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Dresbachian trilobites and stratigraphy of the Cass Fjord Formation, western North Greenland

by

Allison R. Palmer and John S. Peel

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Abstract

Twenty-five species of trilobites are described, some in open nomenclature. They represent four faunules of Dresbachian age and one faunule of possible pre-Dresbachian age from the lower 150 m of the Cass Fjord Formation in Daugaard-Jensen Land, western North Greenland. The Cass Fjord Formation ranges in age from Middle Cambrian–Early Ordovician, although until recently it was widely assumed to be entirely of Ordovician age. All the trilobites are typical North American endemic forms. New taxa include: *Bonneterrina greenlandica* n. sp., *Prolonchocephalus spinosus* n. gen. n. sp., *Kingstonia peltata* n. sp., and *Terranovella arcuata* n. sp. Biogeographic affinities of the older faunules are with faunas of the inner part of the carbonate belt of the Cordilleran region, while the younger faunules have affinities with faunas from the outer(?) part of the carbonate belt in the northern Appalachian region. Evidence of extension of the Dresbachian–Franconian cratonic unconformity to western North Greenland is presented and the problem of repetition of trilobites in the crisis fauna at the base of the Pterocephaliid biomere is discussed.

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INTRODUCTION

The idea of a concentric development of facies-controlled trilobite faunas around North America during Cambrian time was first stated by Lochman-Balk & Wilson (1958) and later elaborated by Palmer (1972, 1974). The thesis was upheld for the Arctic region by sparse Early Cambrian and Middle Cambrian data, but no actual information was available from the Late Cambrian of this region. The opportunity to evaluate the regional reliability of biogeographic and bio-stratigraphic statements about faunas of Late Cambrian age has been provided by the discovery of trilobite faunas of Dresbachian age in Daugaard-Jensen Land, western North Greenland (fig. 1), described here. The only previously described fauna of this or any other Late Cambrian age between east-central Alaska (Palmer, 1968) and western Newfoundland (Lochman, 1938) is a small faunule of Dresbachian age on the Boothia Peninsula, Arctic Canada (Palmer, Cowie & Eby, 1981), although Late Cambrian faunas have also recently been discovered in central and eastern North Greenland (Peel, 1979; Palmer & Peel, 1979; Ineson & Peel, 1980; Peel, 1980).

The material from Daugaard-Jensen Land has a greater stratigraphic range and species richness than the material from Boothia Peninsula and provides new insights into both Dresbachian biostratigraphy and biogeography. It also provides documentation for a dramatic change in age assignment for the Cass Fjord Formation which until recently was thought to be an Early Ordovician formation resting disconformably on beds of Middle Cambrian age (Poulsen, 1927, 1946; Troelsen, 1950, 1956; Cowie, 1961, 1971), even though the only faunal control of its age came from the uppermost beds (Poulsen, 1927; Troelsen, 1956).

Discovery of Late Cambrian faunas in Daugaard-Jensen Land

The first faunas of Late Cambrian age from western North Greenland were collected by geologists of Greenarctic Consortium in Daugaard-Jensen Land (figs 1,2) during the summer of 1969, in the course of petroleum geology exploration. The collections were submitted to G. O. Raasch who identified faunules of Dresbachian and Franconian ages, the identifications being reported by Dawes (1976, p. 268)). Through the kindness of Dr. J. Stuart Smith (J. C. Sproule and Associates) the collections were donated by Greenarctic Consortium to the Geological Survey of Greenland (GGU) during late 1975. Unfortunately, with the exception of the single Dresbachian collection, GGU collection 212980 (fig. 3), it has not been possible to establish the precise geographical localities of the Greenarctic

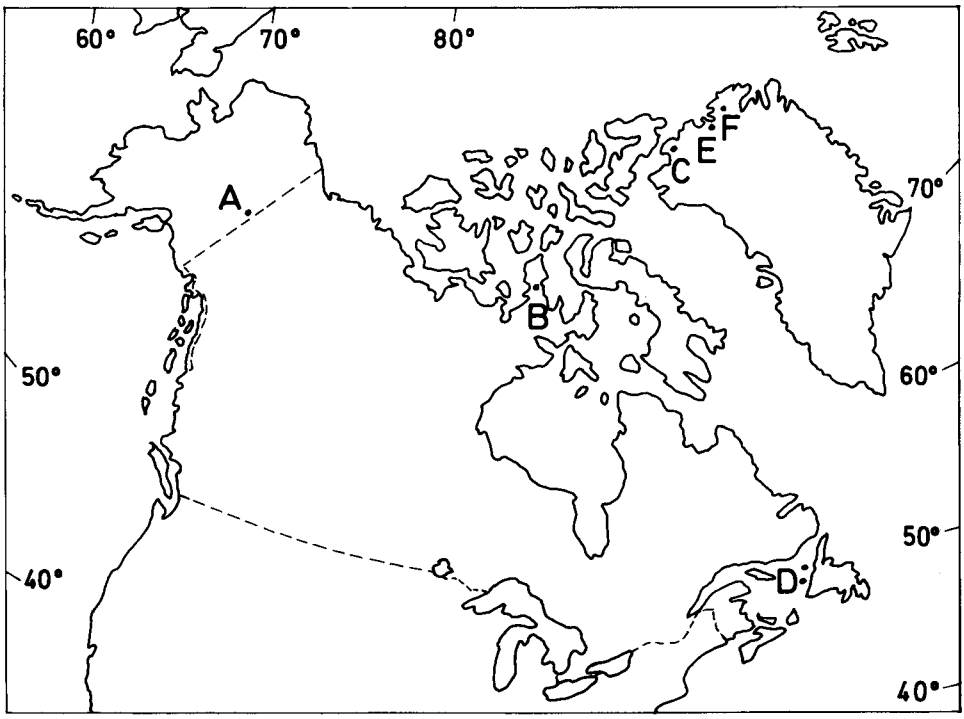

Fig. 1. Map of northern North America showing locations of described Dresbachian faunules. A, eastern Alaska (Palmer, 1968); B, Boothia Peninsula (Palmer, Cowie & Eby, 1981); C, Daugaard-Jensen Land (this paper); D, Newfoundland (Lochman, 1938; Kindle & Whittington, 1959). E, F, locate recently discovered, as yet undescribed, faunules of Dresbachian age in Warming Land – Wulff Land and eastern Peary Land respectively (Palmer & Peel, 1979; Peel, 1980).

Late Cambrian samples. None of the four collections were located with reference to geological units previously described from the Washington Land – Daugaard-Jensen Land area.

In the summer of 1975, Peel and Niels Henriksen (GGU) visited Daugaard-Jensen Land to establish a geological succession as a preliminary to regional geological mapping (Henriksen & Peel, 1976). In addition to section compilation and general reconnaissance, particular emphasis was placed on collecting for biostratigraphical purposes, with special reference to the search for Late Cambrian faunas. A number of Middle and Late Cambrian faunas were collected and submitted to Palmer who identified Dresbachian and Trempealeauan faunules from localities within the Cass Fjord Formation.

Additional sparsely fossiliferous collections made during 1976 by Peel and Hans Jepsen (GGU) included Franconian trilobites, in addition to Dresbachian and Trempealeauan assemblages. At this time mapping, principally by Jepsen, estab-

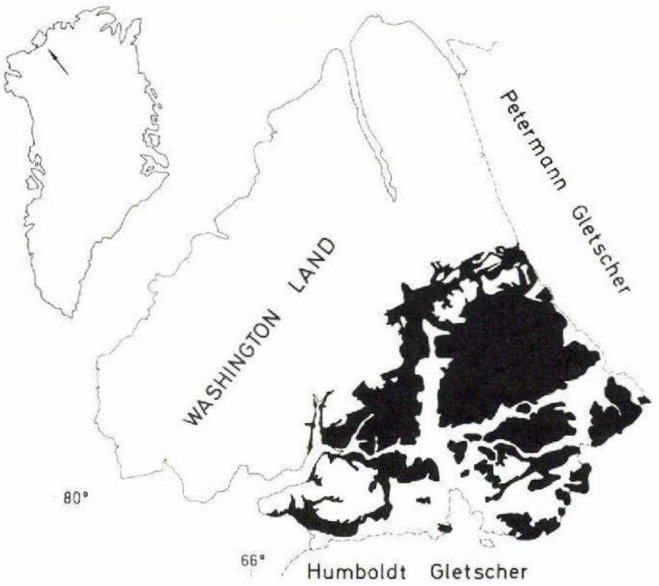

Fig. 2. Distribution of the Cass Fjord Formation (black) which outcrops throughout Daugaard-Jensen Land, from Humboldt Gletscher in the south to Petermann Gletscher in the north-east.

lished the widespread outcrop pattern of the Cass Fjord Formation throughout Daugaard-Jensen Land (fig. 2). In 1977, Peel and J. D. Collinson (Keele) collected Dresbachian, Franconian and Trempealeauan trilobites in sequence through a reference section of the Cass Fjord Formation some 35 km north-east of Cass Fjord (fig. 3, locality 4).

All the Late Cambrian material from Daugaard-Jensen Land was made available to Palmer and was prepared, described and illustrated at the State University of New York at Stony Brook. Photographs were prepared by R. G. Eby whose skill is greatly appreciated and gratefully acknowledged.

CAMBRIAN STRATIGRAPHY IN DAUGAARD-JENSEN LAND

Recent work on the Cambrian of Daugaard-Jensen Land has been briefly reported by Henriksen & Peel (1976), Peel (1977,1978), Jepsen & Dueholm (1978) and Peel & Cowie (1979). The oldest exposed sediments (fig. 3) are sandstones and siltstones which have been informally named the Humboldt Formation (*c.* 120 m). B. R. Pelletier (written communication to GGU, 1980) comments that sandstones, presumably of the Humboldt Formation, overlie crystalline basement in south-east Daugaard-Jensen Land. The formation contains *Cruziana* and *Skolithos,* while a thin calcareous bed near the junction with the overlying Kastrup

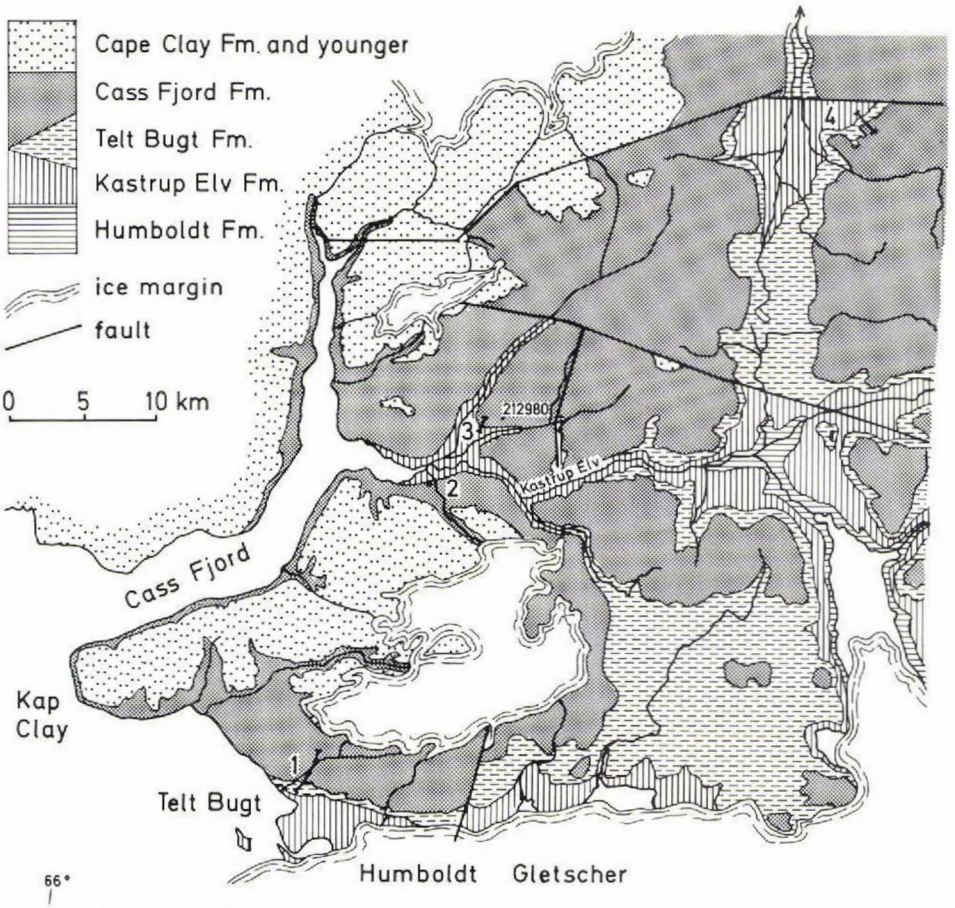

Fig. 3. Geological map of the Cass Fjord – Telt Bugt region of south-west Daugaard-Jensen Land showing localities yielding Dresbachian trilobites (1-4, see figs 4, 6). Map based on field work by Niels Henriksen, Hans F. Jepsen and John S. Peel during 1975-77.

Elv Formation has produced an olenellid head shield, hyolithids and archaeocope ostracods, together indicative of an Early Cambrian age.

Dolomites of the Kastrup Elv Formation (*c.* 140 m) are generally unfossiliferous, although early Middle Cambrian trilobites occur near the top of the formation near Telt Bugt (fig. 3). The boundary with the overlying Telt Bugt Formation reflects a rising dolomitisation front from dolomites, below, to lime muds with thin bioclastic beds, above. However, dolomitisation alone can probably not explain the variation in thickness seen within the Telt Bugt Formation in Daugaard-Jensen Land. More than 100 m of grey limestones are referred to the formation in south-eastern Daugaard-Jensen Land, while only about 40 m are present at Telt Bugt (fig. 3). In the inner parts of Cass Fjord (fig. 3, locality 3), the formation is only a few metres

thick. The fauna of the lower part of the Telt Bugt Formation in western outcrops is dominated by *Kootenia,* but the presence of *Clavaspidella* in more easterly outcrops indicates an early Middle Cambrian age in that area. Late Middle Cambrian, pre-Dresbachian, faunas occur in the uppermost beds of the Telt Bugt Formation near Telt Bugt.

The Telt Bugt Formation passes with apparent conformity into the overlying Cass Fjord Formation (400-470 m), outcrops of which dominate the geological map of Daugaard-Jensen Land (fig. 2).

Cass Fjord Formation

The name Cass Fjord Formation was given by Poulsen (1927) for a sequence in the Cass Fjord area of Washington Land and Daugaard-Jensen Land (figs 2, 3) briefly described by Koch (1925). A fuller description was subsequently published by Koch (1929a) and a preliminary re-description by Henriksen & Peel (1976). The formation name has also been employed in eastern North Greenland (Koch, 1929b) and northern East Greenland (Cowie & Adams, 1957) but Peel & Cowie (1979) restricted usage of the formation to western North Greenland and adjacent Ellesmere Island (Troelsen, 1950; Christie, 1967). In discussing outcrops of the Cass Fjord Formation, Henriksen & Peel (1976) and Peel & Cowie (1979) followed a common 'unofficial' practice of referring to the entire Washington Land and Daugaard-Jensen Land area as Washington Land.

The Cass Fjord Formation (400-470 m) is dominated by greenish grey, nodular and lenticular bedded, lime muds (figs 4, 5). Thin beds (5-50 cm) of intraformational conglomerate with tabular limestone clasts up to 10 cm in diameter, generally less, are characteristic. In detail, a variety of other lithologies are present, including yellowish weathering fine dolomites, anhydritic shales, lime grainstones and, near the top, white quartzites. Boundaries with the underlying Telt Bugt Formation (Middle Cambrian) and overlying Cape Clay Formation (Early Ordovician) appear gradational and conformable.

Henriksen & Peel (1976) loosely divided the Cass Fjord Formation into three subequal parts for the purposes of their preliminary description, although a finer subdivision into members is possible and is partly undertaken here. The lowest third of the formation is dominated by the greenish grey, nodular and lenticular, lime muds and intraformational conglomerates considered characteristic of the formation as a whole. It contains two conspicuous resistant mapping horizons (figs 5, 6) yielding the faunas described herein, members B and D of present usage, which were rather inappropriately termed the 'lower and upper massive' units by Henriksen & Peel (1976). In detail, they are usually just as well bedded as the rest of the sequence, but their weathering appearance may be more massive due to the loss of the silty interbeds present in less resistant parts of the formation.

The middle third of the formation contains many beds of yellowish weathering

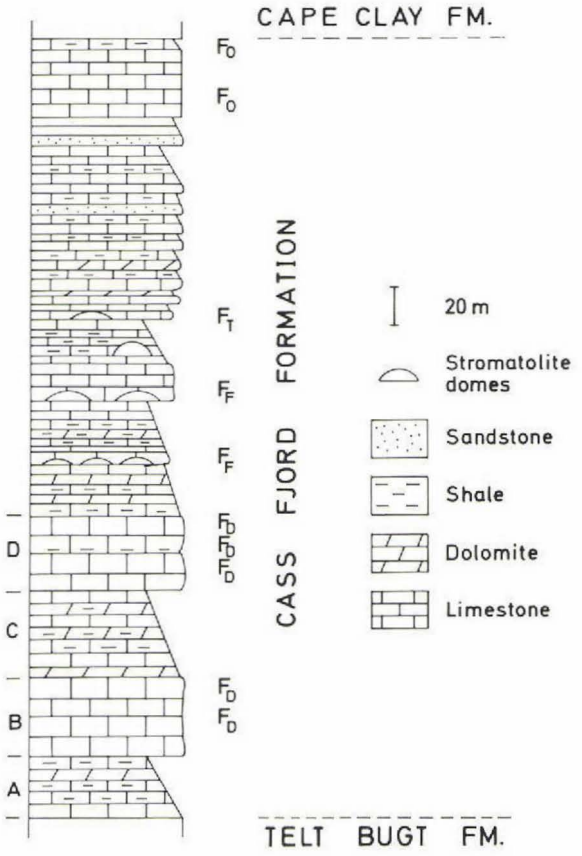

Fig. 4. Generalised geological profile through the Cass Fjord Formation, based on the section at locality 4 (fig. 3). F_D, Dresbachian faunules; F_F, Franconian faunules; F_T, Trempealeauan faunule; F_o, Early Ordovician faunules.

fine dolomite, alternating with the lime muds and intraformational conglomerates. Thin, pale weathering anhydritic shales occur sporadically. The upper third of the Cass Fjord Formation commences with an alternation of limestone and dolomites forming characteristic striped outcrops in many sections. Overlying beds are often anhydritic and poorly exposed, but contain thin, often cross-bedded, quartz sandstone beds. The top 20-30 m of the Cass Fjord Formation consists of resistant, lenticular and nodular, grey-green lime muds with intraformational conglomerates, similar to basal units of the formation.

The Dresbachian faunas described below were collected entirely from the lower third of the Cass Fjord Formation (F_D in fig. 4) which is subdivided (fig. 6) into four members (A-D). Franconian faunas occur near the middle of the formation (F_F), while Trempealeauan trilobites (F_T) were obtained from the basal part of the upper third of the formation as recognised by Henriksen & Peel (1976). Early Ordovician faunas (F_O) originally described by Poulsen (1927) occur in the resistant limestones at the top of the formation.

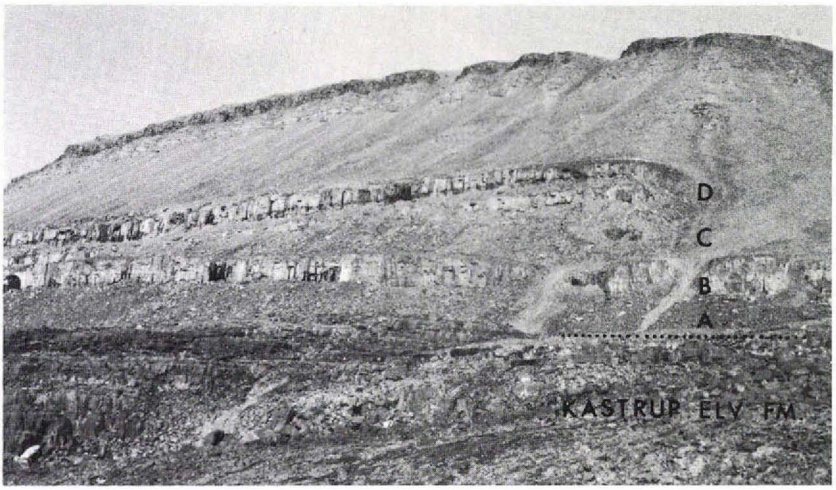

Fig. 5. Cass Fjord Formation in the inner part of Cass Fjord, north and immediately across the fjord from locality 2 in fig. 3, showing typical weathering characteristics of members A–D. The skyline is formed by a prominent brown weathering limestone and sandstone horizon which is located about 50 m above the Trempealeauan fossil horizon in fig. 4. In this area, the Telt Bugt Formation is so reduced in thickness that the Cass Fjord Formation appears to sit directly on dolomites of the Kastrup Elv Formation.

Member A

This unit appears to vary in thickness from about 20-40 m and is generally poorly exposed on account of its recessive character below the resistant member B, above. It was principally examined in section 1 (fig. 3) where a conformable, gradational contact with the underlying Telt Bugt Formation was observed. Yellowish weathering, grey to grey-green lime muds with silty interbeds and yellow dolomites in lenticular or planar beds from 2-10 cm thick dominate, with horizontal burrows, scattered flat limestone clasts and ripple marks frequently present on bedding surfaces. Planar or lenticular, massive weathering beds of intraformational conglomerate up to about 40 cm in thickness contain thin, flat, limestone clasts with rounded edges which attain a maximum observed diameter of 10 cm. The clasts may be imbricated, flat lying or convoluted. Fossils have not been found in member A.

Member B

Carbonates forming this approximately 30-45 m thick member, the 'lower massive' mapping horizon of Henriksen & Peel (1976), are generally well exposed throughout Daugaard-Jensen Land. The lenticular bedded, grey-green lime muds again dominate, but the silty interbeds which give member A its recessive character

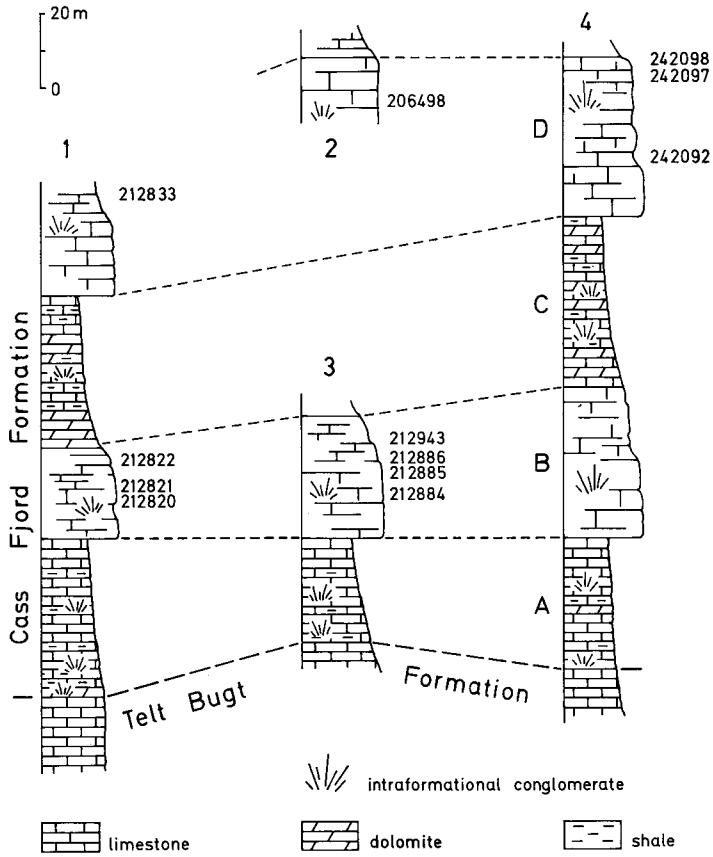

Fig. 6. Profiles through the lower Cass Fjord Formation indicating the derivation of samples yielding Dresbachian faunules. Sections are located in fig. 3, which also locates GGU 212980. A–D, members of the Cass Fjord Formation.

are apparently absent, making the unit more resistant to weathering. Pale weathering grainstones and less frequent oolites and fine conglomerates appear thick or massive bedded in comparison with the lime muds and may form units up to more than 2 m thick. Thin (10-20 cm) beds of digitate stromatolites occur near the top of the member. The grainstones may be locally richly fossiliferous. The boundaries of member B with the recessive members A and C are generally only poorly exposed but the increase in resistance due to decreasing silt content from member A to member B can be sudden.

Member C

Member C consists of approximately 45 m of generally recessive lime muds, fine yellowish dolomites and, near the middle of the member, reddish shales and

siltstones. Bed thickness generally varies from 5 to 15 cm with pockets and some thicker beds of intraformational conglomerate. No fossils have been found, but the member is generally poorly exposed.

Member D

Member D, the so-called 'upper massive' of Henriksen & Peel (1976), forms a second conspicuous resistant mapping horizon reminiscent of member B. Grey-green lime muds are again dominant, in association with intraformational conglomerates. Pale weathering grainstones are less conspicuous than in member B. The member is divided into two approximately equal courses by a few metres of lime mud and silty interbeds. Fossils occur sporadically in thin grainstone beds and pockets.

PALAEONTOLOGY

Five distinct trilobite faunules have been recovered from the lower 150 m of the Cass Fjord Formation; two from member B and three from member D. Twenty-five species of trilobites are recognised, many in open nomenclature because of incomplete information or small sample sizes. Their stratigraphic occurrences and ranges are shown in figs 3, 6, 7.

The oldest faunule is represented by GGU collections 212884 and 212820. This faunule consists of a single simple ptychoparioid here described as Ptychoparioid undetermined 1 (plate 1, figs 1-3). Exact correlation of this faunule is not possible, but the general aspect of the trilobite is more typical of trilobites of North American Middle Cambrian than of Late Cambrian age. The basal beds of the Cass Fjord Formation, therefore, may be as old as latest Middle Cambrian in North American terms, i.e. pre-Dresbachian. The absence of agnostids or any other intercontinental elements in all of the faunules of members A-D of the Cass Fjord Formation makes direct intercontinental correlation of the faunules effectively impossible. However, Robison (personal communication, 1979), based on work now in progress with early Dresbachian faunas in Nevada and Utah, concurs with the recommendation of Daily & Jago (1975) that, in intercontinental terms, a part of the North American Dresbachian stage is of Middle Cambrian age. According to this correlation, both faunules of member B are probably of Middle Cambrian age. The younger of the two faunules in this member, however, is clearly also of earliest Dresbachian age.

The youngest faunule of member B, here termed the *Bonneterrina greenlandica* Faunule, is represented by 5 collections: GGU 212821, 212822, 212885, 212886 and 212943 (table 1) from localities at Telt Bugt and near Kastrup Elv (figs 3, 6). As shown in fig. 7, the faunule seems to be fairly cohesive. It is characterised by

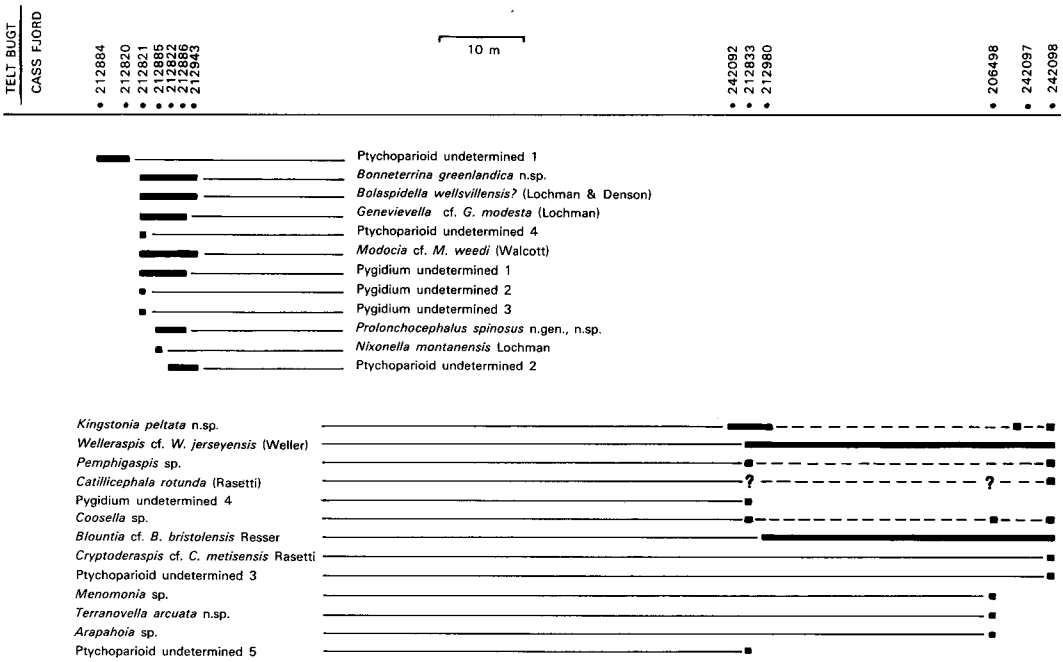

Fig. 7. Stratigraphic distribution of all trilobites described in this paper. Six digit numbers are GGU collection numbers.

Bonneterrina greenlandica n.sp., which has been found in all samples, and *Bolaspidella wellsvillensis?* (Lochman & Denson) and *Modocia* cf. *M. weedi* (Walcott). The latter two species occur in three samples but range through the fossiliferous interval. Other distinctive components which range through much of the interval are *Genevievella* cf. *G. modesta* Lochman and *Prolonchocephalus spinosus* n.gen., n.sp. *Nixonella* cf. *N. montanensis* Lochman is moderately abundant in one sample

Table 1. Maximum number of cranidia (C) or pygidia (P) recorded for trilobite species in member B of the Cass Fjord Formation

	212821	212822	212885	212886	212943
Bonneterrina greenlandica n.sp.	>100C	12C	>20C	1P	2P
Bolaspidella wellsvillensis? (Lochman & Denson)	25C	1C			1C
Genevievella cf. *G. modesta* Lochman	8C			6C	
Modocia cf. *M. weedi* (Walcott)	2C		7C	3C	9C
Prolonchocephalus spinosus n.gen., n.sp		10C	6C	9C	
Nixonella montanensis Lochman			5C		
Ptychoparioid undetermined 2		12C		1C	1C
Ptychoparioid undetermined 4	12C				
Pygidium undetermined 1	8P				
Pygidium undetermined 2	1P				
Pygidium undetermined 3	1P				

6 digit numbers are GGU collection numbers.

Table 2. Maximum number of cranidia (C) or pygidia (P) recorded for trilobite species from member D of the Cass Fjord Formation

	242092	212833	212980	206498	242097	242098
Kingstonia peltata n.sp.	9P	1P	4C			
Kingstonia sp.					1C	1C
Welleraspis cf. *W. jerseyensis* (Weller)		3C				9C
Welleraspis spp.		5C				
Pemphigaspis sp.		3C				1C
Catillicephala rotunda (Rasetti)		1P		1C		7C
Coosella spp.		2C		5P		1P
Blountia cf. *B. bristolensis* Resser			1P			4P
Cryptoderaspis cf. *C. metisensis* Rasetti						1C
Menomonia sp.				2C		
Terranovella arcuata n.sp				3C		
Arapahoia sp.				6C		
Ptychoparioid undetermined 3						1C
Ptychoparioid undetermined 5		1C				
Pygidium undetermined 4		1P				

6 digit numbers are GGU collection numbers.

in the midle of the fossiliferous interval. The trilobites of this faunule are illustrated on plates 2-3.

The assemblage in this faunule is remarkably similar in composition to faunules described from Montana and Wyoming in the United States by Lochman & Duncan (1944) and Lochman & Hu (1961) and assigned to the early *Cedaria* subzone at the base of the Dresbachian stage. The palaeogeographic position of the American faunules is in the inner part of the carbonate belt on the western (present) shelf of Cambrian North America. In the absence of any evidence to the contrary, a similar palaeogeographic position, in the inner part of the carbonate belt, and stratigraphic position, at the base of the Dresbachian stage, is suggested for this faunule in western North Greenland.

The three faunules in member D of the Cass Fjord Formation are represented by several small collections (table 2). The oldest of the faunules, here named the *Kingstonia peltata* Faunule is represented by three collections: GGU 242092, 212833 and 212980. In addition to *Kingstonia peltata* n.sp., its identifiable trilobites include *Welleraspis* cf. *W. jerseyensis* (Weller), *Pemphigaspis* sp., *Catillicephala* sp., *Coosella* sp. and *Blountia* cf. *B. bristolensis* Resser. The largest sample, GGU 212833, is dominated by small trilobites representing *Welleraspis, Pemphigaspis* and *Catillicephala.* The stratigraphically intermediate faunule, represented by GGU 206498, includes species of *Coosella, Menomonia, Terranovella, Arapahoia* and *Catillicephala.* The youngest faunule is represented by two collections: GGU 242097 and 242098. Collection 242097 contains only an indeterminate species of *Kingstonia.* Collection 242098 includes identifiable specimens referable to *Kingstonia* sp., *Welleraspis* cf. *W. jerseyensis* (Weller), *Pemphigaspis* sp., *Catillicephala rotunda* (Rasetti), *Coosella* sp., *Blountia* cf. *B. bristolensis* Resser,

and *Cryptoderaspis metisensis* Rasetti. As in the lower faunule, small trilobites representing *Pemphigaspis, Catillicephala,* and *Welleraspis* predominate.

These faunules in member D illustrate several interesting problems in Dresbachian biogeography and biostratigraphy. Utilising the range charts provided by Lochman-Balk & Wilson (1958), which represent the most recent summary of the ranges of Dresbachian trilobite genera, all three faunules of member D seem most likely to represent ages within the middle or upper parts of the *Cedaria* zone. It is only in this interval on their charts where all of the recorded genera from the younger Dresbachian faunules in western North Greenland fall. However, as Lochman-Balk & Wilson indicate, the biozones of many Dresbachian genera have been extended with each new area studied.

None of the trilobite genera from these faunules are unequivocally younger than the *Cedaria* zone, although *Pemphigaspis* and *Terranovella* are more characteristic of the *Crepicephalus* zone, and *Blountia bristolensis* (see below) is known only from the basal beds of the *Aphelaspis* zone. Thus, the age assignment for these faunules should be recognised as only tentative.

Despite the uncertainty of the age assignment of the younger Dresbachian faunules, dating of member D does provide focus for a stratigraphic anomaly of probably regional importance. About 30 m above member D, a single collection contains *Irvingella,* a characteristic genus of the upper part of the *Elvinia* zone at the top of the Pterocephaliid biomere and the base of the Franconian stage. The intervening interval is hardly enough to encompass the *Crepicephalus, Aphelaspis* (*s.l.*), and *Dunderbergia* zones of the fully developed geosynclinal sections of the Appalachian and Cordilleran regions; however, the interval is at the position of a widespread disconformity in the midcontinent region between the Dresbachian and Franconian stages. The evidence from western North Greenland strongly suggests that this disconformity is truly continent-wide and should be further examined as a reflection of an important event in Late Cambrian history.

The occurrence in the lower and upper faunules of a species of *Blountia* close to if not actually representing *B. bristolensis* Resser may contribute a significant clue to the origin of the trilobites in the crisis fauna at the base of the Pterocephaliid biomere (Palmer, 1979). *B. bristolensis* has previously been reported only from the crisis fauna at the base of the *Aphelaspis* zone in the Pterocephaliid biomere where it is associated with *Coosella perplexa* (Palmer), a trilobite having its morphological similarities closest to *ancestors* of *Crepicephalus,* the characteristic genus from the immediately underlying beds (Palmer, 1954a). The phosphatic brachiopods *'Prototreta'* sp. and *Dictyonina perforata* Palmer in the crisis interval in several areas also represent forms more similar to older forms than to any forms found in the immediately pre-crisis beds. The evidence increasingly points to some kind of repetition in the crisis interval not only of simple ptychoparioids represented by *Aphelaspis* and *Olenaspella,* but also of other elements of the crisis fauna. The mechanism for this repetition is still not understood.

The strong similarity of the upper and lower faunules of member D, which are separated by about 35 m of section but share 5 genera, whereas they have only 2 genera in common with a stratigraphically intermediate fauna, suggests an apparent ecological control on trilobite distribution in this area during Dresbachian time. The upper and lower faunules come from the upper parts of the upper and lower courses of member D; the intermediate faunule comes from within the upper course. This suggests a repetition of environments that is reflected lithologically by the two distinct courses within member D, and paleontologically by strong similarity of the trilobites in the upper part of each course.

Finally, *Catillicephala* and *Cryptoderaspis* have been known previously only from limestone clasts in conglomerates that accumulated on the seaward side of the carbonate platform in the northern Appalachian region. *Catillicephala* has been found in this position from Vermont (Shaw, 1966) to Newfoundland (Kindle & Whittington, 1959). *Cryptoderaspis* has been found only in a boulder within the Levis conglomerates of Quebec, associated with *Catillicephala.* This is the first record of these genera *in situ* and may be an important clue to the source of some of the boulders in the carbonate platform edge conglomerates. Also, the absence of either of these genera from the relatively well-studied Dresbachian beds of the U.S. midcontinent and Cordilleran regions strongly suggests some limiting factor, perhaps of environmental origin, to their geographic distribution and emphasises the fact that while there is a general concentric arrangement to Cambrian faunas around North America, there are important regional details that are different within the major litho-facies belts. Reasonable interpretation of these differences may become more apparent as our understanding of the palaeogeography of the Cambrian regarding ocean-current circulation and climate zonation improves.

CONCLUSIONS

(1) The currently described Dresbachian and older (?) trilobites provide partial documentation for the age revision of the Cass Fjord Formation suggested by Henriksen & Peel (1976). The formation is now known to extend from the late Middle Cambrian, through the Late Cambrian and into the Early Ordovician.

(2) The trilobites were collected from two of the four members (A-D) which together comprise the lower third of the Cass Fjord Formation (400-470 m total thickness) in Daugaard-Jensen Land, western North Greenland. They represent five faunules, none of which seem to be younger than the *Cedaria* Zone.

(3) A disconformity is postulated at or near the top of member D which may reflect the break between beds of Dresbachian and Franconian ages that is well known from the midcontinent region of the United States.

(4) In terms of biogeography, the faunules of member B of the Cass Fjord Formation have their affinities with faunas from the inner part of the carbonate belt in Montana and Wyoming in western United States. The faunules of member D have their affinities with faunas known previously only from carbonate clast conglomerates along the seaward margin of the carbonate platform in the northern Appalachian region.

(5) All of the faunules contain typical endemic North American genera and clearly support the association of Greenland with North America during Cambrian time.

TRILOBITE DESCRIPTIONS

The terminology used here is essentially that of the trilobite treatise (Harrington *et al.*, 1959). All specimens were photographed after whitening with ammonium chloride. Latex casts and exfoliated specimens are noted in the plate descriptions. All types and figured specimens are deposited in the collections of the Geological Museum, Copenhagen, Denmark, and carry the prefix MGUH. Additional material (GGU prefix) is in the collections of the Geological Survey of Greenland.

Authorship of taxa

All systematic descriptions are by Palmer alone. Taxa should be cited as "Palmer *in* Palmer & Peel, 1981".

Family ASAPHISCIDAE Raymond
Subfamily BLOUNTIINAE Lochman
Genus *Blountia* Walcott

Blountia Walcott, 1916, p. 396; Shimer & Shrock, 1944, p. 619; Palmer, 1954a, p. 721; Howell *in* Harrington *et al.*, 1959, p. 292; Palmer, 1962, p. 22; Öpik, 1967, p. 233.

Homodictya Raymond, 1937, p. 1114; Rasetti, 1946, p. 454; Shaw, 1952, p. 473; Howell *in* Harrington *et al.*, 1959, p. 292.

Stenocombus Raymond, 1937, p. 1106.

Type species. Blountia mimula Walcott, 1916, p. 399, pl. 61, figs 4-4c.

Discussion. The small suite of specimens from Greenland conforms in all respects to the description of this genus by Palmer (1962).

Blountia cf. *B. bristolensis* Resser

Plate 4, figs 12, 15-17.

Blountia bristolensis Resser, 1938a, p. 65, pl. 12, fig. 24; Palmer, 1962, p. 22, pl. 3, figs 33, 34; Palmer, 1965, p. 29, pl. 1, figs 1, 2, 4; Rasetti, 1965, p. 58, pl. 10, figs 1, 2; pl. 11, figs 9-12.
Maryvillia bristolensis Resser, 1938a, p. 87, pl. 12, fig. 38.
Maryvillia hybrida Resser (part), 1942b, p. 71, pl. 13, figs 14, 15.
Blountia nixonensis Lochman *in* Lochman & Duncan, 1944, p. 43, pl. 4, figs 7-12; Palmer, 1954a, p. 722, pl. 79, fig. 4; Hu, 1975, p. 258, pl. 2, figs 1-35.

Material. Moderately rare. GGU 242098 (1 cranidium, 4 pygidia), GGU 212980 (1 pygidium). Figured specimens: MGUH 14931 from GGU 212980; MGUH 14929, 14930 from GGU 242098.

Diagnosis. "Members of *Blountia* with cranidium having anterior margin evenly rounded. Width of fixed cheek about one-third basal glabellar width. Length of border (sagittal) slightly greater than length of brim. Pygidium subsemicircular in outline, border furrow well defined at anterolateral margin, becoming shallow towards rear, interrupted by end of axis that extends onto border". (Palmer, 1962, p. 22.)

Remarks. Five pygidia and a single cranidium from two collections (GGU 242098, 212980) represent a species of *Blountia* that is very similar to *B. bristolensis* Resser. The specimens have the diagnostic characters quoted above for this species, but the cranidium from Greenland seems to have its border better defined and is somewhat shorter, relative to the brim, than typical specimens of *B. bristolensis.* However, it is an exfoliated specimen. In addition, the associated trilobites suggest a slightly older age (*Cedaria* zone) for the Greenland specimens. Until now, *B. bristolensis* has been found all across the United States only in association with species of the Late Dresbachian genus *Aphelaspis.* Without a larger sample, to permit evaluation of what seems to be subtle differences between the Greenland species and the forms from the United States, a confident identification of *B. bristolensis,* which would significantly extend its stratigraphic range, cannot be made.

Family Catillicephalidae Raymond

Genus *Catillicephala* Raymond

Cephalocoelia, Raymond, 1937, p. 1124; Rasetti, 1946, p. 449 (*not* Etallon, 1859).
Catillicephala Raymond, 1938, p. xv; Shaw, 1952, p. 462; Wilson, 1951, p. 627; Rasetti, 1954, p. 604; Rasetti *in* Harrington *et al.,* 1959, p. 284; Shaw, 1966, p. 286.

Type species. Cephalocoelia ovoides Raymond, 1937, p. 1124, pl. 3, fig. 22.

Discussion. This genus is well described by Rasetti (1946, 1954) and the Greenland specimens conform in all respects to the description. It is characterised by small trilobites with an unfurrowed, inflated or anteriorly expanded glabella, small

palpebral lobes situated anterior to the glabellar midlength, and no clearly defined frontal area. Pygidia have a prominent, unfurrowed axis that extends nearly to the posterior border, unfurrowed pleural regions, and a narrow, poorly defined lateral border.

Catillicephala rotunda (Rasetti)

Plate 6, figs 8, 11, 13

Cephalocoelia rotunda Rasetti, 1946, p. 762.
Catillicephala rotunda (Rasetti), Shaw, 1966, p. 287.

Material. Moderately common. GGU 242098 (7 cranidia, 5 pygidia). ?Rare. GGU 212833 (1pygidium); GGU 206498 (1 fragmentary cranidium). Figured specimens: MGUH 14948, 14949, 14950 from GGU 242098.

Remarks. This species is characterised by a glabella that has its sides slightly bowed and its sagittal length about equal to its basal width. In addition, the end of the axis on the pygidium does not overhang the pygidial border. The cranidia and pygidia from GGU 242098 agree in all proportions with those of *C. rotunda* and they are assigned with confidence to that species. A pygidium in GGU 212833 and a cranidium in GGU 206498 may also represent this species, but without more information about associated parts and without larger samples, they cannot be confidently identified below the generic level.

Genus *Pemphigaspis* Hall

Pemphigaspis Hall, 1863, p. 221; Rasetti, 1954, p. 603; Palmer, 1951, p. 763; Tasch, 1951, p. 302; Rasetti *in* Harrington *et al.*, 1959, p. 285; Hu, 1968, p. 329.
Hallaspis Raasch & Lochman, 1943, p. 230.

Type species. Pemphigaspis bullata Hall, 1863, p. 221, pl. 5a, figs 3-5.

Discussion. This genus has been fully described by Palmer (1951) and the Greenland material assigned to it adds no new morphological information.

Pemphigaspis sp.

Plate 6, figs 10, 16

Material. Moderately rare, GGU 212833 (3 cranidia). Rare, GGU 242098 (1 cranidium). Figured specimens: MGUH 14953 from GGU 212833; MGUH 14952 from GGU 242098.

Remarks. Several incomplete exfoliated cranidia have the strong occipital spine and the anteriorly expanded glabella with strong lateral furrows, including a bifurcate posterior pair, characteristic of this genus. Without knowledge of the external surface or of associated parts, they cannot be specifically identified.

Family CREPICEPHALIDAE Kobayashi
Genus *Coosella* Lochman

Coosella Lochman, 1936, p. 39; Tasch, 1951, p. 289; Shimer & Shrock, 1944, p. 621; Palmer, 1954a, p. 728; Lochman *in* Harrington *et al.*, 1959, p. 309.

Type species. Coosella prolifica Lochman, 1936, p. 39, pl. 9, figs 4-11.

Discussion. This genus has been adequately described and discussed earlier (Palmer, 1954a). The fragmentary material from Greenland does not contribute any new morphological information.

Coosella spp.
Plate 5, figs 1-3, 6

Material. Rare. GGU 212833 (2 cranidia, 1 free cheek, 1 pygidium); GGU 206498 (5 fragmentary pygidia); GGU 242098 (1 pygidium, 1 fragmentary cranidium?). Figured specimens: MGUH 14932, 14934, 14935 from GGU 212833; MGUH 14933 from GGU 206498.

Remarks. Specimens in three collections are referable to indeterminate species of *Coosella.* In GGU 206498 and GGU 242098 only fragmentary pygidia are present. The best one is illustrated (plate 5, fig. 2) and shows the typical development of pleural furrows, moderately wide border, and posterior median inbend of the pygidial margin characteristic for the genus. A meaningful specific designation is not possible on such material.

Although GGU 212833 has cranidia, a free cheek and a pygidium referable with varying degrees of confidence to *Coosella,* the sample is so small that association of parts is not certain. The cranidium is characterised by a well defined, convex border that occupies about half the sagittal length of a short frontal area. The sagittal length of the frontal area is slightly less than one third the sagittal length of the glabella exclusive of the occipital ring. The fixed cheeks, exclusive of the palpebral lobe are slightly more than one fourth the basal glabellar width. The external surface lacks any distinct ornamentation on the fragmentary areas preserved.

The cranidium differs from most other species of *Coosella* by having a frontal area slightly less than one third the sagittal length of the glabella exclusive of the occipital ring. It is intermediate in length between most *Coosella* species and *C. perplexa* (Palmer) which has a still shorter frontal area. Lack of reasonable confidence in the association of the pygidium, and of information about the external surface and variability, in conjunction with the small sample size, preclude a useful specific diagnosis for a generalised species such as this. It is probably a new form characterised by its short frontal area, but more and better material is necessary for formal naming.

The pygidium is a small specimen that may not be properly assigned to the same species as the cranidium. It has the general shape of a *Coosella* pygidium but lacks

any trace of a median inbend of the posterior margin. Both the axis and pleural regions bear rare, scattered large granules, while only the first ring furrow is distinct.

The free cheek is also small. The border structure seems to be comparable to that of the cranidium in the same collection, and the cheek is probably correctly associated with it. The lateral border furrow is intersected near the genal angle by the posterior section of the facial suture.

Family CEDARIIDAE Raymond
Genus *Bonneterrina* Lochman

Bonneterrina Lochman, 1936, p. 41; Palmer, 1954a, p. 725; Lochman *in* Harrington *et al.*, 1959, p. 248; Rozova, 1964, p. 68.
Piedmontia Resser, 1938a, p. 74.

Type species. Bonneterrina prima Lochman, 1936, p. 42, pl. 9, figs 1–3.

Discussion. This genus has been characterised by relatively generalised ptychoparioid trilobites with an evenly defined, anteriorly tapered glabella strongly rounded at the front, palpebral lobes opposite or slightly posterior to the glabellar midlength, and slightly cedariform posterior limbs. The cedariform nature is confirmed for *B. prima* Lochman, *B. appalachia* and *B. greenlandica* n.sp. by the associated free cheeks which show the posterior section of the facial suture crossing the lateral border furrow of the cheek before curving backward to the cephalic margin. All species assigned to the genus possess strong occipital spines. Pygidia associated with *B. appalachia* (Walcott) have a short axis and a narrow, indistinct border and are quite distinct from the broad-bordered pygidia associated with *B. greenlandica* n.sp. The associations are virtually certain for both species, which raises the possibility that the genus may be somewhat artificial. More will have to be learned about other species assigned to this genus before it can be considered as a well defined entity.

The most similar related genus is *Cedarina.* Cranidia of all species of this genus have palpebral lobes that are more anteriorly placed than those of cranidia of species of *Bonneterrina,* and pygidia are generally transversely subelliptical in outline. Also, posterior limbs of the type and several other species do not taper distally as do those of the species assigned to *Bonneterrina.*

The cranidial structure, particularly the posterior limbs, and the structure of the pleural regions of the pygidium are consistent with the placement of the Greenland specimens in the Cedariidae and most probably in *Bonneterrina* as now conceived, but as a new species most strikingly identifiable by the broad pygidial border and subtriangular pygidial outline.

Bonneterrina greenlandica n.sp.
Plate 2, figs 1–16

Material. Common. GGU 212821 (>100 cranidia, 15 pygidia, 5 free cheeks), GGU 212822 (12 cranidia, 10 pygidia), GGU 212885 (>20 cranidia, 6 pygidia, 2 free cheeks, one nearly complete specimen), GGU 212886 (5 cranidia, 11 pygidia), GGU 212943 (1 cranidium, 1 free cheek, 2 pygidia), GGU ?212820 (1 pygidium). Figured specimens: Holotype, MGUH 14904 from GGU 212885. Paratypes, MGUH 14900, 14901, 14903, 14905, 14907, 14908 from GGU 212885; MGUH 14896–14899, 14902 from GGU 212821; MGUH 14906 from GGU 212943.

Description. Cranidium elongate trapezoidal in outline, anterior margin moderately rounded; transverse and longitudinal profiles moderately convex. Glabella prominent, well defined by shallow circumglabellar furrow of uniform depth, tapered forward, strongly rounded anteriorly. Glabellar furrows barely perceptible on some specimens. Occipital furrow straight, deepest across axis. Occipital ring has prominent, sharply pointed median spine upsloping from posterior margin. Frontal area short; sagittal length about one third sagittal length of glabella exclusive of occipital ring. Border moderately convex, separated from preglabellar field by shallow, evenly curved border furrow; sagittal length about twice sagittal length of preglabellar field. Fixed cheeks narrow, slightly downsloping; transverse width, exclusive of palpebral lobes between one third and one fourth basal glabellar width. Palpebral lobes moderately well defined by shallow palpebral furrow, situated about opposite glabellar midlength, connected to anterior part of glabella by low, poorly defined, diagonal ocular ridge. Exsagittal length of palpebral lobe between one half and one third sagittal glabellar length exclusive of occipital ring. Posterior limb tapered distally. Posterior border furrow well defined, very slightly deflected forward just before intersecting sutural margin. Posterior band widens slightly distally. Course of anterior section of facial suture very slightly divergent forward from palpebral lobe; course of posterior section divergent-sinuous.

Free cheek has moderately curved lateral margin. Border convex, width about one half width of pleural platform, well defined by shallow border furrow. Posterior sutural margin interrupts trend of border furrow and follows curved path on inner proximal part of moderately short, sharp genal spine.

Hypostome not known.

Thorax consists of at least seven segments, perhaps several more, each with deep, centrally located pleural furrow and short, sharp pleural tip. Axial parts of segments, when preserved, without obvious nodes or spines.

Pygidium subtriangular in outline, greatest width slightly less than twice length, transverse profile more strongly arched than longitudinal profile; longitudinal profile deflected downward behind end of axis. Axis prominent, well defined by abrupt changes in slope of exoskeleton, tapered slightly posteriorly, strongly rounded at rear; anterior width slightly more than one third maximum pygidial width. Three or four straight, narrow ring furrows present in addition to articulat-

ing furrow. Pleural regions have five or six well defined pleural furrows that terminate in slight depressions at inner margin of border. Three shallow interpleural furrows visible; posterior bands of segments generally slightly narrower than anterior bands. Border flat, of nearly constant width, well defined by change in slope and by distal terminations of furrows of pleural regions; greatest width about equal to greatest width of pleural platform.

Most specimens of all parts are exfoliated. A few cranidia show external ornamentation consisting of fine, closely spaced granules on the axial part of the glabella and on the anterior part of the border. Several prominent terrace lines are present along the anterior margin of the border.

Remarks. The cranidium of this species is very similar to that of *Bonneterrina appalachia* (Walcott) as illustrated by Rasetti (1965, plate 2, figs 10–12). However, the pygidium that Rasetti assigns with 'virtual certainty' to the Appalachian species has a narrow border and a transversely ovate outline and is strikingly different from the pygidium that seems to be clearly associated with the cranidia from Greenland. For this reason, the Greenland forms are assigned to a new species. It differs from the type species by having a clearly defined occipital furrow on the cranidium and different proportions to the frontal area. Three species have been assigned to *Bonneterrina* from the Soviet Union. Of these, *B. saamica* Rozova and *B. sachaica* Rozova (Rozova, 1964) both have noncedariform posterior limbs and much narrower fixed cheeks than *B. greenlandica* n.sp., while the associated pygidium is transversely subovate and lacks a broad border. The cranidium figured by Chernysheva (1968) as *Bonneterrina? convexa* seems to have cedariform posterior limbs and might represent this genus. It has a much broader preglabellar field and, if correctly assigned to *Bonneterrina,* differs in this feature from *B. greenlandica* n.sp.

Three cranidia from GGU 212821 (plate 2, fig. 1) represent either an extreme variant of this species or another similar species. They are characterised by strongly depressed anterolateral parts of the frontal area, and a nearly subequally divided frontal area. The glabella seems to have its anterior end somewhat less evenly rounded than typical *B. greenlandica.* In all other respects, the cranidia are essentially identical. In the absence of a larger sample of the 'variant' specimens, they are included here within *B. greenlandica,* although with some hesitation.

Family KINGSTONIIDAE Kobayashi
Genus *Kingstonia* Walcott

Kingstonia Walcott, 1924, p. 58; Walcott, 1925, p. 103; Resser, 1936, p. 24; Shimer & Shrock, 1944, p. 627; Shaw, 1952, p. 471; Tasch, 1952, p. 859; Lochman, 1953, p. 886; Palmer, 1954a, p. 724; Palmer, 1962, p. 29.

Ucebia Walcott, 1924, p. 60; Walcott, 1925, p. 118.

Type species. Kingstonia apion Walcott, 1925, p. 103, pl. 16, figs 27-28a.

Discussion. This genus includes many species of small, generally featureless trilobites with a strongly convex cranidium and a subtriangular to semicircular pygidium. The specimens described below represent a new species with a distinctive development of the anterolateral pygidial margin.

Kingstonia peltata n.sp.

Plate 4, figs 1–11, 13, 14

Material. Common. GGU 242092 (8 cranidia, 9 pygidia); GGU 212980 (4 cranidia, 1 pygidium). Rare. GGU 212833 (1 cranidium, 1 pygidium). In addition, two collections, GGU 242097 and GGU 242098, have only one cranidium apiece. These may also represent this species. Figured specimens: Holotype, MGUH 14924 from GGU 242092. Paratypes, MGUH 14921-14923 from GGU 242092; MGUH 14926, 14928 from GGU 212980; MGUH 14925, 14927 from GGU 212833.

Description. Cranidium subtrapezoidal in outline with evenly rounded anterior margin; transverse and longitudinal profiles both strongly convex, longitudinal convexity strongest. Glabella broad, low, not differentiated on external surface, poorly defined on mold, reaches to anterior border. Lateral glabellar furrows, occipital furrow and posterior border furrows absent. Anterior border consists of narrow band of terrace lines parallel to anterior margin. Palpebral lobes undifferentiated, situated about opposite cranidial midlength. Fixed cheeks narrow, only separable from glabella on exfoliated specimens; width between one fourth and one fifth basal glabellar width. Posterior limbs bluntly pointed distally; transverse length slightly less than three fourths basal glabellar width. External surface smooth.

Pygidium semicircular in outline with truncated anterolateral corners; gently convex transversely; longitudinal convexity increases backward. Axis not defined on external surface; poorly defined even on mold where it tapers backward and merges with posterior slope; eight poorly defined segments visible on mold. Border not differentiated. Each anterolateral corner indented by long notch parallel to axis, with inner sides vertical and surface covered with terrace lines parallel to lateral margin.

Remarks. The unusual structure at the anterolateral corners of the pygidium clearly distinguish this species from all others in *Kingstonia.* The longitudinal notch probably served to accommodate an unusual pleural tip on the last thoracic segment. Cranidia, in the absence of associated pygidia, are probably not identifiable to species.

Family LONCHOCEPHALIDAE Hupé
Genus *Prolonchocephalus* n. gen.

Type species. Prolonchocephalus spinosus n.sp.

Diagnosis. Lonchocephalidae characterized by prominent anteriorly rounded glabella, reaching to or nearly to border furrow. Glabellar furrows shallow. Fixed cheeks narrow. Palpebral lobes small, situated about opposite glabellar midlength. Occipital furrow deep. Occipital ring with well developed occipital spine.

Free cheek, hypostome and thoracic segments not known.

Pygidium simple, with long, prominent, furrowed axis, reaching nearly to posterior margin. Border narrow, poorly defined.

Discussion. The structure of the frontal area clearly distinguishes this monotypic genus from all other lonchocephalid genera. Among the Lonchocephalidae, the most similar genus is *Lonchocephalus,* which has a similar glabellar shape but has a well defined preglabellar field on the cranidium, and a sharp ridge along the trend of the geniculation of the pleural regions of the pygidium.

Prolonchocephalus spinosus n.sp.
Plate 1, figs 5–7, 9, 10

Material. Moderately common, GGU 212822 (10 cranidia), GGU 212885 (6 cranidia, 1 pygidium), GGU 212886 (9 cranidia). Figured specimens: Holotype, MGUH 14887 from GGU 212885. Paratypes MGUH 14886, 14888, 14889 from GGU 212885.

Description. Small trilobites, total length probably less than 2 cm. Cranidium subtrapezoidal in outline, moderately rounded anteriorly, moderately to strongly convex transversely and longitudinally. Glabella prominent, large, elevated above cheeks and frontal area, moderately to strongly convex transversely and longitudinally, defined by sharp changes in slope of exoskeleton, tapered slightly forward, sides gently curved, anterior margin strongly rounded; sagittal length slightly greater than basal glabellar width. Glabellar furrows faint or absent; posterior pair strongly curved when visible. Occipital furrow deep, straight, moderately wide; depth uniform. Occipital ring produced into slightly upsloping, gently arched, sharply pointed occipital spine; sagittal length, including spine, about half length of glabella anterior to occipital furrow. Frontal area short, composed almost entirely of convex border poorly defined on axial line so that preglabellar field, if present, is part of broad furrow between glabella and border; defined laterally by moderately sharp change in slope of exoskeleton; sagittal length slightly less than one fourth sagittal length of glabella anterior to occipital furrow. Fixed cheeks narrow, gently convex, slightly downsloping; width, exclusive of palpebral lobes, about one third basal glabella width. Palpebral lobes, gently curved, poorly defined by shallow curved palpebral furrow, connected to front of glabellar midlength; exsagittal

length about one third sagittal length of glabella anterior to occipital furrow. Posterior limbs tapered distally, downsloping; transverse length slightly less than basal glabellar width; posterior border furrow deep; posterior band widens slightly distally. Course of anterior section of facial suture nearly straight forward in front of palpebral lobe; course of posterior section divergent sinuous. External surface covered with fine granules, barely apparent on most specimens, anterior part of border has faint terrace lines paralleling anterior margin.

Free cheek, hypostome and thoracic segments not known.

Pygidium transversely subovate in outline, anterior and posterior margins moderately curved, lateral margins bluntly pointed; width nearly twice length. Axis prominent, tapered posteriorly, merges with steeply downsloping posterior part of pygidium on axial line; includes five axial rings well defined by four complete and one partial ring furrow and articulating furrow; sagittal length slightly more than four fifths sagittal length of pygidium; width at anterior end slightly less than one third maximum pygidial width. Pleural regions gently convex, triangular, downsloping; pleural furrows very shallow, even on exfoliated specimens. Border not differentiated; margin smooth. External surface not well enough preserved to determine external ornamentation, preserved fragments appear roughened.

Remarks. This species is easily distinguished from the associated species *Bonneterrina greenlandica.* n.sp. by lacking a preglabellar field and by the strongly convex, elevated posterior end of the glabella. It is also a distinctly smaller trilobite.

Genus *Terranovella* Lochman

Terranovella, Lochman, 1938, p. 473; Shimer & Shrock, 1944, p. 635; Rasetti *in* Harrington *et al.* , 1959, p. 280; Palmer, 1965, p. 51.

Type species. Terranovella obscura Lochman, 1938, p. 473, pl. 56, figs 29-31.

Discussion. The specimens described below conform in all respects to the description of this genus given earlier (Palmer, 1965).

Terranovella arcuata n. sp.

Plate 5, figs 9, 10

Material. Rare. GGU 206498 (3 cranidia). Figured specimens: Holotype, MGUH 14940. Paratype, MGUH 14941.

Description. Cranidium subtrapezoidal in outline, moderately to strongly rounded anteriorly, gently convex transversely and longitudinally, all parts well defined. Glabella straight sided, tapered forward, bluntly rounded, anteriorly well defined by deep circumglabellar furrow. Two pairs of short, deep glabellar furrows present;

posterior pair slightly curved; neither pair clearly connected to axial furrow. Occipital furrow straight, deepest at distal ends. Occipital ring gently convex, extended posteriorly into short, broad based spine that continues the backward profile of the top of the glabella. Frontal area divided into strongly convex, subhorizontal preglabellar field, and narrow wirelike border; sagittal length of frontal area about two thirds sagittal length of glabella exclusive of occipital ring; sagittal length of border about one fourth sagittal length of preglabellar field. Fixed cheeks flat, nearly horizontal, width, exclusive of palpebral lobe, between two thirds and three fourths basal glabellar width. Palpebral lobes long, arcuate, well defined by arcuate palpebral furrow, situated about opposite glabellar midlength; exsagittal length about two thirds sagittal glabellar length exclusive of occipital ring. Ocular ridges distinct, narrow, gently arcuate, directed nearly straight laterally from point in axial furrow just posterior to anterior end of glabella. Distal part of posterior limb, beyond palpebral lobe, short, not well preserved on available specimens. Posterior border furrow moderately deep. Course of anterior section of facial suture nearly straight forward from palpebral lobe; course of posterior section divergent sinuous. External ornamentation consists of well defined longitudinal caecal veination on the preglabellar field and scattered low granules on all convex parts.

Other parts not known.

Remarks. This species is represented by only three cranidia; but their distinctive morphology clearly separates them from other described species of *Terranovella.* The most distinctive characteristics of the species are the strongly arcuate palpebral lobes and the scattered granular ornamentation. All other species of *Terranovella* have narrow, gently curved palpebral lobes, and only *T. obscura* Lochman (1938) has a granular ornamentation. However, in addition to the less arcuate palpebral lobes, that species also has narrower fixed cheeks and the ocular ridges and anterior border are much less prominent.

Genus *Welleraspis* Kobayashi

Welleraspis, Kobayashi, 1935, p. 263; Shimer & Shrock, 1944, p. 635; Shaw, 1952, p. 479; Rasetti, 1954, p. 601; Rasetti *in* Harrington *et al.,* 1959, p. 281.

Types species. Liostracus? jerseyensis, Weller, 1899, p. 51, pl. 1, figs 1-8.

Discussion. This genus is well discussed by Rasetti, (1954) who also gives the best illustration of the type species. The large, well furrowed, quadrate glabella on the cranidium, and the narrow border, long axis, and well segmented pleural and axial parts of the pygidium distinguish species of this genus from others in the Lonchocephalidae. The specimens described below possibly represent a new species most similar to the genotype.

Welleraspis cf. *W. jerseyensis* (Weller)

Plate 6, figs 1-4

Liostracus? jerseyensis Weller, 1899, p. 51, pl. 1, figs 1-8.
Solenopleura jerseyensis (Weller). Weller, 1903, p. 119, pl. 2, figs 1-8.
Welleraspis jerseyensis (Weller). Kobayashi, 1935, p. 263, text fig. 30; Shimer & Shrock, 1944, pl. 266, fig. 24; Howell, 1945, p. 2, pl. 1, figs 1-4; Rasetti, 1954, p. 602, fig. 1c.
Welleraspis lata Howell, 1957, p. 9, pl. 2, figs 2-9, pl. 3, fig. 1, pl. 4, fig. 2, pl. 5, fig. 2; Hu, 1964, p. 95, pl. 24, figs 1-44.

Material. Moderately rare. GGU 212833 (5 cranidia, 5 pygidia); Moderately common. GGU 242098 (9 cranidia, 1 pygidium). Figured specimens: MGUH 14943, 14945 from GGU 212833; MGUH 14944 from GGU 242098.

Remarks. Several small cranidia and associated pygidia represent a species of *Welleraspis* close to, if not conspecific with, *W. jerseyensis* (Weller). The pygidia cannot be objectively distinguished from those illustrated by Hu (1964) as *W. lata* Howell, a species which Lochman (1968) considered with good justification to be a junior synonym of *W. jerseyensis*. In dorsal aspect, the cranidia also cannot be distinguished from cranidia that have been illustrated for *W. jerseyensis*. However, in lateral profile, some Greenland cranidia have a more convex and robust glabella and an upsloping occipital spine, so that the occipital ring is a deep cleft. The occipital spine is also longer than in typical *W. jerseyensis*. The Greenland sample is too small to be sure of the range of variation present, but it seems to fall beyond that of typical *W. jerseyensis* and more and better material will probably permit recognition of a new species.

Welleraspis spp.

Plate 6, figs 5-7

Material. Rare. GGU 212833 (3 cranidia). Figured specimens: MGUH 14946, 14947.

Remarks. Several small lonchocephalid cranidia which represent at least two species have the subquadrate glabella characteristic of *Welleraspis* and may also represent species of this genus. One (plate 6, figs 5, 6) represented by two small specimens, has a subhorizontally directed occipital spine and may be *W. jerseyensis* (Weller). The other (plate 6, fig. 7) represented by a single incomplete cranidium has much shallower glabellar furrows than typical for *Welleraspis* and may either represent a distinct new species, or even another related genus. Neither species is represented by sufficient material for adequate identification or description, and the specimens are illustrated here to record the range of forms found in collection 212833.

Family MARJUMIIDAE Kobayashi
Genus *Modocia* Walcott

Modocia Walcott, 1924, p. 59; Walcott, 1925, p. 105; Kobayashi, 1935, p. 291; Kobayashi, 1943, p. 322; Resser, 1935, p. 41; Resser, 1936, p. 25; Shimer & Shrock, 1944, p. 629; Tasch, 1951, p. 301; Palmer, 1954a, p. 762; Palmer, 1954b, p. 81; Lochman *in* Harrington *et al.*, 1959, p. 306; Robison, 1964, p. 550; Rasetti, 1965, p. 106; Palmer, 1968, p. 65.
Armonia Walcott, 1924, p. 54; Walcott, 1925, p. 69; Resser, 1936, p. 4; Shimer & Shrock, 1944, p. 605.
Metisia Resser, 1937, p. 19.
Perioura Resser, 1938a, p. 94; Howell *in* Harrington *et al.*, 1959, p. 241.
Semnocephalus Resser, 1942a, p. 50.

Type species. Arionellus (Crepicephalus) oweni Meek & Hayden, 1861, p. 436.

Discussion. The content and concept of this genus have been well reviewed by Robinson (1964), and the Greenland material adds no new morphological information.

Modocia cf. *M. weedi* (Walcott)
Plate 3, figs 1–7

Solenopleura? weedi Walcott, 1899, p. 464, pl. 65, fig. 9.
Modocia weedi (Walcott). Lochman & Duncan, 1944, p. 128, pl. 11, figs 36-39.
Modocia centralis (Whitfield). Lochman & Duncan, 1944, p. 127, pl. 11, figs 40-43.

Material. Moderately common, GGU 212885 (7 cranidia, 3 pygidia); GGU 212886 (3 cranidia, 1 pygidium); GGU 212821 (2 cranidia); GGU 212943 (9 cranidia). Figured specimens: MGUH 14909, 14910 from GGU 212885; MGUH 14911 from GGU 212943; MGUH 14912 from GGU 212821.

Description. Cranidium subtrapezoidal in outline, gently to moderately arched longitudinally. Glabella prominent, evenly defined by shallow circumglabellar furrow, tapered forward, strongly rounded at front; sagittal length distinctly greater than basal glabellar width. Glabellar furrows only apparent as smooth areas on otherwise granular surface. Occipital furrow deep straight. Occipital ring simple. Frontal area subequally divided into well defined convex border and less convex preglabellar field; sagittal length slightly less than one third sagittal length of glabella exclusive of occipital ring. Fixed cheeks gently convex, slightly downsloping; width, exclusive of palpebral lobes, slightly more than one third basal glabellar width. Palpebral lobe well defined by shallow, curved palpebral furrow, situated about opposite glabellar midlength; exsagittal length about one third sagittal glabellar length exclusive of occipital ring. Posterior limb tapered distally, bluntly pointed, border furrow deep; transverse length about equal to basal glabellar width. Anterior section of facial suture slightly convex outward from palpebral lobe to anterior margin; posterior course divergent sinuous. External surfaces of all parts except furrows are covered with evenly spaced granules; granules on border

more uniform in size than those on cheeks and glabella. Surface of mold also granular.

Free cheeks and hypostome not known.

Pygidium transversely elliptical in outline, moderately arched transversely and longitudinally. Axis prominent, wide, slightly tapered posteriorly, bluntly terminated before reaching narrow, poorly defined border of uniform width. Anterior width of axis about one third maximum pygidial width. Articulating furrow and two complete ring furrows well defined, broad, deep; terminal part indented by pair of broad depressions, pleural fields crossed by three broad, deep pleural furrows and two shallower interpleural furrows. External surface, where preserved, weakly granular.

Remarks. There is no question about the generic assignment of this species. Its cranidium has the convex border and well defined, anteriorly tapered, poorly furrowed glabella sharply rounded at the front that is typical for the genus. The pygidium has the simple margin, subovate outline, short axis, narrow poorly defined border and development of both pleural and interpleural furrows that distinguish members of *Modocia* from its closest relative *Marjumia.* The problem of a specific name is complicated. The most similar specimens are those figured by Lochman & Duncan (1944) as *Modocia centralis* and *Modocia weedi* which were shown by Shaw (1956) to be conspecific. However, in suppressing *M. weedi* in favour of *M. centralis,* Shaw did not mention ornamentation. He gave reasons why the specimens figured by Walcott (1925, pl. 16, figs 1, 2) are the types of *M. centralis,* but there is no sign nor mention of a strong granular ornamentation on these specimens either by Whitfield (1880) in his original description or by Walcott. However, Walcott's original description of *M. weedi* clearly mentions the granular ornamentation. Thus, it seems probable that the specimens with granular ornamentation figured by Lochman & Duncan as *M. centralis* are more properly assigned to *M. weedi*, which is then characterised as a species of *Modocia* with elongate glabella, subequally divided frontal area, and strong granular ornamentation. Unfortunately, none of the species, *weedi, centralis* or *oweni* have pygidia associated with their types. Thus, there will always be some uncertainty about any specific comparisons with those species. The Greenland specimens have well preserved external ornamentation on parts of several specimens. They show that the granules are of two sizes on the exterior of both the pygidium and cranidium; that there is no ornamentation over areas of muscle scars on either cranidium or pygidium; and that there is no prominent occipital node or spine. Until more is known about the western American specimens, the Greenland specimens are compared with *M. weedi.* The coarsely granular ornamentation seems to characterise early Dresbachian species of *Modocia.*

Family MENOMONIIDAE Walcott
Genus *Bolaspidella* Resser

Bolaspidella Resser, 1937, p. 3; Shimer & Shrock, 1944, p. 609; Shaw, 1952, p. 477; Lochman, 1953, p. 892; Palmer, 1954a, p. 739; Lochman *in* Harrington *et al.*, 1959, p. 304; Robison, 1964, p. 553.
Hysteropleura Raymond, 1937, p. 1094.
Deissella Howell & Duncan, 1939, p. 7.
Howellaspis Lochman & Denson *in* Lochman & Duncan, 1944, p. 125.

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

Discussion. Robison (1964) has given an excellent description of the characteristics of this genus. The Greenland specimens add no new morphological information.

Bolaspidella wellsvillensis? (Lochman & Denson)
Plate 1, figs 11, 12, 14

Howellaspis wellsvillensis Lochman & Denson *in* Lochman & Duncan, 1944, p. 125, pl. 15, figs 18-20.
Howellaspis snowiensis Duncan *in* Lochman & Duncan, 1944, p. 126, pl. 15, figs 14-17.
Bolaspidella wellsvillensis (Lochman & Denson), Lochman & Duncan, 1949, p. 439; Palmer, 1954a, p. 741, pl. 83, fig. 11; Lochman & Hu, 1961, p. 138, pl. 30, figs 1-5; Palmer, 1968, p. 66, pl. 5, fig. 23; Robison, 1971, p. 801, pl. 91, figs 10-14.

Material. Moderately common, GGU 212821 (25 cranidia). Rare, GGU 212822 (1 cranidium); GGU 212943 (1cranidium). Figured specimens: MGUH 14890 - 14892 from GGU 212821.

Remarks. This species is well represented by cranidia which are characterised by fixed cheeks only slightly narrower than the basal glabellar width, a frontal area that averages about three fourths as long as the glabella exclusive of the occipital ring, by a well defined border about half the length of the preglabellar field, and an occipital ring without an occipital spine. The ornamentation consists of scattered coarse granules on all parts. Most specimens show low buccal swellings on the fixed cheeks adjacent to the posterior part of the glabella. The palpebral lobes are situated about opposite the glabellar midlength.

The general cranidial proportions, position of the palpebral lobes, and character of ornamentation seem to be within the general range of characteristics of the specimens that have been assigned to *Bolaspidella wellsvillensis* by various authors. However, it may be that too great a range of variability has been included within this suite of described specimens, and the specific identification of the Greenland material is qualified until *B. wellsvillensis* can be restudied. It clearly differs from most other species assigned to *Bolaspidella* by its distinctly longer frontal area, more posteriorly placed palpebral lobes and lack of an occipital spine. Rasetti (1963) described two species of *Bolaspidella* from the Levis conglomerates of Quebec that also bear some resemblance to the Greenland specimens in cranidial proportions. However, *B. interrupta* Rasetti has the palpebral lobes placed opposite

the posterior part of the glabella, and distincly backswept ocular ridges; and *B? tuberculata* Rasetti has a strongly granular ornamentation with granules much more densely distributed than the Greenland forms.

Genus *Menomonia* Walcott

Menomonia Walcott, 1916a, p. 161; Resser, 1938b, p. 34; Lochman, 1940, p. 9; Shimer & Shrock, 1944, p. 627; Palmer, 1954a, p. 742; Lochman *in* Harrington *et al.*, 1959, p. 303.

Type species. Conocephalites calymenoides Whitfield, 1878, p. 52.

Discussion. This genus was adequately defined earlier (Palmer, 1954a) and the scrappy material from Greenland adds no new morphological information.

Menomonia sp.

Plate 5, fig. 11

Material. Rare, GGU 206498 (2 fragmentary cranidia). Figured specimen: MGUH 14942 from GGU 206498.

Remarks. Two fragmentary cranidia have the triangular glabella, anteriorly placed palpebral lobes, strongly upsloping fixed cheeks and convex border typical of species of *Menomonia.* There is not enough information about the posterior limbs, occipital structure, palpebral lobes and external ornamentation to permit any meaningful comparisons at the specific level.

Family Plethopeltidae Raymond

Genus *Arapahoia* Miller

Arapahoia Miller, 1936, p. 24; Shimer & Shrock, 1944, p. 619; Lochman *in* Harrington *et al.*, 1959, p. 409.
Hesperaspis Stoyanow, 1936, p. 469.

Type species. Arapahoia typa Miller, 1936, p. 25, pl. 8, fig. 6.

Discussion. This distinctive genus was adequately described by Miller (1936) with information about the pygidium and free cheeks added by Lochman & Duncan (1944). No new morphological information is provided by the Greenland material.

Arapahoia sp.

Plate 5, figs 4, 5, 7

Material. Moderately common, GGU 206498 (6 cranidia, 3 pygidia). Figured specimens: MGUH 14936 - 14938.

Remarks. The Greenland specimens representing *Arapahoia* are all exfoliated, and thus the external characteristics of the various parts of the cranidia and pygidia are not known. The cranidia are characterised by a prominent occipital spine that continues the longitudinal profile of the glabella, and a frontal area that has a poorly defined transversely elliptical border that is nearly twice as wide sagittally as the preglabellar field. The occipital furrow is shallow and curved forward. The palpebral lobes are not separated from the remainder of the fixed cheek and the entire area is narrow, situated anterior to the glabellar midlength and is slightly upsloping. The posterior limbs are shorter transversely than the basal glabellar width. The surface of the mold is smooth in the glabellar area, weakly pitted on the fixed cheeks and posterior limbs and more strongly pitted on the frontal area.

The associated pygidium has two distinct ring furrows on the mold, and a faintly defined, moderately wide border of nearly constant width that is as wide as the pleural field at the anterior pygidial margin.

None of the described species of *Arapahoia* for which frontal area proportions are given have a preglabellar field as narrow as the one on the Greenland specimens which suggests that these forms may represent a new species. The Greenland pygidia have no clearly distinctive specific characteristics. Without a larger and better preserved sample, an adequate characterisation of the Greenland species cannot be made.

Family RAYMONDINIDAE Clarke

Genus *Genevievella* Lochman

Genevievella Lochman, 1936, p. 40; Shimer & Shrock, 1944, p. 625; Lochman, 1953, p. 891; Palmer, 1954a, p. 736; Lochman *in* Harrington *et al.*, 1959, p. 301.

Type species. Genevievella neunia Lochman, 1936, p. 41, pl. 9, figs 12-21.

Discussion. The Greenland specimens discussed below conform in all respects to the diagnosis of this genus given by Palmer (1954a).

Genevievella cf. *G. modesta* Lochman

Plate 1, figs 13, 15, 16

Genevievella modesta Lochman, 1940, p. 38, pl. 4, figs 30-33.

Material. Moderately rare. GGU 212821 (8 cranidia, 1 pygidium); GGU 212886 (6 cranidia, 1 pygidium). Figured specimens: MGUH 14893 - 14895 from GGU 212821.

Remarks. Fourteen cranidia from two collections may represent this species. They are characterised by a low, subquadrate glabella, rounded at front and with its anterior end tangent to a straight or very gently curved border furrow, or separated from it by a very narrow preglabellar field. Glabellar furrows on most specimens are not clear, although one exfoliated cranidium (plate 1, fig. 13) shows three shallow pairs. The occipital furrow is straight and moderately deep, and the occipital ring is simple. The border is flat or gently convex sagittally, and the anterior margin is gently curved. The fixed cheeks are gently convex and horizontal, and their width, exclusive of the palpebral lobes, is slightly more than one third the basal glabellar width. Low, poorly defined, diagonal eye ridges are visible on some specimens. The posterior parts of the palpebral lobes are moderately well defined by shallow palpebral furrows. The palpebral lobes are located opposite the glabellar midlength. The posterior limbs are about equal in transverse length to the basal glabellar width and have moderately deep, narrow, straight border furrows. The posterior band widens distally. Ornamentation consists of a finely shagreened surface that is clearest on the axial part of the glabella and the occipital ring, and small, low, scattered coarse granules on the glabella and cheeks.

The Greenland sample exhibits some variation in the presence or absence of a narrow preglabellar field. Specimens with the narrow preglabellar field resemble some specimens described as *G. oblonga* Lochman & Hu (1962), although the Greenland specimens all have wider fixed cheeks than specimens of *G. oblonga. G. modesta* is reported to lack a preglabellar field, and no mention is made of scattered granules. However, the variability of ornamentation in this species is not known, and all samples of this kind of *Genevievella* are small, preventing evaluation of the significance of these small differences. Certainly, the Greenland specimens seem to be closest in form to *G. modesta* and *G. oblonga* but confident identification will have to await more and better material.

One pygidium from each sample containing *Genevievella* cranidia has the general morphologic characteristics of pygidia assigned to *Genevievella.* These pygidia have a well segmented, tapered axis and well defined pleural and interpleural furrows that continue from the pleural fields onto the poorly defined border. Ornamentation consists of pairs of low granules on each axial segment, and very obscure granular ornamentation on the pleural regions.

Family Uncertain
Genus *Cryptoderaspis* Rasetti

Cryptoderaspis Rasetti, 1946, p. 451.

Type species. Cryptoderaspis metisensis Rasetti, 1946, p. 451, pl. 68, figs 28-30.

Diagnosis. Small ptychoparioid trilobites of uncertain familial affinities with glabella prominent, well defined, strongly rounded anteriorly, unfurrowed; pos-

terior part strongly elevated, egg-shaped, extended posteriorly over narrow occipital ring that is continuous with posterior part of fixed cheek. Frontal area undivided, downsloping. Fixed cheeks downsloping; palpebral lobes not well defined, small, situated opposite anterior end of glabella.

Other parts not known.

Discussion. This is a striking genus easily distinguished from all other Dresbachian trilobites by the unusual egg-shaped glabellar profile, the downsloping anterior and lateral parts of the cranidium, and the anteriorly located palpebral lobes. Three other described Dresbachian species have similar glabellar structures: *Onchonotopsis eminens* (Raymond), *O. pergibba* Rasetti, and *Genevievella rizantans* Lochman. The species of *Onchonotopsis* both have a well defined narrow border, and *G. rizantans* has its palpebral lobes opposite the posterior part of the glabella. Perhaps all of these species should be segregated on the basis of glabellar structure into a small independent family.

Cryptoderaspis cf. *C. metisensis* Rasetti

Plate 6, figs 9, 12

Cryptoderaspis metisensis Rasetti, 1946, p. 451, pl. 68, figs 28-30.

Material. Rare. GGU 242098 (1 cranidium). Figured specimen: MGUH 14951.

Remarks. The generic diagnosis may also serve as a specific diagnosis in this monotypical genus. The single Greenland specimen seems to have the posterior end of the glabella more elevated than the specimen illustrated in profile by Rasetti, but in all other respects it is identical with *C. metisensis.* In the absence of a larger sample, the significance of the profile difference cannot be evaluated.

Genus *Nixonella* Lochman

Nixonella, Lochman, 1944 *in* Lochman & Duncan, 1944, p. 105; Lochman *in* Harrington *et al.,* 1959, p. 312; Hu, 1972, p. 250.

Type species. Nixonella montanensis Lochman *in* Lochman & Duncan, 1944, p. 105, pl. 13, figs 27-31.

Discussion. This genus was well described by Lochman (1944), and the Greenland specimens conform in all respects not only to the genus, but also to the type species.

Nixonella montanensis Lochman

Plate 1, figs 4, 8

Nixonella montanensis Lochman *in* Lochman & Duncan, 1944, p. 105; pl. 13, figs 27-31; Lochman & Hu, 1962, p. 16, pl. 5, figs 48-52; Hu, 1972, p. 215, pl. 30, figs 27-29.

Material. Rare. GGU 212885 (5 cranidia). Figured specimens: MGUH 14884, 14885.

Remarks. The Greenland specimens assigned to this species do not differ in any significant features from the specimens described and figured by Lochman from Montana. The species is easily distinguished from others in the associated fauna by its small size, anteriorly placed palpebral lobes, subparallel sides to the glabella, simple occipital ring, broad posterior limbs, and nearly flat cranidial border that is tangential to the front of the glabella.

Ptychoparioid undetermined 1

Plate 1, figs 1-3

Material. Moderately common. GGU 212884 (2 cranidia, 2 pygidia, 1 free cheek); GGU 212820 (17 cranidia, 1 pygidium, 2 free cheeks). Figured specimens: MGUH 14881, 14882 from GGU 212884; MGUH 14883 from GGU 212820.

Description. Cranidium subtrapezoidal in outline, moderately rounded anteriorly; sagittal and transverse convexity moderate. Glabella well defined by shallow circumglabellar furrow of uniform depth, tapered slightly forward, bluntly rounded anteriorly; sagittal and longitudinal convexity moderate. Glabellar furrows indistinct, even after whitening. Occipital furrow straight, deepest at sides. Occipital ring simple, without node or spine. Frontal area short, subequally divided into border and preglabellar field by gentle change in slope of exoskeleton; sagittal length between one third and one half sagittal length of glabella exclusive of occipital ring. Border nearly flat, slightly downsloping. Fixed cheeks nearly flat, gently upsloping; width, including palpebral lobes, about one half basal glabellar width. Palpebral lobes moderately long, arcuate, poorly defined by shallow, curved palpebral furrow, situated about opposite a glabellar midlength; connected to glabella by weak eye ridge; exsagittal length about one half sagittal glabellar length exclusive of occipital ring. Posterior limbs slender bluntly pointed, posterior border furrow deep; transverse length about equal to basal glabellar width.

Course of anterior section of facial suture moderately divergent forward from palpebral lobe; course of posterior section strongly divergent, sinuous.

Free cheek represented only by fragments showing moderately defined border, evenly curved lateral margin and moderately short, pointed genal spine.

Thorax and hypostome unknown.

Pygidium transversely subelliptical in outline. Axis prominent, very slightly tapered backward, reaches nearly to posterior margin. Five straight shallow ring

furrows present posterior to articulating furrow. Pleural platforms gently convex, merged with broad, poorly defined border. Four pleural furrows of uniform depth extend onto and nearly across border. Very shallow interpleural furrow visible on border only, between first and second segments.

Surfaces of all parts appear smooth.

Remarks. This species is the commonest form in the two lowest collections from the Cass Fjord Formation. It is a generalised ptychoparioid that is characterised by having the glabella uniformly outlined by a shallow circumglabellar furrow, and by having the pleural furrows on the associated pygidium continue onto the border. The general aspect of the cranidium is similar to forms typical of late Middle Cambrian age, and the pleural structure on the pygidium somewhat resembles that of *Glyphaspis*. However, the axis is much longer than any of the described species of that genus. The species does not fit comfortably into any existing late Middle Cambrian or Dresbachian genus; in the absence of larger samples and more certain information about correct association of parts, it is not formally named.

A very similar cranidium and pygidium were identified as *Ptychoparia* sp. and illustrated by Holtedahl (1913) from float collected at Cape Camperdown on the Bache Peninsula, Ellesmere Island by the second Fram expedition, 1898-1902. This suggests that further collecting in the Cape Camperdown area may yield other faunas comparable to those of the Cambrian part of the Cass Fjord Formation.

Ptychopariod undetermined 2

Plate 3, figs 9, 10

Material. Moderately common. GGU 212822 (12 cranidia), GGU 212943 (1 cranidium), GGU 212886 (1 cranidium). Figured specimens: MGUH 14916, from GGU 212943; MGUH 14915 from GGU 212886.

Remarks. This species is best represented in collection GGU 212822 by cranidia ranging in length from 2 to 10 mm. Single cranidia from two additional collections at about the same stratigraphic interval may also represent this species. It has a characteristic marjumiid glabellar shape, but the frontal area is unusually short, and no marjumiid pygidia were found in collection GGU 212822. The only pygidia there that might represent this species are two specimens tentatively identified as *Bonneterrina greenlandica* n.sp. These differ from typical pygidia of that species by having the ring furrows poorly defined, and narrower pleural regions with fewer pleural furrows. If these pygidia are parts of the same trilobite as the cranidia described above, then a case might be made for this trilobite and *Bonneterrina greenlandica* being dimorphs. Cranidia of both forms have essentially identical ornamentation of strong terrace lines parallel to the anterior cranidial margin and fine granules only along the top of the glabella. Ptychoparioid undetermined 2

differs from *B. greenlandica* by having a shorter frontal area and more poorly defined palpebral lobes, and by lacking an occipital spine. Without more knowledge of associated parts, the affinity to *B. greenlandica* suggested by the ornamentation cannot be assessed and the species cannot be properly named.

Ptychoparioid undetermined 3

Plate 5, figs 8, 10

Material. Rare. GGU 242098 (1 cranidium). Figured specimen: MGUH 14939.

Description. Cranidium small, subquadrate in outline, anterior margin gently curved; sagittal and transverse profiles moderately to strongly convex; sagittal length, exclusive of occipital spine, 2 mm. Glabella prominent, strongly elevated above cheeks and frontal area, well defined by circumglabellar furrow, separated from border only by circumglabellar furrow, strongly convex transversely and longitudinally. Glabellar furrows barely apparent; posterior pair strongly curved. Occipital furrow deep, straight. Occipital ring bears long, upsloping, slender median spine developed from posterior margin. Frontal area short, consists only of narrow, convex border. Fixed cheeks narrow, moderately convex, horizontal; width exclusive of palpebral lobes, about one fourth basal glabellar width. Palpebral lobes small, well defined by palpebral furrow, flexed upward from surface of cheek, situated opposite glabellar midlength. Narrow, diagonal ocular ridges present. Posterior limbs moderately broad, bluntly rounded; transverse length slightly less than basal glabellar width. Posterior border furrow deep, turned slightly forward just before reaching sutural margin of posterior limb; without apparent ornamentation.

Remarks. This species, represented by a single cranidium, has a lonchocephalid glabella and characteristic occipital spine, but differs from all other lonchocephalids by lacking any trace of a preglabellar field, even though the border is well developed. It may represent a new lonchocephalid genus. However, in the absence of a larger sample, no formal name is proposed here.

Ptychoparioid undetermined 4

Plate 3, figs 8-11

Material. Moderately common. GGU 212821 (12 cranidia). Figured specimens: MGUH 14913, 14914.

Description. Cranidium subtrapezoidal in outline, stongly rounded anteriorly, moderately convex transversely, strongly convex longitudinally with convexity greatest across anterior end of glabella. Glabella prominent, but poorly defined by abrupt changes in slope of the exoskeleton, sides subparallel to very slightly con-

vergent forward, anterior end strongly rounded, furrows absent. Occipital ring simple, narrow sagittally, poorly defined by shallow occipital furrow; sagittal length between one sixth and one seventh length of glabella anterior to occipital furrow. Frontal area short, sagittal length about one fourth glabellar length exclusive of occipital ring; border furrow shallow, curved sagittal length of border about three times sagittal length of brim. Fixed cheeks gently downsloping, width, including poorly defined palpebral lobes, slightly less than one half basal glabellar width. Palpebral lobes situated slightly anterior to glabellar midlength; exsagittal length about one third sagittal glabellar length exclusive of occipital ring. Posterior limbs simple, transverse length about equal to basal glabellar width; posterior border furrow shallow. Course of anterior section of facial suture very slightly divergent in front of palpebral lobes; course of posterior section divergent sinuous. External surfaces of all parts smooth.

Remarks. This species is represented by 12 cranidia in a single collection. It does not fit comfortably into any of the genera of small trilobites of Dresbachian age and even its familial affinities are not clear. It is particularly characterised by its smooth glabella, poor occipital furrow, short frontal area, curved border furrow and anterior margin, and palpebral lobes situated somewhat anterior to the glabellar midlength. It is not formally assigned to a new genus at this time, due to its lack of any particularly striking features that might make any other congeneric species easy to recognise.

Ptychoparioid undetermined 5

Plate 6, fig. 15

Material. Rare. GGU 212833 (1 cranidium). Figured specimen: MGUH 14955.

Description. Cranidium small, subquadrate in outline, sagittal convexity moderately strong, greater than transverse convexity; length 2 mm. Glabella large, parallel sided, bluntly rounded at front, reaches to inner part of poorly defined border; glabellar furrows lacking. Occipital furrow straight, of nearly uniform depth. Occipital ring simple, without apparent node or spine, slightly tapered distally. Frontal area consists only of poorly defined border with faint terrace lines parallel to margin. Fixed cheeks gently convex, horizontal; width, exclusive of palpebral lobes about one fourth basal glabellar width. Palpebral lobes moderately long, poorly defined, situated about opposite glabellar midlength; exsagittal length slightly more than one half sagittal length of glabella exclusive of occipital ring. Posterior limbs not well preserved; transverse length about equal to basal glabellar width. Posterior border furrow deep. Course of anterior section of facial suture straight forward from palpebral lobe; course of posterior section not preserved.

Remarks. This species bears some resemblance to species of *Komaspidella* in the low, quadrate, unfurrowed glabella and the frontal area consisting only of a poorly defined border. However, the occipital ring has a lateral taper and lacks an axial node. Without more material, this specimen cannot be placed with confidence in any genus.

Pygidium undetermined 1

Plate 3, figs 12, 13

Material. Moderately rare. GGU 212821 (8 specimens), GGU 212886 (1 specimen). Figured specimens: MGUH 14917, 14918, from GGU 212821.

Description. Pygidium small, semicircular in outline, gently convex transversely and longitudinally. Axis well defined, narrow tapered slightly posteriorly, reaches nearly to inner edge of poorly defined border. Seven distinct rings and small terminal piece well defined by straight ring furrows. Pleural platforms crossed by six deep pleural furrows that terminate at inner edge of poorly defined, narrow border. Interpleural furrows weakly developed between all segments, deepest distally. External surface has few scattered granules on axial and pleural regions.

Remarks. The eight specimens in GGU 212821 are the second most abundant pygidia in the collection. The second most abundant cranidia in that sample represent *Bolaspidella* cf. *B. wellsvillensis* (Lochman & Denson). The pygidia have a scattered ornamentation of large granules, as do the *Bolaspidella* cranidia, and might reasonably be assigned to *B.* cf. *B. wellsvillensis.* However, in shape, structure of the pleural regions and number of segments, these differ strongly from pygidia associated with articulated specimens assigned to *B. wellsvillensis* by Robison (1971), and are consequently left unassigned.

Pygidium undetermined 2

Plate 3, figs 14, 15

Material. Rare. GGU 212821 (1 specimen). Figured specimen: MGUH 14919.

Remarks. In dorsal view, this pygidium is most like pygidia described by Lochman & Hu (1962) from the upper *Cedaria* Subzone in Wyoming and assigned to *Ankoura orbiculata* Lochman, particularly in the relatively wide and long axial lobe and narrow border. However, the pleural regions are more strongly defined, and the anterior pleural segment has a distinct deep distal depression in the position of the first interpleural furrow. Also, the axis is strongly elevated above the pleurae, which is quite atypical for members of the Kingstoniidae. The affinities of this pygidium are unknown. The similar dorsal aspect between this and *A. orbiculata* is considered to be more fortuitous than indicative of any close systematic relationship.

Pygidium undetermined 3

Plate 3, fig. 3

Material. Rare. GGU 212821 (1 specimen). Figured specimen: MGUH 14920.

Remarks. This pygidium may be a variant of the pygidium of *Bonneterrina greenlandica* n.sp. It has the same outline as small forms of this species, and a similar number of axial and pleural furrows. It differs by having a slightly longer axis, in this respect resembling more the pygidium from slightly older collections assigned to Ptychoparioid undetermined 1. However, it differs from both of these by having a distinct median node (or broken spine?) on the first axial segment. Its assignment to a named species will have to await more material.

Pygidium undetermined 4

Plate 6, fig. 14

Material. Rare GGU 212833 (1 specimen). Figured specimen: MGUH 14954.

Remarks. A small pygidium with a granular ornamentation and short nubbins of spines along the posterior margin cannot be referred with confidence to any Dresbachian genus. It is characterised by a prominent axis that bears one distinct ring furrow and that reaches nearly to the posterior margin. The pleural regions are nearly flat and are crossed by three shallow pleural furrows that reach to the inner edge of a moderately narrow poorly defined border. Along the margin, in positions equivalent to the terminal parts of the anterior bands of each pleural segment, are at least four rounded nubbins that represent a kind of incipient marginal spine. Without more material and more knowledge of associated parts, this pygidium is specifically and generically indeterminate.

REFERENCES

Chernysheva, N. E. 1968: Srednekembriyskie trilobity severnogo Kavkaza. *Pal. Zhur.* **1968,** 71-80. [Transl.: Paleont. J. **2,** 64-72].

Christie, R. L. 1967: Bache Peninsula, Ellesmere Island, Arctic Archipelago. *Mem. Geol. Surv. Can.* **347,** 63 pp.

Cowie, J. W. 1961: The Lower Paleozoic Geology of Greenland. *In* Raasch, G. O. (edit.) *Geology of the Arctic* **1.** 160-169. Toronto, Toronto U. P.

Cowie, J. W. 1971: The Cambrian of the North American Arctic regions. *In* Holland, C. H. (edit.) *Cambrian of the New World,* 325-383. London: Wiley-Interscience.

Cowie, J. W. & Adams, P. J. 1957: The Geology of the Cambro-Ordovician rocks of central East Greenland 1. *Meddr Grønland* **153** (1), 193 pp.

Daily, B. & Jago, J. B. 1975: The trilobite *Lejopyge* Hawle and Corda and the middle-upper Cambrian boundary.-*Palaeontology* **18,** 527-550.

Dawes, P. R. 1976: Precambrian to Tertiary of northern Greenland. *In* Escher, A. & Watt, W. S. (edit.) *Geology of Greenland.* 249-303. Copenhagen: Geol. Surv. Greenland.

Hall, J. 1863: Preliminary notice of the fauna of the Potsdam sandstone. *N.Y. State Cabinet Nat. Hist. 16th Ann. Rep.* 119-222.

Harrington, H. J. *et al.* 1959: Arthropoda 1. *In* Moore, R. C. (edit.) *Treatise on Invertebrate Paleontology,* O, 520 pp. Lawrence: Geol. Soc. Am. and Kansas U. P.

Henriksen, N. & Peel, J. S., 1976: Cambrian-Early Ordovician stratigraphy in south-western Washington Land, western North Greenland. *Rapp. Grønlands geol. Unders.* **80,** 17-23.

Holtedahl, O. 1913: The Cambro-Ordovician beds of Bache Peninsula and the neighboring regions of Ellesmere Land. *Rept. 2nd Norwegian Arctic Exped. in the Fram, 1898–1902* **28,** 3-14.

Howell, B. F. 1945: Revision of the Upper Cambrian faunas of New Jersey. *Mem. geol. Soc. Am.* **12,** 46 pp.

Howell, B. F. 1957: Upper Cambrian fossils from Bucks County, Pennsylvania. *Bull. Pennsylvania Geol. Surv.* (4) **G28,** 39 pp.

Howell, B. F. & Duncan D. 1939: Middle-upper Cambrian transition faunas of North America. *Bull. Wagner Free Inst. Sci.* **14,** 10 pp.

Hu, C. H. 1964: The ontogeny and dimorphism of *Welleraspis lata* Howell (Trilobita). *J. Paleont.* **38,** 95-97.

Hu, C., H. 1968: Notes on the ontogeny and sexual dimorphism of Upper Cambrian trilobites of the *Welleraspis* faunule from Pennsylvania. *J. Nanyang Univ.* **2,** 321-357.

Hu, C. H. 1972: Ontogeny of three *Cedaria* Zone trilobites from Upper Cambrian, Montana, *Trans. Proc. Paleont. Soc. Japan* N. S. **85,** 245-259.

Hu, C. H. 1975: Ontogenies of three Late Cambrian trilobites from the Deadwood Formation, northern Black Hills, South Dakota. *Bulls Am. Paleont.* **67,** 251-272.

Ineson, J. R. & Peel, J. S. 1980: Cambrian stratigraphy in Peary Land, eastern North Greenland. *Rapp. Grønlands geol. Unders.* **99,** 33-42.

Jepsen, H. F. & Dueholm, K. S. 1978: Computer supported geological photo-interpretation. *Rapp. Grønlands geol. Unders.* **90,** 146-150.

Kindle, C. H. & Whittington, H. B. 1959: Some stratigraphic problems of the Cow Head area in western Newfoundland. *Trans. N. Y. Acad. Sci.* **22,** 7-18.

Kobayashi, T. 1935: The Cambro-Ordovician formations and faunas of south Chosen-Paleontology, part 3. *J. Tokyo Univ. Fac. Sci.* (2) **4,** 49-344.

Kobayashi T. 1943: Cambrian faunas of Siberia. *J. Tokyo Univ. Fac. Sci.* (2) **6,** 271-344.

Koch, L. 1925: The geology of North Greenland. *Amer. J. Sci.* (5) **9,** 271-285.

Koch, L. 1929a: The geology of the south coast of Washington Land. *Meddr. Grønland* **73** (1), 1, 39 pp.

Koch, L. 1929b: Stratigraphy of Greenland. *Meddr Grønland* **73** (2), 2, 205-320.

Lochman, C. 1936: New trilobite genera from the Bonneterre Dolomite (Upper Cambrian) of Missouri. *J. Paleont.* **10,** 35-43.

Lochman, C. 1938: Middle and Upper Cambrian faunas from western Newfoundland. *J. Paleont.* **12,** 461-477.

Lochman, C. 1940: Fauna of the basal Bonneterre Dolomite (Upper Cambrian) of southeastern Missouri. *J. Paleont.* **14,** 1-53.

Lochman, C. 1953: Notes on Cambrian trilobites-homonyms and synonyms. *J. Paleont.* **27,** 886-889.

Lochman, C. 1968: *Crepicephalus* faunule from the Bonneterre Dolomite (Upper Cambrian) of Missouri. *J. Paleont.* **42,** 1153-1162.

Lochman, C. & Duncan, D. 1944: Early Upper Cambrian faunas of central Montana. *Spec. Pap. geol. Soc. Am.* **54,** 181 pp.

Lochman, C. & Duncan, D. 1949: Homonyms and synonyms in "Early Upper Cambrian faunas of central Montana". *J. Paleont.* **23,** 439 only.

Lochman, C. & Hu, C. H. 1961: Upper Cambrian faunas from the northwest Wind River Mountains, Wyoming. Part II. *J. Paleont.* **35,** 125-146.

Lochman, C. & Hu, C. H. 1962: Upper Cambrian faunas from the northwest Wind River Mountains, Wyoming. Part III. *J. Paleont.* **36,** 1-28.

Lochman-Balk, C. & Wilson, J. L. 1958: Cambrian biostratigraphy in North America. *J. Paleont.* **32,** 312-350.

Meek, F. G. & Hayden, F. V. 1861: Descriptions of new lower Silurian (Primordial), Jurrassic, Cretaceous and Tertiary fossils collected in Nebraska Terr. *Proc. Acad. Nat. Sci. Philadelphia.* **13,** 415-447.

Miller, B. M. 1936: Cambrian trilobites from northwestern Wyoming. *J. Paleont.* **10,** 23-34.

Öpik, A. A. 1967: The Mindyallan fauna of northwestern Queensland. *Bull. Aust. Bur. Min. Res. Geol. Geophys.* **74,** 570 pp.

Palmer, A. R. 1951: *Pemphigaspis,* a unique Upper Cambrian trilobite. *J. Paleont.* **25,** 762-764

Palmer, A. R. 1954a: The faunas of the Riley Formation in central Texas: *J. Paleont.* **28,** 710-786.

Palmer, A. R. 1954b: An appraisal of the Great Basin Middle Cambrian trilobites described before 1900. *Prof. Pap. U.S. geol. Surv.* **264-D,** 55-86.

Palmer, A. R. 1962: *Glyptagnostus* and associated trilobites in the United States. *Prof. Pap. U.S. geol. Surv.* **374-F,** 49 pp.

Palmer, A. R. 1965: Trilobites of the Late Cambrian Pterocephaliid Biomere in the Great Basin, United States. *Prof. Pap. U.S. geol. Surv.* **493,** 105 pp.

Palmer, A. R. 1968: Cambrian trilobites of east-central Alaska. *Prof. Pap. U.S. geol. Surv.* **559-B,** 115 pp.

Palmer, A. R. 1972: Problems in Cambrian biogeography. *Proc. 24th Int. Geol. Cong.* **7,** 310-315.

Palmer, A. R. 1974: Search for the Cambrian world. *Am. Sci.* **62,** 216-224.

Palmer, A. R. 1979: Biomere boundaries reexamined. *Alcheringa* **3,** 33.41.

Palmer, A. R., Cowie, J. W. & Eby, R. G. 1981: A Late Cambrian (Dresbachian, *Crepicephalus* zone) fauna from the Boothia Peninsula, District of Franklin, Arctic Canada. *Bull. geol. Surv. Can.* **300,** 1–6.

Palmer, A. R. & Peel, J. S. 1979: New Cambrian faunas from Peary Land, eastern North Greenland. *Rapp. Grønlands geol. Unders.* **91,** 29-36.

Peel, J. S. 1977: Cambrian-Silurian studies in Washington Land, western North Greenland. *Rapp. Grønlands geol. Unders.* **85,** 30-33.

Peel, J. S. 1978: Geological investigations in Lower Palaeozoic terrain of northern Greenland between 78° 30'N and 81° 30'N. *Rapp. Grønlands geol. Unders.* **90,** 14-16.

Peel, J. S. 1979: Cambrian-Middle Ordovician stratigraphy of the Adams Gletscher region, south-west Peary Land, eastern North Greenland. *Rapp. Grønlands geol. Unders.* **88,** 29-39.

Peel, J. S. 1980: Cambrian and Ordovician geology of Warming Land and southern Wulff Land, central North Greenland. *Rapp. Grønlands geol. Unders.* **101,** 55-60.

Peel, J. S. & Cowie, J. W. 1979: New names for Ordovician formations in Greenland. *Rapp. Grønlands geol. Unders.* **91,** 117-124.

Poulsen, C. 1927: The Cambrian, Ozarkian and Canadian faunas of northwestern Greenland. *Meddr Grønland* **70,** 239-343.

Poulsen, C. 1946: Notes on the Cambro-Ordovician fossils collected by the Oxford University Ellesmere Land expedition, 1935-36. *Q. Jl geol. Soc. Lond.* **102,** 299–337.

Raasch, G. O. & Lochman, C. 1943: Revision of three early Upper Cambrian trilobite genera. *J. Paleont.* **17,** 221-235.

Rasetti, F. 1946: Early Upper Cambrian trilobites from western Gaspé. *J. Paleont.* **20,** 442-462.

Rasetti, F. 1954: Phylogeny of the Cambrian trilobite family Catillicephalidae and the ontogeny of *Welleraspis. J. Paleont.* **28,** 599-612.

Rasetti, F. 1965: Upper Cambrian trilobite faunas of northeastern Tennessee. *Smiths. Misc. Colln* **148,** 127 pp.

Raymond, P. E. 1937: Upper Cambrian and Lower Ordovician Trilobita and Ostracoda from Vermont. *Bull. geol. Soc. Am.* **48,** 1079-1146.

Raymond, P. E. 1938: Nomenclature note. *Bull. geol. Soc. Am.* **48** suppl., xv only.

Resser, C. E. 1935: Nomenclature of some Cambrian trilobites. *Smiths. Misc. Colln* **93,** (5), 46 pp.

Resser, C. E. 1936: Second contribution to nomenclature of Cambrian trilobites. *Smiths. Misc. Colln* **95,** (4), 29 pp.

Resser, C. E. 1937: Third contribution to nomenclature of Cambrian trilobites. *Smiths. Misc. Col* **95,** (22), 29 pp.

Resser, C. E. 1938a: Cambrian system (restricted) of the southern Appalachians.*Spec. Pap. geol. Soc. Am.* **15,** 140 pp.

Resser, C. E. 1938b: Fourth contribution to nomenclature of Cambrian fossils. *Smiths. Misc. Colln* **97,** (10), 43 pp.

Resser, C. E. 1942a: Fifth contribution to nomenclature of Cambrian fossils. *Smiths. Misc. Colln* **101,** (15), 58 pp.

Resser, C. E. 1942b: New Upper Cambrian trilobites. *Smiths. Misc. Colln* **103,** (5), 136 pp.

Robison, R. A. 1964: Late Middle Cambrian faunas from western Utah. *J. Paleont.* **38,** 510-566.

Robison, R. A. 1971: Additional Middle Cambrian trilobites from the Wheeler Shale of Utah. *J. Paleont.* **45,** 796-804.

Rozova, A. V. 1964: *Biostratigrafiya i opisanie trilobitov srednegeo i verkhnego Kembriya severo-zapada Sibirskoy Platformy.* 147 pp. Moscow: Nauka.

Shaw, A. B. 1952: Paleontology of northwestern Vermont. 2. Fauna of the Upper Cambrian Rockledge Conglomerate near St. Albans. *J. Paleont.* **26,** 459-483.

Shaw, A. B. 1956: Notes on *Modocia* and Middle Cambrian trilobites from Wyoming. *J. Paleont.* **30,** 141-145.

Shaw, A. B. 1966: Paleontology of northwestern Vermont X. Fossils from the (Cambrian) Skeels Corners Formation. *J. Paleont.* **40,** 269-295.

Shimer, H. W. & Shrock, R. R. 1944: *Index fossils of North America.* 837 pp. Cambridge: Technology Press.

Stoyanow, A. A. 1936: Correlation of Arizona Paleozoic formations. *Bull. geol. Soc. Am.* **47,** 459-540.

Tasch, P. 1951: Fauna and paleoecology of the Upper Cambrian Warrior formation of central Pennsylvania. *J. Paleont.* **25,** 275-306.

Tasch, P. 1952: Nomenclatural notes: Notes on the taxonomy of the Kingstoniid trilobites. *J. Paleont.* **26,** 859-861.

Troelsen, J. C. 1950: Contributions to the geology of Northwest Greenland, Ellesmere Island and Axel Heiberg Island. *Meddr Grønland* **149** (7), 86 pp.

Troelsen, J. C. 1956: The Cambrian of North Greenland and Ellesmere Island. *In* El Sistema Càmbrico, su paleogeografía y el problema de su base. *20 Congr. geol. int. Mexico* **3,** (1), 71-90.

Walcott, C. D. 1886: Second contribution to the studies on the Cambrian faunas of North America. *Bull. U.S. geol. Surv.* **30,** 225 pp.

Walcott, C. D. 1899: Cambrian fossils of the Yellowstone National Park. *Monogr. U.S. geol. Surv.* **32,** 440-478.

Walcott, C. D. 1916: Cambrian geology and paleontology. 5. Cambrian trilobites. *Smiths. Misc. Colln* **64,** (5), 303-456.

Walcott, C. D. 1924: Cambrian geology and Paleontology. 2. Cambrian and lower Ozarkian trilobites. *Smiths. Misc. Colln* **75,** (2), 53-60.

Walcott, C. D. 1925: Cambrian geology and paleontology. 3. Cambrian and Ozarkian trilobites *Smiths. Misc. Colln* **75,** (3), 61-146.

Weller, S. 1899: Descriptions of Cambrian trilobites from New Jersey, with notes on the age of the Magnesian Limestone series. *Ann. Rep. geol. Surv. N. J.* **1899,** 47 only.

Weller, S. 1903: A report on the Paleozoic paleontology of New Jersey. *Geol. Surv. N. J.* **3,** 111-122

Whitfield, R.P. 1878: Preliminary descriptions of new species of fossils from the lower geological formations of Wisconsin. *Ann. Rep. geol. Surv. Wisc.* **1877,** 50-89.

Whitfield, R. P. 1880: Rep. Geol. & Res. Black Hills Dakota: U.S. geol. geogr. Survey Rocky Mt. Region,341-343.

Wilson, J. L. 1951: Franconian trilobites of the central Appalachians. *J. Paleont.* **25,** 617-654.

Plates

Plate 1

Ptychoparioid undetermined 1

Fig. 1. MGUH 14881 from GGU 212884. Exfoliated cranidium, ×5.
Fig. 2. MGUH 14882 from GGU 212884. Pygidium, ×4.
Fig. 3. MGUH 14883 from GGU 212820. Exfoliated cranidium, ×8.

Nixonella montanensis Lochman

Figs 4, 8. MGUH 14884, 14885 from GGU 212885. Small and large cranidia, ×10.

Prolonchocephalus spinosus n.sp.

Fig. 5. MGUH 14886, from GGU 212885. Paratype pygidium, ×5.
Figs 6, 9. MGUH 14887 from GGU 212885. Holotype cranidium, left side and top views, ×10.
Figs 7, 10. MGUH 14888, 14889 from GGU 212885. Paratype cranidia, ×10.

Bolaspidella wellsvillensis? (Lochman & Denson)

Fig. 11. MGUH 14890 from GGU 212821. Cranidium, oblique view, ×5.
Fig. 12. MGUH 14891 from GGU 212821. Small cranidium, ×7.
Fig. 14. MGUH 14892 from GGU 212821. Cranidium, top view of latex cast of counterpart of fig. 11, ×5.

Genevievella cf. *G. modesta* Lochman

Fig. 13. MGUH 14893 from GGU 212821. Small cranidium, ×6.
Fig. 15. MGUH 14894 from GGU 212821. Pygidium, ×4.
Fig. 16. MGUH 14895 from GGU 212821. Cranidium, ×6.

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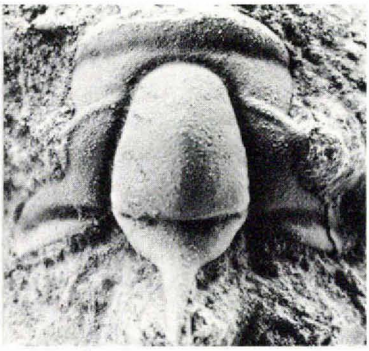

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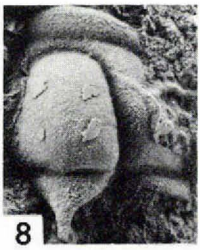

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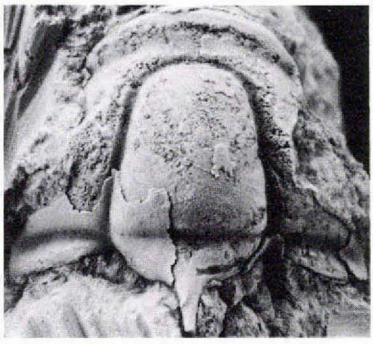

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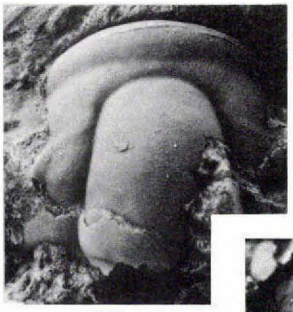

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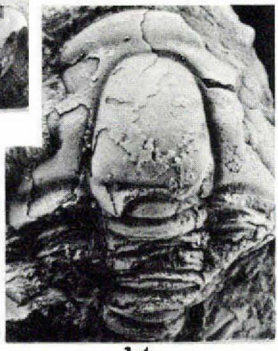

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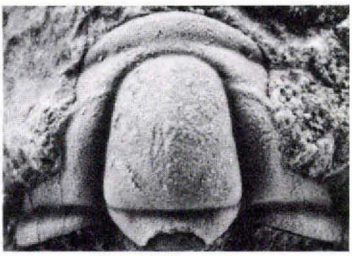

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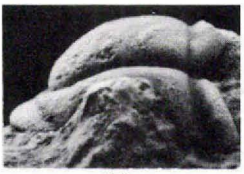

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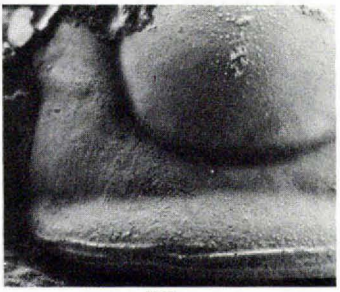

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Plate 2

Bonneterrina greenlandica n.sp.

Fig. 1. MGUH 14896 from GGU 212821. Exfoliated cranidium, ×6, showing strong transverse arching of frontal area.

Figs 2, 3. MGUH 14897, 14898 from GGU 212821. Variability in shape of pygidia, ×5 and ×3 respectively. Fig. 3 is more common type.

Fig. 4. MGUH 14899 from GGU 212821. Exfoliated typical cranidium, ×5.

Figs 5, 6. MGUH 14900, 14901 from GGU 212885. Paratype pygidia, ×3 and ×4 respectively.

Fig. 7. MGUH 14902 from GGU 212821. Free cheek, ×3.

Fig. 8. MGUH 14903 from GGU 212885. Small, exfoliated paratype cranidium, ×5.

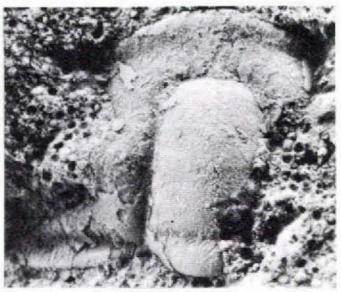
Figs 9, 12. MGUH 14904 from GGU 212885. Top and left oblique of holotype cranidium, ×4.

Figs 10, 14. MGUH 14905 from GGU 212885. Right side and top view of nearly complete paratype specimen showing evidence for association of parts, ×2 and ×3 respectively.

Fig. 11. MGUH 14906 from GGU 212943. Narrow pygidium tentatively assigned to this species, ×3.

Figs 13, 17. MGUH 14907 from GGU 212885. Top and anterior views of rare specimen with exoskeleton preserved, showing distinctive ornamentation on glabella and border.

Figs 15, 16. MGUH 14908 from GGU 212885. Top and left profile views of small paratype cranidium, ×10.



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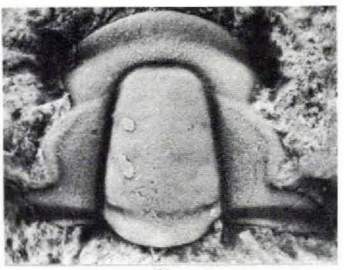

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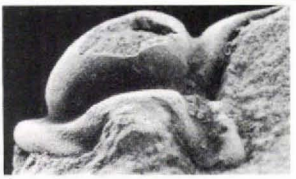

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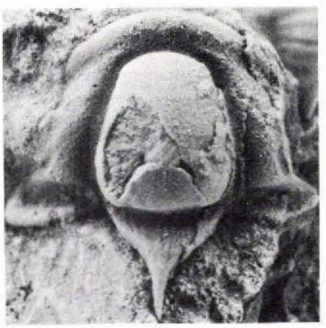

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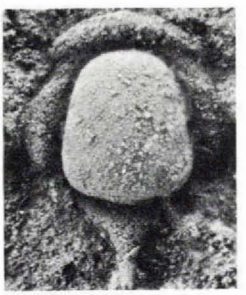

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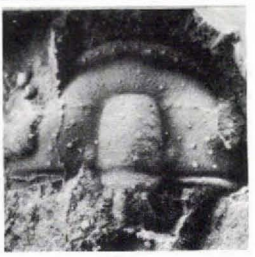

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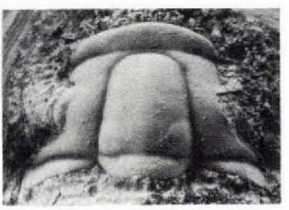

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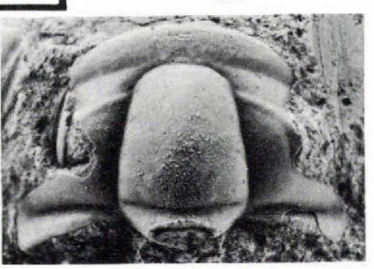

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Plate 3

Modocia cf. *M. weedi* (Walcott)

Figs 1, 2, 4. MGUH 14909 from GGU 212885. Top, close-up and oblique views of cranidium showing typical ornamentation, ×2, ×6, and ×2 respectively.

Figs 3, 5. MGUH 14910 from GGU 212885. Top and close-up views of latex cast of pygidium, ×2 and ×8.

Fig. 6. MGUH 14911 from GGU 212943. Top view, exfoliated cranidium, ×4.

Fig. 7. MGUH 14912 from GGU 212821. Top view, exfoliated cranidium, ×3.

Ptychopariod undetermined 4

Figs 8, 11. MGUH 14913, 14914 from GGU 212821. Top views, cranidia, ×10.

Ptychopariod undetermined 2

Fig. 9. MGUH 14915 from GGU 212886. Top view, exfoliated cranidium, ×3.

Fig. 10. MGUH 14916 from GGU 212943. Top view, cranidium, ×5.

Pygidium undetermined 1

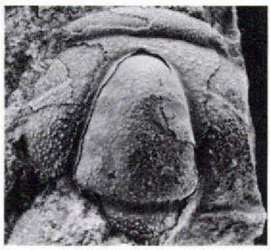
Figs 12, 13. MGUH 14917, 14918 from GGU 212821. Top views, large and small exfoliated pygidia, ×6.

Pygidium undetermined 2

Figs 14, 15 MGUH 14919 from GGU 212821. Top and left profile, exfoliated pygidium, ×4.

Pygidium undetermined 3

Fig. 16. MGUH 14920 from GGU 212821. Top view, pygidium, ×3.



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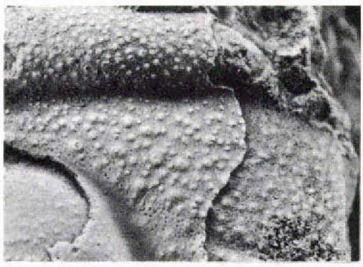

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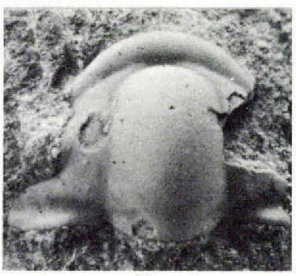

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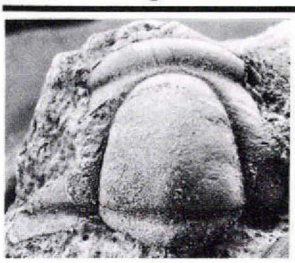

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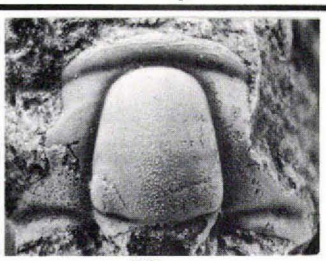

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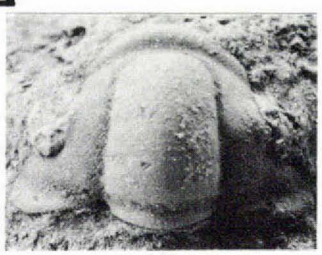

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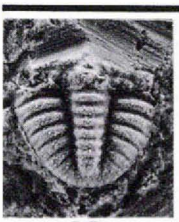

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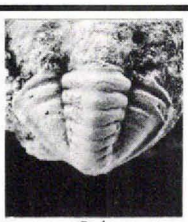

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Plate 4

Kingstonia peltata n.sp.

Figs 1, 2. MGUH 14921 from GGU 242092. Top and right side views, exfoliated paratype cranidium, ×4.

Figs 3, 7, 11. MGUH 14922 from GGU 242092. Right oblique, top, and right side views of paratype cranidium, ×5.

Fig. 4. MGUH 14923 from GGU 242092. Exfoliated paratype pygidium, ×4.

Figs 5, 6. MGUH 14924 from GGU 242092. Right oblique and top views, holotype pygidium, ×3.

Fig. 8. MGUH 14925 from GGU 212833. Small pygidium, ×5.

Figs 9, 10. MGUH 14926 from GGU 212980. Top and right oblique views, partly exfoliated pygidium showing distinctive anterolateral notch, ×2 and ×5 respectively.

Fig. 13. MGUH 14927 from GGU 212833. Cranidium, ×4.

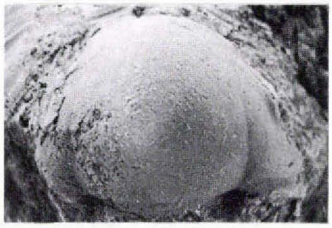
Fig. 14. MGUH 14928 from GGU 212980. Small, partly exfoliated cranidium, ×8.

Blountia cf. *B. bristolensis* Resser

Figs 12, 15. MGUH 14929 from GGU 242098. Top and right side views, exfoliated cranidium, ×3.

Fig. 16. MGUH 14930 from GGU 242098. Pygidium, ×3.

Fig. 17. MGUH 14931 from GGU 212980. Pygidium, ×3.



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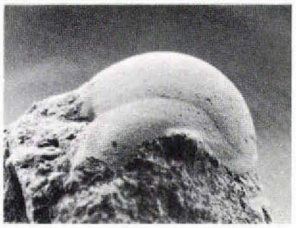

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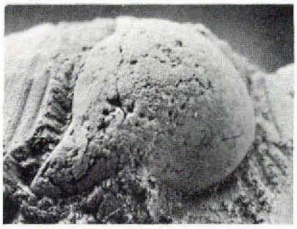

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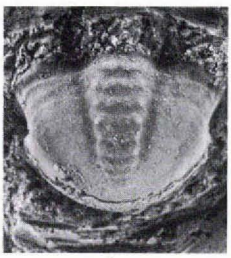

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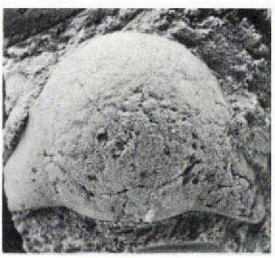

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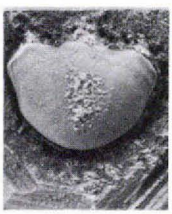

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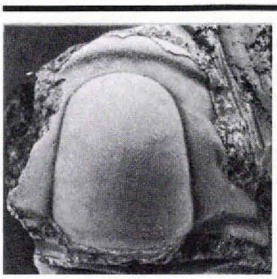

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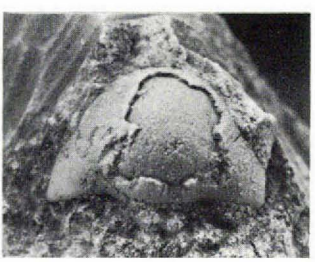

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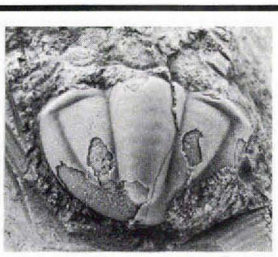

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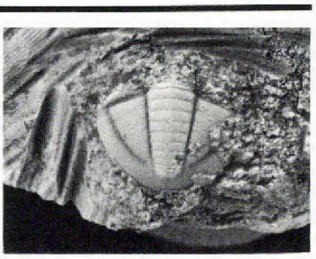

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Plate 5

Coosella spp.

Fig. 1. MGUH 14932 from GGU 212833. Exfoliated cranidium, ×3.
Fig. 2. MGUH 14933 from GGU 206498. Imcomplete pygidium, ×2.
Fig. 3. MGUH 14934 from GGU 212833. Free cheek, ×4.
Fig. 6. MGUH 14935 from GGU 212833. Small pygidium, ×6.

Arapahoia sp.

Fig. 4. MGUH 14936 from GGU 206498. Incomplete cranidium, ×5.
Fig. 5. MGUH 14937 from GGU 206498. Latex cast of incomplete cranidium, ×6.
Fig. 7. MGUH 14938 from GGU 206498. Pygidium, ×4.

Ptychoparioid undetermined 3

Figs 8, 10. MGUH 14939 from GGU 242098. Top and left side views of cranidium, ×10.

Terranovella arcuata n.sp.

Fig. 9. MGUH 14940 from GGU 206498. Composite photo of holotype cranidium, ×10.
Fig. 12. MGUH 14941 from GGU 206498. Small cranidium, ×20.

Menomonia sp.

Fig. 11. MGUH 14942 from GGU 206498. Incomplete cranidium, ×6.

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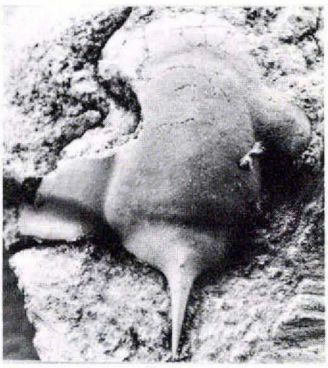

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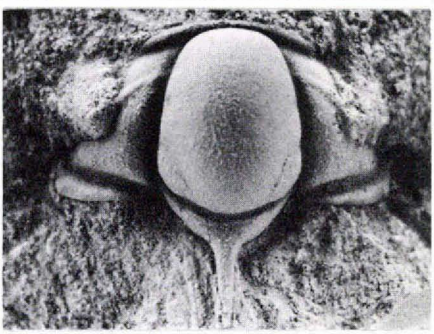

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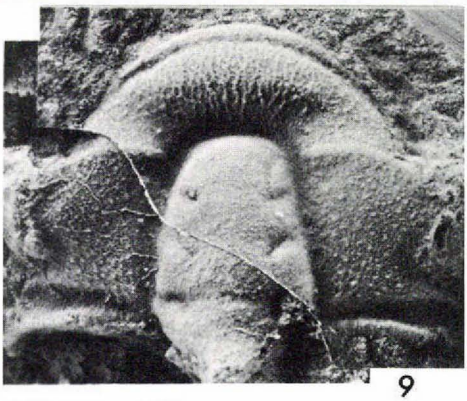

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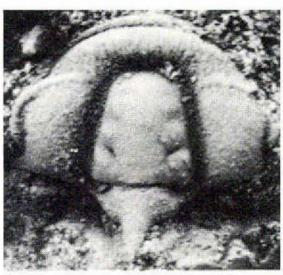

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Plate 6

Welleraspis cf. *W. jerseyensis* (Weller)

Figs 1, 2. MGUH 14943 from GGY 212833. Top and left side views, cranidium, ×10.
Fig. 3. MGUH 14944 from GGU 242098. Cranidium, ×8.
Fig. 4. MGUH 14945 from GGU 212833. Pygidium, ×15.

Welleraspis spp.

Figs 5, 6. MGUH 14946 from GGU 212833. Top and right side views, cranidium, ×20.
Fig. 7. MGUH 14947 from GGU 212833. Exfoliated cranidium, ×15.

Catillicephala rotunda (Rasetti)

Fig. 8. MGUH 14948 from GGU 242098. Cranidium, ×10.
Fig. 11. MGUH 14949 from GGU 242098. Exfoliated cranidium, ×6.
Fig. 13. MGUH 14950 from GGU 242098. Exfoliated pygidium, ×4.

Cryptoderaspis cf. *C. metisensis* Rasetti

Figs 9, 12. MGUH 14951 from GGU 242098. Left side and top views of exfoliated cranidium, ×6.

Pemphigaspis sp.

Fig. 10. MGUH 14952 from GGU 242098. Cranidium, ×15.
Fig. 16. MGUH 14953 from GGU 212833. Cranidium, ×10.

Pygidium undetermined 4

Fig. 14. MGUH 14954 from GGU 212833. Pygidium, ×7.

Ptychoparioid undetermined 5

Fig. 15. MGUH 14955 from GGU 212833. Cranidium, ×10.

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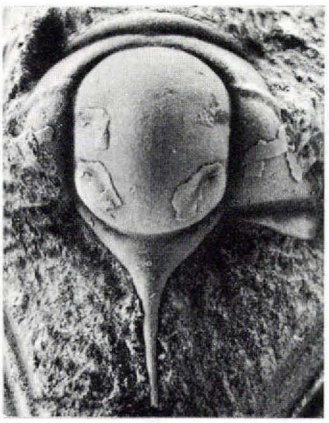

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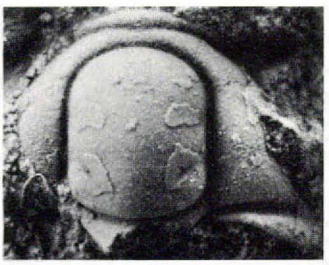

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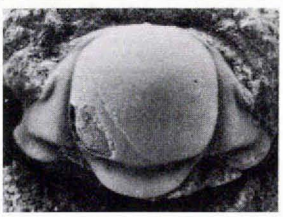

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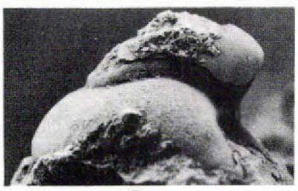

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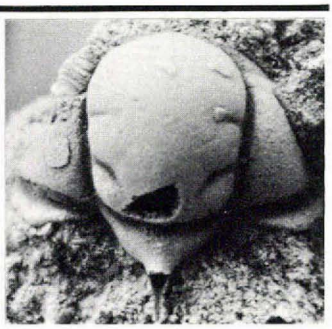

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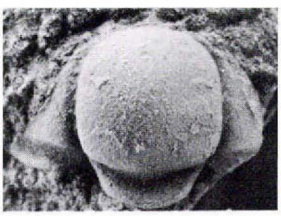

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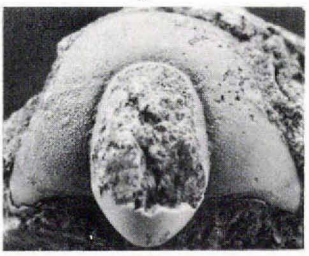

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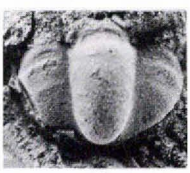

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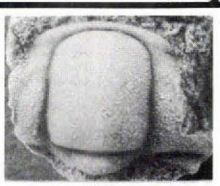

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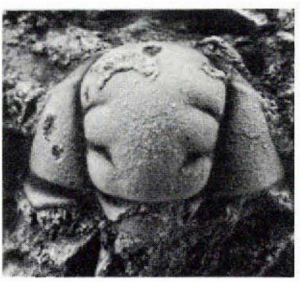

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