genera that are commonly present in the uppermost strata in the zone are *Antagmus*, *Bonnia*, *Olenellus*, *Onchocephalus*, and *Zacanthopsis*. In the type Sekwi trilobites assigned to the *Bonnia-Olenellus* Zone occur 1,182 to 2,319 feet above the base of the formation (see Fig. 3).

Strata in the northern Cariboo Mountains, British Columbia, that belong to the *Bonnia-Olenellus* Zone are present in part of the middle shale member and in all of the upper limestone member of the Mural Formation. An unnamed shale formation overlying the Mural also belongs in this zone.

To the east, in the Main Ranges of the Rocky Mountains, the upper part of the Gog Group belongs to this zone. Strata from the base of a thin Mural tongue (= upper Mural Member) to the top of the Gog on Mount Kerkeslin, Alberta, have been dated by fossils diagnostic of the *Bonnia-Olenellus* Zone.

In the White-Inyo Mountains of southeastern California (Nelson and Durham, 1966, Fig. 1), part of the upper Poleta Formation and all of the Harkless, Saline Valley, and Mule Springs Formations are considered by the writer to belong to the *Bonnia-Olenellus* Zone. *Olenellus* and *Laudonia* are present near the base of the zone, and *Olenellus*, *Bonnia*, and *Onchocephalus* are present near the top.

In the Atlantic Faunal Province of eastern North America, Great Britain, and Europe, the *Protolenus* Zone correlates with the *Bonnia-Olenellus* Zone. The equating of these zones is best supported by the correlation between the West Castleton Formation of the Taconic sequence in New York (Rasetti, 1966b) and a late *Protolenus* Zone faunule from the Purley Shales of Warwickshire, England (Rushton, 1966). Of particular interest in this correlation is the similarity between *Serrodiscus subclavatus* and *Acidiscus hexacanthus* from the West Castleton Formation and *Serrodiscus ctenoa* and *Acidiscus theristes* from the Purley Shales (Rasetti, 1966b, p. 6).

Correlation of the *Bonnia-Olenellus* Zone in North America with stages used in Siberia is difficult because of the wide dissimilarities between trilobites from the two regions. Palmer (1968, pp. 6-8) has noted that his three Lower Cambrian trilobite faunules from Alaska (all of which the writer believes to belong in the *Bonnia-Olenellus* Zone) correlate with a part of the Lower Cambrian of Siberia that is no older than the Botoma Stage. In the Alaska material *Polliaxis*, a genus very close to *Edelsteinaspis* from the Botoma and Lena Stages of Siberia (Komentovskiy and Repina, 1965, table 9) is found. In Canada, *Polliaxis* is present (GSC locs. 82788, 82789) in the upper limestone member of the Mural Formation in the northern Cariboo Range, British Columbia. The occurrence of *Polliaxis* in Canada is documented therefore as locally being within and well above the base of the *Bonnia-Olenellus* Zone.

In Figure 2 the writer has tentatively correlated the base of the *Bonnia-Olenellus* Zone with the base of the Botoma, and the Botoma-Lena boundary is placed within the *Bonnia-Olenellus* Zone. The correlation between the top of the *Bonnia-Olenellus* Zone and the top of the Lena is questionable.

Systematic Descriptions

Prefix GSC refers to specimens in the type collection of the Geological Survey of Canada; these type numbers appear in the plate explanations. The GSC localities are given in the text description, in the plate explanations, and on Figure 3. Unfigured trilobite material has been stored in the GSC index collections.

Descriptions and illustrations are of external surfaces of trilobite exoskeletons unless otherwise indicated. Most of the terminology and classification is in accordance with the *Treatise on Invertebrate Paleontology* (Harrington, *et al.*, 1959). In the present paper, the width of the palpebral area is the distance between the middle of the axial furrow and the middle of the palpebral furrow; the palpebral lobe is excluded. "Test" has been substituted for the more cumbersome term "dorsal exoskeleton." On olenellids, "interocular area" describes the area between the axial furrow and the eye lobe (Palmer, 1957, p. 106); "extraocular area" describes the area between the eye lobe and the lateral border furrow. Various parts of the cephalon and pygidium are said to be "insloping" or sloping "inward" rather than the more commonly used modifier "upward"; the reverse slope is said to be "outsloping" or to be sloping "outward" rather than "downward." "Fingerprint pattern" describes olenellid ornamentation consisting of low, narrow lines that are semiparallel and discontinuous.

Nearly all trilobite tests are disarticulated, and parts representing each species are listed in the descriptions under "material." The total number of individual specimens at each locality is shown on Figure 3. Each cranidium or cephalon and each pygidium is arbitrarily considered to represent one individual. Thus eight cranidia (or cephalae) and two pygidia are listed on the chart as ten individuals. If these belong to one species and are from one locality, the number 10 is placed inside the range bar approximately opposite the collecting level (GSC loc.) on the stratigraphic section. Tick marks opposite the number 10 on the outer margins of the range bar give the exact collecting level.

Family PAGETIIDAE Kobayashi

Genus *Pagetides* Rasetti

Pagetides Rasetti, 1945, p. 311; 1966a, p. 503; 1967, p. 63; Hupé, 1953, p. 57; Howell, 1959, p. 190; Lazarenko, 1959, p. 5; Pokrovskaya, 1960, p. 55; Chernysheva, 1961, p. 42; Palmer, 1968, p. 36.

Type species. Pagetides elegans Rasetti, 1945.

Discussion. Rasetti's original description and supplementary remarks (1966a, p. 503) adequately describe this genus. He has also presented criteria for separating *Pagetides* from *Pagetia*, a closely related genus. *Neopagetina*, another close genus, has been tentatively restricted by Rasetti (1966a, p. 502) to the type species *Pagetia rjonsnitzkii* Lermontova, 1940. The writer follows Rasetti in tentatively recognizing *Neopagetina* as a separate genus despite Palmer's (1968, pp. 33, 36) placement of this genus under *Pagetides*. Until *Neopagetina* is better known, its position is difficult to assess.

Pagetides spinulus sp. nov.

Plate 1, figures 9-17

Material. Forty-six cranidia 1½ to 2 mm long and forty pygidia 1½ to 2 mm long.

Description. Cranidium of medium height, curved very broadly along front margin. Glabella parallel sided, front bluntly pointed and terminating on most specimens before reaching

anterior border furrow. Two sets of shallow, broad glabellar furrows, both sets transverse, joined across glabella, posterior set deepening at distal ends causing slight indentation at glabella sides. Axial furrow of medium width and shallow. Palpebral area flat, tilted inward, distal part drops abruptly down into deep palpebral furrow. Palpebral lobes narrow (tr.) and well developed. Ocular ridges low but distinct, elevating somewhat as they approach palpebral lobes. Anterior border furrow broad and of medium depth, about as wide (exsag.) as adjacent border; transition from anterior border furrow to border gradational. Border exhibits no radial markings. Spine at rear of axis is of medium length, elevated slightly at base, extending almost horizontally back for remaining distance.

Pygidium convex. Axis consists of six rings and very small terminal piece that does not touch border furrow; each ring becomes progressively narrower (tr.) than preceding ring, anterior ring shorter (sag.) than adjacent ring; each ring bears node (more prominent on small specimens), node on anterior ring considerably higher. Pleural field marked by very faint pleural and interpleural furrows. Border furrow of medium width and depth, width approximates width of border. Border bears one to three sets of very small, short spines at lateral margin of pygidium. Ornamentation lacking on cranidium; pygidium marked by granules in transverse row across each of five posterior axial rings, in irregular rows at margin of interpleural furrows, and in random distribution on border.

Discussion. This species is placed in *Pagetides* rather than *Pagetia* because it lacks both radial markings on the anterior cephalic border and a spine on the terminal piece of the pygidium. It is probably the oldest species of *Pagetides* yet described from North America. *Pagetides spinulus* resembles *Pagetia connexa* (Walcott, 1877) and *Pagetides minutus* Rasetti, 1945. It differs from *P. connexa* in having a cranial axis with less forward taper, no radial markings on the anterior border, and visible furrows on pleural areas of adult specimens. *P. spinulus* differs from *P. minutus* in having eye ridges, no medial swelling or radial markings on the anterior border, furrows on the pleural field of adult specimens, and a wider pygidial border. *P. spinulus* differs from all known species of *Pagetides* and *Pagetia* in having spines on the pygidial border.

Occurrence. Nevadella Zone, GSC locs. 73026, 73027, 73030, 73032–73034, 73036–73039.

Pagetides? sp. 1

Plate 8, figures 13, 14

Material. One pygidium 1½ mm long.

Description. Pygidial outline and general construction very similar to that of *Pagetides spinulus* sp. nov. Axis wide, rapidly tapering toward rear, first two rings probably bear large nodes (broken?), remaining four lack both spines and nodes, terminal piece touches border furrow. Pleural field faintly marked by interpleural furrows and single line of granules closely paralleling furrows on either side. Border flat, horizontal, of medium width, and bearing four sets of very small spines. Transverse row of granules on posterior four sets of axial rings.

Discussion. A wider, more rapidly tapering axis that extends back to the border furrow differentiates this pygidium from that of *Pagetides spinulus* sp. nov.

Occurrence. Nevadella Zone, GSC loc. 73036.

Genus *Yukonides* gen. nov.

Type species. Yukonides lacrinus sp. nov.

Diagnosis. Cephalon and pygidium like those of *Pagetia* and *Pagetides* except for following differences: eye ridges extend to eye tubercles on lateral margin of cephalon (and therefore no librigenae present), pygidium has narrow axis that tapers rapidly toward rear, pygidial border bearing spines or nodes.

Discussion. This genus resembles *Yukonia* Palmer, 1968 in having eye tubercles, in lacking librigenae, and in having small spines or nodes on the pygidial border. The cranidium differs from that of *Yukonia* in having a smaller, lower axis and in the position of the eye tubercles which are on rather than near the cephalic margin. The pygidium differs in being less transverse, and in lacking an unusually large spine near the middle of the axis. One species that may belong to this genus has been figured by Lazarenko (*in* Datsenko, *et al.*, 1968, Pl. 20, figs. 7-14) as *Calodiscus* ex gr. *schucherti* (Matthew). The species in question is from outcrops on Lena River, Siberia, that have been assigned (Zhuravleva, loc. cit., p. 149) to the Botoma Stage.

Yukonides lacrinus sp. nov.

Plate 8, figures 1-12

Material. Twenty-four cephalon $1\frac{1}{4}$ to $2\frac{1}{2}$ mm long and twenty-three pygidia $1\frac{1}{4}$ to $2\frac{1}{2}$ mm long.

Description. Cephalon low and wide for pagetiid. Glabella small, sides taper slightly forward, front pointed. Glabellar furrows consist of one set of slight indentations just posterior to eye ridges and one set of slit-like depressions centred opposite glabellar midpoint and closely paralleling axial furrow. "Palpebral" and posterior area low except for small but sharp rise near centre of combined areas. Eye ridges low, of medium strength, narrowing across lateral border furrow, terminating at bead-like eye tubercle on border and overlapping it on either side. Anterior border furrow broad, slightly deeper just anterior to glabella. Anterior and lateral borders narrow, poorly differentiated from border furrow, marked by very small pits. Posterior border widens distally. Occipital ring drawn back into spine without abrupt rise in axial profile; cross-section of spine is elongate in vertical direction, length unknown (broken).

Pygidium has medium convexity. Axis composed of six rings bearing spines and small terminal piece that does not reach border furrow. Pleural fields on some pygidia very faintly marked by furrows. Border furrow has uniformly moderate depth and width. Border narrow, somewhat rounded in cross-section and outslipping. Up to four sets of small spines or swellings on border. Surface of cephalon and pygidium rather rough but not distinctly granular.

Discussion. The differences between this species and *Yukonia intermedia* Palmer, 1968, the only species at present assigned to *Yukonia*, are as mentioned in the generic discussion. The species figured by Lazarenko as *Calodiscus* ex gr. *schucherti* (Matthew) has not been seen by the writer. Figures suggest that it differs from *Y. lacrinus* in having more relief at the inner margin of the cephalic anterior border and much deeper furrows on the pygidial pleural field.

Occurrence. Nevadella Zone, GSC locs. 73034, 73035, 73037, and 73038.

Family OLENELLIDAE Vogdes, 1893

General Remarks on the Relationship between the Type Species Olenellus, and Paedeumias

Dr. John Price, North Museum, Lancaster, Pennsylvania, and L. D. Campbell (see also Kauffman and Campbell, 1969) have expressed to the writer their belief that the type species of *Paedeumias*, *P. transitans* Walcott, 1910, is conspecific with the type species of *Olenellus*, *O. thompsoni* (Hall, 1859). They conclude that this is a valid reason to suppress *Paedeumias* in favour of *Olenellus*, and the writer agrees. Supporting their conclusion is the fact that the two types are similar and come from the same locality in Vermont. Others (Raw, 1927, p. 137; Raymond, 1928a, p. 169) noted that *O. thompsoni* and *P. transitans* are conspecific, but they did not argue for the suppression of *Paedeumias*.

The Vermont association, in which "*P. transitans*" is a younger growth stage of *O. thompsoni*, is repeated many times in collections from various localities near York, Pennsylvania. Although Walcott (1910) recognized *O. thompsoni* in the York area, Price and Campbell (oral com.) point out that the local distribution was unnecessarily masked when Resser and Howell (1938) wrongly split *O. thompsoni* into eight species. After reviewing the species, the writer agrees with Price and Campbell that the following species should be suppressed in favour of *O. thompsoni*: Resser and Howell's 1938 species *Olenellus alius*, *Paedeumias ebora-cense*, *P. glabrum*, *O. jonasaе*, *O. nitidus*, *O. rodnyi*, *O. similaris*, *P. yorkense*, and also *O. getzi* Dunbar, 1925.

For additional discussions on the relationship between *Olenellus* and *Paedeumias*, see papers by Bell (1931), Best (1952), Riccio (1952), Shaw (1955), Palmer (1957), Poulsen (1959), and Cowie (1968).

Genus *Olenellus* Billings

- Olenellus* Billings, 1861, p. 11; Walcott, 1910, p. 311 [synonymy to date]; Resser, 1928, p. 3; Bell, 1931, pp. 1-22; Poulsen, 1932, p. 35; 1959, p. 192; Resser and Howell, 1938, p. 217; Lake, 1937, p. 236; Størmer, 1939, p. 242; Shimer and Shrock, 1944, p. 613; Kindle and Tasch, 1948, p. 135; Riccio, 1952, pp. 29, 33; Hupé, 1953, p. 73; Shaw, 1955, p. 790; Raw, 1957, p. 149; Pokrovskaya, 1959, p. 157; Suvorova, 1960, p. 62.
- Fremontia* Raw, 1936, p. 243; Harrington, 1956, p. 57; Poulsen, 1959, p. 192.
- Mesonacis* Walcott, 1885, p. 328; 1910, p. 261 [synonymy to date]; Resser, 1928, p. 5; Bell, 1931, pp. 1-22; Kobayashi, 1935, p. 117.
- Paedeumias* Walcott, 1910, p. 304; Raw, 1927, p. 137; 1936, p. 242; Raymond, 1928a, p. 169; Resser, 1928, p. 4; Bell, 1931, pp. 1-22; Poulsen, 1932, p. 36; 1959, p. 192; Resser and Howell, 1938, p. 225; Shimer and Shrock, 1944, p. 615; Lermontova, 1951, p. 46; Riccio, 1952, p. 30; Best, 1952, p. 15; Palmer, 1957, pp. 124, 126; Suvorova, 1960, p. 62; Öpik, 1961, p. 419; Cowie, 1968, p. 13.

Type species. Olenus thompsoni Hall.

Diagnosis. Cephalon low, outline in plan view is half circle, length slightly greater than half width. Axis low, sides constricted slightly at posterior glabellar furrow, usually expanding at anterior glabellar lobe where elevation increases, front terminating against or near anterior border furrow on most specimens, farther back on some species which may or may not have preglabellar ridge or ridges. Three pairs of glabellar furrows present, anterior two pairs usually arcuate and shallow, posterior pair nearly straight and inclined toward the rear. Occipital furrow closely resembles posterior glabellar furrow: occipital spine very short. Eye lobes arcuate, medium to long; lobe defines an interocular genal area that is much narrower (tr.) than extraocular genal area. Border of narrow to medium width, extending back without appreciable change in curvature to genal spines. Posterior border

directed nearly straight out from axis, marked by slight swelling or very small spine at intergenal position, remaining section directed out to genal spine in normal position, or slightly forward to spine that is slightly advanced.

Thorax consists of fifteen segments, third segment macropleural, fifteenth bearing large axial spine. Opisthothorax may be present but rarely preserved. Pygidium very small. Ornamentation usually consists of fingerprint pattern and venation on genae; light reticulate network rarely present.

Discussion. Three genera that have received numerous species of *Olenellus* are *Mesonacis*, *Paedeumias*, and *Fremontia*. *Mesonacis* has been dropped as a junior synonym of *Olenellus* (see Resser and Howell, 1938, p. 217). *Paedeumias* has been found by some workers (Bell, 1931, p. 11; Best, 1952, pp. 15, 16; Shaw, 1955, p. 791) to lack the morphologic features necessary to separate it from *Olenellus*. The writer agrees with these workers, and also favours the suppression of *Paedeumias* because the type species is conspecific with the type species for *Olenellus* (see p. 11). *Fremontia* is dropped in this paper because the genus is based on criteria that do not effectively separate it from *Olenellus*. The slightly advanced genal spines and short eye lobes attributed to *Fremontia* are not morphologic features that develop in unison, and by using various species of *Olenellus* either feature can be demonstrated to range in position or size without a significant break. Finally, with increasing size most species of *Olenellus* have eye lobes that become relatively shorter and genal spines that advance somewhat forward.

Fremontella and *Bristolia* are the closest genera to *Olenellus*. Genal spines on these genera are far advanced from the genal angles, and therefore provide a criterion that can be used to distinguish them from *Olenellus*.

Olenellus altifrontatus sp. nov.

Plate 18, figures 14-17

Material. Two cephalons 7 and approximately 18 mm long.

Description. Cephalon of medium convexity except for unusually high relief of anterior glabellar lobe. Axis contracts slightly from rear margin to posterior pair of glabellar furrows, expands moderately to intersection of axial furrows with furrow at inner margin of eye lobes, then contracts rapidly to base of anterior glabellar lobe. Anterior glabellar lobe very large, nearly circular in plan view, very high at front where it terminates against anterior border furrow. All three pairs of glabellar furrows cross axial midline, anterior pair inclined slightly back, medial pair nearly transverse, posterior pair inclined moderately back; occipital furrow resembles posterior pair of glabellar furrows. On small cephalon (7 mm) medial node present on posterior two lobes of glabella. Eye lobes swept strongly back, terminating opposite occipital furrow on medium-sized cephalon (± 18 mm). Genae moderately convex (tr.). Anterior and lateral border furrows of medium depth and narrow; adjacent border moderately convex in cross-section, narrow, and tilted outward.

Posterior border on small cephalon (7 mm) directed out and moderately back to intergenal spine located three-fourths border length from axis, remainder of border inclined slightly forward. Length of occipital spine and genal spines unknown (broken). Ornamentation consists of irregular "granules" on anterior glabellar lobe and radial venation on genae.

Discussion. Material from California that Walcott (1910, p. 314, Pl. 40, figs. 12, 13, 15, 15a, 16; non fig. 14) assigned to "*Olenellus*" *argenteus* resembles this species in having an axis

with a similar furrow pattern, a large, round anterior lobe, and a granular ornamentation. However, the narrow extraocular genal area, wide lateral border, and closely set intergenal spines of "*O.*" *argenteus* differ from the present species and are not found on other species assigned to *Olenellus*. "*O.*" *argenteus* should be placed under *Holmia*, or at least be questionably assigned to that genus until more parts are found.

A species from Vermont described by Kindle and Tasch (1948, p. 136) as *Olenellus hermani* has some resemblance to *O. altifrontatus*. *O. hermani* is known from two partial cephalons that differ from the present species in having a spine near the rear margin of the anterior glabellar lobe and much smaller eye lobes.

Occurrence. *Bonnina-Olenellus* Zone, GSC loc. 73071.

Olenellus laxocules sp. nov.

Plate 11, figures 7-21

Material. Thirty-three cephalons 2 to 13 mm long and two hypostomata.

Description. Cephalon broadly convex in cross-section (tr.), in plan view curvature much stronger at front than at sides. Axis between rear and base of eye lobes nearly parallel and only slightly constricted at posterior glabellar furrows, slightly wider immediately ahead of eye lobes, front strongly rounded to blunt-pointed and terminating before reaching anterior border furrow. Anterior two pairs of glabellar furrows parallel, very shallow and arcuate, averaging transverse; posterior pair of furrows shallow, inclined back, broadly arcuate. Three to five preglabellar ridges present on larger cephalons, two to three on small cephalons. Eye lobes strongly swept back, marked by shallow longitudinal furrow, terminating opposite distal ends of occipital furrow. Intraocular area very small. Anterior and lateral borders of medium width, convex in cross-section, average slope is inward; posterior border slightly narrower, flat, directed transversely, width fairly uniform. Genal spines of medium length, directed straight back on medium-sized specimens, inclined slightly outward on large specimens; metagenal spine located three-fifths distance out from proximal end of posterior border. Occipital furrow consists of two distal segments that are shorter, deeper, and inclined less strongly back than adjacent set of glabellar furrows. Occipital ring bears very small spine on posterior margin.

Small hypostoma has broadly curved front margin, sides moderately converging toward rear. Maculae widest and deepest at distal ends, not joined across axial midline. Posterior border marked by six (?) pairs of spines and one medial spine. Ornamentation on cephalons consists of fingerprint pattern, weak reticulate pattern on axis, and radiating venation on genae. Anterior and lateral borders have "terrace" lines arranged in crude chevron pattern with apices pointed forward. Hypostoma marked by fine, densely spaced fingerprint pattern.

Discussion. Eye lobes positioned close to the glabella and a bluntly pointed glabellar front distinguishes *O. laxoculus* from most species placed under *Olenellus*. *Olenellus simplex* Poulsen, 1932, has similar eye lobes, but the glabellar front on this species is farther forward and more broadly rounded. Genal spines on *O. simplex* differ by being slightly advanced. Incomplete olenellid cephalons assigned by Poulsen (1958) to *Olenellus troelseni* and *Paedeumias groenlandicus* have eye lobes set close to the glabella, but exhibit numerous characters suggesting assignment to other genera such as *Nevadella* or *Judomia*.

Occurrence. *Bonnina-Olenellus* Zone, GSC loc. 72049.

Olenellus paraoculus sp. nov.

Plate 15, figures 8–22

Material. Forty-eight cephalae 1 to 25 mm long.

Description. Cephalon very broadly convex in cross-section (tr.), local relief medium along margin of anterior glabellar lobe. Axis narrows slightly from back of occipital ring forward to posterior pair of glabellar furrows, then expands moderately to medial pair of glabellar furrows before contracting to base of eye lobes. Axis immediately in front of eye lobes considerably wider than greatest width in back, front margin broadly curved and terminating against anterior border furrow. Anterior two pairs of glabellar furrows very shallow, arcuate, averaging transverse, and not reaching axial furrow on most specimens. Posterior pair of glabellar furrows and distal segments comprising occipital furrow nearly straight, parallel, of medium depth, and inclined moderately back. Eye lobes marked by longitudinal furrow, terminating opposite distal ends of occipital furrow, and swept so strongly back that inner margins lie against or nearly against axial furrow. Anterior and lateral border of medium width, moderately convex in cross-section, average slope is slightly outward. Posterior border nearly straight, transverse to inclined slightly back, bearing small intergenal spine short distance inward from point two-thirds border length from axial furrow. Occipital ring bearing small spine on posterior margin. Small hypostoma bears medial spine on posterior margin and approximately eight pairs of spines on posterolateral margins. Ornamentation on cephalae over 5 mm long consists of fingerprint pattern on most of cephalae, faint venation on genae, reticulate meshwork on posterior part of axis, and terrace lines on anterior and lateral borders.

Discussion. Eye lobes that press against or nearly against the glabella distinguish *O. paraoculus* from most species in this genus. *Olenellus simplex* Poulsen, 1932 has similar eye lobes, but they are associated with a narrower anterior glabellar lobe that terminates farther back. Two cephalae described by Resser (1945) as *Olenellus* cf. *fremonti* Walcott have axes and eye lobes similar to those of *O. paraoculus*, but are too incomplete for identification at the specific level.

Occurrence. Bonnia–Olenellus Zone, GSC locs. 73058–73061, 73064, 73065.

Olenellus puertoblancoensis (Lochman)

Plate 17, figures 1–7

Paedeumias puertoblancoensis Lochman, 1952, p. 94, Pl. 19, figs. 9–16.

Material. Eighteen cephalae 3 to about 50 mm long and two partly preserved prothoraxes.

Description. Cephalon low. Axis parallel sided in gross aspect, slightly constricted at posterior set of glabellar furrows, rapidly diverging from posterior pair forward almost to point where axial furrow intersects furrow at inner edge of eye lobe, then converging rapidly to base of anterior glabellar lobe; front of axis low, strongly curved, terminating short distance from anterior border furrow and preceded by short preglabellar ridge. Anterior two pairs of axial furrows have straight proximal segments of moderate depth, anterior pair of segments inclined moderately toward rear, second pair slightly toward rear; distal segments of anterior two pairs of furrows very shallow, these segments (where visible) combine with proximal segments to produce chevron pattern. Posterior pair of glabellar furrows straight, inclined back at about same angle as proximal segments on anterior pair of glabellar furrows. Occipital

furrow confined to distal segments which are inclined slightly back; occipital ring bears small spine on posterior margin. Eye lobes long, marked by shallow longitudinal furrow, terminating very close to posterior border and opposite midpoints on lateral margin of occipital ring. Border furrow narrow and shallow; anterior and lateral borders narrow. Posterior border transversely directed, initially narrow, widening near middle where anterior margin bowed slightly forward, narrowing again at intergenal spine which is located eleven-thirteenths of border length from axial furrow, remaining border narrow.

Prothorax bears axial rings with short spine on posterior margins; pleurae end in short spines that are turned abruptly back; macropleurae very large with anterior pleural band becoming markedly wide (exsag.) at anterolateral position, spines at distal ends long. Ornamentation consists of terrace lines on anterior and lateral borders that cross border at low angle ($\pm 20^\circ$), fingerprint pattern over remainder of cephalon, and light radial venation on genae.

Discussion. This species is very close to *Olenellus thompsoni* (Hall, 1859). On small specimens of *O. thompsoni*, the glabellar front is farther back than it is on small specimens of *O. puertoblancoensis*, and on larger specimens the front of *O. thompsoni* is farther ahead. Intergenal spines on *O. thompsoni* are in a more distal position and the genal spines are slightly advanced. Eye lobes on *O. thompsoni* are slightly shorter than those of *O. puertoblancoensis*. *Olenellus clarki* (Resser, 1928) and *Olenellus gilberti* Meek, 1874 differ from *O. puertoblancoensis* in having eye lobes that are shorter and directed more strongly back. The extraocular area on *O. clarki* is wider (tr.). An unusually large specimen that represents *Olenellus robsonensis* (Burling, 1916) may be conspecific with *O. puertoblancoensis*, but a satisfactory comparison cannot be made because the cephalon on the holotype of *O. robsonensis* is incomplete, and the projected length is twice that of the largest *O. puertoblancoensis* cranidium available. No topotype material accompanies the holotype, which was "collected from drift block on the slope of the Mural Glacier just under Mumm Peak, Mount Robson region, British Columbia" (Burling, 1916, p. 55).

Occurrence. Bonnia–*Olenellus* Zone, GSC locs. 73068–73072.

Olenellus sequomalus sp. nov.

Plate 12, figures 14–25

Material. Twelve cephalae 2 to 19 mm long and one hypostoma.

Description. Cephalon rather convex (tr.) for genus, outline in plan view is half circle with posterolateral parts extending back across equatorial line. Glabella low, sides converging slightly in forward direction along posterior pair of glabellar lobes, diverging rapidly along next two anterior pairs to base of eye lobes, slightly wider anterior to eye lobes, and converging rapidly forward to blunt point. Glabella front low for genus, not reaching anterior border furrow, and preceded by preglabellar ridge. Anterior two pairs of glabellar furrows very shallow, chevron shaped; posterior pair of medium depth, nearly straight, inclined back more steeply than proximal segments of anterior two pairs of furrows and more steeply than distal segments comprising occipital furrow. Occipital ring bears small spine just anterior to back margin. Eye lobes marked by longitudinal furrow, lobes initially directed strongly out and curving rapidly along first half, moderately curved along remaining half, and directed back and slightly inward near ends. Eye lobes terminate just posterior to level of intersection of occipital and axial furrows. Anterior and lateral border furrows of medium depth and width throughout. Anterior and lateral borders tilted outward, of uniformly medium width;

posterior border slightly narrower (exsag.), poorly defined by shallow border furrow, bearing short intergenal spine or node four-fifths distance from axial furrow. Genal spine tapers rapidly near base, remaining part thin.

Small hypostoma has maculae steeply inclined toward rear, posterior lobe and posterior border not differentiated, medial spine present on posterior margin and six pairs of radiating spines present on posterolateral margins. Ornamentation on cephalon up to 6 mm long consists of radial venation on genae; cephalon 6, 10, and 12 mm long have anastomosing venation on axis and genae; cephalon 19 mm long have reticulate pattern on axis with granule in each polygon and fingerprint pattern grading into reticulate pattern on genae. Anterior and lateral borders on medium and large cephalon marked by terrace lines. Small hypostoma nearly smooth.

Discussion. The anterior glabella lobe and adjacent two pairs of lobes combine to give the front two-thirds of the glabella a nearly circular outline. This feature plus cephalic posterolateral margins that extend back beyond the level of the axis serve to distinguish *O. sequomalus* from most other species in this genus. *Olenellus hansenii* (Poulsen, 1932) resembles *O. sequomalus* but has narrower anterior and lateral borders, longer eye lobes situated closer to the glabella, and intergenal spines situated closer to the axis. Several small specimens that Lochman (1952, Pl. 18, figs. 6, 8) described as *Olenellus (Olenellus) truemani* resemble small specimens of *O. sequomalus*, but have intergenal spines that are closer to the axis.

Occurrence. Bonnia–*Olenellus* Zone, GSC loc. 73049.

Olenellus truemani Walcott

Plate 9, figures 1–14

Olenellus truemani Walcott, 1913, p. 316, Pl. 54, figs. 2–10; 1916b, p. 253, Pl. 17, figs. 2–10.

Olenellus (Olenellus) truemani Walcott, Lochman, 1952, p. 89, Pl. 18, figs. 6–12.

Olenellus praenuntius Cowie, 1968, p. 9, Pl. 1, figs. 1–10.

Material. Twenty-six cephalon 3 to 24 mm long and two small hypostomata.

Description. Cephalic margin uniformly curved along sides and front. Glabella sides subparallel with but slight narrowing where posterior glabella furrow intersects axial furrow, width nearly equal immediately behind and ahead of contact with eye lobes, front strongly rounded and terminating near anterior border furrow. Glabella furrows have proximal halves inclined equally toward rear; anterior two pairs nearly parallel throughout, having arcuate to chevron course along distal three-fourths; medial pair very shallow distally and not reaching axial furrow on some specimens; posterior set nearly straight along entire course. Eye lobes angle strongly back and thus remain close to glabella, terminating on medium and large specimens opposite intersection of anterior margin of occipital furrow and axial furrow, terminating farther back on small specimens. One set of faint, narrow ridges running forward from base of eye lobes along margin of anterior glabella lobe and merging with lobe near front. Anterior and lateral borders of uniformly medium width, nearly horizontal. Posterior border rather narrow and directed out and slightly back from axial furrow to small intergenal spine or node at spine positioned somewhat less than two-thirds distance out from axial furrow; remaining segment of medium width, transverse on small specimens, angling slightly forward on medium and large specimens. Genal spines of medium length, directed back and slightly outward, uniformly tapering to very slender point. Occipital furrow obsolete near middle, distal segments are slightly more transverse, shorter, wider, and deeper than posterior set of glabella furrows. Occipital ring broadly curved at posterior

margin which is interrupted by very small spine. Ornamentation on cephalon consists of radial venation on genae and fine reticulate pattern on both upper and lower surface of cephalon that exceed 12 mm in length. Hypostoma subtriangular, posterolateral margin marked by about seven sets of spines.

Thorax has small spine on each axial ring, second set of pleurae nearly as large as macropleural (third) set; all pleurae terminate in long spines that curve steeply back.

Discussion. Walcott's primary types of *O. truemani* could not be found in the U.S. National Museum. The above description was made using his topotype material and cephalon from the Sekwi collection. There is close agreement between specimens in these collections and specimens from Ellesmere Island, which Cowie (1968) assigned to *Olenellus praenuntius*. On the Ellesmere material, the anterior and medial sets of glabellar furrows join across the axial midline, and the associated large hypostoma have six sets of posterolateral spines as opposed to seven sets on a hypostoma of the same size in Walcott's collection. These differences are considered to be within the range of specific variation.

Specimens from Mexico described by Lochman (1952) as *Olenellus (Olenellus) truemani* are too incomplete for definite assignment. Cephalon in the Mexican material differ from those described above in having longer glabellar lobes, anterior and lateral borders tilted strongly inward, and fingerprint ornamentation rather than a reticulate pattern.

A species from Virginia, *Olenellus romensis* Resser and Howell, closely resembles *O. truemani*. The type lot of *O. romensis* contains only cephalic moulds in shale. The Virginia specimens differ from *O. truemani* in lacking a reticulate ornamentation and lacking a faint ridge running forward from the base of the eye lobes.

Occurrence. Bonnia–Olenellus Zone, GSC loc. 73040.

Olenellus sp. 1

Plate 10, figures 6–16

Material. Nineteen cephalon 3 to 16 mm long and four hypostomata.

Description. Cephalon like that of *Olenellus puertoblancoensis* except for the following differences: (1) anterior glabellar lobe rounded at front, (2) no preglabellar ridge present, (3) eye lobes terminating opposite occipital furrow, (4) longitudinal furrow on eye lobes deeper, narrower, positioned closer to outer margin of lobe. Hypostoma has maculae that are narrow and shallow near distal ends, rapidly expanding and deepening inward, then shallowing and becoming extinct before reaching axial midline. Posterior and posterolateral borders very narrow and bearing at least eight pairs of short spines.

Discussion. The above differences distinguish this species from *Olenellus puertoblancoensis* Lochman.

Occurrence. Bonnia–Olenellus Zone, GSC loc. 73043.

Olenellus sp. 2

Plate 13, figures 6–18

Material. Thirteen cephalon 1 to 10 mm long and one hypostoma.

Description. Cephalon similar to that of *Olenellus puertoblancoensis* except for following differences: (1) preglabellar ridge lacking or consisting of narrow strands of intertwined

venation, (2) eye lobes slightly shorter, (3) anterior and lateral borders wider, very broadly curved in cross-section, and tilted inward, (4) genal spines directed slightly outward, (5) axis lightly marked with reticulate network. Hypostoma bearing at least six pairs of slender spines of medium length.

Discussion. *Olenellus puertoblancoensis* and *Olenellus* sp. 1 closely resemble *Olenellus* sp. 2. These species can best be differentiated from *O.* sp. 2 by their narrower anterior and lateral borders.

Occurrence. *Bonnia-Olenellus* Zone, GSC locs. 73051–73054, 73056, 73057, 73062.

Olenellus sp. 3

Plate 13, figures 19, 20

Material. One cephalon 7 mm long.

Description. Cephalon has strong curvature along front margin for genus. Axis nearly parallel sided, only slightly wider at anterior glabellar lobe, front broadly curved and terminating against anterior border furrow. All three pairs of glabellar furrows shallow, arcuate, anterior two pairs averaging transverse; posterior pair has slight rearward average inclination; distal ends of posterior pair and occipital furrow are of medium depth. Eye lobes swept very strongly back so that inner margin is against or nearly against axial furrow, terminating approximately opposite midpoint on occipital lobe. Longitudinal furrow narrow and located near outer margin of eye lobes. Genae very broadly curved in cross-section (tr.). Anterior and lateral borders narrow, nearly round in cross-section, adjacent border furrow narrow and of medium depth. Posterior border transverse, slightly wider than lateral border. Genal, intergenal, and occipital spines unknown (broken). Ornamentation on axis consists of fingerprint and reticulate pattern; ornamentation on remainder of cephalon unknown (exfoliated and worn).

Discussion. *Olenellus laxoculus* sp. nov. and *Olenellus paraoculus* sp. nov. are two Sekwi species that have eye lobes directed strongly back as on *Olenellus* sp. 3. Both differ from *O.* sp. 3 in having eye lobes that are shorter and in having anterior glabellar lobes of greater relative width. The anterior glabellar lobe of *O. laxoculus* does not reach the anterior border furrow, and genae of *O. paraoculus* are wider (tr.). *Olenellus simplex* Poulsen, 1932, from eastern Greenland, has eye lobes closely set against an axis with parallel sides, but the lobes are shorter and the axis terminates before reaching the anterior border furrow.

Occurrence. *Bonnia-Olenellus* Zone, GSC loc. 73052.

Olenellus sp. 4

Plate 16, figures 8–15

Material. Three cephalata 1 to 7 mm long, one questionably assigned cephalon, and two hypostomata.

Description. Cephalon has low to medium convexity (tr.). Axis long and narrow, only slightly constricted near midlength and moderately expanded at anterior lobe, front broadly curved and terminating near or against anterior border furrow. Anterior two pairs of glabellar furrows of medium depth, arcuate, averaging transverse; posterior pair deeper but of medium depth, wide near distal ends, rapidly narrowing and shallowing inward, inclined moderately

back. Two distal segments comprising occipital furrow deep and wide, inclined slightly back. Eye lobes long and marked by longitudinal furrow, directed strongly out from axis, curving rapidly near opposite end, terminating against posterior border furrow and near lateral midpoints on occipital ring. Anterior and lateral border furrow of medium depth, narrow, and containing shallow pits; adjacent border of medium width and tilted moderately outward. Genal spines nearly straight, diverging slightly toward rear, tapering uniformly. Posterior border directed transversely, narrow near axis and widening outward to swelling at intergenal position located three-fifths distance from axis, remaining border has uniform width (exsag.). Occipital spine or node unknown (broken). Hypostoma has maculae that widen rapidly inward, posterolateral borders curl slightly upward, posterior margin straight to broadly cusate, approximately two pairs of small spines at posterolateral margin of hypostoma, small swellings (incipient spines?) farther forward on adjacent margin.

Discussion. There is a close resemblance between small specimens (6 mm, 7 mm) of this species and the small (7 mm) specimen of *Olenellus altifrontatus* sp. nov. (cf. Pl. 16, figs. 9-12 and Pl. 18, fig. 17). Small specimens of the two species differ in that *O.* sp. 4 has a lower anterior glabellar lobe, lacks nodes on the posterior two glabellar lobes, has wider anterior and lateral borders, and has transversely directed posterior borders.

Occurrence. *Bonnia-Olenellus* Zone, GSC loc. 73066.

Olenellus sp. 5

Plate 20, figures 9-14

Material. Seven partial cephalons 10 to \pm 42 mm long.

Discussion. Most of the description of *Olenellus puertoblancoensis* applies to this species. One striking feature that differentiates the two species is a large occipital spine on *Olenellus* sp. 5 which is directed back and upward. Minor differences on *O.* sp. 5 include wider anterior and lateral borders tilted inward, a lighter fingerprint pattern on the cephalon, and stronger radial venation on the genae.

Occurrence. *Bonnia-Olenellus* Zone, GSC loc. 73073.

Genus *Bradyfallotaspis* gen. nov.

Type species. *Bradyfallotaspis fusa* sp. nov.

Diagnosis. Glabella high and small for olenellid, cylindrical, terminating at strongly rounded front before reaching anterior border. Three pairs of glabellar furrows, each pair joins or nearly joins across axial midline. Eye lobes originating close to glabella front, of medium height along anterior half, highly raised along posterior half which bears visual surface. Set of narrow ridges bifurcate from anterior part of eye lobes and run forward along anterior margin of glabella. Extraocular gena rises steeply but not abruptly before attaching to outer margin of visual surface. Anterior and lateral borders broad. Genal spines taper rapidly back.

Discussion. This genus resembles *Fallotaspidella* Repina, 1961, especially in having eye lobes that are highly raised along the posterior half and a ridge that passes forward along the front of the glabella. It differs from *Fallotaspidella* in lacking a preglabellar ridge and thread-like structures that project from the lateral and posterior margins of the eye lobes. The genal spines of *Bradyfallotaspis* taper rapidly back, those of *Fallotaspidella* do not.

Bradyfallotaspis fusa sp. nov.

Plate 3, figures 1-7

Material. Three exfoliated cephalons 5 to 6 mm long and one cephalon external mould 7 mm long.

Description. Cephalon broadly curved along front and sides, more strongly curved at anterolateral margin. Glabella sides parallel except for slight lateral bulging of posterior lobes and of next adjacent pair; anterior lobe long, terminating in a blunt point. Anterior pair of glabellar furrows shallow and nearly transverse, slightly bowed back and faintly joined across axial midline; middle pair like anterior pair but slightly deeper; posterior pair well impressed and steeply inclined toward rear, shallowing and becoming transverse before joining across axial midline. Occipital furrow almost identical to posterior glabellar furrows. Eye lobes close to glabella and slightly lower, departing from anterior glabellar lobe at low angle, extending back almost to posterior border. Occipital ring at distal ends approximately as long (exsag.) as posterior glabellar lobe, higher and longer than posterior lobe near axial midline, bearing small, uptilted spine on posterior margin. Anterior and lateral border furrows broad and deep; posterior border furrow of similar dimensions at distal end, but narrowing considerably behind eye lobes. Anterior and lateral borders uniformly wide, out-sloping; posterior border narrow along distal part, widening slightly at intergenal position (no spine), then becoming very narrow as axial furrow is approached. Genal spine short, rapidly tapering to thin point. Ornamentation on exfoliated cephalons consists of sparse, large granules on gena and border, radiating venation on gena near anterior and lateral border furrows, faint row of small pits visible near outer margin of anterolateral part of border furrow.

Discussion. A higher glabella with a much longer anterior lobe and a wider, out-sloping anterior and lateral border readily serves to distinguish cephalons of this species from those of *Bradyfallotaspis patula* sp. nov., *Bradyfallotaspis* sp. 1, and *Bradyfallotaspis* sp. 2.

Occurrence. Nevadella Zone, GSC locs. 73027 and 73030.

Bradyfallotaspis patula sp. nov.

Plate 6, figures 1-9

Material. Five cephalons 2 to 6 mm long and two genae.

Description. Cephalon approximately half as long as wide. Glabella situated well below maximum elevation of eye lobes, sides converging forward to middle pair of glabellar furrows, parallel from middle pair to bluntly pointed front, terminating before reaching anterior border furrow. Glabellar furrows rather deep near axial furrow, rapidly shallowing inward, joining across axial midline; distal parts of furrows on anterior pair transverse, middle pair directed slightly back, posterior pair directed moderately back. Occipital furrow deeper than glabellar furrows, shallowing inward until only slightly deeper than axial furrows at axial midline. Occipital ring as long (sag.) as posterior glabellar lobe, but not so wide (tr.). Eye lobes high, supported by local, steep rise on genae, length less than one-third that of cephalon. Gena slopes moderately and uniformly outward from abrupt rise near eye lobe to lateral border furrow; furrow is of medium depth and width. Anterior and lateral borders

are of medium width, broadly rounded in cross-section, average slope is horizontal. Posterior border only slightly narrower than lateral border along distal half, proximal half narrow and more strongly rounded, bearing blunt intergenal spines near midlength. Genal spine short on small (2 mm) cephalon, of unknown length (broken) on larger cephalo. Ornamentation consists of sparse, small and medium-sized granules and venation on gena.

Discussion. Cephalo of *Bradyfallotaspis patula* are far wider than those belonging to other species in this genus. They can be readily recognized by their small genal angle which is especially noticeable on the larger cephalo.

Occurrence. Nevadella Zone, GSC locs. 73030, 73032, and 73038.

Bradyfallotaspis sp. 1

Plate 2, figures 14, 15

Material. Less than half of one cephalon about 10 mm long.

Description. Cephalon margin broadly curved along sides and probably more strongly curved at front. Eye lobes approximately three-tenths as long as cephalon. Border furrow broad and deep except for abrupt shallowing and narrowing between intergenal position and axial furrow. Anterolateral and lateral part of border of medium width and tilted inward. Genal spine directed slightly outward at base, length unknown (broken). Ornamentation consists of sparse granules and venation.

Discussion. This species resembles *Bradyfallotaspis* sp. 2, but lacks a flat area near the glabella front.

Occurrence. Nevadella Zone, GSC loc. 73027.

Bradyfallotaspis sp. 2

Plate 4, figures 14-16

Material. Half of one cephalon 10 mm long.

Description. Glabella small and short, front strongly rounded, terminating well back from anterior border. Glabellar furrows narrow and of medium depth near axial furrow, anterior pair directed moderately forward, middle pair transverse, posterior pair directed moderately back. Occipital furrow at distal ends deeper and wider than glabellar furrows; occipital ring considerably shorter (sag.) than posterior glabellar lobe. Eye lobes short, directed strongly outward from glabella. Small ridge at anterolateral margins of lobes continues forward for short distance against margin of glabella. Gena broadly swollen from lateral border to outer margin of eye lobe, abruptly flattened near and in area of preglabellar field. Anterior and lateral borders nearly flat and horizontal; adjacent border furrow of moderate width and shallow.

Discussion. A flat preglabellar field and a narrow, shallow border furrow distinguish this species from other species of *Bradyfallotaspis*.

Occurrence. Nevadella Zone, GSC loc. 73030.

Genus *Nevadella* Raw

Nevadella Raw, 1936, pp. 243, 244, 249, 250; Whitehouse, 1939, p. 191; Hupé, 1953, p. 73; Poulsen, 1959, p. 196.

Type species. *Callavia eucharis* Walcott, 1913.

Diagnosis. Olenellid with a low, wide (width about twice length) cephalon. Glabella small, narrow, sides nearly straight or slightly concave and converging forward, front pointed or strongly rounded. Three to four pairs of glabellar furrows, all pairs lightly or moderately impressed, all straight, and most inclined toward rear. Eye lobes crescentric, extending back to level opposite posterior glabellar lobe or occipital ring, inner margins slightly raised above adjacent genae, outer margin abruptly raised. Occipital ring wider than glabella, broadly curved to nearly straight along rear margin, usually bearing a node. Posterior margin of genae inclined back so that distal parts are posterior to level of occipital ring.

Thoracic segments known to range between 18 and 23 in number, macropleurae not developed, pleural spines long and curved strongly back. Pygidium very small.

Discussion. *Nevadella* differs from most olenellids in having a small, cone-shaped glabella and genal angles that extend back beyond the level of the occipital lobe. *Judomia* closely resembles *Nevadella*, but has a proportionately larger glabella that has parallel sides. *Nevadia* is also close to *Nevadella* but differs in having an even wider cephalon and a very short, rounded anterior glabellar lobe. A larger, parallel-sided glabella and a large axial spine serve to differentiate *Callavia* from *Nevadella*.

Species from the Pacific Faunal Province that can be assigned to *Nevadella* are *Nevadia addyensis* Okulitch, 1951 and *Callavia eucharis* Walcott, 1913. *Callavia perfecta* Walcott, 1913 is a junior synonym for *C. eucharis* (see Raw, 1936, p. 249). Thus far, in this province *Nevadella* is known to occur only in the *Nevadella* Zone, and its range is not known to overlap the range of the younger genus *Olenellus*. A report of such an overlap by Walcott (1913) is probably in error (see p. 6).

Trilobites from the Atlantic Faunal Province that belong to *Nevadella* are *Nevadella burri* (Walcott, 1910) and *Callavia cartlandi* Raw (in Walcott, 1910). *Nevadella burri* is from North Weymouth, Massachusetts where it was found associated with *Callavia crosbyi* (Walcott, 1910, p. 281). *Nevadella cartlandi* was found in float thought to have come from the *Callavia callavei* bed at the quarry at Comley in Shropshire, England (Walcott, 1910, p. 282). Thus, in the Atlantic Faunal Province *Nevadella* seems to be restricted to the *Callavia* Zone.

Nevadella bacculenta sp. nov.

Plate 5, figures 1-9

Material. Four partly exfoliated, incomplete cephalae 7 to 15 mm long and three genae.

Description. Cephalon low, broadly curved in cross-section (tr.) with considerable increase in outward slope on distal third of genae. Glabella sides converging rapidly along posterior lobe, moderately along next two and one-third lobes, then curving inward more rapidly to strongly rounded front. Three pairs of medium glabellar furrows, posterior pair inclined back slightly more than anterior two. Eye lobes close to glabella, terminating opposite lateral midlength of posterior glabellar lobe. Occipital furrow deep near ends, becoming shallow inwards and broadening at expense of occipital ring. Occipital ring wider (tr.) and higher than glabella. Anterior border furrow shallow, nearly obsolete at axial midline

where border is intercepted by low preglabellar ridge composed of anastomosing veins; lateral border furrow uniformly shallow and narrow. Anterior and lateral borders slightly rounded to nearly flat, width uniform except for expansion near genal angles and preglabellar ridge, slope slightly forward at front of cephalon, moderately outward at sides. Posterior border furrow broad and very shallow; posterior border maintains nearly uniform width (exsag.). Genal spines tapering rapidly to narrow point. Ornamentation consists of venation on genae, sparse granules of medium size on glabella, and reticulate network of raised lines on axis and on genae near terminal ends of eye lobes.

Discussion. *Nevadella bacculenta* has a wider cephalon, smaller glabella, and shorter eye lobes than other species of *Nevadella* in the Sekwi collections. Of the species known from elsewhere, *Nevadella cartlandi* (Raw) is closest to *N. bacculenta*. The glabella of *N. cartlandi* is longer than that of *N. bacculenta*, and there are four rather than three pairs of glabellar furrows. The two anterior pairs of glabellar furrows on *N. cartlandi* are directed forward while all three pairs on *N. bacculenta* are directed back. *Nevadella addyensis* (Okulitch) differs from the present species in having an anterior glabellar lobe that is more pointed, much larger, and terminates closer to the anterior border. Glabellar furrows on *N. addyensis* are more steeply inclined toward the rear. Eye lobes on *N. addyensis* are shorter and not bowed outward as strongly along their outer margins. Nelson and Durham (1966, Pl. 3, figs. 1-3) have referred specimens to *N. addyensis* that may belong to another species and appear to bear a closer resemblance to *N. bacculenta*. Figures by Nelson and Durham suggest the material is poorly preserved. The specimens have not been seen by the writer.

Occurrence. *Nevadella* Zone, GSC loc. 73030.

Nevadella faceta sp. nov.

Plate 3, figures 8-14

Material. Ten cephalae 2 to 12 mm long, three genae, and one hypostoma.

Description. Cephalon low, uniformly convex in cross-section (trans.) except for abrupt rise at outer margin of eye lobes and low rise at glabella. Glabella together with occipital ring narrow, sides slightly concave and gradually converging, terminating in blunt point, and preceded by short, faint preglabellar ridge. Glabellar furrows (three pairs) and occipital furrow are equally inclined toward rear, each pair slightly deeper than next anterior pair, interspace between pairs increases posteriorly, all pairs near axial midline are very shallow but joining. Occipital ring only slightly higher than adjacent glabella, low node present just ahead of posterior margin. Eye lobes uniformly curved, tilted slightly inward near anterior and posterior ends and nearly horizontal near middle, terminating close to occipital ring and opposite anterior one-third point on ring's lateral margin. Furrow marking inner edge of lobes shallow near front and back of lobes, nearly extinct near middle. Anterior and lateral border furrows uniformly narrow and shallow, faintly marked by small pits. Adjacent border of uniform width except for widening near genal angle. Genal spine of medium length, uniformly tapering to narrow point. Border and genal spine tilted outward, tilt moderate at front of cephalon, progressively stronger toward rear. Posterior border expands slightly in distal direction, posterior margin has slight protuberance near distal end, but no developed intergenal spine. Posterior border furrow broader and shallower than anterior and lateral border furrows, very broad, shallow, depression developed on furrow just anterior to intergenal spine position. Hypostoma long and narrow, relief high, particularly near anterior margin. Anterior wings short and steeply inclined. At least three pairs of spines present on

posterolateral border. Ornamentation consists of faint venation on genae, terrace lines on lateral borders, and light reticulate network on hypostoma.

Discussion. This species somewhat resembles *Nevadella* sp. 2, however the latter species has a stronger preglabellar ridge and raised anterior and lateral borders. The glabella on *N.* sp. 2 exhibits a fingerprint pattern whereas the glabella of *N. faceta* is smooth. Of the species known from elsewhere, *Nevadella burri* (Walcott) is closest to *N. faceta*. The eye lobes on *N. burri* extend farther outward than do those on *N. faceta*, and they terminate farther from the axis.

Occurrence. *Nevadella* Zone, GSC locs. 73027, 73032, 73034–73037.

Nevadella sp. 1

Plate 8, figures 18–20

Material. One exfoliated cephalon approximately 9 mm long.

Description. Cephalon width slightly less than twice length. Glabella large for genus, sides nearly straight with only slight convexity, front well rounded. Three pairs of shallow glabellar furrows, all equally inclined toward rear, posterior two pairs continue across axial midline where they are very shallow. Occipital furrow at distal parts like glabellar furrow but deeper, medial three-fifths of furrow broad and very shallow. Occipital ring only slightly raised above level of glabella, small node present near posterior margin. Palpebral lobes uniformly curved and terminating approximately opposite midpoint of lateral margin of occipital ring. Genae slope moderately and uniformly outward. Lateral border furrow narrow and shallow. Lateral border of uniform width, inner third curves moderately outward, outer two-thirds nearly flat and inclined steeply outward. Posterior border furrow very shallow; posterior border almost obsolete near occipital ring, expands outward along proximal half, distal half unknown (broken). Genal spines unknown. Ornamentation on exfoliated surface consists of small pits in border furrow and terrace lines on border and posterior margin of occipital ring; remaining surface rough.

Discussion. A larger glabella with a well-rounded front and a lateral border that is inclined steeply outward distinguishes this cephalon from others in the Sekwi collections. *N.* sp. 1 has the general proportions of *Nevadella eucharis* (Walcott), but the latter species has a more rapidly tapering glabella and shorter eye lobes.

Occurrence. *Nevadella* Zone, GSC loc. 73038.

Nevadella sp. 2

Plate 5, figures 12–15

Material. Three exfoliated, partial cephalons 4 to 8 mm long.

Description. Glabella sides straight, margins rise abruptly above adjacent genae, front strongly rounded to bluntly pointed. Three pairs of glabellar furrows, all equally inclined toward rear, posterior pair joined across axial midline. Palpebral lobes extend back beyond level of posterior pair of glabellar furrows. Occipital ring rises only slightly above level of glabella. Anterior border and known part of lateral border of uniform width, upper surface flat and horizontal, inner margin raised abruptly above shallow, narrow border furrow. Preglabellar ridge weakly developed immediately in front of glabella, widens and rises before

forming strong union with anterior border. Ornamentation consists of terrace lines on anterior and lateral borders, fingerprint pattern on glabella, and small, deep pits along border-border furrow contact.

Discussion. An abrupt rise at the inner margin of the border plus a preglabellar ridge that is strong at its anterior end distinguish this species of *Nevadella* from others in the Sekwi collections.

Occurrence. *Nevadella* Zone, GSC locs. 73030, 73032, 73033.

Genus *Holmiella* gen. nov.

Type species. *Holmiella preancora* sp. nov.

Diagnosis. Olenellid with advanced genal spines on anterolateral margin. Cephalon sides parallel or converging slightly toward rear, intergenal spines situated short distance in from posterolateral corner of cephalon. Glabella sides along posterior two-thirds concave and averaging parallel to axial midline, anterior third expanding forward before terminating with broadly curved front against anterior border furrow. Eye lobes long, curved strongly outward and then back, so that maximum width (tr.) of interocular genae greatly exceeds width of extraocular genae. Small occipital spine present. Pygidium large for an olenellid, wide, approximately two axial rings present. Posterior pygidial margin transverse, lacking border, bearing short spines.

Discussion. No known olenellid genus has a pygidium matching this one in size or configuration. Cephalae of *Holmia* bear some resemblance, particularly in having narrow (tr.) extraocular genae. Glabellae of *Elliptocephala* exhibit a similar outline and furrow pattern. Cephalae of these two genera could not be mistaken for those of *Holmiella*, however, as they lack advanced genal spines. One cephalon described by Walcott (1910, Pl. 40, fig. 14; *non* figs. 12, 13, 15, 15a, 16) as *Olenellus argentus* may belong in this genus. The cephalon in question could not be found at the U.S. National Museum.

Holmiella preancora sp. nov.

Plate 4, figures 1–13

Material. Ten cephalae 5 to about 46 mm long and three pygidia 7 to 12 mm long.

Description. Cephalon subrectangular in plan view. Glabella of moderate relief along posterior three-fourths, considerably higher along anterior fourth. Three pairs of glabellar furrows; anterior pair shallow, arcuate and averaging transverse; second pair of medium depth, broadly arcuate to nearly straight, inclined slightly toward rear; posterior pair slightly deeper, shorter and wider than second pair and directed moderately back. Ocular lobes of uniform width (tr.) terminating opposite occipital furrow on medium (6–10 mm) and large cephalae, terminating farther back on smaller cephalae. Anterior border furrow narrow and shallow, lateral border furrow of medium depth and width. Anterior and lateral borders fairly uniform in width except for large increase in width at base of genal spine and small increase at posterolateral margin of cephalon. Genal spine directed slightly back and broadly curved near base, then curving rapidly back; distal part broadly curved and pointing nearly straight back. Inner margin of genal spine joins cephalon at level about opposite anterior

pair of glabellar furrows. Small node present at intergenal position. Occipital ring at nearly same elevation as glabella, shorter (sag.) than posterior glabellar lobe, bearing very small spine on posterior margin.

Pygidium width slightly greater than twice length. Axis consists of anterior ring of moderate elevation, low second ring, and terminal piece with flat top and steep flanks. Margin of pleural region straight and inclined moderately back along anterolateral part, straight and directed slightly inward along lateral part, rear part curved broadly back in gross aspect, bearing two and probably one additional pairs of marginal spines. All spines small, directed nearly straight back, grading in size with outer pair largest. Pleural region marked by two pairs of shallow, broad furrows, anterior pair originating between anterior and second axial ring, terminating between outer and second pair of spines; posterior pair originating between second ring and terminal piece, visible near axis only. Ornamentation on cephalon shorter than 30 mm consists of venation on genae, larger cephalon covered by irregular, raised fingerprint pattern. Pygidium marked by coarse, irregular ridges on axis and more densely spaced, anastomosing ridges on pleural region.

Discussion. Pygidia of this species best serve to distinguish it from *Holmiella falcata* sp. nov. Pygidia of *H. preancora* are wider and have anterolateral margins that are inclined less steeply toward the rear and are not curled downward. The axis contains a more clearly defined second axial ring and the flat upper surface of the terminal piece has a more abrupt drop at the margins and lacks a medial (sag.) furrow. Cephalic differences between this species and *H. falcata* are given under the description of the latter species.

Occurrence. Nevadella Zone, GSC locs. 73027, 73030, 73032, 73033, 73034.

Holmiella falcata sp. nov.

Plate 7, figures 7-17

Material. Thirty-six cephalon 2 to 18 mm long and eleven pygidia 4 to 6 mm long.

Description. Cephalon like that of *Holmiella preancora* except for following differences: (1) front margin of cephalon and front of glabella more strongly curved; (2) genal spines not so far advanced, inner margin of spines intersect lateral margin of cephalon at level approximately opposite medial pair of glabellar furrows; (3) genal spines broadly and uniformly curved out and moderately back; (4) intergenal spines and occipital spine small but exhibiting well-developed points.

Pygidium nearly twice as wide as long. Anterolateral margin straight, originating at sharp node near axis, inclined strongly back to short, strongly curved posterolateral margin. Anterolateral margin at anterior end dips steeply outward because of strong downward curl on adjacent pleural region, curl near margin progressively diminishes toward rear so that dip is only slightly outward near posterolateral margin. Rear margin roughly transverse and bearing three pairs of spines. Spines inclined slightly inward, outer pair largest, second pair small, inner pair very small and situated close to second pair. Axis low, nearly flat on top, consisting of anterior ring, very poorly defined second ring, and terminal piece with irregular medial (sag.) furrow. Pleural region marked by two broad, shallow pairs of furrows originating at triangular pits lateral to junction of anterior and second axial rings and lateral(?) to junction between second ring and terminal piece, and terminating between outer and second pairs of spines and medial and inner pairs respectively. Ornamentation lacking on medium (18 mm) and small cephalon, pygidia covered by raised anastomosing ridges.

Discussion. Cranidial distinctions between this species and *Holmiella preancora* sp. nov. are listed in the above description. Pygidial differences are listed under discussion of *H. preancora*.

Occurrence. *Nevadella* Zone, GSC locs. 73034, 73037, 73038, 73039.

Genus *Laudonia* Harrington

Laudonia Harrington, 1956, p. 60; Poulsen, 1959, p. 192.

Type species. *Laudonia bispinata* Harrington, 1956.

Discussion. Harrington has given an adequate description of this genus. The occurrence of *Laudonia prima* (Lochman) at a low horizon in the *Bonnia-Olenellus* Zone in Mexico, and the low occurrence of this genus in the type Sekwi Formation suggest that *Laudonia* may be of use in subdividing the *Bonnia-Olenellus* Zone. In the northern Cariboo Range, British Columbia, *Laudonia* also occurs (GSC loc. 82782) low in the *Bonnia-Olenellus* Zone.

Laudonia? sp. 1

Plate 9, figure 21

Material. One cephalon approximately 7 mm long preserved as a partial impression of an external surface.

Discussion. The cephalon is not complete enough to warrant a written description. However, it can be seen from the figure that the specimen differs from the two known species of *Laudonia*. *Laudonia prima* (Lochman) has a much narrower extraocular gena. The same feature on *Laudonia bispinata* Harrington, although a great deal wider, is clearly narrower than the extraocular gena on *Laudonia* sp. 1.

Occurrence. *Bonnia-Olenellus* Zone, GSC loc. 73041.

Genus *Parafallotaspis* gen. nov.

Type species. *Parafallotaspis grata* sp. nov.

Diagnosis. Olenellid having glabella that is small, of medium height, straight sided, tapered moderately forward, medium curved along front margin, and terminated well back from anterior border. Three pairs of glabellar furrows, pairs inclined toward rear, only lightly joined or shallowing to extinction before crossing axial midline. Eye lobes long, narrow, originating at anterolateral corners of glabella and extending back nearly to posterior border. Low ridge continues from eye lobes forward along front margin of glabella and merges with preglabellar ridge. Thread-like ridge emerges laterally from side of eye lobes and curves strongly back on extraocular genae toward genal angles. Occipital ring marked by set of transverse furrows that extend inward for short distance from lateral margin.

Pygidium very small, axis proportionately large and consisting of one or two rings and terminal piece. Test granular.

Discussion. *Fallotaspidella* Repina, 1961 and *Bradyfallotaspis* gen. nov. resemble this genus, but have higher, parallel-sided glabellae with glabellar furrows that are well impressed across the axial midline. Both genera have eye lobes that are highly elevated along the posterior

half, while those of *Parafallotaspis* maintain a medium elevation throughout. *Bradyfallotaspis* lacks both a preglabellar ridge and a thread-like ridge extending laterally from the eye lobes. The thread-like ridge on *Fallotaspidella* does not turn back so strongly as it approaches the lateral border. *Fallotaspis* differs from *Parafallotaspis* in having genal spines that are moderately advanced, in having a larger, parallel-sided glabella, and in lacking a preglabellar ridge.

Parafallotaspis grata sp. nov.

Plate 1, figures 1-8

Material. Five cephalons 3 to 18 mm long and one pygidium 2 mm long.

Description. Cephalon twice as wide as long, curvature along front margin stronger than at sides, broadly convex in cross-section (tr.). Glabella delineated by shallow, narrow axial furrow, sides converging moderately forward. Glabellar furrows all equally inclined toward rear; anterior pair very shallow and joining across axial midline; posterior two pairs moderately deep, abruptly shallowing outward near axial furrow, gradually shallowing inward to extinction. Occipital furrow similar to posterior pairs of glabellar furrows except for broad, shallow continuation across axial midline. Eye lobes straight and inclined strongly outward along anterior half, curving strongly along posterior half, and terminating close to posterior border opposite midpoint on lateral margin of occipital lobe. Extraocular genae moderately curved (tr.) and sloping outward; preglabellar field much lower and sloped slightly forward. Preglabellar ridge low and broad. Anterior and lateral borders of uniform width except for slight expansion near genal angles, slope is moderately outward near angles and decreases to horizontal in front of glabella. Border furrow of uniformly moderate depth and width throughout. Genal spines taper back at moderate rate, length at least equal to that of glabella plus occipital lobe. Posterior border furrow transverse, narrow, and shallow; posterior border narrow for more than half length from axial furrow, abruptly widening at faint suggestion of intergenal spine, remaining part continues at this greater width to genal spine. Occipital ring bears short spine.

Pygidium very small. Articulating half ring short (sag.), set well below level of adjacent axis. One axial ring posteriorly bordered by weak transverse furrow. Terminal piece defined in back by shallow "V"-shaped furrow closely followed by second "V"-shaped furrow of medium depth that parallels first. Rear margin of pygidium unknown (broken). Ornamentation on cephalon and pygidium consists of small to medium-sized granules. Extraocular genae exhibit faint radial venation.

Discussion. This is the only known species in *Parafallotaspis*.

Occurrence. *Fallotaspis* Zone, GSC loc. 73025.

Genus *Wanneria* Walcott

Wanneria Walcott, 1910, p. 296; Poulsen, 1932, p. 35; 1958, p. 16; 1959, p. 197; 1969, p. 15; Lake, 1937, p. 245; Resser and Howell, 1938, p. 227; Shimer and Shrock, 1944, p. 619; Hupé, 1953, p. 75; Suvorova, 1960, p. 62; Palmer, 1964, p. 3.

Type species. *Olenellus (Holmia) walcottanus* Wanner, 1901.

Diagnosis. Olenellid with large anterior glabellar lobe that is broadly curved across front and terminates against or nearly against anterior border furrow. Eye lobes directed strongly back and marked by longitudinal furrow. Anterior and lateral borders strongly developed;

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SYSTEMATIC DESCRIPTIONS

posterior border lacks intergenal spine. Thorax at forward end nearly as wide as cephalon, pleurae terminating in long spines that curve strongly back, no macropleurale segments present. Test strongly ornamented by raised, reticulate network.

Discussion. A large anterior glabellar lobe and a well-developed reticulate network distinguish this genus from other olenellids. *Holmia* is closest to *Wanneria*, but has a narrower (tr.) extraocular gena, possesses intergenal spines, and has a narrower thorax.

Occurrence. Middle and younger part of the *Bonnia-Olenellus* Zone.

Wanneria logani (Walcott)

Plate 14, figures 1-14; Plate 16, figures 1-7

Olenellus logani Walcott, 1910, p. 333, Pl. 41, figs. 5, 6.

Wanneria nathorsti Poulsen, 1932, p. 40, Pl. 12, figs. 1-13.

Wanneria logani (Walcott), Poulsen, 1958, p. 16.

Material. Thirty-one cephalons 2 to 13 mm long and two hypostomata.

Description. Cephalon has outline in plan view of half circle, high relief at front of glabella. Axis strongly constricted at level of posterior glabellar furrows, greatly expanded toward large anterior glabellar lobe. Three pairs of glabellar furrows, anterior pair shallow, arcuate, averaging transverse except for steep posterior inclination at distal ends; second pair of moderate depth, arcuate, averaging transverse; posterior pair slightly deeper than second pair, nearly straight, moderately to steeply inclined toward rear. Eye lobes uniformly arcuate, terminating opposite occipital furrow. Genae near outer margin of eye lobes broadly convex (tr.), within short distance of lobes curvature becomes strong and continues so to lateral border furrow. Lateral border furrow is narrow and deep; anterior border furrow is shallow and much broader (exsag.). Anterior and lateral borders broadly convex in cross-section and of uniform width except for widening near genal angles; anterior border tilted strongly forward, lateral border tilted moderately outward. Genal spines strong and directed straight back to slightly inward. Posterior border narrow and extending nearly straight out from axis for two-thirds length to small swelling at intergenal position, remaining third is of moderate width and inclined slightly back. Occipital furrow consists of two short, distal parts that are deep and inclined moderately back. Occipital ring slightly raised above elevation of adjacent glabella, posterior margin bowed moderately back and bearing small node or spine. Hypostoma broadly curved near centre of medial body, steeply sloped at sides, converging rapidly toward maculae; posterior lobe small; at least six spines present at posterolateral margin (broken). Ornamentation consists of terrace lines on anterior and lateral borders, shallow pits in border furrow, reticulate network on remainder of cephalon and on hypostoma. Cephalons less than 4 mm long lack the above ornamentation, but have radiating venation on genae.

Discussion. The primary types of this species, from the Forteau Formation, Labrador, and specimens from the Sekwi Formation agree in every respect. A like agreement was obtained when the above material was compared with *Wanneria nathorsti* from eastern Greenland. The latter comparison was made using replicas of *W. nathorsti* primary types. Two species described by Poulsen (1958) from northwest Greenland, *Wanneria mediocris* and *Wanneria troelsenii*, are close to *W. logani*. Because these species are represented by meagre material and have slight differences from *W. logani*, such as ornamentation, their relationship to the

present species remains open to question. A species described by Palmer (1964) as *Wanneria* cf. *W. walcottana* is similar to *W. logani*, but has wider genae, longer eye lobes, and an anterior and anterolateral border that is flatter and tilts inward rather than outward.

Occurrence. *Bonnia-Olenellus* Zone, GSC locs. 73049, 73050?, 73051, 74053-7, 73064.

Wanneria parvifrons sp. nov.

Plate 13, figures, 1-5

Material. Three partial cephalon 3 to 14 (estimated) mm long.

Description. Cephalon wide, length-width ratio 1:2. Glabella sides only moderately constricted at posterior pair of glabellar furrows, expansion at anterior lobe less than average for genus, broadly curved along front margin, relief at front of glabella low for genus. Three pairs of glabellar furrows, anterior two pairs equally shallow and arcuate, average direction is slightly forward; posterior pair inclined back and of medium depth along distal segments, shallowing slightly and joining across axial midline. Eye lobes terminate at level just anterior to distal ends of occipital furrow, marked by strong longitudinal furrow. Extraocular gena moderately curved, sloping slightly outward near lobes and becoming steep near furrow. Anterior and lateral borders of medium width throughout, tilted moderately outward. Anterior and lateral border furrows of medium width, depth medium along lateral course, shallow in front of glabella. Posterior border narrow and directed straight out along proximal half, of medium width (exsag.) and curving moderately downward along distal half. Occipital furrow narrow and of medium depth along distal segments, nearly obsolete across axial midline. Occipital ring tilted upward from glabella. Genal spines directed slightly outward, uniformly tapered. Ornamentation consists of light terrace lines on border, fine reticulate network over remainder of cephalon, small granule in centre of each polygon in network, near terminus of eye lobes granules on genae are of medium size. Lateral border furrow marked with shallow pits. Small (3 mm) cephalon lacks above ornamentation, but is marked by radial venation on genae.

Discussion. A wide cephalon with a small anterior glabellar lobe serves to differentiate this species from most other *Wanneria*. *Wanneria* cf. *W. walcottana* (Wanner), Palmer, 1964 resembles this species, but has longer eye lobes, a longer anterior glabellar lobe, and an anterior and anterolateral border that tilts inward rather than outward.

Occurrence. *Bonnia-Olenellus* Zone, GSC loc. 73049.

Wanneria sp. 1

Plate 15, figures 23-26

Material. One partial cephalon approximately 6 mm long, one gena, and one tentatively assigned pygidium.

Description. Cephalon convex, reconstructed outline in plan view is half circle distended in transverse direction. Axis unknown except for part of anterior glabellar lobe which is small for genus. Eye lobes greatly elevated, height at least equals that of anterior lobe of glabella, probably terminates just posterior to point opposite occipital furrows. Gena near outer margin of eye lobe nearly horizontal, strongly convex midway between lobes and lateral border furrow, and then dipping steeply outward. Anterior and lateral borders broadly

curved in cross-section, average dip moderately outward, width medium in front of cephalon, gradually widening toward genal angle. Lateral border furrow of medium width and deep. Posterior border along proximal two-thirds (slightly less) directed outward, horizontal, and expanding in distal direction to slight swelling at metagenal position; distal part (beyond swelling) maintains width (exsag.) attained at metagenal position, directed slightly forward, nearly horizontal except for drop in elevation near metagenal position. Genal spine broadly curved, directed back and slightly outward at base, slightly inward at end.

Pygidium convex, length-width ratio 5:7. Axis consists of two rings and terminal piece with medial (sag.) furrow. Pleural fields slope steeply outward, marked by two pairs of very shallow, broad furrows. Border poorly outlined by "furrow" consisting of slight decrease in slope so that area around margin dips less steeply outward; small medial indentation at posterior margin. Ornamentation on cephalon consists of terrace lines on anterior and lateral borders, shallow pits in adjacent furrow. Remainder of cephalon and all of pygidium covered by raised reticulate meshwork. All parts of existing collection marked by sparse granules of small to medium size.

Discussion. Genal spines which are in a more advanced position and which are directed initially outward as well as back differentiate this species from other *Wanneria* in the Sekwi collections.

Occurrence. *Bonnia-Olenellus* Zone, GSC loc. 73059.

Olenellid genus and species undet.

Plate 2, figures 16, 17

Material. Two partial cranidia 2 and 5 mm long.

Discussion. There is some resemblance between these specimens and others of similar size assigned to *Holmiella preancora* sp. nov. and *Holmiella faculata* sp. nov. The present material differs from these species in having a glabella that does not expand as rapidly forward, nearly flat rather than convex (tr.) interocular areas, deeper furrows at the inner edge of the eye lobes, eye lobes that are longer and positioned closer to the glabella, and a rough rather than smooth surface. Because of the small amount of material available, no generic assignment is attempted.

Occurrence. *Nevadella* Zone, GSC locs. 73027, 73030.

Family DORYPYGIDAE Kobayashi, 1935

Genus *Bonnia* Walcott

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

Bonnia Walcott. Raymond, 1928b, p. 309; Resser, 1936, p. 6; 1937a, p. 44; Lermontova, 1940, p. 142; 1951, p. 118; Lochman, 1947, p. 68; Rasetti, 1948a, p. 14; 1966b, p. 43; Hupé, 1955, p. 111; Pokrovskaya, 1959, p. 135; Poulsen, 1959, p. 217; Suvorova and Chernysheva, 1960, p. 80; Egorova, et al., 1960, pp. 194, 195; 1961, p. 225; Demokidov and Lazarenko, 1964, p. 207; Repina, 1964, p. 300; Suvorova, 1964, p. 143; Palmer, 1964, p. 5; 1968, p. 46.

Type species. *Bathyrurus parvulus* Billings, 1861.

Discussion. This genus has been adequately described previously. In general, it consists of a compact group of small dorypygid trilobites with thick, usually rather smooth tests. In

North America, *Bonnia* is known only from strata of the late Lower Cambrian *Bonnia-Olenellus* Zone. *Kootenia* resembles *Bonnia*, but most species of *Kootenia* are larger and have five to seven sets of well-developed spines on the pygidium as opposed to the usual one set on *Bonnia*. Pygidia of *Bonnia* with more than one set of spines differ from those of *Kootenia* by having spines that are smaller, borders that are wider, and furrows on the pleural fields and axes that are shallower.

Cranidia of *Bonnia* commonly have glabellae that expand forward and are broadly curved across the front, while those of *Kootenia* are more nearly parallel sided and more strongly curved at the front.

Bonnia columbensis Resser

Plate 18, figures 1-13

Corynexochus senectus Walcott, 1916, p. 319, Pl. 55, figs. 7, 7a-c. [non Pl. 56, figs. 1, 1a-g]; 1917, p. 66, Pl. 9, figs. 2, 2a-c [non Pl. 9, figs. 1, 1a-d].

Bonnia columbensis Resser, 1936, p. 9; Lochman, 1947, p. 69.

Bonnia fieldensis (Walcott), Rasetti, 1951, p. 82.

Bonnia copia Fritz, 1968, p. 194, Pl. 36, figs. 17-24.

Material. Eighteen cranidia 4 to 13 mm long, twenty-two pygidia 7 to 13 mm long, and two hypostomata.

Description. Cranidium has length-width ratio of slightly more than 2:3. Glabella rather low, sides straight and diverging moderately in forward direction, front broadly curved. Glabellar furrows very faint except for shallow indentation at sides of glabella at distal ends of posterior set. Axial furrow broad and shallow. Palpebral area broadly convex in cross-section (tr.), outslowing, half as wide (tr.) as glabella at base. Palpebral lobes narrow (tr.), centred well back of glabellar midpoint, length between one-third and one-fourth total length of glabella. Palpebral furrows wide and of medium depth. Anterior border furrow shallow; both anterior border and border furrow narrow in front of glabella and of medium width elsewhere. Posterior area about as wide (tr.) as glabella at base; posterior border uniformly narrow; posterior border furrow deep and very broad (exsag.). Occipital furrow deep near ends, medial part shallow. Occipital ring rather short (sag.), bearing node on some cranidia and small spine on others.

Pygidium rather low, length-width ratio approximately 2:3, converging only slightly back along lateral margins, posterolateral margins broadly curved, posterior margin nearly straight or with slight recurvature behind axis. Axis low, consisting of two clearly defined rings, three faint rings, and terminal piece. Pleural field marked by one deep (anterior) pair of pleural furrows and two shallow pairs. Three pairs of very narrow and shallow interpleural furrows visible on exfoliated pygidia. Border and border furrow of medium width, both narrowing toward anterolateral corner of pygidium. One pair of short marginal spines in anterolateral position.

Hypostoma has elongate medial body with nearly parallel sides. Maculae very low; medial furrow very shallow throughout. Border uniformly narrow; border furrow of uniformly medium width and depth. Anterior wings large. Ornamentation consists of finely granular to nearly smooth test. Terrace lines are present on anterior border of cranidium and on border of pygidium.

Discussion. In 1961, after studying the primary types of *Bonnia columbensis* and *Bonnia fieldensis*, the writer accepted Rasetti's conclusion that the material was conspecific and wrongly erected *Bonnia copia* as a new species. In 1969 he reviewed the primary types to-

gether with abundant supporting material from the type localities. A number of consistent (specific) differences not seen earlier became apparent when the large populations in the two toptype collections were compared. *B. columbensis* differs from *B. fieldensis* as follows: (1) glabella expands forward and has steep lateral flanks as opposed to *B. fieldensis* which has a parallel-sided glabella with low lateral flanks; (2) facial sutures angle strongly outward from palpebral lobes whereas facial sutures on *B. fieldensis* are directed more steeply back; (3) pygidial axis tapers toward rear and has steep lateral flanks in contrast to axis on *B. fieldensis* which is parallel-sided and has low lateral flanks; (4) pleural field has low outward dip while field on *B. fieldensis* has low dip near axis but moderate to strong outward dip near border; (5) hypostoma has wide (sag.) anterior border as opposed to narrow anterior border on *B. fieldensis*; (6) test marked by fine granules in contrast to test of *B. fieldensis* which is marked by sparse pits visible even on worn surfaces.

Occurrence. *Bonnia-Olenellus* Zone, GSC loc. 73073.

Bonnia laterispina sp. nov.

Plate 15, figures 1-7

Material. Five cranidia 4 to 7 mm long and five pygidia 2 to 5 mm long.

Description. Cranidium has length-width ratio of 7:10. Glabella widest near middle, sides converge forward and back from middle at about equal rates. Three pairs of very shallow glabellar furrows, all pairs transverse and branching, posterior pair indented slightly into glabella sides. Palpebral areas half as wide as glabella at base and outslipping. Palpebral lobes and furrows narrow, nearly two-fifths as long as glabella, centred well back of glabella midpoint. Eye ridges low, narrow, located along posterior margin of anterior border furrow. Anterior border furrow shallow and of medium width; adjacent border of medium width (exsag.) on fixigenae, narrower in front of glabella. Posterior area about five-sixths as wide (tr.) as glabella at base. Posterior border and border furrow expand distally; border furrow deep except for shallowing at distal end. Occipital furrow deep near ends; medial segment bowed forward, much wider and shallower than distal ends. Occipital ring long (sag.) near middle, short near ends, marked by very small node near posterior margin.

Pygidium in plan view has outline of half circle. Axis narrows slightly in posterior direction, consists of three distinct rings, two faint rings, and terminal piece. Pleural field marked by three pairs of pleural furrows that are of medium width and depth and by three pairs of shallow interpleural furrows. Border furrow shallow; border convex in cross-section, tilted outward, widest near back of pygidium, narrowing considerably near anterolateral corners. Two to three pairs of lateral spines, all very small, anterolateral pair largest, next pair smaller, third pair very small or represented by slight swelling. Ornamentation of both cranidium and pygidium consists of fine puncta, anterior border of cephalon marked by weak terrace lines.

Discussion. Three species that resemble *Bonnia laterispina* and have more than one pair of pygidial spines are *Bonnia bicensis* Resser, *Bonnia busa* (Walcott), and *Bonnia tatondukensis* Palmer. *B. bicensis* differs from the present species in having a glabella that expands forward, wider (tr.) palpebral lobes and furrows, an occipital ring that tilts upward and back, and a pygidium that has a wider border. *B. busa* has a wider (exsag.) anterior border, narrower (tr.) palpebral areas, one less axial ring on the pygidium, and a wider pygidial border. *B. tatondukensis* has a much higher glabella and narrower palpebral area. The pygidium of *B. tatondukensis* is wider, lacks interpleural furrows, and has a much lower terminal piece.

Occurrence. *Bonnia-Olenellus* Zone, GSC locs. 73057, 73063.

Bonnia sp. 1

Plate 14, figures 15–18

Material. Two cranidia 4 and 5 mm long and one partial pygidium about 4 mm long.

Description. Cranidium rather low for genus, length width ratio 2:3. Glabella nearly parallel sided, front very broadly curved to nearly straight. Three pairs of glabellar furrows; anterior pair very faint; second pair very shallow and arcuate, averaging transverse; posterior pair inclined back, of medium depth for short distance, then shallow. Axial furrow of medium width and shallow. Palpebral area very broadly curved (tr.), slightly outslowing. Eye lobes three-eighths as long as glabella, centred opposite point on glabella five-eighths distance back from glabellar front. Anterior border wide (exsag.) for genus, flat, narrows to half width in front of glabella; anterior border furrow very shallow. Facial sutures directed strongly outward from posterior edge of palpebral lobes and then abruptly curved steeply back so that distal ends of posterior areas appear somewhat truncated.

Pygidium marked by three pairs of pleural furrows and two lateral pairs of border spines. Ornamentation on cranidium consists of medium spaced puncta.

Discussion. The three available specimens in the Sekwi collections are too incomplete for specific identification. The elongate glabella and pygidium plus two pairs of pygidial spines invite comparison with *Bonnia bubaris* (Walcott, 1916) as interpreted by Rasetti (1948a, p. 17). Cranidia in the Sekwi material differ from those of *B. bubaris* in having wider (tr.) palpebral areas and palpebral lobes that are located farther forward.

Occurrence. *Bonnia*–*Olenellus* Zone, GSC loc. 73054.

Bonnia sp. 2

Plate 16, figures 16–18

Material. Four cranidia 2 to 5 mm long.

Description. Cranidium convex, length-width ratio 5:8. Glabella has straight sides that diverge forward at moderate rate, front margin broadly curved. Anterior two pairs of glabellar furrows very shallow if present at all; posterior two pairs shallow, transverse for short distance and then branching. Palpebral area broadly convex, averaging horizontal, width four-sevenths that of glabella at base. Palpebral lobes three-eighths as long as glabella, centred opposite or slightly behind point two-thirds distance back from glabella front. Width of posterior area (tr.) equals width of glabella at base. Posterior border furrows, axial furrows, and occipital furrow of medium width and depth. Occipital ring of medium length (exsag.), raised above level of adjacent glabella, presence or absence of spine unknown (broken). Ornamentation consists of irregular, closely spaced granules of medium size on fixigenae, granules somewhat similar on axis but interlocking to give punctate appearance.

Discussion. There is a very close agreement between these cranidia and those of *Bonnia bicensis* Resser, 1936. Since only cranidia are present in the Sekwi material, a full comparison cannot be made and no specific assignment is attempted.

Occurrence. *Bonnia*–*Olenellus* Zone, GSC loc. 73067.

Bonnia sp. 3

Plate 17, figures 8–12

Material. Seven cranidia 2 to 12 mm long.

Description. Cranidium nearly smooth, very lightly furrowed, moderately and uniformly convex in both directions (sag., tr.), length-width ratio 3:5. Glabella has almost no local relief at margins; on small and medium-sized cranidia glabella sides concave and expanding somewhat in forward direction; on large cranidia glabella sides straight and parallel, front margin broadly to moderately curved. Eye ridges, palpebral furrows, and occipital furrow faint, only visible on exfoliated cranidia. Palpebral lobes approximately three-tenths as long as glabella and centred opposite point on glabella three-fifths distance back from glabella front. Anterior border furrow shallow, marked by abrupt but slight change in forward slope at front of cranidium; anterior border is of medium width (exsag.). Occipital ring lower than adjacent glabellum, tilted back, unmarked by node or spine. No ornamentation on either upper or lower surface of cranidium.

Discussion. *Bonnia laevigata* Rasetti, 1948 and *Bonnia tensa* Resser, 1938 have low, lightly furrowed cranidia that resemble this species. Of the two established species, *B. laevigata* has the smoothest cranidium, but has more relief and deeper furrows than the Sekwi specimens. Glabellae of *B. laevigata* expand forward far more rapidly than do those on the Sekwi specimens.

Occurrence. *Bonnia-Olenellus* Zone, GSC locs. 73070, 73071.

Genus *Kootenia* Walcott

Bathyriscus (*Kootenia*) Walcott, 1889, p. 446.

Notasaphus Gregory, 1903, p. 155; Whitehouse, 1939, p. 241.

Kootenia Walcott, 1925, p. 92; Kobayashi, 1935, p. 156; Lermontova, 1940, p. 139; 1951, p. 122; Shimer and Shrock, 1944, p. 613; Rasetti, 1948b, p. 332; Thorslund, 1949, p. 3; Palmer, 1954, p. 64; 1968, p. 47; Hupé, 1955, p. 111; Egorova, Lomovitskaya, Poletaeva, and Sivov, 1955, p. 120; Ivshin, 1957, p. 37; Poulsen, 1959, p. 218; Egorova, *et al.*, 1960, p. 192; Suvorova and Chernysheva, 1960, p. 78; Chernysheva, 1961, p. 126; Lazarenko, 1962, p. 60; Suvorova, 1964, p. 86.

Type species. *Bathyriscus* (*Kootenia*) *dawsoni* Walcott, 1889.

Diagnosis. Cranidium convex (tr.). Glabella rectangular, sides parallel or slightly diverging in forward direction, front usually pressing against and restricting width of anterior border furrow. Glabellar furrows faint or absent. Palpebral lobes small, centred opposite or nearly opposite glabellar midpoint.

Pygidium has high axis, sides parallel or converging moderately toward rear, three to six axial rings present, terminal piece usually fused to border. Pleural field crossed by three to five well-impressed pleural furrows. Border of medium width and bearing three to seven pairs of spines. Spines evenly spaced, size of spines about equal or grading evenly along border.

Discussion. Three genera in North America that resemble *Kootenia* are *Dorypyge*, *Bonnia*, and *Ogygopsis*. *Dorypyge* has a higher glabella, lacks a well-defined pygidial border, has one unusually large pair of spines on the rear margin of the pygidium, and is ornamented with larger granules. Species of *Bonnia* are generally smoother, smaller, and have a relatively

thicker test. Glabellae of *Bonnina* have sides that diverge more rapidly in the forward direction and are more broadly curved across the front. Pygidia of *Bonnina* generally exhibit only one pair of marginal spines, one or two axial rings on the upper surface of the test, only one (anterior) pair of pleural furrows, and a wider border. Species of *Bonnina* are known to have up to three pairs of spines. Tests of *Bonnina* are usually smooth or finely pitted, but some species exhibit small granules or a raised fingerprint pattern. Species of *Ogygopsis* average larger than do those of *Kootenia*. Glabellar sides are either straight and parallel or convex with equal convergence forward and back, and they do not rise as abruptly from the axial furrow as on *Kootenia* and *Bonnina*. Pygidia are not so convex as those on *Kootenia*, there are more rings on the axis and more furrows on the pleural field. Most species lack spines on the border, but up to six pairs may be present.

Kootenia diutina sp. nov.

Plate 2, figures 1-13

Material. Eighty cranidia 1 to 9 mm long, fifty-five pygidia 1 to 6 mm long, three librigenae, and eleven hypostomata.

Description. Cranidium convex, length-width ratio of large cranidia approximately 7:10. Glabella parallel sided, broadly curved across front. Three pairs of shallow glabellar furrows, all pairs somewhat arcuate, anterior pair averages transverse, posterior two pairs inclined back and nearly parallel. Axial furrows of medium depth and width. Palpebral area convex; palpebral furrows broad and of medium depth. Palpebral lobes tilted moderately inward, centred opposite glabellar midpoint, length slightly less than one-third cranidial length. Ocular ridges strong and swelling slightly near axial furrow. Anterior border furrow narrow and shallow across anterior area of fixigena, deeper and much wider in front of glabella. Anterior border tilted strongly back, bowed forward in plan view, and arched upward in front view. Posterior border furrow wide and deep except for shallowing near distal ends. Posterior border narrow at proximal end, expanding in horizontal, transverse direction along first half, much wider and inclined downward and forward along distal half. Occipital furrow deep near ends, of medium depth and wider near midlength. Occipital ring short (exsag.) and bearing a short medial spine that is inclined upward.

Hypostoma has long medial body, curvature at anterior margin of body stronger than at posterior; body traversed by shallow, broad, medial furrow containing ridge which in turn contains narrow, irregular furrow. Posterior border of hypostoma of uniform width and without spines. Anterior wings bent very steeply upward near distal ends.

Librigena has border of uniform width; border furrow deep and wide near anterior end, shallows posteriorly until very shallow near genal angle; length of spine unknown (broken).

Pygidium has length-width ratio of approximately 4:7. Axis consists of five rings and terminal piece, anterior three rings bear nodes. Pleural field traversed by three strong pairs and one medium pair of pleural furrows; anterior two pairs of interpleural furrows faint near axis and visible for only short distance on field. Border furrow narrow and shallow. Border marked by four pairs of short, thin spines and small swellings or very small spines in fifth position. Ornamentation on all described parts except hypostoma consists of closely spaced granules of medium size. Hypostoma smooth except for scattered granules on posterior border.

Discussion. *Kootenia diutina* is probably the oldest species of *Kootenia* described from North America. The largest specimens in the present collections are small as compared to other

adults of this genus. A cranidium with a wide, deep anterior border furrow in front of the glabella, and a pygidium with an unusually great relative width, very deep furrows on the axis, and four to five pairs of very thin spines distinguish *K. diutina* from other species of *Kootenia*.

Occurrence. Nevadella Zone, GSC locs. 73026, 73027, 73030, and 73032-9.

Family ORYCTOCEPHALIDAE Beecher, 1897

Genus *Oryctocephalus* Walcott

Oryctocephalus Walcott, 1886, p. 210; Miller, 1889, p. 558; Beecher, 1897, p. 192; Matthew, 1899, p. 63; Reed, 1910, p. 10; Kobayashi, 1935, p. 146; Resser, 1938b, p. 37; Lermontova, 1940, p. 136; Shimer and Shrock, 1944, p. 615; Palmer, 1954, p. 68; Hupé, 1955, p. 111; Rasetti, 1959, p. 220; Suvorova and Chernysheva, 1960, p. 82; Egorova, *et al.*, 1960, p. 198; Chernysheva, 1962, p. 11.

Type species. *Oryctocephalus primus* Walcott, 1886.

Discussion. The diagnoses by Palmer and Lermontova are used in placing the specimen described below.

Oryctocephalus? sp.

Plate 19, figures 20, 21

Material. One exfoliated cranidium 5 mm long.

Description. Cranidium has length-width ratio of 5:8. Glabella sides diverging moderately to eye ridges, then converging for short distance to broadly curved glabellar front. Four pairs of glabellar furrows; anterior pair uniformly narrow, angle slightly forward, distal ends intersect axial furrow; posterior three pairs consist of pits with short, transverse extensions directed outward but not reaching axial furrow. Palpebral area as wide (tr.) as glabella at base, broadly convex, average dip horizontal. Palpebral lobes three-eighths as long as glabella and centred opposite point one-third distance forward from base of glabella. Anterior border on fixigenae of medium width (exsag.) and tilted slightly back, much narrower in front of glabella. Surface of exfoliated specimen smooth.

Discussion. This cranidium is too incomplete for identification, but it may belong to the genus *Oryctocephalus*. It lacks the wire-like anterior border of *Lancastria* and *Goldfieldia*, and unlike *Goldfieldia* it has a well-defined glabellar front. In North America *Lancastria* and *Goldfieldia* are the only known oryctocephalids from the Lower Cambrian.

Occurrence. Bonnia-Olenellus Zone, GSC loc. 73075.

Family ZACANTHOIDIDAE Swinnerton, 1915

Genus *Zacanthopsis* Resser

Zacanthopsis Resser, 1938a, p. 106; Hupé, 1953, p. 105; Rasetti, 1959, p. 230; Palmer, 1964, p. 9.

Type species. *Olenoides levis* Walcott, 1886.

Discussion. Palmer's diagnosis of this genus is followed here.

Zacanthopsis stribuccus sp. nov.

Plate 16, figures 19, 20

Material. One cranidium and one questionably assigned cranidium, both 5 mm long.

Description. Cranidium has length-width ratio of slightly more than 5:7. Glabella sides parallel along posterior half, expanding slightly along anterior half, front broadly curved. Four pairs of glabellar furrows, anterior three pairs very shallow, anterior two inclined forward, third transverse, posterior pair inclined steeply back and of medium depth. Palpebral area as wide (tr.) as glabella at base, broadly convex, average tilt is moderately inward. Eye ridges narrow (exsag.). Palpebral lobes much wider (tr.) than eye ridges, length slightly greater than half glabellar length, average direction is back and slightly outward. Palpebral furrow of medium depth, narrow at anterior end, becoming very wide opposite posterior one-third mark on palpebral lobe, narrowing again at posterior end. Anterior border furrow wide and shallow; adjacent border consists of upturned front of cranidium. Facial sutures slightly divergent from palpebral lobes forward. Occipital ring bears small spine that is continuation of low medial (sag.) ridge extending across ring. Cranidial ornamentation consists of fine granules.

Discussion. This species differs from *Zacanthopsis levis* (Walcott) and *Zacanthopsis virginicus* Resser in having anterior facial sutures that are less divergent forward, palpebral lobes that are directed (average direct.) slightly outward, and a much smaller occipital spine. *Zacanthopsis contractus* Palmer is closer to *Z. stribuccus* sp. nov., but has much shorter (tr.) eye ridges and longer palpebral lobes. *Z. stribuccus* differs from all the above-mentioned species in having a wider and therefore more prominent palpebral furrow.

Occurrence. Bonnia-Olenellus Zone, GSC locs. 73067, 73074(?).

Family Uncertain

Genus *Sekwiaspis* gen. nov.

Type species. *Sekwiaspis artifrons* sp. nov.

Diagnosis. Cranidium convex and long. Glabella converging moderately forward, front has medium curvature. Glabellar furrows lightly impressed, posterior pair joined or nearly joined in broad arc across axial midline. Palpebral area slightly less than half as wide as glabella at base, nearly horizontal. Eye ridges originating close behind anterolateral corners of glabella, inclined back rather steeply. Palpebral lobes narrow (tr.), half as long as glabella, centred approximately opposite glabellar midpoint. Facial sutures diverge slightly forward from palpebral lobes; posterior sutures inclined steeply back from lobes to posterior border. Anterior area of medium length, several times as long (sag.) as narrow anterior border. Posterior area wedge-shaped and approximately two-thirds as wide as glabella at base.

Pygidium small, lateral margin inclined steeply back, posterior margin nearly transverse. Axis proportionately large, consisting of one or two clearly defined rings and terminal piece. Pleural region marked by several pairs of furrows.

Discussion. *Ezhimia*, a genus known from Russia, has a similar glabellar construction. *Sekwiaspis* differs from *Ezhimia* in having both anterior and posterior pairs of facial sutures that diverge far less rapidly from the palpebral lobes, and in having posterior glabellar furrows that do not bifurcate.

Sekwiaspis artifrons sp. nov.

Plate 6, figures 10-19

Material. Six cranidia 3 to 14 mm long and one pygidium 2 mm long.

Description. Cranidium very convex, length-width ratio 4:5. Glabella high, sides straight and converging forward, front margin has medium curvature. Three pairs of glabellar furrows; anterior pair very shallow and inclined slightly forward; posterior two pairs inclined moderately back (posterior steepest), both pairs nearly join across axial midline. Axial furrows of medium depth and width. Palpebral area has medium convexity (tr.), averaging horizontal, width (tr.) three-eighths that of glabella at base. Eye ridges wide and of medium height. Palpebral furrows narrow (tr.). Palpebral lobes narrow, half as long as glabella, centred opposite glabellar midpoint. Facial sutures diverging moderately forward from palpebral lobes and nearly straight. Preglabellar field of medium length, sloping forward, much longer (sag.) than narrow anterior border. Anterior border furrow shallow and broad (sag.). Posterior area only slightly wider (tr.) than half glabellar width at base. Posterior border furrow wide and deep; adjacent border narrow. Occipital furrow narrow and deep near ends, front margin of medial segment bowed forward, wide and shallow at midlength. Occipital ring of medium length (sag.) and bearing raised spine on posterior margin.

Pygidium small, lateral margin inclined steeply back, posterior margin transverse and nearly straight. Axis consists of two (?) rings and terminal piece. Pleural region marked by two pleural furrows of medium depth and width and one narrow interpleural furrow. Ornamentation on cranidium and pygidium consists of granules of various sizes and terrace lines on the anterior border.

Discussion. The writer knows of no species that resembles this one.

Occurrence. Nevadella Zone, GSC locs. 73032, 73033, 73035, 73036.

Family EDELSTEINASPIDIDAE Hupé, 1953

Genus *Paleofossus* Pokrovskaya

Paleofossus Pokrovskaya, 1959, p. 131; Egorova, et al., 1960, p. 190; Repina, 1964, p. 297.

Type species. *Paleofossus zaicevi* Pokrovskaya, 1959.

Discussion. The incomplete specimen described below may belong to the genus *Paleofossus* as diagnosed by Pokrovskaya (1959).

cf. *Paleofossus* sp. 1

Plate 5, figures 10, 11

Material. One damaged cranidium 4 mm long.

Description. Cranidium convex, length-width ratio slightly greater than 3:4. Glabella high, sides straight to slightly convex, gradually converging forward, curvature medium at front margin. Three pairs of glabellar furrows; anterior pair shallow and transverse; second pair of medium depth and width, joining across axial midline to form broad arc that is concave forward; posterior pair of medium width, deep, inclined strongly back along distal thirds, joined by transverse medial third. Axial furrow shallow and of medium width. Palpebral

area horizontal (tr.), about half as wide as glabella at base. Eye ridges of medium width and height. Palpebral lobes one third as long as glabella, tilted slightly inward, centred well back of glabellar midpoint. Preglabellar field short. Anterior border furrow shallow and of moderate width; anterior border narrow (exsag.) and tilted strongly back. Posterior area about as wide (tr.) as glabella at base; posterior border furrow wide and deep; adjacent border of medium width (exsag.), narrowing at both ends, bearing small spine at postero-lateral margin. Occipital furrow transverse, depth and width approximately equal those of posterior pair of glabellar furrows. Occipital ring of medium length (sag.), bearing an elevated spine on posterior margin. Ornamentation on cranidium consists of granules of various sizes.

Discussion. A cylindrical glabella, two nearly transverse anterior pairs of glabellar furrows, and strong eye ridges that merge with little change of relief or width into the palpebral lobes are some of the features that this small cranidium has in common with small cranidia of *Paleofossus*.

Occurrence. Nevadella Zone, GSC loc. 73030.

Family PTYCHOPARIIDAE Matthew, 1887

Genus *Antagmus* Resser

Antagmus Resser, 1936, p. 3; Shimer and Shrock, 1944, p. 605; Lochman, 1947, p. 62; Hupé, 1955, p. 126; Rasetti, 1955, p. 9; 1959, p. 235.

Antagmus (*Antagmus*) Shaw, 1962, p. 335.

"*Antagmus*" Palmer, 1968, p. 74.

Type species. *Antagmus typicalis* Resser, 1936 (= *Ptychoparia teucer* Walcott, 1886, p. 197, Pl. 26, fig. 3).

Discussion. Rasetti's (1955) diagnosis of this genus is followed in this paper.

Antagmus truncatus sp. nov.

Plate 19, figures 1-10

Material. Ten cranidia 2 to 8 mm long.

Description. Cranidium of medium convexity, length-width ratio 2:3. Glabella low, sides straight and converging forward at moderate rate, front truncated and only elevated to approximate level of adjacent fixigena. Glabellar front on exfoliated specimens strongly curved rather than truncated. Four pairs of shallow glabellar furrows, anterior pair short and inclined forward, second pair inclined forward and slightly longer, third pair transverse and then branching with one limb inclined forward and other back, posterior pair inclined slightly back and branching with one limb directed slightly forward and other moderately to strongly back. Axial furrows of medium depth and width; furrows deep and wide on exfoliated specimens. Palpebral area flat and tilted toward rear, nearly three-fourths as wide (tr.) as glabella at base. Eye ridges of medium width and low. Palpebral lobes centred opposite or just anterior to glabellar midpoint and one-fourth as long as glabella. Facial sutures slightly divergent from palpebral lobes to posterior margin of anterior glabellar furrow. Anterior border furrow wide and deep, extending back near axial midline so that furrow reaches or

nearly reaches front of glabella. Anterior border narrow near ends (exsag.) and wide elsewhere, convex in cross-section, average slope is horizontal, posterior margin has slight recurvature in front of glabella. Posterior area slightly wider (tr.) than glabella at base; posterior border of medium width (exsag.) throughout. Posterior border furrow wide and deep except for marked shallowing at both ends. Occipital furrow of medium depth and narrow near ends, shallow and slightly wider elsewhere. Occipital ring of medium length (sag.), raised slightly above level of glabella, and bearing mesial node that is raised considerably higher. Ornamentation on cranidium consists of densely spaced, small granules and sparse, faint large granules. Exfoliated cranidia exhibit sparse large granules, remaining area covered by densely spaced puncta.

Discussion. Flat palpebral areas that are tilted back and a truncated glabellar front differentiate this species from others in the genus. As mentioned above, the glabellar front is strongly curved rather than truncated on exfoliated specimens. "*Antagmus*" *laminatus* Palmer, 1968, has a glabella with truncated front, but a narrower (exsag.) anterior border, eye ridges that are located much farther forward, and a long (sag.) occipital ring. Palmer (1968, p. 75) is correct in stating that "*A.*" *laminatus* "probably represents a genus as yet unnamed."

Occurrence. *Bonnia-Olenellus* Zone, GSC loc. 73073.

Genus *Poulsenia* Resser

Poulsenia Resser, 1936, p. 26; Hupé, 1955, p. 127; Rasetti, 1955, p. 5; 1959, p. 237; Balashova, Ivshin, and Chernysheva, 1960, p. 106; Shaw, 1962, p. 343.

Type species. *Solenopleura groenwalli* Poulsen, 1927.

Discussion. Rasetti restricted this genus to the type species, but later (1957) added *Poulsenia columbiana*. The writer believes the latter species belongs under either *Caborcella* or *Onchocephalus*. No attempt is made here to present a new generic diagnosis for *Poulsenia*, as the type species is not readily accessible and the Sekwi species is represented by a meagre collection.

Poulsenia sp. 1

Plate 11, figures 3-6

Material. Three exfoliated cranidia 5 to 7 mm long.

Description. Cranidium convex, length-width ratio approximately 6:10. Glabella quadrate, raised only slightly above adjacent fixigenae, sides straight and converging moderately forward, front truncated against anterior border furrow. Three pairs of shallow glabellar furrows, anterior pair inclined forward, second pair branching with one limb inclined forward and other back, posterior pair branching with one limb transverse and other inclined steeply back. Axial furrows very wide and deep. Palpebral area convex (tr.), half as wide as glabella at base, average slope is outward. Eye ridges of medium width and low. Palpebral lobes one-third as long as glabella and centred well back of glabellar midpoint. Facial sutures initially directed straight forward from palpebral lobes, curving within short distance and rapidly converging forward over remaining course. Anterior border convex in cross-section, of medium width (exsag.), bowed upward when seen in front view. Posterior areas nearly as wide as glabella at base. Posterior border narrow (exsag.) along proximal half, of medium width

along distal half; posterior border furrow wide and deep. Occipital furrow of medium depth; occipital ring short (exsag.), neither node nor spine visible. Ornamentation on exfoliated cranidia consists of medium spaced puncta.

Discussion. Cranidia in the Sekwi collection differ from those of *Poulsenia groenwalli* (Poulsen) in having a more quadrate glabella that terminates closer to the anterior border.

Occurrence. *Bonnina-Olenellus* Zone, GSC loc. 73047, 73048.

Genus *Piaziella* Lochman

Piaziella Lochman, 1947, p. 69; Hupé, 1955, p. 126; Rasetti, 1955, p. 6; 1959, p. 237.

Type species. *Ptychoparia pia* Walcott, 1917.

Discussion. Lochman's diagnosis of *Piaziella* is followed in this paper. *Piaziella* resembles *Antagmus*, but has a cranium with less convexity, has wider (tr.) palpebral and posterior areas, and lacks a shallow depression in front of the glabella. Exfoliated cranidia of *Antagmus* have unusually broad and deep furrows, suggesting that the genus has a thicker test than that of *Piaziella*.

Piaziella pia (Walcott)

Plate 19, figures 11-19

Ptychoparia pia Walcott, 1917, p. 93, Pl. 12, fig. 8.

Antagmus pia (Walcott), Resser, 1937b, p. 1.

Piaziella pia (Walcott), Lochman, 1947, p. 69, figs. 4-6; Rasetti, 1951, p. 236, Pl. 8, figs. 3-5.

Material. Six cranidia 2 to 13 mm long and one tentatively assigned pygidium 2 mm long.

Description. Cranium of medium to low convexity (tr.), length-width ratio slightly greater than 5:8. Glabella small, low, sides slightly convex and converging forward, front truncated. Three pairs of very shallow glabellar furrows, anterior pair inclined moderately forward, second pair inclined moderately back, third inclined moderately back and branching with one limb inclined forward and other back. Axial furrow narrow and shallow. Palpebral area two-thirds as wide (tr.) as glabella at base, broadly convex (tr.), moderately outslipping. Eye ridge on exfoliated cranidia low but distinct, wide. Palpebral lobes approximately one-third as long as glabella and centred slightly back of glabellar midpoint. Preglabellar area rather long (sag.) and inclined forward. Facial suture broadly curved and diverging from palpebral lobes forward, directed nearly straight forward where intersecting with anterior border furrow. Border furrow shallow, narrow, very broadly bowed back to nearly straight along medial segment, more strongly curved near ends. Anterior border flat and tilted moderately forward. Posterior area slightly wider (tr.) than glabella at base; posterior border and border furrow narrow (exsag.), directed out and slightly back. Occipital furrow narrow and shallow; occipital ring short (sag.) and marked by small node.

Tentatively assigned pygidium low, width exceeds twice length. Axis low, consisting of four (?) rings and short terminal piece. Pleural regions flat and horizontal, marked by one pair (anterior) of narrow pleural furrows of medium depth. Ornamentation consists of small, closely set granules on cranium and sparse, faint granules of medium size on tentatively assigned pygidium. Exfoliated cranium marked by longitudinal venation and faint to moderately strong puncta on genae anterior to eye ridges and on preglabellar field.

Discussion. Lower Cambrian specimens from Vermont that Resser (1937a, Pl. 8, figs. 31–37) figured as *Ptychoparella adamsi* (Billings) and *Ptychoparella billingsi* Resser are close to this species, but have proportionately larger and higher glabellae. The Vermont material is poorly preserved, and therefore further comparison with the Sekwi specimens is difficult.

Occurrence. *Bonnia–Olenellus* Zone, GSC loc. 73073.

Piaziella? rara sp. nov.

Plate 20, figures 15–19

Material. Three cranidia 2 to 6 mm long.

Description. Cranidium of medium to low relief, length-width ratio slightly greater than 1:2. Glabella low, sides straight and converging forward, front margin broadly curved. Three pairs of shallow glabellar furrows, anterior pair nearly transverse, second pair arcuate and inclined slightly back and possibly branching, posterior pair inclined moderately back and branching into limb inclined moderately forward and limb inclined strongly back. Axial furrow narrow, of shallow to medium depth. Palpebral area broadly curved and outslipping, half as wide (tr.) as glabella at base. Eye ridges of medium height and width. Palpebral lobes narrow (tr.), raised, tilted steeply inward, centred well back of glabellar midpoint, and about one-third as long as glabella. Preglabellar field short (sag.). Facial sutures exhibit medium curvature between palpebral lobes and anterior border furrow, average direction is straight forward. Anterior border furrow narrow and shallow, nearly straight except for broad curvature near ends. Anterior border flat, tilted moderately forward, fairly uniform in width (exsag.) except for narrowing near ends. Posterior area as wide (tr.) as glabella at base. Both posterior border and border furrow maintain fairly uniform width (exsag.), furrow is of medium depth. Occipital furrow narrow, deepening near ends. Occipital ring short (sag.) and bearing node. Ornamentation on cranidium consists of densely spaced, very fine granules.

Discussion. The proportions of these cranidia are intermediate between those of *Antagmus* and *Piaziella*. Both the present species and the type species of *Piaziella* lack the following morphologic features seen on most species of *Antagmus*: a shallow depression in front of the glabella, palpebral areas that are moderately to strongly convex, and axial furrows that are wide and deep, especially on exfoliated specimens. The present species differs from *Piaziella pia* (Walcott) in having a proportionally larger glabella and a shorter (sag.) preglabellar field.

Occurrence. *Bonnia–Olenellus* Zone, GSC loc. 73075.

Genus *Proliostracus* Poulsen

Proliostracus Poulsen, 1932, p. 48; Lochman, 1947, p. 68; Hupé, 1955, p. 126; Rasetti, 1955, p. 5; 1959, p. 237; Shaw, 1959, pp. 474–487; 1962, p. 338.

Type species. *Proliostracus strenuelliformis* Poulsen, 1932.

Diagnosis. Ptychoparioid with wide axial, preglabellar, and posterior border furrows. Glabellar sides straight, converging moderately forward, front abruptly truncated. Three to four pairs of shallow glabellar furrows, most expand inward and some bifurcate. Palpebral lobes centred opposite midpoint on glabella or slightly ahead. Anterior border furrow shallow, contact between furrow and anterior border marked by only slight change in relief,

furrow locally displaced by low preglabellar swelling or boss. Anterior segments of facial sutures slightly converging or slightly diverging. Occipital ring rather long (sag.).

Pygidium wide, somewhat pointed at anterolateral ends, broadly curved along rear margin. Axis very low and consists of approximately four poorly defined rings and short terminal piece.

Discussion. In addition to the type species, Poulsen erected three species from the same general locality in east Greenland. Lochman placed two and Shaw placed all three of the additional species under the type species. To date, only the east Greenland material and the herein described Sekwi species are recognized by the writer as belonging to this genus. *Proliostracus* can be distinguished from most other genera by applying the following combined criteria: wide axial, preglabellar, and posterior border furrows, truncated glabella, low preglabellar boss, gradual transition from anterior border furrow to adjacent border, and long occipital ring. *Bicella* incorporates most of these features, but has much larger eye ridges and palpebral lobes, and much narrower (tr.) palpebral areas. *Syspacephalus* has narrow rather than wide axial and preglabellar furrows and lacks a preglabellar boss.

Occurrence. Thus far, *Proliostracus* is known only from the *Bonnia-Olenellus* Zone.

Proliostracus annosus sp. nov.

Plate 10, figures 17-22

Material. Twelve cranidia 2 to 5 mm long and one questionably assigned pygidium. As all but two small cranidia are exfoliated, the description below refers only to exfoliated material.

Description. Cranidium rather low. Glabella sides straight and gradually converging forward. Four pairs of shallow glabellar furrows; anterior pair very shallow and narrow, located close to second pair and inclined forward; second pair expanding inward and inclined slightly forward; third pair branching into transverse and posteriorly inclined limb; posterior pair similar to third pair but larger. Palpebral area about as wide (tr.) as axial furrow, but relative width is variable on different specimens and inversely proportional to width of axial furrow. Palpebral lobes very narrow, half as long as glabella, centred opposite glabellar midpoint; palpebral furrow broad and shallow. Eye ridges rather narrow but well defined. Facial suture directed nearly straight forward from palpebral lobes to anterior border furrow. Anterior border furrow of medium depth and width except medially where displaced by low preglabellar boss. Anterior border slightly convex in cross-section (exsag.), highest along posterior margin, and inclined moderately forward. Posterior area as wide (tr.) as glabella at base. Posterior border very narrow (exsag.) near axial furrow, expanding slightly outward. Occipital furrow of medium depth and width. Presence of occipital node or spine unknown (broken).

Pygidium has length-width ratio of 2:5. Axis low, consisting of four rings and terminal piece. Anterior ring defined at posterior margin by shallow furrow, marked by pair of nodes at back margin that extend into furrow and by second, more widely spaced pair near distal ends of ring. Additional three rings suggested by similarly arranged nodes, but rings not defined by furrows. Short (sag.) terminal piece defined by shallow furrow at anterior margin. Pleural region slopes moderately outward near anterolateral margin, slope near margin increases posteriorly until quite steep near back of pygidium. Pleural region marked by anterior pair of pleural furrows of medium depth and width, second pair of equal width but shallow, and at least two additional, very faint pairs. Surface of exfoliated cranidia is slightly rough,

venation on fixigenae and sublongitudinal venation on preglabellar boss. Exfoliated pygidium has slightly rough surface.

Discussion. This species is very close to *Proliostracus strenuelliformis* Poulsen, but differs in having narrower (tr.) palpebral areas and palpebral lobes that are situated farther back.

Occurrence. *Bonnia-Olenellus* Zone, GSC loc. 73044.

Proliostracus contractus sp. nov.

Plate 10, figures 1–5

Material. Six cranidia 2 to 5 mm long; all except one are exfoliated. The following description is based on the exfoliated cranidia.

Description. Glabella marked by three pairs of glabellar furrows, all pairs expand inward, average direction of anterior pair is slightly forward, middle and posterior pairs average transverse, posterior pair bifurcates with limbs inclined forward and back. Palpebral areas half as wide as glabella at midlength, convex, average slope is horizontal. Palpebral lobes narrow (tr.), centred opposite glabellar midpoint, half as long as glabella, and defined by wide, shallow palpebral furrow. Eye ridges very thin but well raised. Facial suture directed nearly straight forward from palpebral lobes to anterior border furrow, then curved inward. Anterior border furrow of medium width and shallow near ends, replaced near axial midline by slight swelling that extends onto posterior edge of anterior border. Anterior border slopes forward. Posterior area wider (tr.) than glabella at base. Posterior border narrow (exsag.). Occipital ring incompletely known (broken). Ornamentation on exfoliated cranidia consists of densely spaced puncta and very faint venation angling inward and forward from eye ridges to anterior border furrow.

Discussion. *P. contractus* resembles *Proliostracus depressus* sp. nov., but has narrower palpebral areas and a much higher glabella that is positioned closer to the anterior border.

Occurrence. *Bonnia-Olenellus* Zone, GSC loc. 73042.

Proliostracus depressus sp. nov.

Plate 9, figures 15–20

Material. Twelve cranidia 3 to 5 mm long.

Description. Cranidium low. Glabella front nearly level with fixigena, rising gradually back to low rear. Three pairs of glabellar furrows, all pairs expand inward, average direction of anterior pair is transverse, posterior two pairs each branch with one limb transverse and second inclined back. Palpebral area half as wide (tr.) as glabella at base, average slope is outward. Eye ridges narrow (exsag.) but distinct. Palpebral lobes very narrow (tr.), half as long as glabella, centred well ahead of glabellar midpoint. Palpebral furrows shallow and broad. Anterior border furrow broad and shallow near ends, medial segment in part merges with furrow bordering glabella and in part displaced by low boss that extends onto posterior part of anterior border. Contact between anterior border furrow and anterior border gradational on large specimens, more sharply defined on medium and small specimens and on all exfoliated specimens. Facial sutures converge moderately forward from palpebral lobes to anterior border; sutures diverge moderately back from palpebral lobes. Posterior area three-fourths as

wide (tr.) as glabella at base. Posterior border very narrow (exsag.) near axial furrow and expanding gradually outward. Occipital furrow wide and shallow. Occipital ring low, marked by low node. Ornamentation consists of large, sparse puncta on occipital ring, weak, irregular venation on fixigena, and weak sublongitudinal venation on preglabellar boss.

Discussion. See discussion under *Proliostracus contractus*.

Occurrence. *Bonnina-Olenellus* Zone, GSC loc. 73040.

Proliostracus latus sp. nov.

Plate 10, figure 23

Material. One exfoliated cranidium 5 mm long.

Description. Exfoliated cranidium low, length-width ratio approximately 5:7. Glabella small, sides converge gradually forward. Three pairs of very faint glabellar furrows, anterior pair inclined forward, second pair transverse, third pair branched with one limb transverse and other inclined back. Palpebral area broadly convex (tr.), average slope is slightly inward. Distance (tr.) from side of glabella to outer margin of palpebral lobe equals width of glabella at base. Palpebral lobes tilted moderately inward, centred opposite glabellar midpoint, length slightly greater than half glabellar length. Palpebral furrow of medium width and shallow. Eye ridges of medium width and height. Facial sutures broadly curved and divergent from palpebral lobes forward to anterior border furrow. Anterior border furrow of medium width (exsag.) and shallow except near middle where interrupted by low preglabellar boss. Anterior border fairly uniform in width (exsag.) and tilted moderately forward. Posterior area as wide (tr.) as glabella at base. Occipital furrow of medium depth and width. Presence of occipital spine or node unknown (broken). Fixigenae in front of eye ridges and preglabellar boss marked by longitudinal venation.

Discussion. Lower cranial relief and wider palpebral areas distinguish this species from other known species of *Proliostracus*.

Occurrence. *Bonnina-Olenellus* Zone, GSC loc. 73044.

Proliostracus aff. *P. annosus* sp. nov.

Plate 11, figures 1, 2

Material. One exfoliated cranidium 5 mm long.

Description. Exfoliated glabella marked by very light furrows, anterior pair narrow and inclined forward, posterior pairs average transverse. Distance from glabella to palpebral lobe half that across base of glabella. Palpebral lobes centred opposite glabellar midpoint and half as long as glabella. Eye ridges intersect glabella at anterolateral corners. Exfoliated surface finely pitted, longitudinal venation on preglabellar boss and sparse, faint venation is directed forward and inward from anterior margin of eye ridges.

Discussion. Very shallow glabellar furrows and eye ridges positioned farther forward suggest that this cranidium may differ specifically from that of *Proliostracus annosus* sp. nov.

Occurrence. *Bonnina-Olenellus* Zone, GSC loc. 73044.

Genus *Syspacephalus* Resser

Syspacephalus Resser, 1936, p. 28; Lochman, 1947, p. 64; Rasetti, 1951, p. 241; 1959, p. 237; Hupé, 1955, p. 126; Shaw, 1962, p. 337.

Type species. *Agraulos charops* Walcott, 1917.

Discussion. The diagnosis by Lochman and remarks by Rasetti (1951) adequately characterize this genus.

Syspacephalus vapidus sp. nov.

Plate 20, figures 1-8

Material. Thirty-four cranidia 1 to 4 mm long.

Description. Cranidium has length-width ratio of slightly less than 2:3. Glabella nearly straight to slightly concave along sides, converging moderately forward, front margin moderately curved. Four pairs of narrow glabellar furrows; anterior pair visible only on exfoliated cranidia, very short and narrow, inclined forward; second pair inclined but slightly forward; third pair inclined moderately back; fourth pair inclined moderately back and branching with one limb inclined slightly forward (?) and other strongly back. Axial furrow of medium depth and width. Eye ridges narrow and low. Palpebral lobes narrow (tr.), approximately two-fifths as long as glabella, centred slightly ahead of glabellar midpoint. Palpebral furrows shallow and narrow. Facial sutures nearly straight and converging forward from palpebral lobes to anterior border. Preglabellar field short (sag.). Anterior border furrow of medium depth and width except for slight shallowing near axial midline. Anterior border convex in cross-section, average tilt is slightly forward. Posterior area not quite as wide (tr.) as glabella at base; posterior border furrow is of medium depth and wide; posterior border narrow. Occipital furrow rather narrow, deepening near distal ends. Occipital ring of medium length (sag.) and marked by small node. Cranidium nearly smooth, exfoliated cranidia exhibit puncta on and near preglabellar field.

Discussion. *Syspacephalus crassus* Rasetti, 1951, has a cranidium with the general proportions of this species, including a glabella which is rather high for the genus. *S. crassus* differs from *S. vapidus* in having a longer (sag.) preglabellar field, a wider (sag.) anterior border, posterior areas that turn strongly downward near their distal ends, and a granular ornamentation. *S. crassus* is known only from early Middle Cambrian strata.

Occurrence. *Bonnia-Olenellus* Zone, GSC loc. 73075.

Genus *Variopelta* gen. nov.

Type species. *Variopelta laevis* sp. nov.

Diagnosis. Cranidium rather smooth and low. Glabella straight sided, converging forward, front truncated. Glabellar furrows lightly impressed or extinct. Palpebral areas about half as wide (tr.) as glabella at base, average slope is horizontal. Palpebral lobes about half as long as glabella, centred slightly ahead of glabellar midpoint. Cranidium anterior to eye ridges and preglabellar furrow undifferentiated by local relief or anterior border furrow.

Facial sutures directed nearly straight forward from palpebral lobes, directed strongly back from lobes so that posterior area is narrow (tr.). Occipital ring very long (sag.) and extending back to broadly pointed spine.

Discussion. *Proliostracus*, *Sombrerella*, and *Syspacephalus* bear some resemblance to this genus in that they have a truncated glabella of similar size and position, and shallow anterior border furrows. However, the anterior border furrow on these genera is distinctly visible, the palpebral lobes are smaller, and the posterior areas wider (tr.). The occipital ring on *Proliostracus* and *Syspacephalus* is much shorter than on *Variopelta*. *Mexicella* differs from *Variopelta* in having broader (tr.) palpebral areas, shallower axial furrows, and a shorter (sag.) occipital ring.

Variopelta laevis sp. nov.

Plate 12, figures 1–13

Material. Twenty-six cranidia 1 to 5 mm long.

Description. Cranidium low, rather smooth except for axial and preglabellar furrows, exfoliated cranidia exhibit considerably more local relief. Glabellar furrows visible only on exfoliated specimens, three very shallow pairs present, all pairs expand inward, anterior pair inclined forward, second pair transverse, posterior pair branches with one limb transverse and other inclined back. Axial furrows broad and shallow, on exfoliated cranidia furrows very broad and of medium depth. Preglabellar furrow of medium width and shallow, furrow broad and shallow on exfoliated cranidia. Palpebral area half as wide as glabella at base, broadly curved (tr.), average slope is horizontal. Eye ridges visible on exfoliated specimens only, narrow (exsag.) and of medium height. Palpebral lobes narrow (tr.), centred ahead of glabellar midpoint, slightly longer than half glabellar length. Palpebral furrows very narrow and shallow, on exfoliated cranidia furrows of medium width and shallow. Anterior area and laterally adjacent test broadly curved (sag.), sloping slightly back near preglabellar furrow and moderately forward near front margin of cranidium. Posterior area somewhat truncated at distal ends, width (tr.) slightly less than half glabellar width at base. Posterior border furrow of medium width (exsag.) and shallow, on exfoliated specimens furrow is shallow, of medium width, expands distally, and contains node near distal end. Posterior border directed out and slightly back, expanding distally. Occipital furrow very shallow; on exfoliated cranidia furrow shallow to medium depth, distal one-thirds have anterior margins that are transverse and posterior margins that bow back, medial one-third bowed forward along both margins. Occipital ring very long (sag.), extending back into broad, rather flat spine; exfoliated ring exhibits strongly rounded posterior margin. Ornamentation consists of fine puncta and of terrace lines located on front margin of cranidium and lateral margin of occipital spine; exfoliated cranidia are more strongly punctate and exhibit venation extending forward and inward from eye ridges.

Discussion. *Lorenzella acalle* (Walcott, 1905) bears some resemblance to this species, but has a lower glabella, deeper axial furrows, a preglabellar boss, and a node rather than a spine on the occipital ring. Since *L. acalle* is from Middle Cambrian strata in China, it is unlikely to be confused with *Variopelta laevis* sp. nov.

Occurrence. *Bonnia–Olenellus* Zone, GSC loc. 73045.

Ptychoparioid genus and species undetermined

Plate 18, figures 18, 19

Material. Two cranidia 4 and 7 mm long.

Description. Cranidium low, width nearly twice length. Glabella narrow, lateral margins slightly concave to nearly straight and converging moderately forward, front truncated. Three pairs of very shallow glabellar furrows, anterior pair directed slightly forward, posterior two pairs directed slightly back, posterior pair bifurcates. Axial furrow narrow and of moderate depth. Palpebral area very broadly convex (tr.), average slope is slightly outward, width about five-sevenths width of glabella at base. Palpebral lobes small, width (tr.) approximately equal to width of shallow palpebral furrow, length of lobes three-eighths length of glabella. Eye ridges faintly defined. Preglabellar field rather long (sag.). Anterior border narrow (sag.), very narrow at distal ends; anterior border furrow narrow and shallow. Facial sutures broadly curved between palpebral lobes and anterior border furrow, directed straight ahead from lobes, converging slightly near anterior border furrow. Posterior areas slightly wider (tr.) than glabella at base, distal ends are pointed. Posterior border and border furrow narrow (exsag.), border directed slightly back near distal ends. Occipital furrow narrow and of moderate depth at distal ends, shallow and wider near middle. Occipital ring short (sag.); occipital spine or node small if present (not preserved). Surface of large cranidium nearly smooth, small cranidium marked by faint, sparse granules.

Discussion. No Lower Cambrian genus known to the writer contains species similar to the specimens described above. The available material is not considered sufficient to erect a new genus.

Occurrence. *Bonnia-Olenellus* Zone, GSC loc. 73073.

Family SOLENOPLEURIDAE Angelin, 1854

Genus *Keeleaspis* gen. nov.

Type species. *Keeleaspis gratia* sp. nov.

Diagnosis. Solenopleurid with pygidium of medium size. Cranidium convex; glabella large high, sides nearly straight and converging to a strongly rounded front; three pairs of moderate to deep glabellar furrows, all pairs inclined back, but at various angles; occipital ring short (tr.); palpebral lobes half as long as glabella and centred opposite glabellar midpoint; frontal area short; posterior area nearly as wide (tr.) as glabella at base. Librigena has raised border. Thorax unknown. Pygidium transverse, of medium size (large for Lower Cambrian Ptychopariida), axis low and having two or three axial rings; anterior pair of pleurae has deep interpleural furrow at posterior margin and extends into short spines.

Discussion. *Gelasene*, known only from the type species, *G. acanthinos* Palmer, 1968, is a Lower Cambrian genus somewhat similar to *Keeleaspis*. The glabella of *G. acanthinos* differs from that of *Keeleaspis* in being lower, more pointed in front, and having all three pairs of glabellar furrows parallel. *G. acanthinos* has deep pits near the anterolateral margin of the glabella, which are not seen on the present genus, and *Gelasene* has far shorter palpebral lobes. The pygidium assigned to *G. acanthinos* is smaller than pygidia belonging to *Keeleaspis* and has one or two more axial rings. *G. acanthinos* is probably from younger strata than are the two species of *Keeleaspis* described below.

Two early Middle Cambrian genera, *Parapoulsenia* and *Caborcella*, also resemble *Keeleaspis*. Particularly striking are the similarities between *Caborcella granosa* (Resser) (cf. Resser, 1939, Pl. 13, figs. 19, 22–30; Fritz, 1968, Pl. 39, figs. 9–15) and the two *Keeleaspis* species described below. *Keeleaspis* differs from *Parapoulsenia* and *Caborcella* in having deeper axial furrows, lower distal regions on the preglabellar field, longer palpebral lobes, and narrower (tr.) palpebral areas.

Keeleaspis stupenda sp. nov.

Plate 3, figures 15–23

Material. Twelve cranidia 5 to 8 mm long, seven pygidia 2 to 3 mm long, and three librigenae.

Description. Cranidium highly convex, width twice length. Glabella high, sides straight to slightly convex, converging forward to strongly rounded front. Three pairs of deep, slightly arcuate, posteriorly inclined glabellar furrows, anterior pair nearly transverse, succeeding two pairs slightly and moderately inclined, respectively. Occipital furrow narrow and deep near ends, shallow, broader, and bowed very slightly forward near axial midline. Occipital ring short (sag.) and bearing node. Axial furrow broad, deep, merging anteriorly with low preglabellar field and anterior border furrow. Palpebral area convex, averaging horizontal, about half as wide (tr.) as maximum glabellar width. Palpebral lobes centred opposite glabellar midpoint, tilted inward, length five-twelfths that of glabella. Eye ridges broad and low. Facial sutures moderately divergent just anterior to palpebral lobes, broadly curved, directed nearly straight ahead near anterior border furrow. Anterior border and border furrow about equal in width (exsag.); posterior margin of border rises almost vertically from border furrow. Posterior area as wide (tr.) as glabella at base, traversed by a broad furrow, bearing small intergenal spine.

Librigena has border that rises abruptly at inner margin, curves uniformly except for slight outward bend near base of genal spine of unknown length (broken).

Pygidium low, width slightly less than twice length. Axis consists of anterior ring, second ring, faintly defined third ring, and terminal piece that touches poorly defined border. Furrow between anterior and second ring widens near axial midline at expense of anterior ring. Pleural field marked by three pairs of pleural furrows, anterior and second pairs turn strongly back near distal ends, anterior pair deep, posterior two pairs shallow. Two pairs of narrow interpleural furrows also present. One pair of spines on lateral margin; spines are short and consist of distal ends of anterior pleura. Margin posterior to spine is broadly curved. Ornamentation consists of intermixed granules and pustules; granules are of all sizes.

Discussion. Cranidia of this species differ from those of *Keeleaspis pustula* sp. nov. in having an arcuate set of posterior glabellar furrows, narrower glabellar and axial furrows, lower preglabellar field, higher anterior border, facial sutures that diverge forward from the palpebral lobes, intergenal spines, ornamentation consisting of more densely spaced pustules and granules, and pustules having a smaller diameter. Pygidia of *K. stupenda* differ from the pygidium tentatively assigned to *K. pustula* in having a greater relative length, more broadly pointed lateral margins, three rather than two axial rings, and pleural furrows that curve more strongly back near their distal ends.

Occurrence. Nevadella Zone, GSC locs. 73027, 73032–4, 73036–8.

Keeleaspis pustula sp. nov.

Plate 7, figures 1-6

Material. Six cranidia 4 to approximately 10 mm long and one tentatively assigned pygidium.

Description. Cranidium highly convex, width about twice length. Glabella high, moderately convex along sides, converging to strongly rounded front. Three pairs of deeply incised glabellar furrows; anterior pair short, inclined slightly back; second pair moderately inclined toward rear; third pair inclined back slightly more than second. Axial furrow broad and of intermediate depth, locally forming set of broad, shallow pits just anterior to eye ridges, then merging forward with low, short (exsag.) preglabellar field. Occipital furrow narrow and deep near ends, shallow and wider near cranidial midline where furrow bends slightly forward. Occipital ring short (sag.) and bearing(?) small spine on posterior margin. Palpebral area five-eighths as wide (tr.) as maximum glabellar width, broadly convex, average slope is moderately inward. Palpebral lobes centred opposite midpoint on glabella and tilted slightly inward, length half that of glabella. Eye ridges broad and low. Facial sutures anterior to palpebral lobes broadly curved, slightly converging forward just anterior to lobes, converging more strongly at anterior border. Anterior border and border furrow nearly straight; border low, half again as wide as furrow, tilted inward and somewhat rounded in cross-section. Posterior area wider (tr.) than maximum glabellar width, traversed by furrow of moderate depth and fairly uniform width.

Tentatively assigned pygidium is low and twice as wide as long, broadly curved along rear margin, broadly pointed at lateral extremities. Axis consists of anterior ring, second ring with poorly defined posterior margin, and terminal piece ending against very shallow border furrow. Furrow between anterior and second ring broad and expanding forward near axial midline at expense of second axial ring. Pleural field marked by three pairs of pleural furrows, anterior pair deep and of medium width; second pair shallow and broad; posterior pair very shallow, broad, and poorly defined. Interpleural furrow between anterior and second pleural segments of pleural field is narrow, but nearly as deep as anterior pleural furrow; second pair of interpleural furrows is barely visible. Short, broad pair of spines at lateral margin of pygidium is extension of anterior pleural segment. Ornamentation consists of large, raised pustules and sparse medium and small granules.

Discussion. Criteria for differentiating this species from *Keeleaspis stupenda* sp. nov. are listed under the latter species.

Occurrence. Nevada Zone, GSC locs. 73033, 73034, and 73036-9.

Genus *Gelasene* Palmer, 1968*Gelasene?* sp. 1

Plate 8, figures 21, 22

Material. One exfoliated cranidium 8 mm long.

Description. Glabella raised slightly to moderately above level of adjacent fixigenae, sides straight to slightly convex and converging to strongly rounded front. Three pairs of wide, deep glabellar furrows, all pairs moderately and equally inclined toward rear. Axial furrows wide and deep at glabellar sides, containing pair of pits just anterior to eye ridges; preglabellar

furrow very shallow. Occipital furrow deep near ends, shallow and bowed slightly forward near axial midline. Occipital ring short (exsag.), existence of spine or node unknown (broken). Preglabellar field short (sag.). Anterior border nearly straight, low, tilted steeply back. Anterior border furrow wider (exsag.) than anterior border and of medium depth. Ornamentation consists of pustules and granules of various sizes.

Discussion. Gross characters of this cranidium resemble those of *Gelasene acanthinos* Palmer, 1968, which is the one known species of *Gelasene*. The Sekwi cranidium is not conspecific with *G. acanthinos*, as it has a narrower glabella and smaller pits at the anterolateral margin of the glabella. As the Sekwi cranidium is incomplete, its assignment to *Gelasene* is questioned.

Occurrence. Nevadella Zone, GSC loc. 73039.

Genus *Nehanniaspis* gen. nov.

Type species. *Nehanniaspis prima* sp. nov.

Diagnosis. Cranidium convex, length about two-thirds width. Glabella high for solenopleurid, sides nearly straight and converging forward to strongly rounded front. Glabellar furrows medium to deep; furrows neither parallel nor joined across axial midline, posterior two pairs inclined back. Palpebral area slightly over half as wide (tr.) as glabella at base; palpebral lobes centred about opposite glabellar midpoint, length less than one-third glabellar length. Eye ridges intersect glabella well back from glabellar front. Anterior segments of facial sutures straight and converging forward from palpebral lobes, posterior segments straight and inclined steeply back from lobes. Posterior area as wide as glabella at base. Occipital lobe of medium length (sag.). Ornamentation granular.

Discussion. Although the new genus is erected upon a single specimen, the unique combination of features and excellent preservation suggest that the type material is adequate. A glabella that is raised high above the adjacent fixigenae, shallower axial furrows, shorter palpebral lobes, and posterior facial sutures that are directed strongly back differentiate this genus from *Gelasene* and from *Keeleaspis*.

Nehanniaspis prima sp. nov.

Plate 8, figures 16, 17

Material. One cranidium 14 mm long.

Description. Cranidium convex, length-width ratio 2:3. Glabellar sides slightly convex and converging forward to strongly rounded front. Three pairs of nearly straight glabellar furrows that are narrow and moderately deep, anterior pair short and transverse, second pair inclined moderately back, third pair inclined steeply back and slightly arcuate. Axial furrow of medium depth along most of course, narrow bordering rear half of posterior glabellar lobes, of medium width forward to eye ridges, then very shallow along remaining anterior segment. Palpebral areas convex, average slope is horizontal, width about five-eighths that of glabella at base. Palpebral lobes flat, tilted inward, centred opposite glabellar midpoint, length slightly less than one-third glabellar length. Eye ridges uniformly narrow and low. Facial sutures straight and slightly converging from palpebral lobes to anterior margin of border furrow; sutures nearly straight and directed strongly back from palpebral lobes to posterior border.

Anterior border furrow wide and of medium depth, medial part unknown (broken). Anterior border nearly flat, tilted back, about as wide as adjacent furrow, medial part unknown (broken). Posterior area about as wide (tr.) as glabella at base. Posterior border furrow of moderate depth and width (exsag.), widening slightly distally, posterior margin near distal end locally displaced by small node. Posterior border narrow near axis and expanding slightly outward; proximal half directed straight out and horizontal; distal half directed slightly forward and downward; small, broad spine present near distal end. Occipital furrow deep and very narrow near ends, medial part narrow and of moderate depth. Occipital ring bears small medial node. Ornamentation consists of small to very small pustules.

Discussion. The writer knows of no similar Lower Cambrian species.

Occurrence. *Nevadella* Zone, GSC loc. 73037.

Undetermined pygidium 1

Plate 8, figure 15

Material. One pygidium 2 mm long.

Description. Pygidium low, length-width ratio slightly less than 1:2, rear margin broadly curved, lateral extremities terminate in broad points. Axis low, consisting of two rings and terminal piece that does not reach rear margin of pygidium. Pleural region marked by anterior and second pair of pleural furrows of medium width, anterior pair medium in depth, second pair shallow. One pair of very shallow and narrow interpleural furrows visible between anterior and second plurae. Border lacking at rear margin of pygidium except for short segment just behind lateral points. Ornamentation consists of small and medium-sized granules.

Discussion. In gross aspect, this pygidium resembles those of *Keeleaspis stupenda* sp. nov. and *Keeleaspis pustula* sp. nov. It is, however, more transverse, and lacks a deep furrow between the anterior and second pair of pleurae. Since pygidia of many ptychoparioid genera tend to be quite similar, no taxonomic assignment is attempted.

Occurrence. *Nevadella* Zone, GSC loc. 73036.

References

- Balashova, E. A., Ivshin, N. K., and Chernysheva, N. E.
1960: in Chernysheva, N. E., 1960.
- Beecher, C. E.
1897: Outline of a natural classification of the trilobites; Amer. J. Sci., vol. 153, no. 14, p. 89-106; no. 15, p. 181-207.
- Bell, G. K.
1931: The disputed structures of the Mesonacidae and their significance; Amer. Mus. Nov.; no. 475, p. 1-23.
- Best, R. V.
1952: Two new species of *Olenellus* from British Columbia; Trans. Roy. Soc. Can., ser. 3, vol. 46, p. 13-22.
- Billings, E.
1861-65: Palaeozoic fossils, vol. 1. Containing descriptions and figures of new or little known species of organic remains from the Silurian rocks; Geol. Surv. Can., Separate Rept. 431.

Burling, L. D.

- 1916: *Paedeumias* and the Mesonacidae, with description of a new species, having at least 44 segments, from the Lower Cambrian of British Columbia; *Ottawa Naturalist*, vol. 30, p. 53-58.

Chernysheva, N. E. (ed.)

- 1960: *Osnovy Paleontologii-Chlenistonogie, Trilobitoobraznye i Rakoobraznye* [Principles of paleontology—arthropods, trilobites and crustaceans]; Moscow, Gosudar. Nauch.-Tekh. Izid. Lit. Geol. i Okhrane Nedr, 515 p.
- 1961: Stratigrafiya kembriya Aldanskoy anteklizy i paleontologicheskoe obosnovanie vydeleniya Amginskogo yarusa [Cambrian stratigraphy of the Aldan anticline and the paleontological basis for the separation of the Amginsk Formation]; *Tr. Vses. Nauch.-Issled. Geol. Inst. (VSEGEI)*, new ser., vol. 49.
- 1962: Kembriyskie trilobity semeystva Oryctocephalidae [Cambrian trilobites of the family Oryctocephalidae], in *Problemy neftegazonosnosti Sovetskoy Arktiki. Paleontologiya i biostratigrafiya* [Problems of the petroleum and gas occurrences in the Soviet Arctic. Paleontology and biostratigraphy]; *Tr. Nauch.-Issled. Inst. Geol. Arktiki*, vol. 127, no. 3, p. 3-52.

Cloud, P. E. and Nelson, C. A.

- 1966: Phanerozoic-Cryptozoic and related transitions: New Evidence; *Science*, vol. 154, no. 3750, p. 766-770.

Cobbald, E. S.

- 1921: The Cambrian horizons of Comley, and their Brachiopoda, Pteropoda, Gastropoda, etc.; *Quart. J. Geol. Soc. London*, vol. 76, p. 325-386.
- 1927: The stratigraphy and geological structure of the Cambrian area of Comley (Shropshire); *Quart. J. Geol. Soc. London*, vol. 83, p. 551-573.

Cowie, J. W.

- 1968: Lower Cambrian faunas from Ellesmere Island, District of Franklin; *Geol. Surv. Can., Bull.* 163, p. 2-27.

Datsenko, V. A., Zhuravleva, I. T., Lazarenko, N. P., Popov, Yu. N., and Chernysheva, N. E.

- 1968: Biostratigrafiya i fauna Kembriyskikh otlozheniy severo-zapada Sibirskoy platformy [Biostratigraphy and fauna of Cambrian deposits in the northwest part of the Siberian Platform]; *Tr. Nauch.-Issled. Inst. Geol. Arktiki, Leningrad*, 244 p.

Demokidov, K. K. and Lazarenko, N. P.

- 1964: Stratigrafiya verkhnego dokembriya i kembriya i nizhnekembriyskie trilobity severnoy chasty sredney Sibiri i ostrovov Sovetskoy Arktiki [Stratigraphy of the Upper Precambrian and Cambrian and Lower Cambrian trilobites from the northern part of Middle Siberia and the islands of the Soviet Arctic]; *Tr. Nauch.-Issled. Inst. Geol. Arktiki*, vol. 137.

Egorova, L. I., Ivshin, N. K., Pokrovskaya, N. V., Poletaeva, O. K., Repina, L. N., Rozova, A. V., Pomanenko, E. V., Sivov, A. G., Tomashpol'skaya, V. D., Fedyanina, E. S., and Chernysheva, N. E.

- 1960: Phylum Arthropoda; in *Khalfina, L. L. (ed.)*, p. 152-253.
- 1961: Trilobity nizhnego kembriya basseyna r. Katun' (Gornyy Altay) [Lower Cambrian trilobites from the Katun River basin (Altai Mountains)], in *Materialy po paleontologii i stratigrafi Zapadnoy Sibiri*; *Tr. Sibir. Nauch.-Issled. Inst. Geol., Geofiz. i Miner. Syr'ya (SNIIGGIMS)*, vol. 15, p. 215-231.

Egorova, L. I., Lomovitskaya, M. P., Poletaeva, O. K., and Sivov, A. G.

- 1955: in *Khalfina, L. L.*

Fritz, W. H.

- 1968: Lower and early Middle Cambrian trilobites from the Pioche Shale, east-central Nevada, U.S.A.; *Palaeontology*, vol. 11, p. 183-235.

Gregory, J. W.

- 1903: The Heathcotian—a pre-Ordovician series—and its distribution in Victoria; *Proc. Roy. Soc. Victoria [Australia]*, new ser., vol. 15, p. 148-175.

Handfield, R. C.

- 1968: Sekwi Formation, a new Lower Cambrian formation in the southern Mackenzie Mountains, District of Mackenzie; *Geol. Surv. Can., Paper* 68-47.

Harrington, H. J.

- 1956: Olenellidae with advanced cephalic spines; *J. Paleontol.*, vol. 30, no. 1, p. 56-61.

- Harrington, H. J., *et al.*
1959: Arthropoda 1, pt. O (Moore, R. C., ed.), Treatise on invertebrate paleontology; Univ. Kansas Press.
- Howell, B. F.
1959: in Harrington, H. J., *et al.*
- Hupé, P.
1952: Contribution à l'étude du Cambrien inférieur et du Précambrien III de l'Anti-Atlas marocain; [Morocco] Serv. Géol., Notes et Mém. 103.
1953: Classification des trilobites; Ann. Paléontologie, vol. 39, p. 61-168.
1955: Classification des trilobites [concluding part]; Ann. Paleontologie, vol. 41, p. 90-325.
- Hutchinson, R. D.
1962: Cambrian stratigraphy and trilobite faunas of southeastern Newfoundland; Geol. Surv. Can., Bull. 88.
- Ivshin, N. K.
1957: Srednekembriyskie trilobity Kazakhstana, chast' 2, Agyrekskii faunisticheski gorizont raiona gor Agyrek [Middle Cambrian trilobites of Kazakhstan, pt. 2, Agyrek faunal horizon of the region of the Agyrek Mountains]; Akad. Nauk Kazakh. SSSR, Inst. Geol. Nauk, Alma-Ata, 108 p.
- Kauffman, M. E. and Campbell, L.
1969: Revised interpretation of the Cambrian Kinzers Formation in southeastern Pennsylvania; Geol. Soc. Amer., Abs. with Programs, pt. 1, p. 32.
- Khalfina, L. L. (ed.)
1955: Atlas rukovodyashchikh form iskopaemykh fauny i flory zapadnoy Sibiri [Atlas of the leading forms of fossil fauna and flora of western Siberia]; Tomsk Politekh. Inst., Moscow, Gosudar. Nauch.-Tekh. Izid. Lit. po Geol. i Okhrane Nedr, vol. 1, 498 p.
1960: Biostratigrafiya Paleozoya Sayano-Altayskoy Gornoy Obasti. Tom 1. Nizhniy Paleozoy. [Biostratigraphy of the Paleozoic in the Sayan-Altai Mountain region. Vol. 1. Lower Paleozoic]; Tr. Sibir. Nauch.-Issled. Inst. Geol. Geofiz. i Miner. Syr'ya (SNIIGGIMS), vol. 9.
- Khomentovskiy, V. V. and Rapina, L. N.
1965: Nizhniy kembriy stratotipicheskovo razreza Sibiri [The Lower Cambrian of the stratotype section of Siberia]; Akad. Nauk SSSR, Sibir. Otdelenie, Inst. Geol. i Geofiz. Moscow, 199 p.
- Kindle, C. H. and Tasch, P.
1948: Lower Cambrian fauna of the Monkton Formation of Vermont; Can. Field Naturalist, vol. 62, no. 1, p. 133-139.
- Kobayashi, T.
1935: The Cambro-Ordovician formations and faunas of South Chosen, pt. 3; J. Fac. Sci. Imp. Univ. Tokyo; sec. 2, vol. 4, p. 49-344.
- Lake, P.
1906-46: A monograph of the British Cambrian trilobites; Palaeontograph. Soc. (14 parts).
- Lazarenko, N. P.
1959: Srednekembriyskie *Pagetides* severa Sibirskoy plaftormy (trilobity) [Middle Cambrian *Pagetides* from the north of the Siberian Platform]; Sb. statei po paleontologii i biostratigrafii Nauch.-Issled. Inst. Geol. Arktiki, no. 14, p. 5-16.
1962: Novye nizhnnekembriyskie trilobity Sovetskoy Arktiki [New Lower Cambrian trilobites of the Soviet Arctic]; Sb. statei po paleontol. i biostratigrafii, vol. 29, p. 29-78.
1968: in Datsenko, V. A., Zhuravleva, I. T., Lazarenko, N. P., Popov, Yu. N., and Chernysheva, N. E., 1968.
- Lermontova, E. V.
1940: Arthropoda-Klass Trilobity [Arthropoda-Class Trilobita] in Vologdin A. (ed.), Atlas rukovodyashchikh form iskopaemykh faun SSSR, tom 1, Kembriy [Atlas of the leading forms of fossil faunas of the USSR, vol. 1, Cambrian]; Vses. Nauch.-Issled. Geol. Inst. (VSEGEI), Moscow, 193 p.
1951: Nizhnnekembriyskie trilobity i brachiopody Vostochnoy Sibiri [Lower Cambrian trilobites and brachiopods from eastern Siberia]; Vses. Nauch.-Issled. Geol. Inst. (VSEGEI), Moscow, 222 p.

- Lochman, C.
 1947: Analysis and revision of eleven Lower Cambrian trilobite genera; *J. Paleontol.*, vol. 21, p. 59-71.
 1952: in Cooper, G. A., *et al.*, Cambrian stratigraphy and paleontology near Caborca, north-western Sonora, Mexico; *Smithson. Misc. Collect.*, vol. 119, no. 1.
- Matthew, G. F.
 1899: Studies on Cambrian faunas, no. 3. Upper Cambrian fauna of Mount Stephen, British Columbia. The trilobites and worms; *Trans. Roy. Soc. Can.*, 2nd ser., vol. 5, sec. 4, p. 39-66.
- Miller, S. A.
 1889: North American geology and palaeontology for the use of amateurs, students and scientists; Western Methodist Book Concern, Cincinnati.
- Nelson, C. A. and Durham, J. W.
 1966: Guidebook for field trip to Precambrian-Cambrian succession, White-Inyo Mountains, California; *Geol. Soc. Amer.*, Guidebook for Ann. Meeting.
- Nelson, C. A. and Hupé, P.
 1964: Sur l'existence de *Fallotaspis* et *Daguinaspis*, Trilobites marocains, dans le Cambrien inférieur de Californie et ses conséquences; *Compt. Rendus Acad. Sci. [Paris]*, vol. 258, p. 621-623.
- Okulitch, V. J.
 1951: A Lower Cambrian fossil locality near Addy, Washington; *J. Paleontol.*, vol. 25, p. 405-407.
- Öpik, A. A.
 1961: Alimentary caeca of agnostids and other trilobites; *Palaeontology*, vol. 3, p. 410-438.
- Palmer, A. R.
 1954: An appraisal of the Great Basin Middle Cambrian trilobites described before 1900; *U.S. Geol. Surv., Prof. Paper* 264-D.
 1957: Ontogenetic development of two olenellid trilobites; *J. Paleontol.*, vol. 31, p. 105-128.
 1964: An unusual Lower Cambrian trilobite fauna from Nevada; *U.S. Geol. Surv., Prof. Paper* 483-F.
 1968: Cambrian trilobites of east-central Alaska; *U.S. Geol. Surv., Prof. Paper* 559-B.
- Pokrovskaya, N. V.
 1959: Trilobitovaya fauna i stratigrafiya kembriyskikh otlozheniy Tuvy [Trilobite fauna and stratigraphy of Cambrian deposits of Tuva]; *Akad. Nauk SSSR, Geol. Inst. Tr.*, no. 27.
 1960: in Chernysheva, N. E.
- Poulsen, C.
 1932: The Lower Cambrian faunas of East Greenland; *Medd. om Grønland*, vol. 87, no. 6.
 1958: Contribution to the palaeontology of the Lower Cambrian Wulff River Formation; *Medd. om Grønland*, vol 162, no. 2.
 1959: in Harrington, H. J., *et al.*, 1959.
 1969: The Lower Cambrian from Slagelse no. 1, western Sealand; *Geol. Surv. Denmark*. 11. series, no. 93.
- Rasetti, F.
 1945: Fossiliferous horizons in the "Sillery Formation" near Lévis, Quebec; *Amer. J. Sci.*, vol. 243, p. 305-319.
 1948a: Lower Cambrian trilobites from the conglomerates of Quebec (exclusive of the Ptychopariidae); *J. Paleontol.*, vol. 22, p. 1-24.
 1948b: Middle Cambrian trilobites from the conglomerates of Quebec (exclusive of the Ptychopariidae); *J. Paleontol.*, vol. 22, p. 315-339.
 1951: Middle Cambrian stratigraphy and faunas of the Canadian Rocky Mountains; *Smithson. Misc. Collect.*, vol. 116, no. 5.
 1955: Lower Cambrian ptychopariid trilobites from the conglomerates of Quebec; *Smithson. Misc. Collect.*, vol. 128, no. 7.

Rasetti, F. (Cont.)

1957: Additional fossils from the Middle Cambrian Mount Whyte Formation of the Canadian Rocky Mountains; *J. Paleontol.*, vol. 31, p. 955-972.

1959: *in* Harrington, H. J., *et al.*

1966a: Revision of the North American species of the Cambrian trilobite genus *Pagetia*; *J. Paleontol.*, vol. 40, p. 502-511.

1966b: New Lower Cambrian trilobite faunule from the Taconic sequence of New York; *Smithson. Misc. Collect.*, vol. 148, no. 9.

1967: Lower and Middle Cambrian trilobite faunas from the Taconic sequence of New York; *Smithson. Misc. Collect.*, vol. 152, no. 4.

Raw, F.

1927: The ontogenies of trilobites, and their significance; *Amer. J. Sci.*, 5th ser., vol. 14, p. 7-35, 131-149.

1936: Mesonacidae of Comely in Shropshire, with a discussion of classification within the family; *Quart. J. Geol. Soc. London*, vol. 92, p. 236-293.

1957: Origin of chelicerates; *J. Paleontol.*, vol. 31, no. 1, p. 139-192.

Raymond, P. E.

1928a: The ontogenies of trilobites and their significance; *Amer. J. Sci.*, vol. 15, no. 86, p. 168-170.

1928b: Two new Cambrian trilobites; *Amer. J. Sci.*, vol. 15, p. 309-313.

Reed, F. R.

1910: The Cambrian fossils of Spiti; *Geol. Surv. India Palaeont. Indica, Mem.*, ser. 15, vol. 7, pt. 1, p. 1-71.

Repina, L. N.

1961: O nakhodkakh olenellid v Lenskom yaruse Batenevskogo kryazha [On the olenellid finds in the Lena Stage of Batenev ridge]; *Doklady Akad. Nauk SSSR*, vol. 136, no. 4, p. 935-937.

Repina, L. N., Khomentovskiy, V. V., Zhuravleva, I. T., and Rozanov, A. Yu.

1964: Biostratigrafiya nizhnego kembriya Sayano-Altayskoy skladchatoy oblasti [Biostratigraphy of the Lower Cambrian in the Sayan-Altai folded region]; *Acad. Nauk SSSR, Sibir. otdelenie, Inst. Geol. i Geofiz.*, 364 p.

Resser, C. E.

1928: Cambrian fossils from the Mohave Desert; *Smithson. Misc. Collect.*, vol. 81, no. 2.

1936: Second contribution to nomenclature of Cambrian trilobites; *Smithson. Misc. Collect.*, vol. 95, no. 4.

1937a: Elkanah Billings' Lower Cambrian trilobites and associated species; *J. Paleontol.*, vol. 11, p. 43-54.

1937b: Third contribution to nomenclature of Cambrian trilobites; *Smithson. Misc. Collect.*, vol. 95, no. 22.

1938a: Cambrian System (restricted) of the southern Appalachians; *Geol. Soc. Amer., Spec. Papers* no. 15.

1938b: Fourth contribution to nomenclature of Cambrian fossils; *Smithson. Misc. Collect.*, vol. 97, no. 10.

1939: The *Ptarmigania* strata of the northern Wasatch Mountains; *Smithson. Misc. Collect.*, vol. 98, no. 24.

1945: Cambrian history of the Grand Canyon region, pt. 2; *Carnegie Inst. Washington, Publ.* 563.

Resser, C. E. and Howell, B. F.

1938: Lower Cambrian *Olenellus* Zone of the Appalachians; *Geol. Soc. Amer., Bull.*, vol. 49, p. 195-248.

Riccio, J. F.

1952: The Lower Cambrian Olenellidae of the southern Marble Mountains, California; *S. Calif. Acad. Sci., Bull.*, vol. 51, pt. 2, p. 25-49.

Rushton, A. W. A.

1966: The Cambrian trilobites from the Purley Shales of Warwickshire; *Palaeontograph. Soc., Mon.*, vol. 120, no. 511.

- Shaw, A. B.
 1955: Paleontology of northwestern Vermont. V. The Lower Cambrian fauna; J. Paleontol., vol. 29, p. 775-805.
 1959: Quantitative trilobite studies III. *Proliostracus strenuelliiformis* Poulsen, 1932; J. Paleontol., vol. 33, p. 474-487.
 1962: Paleontology of northwestern Vermont IX. Fauna of the Monkton Quartzite; J. Paleontol., vol. 36, p. 322-345.
- Shimer, H. W. and Shrock, R. R.
 1944: Index fossils of North America; New York, John Wiley and Sons, Inc., 837 p.
- Størmer, L.
 1939: Studies on trilobite morphology. Part 1. The thoracic appendages and their phylogenetic significance; Nor. Geol. Tidsskr., vol. 19, p. 143-273.
- Suvorova, N. P.
 1960: in Chernysheva, N. E., 1960.
 1964: Trilobity korineksokhoidy i ikh istoricheskoe razvitiye [Corynexochoid trilobites and their historical development]; Akad. Nauk SSSR, Tr. Paleont. Inst., vol. 103.
- Tash, P.
 1952: Adaptive trend in eyeline development in the Olenellidae; J. Paleontol., vol. 26, p. 484-488.
- Thorslund, P.
 1949: Notes of *Kootenia* sp. n. and associated *Paradoxides* species from the lower Middle Cambrian of Jemtland, Sweden; Sver. Geol. Unders. Årsb. 43, no. 8, ser. C., 510, p. 3-7.
- Walcott, C. D.
 1885: Paleozoic notes: new genus of Cambrian trilobites, *Mesonacis*; Amer. J. Sci., vol. 29, p. 328-330.
 1886: Second contribution to the studies on the Cambrian faunas of North America; U.S. Geol. Surv., Bull. 30.
 1889: Description of new genera and species of fossils from the Middle Cambrian; Proc. U.S. Nat. Mus., vol. 11, p. 441-446.
 1890: The fauna of the Lower Cambrian or *Olenellus* Zone; U.S. Geol. Surv., 10th Ann. Rept., p. 511-774.
 1905: Cambrian faunas of China; Proc. U.S. Nat. Mus., vol. 29, p. 1-106.
 1910: *Olenellus* and other genera of the Mesonacidae; Smithson. Misc. Collect., vol. 53, no. 6.
 1912: Group terms for the Lower and Upper Cambrian series of formations; Smithson. Misc. Collect., vol. 57, p. 305-307.
 1913: New Lower Cambrian subfauna; Smithson. Misc. Collect., vol. 57, p. 309-326.
 1916a: Cambrian trilobites; Smithson. Misc. Collect., vol. 64, no. 5.
 1916b: Evidences of primitive life; Smithson. Inst., Ann. Rept. (1915), p. 235-255.
 1917: Fauna of the Mount Whyte Formation; Smithson. Misc. Collect., vol. 67, no. 3.
 1925: Cambrian and Ozarkian trilobites; Smithson. Misc. Collect., vol. 75, no. 3.
- White, C. A.
 1874: Preliminary report upon invertebrate fossils collected by the expeditions of 1871, 1872, and 1873, with descriptions of new species; U.S. Geog. and Geol. Surv. W. 100th Mer. Rept., p. 5-27.
- Whitehouse, F. W.
 1939: The Cambrian faunas of north-eastern Australia, pt. 3: the polymerid trilobites; Mem. Queensld. Mus., vol. 11, pt. 3, p. 179-282.
- Wilson, J. T.
 1966: Did the Atlantic close and then re-open?; Nature, vol. 211, p. 676-681.

PLATES 1 to 20

PLATE 1

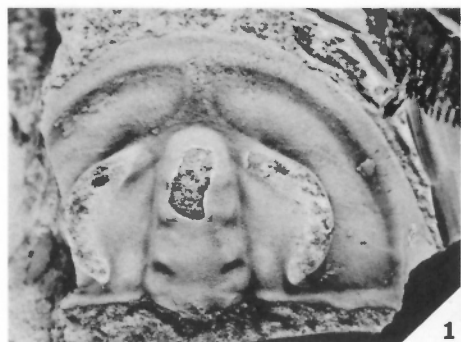
Fallotaspis and *Nevadella* Zone

Figures 1-8. *Parafallotaspis grata* gen. and sp. nov., GSC loc. 73025 (p.28)

- 1,2. Holotype cephalon, plan and side views, x2.6, GSC No. 27202.
3. Two paratype cephalo, x2.0, GSC No. 27203 (large), GSC No. 27204 (small).
4. Paratype pygidium, x10.0, GSC No. 27205.
5. Paratype glabella, x3.5, GSC No. 27206.
6. Paratype partial cephalon, x3.4, GSC No. 27207.
7. Paratype small cephalon, x4.2, GSC No. 27208.
8. Paratype very small cephalon, x8.0, GSC No. 27209.

Figures 9-17. *Pagetides spinulus* sp. nov. (p. 8)

- 9,10,11. Paratype cranidium, plan, oblique, and side views, x10.3, GSC loc. 73030, GSC No. 27210.
- 10,12,13. Holotype pygidium, oblique, plan, and side views, x10.3, GSC loc. 73030, GSC No. 27211.
- 14,15. Paratype pygidium, side and plan views, x10.3, GSC loc. 73036, GSC No. 27212.
16. Paratype cranidium, x13.3, GSC loc. 73036, GSC No. 27213.
17. Paratype pygidium, x12.5, GSC loc. 73036, GSC No. 27214.



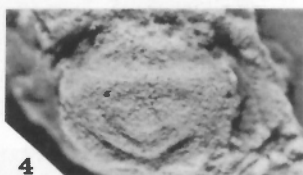
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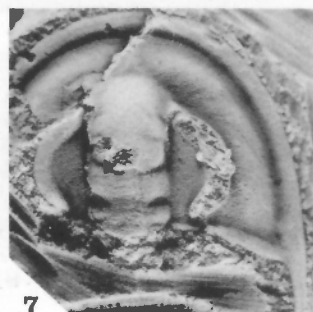
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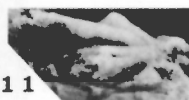
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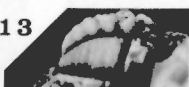
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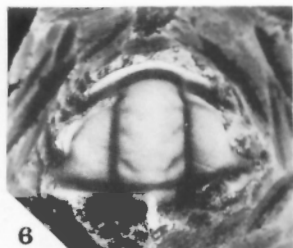
PLATE 2



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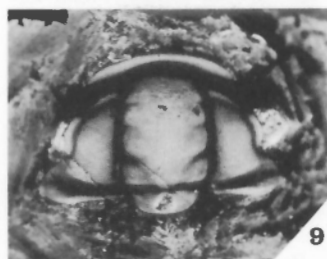
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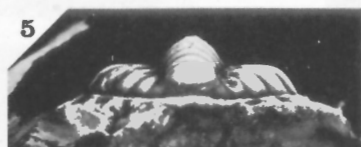
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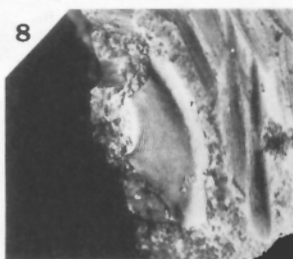
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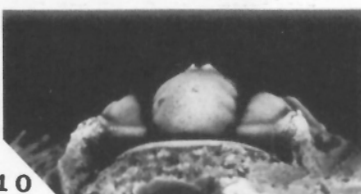
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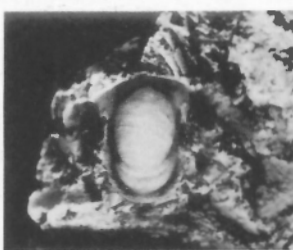
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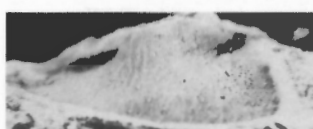
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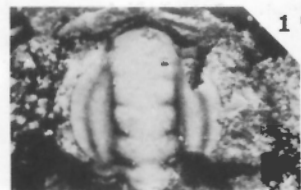
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PLATE 2

Nevadella Zone

- Figures 1-13. *Kootenia diutina* sp. nov. (p. 36)
- 1,2. Paratype cranium, plan and side views, x3.5, GSC loc. 73036, GSC No. 27215.
 - 3-5. Holotype pygidium, plan, side, and rear views, x4.5, GSC loc. 73036, GSC No. 27216.
 - 6,7. Paratype cranium, plan and side views, x4.5, GSC loc. 73030, GSC No. 27217.
 8. Paratype librigena, x4.8, GSC loc. 73026, GSC No. 27218.
 - 9,10. Paratype cranium, plan and front views, x4.2, GSC loc. 73032, GSC No. 27219.
 11. Paratype pygidium, x4.1, GSC loc. 73038, GSC No. 27220.
 12. Paratype hypostoma, x7.2, GSC loc. 73036, GSC No. 27221.
 13. Paratype hypostoma, x7.2, GSC loc. 73030, GSC No. 27222.
- Figures 14,15. *Bradyfallotaspis* sp. 1 (p. 21)
- Hypotype partial cephalon, plan and side views, x3.8, GSC loc. 73027, GSC No. 27223.
- Figures 16,17. Olenellid, gen. and sp. undet. (p. 31)
16. Hypotype partial cephalon, x9.5, GSC loc. 73030, GSC No. 27224.
 17. Hypotype partial cephalon, x11.0, GSC loc. 73027, GSC No. 27225.

PLATE 3

Nevadella Zone

- Figures 1-7. *Bradyfallotaspis fusa* gen. and sp. nov., GSC loc. 73027 (p. 20)
- 1-3. Holotype cephalon, plan and side views, x4.7, GSC No. 27226.
 - 4. Paratype cephalon, x5.0, GSC No. 27227.
 - 5-7. Latex cast from paratype mould, plan, side, and front views, x5.4, GSC No. 27228
- Figures 8-14. *Nevadella faceta* sp. nov. (p. 23)
- 8, 13. Holotype cephalon, plan and front views, x2.5, GSC loc. 73032, GSC No. 27229.
 - 9. Paratype cephalon, x4.3, GSC loc. 73032, GSC No. 27230.
 - 10. Paratype cephalon, x3.6, GSC loc. 73037, GSC No. 27231.
 - 11, 12. Paratype hypostoma, plan and side views, x2.6, GSC loc. 73032, GSC No. 27232.
 - 14. Paratype cephalon, x13.3, GSC loc. 73037, GSC No. 27233.
- Figures 15-23. *Keeleaspis stupenda* gen. and sp. nov. (p. 50)
- 15, 16. Holotype cranidium, plan and side views, x3.2, GSC loc. 73036, GSC No. 27234.
 - 17, 18. Paratype pygidium, plan and side views, x4.2, GSC loc. 73032, GSC No. 27235.
 - 19. Partial paratype cranidium, x4.5, GSC loc. 73032, GSC No. 27236.
 - 20. Paratype cranidium, x4.0, GSC loc. 73034, GSC No. 27237a.
 - 21. Paratype librigena, x5.5, GSC loc. 73036, GSC No. 27237b.
 - 22. Paratype cranidium, x2.9, GSC loc. 73037, GSC No. 23238.
 - 23. Paratype pygidium, x4.8, GSC loc. 73037, GSC No. 27239.



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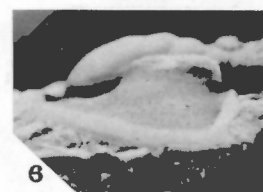
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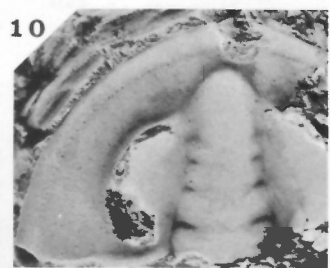
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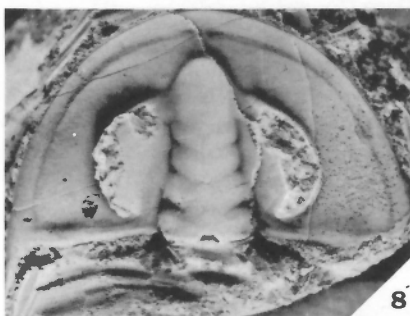
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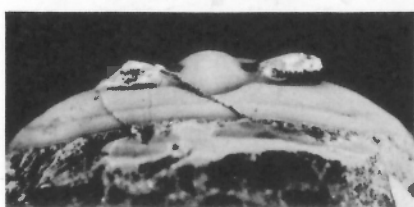
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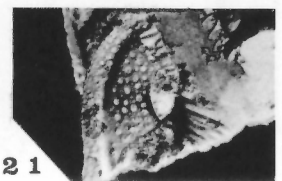
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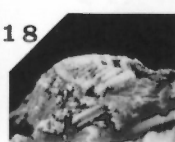
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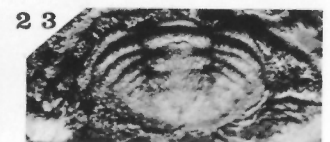
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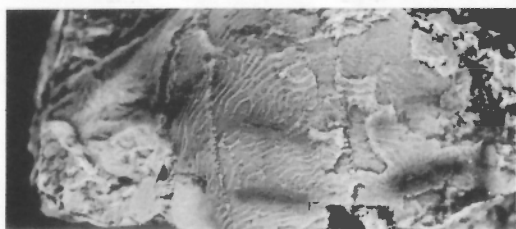
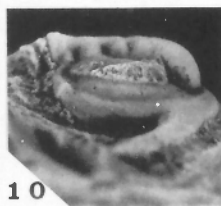
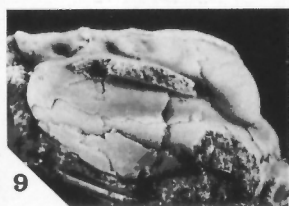
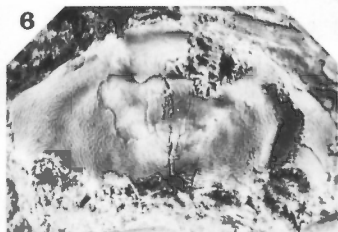
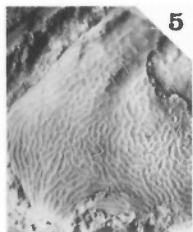
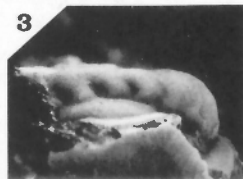
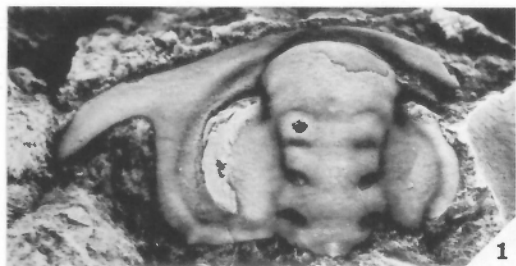


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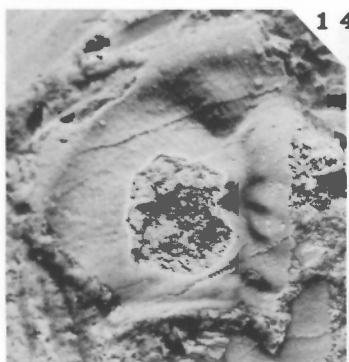


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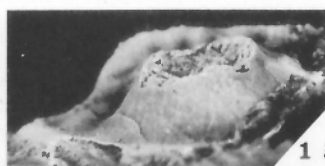
PLATE 4



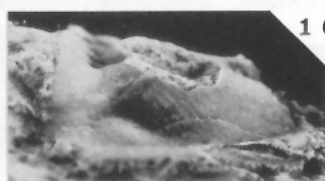
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PLATE 4

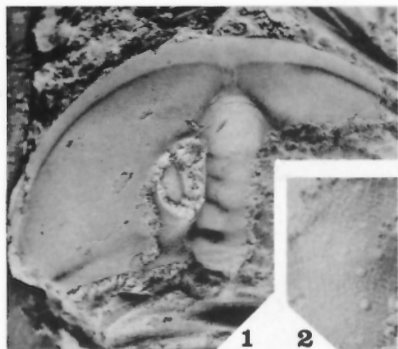
Nevadella Zone

- Figures 1-13. *Holmiella preancora* gen. and sp. nov. (p. 25)
- 1-3. Latex cast of paratype mould, plan, front, and side views, x4.1, GSC loc. 73030, GSC No. 27240.
 - 4-6. Holotype pygidium, side (x3.5), plan enlarged (x7.0), and plan (x3.5) views, GSC loc. 73030, GSC No. 27241.
 - 7. Paratype cephalon, x4.9, GSC loc. 73034, GSC No. 27242.
 - 8,9. Paratype cephalon, plan and side views, x1.9, GSC loc. 73032, GSC No. 27243.
 - 10,11. Paratype cephalon, side and plan views, x4.8, GSC loc. 73027, GSC No. 27244.
 - 12. Paratype partial glabella, x1.4, GSC loc. 73032, GSC No. 27245.
 - 13. Paratype cephalic border and spine, x2.6, GSC loc. 73032, GSC No. 27246.
- Figures 14-16. *Bradyfallotaspis* sp. 2 (p. 21)
- Hypotype cephalon, plan, side, and front views, x4.0, GSC loc. 73030, GSC No. 27247.

PLATE 5

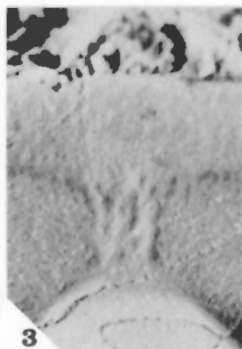
Nevadella Zone

- Figures 1-9 *Nevadella bacculenta* sp. nov., GSC loc. 73030 (p. 22)
- 1-4. Holotype cephalon, plan view (x3.3), enlarged part of glabella (x10.7), enlarged frontal area (x12.5), and side view (x3.3), GSC No. 27248.
 - 5. Paratype partial cephalon, x3.5, GSC No. 27249.
 - 6,7. Paratype cephalon, plan and side views, x3.5, GSC No. 27250.
 - 8,9. Paratype gena, side and plan views, x6.9, GSC No. 27251.
- Figures 10,11. cf. *Paleofossus* sp. 1 (p. 39)
- Hypotype cranidium, plan and side views, x5.1, GSC loc. 73030, GSC No. 27252.
- Figures 12-15. *Nevadella* sp. 2 (p. 24)
- 12,13. Hypotype partial cephalon, plan and side views, x5.3, GSC loc. 73032, GSC No. 27253.
 - 14. Hypotype partial cephalon, x4.8, GSC loc. 73033, GSC No. 27254.
 - 15. Hypotype partial cephalon, x8.3, GSC loc. 73030, GSC No. 27255.



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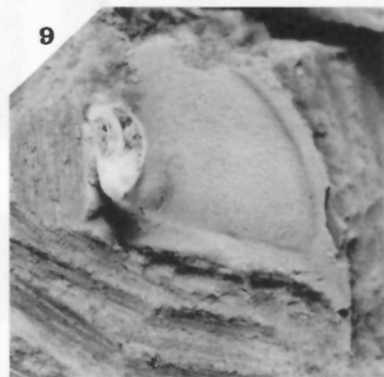
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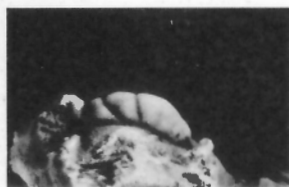
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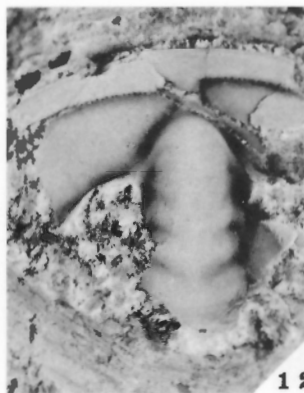
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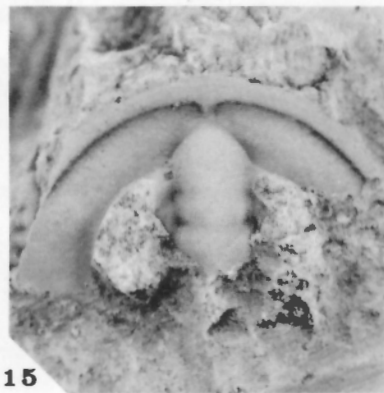
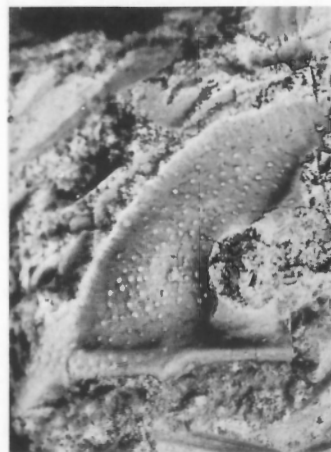
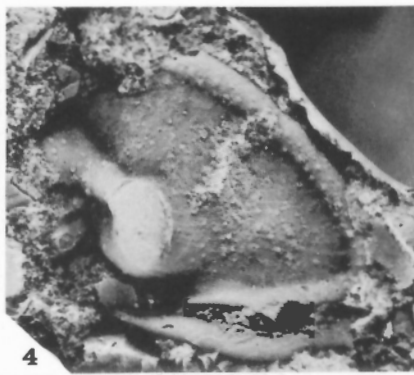
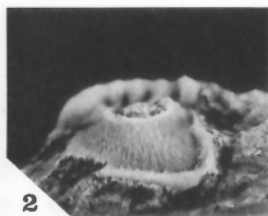
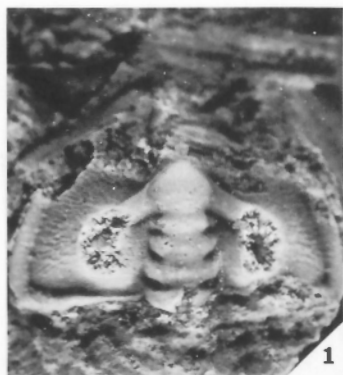
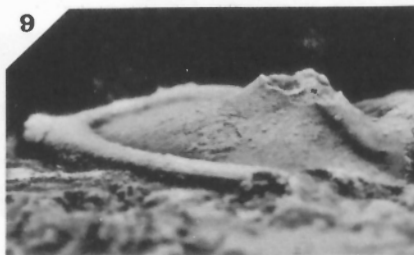


PLATE 6



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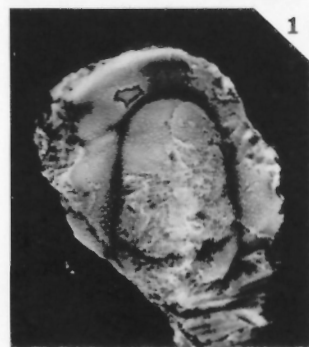
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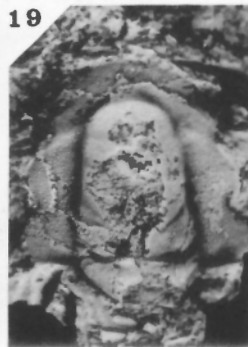
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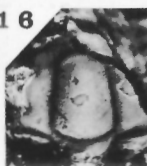
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PLATE 6

Nevadella Zone

Figures 1-9. *Bradyfallotaspis patula* gen. and sp. nov. (p. 20)

- 1, 2. Holotype cephalon, plan and side views, x6.9, GSC loc. 73032, GSC No. 27256.
3. Paratype cephalon, x15.4, GSC loc. 73030, GSC No. 27257.
- 4, 5. Latex cast from paratype partial cephalon mould, plan and front views, x6.9, GSC loc. 73038, GSC No. 27258.
6. Paratype gena, x4.0, GSC loc. 73038, GSC No. 27259.
- 7-9. Paratype partial cephalon, side, plan, and front views, x4.6, GSC loc. 73038, GSC No. 27260.

Figures 10-19. *Sekwiaspis artifrons* gen. and sp. nov. (p. 39)

- 10-12. Holotype cranidium, plan, front, and side views, x3.0, GSC loc. 73033, GSC No. 27261.
- 13, 14. Paratype cranidium, plan and side views, x2.7, GSC loc. 73032, GSC No. 27262.
15. Paratype cranidium, x6.4, GSC loc. 73036, GSC No. 27263.
16. Paratype cranidium, x3.6, GSC loc. 73036, GSC No. 27264.
17. Paratype cranidium, x3.2, GSC loc. 73035, GSC No. 27265.
18. Paratype pygidium, x4.5, GSC loc. 73036, GSC No. 27266.
19. Paratype cranidium, x2.4, GSC loc. 73036, GSC No. 27267.

PLATE 7
Nevadella Zone

- Figures 1-6. *Keeleaspis pustula* gen. and sp. nov. (p. 51)
- 1-3. Holotype cranidium, plan, front, and side views, x3.0, GSC loc. 73039, GSC No. 27268.
 - 4, 5. Paratype pygidium, plan and side views, x4.5, GSC loc. 73036, GSC No. 27269.
 - 6. Paratype cranidium, x3.4, GSC loc. 73034, GSC No. 27270.
- Figures 7-17. *Holmiella falcata* gen. and sp. nov. (p. 26)
- 7-9. Paratype cephalon, plan, front, and side views, x4.9, GSC loc. 73034, GSC No. 27271.
 - 10. Paratype cephalon, x12.0, GSC loc. 73034, GSC No. 27272.
 - 11. Paratype cephalon, x3.7, GSC loc. 73037, GSC No. 27273.
 - 12. Paratype cephalon, x7.0, GSC loc. 73037, GSC No. 27274.
 - 13. Paratype cephalon, x3.1, GSC loc. 73034, GSC No. 27275.
 - 14, 15. Paratype pygidium, plan and side views, x4.1, GSC loc. 73034, GSC No. 27276.
 - 16, 17. Holotype pygidium, plan and side views, x4.1, GSC loc. 73034, GSC No. 27277.



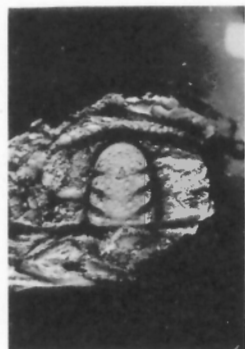
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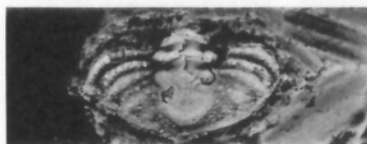
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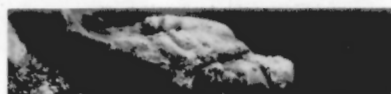
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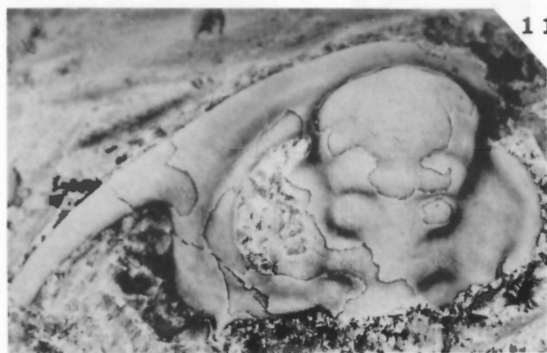
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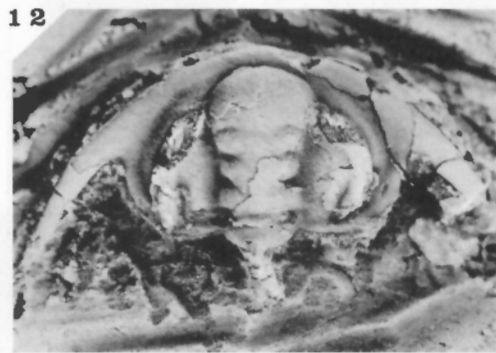
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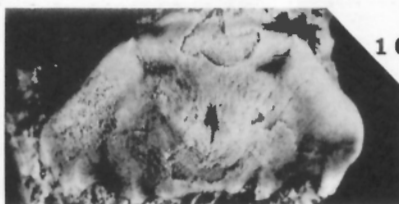
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PLATE 8

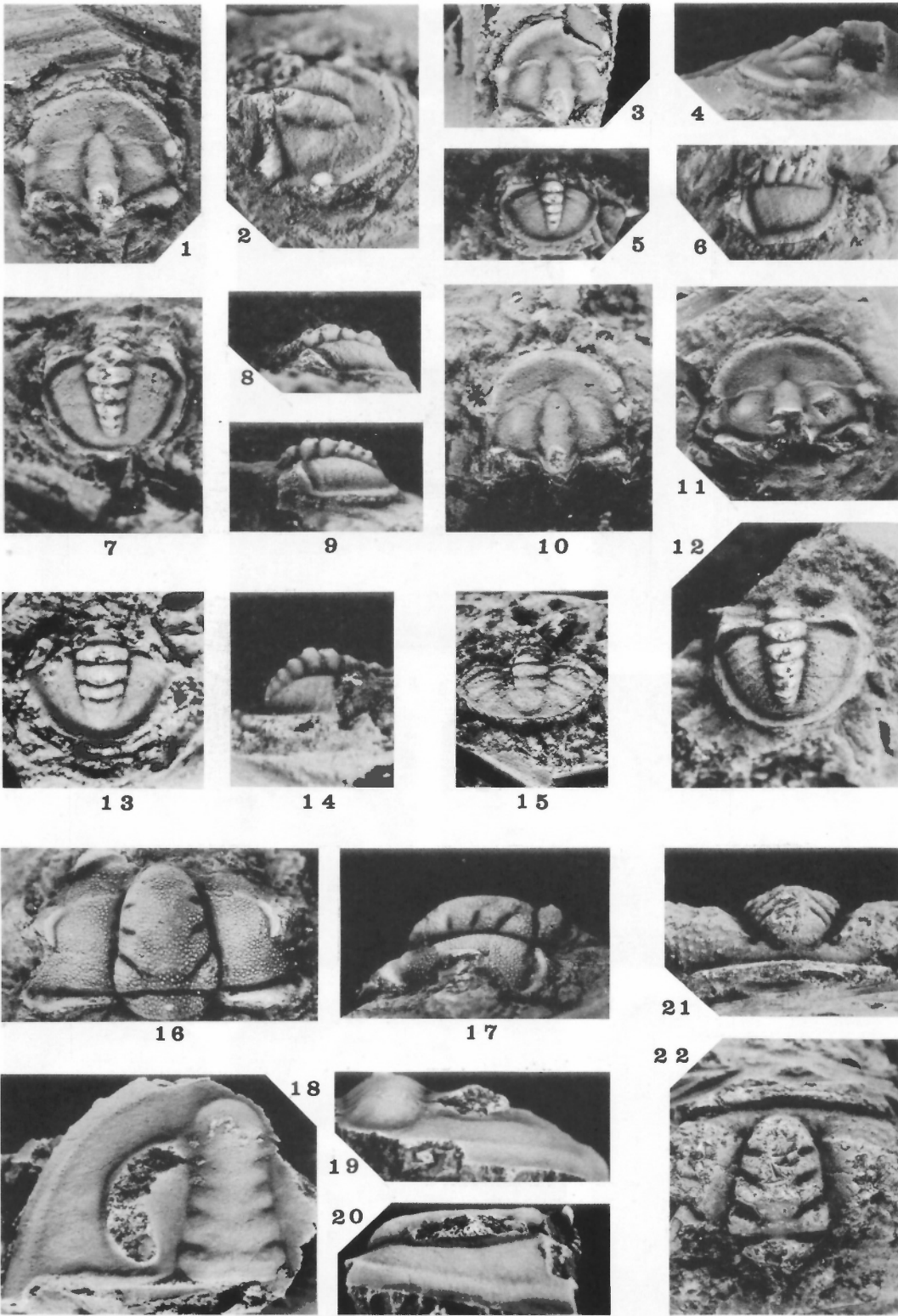


PLATE 8

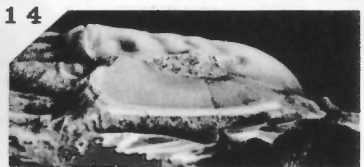
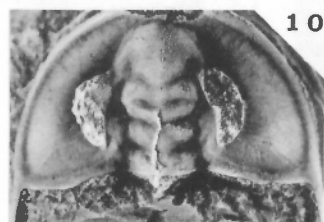
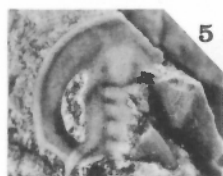
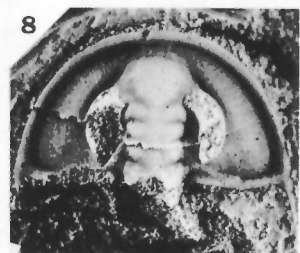
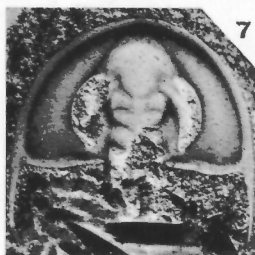
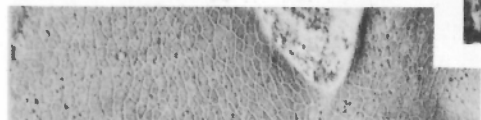
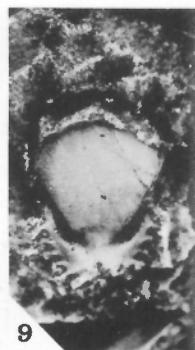
Nevadella Zone

- Figures 1–12. *Yukonides lacrinus* gen. and sp. nov. (p. 10)
1,2. Holotype cranidium, plan and oblique views, x8.7, GSC loc. 73034, GSC No. 27278
3,4. Paratype cranidium, plan and side views, x7.5, GSC loc. 73037, GSC No. 27279.
5. Paratype pygidium, x9.6, GSC loc. 73034, GSC No. 27280.
6. Paratype pygidium, side view, x10.7, GSC loc. 73037, GSC No. 27281.
7,8. Paratype pygidium, plan and side views, x9.2, GSC loc. 73034, GSC No. 27282.
9,12. Paratype pygidium, side and plan views, x10.8, GSC loc. 73035, GSC No. 27283.
10. Paratype cranidium, x8.5, GSC loc. 73034, GSC No. 27284.
11. Paratype cranidium, x7.7, GSC loc. 73037, GSC No. 27285.
- Figures 13,14. *Pagetides?* sp. 1 (p. 99)
Hypotype pygidium, x13.0, GSC loc. 73036, GSC No. 27286.
- Figure 15. Undetermined pygidium 1 (p. 53)
Hypotype, x5.1, GSC loc. 73036, GSC No. 27287.
- Figures 16,17. *Nehanniaspis prima* gen. and sp. nov. (p. 52)
Holotype cranidium, plan and side views, x4.0, GSC loc. 73037, GSC No. 27288.
- Figures 18–20. *Nevadella* sp. 1 (p. 24)
Hypotype cephalon, x4.3, GSC loc. 73038, GSC No. 27289.
- Figures 21,22. *Gelasene?* sp. undet. (p. 51)
Hypotype cranidium, front and plan views, x3.5, GSC loc. 73039, GSC No. 27290.

PLATE 9

Bonnia-Olenellus Zone

- Figures 1–14. *Olenellus truemani* Walcott, GSC loc. 73040 (p. 16)
- 1–4. Hypotype cephalon, plan, front, and side views, x2.1, enlarged part of gena, x8.6, GSC No. 27291.
 - 5. Hypotype cephalon, x6.7, GSC No. 27292.
 - 6. Hypotype cephalon, x3.6, GSC No. 27293.
 - 7. Hypotype cephalon, x3.6, GSC No. 27294.
 - 8. Hypotype cephalon, x3.6, GSC No. 27295.
 - 9. Hypotype hypostoma, x8.8, GSC No. 27296.
 - 10, 11. Hypotype cephalon, x2.8, enlarged part of gena, x12.6, GSC No. 27297.
 - 12–14. Hypotype cephalon, plan (with small cephalon shown in fig. 6), front, and side views x1.5, GSC No. 27298.
- Figures 15–20. *Proliostracus depressus* sp. nov., GSC loc. 73040 (p. 45)
- 15. Paratype cranidium, x5.1, GSC No. 27299.
 - 16. Paratype cranidium, x5.1, GSC No. 27300.
 - 17, 18. Paratype cranidium, plan and side views, x4.8, GSC No. 27301.
 - 19, 20. Holotype cranidium, plan and side views, x4.8, GSC No. 27302.
- Figure 21. *Laudonia?* sp. 1 (p. 27)
- Latex cast of hypotype mould, x3.7, GSC loc. 73041, GSC No. 27303.



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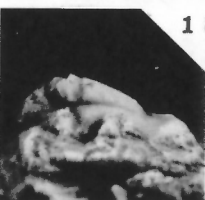
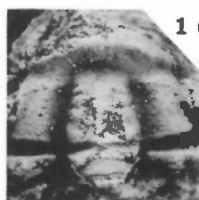
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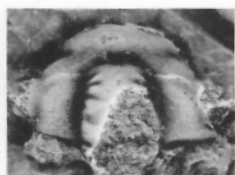
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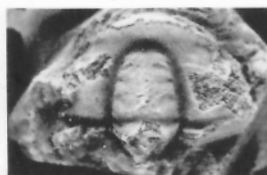
PLATE 10



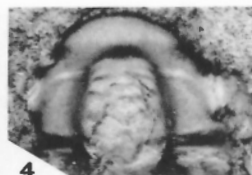
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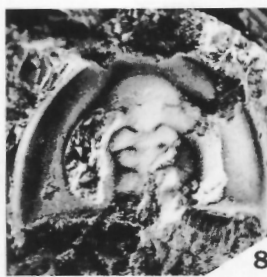
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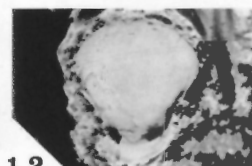
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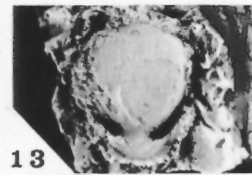
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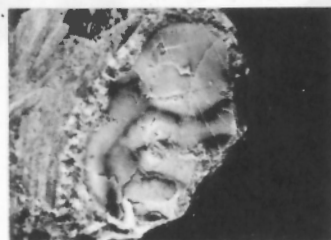
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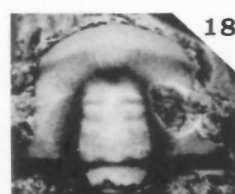
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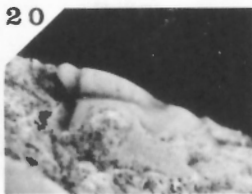
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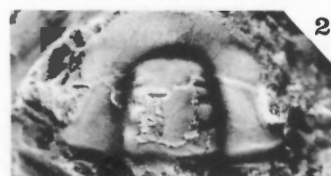
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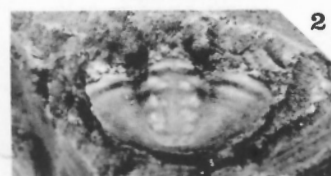
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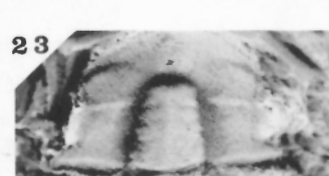
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PLATE 10

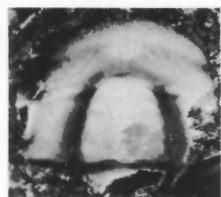
Bonnia-Olenellus Zone

- Figures 1-5. *Proliostracus contractus* sp. nov., GSC loc. 73042 (p. 45)
1. Paratype cranidium, x10.0, GSC No. 27304.
 2. Paratype exfoliated cranidium, x5.3, GSC No. 27305.
 - 3,5. Holotype exfoliated cranidium, plan and side views, x5.3, GSC No. 27306.
 4. Latex cast of internal surface of paratype cranidial mould, x5.3, GSC No. 27307.
- Figures 6-16. *Olenellus* sp. 1, GSC loc. 73043 (p. 17)
6. Hypotype cephalon, x6.4, GSC No. 27308.
 7. Hypotype cephalon, x5.1, GSC No. 27309.
 8. Hypotype cephalon, x5.1, GSC No. 27310.
 9. Hypotype cephalon, x5.1, GSC No. 27311.
 10. Hypotype cephalon, x3.5, GSC No. 27312.
 11. Hypotype gena, x4.0, GSC No. 27313.
 12. Hypotype hypostoma, x3.5, GSC No. 27314.
 13. Hypotype hypostoma, x3.5, GSC No. 27315.
 14. Hypotype partial cephalon, x2.3, GSC No. 27316.
 - 15,16. Hypotype partial cephalon, plan and side views, x2.3, GSC No. 27317.
- Figures 17-22. *Proliostracus annosus* sp. nov., GSC loc. 73044 (p. 44)
- All figured specimens exfoliated.
17. Paratype cranidium, x5.0, GSC No. 27318.
 18. Paratype cranidium, x7.3, GSC No. 27319.
 - 19,20. Latex cast of holotype cranidial mould, plan and side views, x7.3, GSC No. 27320.
 21. Paratype cranidium, x4.9, GSC No. 27321.
 22. Paratype pygidium, x7.2, GSC No. 27322.
- Figure 23. *Proliostracus latus* sp. nov. (p. 46)
- Exfoliated holotype cranidium, x3.9, GSC loc. 73044, GSC No. 27323.

PLATE 11

Bonnia-Olenellus Zone

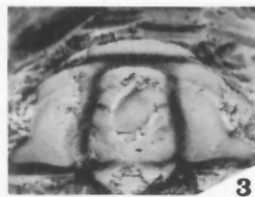
- Figures 1,2. *Proliostracus* aff. *P. annosus* sp. nov. (p. 46)
Hypotype exfoliated cranidium, plan and side views, x5.4, GSC loc. 73044, GSC No. 27324.
- Figures 3-6. *Poulsenia* sp. 1 (p. 41)
3,4. Hypotype exfoliated cranidium, plan and front views, x3.1, GSC loc. 73047, GSC No. 27325.
5,6a,6b. Hypotype exfoliated cranidium, plan, front, and side views, x3.4, GSC loc. 73048, GSC No. 27326.
- Figures 7-21. *Olenellus laxocules* sp. nov., GSC loc. 73049 (p. 13)
7. Paratype cephalon, x8.0, GSC No. 27327.
8. Paratype cephalon, x6.8, GSC No. 27328.
9. Paratype cephalon, x5.2, GSC No. 27329.
10. Paratype cephalon, x5.5, GSC No. 27330.
11. Paratype cephalon, x5.5, GSC No. 27331.
12. Paratype cephalon, x7.8, GSC No. 27332.
13-15. Paratype cephalon, plan, front, and side views, x4.8, GSC No. 27333.
16. Paratype cephalon, x2.4, GSC No. 27334.
17,18,20,21. Holotype cephalon, plan and side views, x2.7, enlarged part of axis and gena, x9.5 GSC No. 27335.
19. Paratype cephalon, enlarged frontal area, x9.5, GSC No. 27336.



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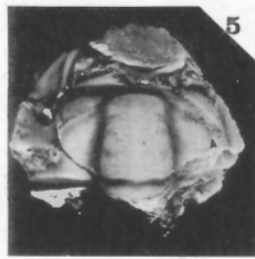
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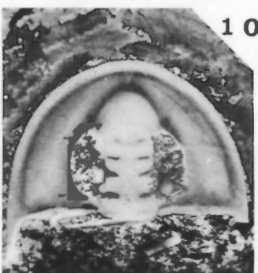
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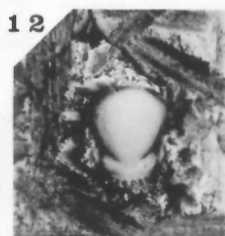
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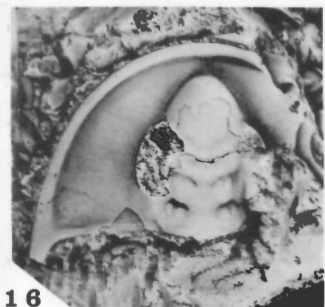
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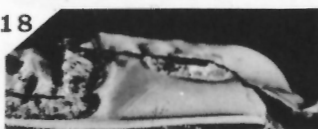
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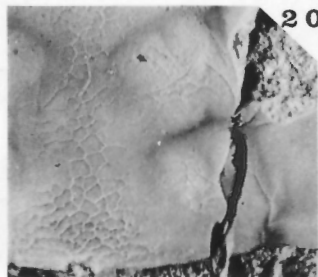
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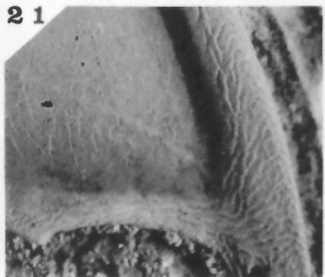
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See Kingaspis sp. 1 Palmer + Rouse 11, 1995 (similar)

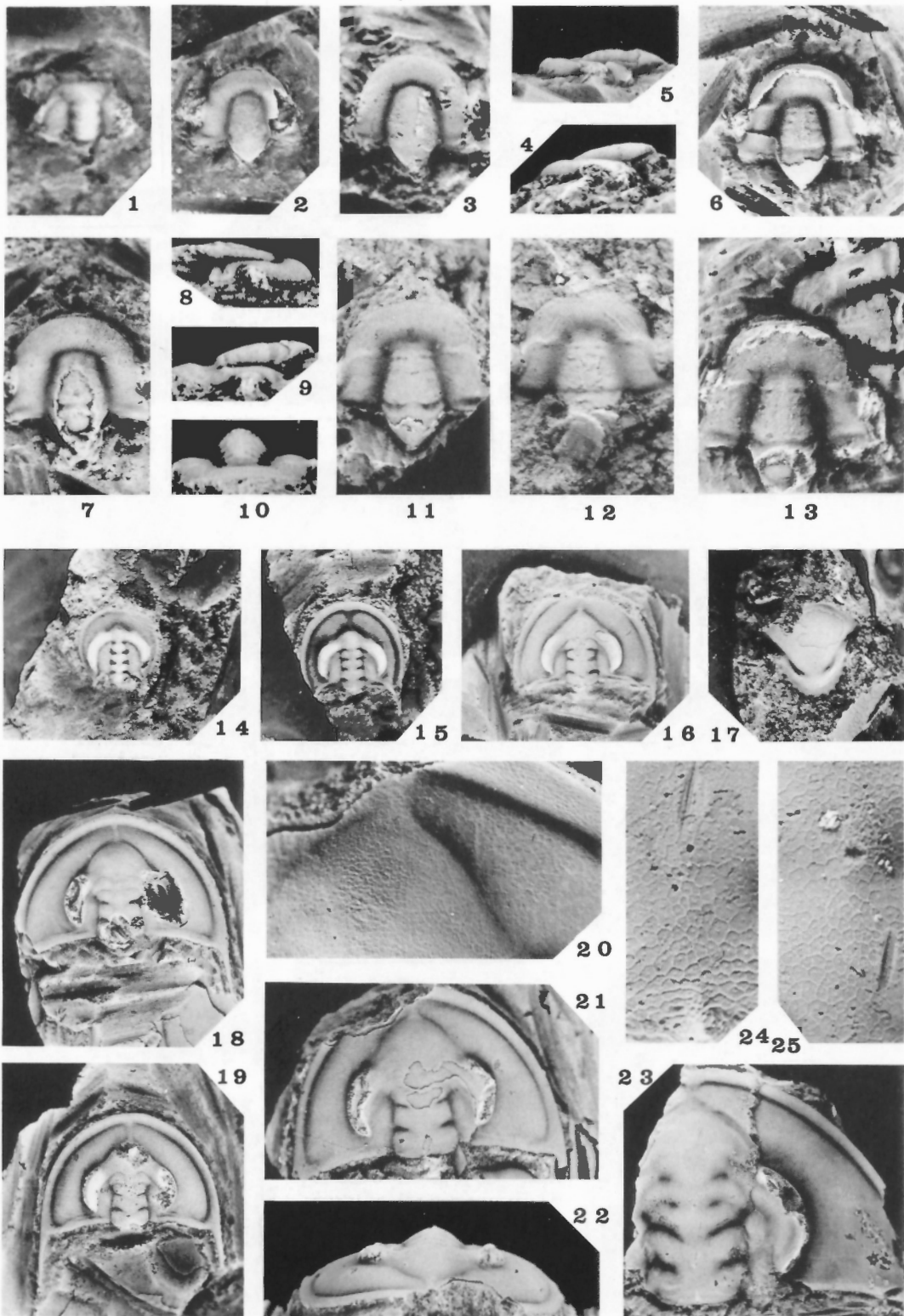


PLATE 12

Bonnia-Olenellus Zone

Figures 1–13. *Variopelta laevis* gen. and sp. nov., GSC loc. 73045 (p. 48)

1. Paratype cranidium, x15.0, GSC No. 27337.
2. Paratype cranidium, x7.0, GSC No. 27338.
- 3,4. Paratype cranidium, plan and side views, x6.0, GSC No. 27339.
- 5,6. Paratype partially exfoliated cranidium, side and plan views, x5.0, GSC No. 27340.
- 7,8. Holotype cranidium, plan and side views, x4.7, GSC No. 27341.
- 9,10,11. Paratype exfoliated cranidium, side, front, and plan views, x5.1, GSC No. 27342.
12. Latex cast of paratype internal cranidial mould, x5.8, GSC No. 27343.
13. Paratype exfoliated cranidia, x5.3, GSC No. 27344 (upper), GSC No. 27345 (lower).

Figures 14–25. *Olenellus sequomalus* sp. nov., GSC loc. 73049 (p. 15)

14. Paratype cephalon, x8.0, GSC No. 27346.
15. Paratype cephalon, x5.6, GSC No. 27347.
16. Paratype cephalon, x3.9, GSC No. 27348.
17. Paratype hypostoma, x5.8, GSC No. 27349.
18. Paratype cephalon, x3.1, GSC No. 27350.
19. Paratype cephalon, x4.5, GSC No. 27351.
- 20–22. Holotype cephalon, plan and front views, x3.1, enlarged front of cephalon, x9.4, GSC No. 27352.
- 23–25. Paratype cephalon, x1.8, enlarged areas on posterior and middle of axis, x10.0, GSC No. 27353.

PLATE 13

Bonnia-Olenellus Zone

- Figures 1-5. *Wanneria parvifrons* sp. nov., GSC loc. 73049 (p. 30)
1. Paratype cephalon, x5.5, GSC No. 27354.
 - 2,3. Holotype cephalon, side and plan views, x3.4, GSC No. 27355.
 - 4,5. Paratype partial cephalon, x2.9, enlargement, x8.5, GSC No. 27356.

- Figures 6-18. *Olenellus* sp. 2 (p. 17)
6. Hypotype cephalon, x16.3, GSC loc. 73051, GSC No. 27357.
 7. Hypotype cephalon, x12.0, GSC loc. 73054, GSC No. 27358.
 8. Hypotype cephalon, x7.6, GSC loc. 73054, GSC No. 27359.
 9. Hypotype partial cephalon, x5.0, GSC loc. 73062, GSC No. 27360.
 10. Hypotype partial cephalon, x1.5, GSC loc. 73062, GSC No. 27361.
 - 11,12. Hypotype cephalon, plan and side views, x5.6, GSC loc. 73054, GSC No. 27362.
 13. Hypotype partial cephalon, x1.9, GSC loc. 73052, GSC No. 27363.
 14. Hypotype partial cephalon, x1.8, GSC loc. 75053, GSC No. 27364.
 - 15,16. Hypotype gena, side and plan views, x2.1, GSC loc. 73062, GSC No. 27365.
 17. Hypotype hypostoma, x5.8, GSC loc. 73052, GSC No. 27366.
 18. Hypotype partial cephalon, x6.2, GSC loc. 73051, GSC No. 27367.

- Figures 19,20. *Olenellus* sp. 3 (p. 18)
- Hypotype cephalon, side and plan views, x3.7, GSC loc. 73052, GSC No. 27368.



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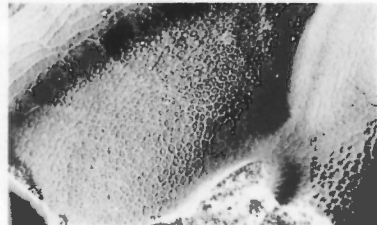
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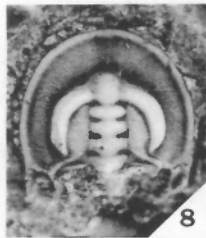
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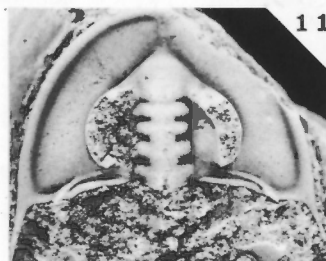
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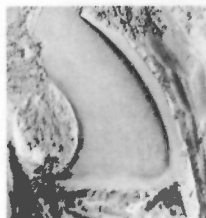
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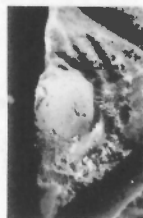
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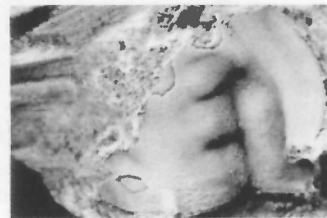
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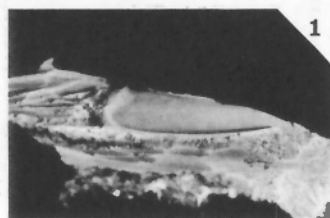
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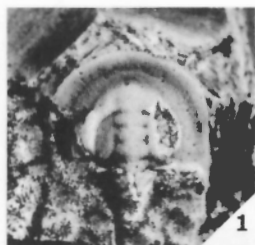


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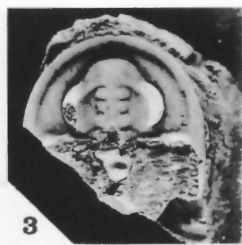
PLATE 14



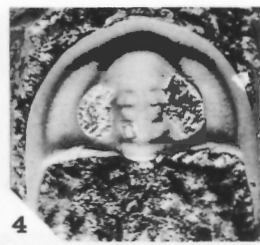
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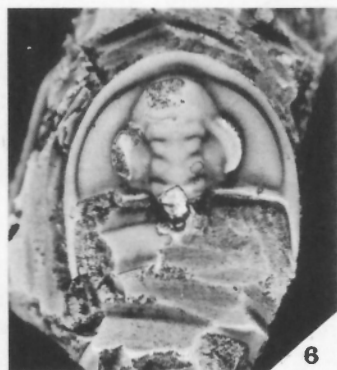
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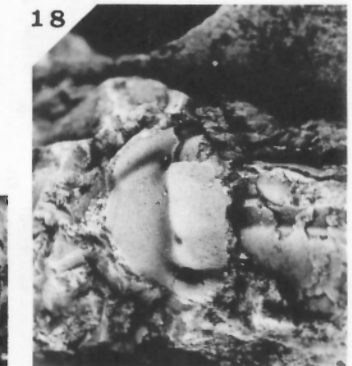
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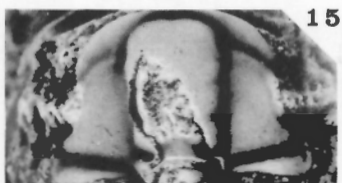
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PLATE 14

Bonnia-Olenellus Zone

- Figures 1-14. *Wanneria logani* (Walcott) (p. 29)
1. Hypotype cephalon, x8.0, GSC loc. 73056, GSC No. 27369.
 2. Hypotype cephalon, x5.2, GSC loc. 73056, GSC No. 27370.
 3. Hypotype cephalon, x5.2, GSC loc. 73049, GSC No. 27371.
 4. Hypotype cephalon, x5.7, GSC loc. 73056, GSC No. 27372.
 5. Hypotype cephalon, x3.8, GSC loc. 73049, GSC No. 27373.
 6. Hypotype cephalon, x3.8, GSC loc. 73049, GSC No. 27374.
 7. Hypotype cephalon, x4.1, GSC loc. 73056, GSC No. 27375.
 - 8,9. Hypotype cephalon, plan and side views, x4.1, GSC loc. 73056, GSC No. 27376.
 - 10,11. Hypotype cephalon, side and plan views, x3.5, GSC loc. 73049, GSC No. 27377.
 12. Hypotype cephalon, x2.8, GSC loc. 73049, GSC No. 27378.
 - 13,14. Hypotype hypostoma, side and plan views, x2.2, GSC loc. 73049, GSC No. 27379.
- Figures 15-18. *Bonnia* sp. 1, GSC loc. 73054 (p. 34)
- 15,16. Hypotype cranidium, plan and side views, x6.3, GSC No. 27380.
 17. Hypotype partial pygidium, x4.0, GSC No. 27381.
 18. Hypotype partial cranidium, x4.4, GSC No. 27382.

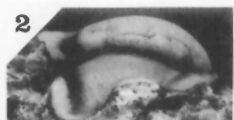
PLATE 15

Bonnia-Olenellus Zone

- Figures 1-7. *Bonnia laterispina* sp. nov., GSC loc. 73057 (p. 33)
- 1,2. Paratype cranidium, plan and side views, x3.5, GSC No. 27383.
 - 3,4. Holotype pygidium, side and plan views, x4.7, GSC No. 27384.
 5. Paratype pygidium, x6.7, GSC No. 27385.
 6. Paratype cranidium, x5.3, GSC No. 27386.
 7. Paratype pygidium, x5.3, GSC No. 27387.
- Figures 8-22. *Olenellus paraoculus* sp. nov. (p. 14)
8. Paratype cephalon, x10.8, GSC loc. 73060, GSC No. 27388.
 9. Paratype cephalon, x7.9, GSC loc. 73060, GSC No. 27389.
 - 10,11. Paratype cephalon, side and plan views, x4.4, GSC loc. 73060, GSC No. 27390.
 12. Paratype cephalon, x6.0, GSC loc. 73060, GSC No. 27391.
 13. Paratype cephalon, x4.6, GSC loc. 73060, GSC No. 27392.
 14. Paratype cephalon, x4.0, GSC loc. 73060, GSC No. 27393.
 - 15,16. Holotype cephalon, side and plan views, x2.7, GSC loc. 73058, GSC No. 27394.
 - 17,18. Paratype cephalon, plan and side views, x3.0, GSC loc. 73065, GSC No. 27395.
 19. Paratype hypostoma, x9.2, GSC loc. 73061, GSC No. 27396.
 20. Paratype partial cephalon, x2.5, GSC loc. 73057, GSC No. 27397.
 - 21,22. Paratype partial cephalon, side and plan views, x1.5, GSC loc. 73061, GSC No. 27398.
- Figures 23-26. *Wanneria* sp. 1, GSC loc. 73059 (p. 30)
23. Hypotype gena, x3.6, GSC No. 27399.
 24. Latex cast of hypotype partial cephalon, x4.3, GSC No. 27400.
 - 25,26. Hypotype pygidium, plan and side views, x6.4, GSC No. 27401.



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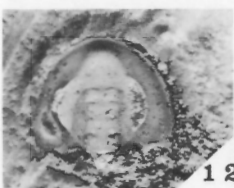
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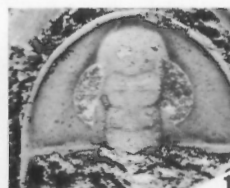
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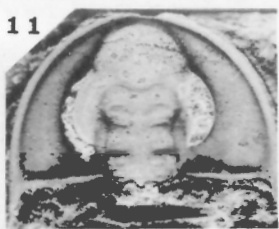
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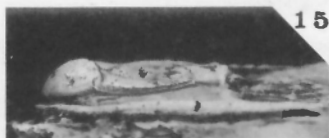
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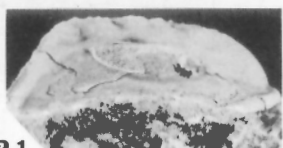
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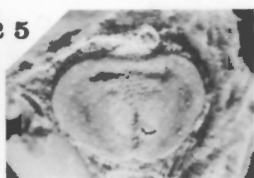
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PLATE 16

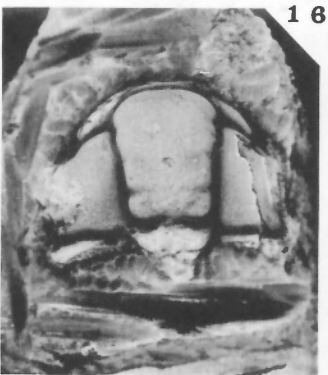
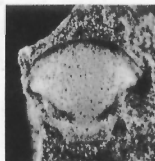
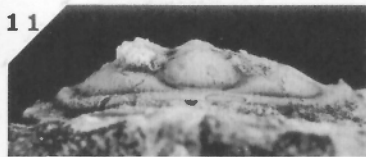
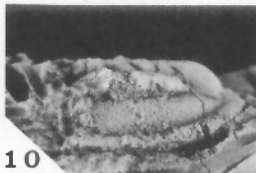
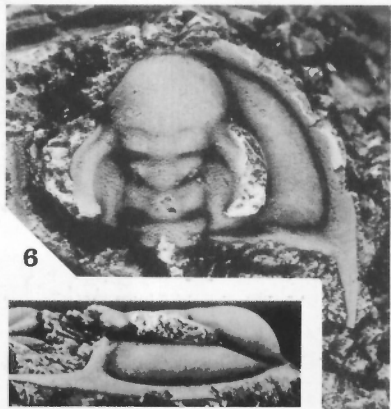
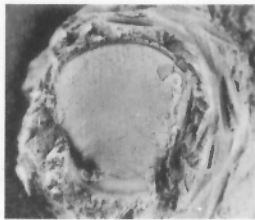
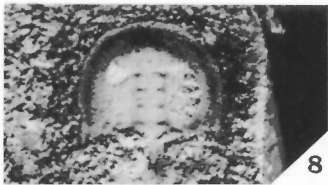
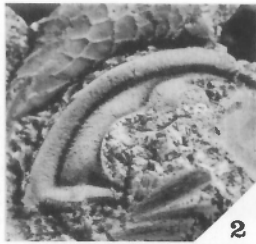


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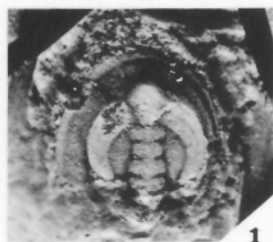
Bonnia-Olenellus Zone

- Figures 1-7. *Wanneria logani* (Walcott), GSC loc. 73064 (p. 29)
1. Hypotype cephalon, x5.2, GSC No. 27402.
 2. Hypotype cephalon, x4.3, GSC No. 27403.
 3. Hypotype partial cephalon, x4.1, GSC No. 27404.
 4. Hypotype partial cephalon, x3.1, GSC No. 27405.
 5. Hypotype hypostoma, x2.2, GSC No. 27406.
 - 6,7. Hypotype cephalon, plan and side views, x4.3, GSC No. 27407.
- Figures 8-15. *Olenellus* sp. 4, GSC loc. 73066 (p. 18)
8. Latex cast of hypotype cephalic mould, x11.3, GSC No. 27408.
 - 9,10,11. Hypotype cephalon, plan, side, and front views, x3.1, GSC No. 27409.
 12. Hypotype cephalon, x3.6, GSC No. 27410.
 13. Hypotype hypostoma, x3.4, GSC No. 27411.
 14. Hypotype hypostoma, x3.0, GSC No. 27412.
 15. Tentatively assigned hypotype cephalon, x2.8, GSC No. 27413.
- Figures 16-18. *Bonnia* sp. 2, GSC loc. 73067 (p. 34)
16. Hypotype cranidium, x4.3, GSC No. 27414.
 - 17,18. Hypotype cranidium, plan and side views, x4.3, GSC No. 27415.
- Figures 19,20. *Zacanthopsis sribuccus* sp. nov. (p. 38)
- Holotype cranidium, plan and side views, x4.2, GSC loc. 73067, GSC No. 27416.

PLATE 17

Bonnia–Olenellus Zone

- Figures 1–7. *Olenellus puertoblancoensis* (Lochman) (p. 14)
1. Hypotype cephalon, x6.2, GSC loc. 73070, GSC No. 27417.
 2. Hypotype cephalon, x4.4, GSC loc. 73071, GSC No. 27418.
 3. Hypotype cephalon, x2.4, GSC loc. 73071, GSC No. 27419.
 4. Hypotype cephalon, x2.1, GSC loc. 73068, GSC No. 27420.
 - 5,6. Hypotype cephalon, plan and side views, x2.4, GSC loc. 73071, GSC No. 27421.
 7. Hypotype cephalon and partial thorax, x2.5, GSC loc. 73072, GSC No. 27422.
- Figures 8–12. *Bonnia* sp. 3, GSC loc. 73070 (p. 35)
8. Hypotype cranidium, x6.2, GSC No. 27423.
 9. Hypotype cranidium, x4.5, GSC No. 27424.
 - 10,11,12. Hypotype cranidium, front, side, and plan views, x4.0, GSC No. 27425.



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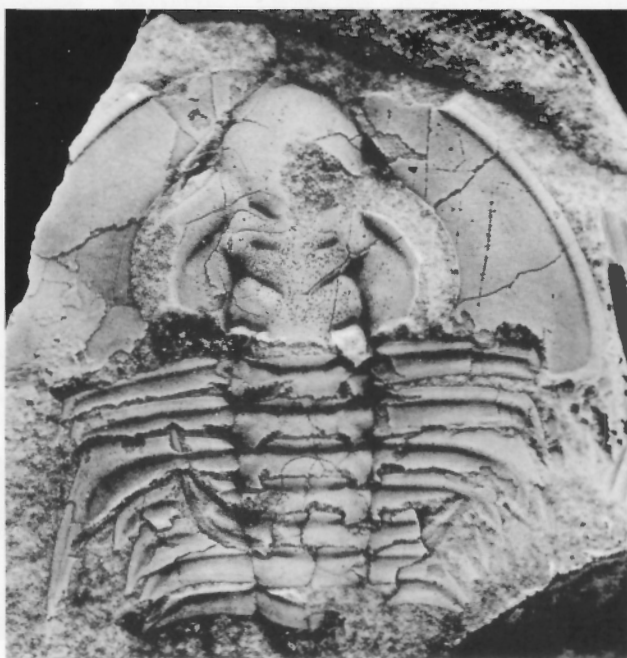
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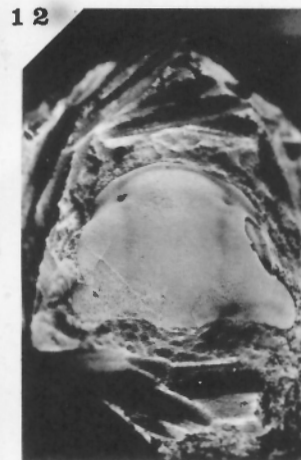
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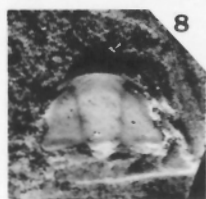
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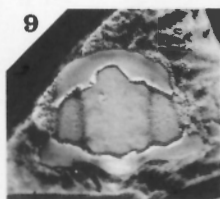
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PLATE 18

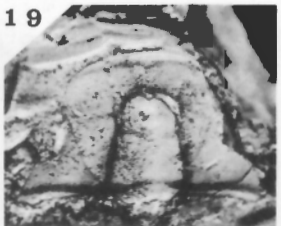
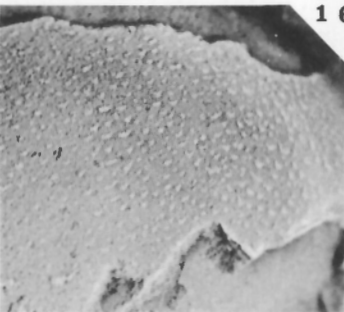
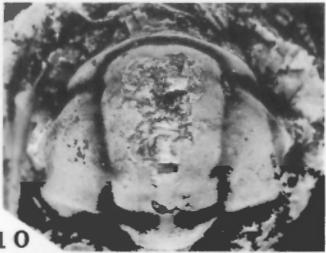
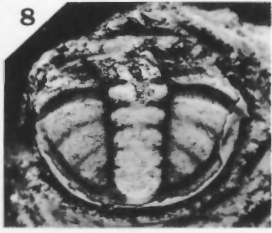
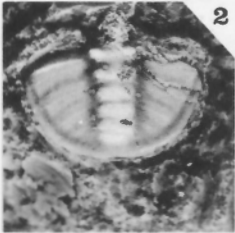
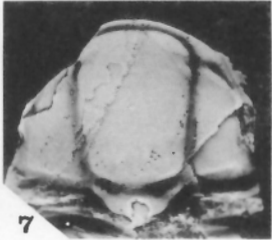
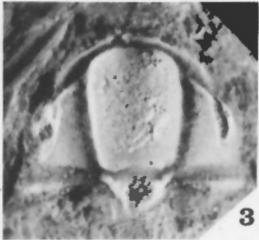
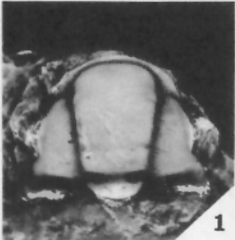


PLATE 18

Bonnia-Olenellus Zone

- Figures 1-13. *Bonnia columbensis* Resser, GSC loc. 73073 (p. 32)
1. Hypotype cranidium, x4.6, GSC No. 27426.
 2. Hypotype exfoliated pygidium, x3.3, GSC No. 27427.
 - 3,4. Hypotype cranidium, plan and side views, x3.8, GSC No. 27428.
 5. Hypotype pygidium, x3.5, GSC No. 27429.
 - 6,7. Hypotype cranidium, side and plan views, x2.5, GSC No. 27430.
 8. Hypotype exfoliated pygidium, x2.6, GSC No. 27431.
 9. Hypotype hypostoma, x3.3, GSC No. 27432.
 10. Hypotype cranidium, x2.3, GSC No. 27433.
 - 11-13. Hypotype exfoliated pygidium, rear, side, and plan views, x2.0, GSC No. 27434.
- Figures 14-17. *Olenellus altifrontatus* sp. nov., GSC loc. 73071 (p. 12)
- 14-16. Holotype cephalon, plan and side views, x2.1, enlarged anterior glabellar lobe, x9.7, GSC No. 27435.
 17. Paratype cephalon, x4.1, GSC No. 27436.
- Figures 18,19. Ptychoparioid, gen. and sp. undet., GSC loc. 73073 (p. 49)
18. Hypotype cranidium, x4.7, GSC No. 27437.
 19. Hypotype cranidium, x3.0, GSC No. 27438.

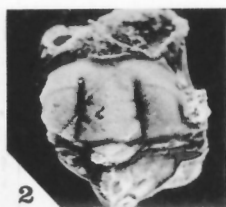
PLATE 19

Bonnia-Olenellus Zone

- Figures 1–10. *Antagmus truncatus* sp. nov., GSC loc. 73073 (p. 40)
1. Paratype cranidium, x5.4, GSC No. 27439.
 2. Paratype cranidium, x5.0, GSC No. 27440.
 3. Paratype cranidium, x4.0, GSC No. 27441.
 - 4–6. Paratype cranidium, plan, front, and side views, x3.3, GSC No. 27442.
 - 7–9. Holotype cranidium, plan, front and side views, x3.0, GSC No. 27443.
 10. Paratype cranidium, x3.6, GSC No. 27444.
- Figures 11–19. *Piaziella pia* (Walcott), GSC loc. 73073 (p. 42)
- 11a, 12. Hypotype cranidium, side and plan views, x3.5, GSC No. 27445.
 - 11b. Hypotype cranidium, x6.7, GSC No. 27446.
 13. Hypotype exfoliated cranidium, x2.1, GSC No. 27447.
 14. Enlarged anterior area of cranidium in fig. 13, x10.0, GSC No. 27447.
 - 15–17. Hypotype exfoliated cranidium, plan, front, and side views, x2.9, GSC No. 27448.
 18. Hypotype cranidium, x2.1, GSC No. 27449.
 19. Tentatively assigned hypotype pygidium, x5.2, GSC No. 27450.
- Figures 20, 21. *Oryctocephalus?* sp. (p. 37)
- Hypotype cranidium, plan and front views, x3.8, GSC loc. 73075, GSC No. 27451.



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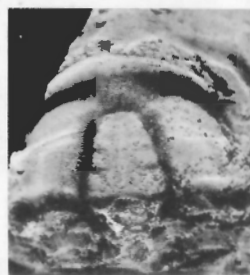
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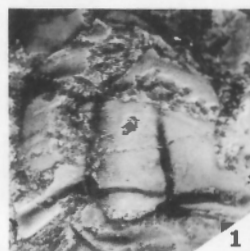
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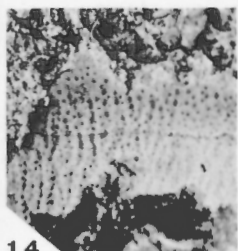
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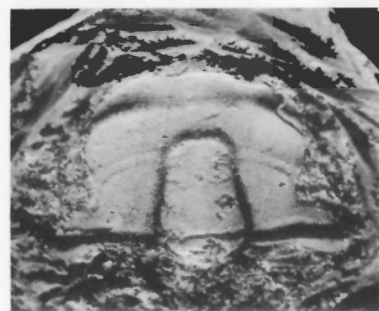
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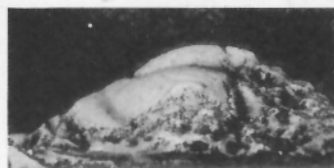
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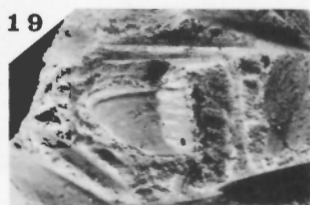
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PLATE 20

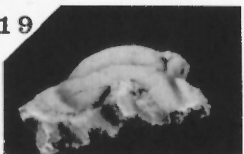
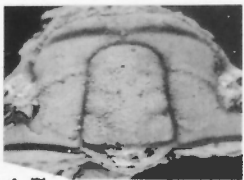
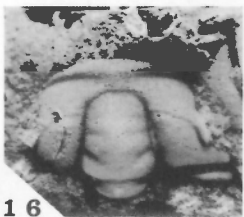
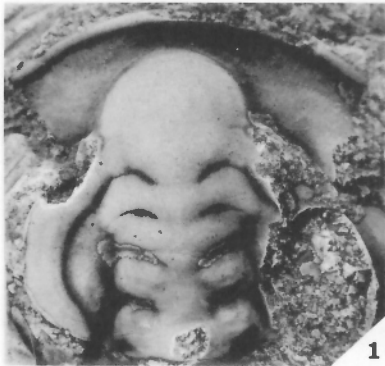
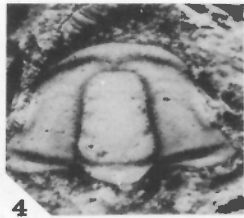
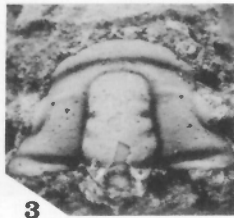
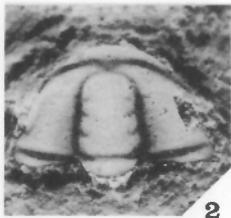


PLATE 20

Bonnia-Olenellus Zone

- Figures 1-8. *Syspacephalus vapidus* sp. nov., GSC loc. 73075 (p. 47)
1. Paratype cranidium, x8.1, GSC No. 27452.
 2. Paratype cranidium, x8.1, GSC No. 27453.
 3. Paratype cranidium, x7.0, GSC No. 27454.
 4. Holotype cranidium, x7.0, GSC No. 27455.
 5. Paratype cranidium, x5.9, GSC No. 27456.
 - 6-8. Paratype exfoliated cranidium, plan, side, and front views, x4.8, GSC No. 27457.
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